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MAR 04 2011

PPPO-02-1157663-11

Mr. Wm. Turpin Ballard
Remedial Project Manager
U.S. Environmental Protection Agency, Region 4
61 Forsyth Street
Atlanta, Georgia 30303

Mr. Edward Winner, FFA Manager
Kentucky Department for Environmental Protection
Division of Waste Management
200 Fair Oaks Lane, 2nd Floor
Frankfort, Kentucky 40601

Dear Mr. Ballard and Mr. Winner:

TRANSMITTAL OF 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/R1/V1)

Please find enclosed 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/V1). The revision addresses comments provided by the Kentucky Department for Environmental Protection and subsequently reconciled by the Risk Assessment Working Group in the fall of 2010 and February 2011. With these revisions, the risk methods document has been updated to ensure that it promotes development of risk assessments in accordance with the most current state and federal guidance.

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

Sincerely,

Reinhard Knerr
Paducah Site Lead
Portsmouth/Paducah Project Office

Enclosure:
D2/R1/V1 Risk Methods Document

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DOE/LX/07-0107&D2/R1/V1

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

DEPARTMENT OF ENERGY
UNITED STATES OF AMERICA

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DOE/LX/07-0107&D2/R1/V1

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

Date Issued—February 2011

Prepared for the
U.S. DEPARTMENT OF ENERGY
Office of Environmental Management

Managed by
LATA ENVIRONMENTAL SERVICES OF KENTUCKY, LLC
managing the
Environmental Remediation Activities at the
Paducah Gaseous Diffusion Plant
under contract DE-AC30-10CC40020

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PREFACE

This *Methods for Conducting Human Health Risk Assessments and Risk Evaluations at the Paducah Gaseous Diffusion Plant, Paducah Kentucky,* DOE/LX/07-0107&D2/R1/V1 (previous version issued as 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 2009). 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) 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.

CONTENTS

FIGURES

TABLES

EXHIBITS

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ACRONYMS

AF	adherence factor
ALM	Adult Lead Model
ARAR	applicable or relevant and appropriate requirement
AT123D	Analytical Transient 1-, 2-, 3-Dimensional Simulation of Waste Transport in the Aquifer System
CAS	Chemical Abstracts Service
CDI	chronic daily intake
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
COC	contaminant of concern
COPC	chemical of potential concern
DAF	dilution attenuation factor
DOE	U.S. Department of Energy
DQA	data quality assessment
DQO	data quality objective
EE/CA	Engineering Evaluation/Cost Analysis
ELCR	excess lifetime cancer risk
EPA	U.S. Environmental Protection Agency
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
K_d	adsorption coefficient/distribution coefficient
K_p	permeability coefficient
KDEP	Kentucky Department for Environmental Protection
KYRHB	Kentucky Radiation Health Branch
MARLAP	Multi-Agency Radiological Laboratory Analytical Protocols
MCL	maximum contaminant level
MOC	medium of concern
MQC	minimum quantification concentration
MQO	measurement quality objective
MDC	minimum detectable concentration
MUSLE	Modified Universal Soil Loss Equation
OSWER	Office of Solid Waste and Emergency Response
PA	preliminary assessment
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
POC	pathway of concern
PGDP	Paducah Gaseous Diffusion Plant
PRA	probabilistic risk assessment
PRG	preliminary remediation goal
ProUCL	EPA's Upper Confidence Limit Software
RAGS	Risk Assessment Guidance for Superfund
RAO	remedial action objective

RAWG	Risk Assessment Working Group
RCRA	Resource Conservation and Recovery Act
RESRAD	RESidual RADioactivity
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
SESOIL	Seasonal Soil Model
SF	slope factor
SI	site investigation
SMP	Site Management Plan
SQL	sample quantitation limit
SSL	soil screening level
SVOC	semivolatile organic compound
SWMU	solid waste management unit
SWMM	Storm Water Management Model
TCDD	2,3,7,8-tetrachlorodibenzo-p-dioxin
TCE	trichloroethene
TEF	toxicity equivalence factor
TEQ	toxicity equivalents
UCL	upper confidence limit
UCRS	Upper Continental Recharge System
UTL	upper tolerance limit
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 2009) 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, 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.

This document also discusses some of the methods used to complete dose assessments at PGDP. Dose assessments are conducted to provide information for risk managers and are separate from the risk assessment conducted for decision making. The methods for dose assessment are presented generally, and additional discussion should be held with regulatory agencies prior to initiating any dose assessment 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.
- 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, U.S. Environmental Protection Agency, Commonwealth of Kentucky Division of Waste Management, and Commonwealth of Kentucky Radiation Health Branch.

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1. INTRODUCTION

The purpose of this document is to present the methods and approaches used for screening level and baseline human health risk assessments at the Paducah Gaseous Diffusion Plant (PGDP) and provide resources [such as preliminary remediation goals (PRGs) and 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 (DOE 2009) 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 triparty 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 (PA/SI)] 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 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.[1] 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 goals 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. As shown in Figure 1.1, these decision points 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.

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[1] 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 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 FS risk evaluation, including remedial level development and consideration of residual risks, are in Section 4. Dose assessments sometimes are provided to risk managers, as well, and also are discussed within these sections. The approach to dose assessments discussed here is based on EPA guidance (EPA 2000a) and is specific to PGDP. The 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.

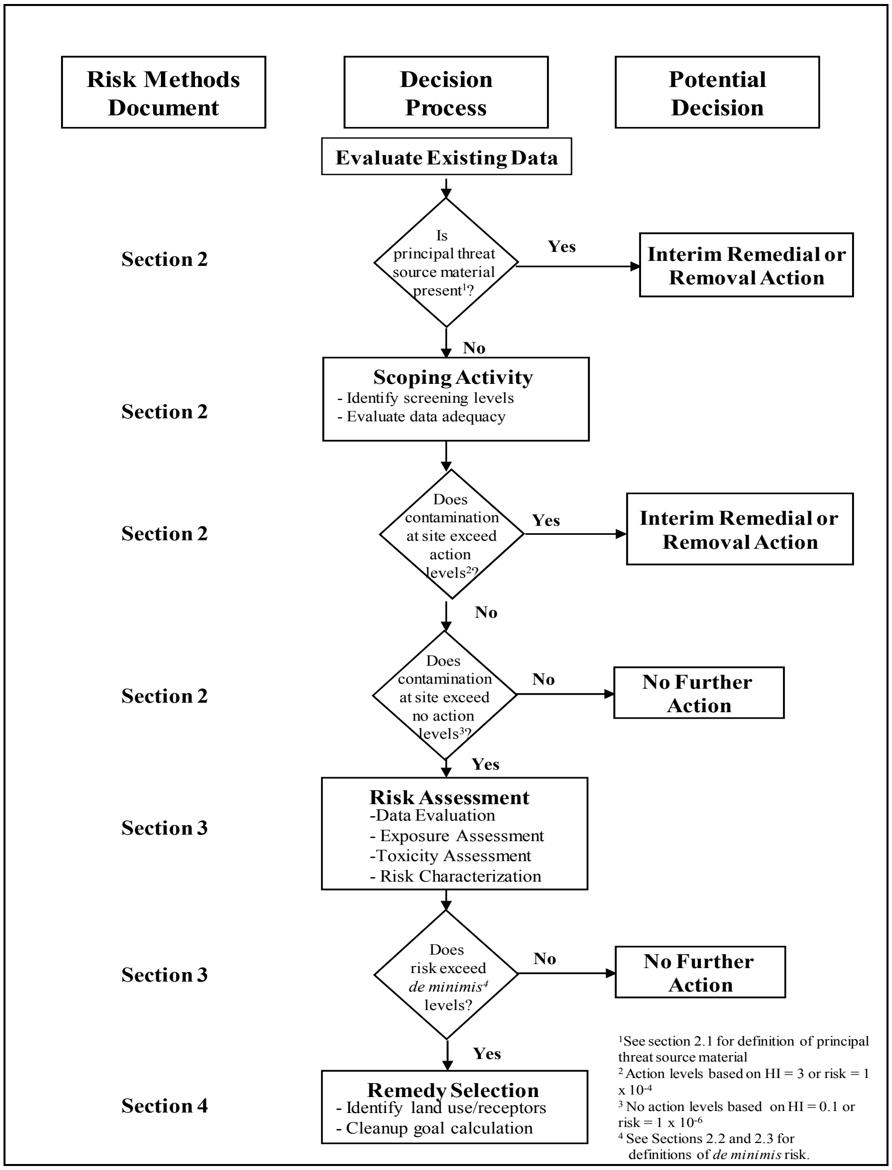

Figure 1.1. Remedy Decision Process

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)/Feasibility Study (FS) (i.e., interim action);[2]
- 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;[3] 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 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, dose-based concentrations (if a dose assessment is conducted), background concentrations, and pertinent applicable or relevant and appropriate requirements (ARARs). Table 2.1 shows the significant chemicals of potential concern (COPCs) at PGDP. Significant COPCs are chemicals that have been retained as contaminants of concern (COCs) (sometimes listed as contaminants 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 dose-based concentrations are provided for the significant COPCs and are presented in Tables A.1 through A.11 in Appendix A. Action and no action soil concentrations based on dose limits are derived by following EPA guidance (EPA 2000a) and are used for dose assessments at PGDP.

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; 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 dose-based levels for radionuclide contaminants in soil and sediment; Table A.9 presents dose-based levels for radionuclide contaminants in groundwater; Table A.10 presents dose-based levels for radionuclide contaminants in surface water; and Table A.11 presents dose-based levels for radionuclide contaminants in soil that are

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[2] 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.

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

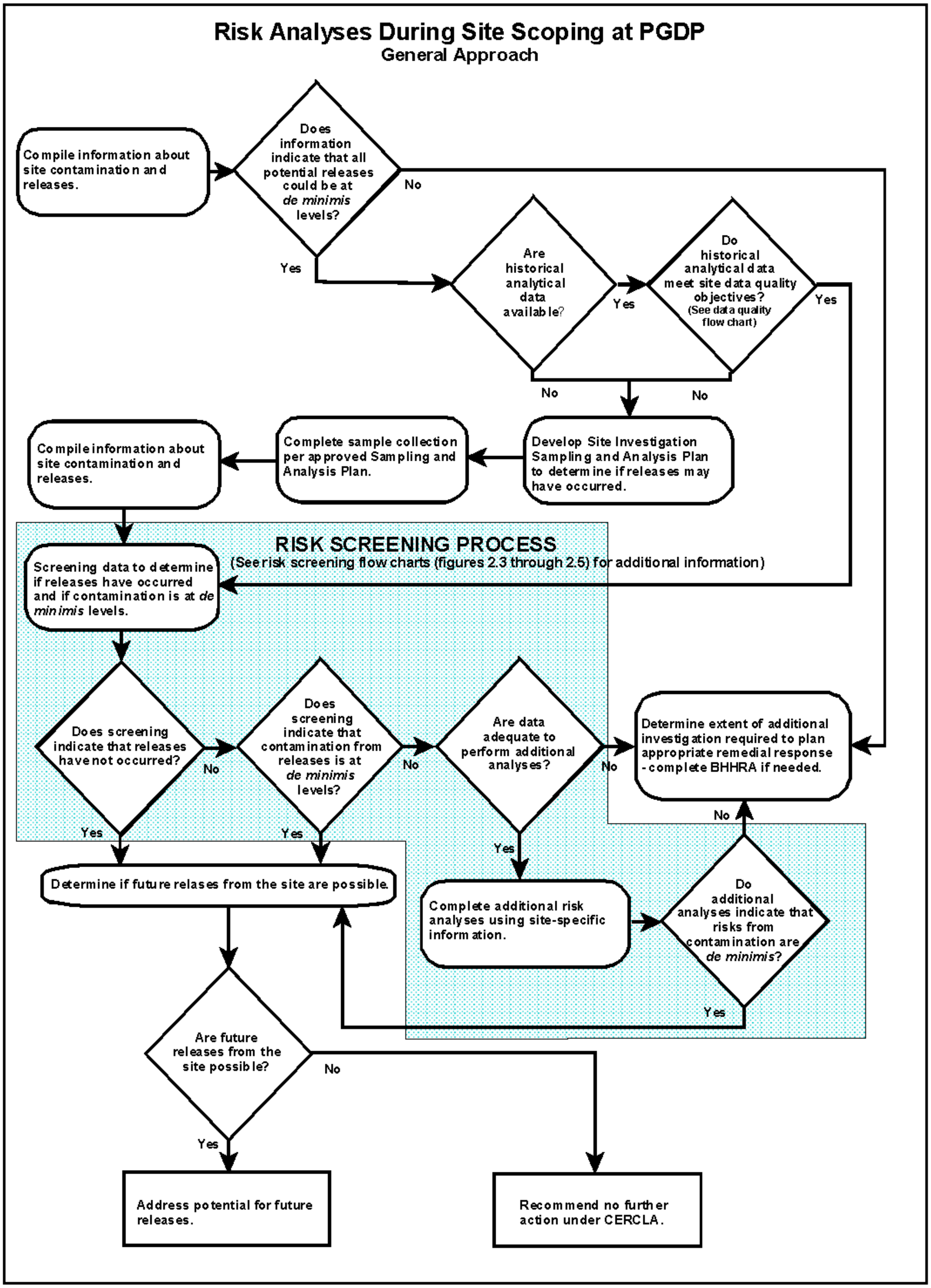


Figure 2.1. General Approach to Risk-Based Site Scoping

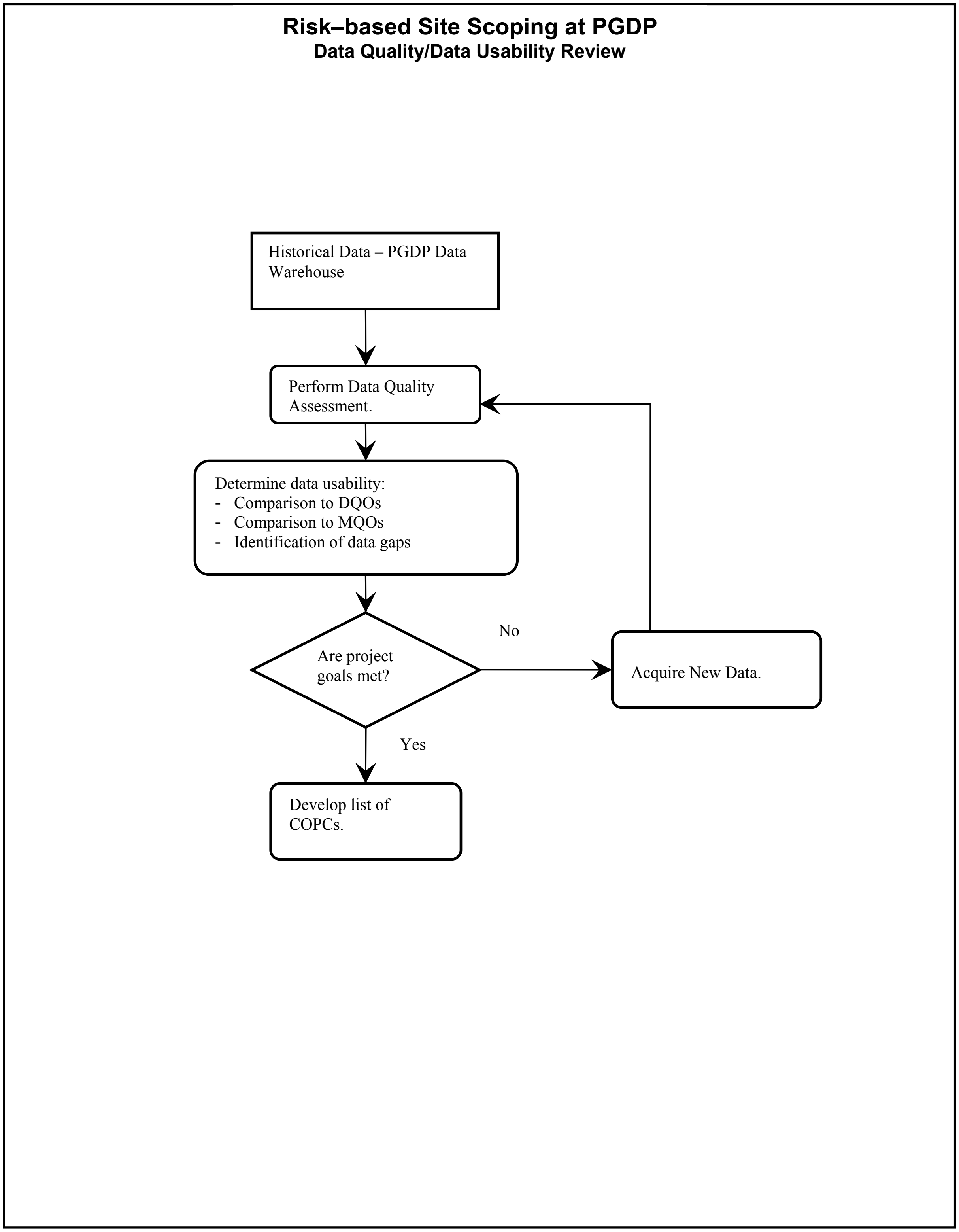


Figure 2.2. Data Quality Review to Support Risk-Based Site Scoping

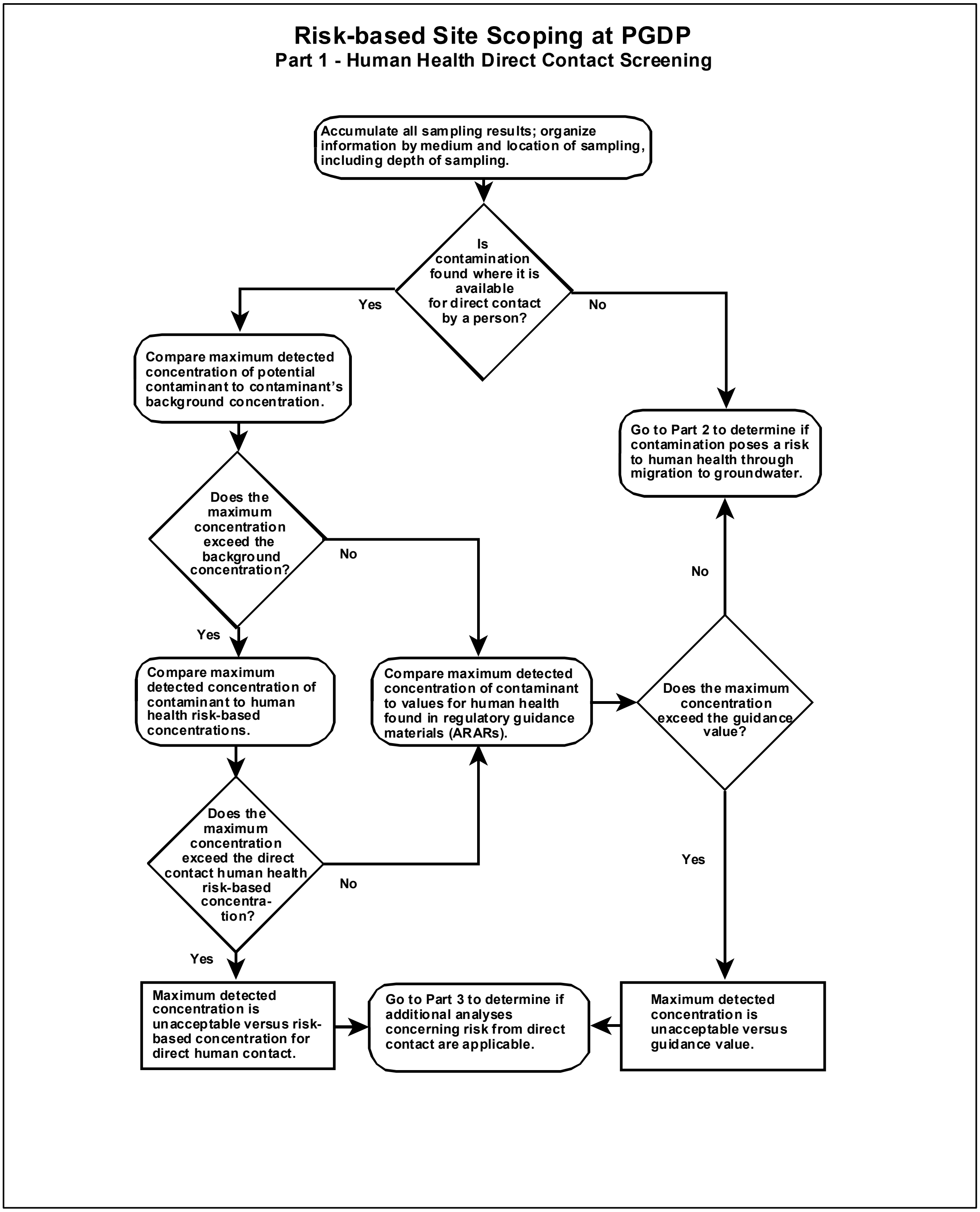


Figure 2.3. Human Health Direct Contact Screening during Risk-Based Site Scoping

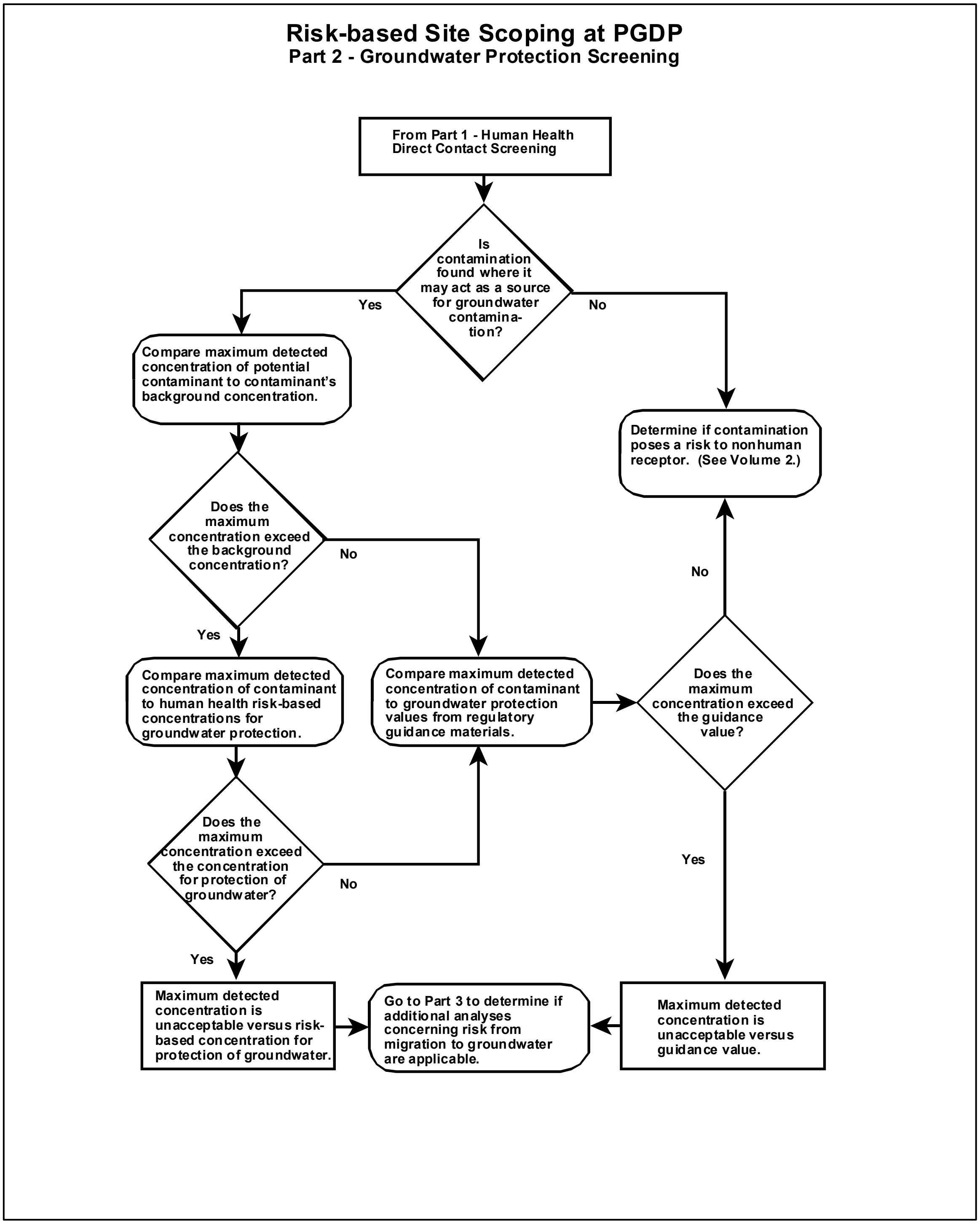


Figure 2.4. Groundwater Protection Screening during Risk-Based Site Scoping

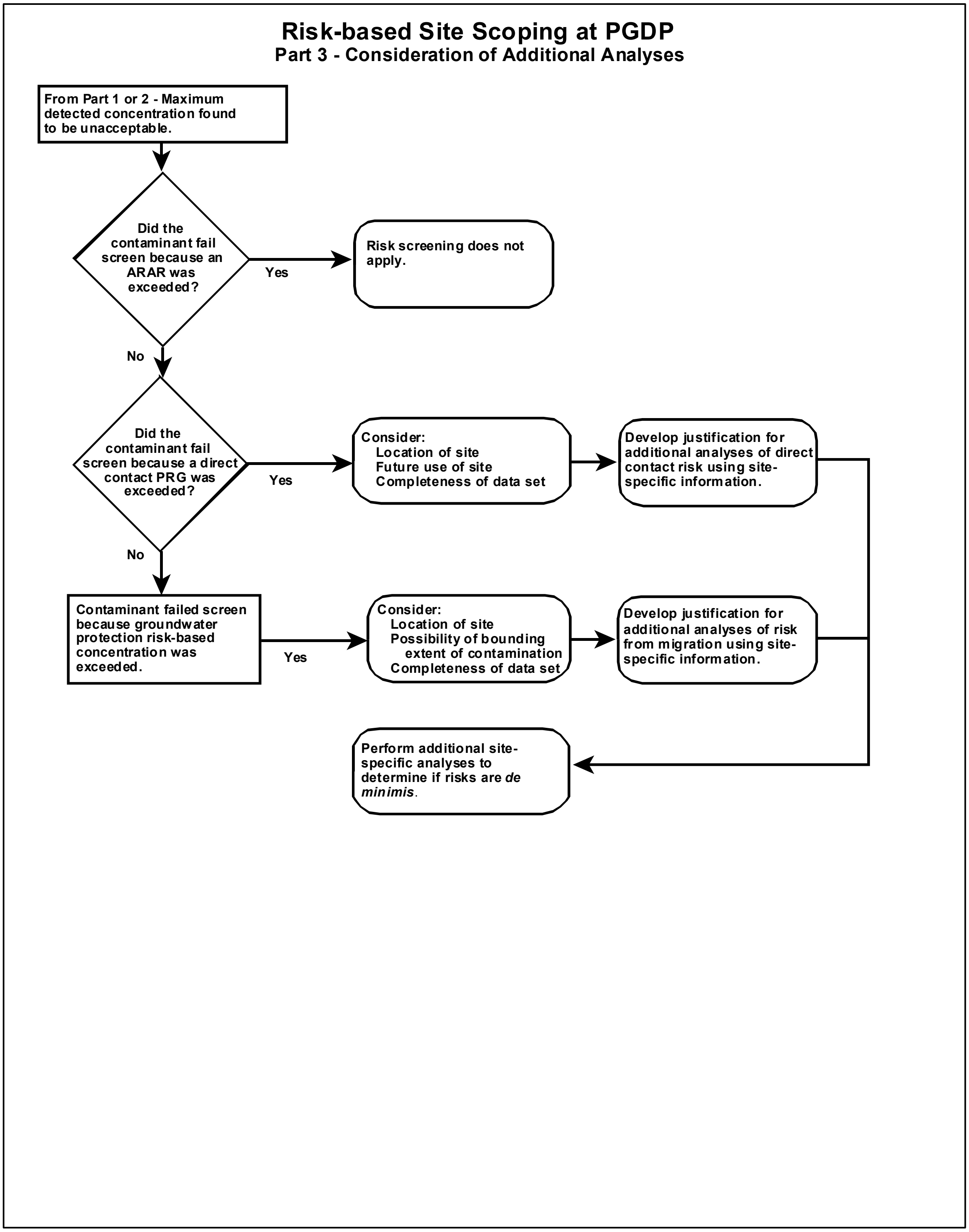


Figure 2.5. Consideration of Additional Analyses during Risk-Based Site Scoping

Table 2.1. Significant Chemicals of Potential Concern at PGDP[1]

Inorganic Chemicals		Organic Compounds		Radionuclides	
Analyte	**CAS Number**	**Analyte**	**CAS Number**	**Analyte**	**CAS Number**
Aluminum	7429905	Acenaphthene	83329	Americium-241	14596102
Antimony	7440360	Acenaphthylene	208968	Cesium-137+D	10045973
Arsenic	7440382	Acrylonitrile	107131	Cobalt-60	10198400
Barium	7440393	Anthracene	120127	Neptunium-237+D	13994202
Beryllium	7440417	Benzene	71432	Plutonium-238	13981163
Boron	7440428	Carbazole	86748	Plutonium-239	15117483
Cadmium	7440439	Carbon tetrachloride	56235	Plutonium-240	14119336
Chromium III	16065831	Chloroform	67663	Technetium-99	14133767
Chromium VI	18540299	1,1-Dichloroethene	75354	Thorium-230	14269637
Cobalt	7440484	1,2-Dichloroethene (mixed)	540590	Uranium-234	13966295
Copper	7440508	*trans*-1,2-Dichloroethene	156605	Uranium-235+D	15117961
Iron	7439896	*cis*-1,2-Dichloroethene	156592	Uranium-238+D	7440611
Lead	7439921	Dieldrin	60571		
Manganese	7439965	Ethylbenzene	100414		
Mercury	7439976	Fluoranthene	206440		
Molybdenum	7439987	Fluorene	86737		
Nickel	7440020	Hexachlorobenzene	118741		
Selenium	7782492	Naphthalene	91203		
Silver	7440224	2-Nitroaniline	88744		
Thallium	7440280	N-Nitroso-di-n-propylamine	621647		
Uranium	NA	Phenanthrene	85018		
Vanadium	7440622	Pyrene	129000		
Zinc	7440666	Tetrachloroethene	127184		
		Trichloroethene	79016		
		Total Dioxins/Furans	1746016		
		2,3,7,8-HpCDD	37871004		
		2,3,7,8-HpCDF	38998753		
		2,3,7,8-HxCDD	34465468		
		2,3,7,8-HxCDF	55684941		
		OCDD	3268879		
		OCDF	39001020		
		2,3,7,8-PeCDD	36088229		
		1,2,3,7,8-PeCDF	57117416		
		2,3,4,7,8-PeCDF	57117314		
		2,3,7,8-TCDD	1746016		
		2,3,7,8-TCDF	5127319		
		Total PAHs	50328		
		Benz(a)anthracene	56553		
		Benzo(a)pyrene	50328		
		Benzo(b)fluoranthene	205992		
		Benzo(k)fluoranthene	207089		
		Chrysene	218019		
		Dibenz(a,h)anthracene	53703		
		Indeno(1,2,3-cd)pyrene	193395		
		Total PCBs	1336363		
		Aroclor 1016	12674112		
		Aroclor 1221	11104282		
		Aroclor 1232	11141165		
		Aroclor 1242	53469219		
		Aroclor 1248	12672296		
		Aroclor 1254	11097691		
		Aroclor 1260	11096825		
		Vinyl chloride	75014		
		Xylenes (Mixture)	1330207		
		p-Xylene	106423		
		m-Xylene	108383		
		o-Xylene	95476		

[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 2008 (i.e., DOE 1996a, DOE 1996b, DOE 1999a, DOE 1999b, DOE 2005, and DOE 2008).
CAS = Chemical Abstract Service

protective of groundwater drawn from the RGA immediately adjacent to a contaminated area. Methods used to develop the risk-based and dose-based screening values are presented in Appendix B of this document.

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 E. Appendix E also contains a discussion of the derivation of the derivation of the background values. Only soil 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 2000). 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.

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 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 concentration or maximum activity for radionuclides with the range of background values also may be conducted in the uncertainty section of the risk assessment (discussed in Section 3.3.37) to further evaluate if a COPC represents a site contaminant. The maximum detected concentrations or activity for radionuclides for all detected analytes with background values will be included in the prepared summary appendix used for screening against background. 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 dose analysis is conducted, similar tables should be prepared to present the results of the 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.

SCREEN FOR SOURCE MATERIALS CONSTITUTING A PRINCIPAL THREAT

Source material may constitutute a principal threat if it contains waste or other material (e.g., dense nonaqueous-phase liquids) that is an obvious threat to human health and the environment, either due to the nature and concentration of the contamination or due to a large mass of leachable material in the ground. No "threshold level" of toxicity/risk has been established to equate to a "principal threat." At the PGDP, expedited remediation decisions can be made at sites that contain source material that may constitute a principal threat without lengthy risk assessment efforts

The screening levels and benchmarks along with other factors considered when determining if source material constitutes a principal threat when characterization data are available are as follows (RAWG 2000a):

- If concentration of a single contaminant exceeds its action level (target risk = 1×10^{-4}), then perform analysis to determine if toxicity and mobility combine to produce a risk greater than 1×10^{-3}. If so, then the source material may present a principal threat.
- If concentration of a single contaminant exceeds its action level (target hazard = 3), then perform analysis to determine if toxicity and mobility combine to produce a hazard greater than 10. If so, then the source material may present a principal threat.
- If concentration of a single contaminant exceeds its action level (target dose 25 mrem), then the source material may present a principal threat.

When performing additional analysis

- For on-site areas, use the industrial no-action levels and Eq. 1 through 4.
- For areas off DOE Property, use the residential no-action levels and Eq. 1 through 4.

This definition is consistent with EPA 1991a. This guidance document should be consulted for additional information regarding source materials constituting a principal threat.

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 (See text box for a description). 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 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 dose estimates are similar and are not presented. Also, note that for a dose assessment the benchmark for dose-based action is 25 mrem/year.)

$$\text{Analyte-specific Risk} = \frac{\text{MAX}}{\text{Cancer PRG}} \times \text{Target Risk}$$ **[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}).

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

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

$$\text{Analyte-specific Hazard} = \frac{\text{MAX}}{\text{Hazard PRG}} \times \text{Target Hazard}$$ **[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).

$$\text{Total Hazard} = \sum \text{Analyte-specific Hazards}$$ **[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 principal threat waste areas (EPA 1997a). 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;
- 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*) 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 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 dose assessments are not specifically described in the following. Generally, if a 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.)

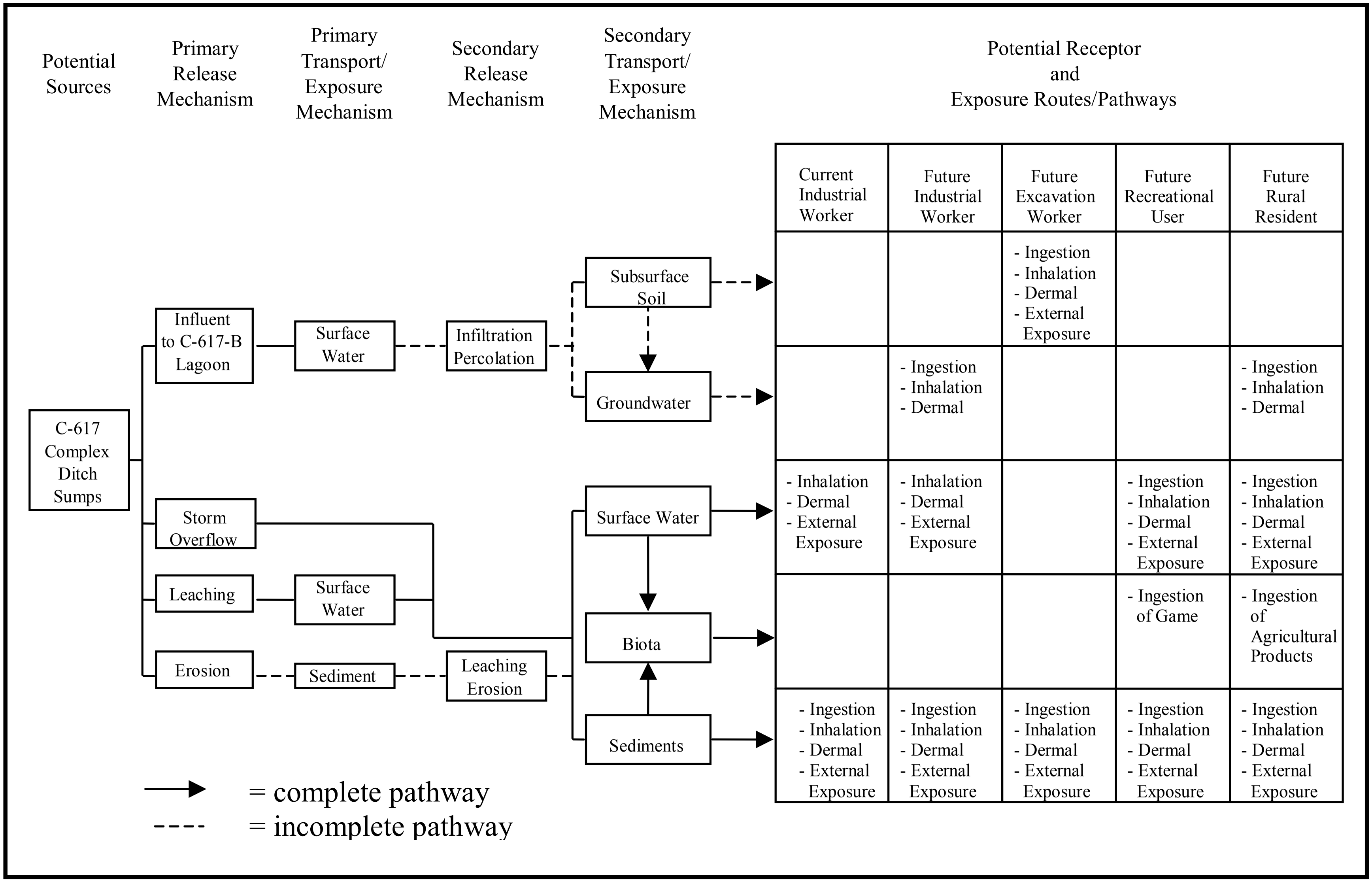
Generally, in work plans, the majority of the risk-related information will appear as part of the initial evaluation. In the work plan’s initial evaluation, the scope, objectives, and methods for the baseline risk assessment will be related; preliminary conceptual site models will be presented; laboratory 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 data quality objectives (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 are integral to this process.

Development of DQOs follows a series of steps. The seven steps in the process are shown in a flowchart in Appendix E. The purpose and goal of each step is described in the text in Appendix E accompanying the flowchart. Appendix E also includes example checklists and 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. As an example, the conceptual site model developed for Solid Waste Management Unit (SWMU) 171 is presented in Figure 3.1.



Current Industrial Worker	Future Industrial Worker	Future Excavation Worker	Future Recreational User	Future Rural Resident
		- Ingestion - Inhalation - Dermal - External Exposure		
	- Ingestion - Inhalation - Dermal			- Ingestion - Inhalation - Dermal
- Inhalation - Dermal - External Exposure	- Inhalation - Dermal - External Exposure		- Ingestion - Inhalation - Dermal - External Exposure	- Ingestion - Inhalation - Dermal - External Exposure
			- Ingestion of Game	- Ingestion of Agricultural Products
- Ingestion - Inhalation - Dermal - External Exposure	- Ingestion - Inhalation - Dermal - External Exposure	- Ingestion - Inhalation - Dermal - External Exposure	- Ingestion - Inhalation - Dermal - External Exposure	- Ingestion - Inhalation - Dermal - External Exposure

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 Decisions, 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 development of contamination concentrations that may remain at or migrate from a site and not pose unacceptable risk; to contaminant migration, and to the activity patterns of present and potential future receptor populations. 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 Decision 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 dose concerns).

Risk analyses will be used during Step 4, Define the Study Boundaries, 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, Identify Decision Rules and Identify Inputs 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 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 Limits on Decision Errors, 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 dose assessment done to provide information for risk managers, the 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, Optimize Sample Design, 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 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 pathways of concern (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

WAG 1, 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 will be discussed. 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 health-based standards (i.e., PRGs, 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 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

	Soil (mg/kg or pCi/g)			**Groundwater (μg/l or pCi/l)**			
Analyte	**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 PRG that appears in this table will be the lesser of the cancer- and hazard-based, no action residential use PRGs taken from Appendix A. Additionally, the hazard-based PRG that is included will be that calculated for a child aged 1 to 7.

[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., maximum contaminant levels) 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 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) 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) 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 remedial action objectives 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 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.

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

Analyte	Soil (mg/kg or pCi/g)			
	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 lesser of the no action cancer- and no action hazard-based PRGs for exposure to soil for the appropriate future use taken from Appendix A. If residential use PRGs are used, then the no action hazard-based PRG should be that for a child aged 1 to 7.

[3] The groundwater protection PRG will be the lesser of the no action cancer- and no action hazard-based 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) will be that presented in Appendix A or the most recent update.

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 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. 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 lesser of the no action cancer- and no action hazard-based PRGs for the appropriate future use taken from Appendix A.

[3] The soil background concentration (or activity) will be that presented in Appendix A or the most recent update.

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 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.

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 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) will be that presented in Appendix A or the most recent update.

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 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. 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. Comparisons to MCLs will not be used to identify COPCs, but will be provided for information only.

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 lesser of the no action cancer- and no action hazard-based PRGs in Appendix A. Note, the hazard-based PRG should be that for a child aged 1 to 7.
[3] The MCL will be taken from Appendix A or the most recent update.
[4] The groundwater background concentration (or activity) 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 remedial goal option (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 dose assessment are not presented in detail. The methods for 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, and 2007c) 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, and E* (EPA 1989a, 1991b, 1991c, 1998b, and 2004a, respectively) (RAGS, Parts A, B, C, D, and E, 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)

- *Human Health Evaluation Manual, Supplemental Guidance: "Standard Default Exposure Factors"* (EPA 1991d)

- *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)

- *Exposure Factors Handbook*, EPA 600/P-95/002Fa,b,c (EPA 1997b)

- *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)

- *Supplemental Guidance to RAGS: Region 4 Bulletins, Human Health Risk Assessment Bulletins,* EPA Region 4, Website version last updated May 2000 (EPA 2000c)

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

- *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)

- *Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils (Subsurface Vapor Intrusion Guidance)* (EPA 2002a)

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

- *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 www.epa.gov/superfund/lead/products.htm; user's guide is EPA 2004a)

- EPA Regional Screening Level Tables, EPA region 3 (EPA 2009a) at www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/index.htm

- *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)

- *ProUCL Version 4.00.04 Technical Guide (Draft)*. ORD NERL ESC Technical Support Center, Characterization and Monitoring Branch, Las Vegas, NV, (EPA/600/R-07/041) (EPA 2009b)

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 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, and 2007c)

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.

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 (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.

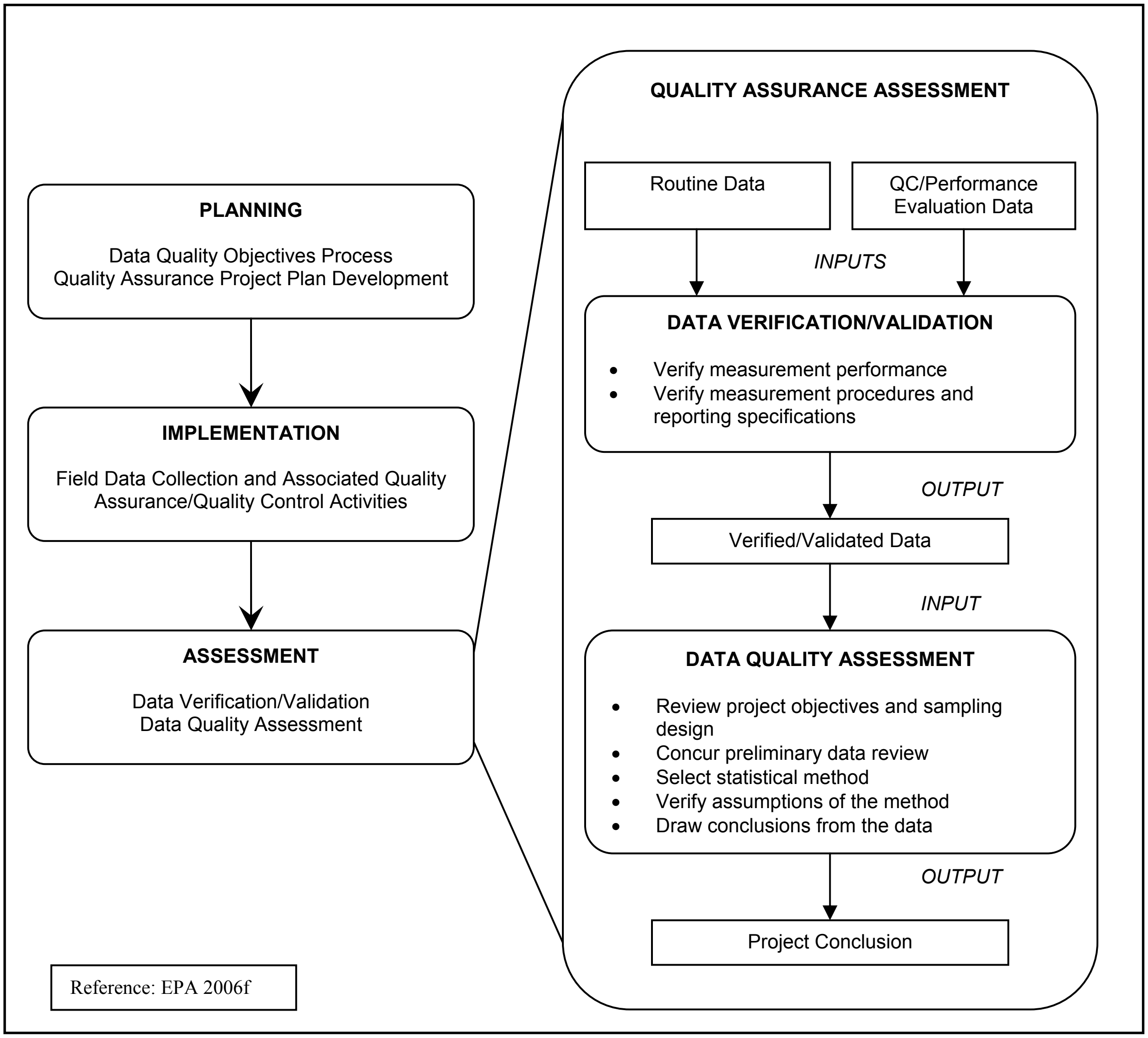
3.3.3.1 Data quality/data usability review

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 and 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 is 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. A flowchart outlining the steps in the DQA process is presented in Appendix E.

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 seven 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.



Reference: EPA 2006f

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. 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.** 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 over all 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 over all 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

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 at which the analyte may pose an unacceptable risk (or dose). If the maximum MDC/MQC for an analyte over all samples within a medium is greater than the concentration or activity that may pose an unacceptable risk (or dose) to human health and the analyte is less than the minimum detectable activity MDC/MQC in any samples, then the data for that analyte will be deemed suspect. The MDCs used for radionuclides should be the MDCs established in the MARLAP Manual (EPA 2004b), which provides guidance for evaluating SQLs for radionuclide data. For all radionuclides detected in at least one sample, all reported values, including negative values, will be used to derive the exposure point concentrations under current conditions after considering any other qualifiers attached to the data point.

Survey-type data. When XRF data are used in the derivation of exposure point concentrations, 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.

- **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 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 is 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 exposure point concentration.

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

    - **KYRHB-LT:** Kentucky Radiation Health and Branch (KYRHTAB) has performed an independent data assessment and the results are less than the MDC or detection limit and should not be plotted.

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

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

  - **KYRHB-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 dataset. 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 exposure point concentration 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 assumed to be a COPC, then others 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 lesser of the lifetime excess cancer-based and child hazard-based no action values 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 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 1995). 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 described in Appendix E will be 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 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 cancerous PAHs, PCBs, and dioxins/furans (dioxins) will be derived. Total 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 PAHs, the toxicity equivalence factors (TEFs) presented in Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities (EPA 2005) 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 PAH concentration in a sample will be the sum of the products of each 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.

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

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
		OCDD	0.0003
Indeno(1,2,3-c,d)pyrene	0.1	2,3,7,8-TCDF	0.1
All other PAHs	0	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 2005
[2] TEFs from Van Den Berg, *et al.* 2006

When deriving total PCBs (if this analyte 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 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-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. The total dioxin concentration will be compared to the EPA residential cleanup level of 1 ppb toxicity equivalents (TEQs) for residential and 5 to 20 ppb TEQs for industrial scenarios (EPA 1998c), in addition to comparison to the PRGs in Appendix A.

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 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 chemicals of potential concern 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.

- Letter and survey form used during the Phase I Site Investigation to determine groundwater use near PGDP (CH2M HILL 1991);

- Summary of the interview with Mr. Kenny E. Perry, Agricultural Extension Agent, Ballard County, Kentucky, regarding agricultural practices in Ballard County held in February 1994;

- Summary of the interview with Mr. Douglas A. Wilson, Agricultural Extension Agent, McCracken County, Kentucky, regarding agricultural practices in McCracken County held in February 1994;
- Letter dated February 24, 1994, from Mr. Douglas A. Wilson, Agriculture Extension Agent, McCracken County, Kentucky, to Mr. Fred Dolislager, Risk Analyst, Oak Ridge National Laboratory, regarding area of crop land in McCracken County;

- Questionnaire dated October 26, 1995, sent to Mr. Charles Logsdon, Kentucky Department of Fish and Wildlife, by FMSM Engineers, Inc., regarding recreational use of Bayou and Little Bayou Creeks near PGDP;

- Facsimile dated November 8, 1995, sent to Mr. Stephen Scott, FMSM Engineers, Inc., containing responses from Mr. Charles Logsdon, Kentucky Department of Fish and Wildlife, to the aforementioned questionnaire;

- Letter dated April 5, 1994, from Kentucky Department of Fish and Wildlife to Mr. Fred Dolislager, Risk Analyst, Oak Ridge National Laboratory, containing annual harvests of geese, ducks, turkeys, and deer in McCracken and Ballard Counties, 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;

- Kentucky Risk Assessment Guidance, Risk Assessment Branch, Department for Environmental Protection, Commonwealth of Kentucky;

- Kentucky Guidance for Ambient Background Assessment, Risk Assessment Branch, Department for Environmental Protection, Commonwealth of Kentucky, January 8, 2004;

- Kentucky Guidance for Groundwater Assessment Screening, Risk Assessment Branch, Department for Environmental Protection, Commonwealth of Kentucky, January 15, 2004;

- Trichloroethylene Environmental Levels of Concern, Risk Assessment Branch, Department for Environmental Protection, Commonwealth of Kentucky, April 2004;

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

- PGDP background document (DOE 1996e);

- DQO materials (flowcharts, process description, example checklists);

- 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;

- Parameters for Integrated Exposure Uptake and Biokinetic (IEUBK) model.

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., dose or intake calculated), and doses will be presented. Methods to complete each of these steps are discussed in the following sections.

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 Site Management Plan (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, and excavation.

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 security fence (if applicable), at the PGDP facility property boundary (if applicable), and at Little Bayou Creek (if applicable). Note that for units or areas outside the security fence controlled area at PGDP, exposure at the security fence will not be considered because it is not necessary for remedial decisions. 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 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, 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
- 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).

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 exposure point concentration and the exposure factors are required. Here, the exposure point concentration can be defined as the concentration or activity 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.

Exposure point concentrations 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 exposure point concentration will be the maximum detected concentration.

(2) If results from ten or more samples are available, then a distribution check will be performed, and the exposure point concentration will be the lesser of the maximum detected concentration and the 95% upper confidence limit (UCL) on the mean of the appropriate distribution. The latest version of EPA's ProUCL software (available at www.epa.gov/nerlesd1/tsc/software.htm) incorporates a number of different distributional tests that may be used to perform the distributional tests and calculate the most appropriate UCL (EPA 2009b).

In determining the UCL when the medium is soil, data will be segregated into depth intervals relevant to receptors. For all scenarios except the outdoor worker/gardener, data from samples collected from 0 to 1 ft below ground surface will be used to estimate the exposure point concentration.[4] For the outdoor worker/gardener, data collected from 0 to 10 ft below ground surface will be used to estimate the exposure point concentration, unless site-specific information indicates that results from samples collected at deeper depths should be included in the derivation of the exposure point concentration.

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

The exposure point concentrations 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 exposure point concentrations 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

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[4] Although a single set of exposure equations and parameters are used for the outdoor worker/gardener scenario, the gardener scenario should only be considered to be a reasonable scenario for areas outside the limited area at the Paducah site. Additionally, all exposure parameters for the outdoor worker/gardener scenario, except exposure duration (ED), can be used for a construction/excavation worker. When used for the construction/excavation worker scenario, the ED should be reduced to 1 and 5 years (based on guidance from the Exposure Factors Handbook).

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 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 exposure point concentrations 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.)

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

where: Intake = The 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 secure 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.)

For assessments for source units outside the fence and for integrator unit baseline risk assessments, results from biota sampling may be available. In cases where this information is available, the exposure point concentration 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.)

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	SSLs and/or RESRAD	At source unit	Value to be used for initial scoping, use DAF of 1 for SSLs unless site-specific values are available.
	(Used for scoping)			Groundwater Protection value based on residential use and targets of 1E-6, 0.1, and 1 for risk, hazard, and 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.
		Vapor intrusion model	At source unit	Initial vapor intrusion model will use default values.
	Tier 2 (Used for scoping)	SESOIL and/or RESRAD	At source unit	Includes source delimitation. Recognize SESOIL limitations when modeling inorganic COPCs-refine K_ds.
DECISION DOCUMENTS	Tier 3 (Enhanced modeling used in decision documents if needed)	SESOIL and RESRAD suite of codes with AT123D	At source unit and at Downgradient points (Fence, property boundary, creek, river)	Uses source delimitation and refined K_ds from above. Use values from this effort to set initial remediation 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 MODFLOW/MT3D/ RT3D	Downgradient points	To be used to refine remediation levels (if needed). Maybe 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 dose, respectively. If site-specific DAF values are used, then need to justify these values.
	Tier 2 (Used for scoping)	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)	SWMM	At source unit and at Downgradient points (Fence, creek)	Uses source delimitation from above. Initial remediation level calculations.
	Tier 4 (Enhanced modeling used in decision and design documents if needed)	Enhanced SWMM	Downgradient points (Fence, creek)	To be used to refine remediation levels (if needed). Maybe 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 (Fence, creek)	Uses source delimitation from above. Initial remediation 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 (Fence, creek)	To be used to refine remediation levels (if needed). Maybe especially important to set monitoring goals.

AT123D = Analytical Transient 1-, 2-, 3-Dimensional Simulation of Waste Transport in the Aquifer System
COPC = chemical of potential concern
DAF = dilution/attenuation factor
HHRAWG = Human Health Risk Assessment Working Group
K_d = adsorption coefficient/distribution coefficient
PGDP = Paducah Gaseous Diffusion Plant
RESRAD = Residual Radiation
SESOIL = Seasonal Soil Model
SSL = Soil Screening Level
SWMM = Storm Water Management Model
MODFLOW/MT3DRT3D = three-dimensional finite-difference groundwater model
MUSLE = Modified Universal Soil Loss Equation

3.3.4.4 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 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 will be rural residential, recreational, industrial, and excavator. Only populations relevant to the time period will be included.

Exhibit 3.10. Presentation of Exposure Point Concentrations[1]

Chemical of Potential Concern[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 chemicals of potential concern 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

Chemical of Potential Concern[1]	Parameter 1[2]	Parameter 2	. . .	Parameter N
Analyte 1			. . .	
Analyte 2			. . .	
. . .	. . .	. . .	. . .	. . .
Analyte N			. . .	

[1] All chemicals of potential concern 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 (Dose) for Receptor 1[1]

Chemical of Potential Concern[2]	Pathway 1[3]	Pathway 2	. . .	Pathway N
Unit of 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 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.

3.3.4.5 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 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.

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 2007)
- Tier 2 sources: EPA Provisional Peer Reviewed Toxicity Values
- Tier 3 sources*:*
  - Health Effects Assessment Summary Tables (HEAST) (EPA 1997c, 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.

Baseline risk assessments for PGDP will be conducted using the Kentucky oral slope factor for trichloroethene (TCE), which is also the value used to develop the action and no action levels in Appendix A of this document. Until a consensus TCE slope factor is developed by EPA, the uncertainty section of the Baseline risk assessment will contain a comparison to TCE risks calculated using the CalEPA slope factor for TCE. The uncertainty section of the baseline risk assessment will discuss the differences in risk associated with the two calculations.

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/gardener. In no case will toxicity values based on subchronic exposure be used for child or teen receptors. For outdoor workers/gardeners, 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. For some chemicals and compounds, a chemical-specific gastrointestinal absorption efficiency is not available. For these chemicals and compounds, the following default chemical-specific gastrointestinal absorption efficiencies in EPA (1995) will be used:

- 0.80 for volatile organic chemicals
- 0.50 for semivolatile organic chemicals
- 0.20 for inorganic chemicals

$$Absorbed\ SF = \frac{Administer\,ed\ SF}{GI\ Efficiency} \qquad \textbf{Eq. 6}$$

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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For many chemicals, toxicity information necessary to derive an inhalation exposure toxicity value is not available. To address this lack of information, inhalation toxicity values extrapolated from administered toxicity values (i.e., oral) taken from the sources listed in this section will be used. The uncertainty section of the baseline human health risk assessment will discuss the effect that using extrapolated toxicity values had on the final risks and hazards derived in the assessment.

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 the dermal-soil pathway, the default values of 25% dermal absorption for volatile organic compounds (VOCs), 10%

dermal absorption from soil for all semivolatile organic compounds (SVOCs) 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, should be applied to a quantitative risk assessment. This approach is consistent with guidance from KDEP. 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.

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 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. 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 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.")

$$HQ_i = \frac{CDI_i}{RfD_i} \qquad \textbf{Eq. 8}$$

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
RfD_i = The chronic reference dose for administered or absorbed dose as appropriate

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

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)

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

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 cancer incidence (i.e., ELCR) in all baseline human health risk assessments performed for PGDP. The result of Eq. 11 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. 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.")

$$ELCR_i = CDI_i \times SF_i \qquad \textbf{Eq. 11}$$

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

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

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

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

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). 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 1996f 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 3.14 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.

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 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).

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	NA	NA	NA	**NV**
% of Total	NV	NV	NV	
Sector 2	<0.1	0.4	NV	**0.4**
% of Total	1%	99%	NV	
Sector 3	<0.1	0.3	<0.1	**0.3**
% of Total	2%	98%	<1%	
Sector 4	<0.1	1.0	<0.1	**1.0**
% of Total	1%	99%	<1%	
Sector 5	<0.1	1.7	<0.1	**1.8**
% of Total	2%	98%	<1%	
Sector 6	<0.1	1.2	<0.1	**1.2**
% of Total	5%	95%	<1%	
Sector 8	<0.1	1.0	<0.1	**1.0**
% of Total	<1%	99%	<1%	
Sector 9	<0.1	1.3	NV	**1.3**
% of Total	1%	99%	NV	

NA indicates that the scenario is not applicable for this location.
NV indicates that a value is not available.
Current convention is to use one significant digit for presentation of hazard indices. Three significant digits are used here when the hazard index is greater than 0.1 to enable the reader to match the numbers reported in the exhibit with those in its associated risk characterization table. Additionally, use of three significant digits, when the exposure route's value is greater than 0.1, allows the reader to sum the route values and check the location total.

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**

NA 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.

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 and 15 µg/l in groundwater and surface water for all scenarios (residential, recreational, industrial, and outdoor worker/gardener). 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/gardener 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, but are not in the on-line risk calculator because of the different method used to calculate those values.

3.3.6.4 Selection of use scenarios, pathways, contaminants, and MOC

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 1.0 and 1×10^{-6}, respectively. 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 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 0.1 and 1×10^{-6}, respectively. 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 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 0.1 and 1×10^{-6}, respectively. 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, PAHs, and PCBs, the total risk over all congeners (for dioxins and furans) or compounds (for PAHs and PCBs) will be used when determining if these are COCs.] The results in the 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 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 0.1 and 1×10^{-6}. For the results presented in the 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 Dose Assessment.** If a dose assessment is conducted to provide additional information to risk managers, a scenario of concern will be one that has a total dose exceeding the PGDP *de minimis* dose of 1 mrem/year. A COC will be one that has a contaminant-specific dose exceeding 1 mrem/year. A POC will be an exposure route that has a route-specific 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 dose assessment if a 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 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 exposure point concentrations for environmental media under current conditions
- 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

- 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)

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 Kentucky DEP oral slope factor and EPA TCE oral slope factor (currently CalEPA value)

- 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)

- Combination of risk estimates from chemical and radioisotope exposure

- Summing cancer risks across pathways and across target organs

(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 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, the following table, 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.

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 goals, but are site-specific, risk- or dose-based criteria that may be used to guide the development of clean-up goals (i.e., remediation levels) by risk managers. Remediation levels are developed as part of the risk analysis in the Record of Decision (ROD) (EPA 2006b).

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.”

3.3.8.1 Calculation of remedial goal options

Guidance in EPA (2000b) 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 in a medium that results in a specific “target risk,” “target hazard,” or “target 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 doses for all media but groundwater are 1, 15, and 25 mrem/year. For groundwater, the dose targets are 1, 4, 15, and 25 mrem/year. As noted above, a 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 of contaminants in the medium not under evaluation is zero.

In addition to calling for the development of RGOs, EPA (2000b) provides two methods that may be used to develop these values. 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 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 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 of the COCs at the exposure point. Fortunately, the concentration or activity 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 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 of COCs is directly and linearly related to risk or hazard.

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

where: $\text{Conc}_{observed}$ = The representative exposure point concentration 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 Risk = Either 1×10^{-4}, 1×10^{-5}, or 1×10^{-6}

$$\frac{Conc_{observed}}{HI_{derived}} = \frac{RGO}{Target\ HI} \qquad \textbf{Eq. 15}$$

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

As noted, dose-based RGOs will be calculated using similar methods. The targets to be used for all media except groundwater are 1, 15, and 25 mrem/year. For groundwater, the dose targets are 1, 4, 15, and 25 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 heath risk assessments prepared for PGDP. Note, the use of 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.

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 with site-specific values. For example, the exposure duration of 25 years for the outdoor worker/gardener 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/gardener scenario also may be used to produce an excavation worker scenario. The dermal absorption of 5% for inorganic chemicals may be replaced with a lower value from EPA dermal guidance. These revised calculations may be considered in the development of remedial goals (RGs) to be used in the preparation of remedy selection documents. These types of decisions would be a product of the consensus of the FFA parties arrived at during project discussions at the appropriate stage in document development.

Exhibit 3.17. Presentation of Remedial Goal Options[1]

Chemical of concern	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 ELCR 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 dose-based RGOs.

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 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 remediation 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 required. 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 dose assessment), the evaluation of the risk analyses to determine the need for remedial action, the identification and screening of technologies and alternatives, and 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 can be copied directly to the FS report. 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 assess what the relative effectiveness of each remedy would be in reducing the baseline risk. For some FS reports recalculation of risk or dose estimates may be required to differentiate between remedial alternatives; these changes to the baseline risk assessment should be conducted within the scope of Chapter 2 of RAGS Part C (EPA 1991c). 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 recalculated 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 or updated toxicity 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.

RGOs may need to be recalculated based on the above considerations or when the calculations of the RGOs in the RI report include exposure routes subsequently deemed improbable (e.g., consumption of fish from an industrial lagoon).

If additional risk assessment computations 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 all FS reports, the summary of the risk assessment 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 Baseline Human Health Risk Assessment Parameters That Could Appear in the Feasibility Study

The evaluation of risks in the FS report focuses on those issues that are important in making decisions about whether remedial action is necessary and choosing between the proposed remedial alternatives; therefore, only a few parameters related to long-term risks should be conducted in the FS. For example, dermal absorption factors used to modify oral toxicity values to an absorbed dose value contain moderate uncertainty in most baseline human health risk assessments prepared for PGDP. Generally, to ensure that risk estimates are consistent with agreements made at technical meetings with the regulatory agencies, the baseline human health risk assessments use default dermal absorption factors specified in EPA's RAGS, Part E, and KDEP default factors when chemical-specific factors are not available. It may be appropriate to reconsider the use of these factors for determining risk if the dermal pathway is the driving pathway for risk for COCs in the FS.

Uncertainties in the risk assessment can affect the values generated for risk and hazard, which affects the importance of the magnitude of differences in the residual risk and hazard associated with different remedial options. The uncertainty section of the baseline human health risk assessment will identify whether an uncertainty is small, moderate, or large for the investigation. If the uncertainty is small, it probably will not be necessary to reevaluate the risk assessment results. If, however, the uncertainty is moderate to large, then the FS will evaluate the uncertainty in more detail and may recalculate risk values as determined by agreement of the three parties.

Calculation of short-term risks during the detailed analysis of remedial alternatives (see Section 4.1.3) may require significant recalculation of risks 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 that is assumed for future industrial workers under a default exposure scenario. Outdoor worker/gardeners 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 short-term risks in the FS.

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 largely due to the inability to predict if existing controls will be in place in the future. There may be scenarios presented 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. The alternatives developed in the FS report will have to ensure protection of potential future receptors. Protection may be accomplished through continuation of existing controls in some instances. Consequently, potential future scenarios will be evaluated in the FS report 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 that will be included for the future industrial worker may include an evaluation of the continuation of existing institutional controls (i.e., controls and procedures that limit access and an alternative water source); continuation of 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).

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) will be assessed in the FS report based on the results of the baseline human heath risk assessment. The risk manager will assume that no controls would be in place to restrict a future on-site recreational user or resident from contact with surface contamination.

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 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 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 risk posed by environmental contamination, the goal of the FS risk analyses is to determine to what extent the various remedial alternatives reduce risk, so that unacceptable levels of risk are not posed by residual environmental contamination.

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 of whether a qualitative or quantitative analysis of alternatives is needed will be made using the 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. 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 remedial level (i.e., the RGO or other numeric standard selected as the cleanup criteria). 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.

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 have not yet been developed for PGDP. These will be included when they become available. It is anticipated that these methods will follow, in large part, the guidance and requirements for quantitative risk evaluations during the detailed analysis of alternatives in RAGS, Part C (EPA 1991c) and the more detailed guidance presented in Section 3 of this report.

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 the 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

Generally, no new risk evaluations will take place during the preparation of the Proposed Plan. The material presented in the Proposed Plan should be taken entirely from the supporting FS. This includes a summary of site risks, the site COCs, and, if applicable, the cleanup goals or a description of the basis for them (i.e., risk or 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 its equivalent screening assessment from scoping activities) 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 baseline 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 remediation levels (i.e., target 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 assessment 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 remediation 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 remediation 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 information that appears in the ROD will be drawn directly from EPA 1999b; however, additional tables or tables of a slightly different format may be used to explain the risk assessment 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 2009), after completion of all investigations and remedial actions at PGDP, the FFA requires that PGDP determine the residual risks remaining at the facility. In addition, 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 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 remediation levels in the ROD for the various source units and areas in the integrator units will 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 December 2010)

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 date of 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 of potential concern (COPCs) for PGDP. Values for other chemicals can be obtained using the electronic Preliminary Remediation Goal (PRG) calculator.

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 lifetime cancer risk value. 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 PRG calculations. Because the action values are not calculated using PGDP default exposure parameters, these values should be used as benchmarks only. Cumulative risk calculations should not be based upon these values. Action values are calculated using the U.S. Environmental Protection Agency (EPA) dermal absorption values. No Action values are calculated using the Kentucky Department for Environmental Protection dermal absorption 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 1×10^{-7} 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. These values are subject to change.

(6) Soil screening levels for chemicals for protection of groundwater were derived using information presented in the EPA Soil Screening Level (SSL) website. The SSL values based upon a dilution attenuation factor of 1 should be considered to be "no action values." "Action" SSLs have not been selected to date for the PGDP.

(7) Regulatory values are for planning purposes only. A qualified regulatory specialist should be consulted before using these values for other purposes.

(8) The outdoor worker/gardener scenario replaces the scenario listed in the 2001 version as "excavation worker" and uses the same exposure parameters. Based on consensus of the work group, the outdoor worker/gardener can be modified by reducing the exposure duration from 25 years to a value between one and five years to generate site-specific values for exposures during excavation.

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

a) General—Several screening values for soil/sediment (especially those on the action level tables) are listed with a value of 100,000 mg/kg. This value was assigned to the chemical 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). If the chemical's environmental concentration exceeds the upper limit value, then additional risk evaluations for the chemical should be performed before accepting the results of a simple comparison

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 'Total Chromium' should be used. The cancer-based screening value for Total Chromium was derived using the cancer slope factor for Chromium VI reported in the EPA Integrated Risk Information System database. Please see the toxicity value tables for additional information regarding this value.

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 and are not included in the electronic PRG calculator. No action levels of 400 mg/kg for soil/sediment represent the current screening values provided by the Kentucky Department for Environmental Protection. Action levels for soil/sediment are 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 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) Thallium–Thallium metal does not have a toxicity value. Therefore, screening values could not be derived. The PGDP Risk Assessment Working Group has agreed to screen thallium results against the screening values derived for thallium chloride.

e) Carcinogenic polynuclear 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.

f) 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.

g) 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.

h) Radionuclides—For Cesium-137, Neptunium-237, Radium-226, Radon-222, Strontium-90, Thorium-228, Uranium-235, and Uranium-238, only 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 levels are (1) 1 mrem/year (from NRCRP Report No. 116, Section 17, Negligible Individual Dose and ANSI/HPS standard N13.12); (2) 15 mrem/year (from Establishment of Cleanup Levels for CERCLA Sites with Radioactive Contamination” OSWER No. 9200.4-18, August 22, 1997) and (3) 25 mrem/year (derived from the public dose limit of 100 mrem/year limit in DOE Order 5400.5 and considering ALARA principals). A value of 4 mrem/year is used for groundwater (from http://www.epa.gov/safewater/contaminants/index.html).

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TABLES

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

(Values calculated on 01/07/2011 and are based on best available information.)

			Outdoor Worker/Gardener[a]			Industrial Worker		
Parameter	**Chemical**	**Units**	**Hazard**	**Cancer**	**Action**	**Hazard**	**Cancer**	**Action**
7429905	Aluminum	mg/kg	8.17E+05		8.17E+05	3.97E+06		3.97E+06
7440360	Antimony (metallic)	mg/kg	3.24E+02		3.24E+02	1.51E+03		1.51E+03
7440382	Arsenic, Inorganic	mg/kg	1.99E+02	4.15E+01	4.15E+01	4.76E+02	9.97E+01	9.97E+01
7440393	Barium	mg/kg	1.40E+05		1.40E+05	3.78E+05		3.78E+05
7440417	Beryllium and compounds	mg/kg	7.13E+02	7.81E+00	7.81E+00	8.37E+02	9.22E+00	9.22E+00
7440428	Boron And Borates Only	mg/kg	1.71E+05		1.71E+05	1.10E+06		1.10E+06
7440439	Cadmium (Diet)	mg/kg	6.10E+02	1.52E+02	1.52E+02	1.23E+03	3.16E+02	3.16E+02
16065831	Chromium (III) (Insoluble Salts)	mg/kg	7.39E+05		7.39E+05	1.12E+06		1.12E+06
7440473	Chromium (Total)	mg/kg	7.39E+05	4.08E+03	4.08E+03	1.12E+06	3.02E+03	3.02E+03
18540299	Chromium VI (chromic acid mists)	mg/kg	2.36E+03	4.08E+03	2.36E+03	9.48E+03	3.02E+03	3.02E+03
18540299	Chromium VI (particulates)	mg/kg	1.85E+03	1.13E+02	1.13E+02	3.81E+03	2.23E+02	2.23E+02
7440484	Cobalt	mg/kg	2.53E+02	3.81E+04	2.53E+02	1.52E+03	2.82E+04	1.52E+03
7440508	Copper	mg/kg	3.42E+04		3.42E+04	2.24E+05		2.24E+05
7439896	Iron	mg/kg	5.98E+05		5.98E+05	3.92E+06		3.92E+06
7439921	Lead And Compounds	mg/kg			4.00E+02			4.00E+02
7439965	Manganese (Diet)	mg/kg	7.24E+04		7.24E+04	1.16E+05		1.16E+05
7439976	Mercury, Inorganic Salts	mg/kg	2.27E+02		2.27E+02	7.85E+02		7.85E+02
7439987	Molybdenum	mg/kg	4.27E+03		4.27E+03	2.80E+04		2.80E+04
7440020	Nickel Soluble Salts	mg/kg	1.33E+04	1.32E+06	1.33E+04	3.18E+04	9.75E+05	3.18E+04
7782492	Selenium	mg/kg	4.27E+03		4.27E+03	2.80E+04		2.80E+04
7440224	Silver	mg/kg	3.47E+03		3.47E+03	9.15E+03		9.15E+03
7791120	Thallium Chloride	mg/kg	6.84E+01		6.84E+01	4.48E+02		4.48E+02
	Uranium (Soluble Salts)	mg/kg	2.56E+03		2.56E+03	1.65E+04		1.65E+04
7440622	Vanadium, Metallic	mg/kg	4.39E+01		4.39E+01	9.30E+01		9.30E+01
7440666	Zinc (Metallic)	mg/kg	2.56E+05		2.56E+05	1.68E+06		1.68E+06
83329	Acenaphthene	mg/kg	1.72E+04		1.72E+04	1.81E+04		1.81E+04
208968	Acenaphthylene	mg/kg						
107131	Acrylonitrile	mg/kg	5.51E+01	2.96E+01	2.96E+01	4.08E+01	2.67E+01	2.67E+01
120127	Anthracene	mg/kg	1.05E+05		1.05E+05	1.22E+05		1.22E+05
12674112	Aroclor 1016 (exposure to soil or food)	mg/kg	2.38E+01	1.59E+01	1.59E+01	2.72E+01	1.82E+01	1.82E+01
11104282	Aroclor 1221 (exposure to soil or food)	mg/kg		1.12E+01	1.12E+01		1.10E+01	1.10E+01
11141165	Aroclor 1232 (exposure to soil or food)	mg/kg		1.12E+01	1.12E+01		1.10E+01	1.10E+01
53469219	Aroclor 1242 (exposure to soil or food)	mg/kg		1.61E+01	1.61E+01		1.86E+01	1.86E+01
12672296	Aroclor 1248 (exposure to soil or food)	mg/kg		1.70E+01	1.70E+01		2.02E+01	2.02E+01
11097691	Aroclor 1254 (exposure to soil or food)	mg/kg	6.98E+00	1.63E+01	6.98E+00	8.11E+00	1.89E+01	8.11E+00
11096825	Aroclor 1260 (exposure to soil or food)	mg/kg		1.66E+01	1.66E+01		1.94E+01	1.94E+01
56553	Benz[a]anthracene	mg/kg		4.82E+01	4.82E+01		5.86E+01	5.86E+01
71432	Benzene	mg/kg	2.60E+02	1.04E+02	1.04E+02	2.06E+02	8.22E+01	8.22E+01

Hazard-based value calculated using target HI of 3.
Cancer-based value calculated using target ELCR of 1E-04.
Action value is the less of the hazard- and cancer- based value.

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

(Values calculated on 01/07/2011 and are based on best available information.)

		Adult Recreational User			Child Recreational User			Teen Recreational User		
Parameter	**Chemical**	**Hazard**	**Cancer**	**Action**	**Hazard**	**Cancer**	**Action**	**Hazard**	**Cancer**	**Action**
7429905	Aluminum	2.05E+07		2.05E+07	2.18E+06		2.18E+06	8.91E+06		8.91E+06
7440360	Antimony (metallic)	5.01E+03		5.01E+03	7.78E+02		7.78E+02	1.90E+03		1.90E+03
7440382	Arsenic, Inorganic	1.15E+03	1.02E+02	1.02E+02	2.78E+02	1.02E+02	1.02E+02	4.09E+02	1.02E+02	1.02E+02
7440393	Barium	1.22E+06		1.22E+06	2.34E+05		2.34E+05	4.58E+05		4.58E+05
7440417	Beryllium and compounds	1.76E+03	8.65E+00	8.65E+00	5.26E+02	8.65E+00	8.65E+00	6.13E+02	8.65E+00	8.65E+00
7440428	Boron And Borates Only	5.46E+06		5.46E+06	5.22E+05		5.22E+05	2.34E+06		2.34E+06
7440439	Cadmium (Diet)	2.91E+03	3.14E+02	3.14E+02	7.41E+02	3.14E+02	3.14E+02	1.03E+03	3.14E+02	3.14E+02
16065831	Chromium (III) (Insoluble Salts)	2.41E+06		2.41E+06	6.85E+05		6.85E+05	8.44E+05		8.44E+05
7440473	Chromium (Total)	2.41E+06	7.15E+03	7.15E+03	6.85E+05	7.15E+03	7.15E+03	8.44E+05	7.15E+03	7.15E+03
18540299	Chromium VI (chromic acid mists)	5.01E+04	7.15E+03	7.15E+03	5.67E+03	7.15E+03	5.67E+03	2.19E+04	7.15E+03	7.15E+03
18540299	Chromium VI (particulates)	8.84E+03	2.31E+02	2.31E+02	2.27E+03	2.31E+02	2.31E+02	3.13E+03	2.31E+02	2.31E+02
7440484	Cobalt	7.65E+03	6.67E+04	7.65E+03	7.52E+02	6.67E+04	7.52E+02	3.29E+03	6.67E+04	3.29E+03
7440508	Copper	1.11E+06		1.11E+06	1.06E+05		1.06E+05	4.75E+05		4.75E+05
7439896	Iron	1.94E+07		1.94E+07	1.85E+06		1.85E+06	8.31E+06		8.31E+06
7439921	Lead And Compounds			4.00E+02			4.00E+02			4.00E+02
7439965	Manganese (Diet)	6.52E+05		6.52E+05	9.32E+04		9.32E+04	2.94E+05		2.94E+05
7439976	Mercury, Inorganic Salts	2.16E+03		2.16E+03	4.31E+02		4.31E+02	7.88E+02		7.88E+02
7439987	Molybdenum	1.39E+05		1.39E+05	1.32E+04		1.32E+04	5.94E+04		5.94E+04
7440020	Nickel Soluble Salts	8.48E+04	2.31E+06	8.48E+04	1.92E+04	2.31E+06	1.92E+04	3.07E+04	2.31E+06	3.07E+04
7782492	Selenium	1.39E+05		1.39E+05	1.32E+04		1.32E+04	5.93E+04		5.93E+04
7440224	Silver	2.26E+04		2.26E+04	5.25E+03		5.25E+03	8.07E+03		8.07E+03
7791120	Thallium Chloride	2.22E+03		2.22E+03	2.11E+02		2.11E+02	9.50E+02		9.50E+02
	Uranium (Soluble Salts)	8.19E+04		8.19E+04	7.83E+03		7.83E+03	3.50E+04		3.50E+04
7440622	Vanadium, Metallic	2.15E+02		2.15E+02	5.50E+01		5.50E+01	7.61E+01		7.61E+01
7440666	Zinc (Metallic)	8.33E+06		8.33E+06	7.92E+05		7.92E+05	3.56E+06		3.56E+06
83329	Acenaphthene	4.85E+04		4.85E+04	1.27E+04		1.27E+04	1.76E+04		1.76E+04
208968	Acenaphthylene									
107131	Acrylonitrile	2.34E+02	5.99E+01	5.99E+01	3.73E+01	5.99E+01	3.73E+01	1.07E+02	5.99E+01	5.99E+01
120127	Anthracene	2.76E+05		2.76E+05	7.89E+04		7.89E+04	9.74E+04		9.74E+04
12674112	Aroclor 1016 (exposure to soil or food)	6.05E+01	1.81E+01	1.81E+01	1.76E+01	1.81E+01	1.76E+01	2.13E+01	1.81E+01	1.81E+01
11104282	Aroclor 1221 (exposure to soil or food)		1.40E+01	1.40E+01		1.40E+01	1.40E+01		1.40E+01	1.40E+01
11141165	Aroclor 1232 (exposure to soil or food)		1.40E+01	1.40E+01		1.40E+01	1.40E+01		1.40E+01	1.40E+01
53469219	Aroclor 1242 (exposure to soil or food)		1.83E+01	1.83E+01		1.83E+01	1.83E+01		1.83E+01	1.83E+01
12672296	Aroclor 1248 (exposure to soil or food)		1.90E+01	1.90E+01		1.90E+01	1.90E+01		1.90E+01	1.90E+01
11097691	Aroclor 1254 (exposure to soil or food)	1.76E+01	1.84E+01	1.76E+01	5.17E+00	1.84E+01	5.17E+00	6.16E+00	1.84E+01	6.16E+00
11096825	Aroclor 1260 (exposure to soil or food)		1.86E+01	1.86E+01		1.86E+01	1.86E+01		1.86E+01	1.86E+01
56553	Benz[a]anthracene		5.54E+01	5.54E+01		5.54E+01	5.54E+01		5.54E+01	5.54E+01
71432	Benzene	1.16E+03	1.91E+02	1.91E+02	1.86E+02	1.91E+02	1.86E+02	5.27E+02	1.91E+02	1.91E+02

Hazard-based value calculated using target HI of 3.
Cancer-based value calculated using target ELCR of 1E-04.
Action value is the less of the hazard- and cancer- based value.

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

(Values calculated on 01/07/2011 and are based on best available information.)

		Adult Resident			Child Resident		
Parameter	**Chemical**	**Hazard**	**Cancer**	**Action**	**Hazard**	**Cancer**	**Action**
7429905	Aluminum	1.81E+06		1.81E+06	2.15E+05		2.15E+05
7440360	Antimony (metallic)	6.35E+02		6.35E+02	8.58E+01		8.58E+01
7440382	Arsenic, Inorganic	2.41E+02	2.38E+01	2.38E+01	4.93E+01	2.38E+01	2.38E+01
7440393	Barium	2.07E+05		2.07E+05	3.47E+04		3.47E+04
7440417	Beryllium and compounds	4.75E+02	3.12E+00	3.12E+00	1.54E+02	3.12E+00	3.12E+00
7440428	Boron And Borates Only	4.11E+05		4.11E+05	4.61E+04		4.61E+04
7440439	Cadmium (Diet)	6.53E+02	8.11E+01	8.11E+01	1.47E+02	8.11E+01	8.11E+01
16065831	Chromium (III) (Insoluble Salts)	6.10E+05		6.10E+05	1.69E+05		1.69E+05
7440473	Chromium (Total)	6.10E+05	1.56E+03	1.56E+03	1.69E+05	1.56E+03	1.56E+03
18540299	Chromium VI (chromic acid mists)	4.91E+03	1.56E+03	1.56E+03	6.09E+02	1.56E+03	6.09E+02
18540299	Chromium VI (particulates)	1.99E+03	5.94E+01	5.94E+01	4.48E+02	5.94E+01	5.94E+01
7440484	Cobalt	6.00E+02	1.46E+04	6.00E+02	6.82E+01	1.46E+04	6.82E+01
7440508	Copper	8.29E+04		8.29E+04	9.26E+03		9.26E+03
7439896	Iron	1.45E+06		1.45E+06	1.62E+05		1.62E+05
7439921	Lead And Compounds			4.00E+02			
7439965	Manganese (Diet)	9.69E+04		9.69E+04	1.59E+04		1.59E+04
7439976	Mercury, Inorganic Salts	3.62E+02		3.62E+02	5.87E+01		5.87E+01
7439987	Molybdenum	1.04E+04		1.04E+04	1.16E+03		1.16E+03
7440020	Nickel Soluble Salts	1.69E+04	5.05E+05	1.69E+04	3.27E+03	5.05E+05	3.27E+03
7782492	Selenium	1.04E+04		1.04E+04	1.16E+03		1.16E+03
7440224	Silver	4.52E+03		4.52E+03	8.69E+02		8.69E+02
7791120	Thallium Chloride	1.66E+02		1.66E+02	1.85E+01		1.85E+01
	Uranium (Soluble Salts)	6.17E+03		6.17E+03	6.92E+02		6.92E+02
7440622	Vanadium, Metallic	4.80E+01		4.80E+01	1.07E+01		1.07E+01
7440666	Zinc (Metallic)	6.22E+05		6.22E+05	6.94E+04		6.94E+04
83329	Acenaphthene	1.22E+04		1.22E+04	3.50E+03		3.50E+03
208968	Acenaphthylene						
107131	Acrylonitrile	4.35E+01	1.26E+01	1.26E+01	9.31E+00	1.26E+01	9.31E+00
120127	Anthracene	7.26E+04		7.26E+04	2.24E+04		2.24E+04
12674112	Aroclor 1016 (exposure to soil or food)	1.61E+01	6.33E+00	6.33E+00	5.08E+00	6.33E+00	5.08E+00
11104282	Aroclor 1221 (exposure to soil or food)		4.37E+00	4.37E+00		4.37E+00	4.37E+00
11141165	Aroclor 1232 (exposure to soil or food)		4.37E+00	4.37E+00		4.37E+00	4.37E+00
53469219	Aroclor 1242 (exposure to soil or food)		6.44E+00	6.44E+00		6.44E+00	6.44E+00
12672296	Aroclor 1248 (exposure to soil or food)		6.82E+00	6.82E+00		6.82E+00	6.82E+00
11097691	Aroclor 1254 (exposure to soil or food)	4.71E+00	6.51E+00	4.71E+00	1.50E+00	6.51E+00	1.50E+00
11096825	Aroclor 1260 (exposure to soil or food)		6.62E+00	6.62E+00		6.62E+00	6.62E+00
56553	Benz[a]anthracene		1.96E+01	1.96E+01		1.96E+01	1.96E+01
71432	Benzene	2.14E+02	4.11E+01	4.11E+01	4.51E+01	4.11E+01	4.11E+01

Hazard-based value calculated using target HI of 3.
Cancer-based value calculated using target ELCR of 1E-04.
Action value is the less of the hazard- and cancer- based value.

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

(Values calculated on 01/07/2011 and are based on best available information.)

			Outdoor Worker/Gardener[a]			Industrial Worker		
Parameter	**Chemical**	**Units**	**Hazard**	**Cancer**	**Action**	**Hazard**	**Cancer**	**Action**
50328	Benzo[a]pyrene	mg/kg		4.85E+00	4.85E+00		5.92E+00	5.92E+00
205992	Benzo[b]fluoranthene	mg/kg		4.85E+01	4.85E+01		5.92E+01	5.92E+01
207089	Benzo[k]fluoranthene	mg/kg		4.81E+02	4.81E+02		5.84E+02	5.84E+02
86748	Carbazole	mg/kg		2.04E+03	2.04E+03		2.75E+03	2.75E+03
56235	Carbon Tetrachloride	mg/kg	4.37E+02	7.34E+01	7.34E+01	3.64E+02	5.76E+01	5.76E+01
67663	Chloroform	mg/kg	7.36E+02	3.33E+01	3.33E+01	5.90E+02	2.49E+01	2.49E+01
218019	Chrysene	mg/kg		4.68E+03	4.68E+03		5.59E+03	5.59E+03
53703	Dibenz[a,h]anthracene	mg/kg		4.85E+00	4.85E+00		5.93E+00	5.93E+00
75354	Dichloroethylene, 1,1-	mg/kg	7.93E+02	7.11E+00	7.11E+00	5.97E+02	5.53E+00	5.53E+00
540590	Dichloroethylene, 1,2- (Mixed Isomers)	mg/kg	2.32E+02		2.32E+02	1.76E+02		1.76E+02
156592	Dichloroethylene, 1,2-cis-	mg/kg	2.29E+02		2.29E+02	1.93E+02		1.93E+02
156605	Dichloroethylene, 1,2-trans-	mg/kg	4.51E+02		4.51E+02	3.42E+02		3.42E+02
60571	Dieldrin	mg/kg	2.18E+01	2.49E+00	2.49E+00	2.95E+01	3.30E+00	3.30E+00
1746016	Dioxins/Furans (Total)	mg/kg	6.65E-04	4.65E-04	4.65E-04	1.59E-03	1.05E-03	1.05E-03
100414	Ethylbenzene	mg/kg	1.19E+04	4.87E+02	4.87E+02	1.01E+04	3.84E+02	3.84E+02
206440	Fluoranthene	mg/kg	1.49E+04		1.49E+04	1.80E+04		1.80E+04
86737	Fluorene	mg/kg	1.31E+04		1.31E+04	1.46E+04		1.46E+04
118741	Hexachlorobenzene	mg/kg	3.49E+02	1.23E+01	1.23E+01	4.72E+02	1.17E+01	1.17E+01
37871004	HpCDD, 2,3,7,8-	mg/kg	6.67E-02	4.79E-02	4.79E-02	1.61E-01	1.15E-01	1.15E-01
38998753	HpCDF, 2,3,7,8-	mg/kg	4.36E-02	3.13E-02	3.13E-02	5.90E-02	4.23E-02	4.23E-02
34465468	HxCDD, 2,3,7,8-	mg/kg	6.67E-03	4.79E-03	4.79E-03	1.61E-02	1.15E-02	1.15E-02
55684941	HxCDF, 2,3,7,8-	mg/kg	4.36E-03	3.13E-03	3.13E-03	5.90E-03	4.23E-03	4.23E-03
193395	Indeno[1,2,3-cd]pyrene	mg/kg		4.85E+01	4.85E+01		5.93E+01	5.93E+01
91203	Naphthalene	mg/kg	3.17E+02	3.03E+02	3.03E+02	2.38E+02	2.24E+02	2.24E+02
88744	Nitroaniline, 2-	mg/kg	5.25E+01		5.25E+01	3.91E+01		3.91E+01
621647	Nitroso-di-N-propylamine, N-	mg/kg		4.55E+00	4.55E+00		5.22E+00	5.22E+00
3268879	OCDD	mg/kg	2.22E+00	1.60E+00	1.60E+00	5.35E+00	3.84E+00	3.84E+00
39001020	OCDF	mg/kg	1.45E+00	1.04E+00	1.04E+00	1.96E+00	1.41E+00	1.41E+00
36088229	PeCDD, 2,3,7,8-	mg/kg	6.67E-04	4.79E-04	4.79E-04	1.61E-03	1.15E-03	1.15E-03
57117416	PeCDF, 1,2,3,7,8-	mg/kg	1.45E-02	1.04E-02	1.04E-02	1.96E-02	1.41E-02	1.41E-02
57117314	PeCDF, 2,3,4,7,8-	mg/kg	1.45E-03	1.04E-03	1.04E-03	1.96E-03	1.41E-03	1.41E-03
85018	Phenanthrene	mg/kg						
1336363	Polychlorinated Biphenyls (Total) (high risk)	mg/kg		1.62E+01	1.62E+01		1.88E+01	1.88E+01
1336363	Polychlorinated Biphenyls (Total) (low risk)	mg/kg		8.15E+01	8.15E+01		9.47E+01	9.47E+01
1336363	Polychlorinated Biphenyls (Total) (lowest risk)	mg/kg		4.63E+02	4.63E+02		5.36E+02	5.36E+02
50328	Polynuclear Aromatic Hydrocarbons (Total)	mg/kg		4.85E+00	4.85E+00		5.92E+00	5.92E+00
129000	Pyrene	mg/kg	1.12E+04		1.12E+04	1.35E+04		1.35E+04
1746016	TCDD, 2,3,7,8-	mg/kg	6.65E-04	4.65E-04	4.65E-04	1.59E-03	1.05E-03	1.05E-03
51207319	TCDF, 2,3,7,8-	mg/kg	4.36E-03	3.13E-03	3.13E-03	5.90E-03	4.23E-03	4.23E-03

Hazard-based value calculated using target HI of 3.
Cancer-based value calculated using target ELCR of 1E-04.
Action value is the less of the hazard- and cancer- based value.

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

(Values calculated on 01/07/2011 and are based on best available information.)

		Adult Recreational User			Child Recreational User			Teen Recreational User		
Parameter	**Chemical**	**Hazard**	**Cancer**	**Action**	**Hazard**	**Cancer**	**Action**	**Hazard**	**Cancer**	**Action**
50328	Benzo[a]pyrene		5.57E+00	5.57E+00		5.57E+00	5.57E+00		5.57E+00	5.57E+00
205992	Benzo[b]fluoranthene		5.57E+01	5.57E+01		5.57E+01	5.57E+01		5.57E+01	5.57E+01
207089	Benzo[k]fluoranthene		5.54E+02	5.54E+02		5.54E+02	5.54E+02		5.54E+02	5.54E+02
86748	Carbazole		2.61E+03	2.61E+03		2.61E+03	2.61E+03		2.61E+03	2.61E+03
56235	Carbon Tetrachloride	2.03E+03	1.34E+02	1.34E+02	3.26E+02	1.34E+02	1.34E+02	9.17E+02	1.34E+02	1.34E+02
67663	Chloroform	3.32E+03	5.85E+01	5.85E+01	5.31E+02	5.85E+01	5.85E+01	1.50E+03	5.85E+01	5.85E+01
218019	Chrysene		5.43E+03	5.43E+03		5.43E+03	5.43E+03		5.43E+03	5.43E+03
53703	Dibenz[a,h]anthracene		5.57E+00	5.57E+00		5.57E+00	5.57E+00		5.57E+00	5.57E+00
75354	Dichloroethylene, 1,1-	3.41E+03	1.29E+01	1.29E+01	5.43E+02	1.29E+01	1.29E+01	1.55E+03	1.29E+01	1.29E+01
540590	Dichloroethylene, 1,2- (Mixed Isomers)	1.00E+03		1.00E+03	1.60E+02		1.60E+02	4.57E+02		4.57E+02
156592	Dichloroethylene, 1,2-cis-	1.07E+03		1.07E+03	1.72E+02		1.72E+02	4.84E+02		4.84E+02
156605	Dichloroethylene, 1,2-trans-	1.95E+03		1.95E+03	3.10E+02		3.10E+02	8.87E+02		8.87E+02
60571	Dieldrin	6.24E+01	3.20E+00	3.20E+00	1.82E+01	3.20E+00	3.20E+00	2.18E+01	3.20E+00	3.20E+00
1746016	Dioxins/Furans (Total)	3.83E-03	1.13E-03	1.13E-03	9.29E-04	1.13E-03	9.29E-04	1.36E-03	1.13E-03	1.13E-03
100414	Ethylbenzene	5.62E+04	8.90E+02	8.90E+02	9.00E+03	8.90E+02	8.90E+02	2.53E+04	8.90E+02	8.90E+02
206440	Fluoranthene	3.83E+04		3.83E+04	1.13E+04		1.13E+04	1.34E+04		1.34E+04
86737	Fluorene	3.52E+04		3.52E+04	9.77E+03		9.77E+03	1.26E+04		1.26E+04
118741	Hexachlorobenzene	9.98E+02	1.78E+01	1.78E+01	2.92E+02	1.78E+01	1.78E+01	3.49E+02	1.78E+01	1.78E+01
37871004	HpCDD, 2,3,7,8-	3.84E-01	1.18E-01	1.18E-01	9.34E-02	1.18E-01	9.34E-02	1.37E-01	1.18E-01	1.18E-01
38998753	HpCDF, 2,3,7,8-	1.25E-01	4.01E-02	4.01E-02	3.65E-02	4.01E-02	3.65E-02	4.36E-02	4.01E-02	4.01E-02
34465468	HxCDD, 2,3,7,8-	3.84E-02	1.18E-02	1.18E-02	9.34E-03	1.18E-02	9.34E-03	1.37E-02	1.18E-02	1.18E-02
55684941	HxCDF, 2,3,7,8-	1.25E-02	4.01E-03	4.01E-03	3.65E-03	4.01E-03	3.65E-03	4.36E-03	4.01E-03	4.01E-03
193395	Indeno[1,2,3-cd]pyrene		5.57E+01	5.57E+01		5.57E+01	5.57E+01		5.57E+01	5.57E+01
91203	Naphthalene	1.31E+03	5.27E+02	5.27E+02	2.15E+02	5.27E+02	2.15E+02	5.85E+02	5.27E+02	5.27E+02
88744	Nitroaniline, 2-	2.21E+02		2.21E+02	3.55E+01		3.55E+01	1.00E+02		1.00E+02
621647	Nitroso-di-N-propylamine, N-		6.10E+00	6.10E+00		6.10E+00	6.10E+00		6.10E+00	6.10E+00
3268879	OCDD	1.28E+01	3.92E+00	3.92E+00	3.11E+00	3.92E+00	3.11E+00	4.56E+00	3.92E+00	3.92E+00
39001020	OCDF	4.15E+00	1.34E+00	1.34E+00	1.21E+00	1.34E+00	1.21E+00	1.45E+00	1.34E+00	1.34E+00
36088229	PeCDD, 2,3,7,8-	3.84E-03	1.18E-03	1.18E-03	9.34E-04	1.18E-03	9.34E-04	1.37E-03	1.18E-03	1.18E-03
57117416	PeCDF, 1,2,3,7,8-	4.15E-02	1.34E-02	1.34E-02	1.21E-02	1.34E-02	1.21E-02	1.45E-02	1.34E-02	1.34E-02
57117314	PeCDF, 2,3,4,7,8-	4.15E-03	1.34E-03	1.34E-03	1.21E-03	1.34E-03	1.21E-03	1.45E-03	1.34E-03	1.34E-03
85018	Phenanthrene									
1336363	Polychlorinated Biphenyls (Total) (high risk)		1.83E+01	1.83E+01		1.83E+01	1.83E+01		1.83E+01	1.83E+01
1336363	Polychlorinated Biphenyls (Total) (low risk)		9.21E+01	9.21E+01		9.21E+01	9.21E+01		9.21E+01	9.21E+01
1336363	Polychlorinated Biphenyls (Total) (lowest risk)		5.24E+02	5.24E+02		5.24E+02	5.24E+02		5.24E+02	5.24E+02
50328	Polynuclear Aromatic Hydrocarbons (Total)		5.57E+00	5.57E+00		5.57E+00	5.57E+00		5.57E+00	5.57E+00
129000	Pyrene	2.87E+04		2.87E+04	8.49E+03		8.49E+03	1.00E+04		1.00E+04
1746016	TCDD, 2,3,7,8-	3.83E-03	1.13E-03	1.13E-03	9.29E-04	1.13E-03	9.29E-04	1.36E-03	1.13E-03	1.13E-03
51207319	TCDF, 2,3,7,8-	1.25E-02	4.01E-03	4.01E-03	3.65E-03	4.01E-03	3.65E-03	4.36E-03	4.01E-03	4.01E-03

Hazard-based value calculated using target HI of 3.
Cancer-based value calculated using target ELCR of 1E-04.
Action value is the less of the hazard- and cancer- based value.

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

(Values calculated on 01/07/2011 and are based on best available information.)

		Adult Resident			Child Resident		
Parameter	Chemical	Hazard	Cancer	Action	Hazard	Cancer	Action
50328	Benzo[a]pyrene		1.97E+00	1.97E+00		1.97E+00	1.97E+00
205992	Benzo[b]fluoranthene		1.97E+01	1.97E+01		1.97E+01	1.97E+01
207089	Benzo[k]fluoranthene		1.96E+02	1.96E+02		1.96E+02	1.96E+02
86748	Carbazole		8.72E+02	8.72E+02		8.72E+02	8.72E+02
56235	Carbon Tetrachloride	3.73E+02	2.89E+01	2.89E+01	7.75E+01	2.89E+01	2.89E+01
67663	Chloroform	6.12E+02	1.28E+01	1.28E+01	1.29E+02	1.28E+01	1.28E+01
218019	Chrysene		1.90E+03	1.90E+03		1.90E+03	1.90E+03
53703	Dibenz[a,h]anthracene		1.97E+00	1.97E+00		1.97E+00	1.97E+00
75354	Dichloroethylene, 1,1-	6.32E+02	2.79E+00	2.79E+00	1.35E+02	2.79E+00	2.79E+00
540590	Dichloroethylene, 1,2- (Mixed Isomers)	1.86E+02		1.86E+02	3.96E+01		3.96E+01
156592	Dichloroethylene, 1,2-cis-	1.97E+02		1.97E+02	4.09E+01		4.09E+01
156605	Dichloroethylene, 1,2-trans-	3.61E+02		3.61E+02	7.69E+01		7.69E+01
60571	Dieldrin	1.63E+01	1.06E+00	1.06E+00	4.89E+00	1.06E+00	1.06E+00
1746016	Dioxins/Furans (Total)	8.05E-04	2.63E-04	2.63E-04	1.65E-04	2.63E-04	1.65E-04
100414	Ethylbenzene	1.03E+04	1.92E+02	1.92E+02	2.13E+03	1.92E+02	1.92E+02
206440	Fluoranthene	1.03E+04		1.03E+04	3.26E+03		3.26E+03
86737	Fluorene	9.12E+03		9.12E+03	2.75E+03		2.75E+03
118741	Hexachlorobenzene	2.61E+02	4.92E+00	4.92E+00	7.82E+01	4.92E+00	4.92E+00
37871004	HpCDD, 2,3,7,8-	8.08E-02	2.75E-02	2.75E-02	1.65E-02	2.75E-02	1.65E-02
38998753	HpCDF, 2,3,7,8-	3.27E-02	1.34E-02	1.34E-02	9.78E-03	1.34E-02	9.78E-03
34465468	HxCDD, 2,3,7,8-	8.08E-03	2.75E-03	2.75E-03	1.65E-03	2.75E-03	1.65E-03
55684941	HxCDF, 2,3,7,8-	3.27E-03	1.34E-03	1.34E-03	9.78E-04	1.34E-03	9.78E-04
193395	Indeno[1,2,3-cd]pyrene		1.97E+01	1.97E+01		1.97E+01	1.97E+01
91203	Naphthalene	2.48E+02	1.15E+02	1.15E+02	5.40E+01	1.15E+02	5.40E+01
88744	Nitroaniline, 2-	4.13E+01		4.13E+01	8.89E+00		8.89E+00
621647	Nitroso-di-N-propylamine, N-		1.89E+00	1.89E+00		1.89E+00	1.89E+00
3268879	OCDD	2.69E+00	9.15E-01	9.15E-01	5.50E-01	9.15E-01	5.50E-01
39001020	OCDF	1.09E+00	4.47E-01	4.47E-01	3.26E-01	4.47E-01	3.26E-01
36088229	PeCDD, 2,3,7,8-	8.08E-04	2.75E-04	2.75E-04	1.65E-04	2.75E-04	1.65E-04
57117416	PeCDF, 1,2,3,7,8-	1.09E-02	4.47E-03	4.47E-03	3.26E-03	4.47E-03	3.26E-03
57117314	PeCDF, 2,3,4,7,8-	1.09E-03	4.47E-04	4.47E-04	3.26E-04	4.47E-04	3.26E-04
85018	Phenanthrene						
1336363	Polychlorinated Biphenyls (Total) (high risk)		6.48E+00	6.48E+00		6.48E+00	6.48E+00
1336363	Polychlorinated Biphenyls (Total) (low risk)		3.26E+01	3.26E+01		3.26E+01	3.26E+01
1336363	Polychlorinated Biphenyls (Total) (lowest risk)		1.85E+02	1.85E+02		1.85E+02	1.85E+02
50328	Polynuclear Aromatic Hydrocarbons (Total)		1.97E+00	1.97E+00		1.97E+00	1.97E+00
129000	Pyrene	7.68E+03		7.68E+03	2.43E+03		2.43E+03
1746016	TCDD, 2,3,7,8-	8.05E-04	2.63E-04	2.63E-04	1.65E-04	2.63E-04	1.65E-04
51207319	TCDF, 2,3,7,8-	3.27E-03	1.34E-03	1.34E-03	9.78E-04	1.34E-03	9.78E-04

Hazard-based value calculated using target HI of 3.
Cancer-based value calculated using target ELCR of 1E-04.
Action value is the less of the hazard- and cancer- based value.

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

(Values calculated on 01/07/2011 and are based on best available information.)

			Outdoor Worker/Gardener[a]			Industrial Worker		
Parameter	**Chemical**	**Units**	**Hazard**	**Cancer**	**Action**	**Hazard**	**Cancer**	**Action**
127184	Tetrachloroethylene	mg/kg	1.52E+03	6.08E+01	6.08E+01	1.34E+03	7.08E+01	7.08E+01
79016	Trichloroethylene	mg/kg	1.25E+02	6.58E+00	6.58E+00	1.64E+02	4.98E+00	4.98E+00
75014	Vinyl Chloride	mg/kg	3.04E+02	4.28E+01	4.28E+01	2.51E+02	4.83E+01	4.83E+01
108383	Xylene, m-	mg/kg	9.03E+03		9.03E+03	7.01E+03		7.01E+03
1330207	Xylene, Mixture	mg/kg	1.44E+03		1.44E+03	1.07E+03		1.07E+03
95476	Xylene, o-	mg/kg	1.05E+04		1.05E+04	8.21E+03		8.21E+03
106423	Xylene, P-	mg/kg	9.21E+03		9.21E+03	7.16E+03		7.16E+03
14596102	Am-241	pCi/g		1.73E+02	1.73E+02		5.01E+02	5.01E+02
10198400	Co-60	pCi/g		2.38E+00	2.38E+00		1.77E+00	1.77E+00
10045973	Cs-137+D	pCi/g		1.15E+01	1.15E+01		8.61E+00	8.61E+00
13994202	Np-237+D	pCi/g		3.28E+01	3.28E+01		2.71E+01	2.71E+01
13981163	Pu-238	pCi/g		1.64E+02	1.64E+02		1.09E+03	1.09E+03
15117483	Pu-239	pCi/g		1.62E+02	1.62E+02		1.07E+03	1.07E+03
14119336	Pu-240	pCi/g		1.61E+02	1.61E+02		1.07E+03	1.07E+03
14133767	Tc-99	pCi/g		5.79E+03	5.79E+03		3.61E+04	3.61E+04
14269637	Th-230	pCi/g		2.20E+02	2.20E+02		1.38E+03	1.38E+03
13966295	U-234	pCi/g		2.83E+02	2.83E+02		1.89E+03	1.89E+03
15117961	U-235+D	pCi/g		4.55E+01	4.55E+01		3.95E+01	3.95E+01
7440611	U-238+D	pCi/g		1.17E+02	1.17E+02		1.70E+02	1.70E+02

Hazard-based value calculated using target HI of 3.
Cancer-based value calculated using target ELCR of 1E-04.
Action value is the less of the hazard- and cancer- based value.

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

(Values calculated on 01/07/2011 and are based on best available information.)

		Adult Recreational User			Child Recreational User			Teen Recreational User		
Parameter	**Chemical**	**Hazard**	**Cancer**	**Action**	**Hazard**	**Cancer**	**Action**	**Hazard**	**Cancer**	**Action**
127184	Tetrachloroethylene	7.37E+03	1.48E+02	1.48E+02	1.18E+03	1.48E+02	1.48E+02	3.30E+03	1.48E+02	1.48E+02
79016	Trichloroethylene	8.10E+02	1.17E+01	1.17E+01	1.33E+02	1.17E+01	1.17E+01	3.47E+02	1.17E+01	1.17E+01
75014	Vinyl Chloride	1.40E+03	1.02E+02	1.02E+02	2.25E+02	1.02E+02	1.02E+02	6.34E+02	1.02E+02	1.02E+02
108383	Xylene, m-	3.98E+04		3.98E+04	6.34E+03		6.34E+03	1.81E+04		1.81E+04
1330207	Xylene, Mixture	6.12E+03		6.12E+03	9.75E+02		9.75E+02	2.79E+03		2.79E+03
95476	Xylene, o-	4.65E+04		4.65E+04	7.42E+03		7.42E+03	2.11E+04		2.11E+04
106423	Xylene, P-	4.06E+04		4.06E+04	6.48E+03		6.48E+03	1.84E+04		1.84E+04
14596102	Am-241		1.28E+03	1.28E+03		1.28E+03	1.28E+03		1.28E+03	1.28E+03
10198400	Co-60		4.06E+00	4.06E+00		4.06E+00	4.06E+00		4.06E+00	4.06E+00
10045973	Cs-137+D		1.98E+01	1.98E+01		1.98E+01	1.98E+01		1.98E+01	1.98E+01
13994202	Np-237+D		6.26E+01	6.26E+01		6.26E+01	6.26E+01		6.26E+01	6.26E+01
13981163	Pu-238		3.64E+03	3.64E+03		3.64E+03	3.64E+03		3.64E+03	3.64E+03
15117483	Pu-239		3.56E+03	3.56E+03		3.56E+03	3.56E+03		3.56E+03	3.56E+03
14119336	Pu-240		3.58E+03	3.58E+03		3.58E+03	3.58E+03		3.58E+03	3.58E+03
14133767	Tc-99		1.11E+05	1.11E+05		1.11E+05	1.11E+05		1.11E+05	1.11E+05
14269637	Th-230		4.49E+03	4.49E+03		4.49E+03	4.49E+03		4.49E+03	4.49E+03
13966295	U-234		6.25E+03	6.25E+03		6.25E+03	6.25E+03		6.25E+03	6.25E+03
15117961	U-235+D		9.12E+01	9.12E+01		9.12E+01	9.12E+01		9.12E+01	9.12E+01
7440611	U-238+D		4.02E+02	4.02E+02		4.02E+02	4.02E+02		4.02E+02	4.02E+02

Hazard-based value calculated using target HI of 3.
Cancer-based value calculated using target ELCR of 1E-04.
Action value is the less of the hazard- and cancer- based value.

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

(Values calculated on 01/07/2011 and are based on best available information.)

		Adult Resident			Child Resident		
Parameter	**Chemical**	**Hazard**	**Cancer**	**Action**	**Hazard**	**Cancer**	**Action**
127184	Tetrachloroethylene	1.34E+03	2.93E+01	2.93E+01	2.76E+02	2.93E+01	2.93E+01
79016	Trichloroethylene	1.40E+02	2.54E+00	2.54E+00	2.61E+01	2.54E+00	2.54E+00
75014	Vinyl Chloride	2.58E+02	2.03E+01	2.03E+01	5.37E+01	2.03E+01	2.03E+01
108383	Xylene, m-	7.35E+03		7.35E+03	1.56E+03		1.56E+03
1330207	Xylene, Mixture	1.14E+03		1.14E+03	2.43E+02		2.43E+02
95476	Xylene, o-	8.58E+03		8.58E+03	1.81E+03		1.81E+03
106423	Xylene, P-	7.50E+03		7.50E+03	1.59E+03		1.59E+03
14596102	Am-241		1.50E+02	1.50E+02		1.50E+02	1.50E+02
10198400	Co-60		5.47E-01	5.47E-01		5.47E-01	5.47E-01
10045973	Cs-137+D		2.67E+00	2.67E+00		2.67E+00	2.67E+00
13994202	Np-237+D		8.39E+00	8.39E+00		8.39E+00	8.39E+00
13981163	Pu-238		3.21E+02	3.21E+02		3.21E+02	3.21E+02
15117483	Pu-239		3.15E+02	3.15E+02		3.15E+02	3.15E+02
14119336	Pu-240		3.16E+02	3.16E+02		3.16E+02	3.16E+02
14133767	Tc-99		1.01E+04	1.01E+04		1.01E+04	1.01E+04
14269637	Th-230		4.10E+02	4.10E+02		4.10E+02	4.10E+02
13966295	U-234		5.47E+02	5.47E+02		5.47E+02	5.47E+02
15117961	U-235+D		1.22E+01	1.22E+01		1.22E+01	1.22E+01
7440611	U-238+D		5.17E+01	5.17E+01		5.17E+01	5.17E+01

Values in this table were calculated using the best available information in December 2010. 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.

[a] The parameters for the outdoor worker/gardener scenario can be used for a construction/excavation worker, but using an ED of from 1-5 years [based on guidance in the Exposure Factors Handbook (EPA 1993)]

Hazard-based value calculated using target HI of 3.
Cancer-based value calculated using target ELCR of 1E-04.
Action value is the less of the hazard- and cancer- based value.

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

(Values calculated on 01/07/2011 and are based on the best available information.)

			Adult Resident			Child Resident		
Parameter	**Chemical**	**Units**	**Hazard**	**Cancer**	**Action**	**Hazard**	**Cancer**	**Action**
7429905	Aluminum	mg/L	1.09E+02		1.09E+02	3.13E+01		3.13E+01
7440360	Antimony (metallic)	mg/L	4.33E-02		4.33E-02	1.24E-02		1.24E-02
7440382	Arsenic, Inorganic	mg/L	3.28E-02	3.80E-03	3.80E-03	9.38E-03	3.80E-03	3.80E-03
7440393	Barium	mg/L	2.13E+01		2.13E+01	6.18E+00		6.18E+00
7440417	Beryllium and compounds	mg/L	1.74E-01	1.12E-03	1.12E-03	5.57E-02	1.12E-03	1.12E-03
7440428	Boron And Borates Only	mg/L	2.19E+01		2.19E+01	6.25E+00		6.25E+00
7440439	Cadmium (Water)	mg/L	5.28E-02	1.46E-02	1.46E-02	1.54E-02	1.46E-02	1.46E-02
16065831	Chromium (III) (Insoluble Salts)	mg/L	1.44E+02		1.44E+02	4.40E+01		4.40E+01
7440473	Chromium (Total)	mg/L	1.44E+02		1.44E+02	4.40E+01		4.40E+01
18540299	Chromium VI (chromic acid mists)	mg/L	3.27E-01		3.27E-01	9.37E-02		9.37E-02
18540299	Chromium VI (particulates)	mg/L	2.87E-01	0.0103	1.03E-02	8.78E-02	0.0103	1.03E-02
7440484	Cobalt	mg/L	3.28E-02		3.28E-02	9.38E-03		9.38E-03
7440508	Copper	mg/L	4.37E+00		4.37E+00	1.25E+00		1.25E+00
7439896	Iron	mg/L	7.65E+01		7.65E+01	2.19E+01		2.19E+01
7439921	Lead And Compounds	mg/L			3.00E-02			3.00E-02
7439965	Manganese (Water)	mg/L	2.51E+00		2.51E+00	7.35E-01		7.35E-01
7439976	Mercury, Inorganic Salts	mg/L	3.20E-02		3.20E-02	9.27E-03		9.27E-03
7439987	Molybdenum	mg/L	5.47E-01		5.47E-01	1.56E-01		1.56E-01
7440020	Nickel Soluble Salts	mg/L	2.17E+00		2.17E+00	6.23E-01		6.23E-01
7782492	Selenium	mg/L	5.47E-01		5.47E-01	1.56E-01		1.56E-01
7440224	Silver	mg/L	5.33E-01		5.33E-01	1.54E-01		1.54E-01
7791120	Thallium Chloride	mg/L	8.74E-03		8.74E-03	2.50E-03		2.50E-03
	Uranium (Soluble Salts)	mg/L	3.28E-01		3.28E-01	9.38E-02		9.38E-02
7440622	Vanadium, Metallic	mg/L	7.16E-03		7.16E-03	2.12E-03		2.12E-03
7440666	Zinc (Metallic)	mg/L	3.28E+01		3.28E+01	9.38E+00		9.38E+00
83329	Acenaphthene	mg/L	1.57E+00		1.57E+00	4.13E-01		4.13E-01
208968	Acenaphthylene	mg/L						
107131	Acrylonitrile	mg/L	2.64E-02	4.77E-03	4.77E-03	5.66E-03	4.77E-03	4.77E-03
120127	Anthracene	mg/L	6.66E+00		6.66E+00	1.92E+00		1.92E+00
12674112	Aroclor 1016 (exposure to water)	mg/L	1.16E-03	3.08E-03	1.16E-03	5.96E-04	3.08E-03	5.96E-04
11104282	Aroclor 1221 (exposure to water)	mg/L		6.73E-03	6.73E-03		6.73E-03	6.73E-03
11141165	Aroclor 1232 (exposure to water)	mg/L		6.73E-03	6.73E-03		6.73E-03	6.73E-03
53469219	Aroclor 1242 (exposure to water)	mg/L		1.59E-03	1.59E-03		1.59E-03	1.59E-03
12672296	Aroclor 1248 (exposure to water)	mg/L		1.49E-03	1.49E-03		1.49E-03	1.49E-03
11097691	Aroclor 1254 (exposure to water)	mg/L	9.83E-05	9.80E-04	9.83E-05	5.61E-05	9.80E-04	5.61E-05
11096825	Aroclor 1260 (exposure to water)	mg/L		1.72E-04	1.72E-04		1.72E-04	1.72E-04
56553	Benz[a]anthracene	mg/L		1.22E-03	1.22E-03		1.22E-03	1.22E-03
71432	Benzene	mg/L	2.00E-01	4.27E-02	4.27E-02	4.99E-02	4.27E-02	4.27E-02

Hazard-based value calculated using target HI of 3.
Cancer-based value calculated using target ELCR of 1E-04.
Action value is the less of the hazard- and cancer- based value.

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

(Values calculated on 01/07/2011 and are based on best available information.)

			Adult Resident			Child Resident		
Parameter	**Chemical**	**Units**	**Hazard**	**Cancer**	**Action**	**Hazard**	**Cancer**	**Action**
50328	Benzo[a]pyrene	mg/L		8.63E-05	8.63E-05		8.63E-05	8.63E-05
205992	Benzo[b]fluoranthene	mg/L		1.35E-03	1.35E-03		1.35E-03	1.35E-03
207089	Benzo[k]fluoranthene	mg/L		8.86E-03	8.86E-03		8.86E-03	8.86E-03
86748	Carbazole	mg/L		2.05E-01	2.05E-01		2.05E-01	2.05E-01
56235	Carbon Tetrachloride	mg/L	2.94E-01	4.19E-02	4.19E-02	8.26E-02	4.19E-02	4.19E-02
67663	Chloroform	mg/L	5.77E-01	2.27E-02	2.27E-02	1.45E-01	2.27E-02	2.27E-02
218019	Chrysene	mg/L		1.15E-01	1.15E-01		1.15E-01	1.15E-01
53703	Dibenz[a,h]anthracene	mg/L		5.73E-05	5.73E-05		5.73E-05	5.73E-05
75354	Dichloroethylene, 1,1-	mg/L	1.74E+00	5.11E-03	5.11E-03	4.13E-01	5.11E-03	5.11E-03
540590	Dichloroethylene, 1,2- (Mixed Isomers)	mg/L	2.87E-01		2.87E-01	6.72E-02		6.72E-02
156592	Dichloroethylene, 1,2-cis-	mg/L	1.42E-01		1.42E-01	3.76E-02		3.76E-02
156605	Dichloroethylene, 1,2-trans-	mg/L	5.73E-01		5.73E-01	1.33E-01		1.33E-01
60571	Dieldrin	mg/L	2.34E-03	1.87E-04	1.87E-04	9.55E-04	1.87E-04	1.87E-04
1746016	Dioxins/Furans (Total)	mg/L	4.71E-09	2.90E-09	2.90E-09	2.69E-09	2.90E-09	2.69E-09
100414	Ethylbenzene	mg/L	5.04E+00	1.51E-01	1.51E-01	1.38E+00	1.51E-01	1.51E-01
206440	Fluoranthene	mg/L	8.80E-01		8.80E-01	4.32E-01		4.32E-01
86737	Fluorene	mg/L	9.76E-01		9.76E-01	2.67E-01		2.67E-01
118741	Hexachlorobenzene	mg/L	1.34E-02	7.74E-04	7.74E-04	6.85E-03	7.74E-04	7.74E-04
37871004	HpCDD, 2,3,7,8-	mg/L	1.13E-07	7.12E-08	7.12E-08	6.69E-08	7.12E-08	6.69E-08
38998753	HpCDF, 2,3,7,8-	mg/L	1.55E-07	9.76E-08	9.76E-08	9.16E-08	9.76E-08	9.16E-08
34465468	HxCDD, 2,3,7,8-	mg/L	8.94E-09	5.63E-09	5.63E-09	5.30E-09	5.63E-09	5.30E-09
55684941	HxCDF, 2,3,7,8-	mg/L	2.08E-08	1.30E-08	1.30E-08	1.22E-08	1.30E-08	1.22E-08
193395	Indeno[1,2,3-cd]pyrene	mg/L		4.52E-04	4.52E-04		4.52E-04	4.52E-04
91203	Naphthalene	mg/L	3.89E-02	0.0176	1.76E-02	8.40E-03	0.0176	8.40E-03
88744	Nitroaniline, 2-	mg/L	1.05E+00		1.05E+00	3.07E-01		3.07E-01
621647	Nitroso-di-N-propylamine, N-	mg/L		8.03E-04	8.03E-04		8.03E-04	8.03E-04
3268879	OCDD	mg/L	6.58E-07	4.17E-07	4.17E-07	3.93E-07	4.17E-07	3.93E-07
39001020	OCDF	mg/L	2.32E-06	1.47E-06	1.47E-06	1.38E-06	1.47E-06	1.38E-06
36088229	PeCDD, 2,3,7,8-	mg/L	1.17E-08	6.90E-09	6.90E-09	6.29E-09	6.90E-09	6.29E-09
57117416	PeCDF, 1,2,3,7,8-	mg/L	1.78E-07	1.09E-07	1.09E-07	1.01E-07	1.09E-07	1.01E-07
57117314	PeCDF, 2,3,4,7,8-	mg/L	1.48E-08	9.10E-09	9.10E-09	8.46E-09	9.10E-09	9.10E-09
85018	Phenanthrene	mg/L						
1336363	Polychlorinated Biphenyls (Total) (high risk)	mg/L		3.18E-04	3.18E-04		3.18E-04	3.18E-04
1336363	Polychlorinated Biphenyls (Total) (low risk)	mg/L		1.59E-03	1.59E-03		1.59E-03	1.59E-03
1336363	Polychlorinated Biphenyls (Total) (lowest risk)	mg/L		9.10E-03	9.10E-03		9.10E-03	9.10E-03
50328	Polynuclear Aromatic Hydrocarbons (Total)	mg/L		8.63E-05	8.63E-05		8.63E-05	8.63E-05
129000	Pyrene	mg/L	5.52E-01		5.52E-01	1.74E-01		1.74E-01
1746016	TCDD, 2,3,7,8-	mg/L	4.71E-09	2.90E-09	2.90E-09	2.69E-09	2.90E-09	2.69E-09
51207319	TCDF, 2,3,7,8-	mg/L	6.31E-08	3.84E-08	3.84E-08	3.55E-08	3.84E-08	3.55E-08

Hazard-based value calculated using target HI of 3.
Cancer-based value calculated using target ELCR of 1E-04.
Action value is the less of the hazard- and cancer- based value.

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

(Values calculated on 01/07/2011 and are based on best available information.)

			Adult Resident			Child Resident		
Parameter	**Chemical**	**Units**	**Hazard**	**Cancer**	**Action**	**Hazard**	**Cancer**	**Action**
127184	Tetrachloroethylene	mg/L	6.63E-01	7.81E-03	7.81E-03	1.99E-01	7.81E-03	7.81E-03
79016	Trichloroethylene	mg/L	2.83E-02	4.65E-03	4.65E-03	8.31E-03	4.65E-03	4.65E-03
75014	Vinyl Chloride	mg/L	2.54E-01	7.25E-03	7.25E-03	6.94E-02	7.25E-03	7.25E-03
108383	Xylene, m-	mg/L	5.87E+00		5.87E+00	1.45E+00		1.45E+00
1330207	Xylene, Mixture	mg/L	1.23E+00		1.23E+00	2.70E-01		2.70E-01
95476	Xylene, o-	mg/L	5.94E+00		5.94E+00	1.45E+00		1.45E+00
106423	Xylene, P-	mg/L	5.91E+00		5.91E+00	1.45E+00		1.45E+00
14596102	Am-241	pCi/L		9.06E+01	9.06E+01		9.06E+01	9.06E+01
10198400	Co-60	pCi/L		6.00E+02	6.00E+02		6.00E+02	6.00E+02
10045973	Cs-137+D	pCi/L		3.10E+02	3.10E+02		3.10E+02	3.10E+02
13994202	Np-237+D	pCi/L		1.40E+02	1.40E+02		1.40E+02	1.40E+02
13981163	Pu-238	pCi/L		7.19E+01	7.19E+01		7.19E+01	7.19E+01
15117483	Pu-239	pCi/L		6.98E+01	6.98E+01		6.98E+01	6.98E+01
14119336	Pu-240	pCi/L		6.98E+01	6.98E+01		6.98E+01	6.98E+01
14133767	Tc-99	pCi/L		3.43E+03	3.43E+03		3.43E+03	3.43E+03
14269637	Th-230	pCi/L		1.04E+02	1.04E+02		1.04E+02	1.04E+02
13966295	U-234	pCi/L		1.33E+02	1.33E+02		1.33E+02	1.33E+02
15117961	U-235+D	pCi/L		1.31E+02	1.31E+02		1.31E+02	1.31E+02
7440611	U-238+D	pCi/L		1.08E+02	1.08E+02		1.08E+02	1.08E+02

Values in this table were calculated using the best available information in December 2010. 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.

Hazard-based value calculated using target HI of 3.
Cancer-based value calculated using target ELCR of 1E-04.
Action value is the less of the hazard- and cancer- based value.

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

(Values calculated on 01/07/2011 and are based on the best available information.)

			Outdoor Worker/Gardener[a]			Industrial Worker		
Parameter	**Chemical**	**Units**	**Hazard**	**Cancer**	**Action**	**Hazard**	**Cancer**	**Action**
7429905	Aluminum	mg/L	1.02E+05		1.02E+05	2.51E+04		2.51E+04
7440360	Antimony (metallic)	mg/L	6.12E+00		6.12E+00	1.51E+00		1.51E+00
7440382	Arsenic, Inorganic	mg/L	3.06E+01	6.34E+00	6.34E+00	7.53E+00	1.56E+00	1.56E+00
7440393	Barium	mg/L	1.43E+03		1.43E+03	3.51E+02		3.51E+02
7440417	Beryllium and compounds	mg/L	1.43E+00	1.55E-02	1.55E-02	3.51E-01	3.81E-03	3.81E-03
7440428	Boron And Borates Only	mg/L	2.04E+04		2.04E+04	5.02E+03		5.02E+03
7440439	Cadmium (Water)	mg/L	2.55E+00	1.25E+00	1.25E+00	6.27E-01	3.08E-01	3.08E-01
16065831	Chromium (III) (Insoluble Salts)	mg/L	1.99E+03		1.99E+03	4.89E+02		4.89E+02
7440473	Chromium (Total)	mg/L	1.99E+03		1.99E+03	4.89E+02		4.89E+02
18540299	Chromium VI (chromic acid mists)	mg/L	1.53E+02		1.53E+02	3.76E+01		3.76E+01
18540299	Chromium VI (particulates)	mg/L	3.82E+00	2.38E-01	2.38E-01	9.41E-01	5.85E-02	5.85E-02
7440484	Cobalt	mg/L	7.64E+01		7.64E+01	1.88E+01		1.88E+01
7440508	Copper	mg/L	4.08E+03		4.08E+03	1.00E+03		1.00E+03
7439896	Iron	mg/L	7.13E+04		7.13E+04	1.76E+04		1.76E+04
7439921	Lead And Compounds	mg/L			3.00E-02			3.00E-02
7439965	Manganese (Water)	mg/L	9.79E+01		9.79E+01	2.41E+01		2.41E+01
7439976	Mercury, Inorganic Salts	mg/L	2.14E+00		2.14E+00	5.27E-01		5.27E-01
7439987	Molybdenum	mg/L	5.10E+02		5.10E+02	1.25E+02		1.25E+02
7440020	Nickel Soluble Salts	mg/L	4.08E+02		4.08E+02	1.00E+02		1.00E+02
7782492	Selenium	mg/L	5.10E+02		5.10E+02	1.25E+02		1.25E+02
7440224	Silver	mg/L	3.40E+01		3.40E+01	8.36E+00		8.36E+00
7791120	Thallium Chloride	mg/L	8.15E+00		8.15E+00	2.01E+00		2.01E+00
	Uranium (Soluble Salts)	mg/L	3.06E+02		3.06E+02	7.53E+01		7.53E+01
7440622	Vanadium, Metallic	mg/L	1.86E-01		1.86E-01	4.57E-02		4.57E-02
7440666	Zinc (Metallic)	mg/L	5.10E+04		5.10E+04	1.25E+04		1.25E+04
83329	Acenaphthene	mg/L	1.48E+02		1.48E+02	1.18E+01		1.18E+01
208968	Acenaphthylene	mg/L						
107131	Acrylonitrile	mg/L	9.27E+03	4.01E+01	4.01E+01	7.42E+02	3.20E+00	3.20E+00
120127	Anthracene	mg/L	3.90E+02		3.90E+02	3.12E+01		3.12E+01
12674112	Aroclor 1016 (exposure to water)	mg/L	2.56E-02	8.54E-02	2.56E-02	2.05E-03	6.84E-03	2.05E-03
11104282	Aroclor 1221 (exposure to water)	mg/L		2.87E-01	2.87E-01		2.30E-02	2.30E-02
11141165	Aroclor 1232 (exposure to water)	mg/L		2.87E-01	2.87E-01		2.30E-02	2.30E-02
53469219	Aroclor 1242 (exposure to water)	mg/L		3.85E-02	3.85E-02		3.08E-03	3.08E-03
12672296	Aroclor 1248 (exposure to water)	mg/L		3.57E-02	3.57E-02		2.86E-03	2.86E-03
11097691	Aroclor 1254 (exposure to water)	mg/L	1.93E-03	2.25E-02	1.93E-03	1.54E-04	1.80E-03	1.54E-04
11096825	Aroclor 1260 (exposure to water)	mg/L		3.70E-03	3.70E-03		2.96E-04	2.96E-04
56553	Benz[a]anthracene	mg/L		3.13E-02	3.13E-02		2.51E-03	2.51E-03
71432	Benzene	mg/L	7.19E+01	3.05E+01	3.05E+01	5.75E+00	2.44E+00	2.44E+00

Hazard-based value calculated using target HI of 3.
Cancer-based value calculated using target ELCR of 1E-04.
Action value is the less of the hazard- and cancer- based value.

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

(Values calculated on 01/07/2011 and are based on the best available information.)

		Adult Recreational (Swimming)			Adult Recreational (Wading)		
Parameter	**Chemical**	**Hazard**	**Cancer**	**Action**	**Hazard**	**Cancer**	**Action**
7429905	Aluminum	9.61E+03		9.61E+03	5.35E+04		5.35E+04
7440360	Antimony (metallic)	1.53E+00		1.53E+00	3.21E+00		3.21E+00
7440382	Arsenic, Inorganic	2.88E+00	3.02E-01	3.02E-01	1.60E+01	1.41E+00	1.41E+00
7440393	Barium	4.24E+02		4.24E+02	7.49E+02		7.49E+02
7440417	Beryllium and compounds	4.96E-01	3.74E-03	3.74E-03	7.49E-01	3.45E-03	3.45E-03
7440428	Boron And Borates Only	1.92E+03		1.92E+03	1.07E+04		1.07E+04
7440439	Cadmium (Water)	7.93E-01	2.52E-01	2.52E-01	1.34E+00	2.79E-01	2.79E-01
16065831	Chromium (III) (Insoluble Salts)	6.80E+02		6.80E+02	1.04E+03		1.04E+03
7440473	Chromium (Total)	6.80E+02		6.80E+02	1.04E+03		1.04E+03
18540299	Chromium VI (chromic acid mists)	2.28E+01		2.28E+01	8.02E+01		8.02E+01
18540299	Chromium VI (particulates)	1.31E+00	5.60E-02	5.60E-02	2.01E+00	5.30E-02	5.30E-02
7440484	Cobalt	3.43E+00		3.43E+00	4.01E+01		4.01E+01
7440508	Copper	3.85E+02		3.85E+02	2.14E+03		2.14E+03
7439896	Iron	6.73E+03		6.73E+03	3.74E+04		3.74E+04
7439921	Lead And Compounds			3.00E-02			3.00E-02
7439965	Manganese (Water)	3.12E+01		3.12E+01	5.13E+01		5.13E+01
7439976	Mercury, Inorganic Salts	6.35E-01		6.35E-01	1.12E+00		1.12E+00
7439987	Molybdenum	4.81E+01		4.81E+01	2.67E+02		2.67E+02
7440020	Nickel Soluble Salts	9.31E+01		9.31E+01	2.14E+02		2.14E+02
7782492	Selenium	4.81E+01		4.81E+01	2.67E+02		2.67E+02
7440224	Silver	1.02E+01		1.02E+01	1.78E+01		1.78E+01
7791120	Thallium Chloride	7.69E-01		7.69E-01	4.28E+00		4.28E+00
	Uranium (Soluble Salts)	2.88E+01		2.88E+01	1.60E+02		1.60E+02
7440622	Vanadium, Metallic	6.13E-02		6.13E-02	9.73E-02		9.73E-02
7440666	Zinc (Metallic)	3.23E+03		3.23E+03	2.67E+04		2.67E+04
83329	Acenaphthene	1.66E+01		1.66E+01	2.52E+01		2.52E+01
208968	Acenaphthylene						
107131	Acrylonitrile	3.51E+02	7.80E-01	7.80E-01	1.58E+03	2.90E+00	2.90E+00
120127	Anthracene	4.44E+01		4.44E+01	6.65E+01		6.65E+01
12674112	Aroclor 1016 (exposure to water)	2.94E-03	6.90E-03	2.94E-03	4.37E-03	6.19E-03	4.37E-03
11104282	Aroclor 1221 (exposure to water)		2.29E-02	2.29E-02		2.08E-02	2.08E-02
11141165	Aroclor 1232 (exposure to water)		2.29E-02	2.29E-02		2.08E-02	2.08E-02
53469219	Aroclor 1242 (exposure to water)		3.12E-03	3.12E-03		2.79E-03	2.79E-03
12672296	Aroclor 1248 (exposure to water)		2.89E-03	2.89E-03		2.59E-03	2.59E-03
11097691	Aroclor 1254 (exposure to water)	2.22E-04	1.82E-03	2.22E-04	3.29E-04	1.63E-03	3.29E-04
11096825	Aroclor 1260 (exposure to water)		3.01E-04	3.01E-04		2.68E-04	2.68E-04
56553	Benz[a]anthracene		2.53E-03	2.53E-03		2.27E-03	2.27E-03
71432	Benzene	7.14E+00	1.94E+00	1.94E+00	1.23E+01	2.21E+00	2.21E+00

Hazard-based value calculated using target HI of 3.
Cancer-based value calculated using target ELCR of 1E-04.
Action value is the less of the hazard- and cancer- based value.

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

(Values calculated on 01/07/2011 and are based on the best available information.)

		Child Recreational (Swimming)			Child Recreational (Wading)		
Parameter	**Chemical**	**Hazard**	**Cancer**	**Action**	**Hazard**	**Cancer**	**Action**
7429905	Aluminum	2.48E+03		2.48E+03	1.37E+04		1.37E+04
7440360	Antimony (metallic)	6.02E-01		6.02E-01	8.20E-01		8.20E-01
7440382	Arsenic, Inorganic	7.45E-01	3.02E-01	3.02E-01	4.10E+00	1.41E+00	1.41E+00
7440393	Barium	1.97E+02		1.97E+02	1.91E+02		1.91E+02
7440417	Beryllium and compounds	2.87E-01	3.74E-03	3.74E-03	1.91E-01	3.45E-03	3.45E-03
7440428	Boron And Borates Only	4.97E+02		4.97E+02	2.73E+03		2.73E+03
7440439	Cadmium (Water)	3.90E-01	2.52E-01	2.52E-01	3.42E-01	2.79E-01	2.79E-01
16065831	Chromium (III) (Insoluble Salts)	3.83E+02		3.83E+02	2.67E+02		2.67E+02
7440473	Chromium (Total)	3.83E+02		3.83E+02	2.67E+02		2.67E+02
18540299	Chromium VI (chromic acid mists)	6.68E+00		6.68E+00	2.05E+01		2.05E+01
18540299	Chromium VI (particulates)	7.39E-01	5.60E-02	5.60E-02	5.13E-01	5.30E-02	5.30E-02
7440484	Cobalt	8.01E-01		8.01E-01	1.03E+01		1.03E+01
7440508	Copper	9.94E+01		9.94E+01	5.47E+02		5.47E+02
7439896	Iron	1.74E+03		1.74E+03	9.57E+03		9.57E+03
7439921	Lead And Compounds			3.00E-02			3.00E-02
7439965	Manganese (Water)	1.59E+01		1.59E+01	1.31E+01		1.31E+01
7439976	Mercury, Inorganic Salts	2.95E-01		2.95E-01	2.87E-01		2.87E-01
7439987	Molybdenum	1.24E+01		1.24E+01	6.84E+01		6.84E+01
7440020	Nickel Soluble Salts	3.40E+01		3.40E+01	5.47E+01		5.47E+01
7782492	Selenium	1.24E+01		1.24E+01	6.84E+01		6.84E+01
7440224	Silver	4.76E+00		4.76E+00	4.56E+00		4.56E+00
7791120	Thallium Chloride	1.99E-01		1.99E-01	1.09E+00		1.09E+00
	Uranium (Soluble Salts)	7.45E+00		7.45E+00	4.10E+01		4.10E+01
7440622	Vanadium, Metallic	3.28E-02		3.28E-02	2.49E-02		2.49E-02
7440666	Zinc (Metallic)	7.81E+02		7.81E+02	6.84E+03		6.84E+03
83329	Acenaphthene	9.58E+00		9.58E+00	6.43E+00		6.43E+00
208968	Acenaphthylene						
107131	Acrylonitrile	9.55E+01	7.80E-01	7.80E-01	4.04E+02	2.90E+00	2.90E+00
120127	Anthracene	2.60E+01		2.60E+01	1.70E+01		1.70E+01
12674112	Aroclor 1016 (exposure to water)	1.75E-03	6.90E-03	1.75E-03	1.12E-03	6.19E-03	1.12E-03
11104282	Aroclor 1221 (exposure to water)		2.29E-02	2.29E-02		2.08E-02	2.08E-02
11141165	Aroclor 1232 (exposure to water)		2.29E-02	2.29E-02		2.08E-02	2.08E-02
53469219	Aroclor 1242 (exposure to water)		3.12E-03	3.12E-03		2.79E-03	2.79E-03
12672296	Aroclor 1248 (exposure to water)		2.89E-03	2.89E-03		2.59E-03	2.59E-03
11097691	Aroclor 1254 (exposure to water)	1.33E-04	1.82E-03	1.33E-04	8.41E-05	1.63E-03	8.41E-05
11096825	Aroclor 1260 (exposure to water)		3.01E-04	3.01E-04		2.68E-04	2.68E-04
56553	Benz[a]anthracene		2.53E-03	2.53E-03		2.27E-03	2.27E-03
71432	Benzene	3.44E+00	1.94E+00	1.94E+00	3.13E+00	2.21E+00	2.21E+00

Hazard-based value calculated using target HI of 3.
Cancer-based value calculated using target ELCR of 1E-04.
Action value is the less of the hazard- and cancer- based value.

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

(Values calculated on 01/07/2011 and are based on the best available information.)

		Teen Recreational (Swimming)			Teen Recreational (Wading)		
Parameter	**Chemical**	**Hazard**	**Cancer**	**Action**	**Hazard**	**Cancer**	**Action**
7429905	Aluminum	6.38E+03		6.38E+03	1.72E+04		1.72E+04
7440360	Antimony (metallic)	1.17E+00		1.17E+00	1.03E+00		1.03E+00
7440382	Arsenic, Inorganic	1.91E+00	3.02E-01	3.02E-01	5.17E+00	1.41E+00	1.41E+00
7440393	Barium	3.39E+02		3.39E+02	2.41E+02		2.41E+02
7440417	Beryllium and compounds	4.19E-01	3.74E-03	3.74E-03	2.41E-01	3.45E-03	3.45E-03
7440428	Boron And Borates Only	1.28E+03		1.28E+03	3.45E+03		3.45E+03
7440439	Cadmium (Water)	6.45E-01	2.52E-01	2.52E-01	4.31E-01	2.79E-01	2.79E-01
16065831	Chromium (III) (Insoluble Salts)	5.71E+02		5.71E+02	3.36E+02		3.36E+02
7440473	Chromium (Total)	5.71E+02		5.71E+02	3.36E+02		3.36E+02
18540299	Chromium VI (chromic acid mists)	1.58E+01		1.58E+01	2.59E+01		2.59E+01
18540299	Chromium VI (particulates)	1.10E+00	5.60E-02	5.60E-02	6.47E-01	5.30E-02	5.30E-02
7440484	Cobalt	2.19E+00		2.19E+00	1.29E+01		1.29E+01
7440508	Copper	2.55E+02		2.55E+02	6.90E+02		6.90E+02
7439896	Iron	4.46E+03		4.46E+03	1.21E+04		1.21E+04
7439921	Lead And Compounds			3.00E-02			3.00E-02
7439965	Manganese (Water)	2.56E+01		2.56E+01	1.66E+01		1.66E+01
7439976	Mercury, Inorganic Salts	5.09E-01		5.09E-01	3.62E-01		3.62E-01
7439987	Molybdenum	3.19E+01		3.19E+01	8.62E+01		8.62E+01
7440020	Nickel Soluble Salts	6.97E+01		6.97E+01	6.90E+01		6.90E+01
7782492	Selenium	3.19E+01		3.19E+01	8.62E+01		8.62E+01
7440224	Silver	8.16E+00		8.16E+00	5.75E+00		5.75E+00
7791120	Thallium Chloride	5.10E-01		5.10E-01	1.38E+00		1.38E+00
	Uranium (Soluble Salts)	1.91E+01		1.91E+01	5.17E+01		5.17E+01
7440622	Vanadium, Metallic	5.09E-02		5.09E-02	3.14E-02		3.14E-02
7440666	Zinc (Metallic)	2.09E+03		2.09E+03	8.62E+03		8.62E+03
83329	Acenaphthene	1.40E+01		1.40E+01	8.11E+00		8.11E+00
208968	Acenaphthylene						
107131	Acrylonitrile	2.38E+02	7.80E-01	7.80E-01	5.10E+02	2.90E+00	2.90E+00
120127	Anthracene	3.76E+01		3.76E+01	2.14E+01		2.14E+01
12674112	Aroclor 1016 (exposure to water)	2.50E-03	6.90E-03	2.50E-03	1.41E-03	6.19E-03	1.41E-03
11104282	Aroclor 1221 (exposure to water)		2.29E-02	2.29E-02		2.08E-02	2.08E-02
11141165	Aroclor 1232 (exposure to water)		2.29E-02	2.29E-02		2.08E-02	2.08E-02
53469219	Aroclor 1242 (exposure to water)		3.12E-03	3.12E-03		2.79E-03	2.79E-03
12672296	Aroclor 1248 (exposure to water)		2.89E-03	2.89E-03		2.59E-03	2.59E-03
11097691	Aroclor 1254 (exposure to water)	1.89E-04	1.82E-03	1.89E-04	1.06E-04	1.63E-03	1.06E-04
11096825	Aroclor 1260 (exposure to water)		3.01E-04	3.01E-04		2.68E-04	2.68E-04
56553	Benz[a]anthracene		2.53E-03	2.53E-03		2.27E-03	2.27E-03
71432	Benzene	5.78E+00	1.94E+00	1.94E+00	3.95E+00	2.21E+00	2.21E+00

Hazard-based value calculated using target HI of 3.
Cancer-based value calculated using target ELCR of 1E-04.
Action value is the less of the hazard- and cancer- based value.

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

(Values calculated on 01/07/2011 and are based on the best available information.)

			Outdoor Worker/Gardener[a]			Industrial Worker		
Parameter	**Chemical**	**Units**	**Hazard**	**Cancer**	**Action**	**Hazard**	**Cancer**	**Action**
50328	Benzo[a]pyrene	mg/L		2.09E-03	2.09E-03		1.67E-04	1.67E-04
205992	Benzo[b]fluoranthene	mg/L		3.55E-02	3.55E-02		2.84E-03	2.84E-03
207089	Benzo[k]fluoranthene	mg/L		2.15E-01	2.15E-01		1.72E-02	1.72E-02
86748	Carbazole	mg/L		1.68E+01	1.68E+01		1.34E+00	1.34E+00
56235	Carbon Tetrachloride	mg/L	5.00E+01	1.67E+01	1.67E+01	1.33E+00	1.33E+00	5.18E+00
67663	Chloroform	mg/L	3.40E+02	1.02E+02	1.02E+02	2.72E+01	8.19E+00	8.19E+00
218019	Chrysene	mg/L		2.90E+00	2.90E+00		2.32E-01	2.32E-01
53703	Dibenz[a,h]anthracene	mg/L		1.32E-03	1.32E-03		1.06E-04	1.06E-04
75354	Dichloroethylene, 1,1-	mg/L	1.08E+03	3.37E+00	3.37E+00	8.67E+01	2.70E-01	2.70E-01
540590	Dichloroethylene, 1,2- (Mixed Isomers)	mg/L	2.07E+02		2.07E+02	1.66E+01		1.66E+01
156592	Dichloroethylene, 1,2-cis-	mg/L	4.60E+01		4.60E+01	3.68E+00		3.68E+00
156605	Dichloroethylene, 1,2-trans-	mg/L	4.60E+02		4.60E+02	3.68E+01		3.68E+01
60571	Dieldrin	mg/L	7.68E-02	8.96E-03	8.96E-03	6.14E-03	7.17E-04	7.17E-04
1746016	Dioxins/Furans (Total)	mg/L	9.23E-08	6.63E-08	6.63E-08	7.39E-09	5.30E-09	5.30E-09
100414	Ethylbenzene	mg/L	5.33E+02	4.53E+01	4.53E+01	4.27E+01	3.62E+00	3.62E+00
206440	Fluoranthene	mg/L	2.06E+01		2.06E+01	1.65E+00		1.65E+00
86737	Fluorene	mg/L	7.07E+01		7.07E+01	5.66E+00		5.66E+00
118741	Hexachlorobenzene	mg/L	2.95E-01	2.15E-02	2.15E-02	2.36E-02	1.72E-03	1.72E-03
37871004	HpCDD, 2,3,7,8-	mg/L	2.14E-06	1.54E-06	1.54E-06	1.71E-07	1.23E-07	1.23E-07
38998753	HpCDF, 2,3,7,8-	mg/L	2.96E-06	2.12E-06	2.12E-06	2.36E-07	1.70E-07	1.70E-07
34465468	HxCDD, 2,3,7,8-	mg/L	1.69E-07	1.21E-07	1.21E-07	1.35E-08	9.70E-09	9.70E-09
55684941	HxCDF, 2,3,7,8-	mg/L	3.97E-07	2.85E-07	2.85E-07	3.17E-08	2.28E-08	2.28E-08
193395	Indeno[1,2,3-cd]pyrene	mg/L		1.02E-02	1.02E-02		8.19E-04	8.19E-04
91203	Naphthalene	mg/L	1.03E+02		1.03E+02	8.21E+00		8.21E+00
88744	Nitroaniline, 2-	mg/L	4.81E+02		4.81E+02	3.84E+01		3.84E+01
621647	Nitroso-di-N-propylamine, N-	mg/L		1.25E+00	1.25E+00		1.00E-01	1.00E-01
3268879	OCDD	mg/L	1.23E-05	8.87E-06	8.87E-06	9.88E-07	7.10E-07	7.10E-07
39001020	OCDF	mg/L	4.37E-05	3.14E-05	3.14E-05	3.50E-06	2.51E-06	2.51E-06
36088229	PeCDD, 2,3,7,8-	mg/L	2.46E-07	1.77E-07	1.77E-07	1.97E-08	1.42E-08	1.42E-08
57117416	PeCDF, 1,2,3,7,8-	mg/L	3.52E-06	2.53E-06	2.53E-06	2.81E-07	2.02E-07	2.02E-07
57117314	PeCDF, 2,3,4,7,8-	mg/L	2.89E-07	2.07E-07	2.07E-07	2.31E-08	1.66E-08	1.66E-08
85018	Phenanthrene	mg/L						
1336363	Polychlorinated Biphenyls (Total) (high risk)	mg/L		7.71E-03	7.71E-03		6.17E-04	6.17E-04
1336363	Polychlorinated Biphenyls (Total) (low risk)	mg/L		3.85E-02	3.85E-02		3.08E-03	3.08E-03
1336363	Polychlorinated Biphenyls (Total) (lowest risk)	mg/L		2.20E-01	2.20E-01		1.76E-02	1.76E-02
50328	Polynuclear Aromatic Hydrocarbons (Total)	mg/L		2.09E-03	2.09E-03		1.67E-04	1.67E-04
129000	Pyrene	mg/L	2.37E+01		2.37E+01	1.89E+00		1.89E+00
1746016	TCDD, 2,3,7,8-	mg/L	9.23E-08	6.63E-08	6.63E-08	7.39E-09	5.30E-09	5.30E-09
51207319	TCDF, 2,3,7,8-	mg/L	1.26E-06	9.01E-07	9.01E-07	1.00E-07	7.21E-08	7.21E-08

Hazard-based value calculated using target HI of 3.
Cancer-based value calculated using target ELCR of 1E-04.
Action value is the less of the hazard- and cancer- based value.

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

(Values calculated on 01/07/2011 and are based on the best available information.)

		Adult Recreational (Swimming)			Adult Recreational (Wading)		
Parameter	Chemical	Hazard	Cancer	Action	Hazard	Cancer	Action
50328	Benzo[a]pyrene		1.69E-04	1.69E-04		1.51E-04	1.51E-04
205992	Benzo[b]fluoranthene		2.87E-03	2.87E-03		2.57E-03	2.57E-03
207089	Benzo[k]fluoranthene		1.74E-02	1.74E-02		1.56E-02	1.56E-02
86748	Carbazole		1.29E+00	1.29E+00		1.22E+00	1.22E+00
56235	Carbon Tetrachloride	5.18E+00	1.13E+00	1.13E+00	8.52E+00	1.21E+00	1.21E+00
67663	Chloroform	3.01E+01	5.52E+00	5.52E+00	5.80E+01	7.41E+00	7.41E+00
218019	Chrysene		2.35E-01	2.35E-01		2.10E-01	2.10E-01
53703	Dibenz[a,h]anthracene		1.07E-04	1.07E-04		9.58E-05	9.58E-05
75354	Dichloroethylene, 1,1-	1.05E+02	2.06E-01	2.06E-01	1.85E+02	2.44E-01	2.44E-01
540590	Dichloroethylene, 1,2- (Mixed Isomers)	1.98E+01		1.98E+01	3.53E+01		3.53E+01
156592	Dichloroethylene, 1,2-cis-	4.40E+00		4.40E+00	7.84E+00		7.84E+00
156605	Dichloroethylene, 1,2-trans-	4.40E+01		4.40E+01	7.84E+01		7.84E+01
60571	Dieldrin	8.72E-03	7.10E-04	7.10E-04	1.31E-02	6.49E-04	6.49E-04
1746016	Dioxins/Furans (Total)	1.06E-08	5.37E-09	5.37E-09	1.57E-08	4.80E-09	4.80E-09
100414	Ethylbenzene	5.86E+01	3.39E+00	3.39E+00	9.10E+01	3.28E+00	3.28E+00
206440	Fluoranthene	2.36E+00		2.36E+00	3.52E+00		3.52E+00
86737	Fluorene	8.01E+00		8.01E+00	1.21E+01		1.21E+01
118741	Hexachlorobenzene	3.39E-02	1.74E-03	1.74E-03	5.04E-02	1.56E-03	1.56E-03
37871004	HpCDD, 2,3,7,8-	2.46E-07	1.25E-07	1.25E-07	3.65E-07	1.11E-07	1.11E-07
38998753	HpCDF, 2,3,7,8-	3.40E-07	1.72E-07	1.72E-07	5.04E-07	1.54E-07	1.54E-07
34465468	HxCDD, 2,3,7,8-	1.94E-08	9.84E-09	9.84E-09	2.88E-08	8.78E-09	8.78E-09
55684941	HxCDF, 2,3,7,8-	4.57E-08	2.31E-08	2.31E-08	6.77E-08	2.06E-08	2.06E-08
193395	Indeno[1,2,3-cd]pyrene		8.30E-04	8.30E-04		7.41E-04	7.41E-04
91203	Naphthalene	1.13E+01		1.13E+01	1.75E+01		1.75E+01
88744	Nitroaniline, 2-	3.89E+01		3.89E+01	8.20E+01		8.20E+01
621647	Nitroso-di-N-propylamine, N-		4.36E-02	4.36E-02		9.08E-02	9.08E-02
3268879	OCDD	1.42E-06	7.20E-07	7.20E-07	2.11E-06	6.42E-07	6.42E-07
39001020	OCDF	5.03E-06	2.55E-06	2.55E-06	7.46E-06	2.27E-06	2.27E-06
36088229	PeCDD, 2,3,7,8-	2.83E-08	1.43E-08	1.43E-08	4.20E-08	1.28E-08	1.28E-08
57117416	PeCDF, 1,2,3,7,8-	4.04E-07	2.05E-07	2.05E-07	6.00E-07	1.83E-07	1.83E-07
57117314	PeCDF, 2,3,4,7,8-	3.32E-08	1.68E-08	1.68E-08	4.92E-08	1.50E-08	1.50E-08
85018	Phenanthrene						
1336363	Polychlorinated Biphenyls (Total) (high risk)		6.24E-04	6.24E-04		5.58E-04	5.58E-04
1336363	Polychlorinated Biphenyls (Total) (low risk)		3.12E-03	3.12E-03		2.79E-03	2.79E-03
1336363	Polychlorinated Biphenyls (Total) (lowest risk)		1.78E-02	1.78E-02		1.59E-02	1.59E-02
50328	Polynuclear Aromatic Hydrocarbons (Total)		1.69E-04	1.69E-04		1.51E-04	1.51E-04
129000	Pyrene	2.71E+00		2.71E+00	4.04E+00		4.04E+00
1746016	TCDD, 2,3,7,8-	1.06E-08	5.37E-09	5.37E-09	1.57E-08	4.80E-09	4.80E-09
51207319	TCDF, 2,3,7,8-	4.20E-08	4.20E-08	4.20E-08	2.14E-07	6.52E-08	6.52E-08

Hazard-based value calculated using target HI of 3.
Cancer-based value calculated using target ELCR of 1E-04.
Action value is the less of the hazard- and cancer- based value.

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

(Values calculated on 01/07/2011 and are based on the best available information.)

		Child Recreational (Swimming)			Child Recreational (Wading)		
Parameter	Chemical	Hazard	Cancer	Action	Hazard	Cancer	Action
50328	Benzo[a]pyrene		1.69E-04	1.69E-04		1.51E-04	1.51E-04
205992	Benzo[b]fluoranthene		2.87E-03	2.87E-03		2.57E-03	2.57E-03
207089	Benzo[k]fluoranthene		1.74E-02	1.74E-02		1.56E-02	1.56E-02
86748	Carbazole		1.29E+00	1.29E+00		1.22E+00	1.22E+00
56235	Carbon Tetrachloride	2.63E+00	1.13E+00	1.13E+00	2.18E+00	1.21E+00	1.21E+00
67663	Chloroform	1.28E+01	5.52E+00	5.52E+00	1.48E+01	7.41E+00	7.41E+00
218019	Chrysene		2.35E-01	2.35E-01		2.10E-01	2.10E-01
53703	Dibenz[a,h]anthracene		1.07E-04	1.07E-04		9.58E-05	9.58E-05
75354	Dichloroethylene, 1,1-	4.87E+01	2.06E-01	2.06E-01	4.72E+01	2.44E-01	2.44E-01
540590	Dichloroethylene, 1,2- (Mixed Isomers)	9.11E+00		9.11E+00	9.02E+00		9.02E+00
156592	Dichloroethylene, 1,2-cis-	2.02E+00		2.02E+00	2.00E+00		2.00E+00
156605	Dichloroethylene, 1,2-trans-	2.02E+01		2.02E+01	2.00E+01		2.00E+01
60571	Dieldrin	5.10E-03	7.10E-04	7.10E-04	3.35E-03	6.49E-04	6.49E-04
1746016	Dioxins/Furans (Total)	6.34E-09	5.37E-09	5.37E-09	4.03E-09	4.80E-09	4.03E-09
100414	Ethylbenzene	3.25E+01	3.39E+00	3.39E+00	2.33E+01	3.28E+00	3.28E+00
206440	Fluoranthene	1.40E+00		1.40E+00	9.00E-01		9.00E-01
86737	Fluorene	4.67E+00		4.67E+00	3.08E+00		3.08E+00
118741	Hexachlorobenzene	2.02E-02	1.74E-03	1.74E-03	1.29E-02	1.56E-03	1.56E-03
37871004	HpCDD, 2,3,7,8-	1.47E-07	1.25E-07	1.25E-07	9.34E-08	1.11E-07	9.34E-08
38998753	HpCDF, 2,3,7,8-	2.03E-07	1.72E-07	1.72E-07	1.29E-07	1.54E-07	1.29E-07
34465468	HxCDD, 2,3,7,8-	1.16E-08	9.84E-09	9.84E-09	7.36E-09	8.78E-09	7.36E-09
55684941	HxCDF, 2,3,7,8-	2.73E-08	2.31E-08	2.31E-08	1.73E-08	2.06E-08	1.73E-08
193395	Indeno[1,2,3-cd]pyrene		8.30E-04	8.30E-04		7.41E-04	7.41E-04
91203	Naphthalene	6.27E+00		6.27E+00	4.47E+00		4.47E+00
88744	Nitroaniline, 2-	1.52E+01		1.52E+01	2.10E+01		2.10E+01
621647	Nitroso-di-N-propylamine, N-		4.36E-02	4.36E-02		9.08E-02	9.08E-02
3268879	OCDD	8.50E-07	7.20E-07	7.20E-07	5.38E-07	6.42E-07	5.38E-07
39001020	OCDF	3.01E-06	2.55E-06	2.55E-06	1.91E-06	2.27E-06	1.91E-06
36088229	PeCDD, 2,3,7,8-	1.69E-08	1.43E-08	1.43E-08	1.07E-08	1.28E-08	1.28E-08
57117416	PeCDF, 1,2,3,7,8-	2.41E-07	2.05E-07	2.05E-07	1.53E-07	1.83E-07	1.83E-07
57117314	PeCDF, 2,3,4,7,8-	1.98E-08	1.68E-08	1.68E-08	1.26E-08	1.50E-08	1.26E-08
85018	Phenanthrene						
1336363	Polychlorinated Biphenyls (Total) (high risk)		6.24E-04	6.24E-04		5.58E-04	5.58E-04
1336363	Polychlorinated Biphenyls (Total) (low risk)		3.12E-03	3.12E-03		2.79E-03	2.79E-03
1336363	Polychlorinated Biphenyls (Total) (lowest risk)		1.78E-02	1.78E-02		1.59E-02	1.59E-02
50328	Polynuclear Aromatic Hydrocarbons (Total)		1.69E-04	1.69E-04		1.51E-04	1.51E-04
129000	Pyrene	1.60E+00		1.60E+00	1.03E+00		1.03E+00
1746016	TCDD, 2,3,7,8-	6.34E-09	5.37E-09	5.37E-09	4.03E-09	4.80E-09	4.03E-09
51207319	TCDF, 2,3,7,8-	8.62E-08	7.30E-08	7.30E-08	5.47E-08	6.52E-08	5.47E-08

Hazard-based value calculated using target HI of 3.
Cancer-based value calculated using target ELCR of 1E-04.
Action value is the less of the hazard- and cancer- based value.

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

(Values calculated on 01/07/2011 and are based on the best available information.)

		Teen Recreational (Swimming)			Teen Recreational (Wading)		
Parameter	**Chemical**	**Hazard**	**Cancer**	**Action**	**Hazard**	**Cancer**	**Action**
50328	Benzo[a]pyrene		1.69E-04	1.69E-04		1.51E-04	1.51E-04
205992	Benzo[b]fluoranthene		2.87E-03	2.87E-03		2.57E-03	2.57E-03
207089	Benzo[k]fluoranthene		1.74E-02	1.74E-02		1.56E-02	1.56E-02
86748	Carbazole		1.29E+00	1.29E+00		1.22E+00	1.22E+00
56235	Carbon Tetrachloride	4.25E+00	1.13E+00	1.13E+00	2.75E+00	1.21E+00	1.21E+00
67663	Chloroform	2.36E+01	5.52E+00	5.52E+00	1.87E+01	7.41E+00	7.41E+00
218019	Chrysene		2.35E-01	2.35E-01		2.10E-01	2.10E-01
53703	Dibenz[a,h]anthracene		1.07E-04	1.07E-04		9.58E-05	9.58E-05
75354	Dichloroethylene, 1,1-	8.40E+01	2.06E-01	2.06E-01	5.96E+01	2.44E-01	2.44E-01
540590	Dichloroethylene, 1,2- (Mixed Isomers)	1.58E+01		1.58E+01	1.14E+01		1.14E+01
156592	Dichloroethylene, 1,2-cis-	3.52E+00		3.52E+00	2.53E+00		2.53E+00
156605	Dichloroethylene, 1,2-trans-	3.52E+01		3.52E+01	2.53E+01		2.53E+01
60571	Dieldrin	7.38E-03	7.10E-04	7.10E-04	4.22E-03	6.49E-04	6.49E-04
1746016	Dioxins/Furans (Total)	9.03E-09	5.37E-09	5.37E-09	5.08E-09	4.80E-09	4.80E-09
100414	Ethylbenzene	4.91E+01	3.39E+00	3.39E+00	2.93E+01	3.28E+00	3.28E+00
206440	Fluoranthene	2.01E+00		2.01E+00	1.13E+00		1.13E+00
86737	Fluorene	6.78E+00		6.78E+00	3.89E+00		3.89E+00
118741	Hexachlorobenzene	2.88E-02	1.74E-03	1.74E-03	1.62E-02	1.56E-03	1.56E-03
37871004	HpCDD, 2,3,7,8-	2.10E-07	1.25E-07	1.25E-07	1.18E-07	1.11E-07	1.11E-07
38998753	HpCDF, 2,3,7,8-	2.89E-07	1.72E-07	1.72E-07	1.63E-07	1.54E-07	1.54E-07
34465468	HxCDD, 2,3,7,8-	1.65E-08	9.84E-09	9.84E-09	9.29E-09	8.78E-09	8.78E-09
55684941	HxCDF, 2,3,7,8-	3.89E-08	2.31E-08	2.31E-08	2.18E-08	2.06E-08	2.06E-08
193395	Indeno[1,2,3-cd]pyrene		8.30E-04	8.30E-04		7.41E-04	7.41E-04
91203	Naphthalene	9.46E+00		9.46E+00	5.64E+00		5.64E+00
88744	Nitroaniline, 2-	2.97E+01		2.97E+01	2.64E+01		2.64E+01
621647	Nitroso-di-N-propylamine, N-		4.36E-02	4.36E-02		9.08E-02	9.08E-02
3268879	OCDD	1.21E-06	7.20E-07	7.20E-07	6.79E-07	6.42E-07	6.42E-07
39001020	OCDF	4.28E-06	2.55E-06	2.55E-06	2.40E-06	2.27E-06	2.27E-06
36088229	PeCDD, 2,3,7,8-	2.41E-08	1.43E-08	1.43E-08	1.36E-08	1.28E-08	1.28E-08
57117416	PeCDF, 1,2,3,7,8-	3.44E-07	2.05E-07	2.05E-07	1.93E-07	1.83E-07	1.83E-07
57117314	PeCDF, 2,3,4,7,8-	2.82E-08	1.68E-08	1.68E-08	1.59E-08	1.50E-08	1.50E-08
85018	Phenanthrene						
1336363	Polychlorinated Biphenyls (Total) (high risk)		6.24E-04	6.24E-04		5.58E-04	5.58E-04
1336363	Polychlorinated Biphenyls (Total) (low risk)		3.12E-03	3.12E-03		2.79E-03	2.79E-03
1336363	Polychlorinated Biphenyls (Total) (lowest risk)		1.78E-02	1.78E-02		1.59E-02	1.59E-02
50328	Polynuclear Aromatic Hydrocarbons (Total)		1.69E-04	1.69E-04		1.51E-04	1.51E-04
129000	Pyrene	2.30E+00		2.30E+00	1.30E+00		1.30E+00
1746016	TCDD, 2,3,7,8-	9.03E-09	5.37E-09	5.37E-09	5.08E-09	4.80E-09	4.80E-09
51207319	TCDF, 2,3,7,8-	1.23E-07	7.30E-08	7.30E-08	6.90E-08	6.52E-08	6.52E-08

Hazard-based value calculated using target HI of 3.
Cancer-based value calculated using target ELCR of 1E-04.
Action value is the less of the hazard- and cancer- based value.

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

(Values calculated on 01/07/2011 and are based on the best available information.)

			Outdoor Worker/Gardener[a]			Industrial Worker		
Parameter	**Chemical**	**Units**	**Hazard**	**Cancer**	**Action**	**Hazard**	**Cancer**	**Action**
127184	Tetrachloroethylene	mg/L	5.79E+01	1.00E+00	1.00E+00	4.63E+00	8.00E-02	8.00E-02
79016	Trichloroethylene	mg/L	5.78E+00	5.58E+00	5.58E+00	4.62E-01	4.47E-01	4.47E-01
75014	Vinyl Chloride	mg/L	9.76E+01	4.22E+00	4.22E+00	7.81E+00	3.37E-01	3.37E-01
108383	Xylene, m-	mg/L	9.94E+02		9.94E+02	7.95E+01		7.95E+01
1330207	Xylene, Mixture	mg/L	1.11E+03		1.11E+03	8.91E+01		8.91E+01
95476	Xylene, o-	mg/L	1.11E+03		1.11E+03	8.91E+01		8.91E+01
106423	Xylene, P-	mg/L	1.07E+03		1.07E+03	8.53E+01		8.53E+01
14596102	Am-241	pCi/L						
10198400	Co-60	pCi/L						
10045973	Cs-137+D	pCi/L						
13994202	Np-237+D	pCi/L						
13981163	Pu-238	pCi/L						
15117483	Pu-239	pCi/L						
14119336	Pu-240	pCi/L						
14133767	Tc-99	pCi/L						
14269637	Th-230	pCi/L						
13966295	U-234	pCi/L						
15117961	U-235+D	pCi/L						
7440611	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 value is the less of the hazard- and cancer- based value.

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

(Values calculated on 01/07/2011 and are based on the best available information.)

		Adult Recreational (Swimming)			Adult Recreational (Wading)		
Parameter	**Chemical**	**Hazard**	**Cancer**	**Action**	**Hazard**	**Cancer**	**Action**
127184	Tetrachloroethylene	6.34E+00	7.45E-02	7.45E-02	9.87E+00	7.24E-02	7.24E-02
79016	Trichloroethylene	5.69E-01	3.51E-01	3.51E-01	9.85E-01	4.04E-01	4.04E-01
75014	Vinyl Chloride	8.74E+00	2.31E-01	2.31E-01	1.66E+01	3.05E-01	3.05E-01
108383	Xylene, m-	1.10E+02		1.10E+02	1.69E+02		1.69E+02
1330207	Xylene, Mixture	1.22E+02		1.22E+02	1.90E+02		1.90E+02
95476	Xylene, o-	1.22E+02		1.22E+02	1.90E+02		1.90E+02
106423	Xylene, P-	1.17E+02		1.17E+02	1.82E+02		1.82E+02
14596102	Am-241		6.09E+03	6.09E+03			
10198400	Co-60		4.03E+04	4.03E+04			
10045973	Cs-137+D		2.08E+04	2.08E+04			
13994202	Np-237+D		9.39E+03	9.39E+03			
13981163	Pu-238		4.83E+03	4.83E+03			
15117483	Pu-239		4.69E+03	4.69E+03			
14119336	Pu-240		4.69E+03	4.69E+03			
14133767	Tc-99		2.30E+05	2.30E+05			
14269637	Th-230		6.96E+03	6.96E+03			
13966295	U-234		8.95E+03	8.95E+03			
15117961	U-235+D		8.82E+03	8.82E+03			
7440611	U-238+D		7.27E+03	7.27E+03			

Hazard-based value calculated using target HI of 3.
Cancer-based value calculated using target ELCR of 1E-04.
Action value is the less of the hazard- and cancer- based value.

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

(Values calculated on 01/07/2011 and are based on the best available information.)

		Child Recreational (Swimming)			Child Recreational (Wading)		
Parameter	Chemical	Hazard	Cancer	Action	Hazard	Cancer	Action
127184	Tetrachloroethylene	3.49E+00	7.45E-02	7.45E-02	2.52E+00	7.24E-02	7.24E-02
79016	Trichloroethylene	2.70E-01	3.51E-01	2.70E-01	2.52E-01	4.04E-01	2.52E-01
75014	Vinyl Chloride	3.74E+00	2.31E-01	2.31E-01	4.26E+00	3.05E-01	3.05E-01
108383	Xylene, m-	6.10E+01		6.10E+01	4.33E+01		4.33E+01
1330207	Xylene, Mixture	6.75E+01		6.75E+01	4.85E+01		4.85E+01
95476	Xylene, o-	6.75E+01		6.75E+01	4.85E+01		4.85E+01
106423	Xylene, P-	6.50E+01		6.50E+01	4.65E+01		4.65E+01
14596102	Am-241		6.09E+03	6.09E+03			
10198400	Co-60		4.03E+04	4.03E+04			
10045973	Cs-137+D		2.08E+04	2.08E+04			
13994202	Np-237+D		9.39E+03	9.39E+03			
13981163	Pu-238		4.83E+03	4.83E+03			
15117483	Pu-239		4.69E+03	4.69E+03			
14119336	Pu-240		4.69E+03	4.69E+03			
14133767	Tc-99		2.30E+05	2.30E+05			
14269637	Th-230		6.96E+03	6.96E+03			
13966295	U-234		8.95E+03	8.95E+03			
15117961	U-235+D		8.82E+03	8.82E+03			
7440611	U-238+D		7.27E+03	7.27E+03			

Hazard-based value calculated using target HI of 3.
Cancer-based value calculated using target ELCR of 1E-04.
Action value is the less of the hazard- and cancer- based value.

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

(Values calculated on 01/07/2011 and are based on the best available information.)

		Teen Recreational (Swimming)			Teen Recreational (Wading)		
Parameter	**Chemical**	**Hazard**	**Cancer**	**Action**	**Hazard**	**Cancer**	**Action**
127184	Tetrachloroethylene	5.29E+00	7.45E-02	7.45E-02	3.18E+00	7.24E-02	7.24E-02
79016	Trichloroethylene	4.59E-01	3.51E-01	3.51E-01	3.18E-01	4.04E-01	3.18E-01
75014	Vinyl Chloride	6.85E+00	2.31E-01	2.31E-01	5.37E+00	3.05E-01	3.05E-01
108383	Xylene, m-	9.18E+01		9.18E+01	5.46E+01		5.46E+01
1330207	Xylene, Mixture	1.02E+02		1.02E+02	6.12E+01		6.12E+01
95476	Xylene, o-	1.02E+02		1.02E+02	6.12E+01		6.12E+01
106423	Xylene, P-	9.81E+01		9.81E+01	5.87E+01		5.87E+01
14596102	Am-241		6.09E+03	6.09E+03			
10198400	Co-60		4.03E+04	4.03E+04			
10045973	Cs-137+D		2.08E+04	2.08E+04			
13994202	Np-237+D		9.39E+03	9.39E+03			
13981163	Pu-238		4.83E+03	4.83E+03			
15117483	Pu-239		4.69E+03	4.69E+03			
14119336	Pu-240		4.69E+03	4.69E+03			
14133767	Tc-99		2.30E+05	2.30E+05			
14269637	Th-230		6.96E+03	6.96E+03			
13966295	U-234		8.95E+03	8.95E+03			
15117961	U-235+D		8.82E+03	8.82E+03			
7440611	U-238+D		7.27E+03	7.27E+03			

Values in this table were calculated using the best available information in December 2010. 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.

[a] The parameters for the outdoor worker/gardener scenario can be used for a construction/excavation worker, but using an ED of from 1-5 years [based on guidance in the Exposure Factors Handbook (EPA 1993)]

Hazard-based value calculated using target HI of 3.
Cancer-based value calculated using target ELCR of 1E-04.
Action value is the less of the hazard- and cancer- based value.

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

(Values calculated on 01/07/2011 and are based on best available information.)

			Outdoor Worker/Gardener[a]			Industrial Worker		
Parameter	**Chemical**	**Units**	**Hazard**	**Cancer**	**No Action**	**Hazard**	**Cancer**	**No Action**
7429905	Aluminum	mg/kg	1.87E+04		1.87E+04	3.32E+04		3.32E+04
7440360	Antimony (metallic)	mg/kg	2.70E+00		2.70E+00	2.53E+00		2.53E+00
7440382	Arsenic, Inorganic	mg/kg	6.65E+00	4.15E-01	4.15E-01	1.59E+01	9.97E-01	9.97E-01
7440393	Barium	mg/kg	7.11E+02		7.11E+02	5.92E+02		5.92E+02
7440417	Beryllium and compounds	mg/kg	5.32E+00	1.74E-02	1.74E-02	4.29E+00	1.40E-02	1.40E-02
7440428	Boron And Borates Only	mg/kg	3.86E+03		3.86E+03	7.14E+03		7.14E+03
7440439	Cadmium (Diet)	mg/kg	2.03E+01	1.52E+00	1.52E+00	4.10E+01	3.16E+00	3.16E+00
16065831	Chromium (III) (Insoluble Salts)	mg/kg	4.00E+03		4.00E+03	3.23E+03		3.23E+03
7440473	Chromium (Total)	mg/kg	1.12E+03	4.08E+01	4.08E+01	8.46E+02	3.02E+01	3.02E+01
18540299	Chromium VI (chromic acid mists)	mg/kg	6.48E+01	4.08E+01	4.08E+01	1.46E+02	3.02E+01	3.02E+01
18540299	Chromium VI (particulates)	mg/kg	7.99E+00	1.49E-01	1.49E-01	6.45E+00	1.20E-01	1.20E-01
7440484	Cobalt	mg/kg	5.75E+00	3.81E+02	5.75E+00	1.05E+01	2.82E+02	1.05E+01
7440508	Copper	mg/kg	7.73E+02		7.73E+02	1.43E+03		1.43E+03
7439896	Iron	mg/kg	1.35E+04		1.35E+04	2.51E+04		2.51E+04
7439921	Lead And Compounds	mg/kg			4.00E+02			4.00E+02
7439965	Manganese (Diet)	mg/kg	1.96E+03		1.96E+03	2.58E+03		2.58E+03
7439976	Mercury, Inorganic Salts	mg/kg	1.08E+00		1.08E+00	9.00E-01		9.00E-01
7439987	Molybdenum	mg/kg	9.66E+01		9.66E+01	1.79E+02		1.79E+02
7440020	Nickel Soluble Salts	mg/kg	5.31E+01	1.32E+04	5.31E+01	4.28E+01	9.75E+03	4.28E+01
7782492	Selenium	mg/kg	9.66E+01		9.66E+01	1.79E+02		1.79E+02
7440224	Silver	mg/kg	1.33E+01		1.33E+01	1.08E+01		1.08E+01
7791120	Thallium Chloride	mg/kg	1.55E+00		1.55E+00	2.87E+00		2.87E+00
	Uranium (Soluble Salts)	mg/kg	5.79E+01		5.79E+01	1.07E+02		1.07E+02
7440622	Vanadium, Metallic	mg/kg	1.87E-01		1.87E-01	1.51E-01		1.51E-01
7440666	Zinc (Metallic)	mg/kg	5.79E+03		5.79E+03	1.08E+04		1.08E+04
83329	Acenaphthene	mg/kg	5.72E+02		5.72E+02	6.02E+02		6.02E+02
208968	Acenaphthylene	mg/kg						
107131	Acrylonitrile	mg/kg	1.83E+00	2.02E-01	2.02E-01	1.36E+00	1.70E-01	1.70E-01
120127	Anthracene	mg/kg	3.49E+03		3.49E+03	4.05E+03		4.05E+03
12674112	Aroclor 1016 (exposure to soil or food)	mg/kg	7.93E-01	1.59E-01	1.59E-01	9.07E-01	1.82E-01	1.82E-01
11104282	Aroclor 1221 (exposure to soil or food)	mg/kg		1.12E-01	1.12E-01		1.10E-01	1.10E-01
11141165	Aroclor 1232 (exposure to soil or food)	mg/kg		1.12E-01	1.12E-01		1.10E-01	1.10E-01
53469219	Aroclor 1242 (exposure to soil or food)	mg/kg		1.61E-01	1.61E-01		1.86E-01	1.86E-01
12672296	Aroclor 1248 (exposure to soil or food)	mg/kg		1.70E-01	1.70E-01		2.02E-01	2.02E-01
11097691	Aroclor 1254 (exposure to soil or food)	mg/kg	2.33E-01	1.63E-01	1.63E-01	2.70E-01	1.89E-01	1.89E-01
11096825	Aroclor 1260 (exposure to soil or food)	mg/kg		1.66E-01	1.66E-01		1.94E-01	1.94E-01
56553	Benz[a]anthracene	mg/kg		4.82E-01	4.82E-01		5.86E-01	5.86E-01
71432	Benzene	mg/kg	7.35E+00	8.92E-01	8.92E-01	5.77E+00	6.98E-01	6.98E-01

Hazard-based value calculated using target HI of 0.1.
Cancer-based value calculated using target ELCR of 1E-06.
Action value is the less of the hazard- and cancer- based value.

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

(Values calculated on 01/07/2011 and are based on best available information.)

			Adult Recreational User			Child Recreational User			Teen Recreational User		
Parameter	Chemical	Units	Hazard	Cancer	No Action	Hazard	Cancer	No Action	Hazard	Cancer	No Action
7429905	Aluminum	mg/kg	7.79E+04		7.79E+04	2.05E+04		2.05E+04	2.77E+04		2.77E+04
7440360	Antimony (metallic)	mg/kg	5.12E+00		5.12E+00	1.60E+00		1.60E+00	1.78E+00		1.78E+00
7440382	Arsenic, Inorganic	mg/kg	3.82E+01	1.02E+00	1.02E+00	9.27E+00	1.02E+00	1.02E+00	1.36E+01	1.02E+00	1.02E+00
7440393	Barium	mg/kg	1.20E+03		1.20E+03	3.80E+02		3.80E+02	4.15E+02		4.15E+02
7440417	Beryllium and compounds	mg/kg	8.58E+00	1.29E-02	1.29E-02	2.75E+00	1.29E-02	1.29E-02	2.98E+00	1.29E-02	1.29E-02
7440428	Boron And Borates Only	mg/kg	1.60E+04		1.60E+04	4.29E+03		4.29E+03	5.66E+03		5.66E+03
7440439	Cadmium (Diet)	mg/kg	9.69E+01	3.14E+00	3.14E+00	2.47E+01	3.14E+00	3.14E+00	3.44E+01	3.14E+00	3.14E+00
16065831	Chromium (III) (Insoluble Salts)	mg/kg	6.44E+03		6.44E+03	2.06E+03		2.06E+03	2.24E+03		2.24E+03
7440473	Chromium (Total)	mg/kg	1.68E+03	7.15E+01	7.15E+01	5.43E+02	7.15E+01	7.15E+01	5.83E+02	7.15E+01	7.15E+01
18540299	Chromium VI (chromic acid mists)	mg/kg	4.07E+02	7.15E+01	7.15E+01	9.07E+01	7.15E+01	7.15E+01	1.49E+02	7.15E+01	7.15E+01
18540299	Chromium VI (particulates)	mg/kg	1.29E+01	1.10E-01	1.10E-01	4.13E+00	1.10E-01	1.10E-01	4.47E+00	1.10E-01	1.10E-01
7440484	Cobalt	mg/kg	2.39E+01	6.67E+02	2.39E+01	6.38E+00	6.67E+02	6.38E+00	8.45E+00	6.67E+02	8.45E+00
7440508	Copper	mg/kg	3.21E+03		3.21E+03	8.61E+02		8.61E+02	1.13E+03		1.13E+03
7439896	Iron	mg/kg	5.62E+04		5.62E+04	1.51E+04		1.51E+04	1.98E+04		1.98E+04
7439921	Lead And Compounds	mg/kg			4.00E+02			4.00E+02			4.00E+02
7439965	Manganese (Diet)	mg/kg	9.04E+03		9.04E+03	1.92E+03		1.92E+03	3.47E+03		3.47E+03
7439976	Mercury, Inorganic Salts	mg/kg	1.80E+00		1.80E+00	5.75E-01		5.75E-01	6.25E-01		6.25E-01
7439987	Molybdenum	mg/kg	4.02E+02		4.02E+02	1.08E+02		1.08E+02	1.42E+02		1.42E+02
7440020	Nickel Soluble Salts	mg/kg	8.57E+01	2.31E+04	8.57E+01	2.74E+01	2.31E+04	2.74E+01	2.98E+01	2.31E+04	2.98E+01
7782492	Selenium	mg/kg	4.02E+02		4.02E+02	1.08E+02		1.08E+02	1.42E+02		1.42E+02
7440224	Silver	mg/kg	2.15E+01		2.15E+01	6.88E+00		6.88E+00	7.45E+00		7.45E+00
7791120	Thallium Chloride	mg/kg	6.43E+00		6.43E+00	1.72E+00		1.72E+00	2.27E+00		2.27E+00
	Uranium (Soluble Salts)	mg/kg	2.41E+02		2.41E+02	6.44E+01		6.44E+01	8.49E+01		8.49E+01
7440622	Vanadium, Metallic	mg/kg	3.01E-01		3.01E-01	9.63E-02		9.63E-02	1.04E-01		1.04E-01
7440666	Zinc (Metallic)	mg/kg	2.41E+04		2.41E+04	6.46E+03		6.46E+03	8.50E+03		8.50E+03
83329	Acenaphthene	mg/kg	1.62E+03		1.62E+03	4.22E+02		4.22E+02	5.87E+02		5.87E+02
208968	Acenaphthylene	mg/kg									
107131	Acrylonitrile	mg/kg	7.72E+00	2.43E-01	2.43E-01	1.24E+00	2.43E-01	2.43E-01	3.51E+00	2.43E-01	2.43E-01
120127	Anthracene	mg/kg	9.19E+03		9.19E+03	2.63E+03		2.63E+03	3.25E+03		3.25E+03
12674112	Aroclor 1016 (exposure to soil or food)	mg/kg	2.02E+00	1.81E-01	1.81E-01	5.86E-01	1.81E-01	1.81E-01	7.10E-01	1.81E-01	1.81E-01
11104282	Aroclor 1221 (exposure to soil or food)	mg/kg		1.40E-01	1.40E-01		1.40E-01	1.40E-01		1.40E-01	1.40E-01
11141165	Aroclor 1232 (exposure to soil or food)	mg/kg		1.40E-01	1.40E-01		1.40E-01	1.40E-01		1.40E-01	1.40E-01
53469219	Aroclor 1242 (exposure to soil or food)	mg/kg		1.83E-01	1.83E-01		1.83E-01	1.83E-01		1.83E-01	1.83E-01
12672296	Aroclor 1248 (exposure to soil or food)	mg/kg		1.90E-01	1.90E-01		1.90E-01	1.90E-01		1.90E-01	1.90E-01
11097691	Aroclor 1254 (exposure to soil or food)	mg/kg	5.86E-01	1.84E-01	1.84E-01	1.72E-01	1.84E-01	1.72E-01	2.05E-01	1.84E-01	1.84E-01
11096825	Aroclor 1260 (exposure to soil or food)	mg/kg		1.86E-01	1.86E-01		1.86E-01	1.86E-01		1.86E-01	1.86E-01
56553	Benz[a]anthracene	mg/kg		5.54E-01	5.54E-01		5.54E-01	5.54E-01		5.54E-01	5.54E-01
71432	Benzene	mg/kg	2.52E+01	1.28E+00	1.28E+00	4.89E+00	1.28E+00	1.28E+00	1.03E+01	1.28E+00	1.28E+00

Hazard-based value calculated using target HI of 0.1.
Cancer-based value calculated using target ELCR of 1E-06.
Action value is the less of the hazard- and cancer- based value.

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

(Values calculated on 01/07/2011 and are based on best available information.)

			Adult Resident			Child Resident		
Parameter	Chemical	Units	Hazard	Cancer	No Action	Hazard	Cancer	No Action
7429905	Aluminum	mg/kg	1.82E+04		1.82E+04	4.41E+03		4.41E+03
7440360	Antimony (metallic)	mg/kg	1.46E+00		1.46E+00	5.52E-01		5.52E-01
7440382	Arsenic, Inorganic	mg/kg	8.04E+00	2.38E-01	2.38E-01	1.64E+00	2.38E-01	2.38E-01
7440393	Barium	mg/kg	3.47E+02		3.47E+02	1.40E+02		1.40E+02
7440417	Beryllium and compounds	mg/kg	2.51E+00	5.67E-03	5.67E-03	1.04E+00	5.67E-03	5.67E-03
7440428	Boron And Borates Only	mg/kg	3.78E+03		3.78E+03	9.18E+02		9.18E+02
7440439	Cadmium (Diet)	mg/kg	2.18E+01	8.11E-01	8.11E-01	4.90E+00	8.11E-01	8.11E-01
16065831	Chromium (III) (Insoluble Salts)	mg/kg	1.89E+03		1.89E+03	7.82E+02		7.82E+02
7440473	Chromium (Total)	mg/kg	4.97E+02	1.56E+01	1.56E+01	2.14E+02	1.56E+01	1.56E+01
18540299	Chromium VI (chromic acid mists)	mg/kg	8.09E+01	1.56E+01	1.56E+01	1.57E+01	1.56E+01	1.56E+01
18540299	Chromium VI (particulates)	mg/kg	3.77E+00	4.86E-02	4.86E-02	1.56E+00	4.86E-02	4.86E-02
7440484	Cobalt	mg/kg	5.63E+00	1.46E+02	5.63E+00	1.37E+00	1.46E+02	1.37E+00
7440508	Copper	mg/kg	7.58E+02		7.58E+02	1.84E+02		1.84E+02
7439896	Iron	mg/kg	1.33E+04		1.33E+04	3.22E+03		3.22E+03
7439921	Lead And Compounds	mg/kg			4.00E+02			4.00E+02
7439965	Manganese (Diet)	mg/kg	1.90E+03		1.90E+03	4.19E+02		4.19E+02
7439976	Mercury, Inorganic Salts	mg/kg	5.25E-01		5.25E-01	2.13E-01		2.13E-01
7439987	Molybdenum	mg/kg	9.48E+01		9.48E+01	2.30E+01		2.30E+01
7440020	Nickel Soluble Salts	mg/kg	2.51E+01	5.05E+03	2.51E+01	1.04E+01	5.05E+03	1.04E+01
7782492	Selenium	mg/kg	9.48E+01		9.48E+01	2.30E+01		2.30E+01
7440224	Silver	mg/kg	6.29E+00		6.29E+00	2.61E+00		2.61E+00
7791120	Thallium Chloride	mg/kg	1.52E+00		1.52E+00	3.68E-01		3.68E-01
	Uranium (Soluble Salts)	mg/kg	5.68E+01		5.68E+01	1.38E+01		1.38E+01
7440622	Vanadium, Metallic	mg/kg	8.81E-02		8.81E-02	3.65E-02		3.65E-02
7440666	Zinc (Metallic)	mg/kg	5.69E+03		5.69E+03	1.38E+03		1.38E+03
83329	Acenaphthene	mg/kg	4.05E+02		4.05E+02	1.17E+02		1.17E+02
208968	Acenaphthylene	mg/kg						
107131	Acrylonitrile	mg/kg	1.44E+00	7.43E-02	7.43E-02	3.09E-01	7.43E-02	7.43E-02
120127	Anthracene	mg/kg	2.42E+03		2.42E+03	7.47E+02		7.47E+02
12674112	Aroclor 1016 (exposure to soil or food)	mg/kg	5.37E-01	6.33E-02	6.33E-02	1.69E-01	6.33E-02	6.33E-02
11104282	Aroclor 1221 (exposure to soil or food)	mg/kg		4.37E-02	4.37E-02		4.37E-02	4.37E-02
11141165	Aroclor 1232 (exposure to soil or food)	mg/kg		4.37E-02	4.37E-02		4.37E-02	4.37E-02
53469219	Aroclor 1242 (exposure to soil or food)	mg/kg		6.44E-02	6.44E-02		6.44E-02	6.44E-02
12672296	Aroclor 1248 (exposure to soil or food)	mg/kg		6.82E-02	6.82E-02		6.82E-02	6.82E-02
11097691	Aroclor 1254 (exposure to soil or food)	mg/kg	1.57E-01	6.51E-02	6.51E-02	5.01E-02	6.51E-02	5.01E-02
11096825	Aroclor 1260 (exposure to soil or food)	mg/kg		6.62E-02	6.62E-02		6.62E-02	6.62E-02
56553	Benz[a]anthracene	mg/kg		1.96E-01	1.96E-01		1.96E-01	1.96E-01
71432	Benzene	mg/kg	5.35E+00	3.33E-01	3.33E-01	1.30E+00	3.33E-01	3.33E-01

Hazard-based value calculated using target HI of 0.1.
Cancer-based value calculated using target ELCR of 1E-06.
Action value is the less of the hazard- and cancer- based value.

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

(Values calculated on 01/07/2011 and are based on best available information.)

			Outdoor Worker/Gardener[a]			Industrial Worker		
Parameter	Chemical	Units	Hazard	Cancer	No Action	Hazard	Cancer	No Action
50328	Benzo[a]pyrene	mg/kg		4.85E-02	4.85E-02		5.92E-02	5.92E-02
205992	Benzo[b]fluoranthene	mg/kg		4.85E-01	4.85E-01		5.92E-01	5.92E-01
207089	Benzo[k]fluoranthene	mg/kg		4.81E+00	4.81E+00		5.84E+00	5.84E+00
86748	Carbazole	mg/kg		2.04E+01	2.04E+01		2.75E+01	2.75E+01
56235	Carbon Tetrachloride	mg/kg	1.12E+01	6.38E-01	6.38E-01	9.10E+00	4.97E-01	4.97E-01
67663	Chloroform	mg/kg	2.04E+01	3.23E-01	3.23E-01	1.62E+01	2.42E-01	2.42E-01
218019	Chrysene	mg/kg		4.68E+01	4.68E+01		5.59E+01	5.59E+01
53703	Dibenz[a,h]anthracene	mg/kg		4.85E-02	4.85E-02		5.93E-02	5.93E-02
75354	Dichloroethylene, 1,1-	mg/kg	2.53E+01	6.33E-02	6.33E-02	1.90E+01	4.89E-02	4.89E-02
540590	Dichloroethylene, 1,2- (Mixed Isomers)	mg/kg	7.22E+00		7.22E+00	5.48E+00		5.48E+00
156592	Dichloroethylene, 1,2-cis-	mg/kg	5.83E+00		5.83E+00	4.74E+00		4.74E+00
156605	Dichloroethylene, 1,2-trans-	mg/kg	1.42E+01		1.42E+01	1.07E+01		1.07E+01
60571	Dieldrin	mg/kg	7.27E-01	2.49E-02	2.49E-02	9.83E-01	3.30E-02	3.30E-02
1746016	Dioxins/Furans (Total)	mg/kg	2.22E-05	4.65E-06	4.65E-06	5.31E-05	1.05E-05	1.05E-05
100414	Ethylbenzene	mg/kg	3.00E+02	4.22E+00	4.22E+00	2.45E+02	3.29E+00	3.29E+00
206440	Fluoranthene	mg/kg	4.98E+02		4.98E+02	6.01E+02		6.01E+02
86737	Fluorene	mg/kg	4.35E+02		4.35E+02	4.87E+02		4.87E+02
118741	Hexachlorobenzene	mg/kg	1.16E+01	1.23E-01	1.23E-01	1.57E+01	1.17E-01	1.17E-01
37871004	HpCDD, 2,3,7,8-	mg/kg	2.22E-03	4.79E-04	4.79E-04	5.35E-03	1.15E-03	1.15E-03
38998753	HpCDF, 2,3,7,8-	mg/kg	1.45E-03	3.13E-04	3.13E-04	1.97E-03	4.23E-04	4.23E-04
34465468	HxCDD, 2,3,7,8-	mg/kg	2.22E-04	4.79E-05	4.79E-05	5.35E-04	1.15E-04	1.15E-04
55684941	HxCDF, 2,3,7,8-	mg/kg	1.45E-04	3.13E-05	3.13E-05	1.97E-04	4.23E-05	4.23E-05
193395	Indeno[1,2,3-cd]pyrene	mg/kg		4.85E-01	4.85E-01		5.93E-01	5.93E-01
91203	Naphthalene	mg/kg	1.03E+01	3.03E+00	3.03E+00	7.78E+00	2.24E+00	2.24E+00
88744	Nitroaniline, 2-	mg/kg	1.75E+00		1.75E+00	1.30E+00		1.30E+00
621647	Nitroso-di-N-propylamine, N-	mg/kg		4.55E-02	4.55E-02		5.22E-02	5.22E-02
3268879	OCDD	mg/kg	7.41E-02	1.60E-02	1.60E-02	1.78E-01	3.84E-02	3.84E-02
39001020	OCDF	mg/kg	4.84E-02	1.04E-02	1.04E-02	6.54E-02	1.41E-02	1.41E-02
36088229	PeCDD, 2,3,7,8-	mg/kg	2.22E-05	4.79E-06	4.79E-06	5.35E-05	1.15E-05	1.15E-05
57117416	PeCDF, 1,2,3,7,8-	mg/kg	4.84E-04	1.04E-04	1.04E-04	6.54E-04	1.41E-04	1.41E-04
57117314	PeCDF, 2,3,4,7,8-	mg/kg	4.84E-05	1.04E-05	1.04E-05	6.54E-05	1.41E-05	1.41E-05
85018	Phenanthrene	mg/kg						
1336363	Polychlorinated Biphenyls (Total) (high risk)	mg/kg		1.62E-01	1.62E-01		1.88E-01	1.88E-01
1336363	Polychlorinated Biphenyls (Total) (low risk)	mg/kg		8.15E-01	8.15E-01		9.47E-01	9.47E-01
1336363	Polychlorinated Biphenyls (Total) (lowest risk)	mg/kg		4.63E+00	4.63E+00		5.36E+00	5.36E+00
50328	Polynuclear Aromatic Hydrocarbons (Total)	mg/kg		4.85E-02	4.85E-02		5.92E-02	5.92E-02
129000	Pyrene	mg/kg	3.73E+02		3.73E+02	4.49E+02		4.49E+02
1746016	TCDD, 2,3,7,8-	mg/kg	2.22E-05	4.65E-06	4.65E-06	5.31E-05	1.05E-05	1.05E-05
51207319	TCDF, 2,3,7,8-	mg/kg	1.45E-04	3.13E-05	3.13E-05	1.97E-04	4.23E-05	4.23E-05

Hazard-based value calculated using target HI of 0.1.
Cancer-based value calculated using target ELCR of 1E-06.
Action value is the less of the hazard- and cancer- based value.

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

(Values calculated on 01/07/2011 and are based on best available information.)

		Adult Recreational User			Child Recreational User			Teen Recreational User		
Parameter	Chemical	Hazard	Cancer	No Action	Hazard	Cancer	No Action	Hazard	Cancer	No Action
50328	Benzo[a]pyrene		5.57E-02	5.57E-02		5.57E-02	5.57E-02		5.57E-02	5.57E-02
205992	Benzo[b]fluoranthene		5.57E-01	5.57E-01		5.57E-01	5.57E-01		5.57E-01	5.57E-01
207089	Benzo[k]fluoranthene		5.54E+00	5.54E+00		5.54E+00	5.54E+00		5.54E+00	5.54E+00
86748	Carbazole		2.61E+01	2.61E+01		2.61E+01	2.61E+01		2.61E+01	2.61E+01
56235	Carbon Tetrachloride	3.49E+01	9.30E-01	9.30E-01	7.40E+00	9.30E-01	9.30E-01	1.37E+01	9.30E-01	9.30E-01
67663	Chloroform	6.85E+01	5.38E-01	5.38E-01	1.36E+01	5.38E-01	5.38E-01	2.78E+01	5.38E-01	5.38E-01
218019	Chrysene		5.43E+01	5.43E+01		5.43E+01	5.43E+01		5.43E+01	5.43E+01
53703	Dibenz[a,h]anthracene		5.57E-02	5.57E-02		5.57E-02	5.57E-02		5.57E-02	5.57E-02
75354	Dichloroethylene, 1,1-	1.01E+02	9.45E-02	9.45E-02	1.70E+01	9.45E-02	9.45E-02	4.44E+01	9.45E-02	9.45E-02
540590	Dichloroethylene, 1,2- (Mixed Isomers)	2.77E+01		2.77E+01	4.84E+00		4.84E+00	1.20E+01		1.20E+01
156592	Dichloroethylene, 1,2-cis-	1.79E+01		1.79E+01	3.84E+00		3.84E+00	7.03E+00		7.03E+00
156605	Dichloroethylene, 1,2-trans-	5.50E+01		5.50E+01	9.50E+00		9.50E+00	2.39E+01		2.39E+01
60571	Dieldrin	2.08E+00	3.20E-02	3.20E-02	6.08E-01	3.20E-02	3.20E-02	7.27E-01	3.20E-02	3.20E-02
1746016	Dioxins/Furans (Total)	1.28E-04	1.13E-05	1.13E-05	3.10E-05	1.13E-05	1.13E-05	4.55E-05	1.13E-05	1.13E-05
100414	Ethylbenzene	9.17E+02	6.11E+00	6.11E+00	1.98E+02	6.11E+00	6.11E+00	3.58E+02	6.11E+00	6.11E+00
206440	Fluoranthene	1.28E+03		1.28E+03	3.78E+02		3.78E+02	4.47E+02		4.47E+02
86737	Fluorene	1.17E+03		1.17E+03	3.26E+02		3.26E+02	4.19E+02		4.19E+02
118741	Hexachlorobenzene	3.33E+01	1.78E-01	1.78E-01	9.73E+00	1.78E-01	1.78E-01	1.16E+01	1.78E-01	1.78E-01
37871004	HpCDD, 2,3,7,8-	1.28E-02	1.18E-03	1.18E-03	3.11E-03	1.18E-03	1.18E-03	4.56E-03	1.18E-03	1.18E-03
38998753	HpCDF, 2,3,7,8-	4.16E-03	4.01E-04	4.01E-04	1.22E-03	4.01E-04	4.01E-04	1.45E-03	4.01E-04	4.01E-04
34465468	HxCDD, 2,3,7,8-	1.28E-03	1.18E-04	1.18E-04	3.11E-04	1.18E-04	1.18E-04	4.56E-04	1.18E-04	1.18E-04
55684941	HxCDF, 2,3,7,8-	4.16E-04	4.01E-05	4.01E-05	1.22E-04	4.01E-05	4.01E-05	1.45E-04	4.01E-05	4.01E-05
193395	Indeno[1,2,3-cd]pyrene		5.57E-01	5.57E-01		5.57E-01	5.57E-01		5.57E-01	5.57E-01
91203	Naphthalene	4.11E+01	5.27E+00	5.27E+00	6.95E+00	5.27E+00	5.27E+00	1.81E+01	5.27E+00	5.27E+00
88744	Nitroaniline, 2-	7.38E+00		7.38E+00	1.18E+00		1.18E+00	3.35E+00		3.35E+00
621647	Nitroso-di-N-propylamine, N-		6.10E-02	6.10E-02		6.10E-02	6.10E-02		6.10E-02	6.10E-02
3268879	OCDD	4.26E-01	3.92E-02	3.92E-02	1.04E-01	3.92E-02	3.92E-02	1.52E-01	3.92E-02	3.92E-02
39001020	OCDF	1.38E-01	1.34E-02	1.34E-02	4.05E-02	1.34E-02	1.34E-02	4.84E-02	1.34E-02	1.34E-02
36088229	PeCDD, 2,3,7,8-	1.28E-04	1.18E-05	1.18E-05	3.11E-05	1.18E-05	1.18E-05	4.56E-05	1.18E-05	1.18E-05
57117416	PeCDF, 1,2,3,7,8-	1.38E-03	1.34E-04	1.34E-04	4.05E-04	1.34E-04	1.34E-04	4.84E-04	1.34E-04	1.34E-04
57117314	PeCDF, 2,3,4,7,8-	1.38E-04	1.34E-05	1.34E-05	4.05E-05	1.34E-05	1.34E-05	4.84E-05	1.34E-05	1.34E-05
85018	Phenanthrene									
1336363	Polychlorinated Biphenyls (Total) (high risk)		1.83E-01	1.83E-01		1.83E-01	1.83E-01		1.83E-01	1.83E-01
1336363	Polychlorinated Biphenyls (Total) (low risk)		9.21E-01	9.21E-01		9.21E-01	9.21E-01		9.21E-01	9.21E-01
1336363	Polychlorinated Biphenyls (Total) (lowest risk)		5.24E+00	5.24E+00		5.24E+00	5.24E+00		5.24E+00	5.24E+00
50328	Polynuclear Aromatic Hydrocarbons (Total)		5.57E-02	5.57E-02		5.57E-02	5.57E-02		5.57E-02	5.57E-02
129000	Pyrene	9.56E+02		9.56E+02	2.83E+02		2.83E+02	3.35E+02		3.35E+02
1746016	TCDD, 2,3,7,8-	1.28E-04	1.13E-05	1.13E-05	3.10E-05	1.13E-05	1.13E-05	4.55E-05	1.13E-05	1.13E-05
51207319	TCDF, 2,3,7,8-	4.16E-04	4.01E-05	4.01E-05	1.22E-04	4.01E-05	4.01E-05	1.45E-04	4.01E-05	4.01E-05

Hazard-based value calculated using target HI of 0.1.
Cancer-based value calculated using target ELCR of 1E-06.
Action value is the less of the hazard- and cancer- based value.

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

(Values calculated on 01/07/2011 and are based on best available information.)

		Adult Resident			Child Resident		
Parameter	**Chemical**	**Hazard**	**Cancer**	**No Action**	**Hazard**	**Cancer**	**No Action**
50328	Benzo[a]pyrene		1.97E-02	1.97E-02		1.97E-02	1.97E-02
205992	Benzo[b]fluoranthene		1.97E-01	1.97E-01		1.97E-01	1.97E-01
207089	Benzo[k]fluoranthene		1.96E+00	1.96E+00		1.96E+00	1.96E+00
86748	Carbazole		8.72E+00	8.72E+00		8.72E+00	8.72E+00
56235	Carbon Tetrachloride	7.85E+00	2.39E-01	2.39E-01	2.02E+00	2.39E-01	2.39E-01
67663	Chloroform	1.48E+01	1.22E-01	1.22E-01	3.62E+00	1.22E-01	1.22E-01
218019	Chrysene		1.90E+01	1.90E+01		1.90E+01	1.90E+01
53703	Dibenz[a,h]anthracene		1.97E-02	1.97E-02		1.97E-02	1.97E-02
75354	Dichloroethylene, 1,1-	1.95E+01	2.37E-02	2.37E-02	4.33E+00	2.37E-02	2.37E-02
540590	Dichloroethylene, 1,2- (Mixed Isomers)	5.49E+00		5.49E+00	1.24E+00		1.24E+00
156592	Dichloroethylene, 1,2-cis-	4.06E+00		4.06E+00	1.05E+00		1.05E+00
156605	Dichloroethylene, 1,2-trans-	1.08E+01		1.08E+01	2.43E+00		2.43E+00
60571	Dieldrin	5.45E-01	1.06E-02	1.06E-02	1.63E-01	1.06E-02	1.06E-02
1746016	Dioxins/Furans (Total)	2.68E-05	2.63E-06	2.63E-06	5.49E-06	2.63E-06	2.63E-06
100414	Ethylbenzene	2.09E+02	1.58E+00	1.58E+00	5.44E+01	1.58E+00	1.58E+00
206440	Fluoranthene	3.42E+02		3.42E+02	1.09E+02		1.09E+02
86737	Fluorene	3.04E+02		3.04E+02	9.15E+01		9.15E+01
118741	Hexachlorobenzene	8.72E+00	4.92E-02	4.92E-02	2.61E+00	4.92E-02	4.92E-02
37871004	HpCDD, 2,3,7,8-	2.69E-03	2.75E-04	2.75E-04	5.51E-04	2.75E-04	2.75E-04
38998753	HpCDF, 2,3,7,8-	1.09E-03	1.34E-04	1.34E-04	3.26E-04	1.34E-04	1.34E-04
34465468	HxCDD, 2,3,7,8-	2.69E-04	2.75E-05	2.75E-05	5.51E-05	2.75E-05	2.75E-05
55684941	HxCDF, 2,3,7,8-	1.09E-04	1.34E-05	1.34E-05	3.26E-05	1.34E-05	1.34E-05
193395	Indeno[1,2,3-cd]pyrene		1.97E-01	1.97E-01		1.97E-01	1.97E-01
91203	Naphthalene	7.96E+00	1.15E+00	1.15E+00	1.77E+00	1.15E+00	1.15E+00
88744	Nitroaniline, 2-	1.38E+00		1.38E+00	2.96E-01		2.96E-01
621647	Nitroso-di-N-propylamine, N-		1.89E-02	1.89E-02		1.89E-02	1.89E-02
3268879	OCDD	8.97E-02	9.15E-03	9.15E-03	1.83E-02	9.15E-03	9.15E-03
39001020	OCDF	3.63E-02	4.47E-03	4.47E-03	1.09E-02	4.47E-03	4.47E-03
36088229	PeCDD, 2,3,7,8-	2.69E-05	2.75E-06	2.75E-06	5.51E-06	2.75E-06	2.75E-06
57117416	PeCDF, 1,2,3,7,8-	3.63E-04	4.47E-05	4.47E-05	1.09E-04	4.47E-05	4.47E-05
57117314	PeCDF, 2,3,4,7,8-	3.63E-05	4.47E-06	4.47E-06	1.09E-05	4.47E-06	4.47E-06
85018	Phenanthrene						
1336363	Polychlorinated Biphenyls (Total) (high risk)		6.48E-02	6.48E-02		6.48E-02	6.48E-02
1336363	Polychlorinated Biphenyls (Total) (low risk)		3.26E-01	3.26E-01		3.26E-01	3.26E-01
1336363	Polychlorinated Biphenyls (Total) (lowest risk)		1.85E+00	1.85E+00		1.85E+00	1.85E+00
50328	Polynuclear Aromatic Hydrocarbons (Total)		1.97E-02	1.97E-02		1.97E-02	1.97E-02
129000	Pyrene	2.56E+02		2.56E+02	8.12E+01		8.12E+01
1746016	TCDD, 2,3,7,8-	2.68E-05	2.63E-06	2.63E-06	5.49E-06	2.63E-06	2.63E-06
51207319	TCDF, 2,3,7,8-	1.09E-04	1.34E-05	4.15E-05	3.26E-05	1.34E-05	3.26E-05

Hazard-based value calculated using target HI of 0.1.
Cancer-based value calculated using target ELCR of 1E-06.
Action value is the less of the hazard- and cancer- based value.

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

(Values calculated on 01/07/2011 and are based on best available information.)

			Outdoor Worker/Gardener[a]			Industrial Worker		
Parameter	**Chemical**	**Units**	**Hazard**	**Cancer**	**No Action**	**Hazard**	**Cancer**	**No Action**
127184	Tetrachloroethylene	mg/kg	3.58E+01	3.11E-01	3.11E-01	2.98E+01	2.82E-01	2.82E-01
79016	Trichloroethylene	mg/kg	1.95E+00	6.19E-02	6.19E-02	1.81E+00	4.69E-02	4.69E-02
75014	Vinyl Chloride	mg/kg	7.94E+00	2.26E-01	2.26E-01	6.40E+00	2.04E-01	2.04E-01
108383	Xylene, m-	mg/kg	2.68E+02		2.68E+02	2.07E+02		2.07E+02
1330207	Xylene, Mixture	mg/kg	4.69E+01		4.69E+01	3.50E+01		3.50E+01
95476	Xylene, o-	mg/kg	3.06E+02		3.06E+02	2.38E+02		2.38E+02
106423	Xylene, P-	mg/kg	2.73E+02		2.73E+02	2.11E+02		2.11E+02
14596102	Am-241	pCi/g		1.73E+00	1.73E+00		5.01E+00	5.01E+00
10198400	Co-60	pCi/g		2.38E-02	2.38E-02		1.77E-02	1.77E-02
10045973	Cs-137+D	pCi/g		1.15E-01	1.15E-01		8.61E-02	8.61E-02
13994202	Np-237+D	pCi/g		3.28E-01	3.28E-01		2.71E-01	2.71E-01
13981163	Pu-238	pCi/g		1.64E+00	1.64E+00		1.09E+01	1.09E+01
15117483	Pu-239	pCi/g		1.62E+00	1.62E+00		1.07E+01	1.07E+01
14119336	Pu-240	pCi/g		1.61E+00	1.61E+00		1.07E+01	1.07E+01
14133767	Tc-99	pCi/g		5.79E+01	5.79E+01		3.61E+02	3.61E+02
14269637	Th-230	pCi/g		2.20E+00	2.20E+00		1.38E+01	1.38E+01
13966295	U-234	pCi/g		2.83E+00	2.83E+00		1.89E+01	1.89E+01
15117961	U-235+D	pCi/g		4.55E-01	4.55E-01		3.95E-01	3.95E-01
7440611	U-238+D	pCi/g		1.17E+00	1.17E+00		1.70E+00	1.70E+00

Hazard-based value calculated using target HI of 0.1.
Cancer-based value calculated using target ELCR of 1E-06.
Action value is the less of the hazard- and cancer- based value.

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

(Values calculated on 01/07/2011 and are based on best available information.)

			Adult Recreational User			Child Recreational User			Teen Recreational User		
Parameter	**Chemical**	**Units**	**Hazard**	**Cancer**	**No Action**	**Hazard**	**Cancer**	**No Action**	**Hazard**	**Cancer**	**No Action**
127184	Tetrachloroethylene	mg/kg	1.04E+02	3.26E-01	3.26E-01	2.35E+01	3.26E-01	3.26E-01	3.98E+01	3.26E-01	3.26E-01
79016	Trichloroethylene	mg/kg	4.49E+00	9.91E-02	9.91E-02	1.25E+00	9.91E-02	9.91E-02	1.61E+00	9.91E-02	9.91E-02
75014	Vinyl Chloride	mg/kg	2.51E+01	2.39E-01	2.39E-01	5.24E+00	2.39E-01	2.39E-01	9.92E+00	2.39E-01	2.39E-01
108383	Xylene, m-	mg/kg	9.68E+02		9.68E+02	1.79E+02		1.79E+02	4.06E+02		4.06E+02
1330207	Xylene, Mixture	mg/kg	1.93E+02		1.93E+02	3.16E+01		3.16E+01	8.66E+01		8.66E+01
95476	Xylene, o-	mg/kg	1.08E+03		1.08E+03	2.04E+02		2.04E+02	4.50E+02		4.50E+02
106423	Xylene, P-	mg/kg	9.83E+02		9.83E+02	1.82E+02		1.82E+02	4.11E+02		4.11E+02
14596102	Am-241	pCi/g		1.28E+01	1.28E+01		1.28E+01	1.28E+01		1.28E+01	1.28E+01
10198400	Co-60	pCi/g		4.06E-02	4.06E-02		4.06E-02	4.06E-02		4.06E-02	4.06E-02
10045973	Cs-137+D	pCi/g		1.98E-01	1.98E-01		1.98E-01	1.98E-01		1.98E-01	1.98E-01
13994202	Np-237+D	pCi/g		6.26E-01	6.26E-01		6.26E-01	6.26E-01		6.26E-01	6.26E-01
13981163	Pu-238	pCi/g		3.64E+01	3.64E+01		3.64E+01	3.64E+01		3.64E+01	3.64E+01
15117483	Pu-239	pCi/g		3.56E+01	3.56E+01		3.56E+01	3.56E+01		3.56E+01	3.56E+01
14119336	Pu-240	pCi/g		3.58E+01	3.58E+01		3.58E+01	3.58E+01		3.58E+01	3.58E+01
14133767	Tc-99	pCi/g		1.11E+03	1.11E+03		1.11E+03	1.11E+03		1.11E+03	1.11E+03
14269637	Th-230	pCi/g		4.49E+01	4.49E+01		4.49E+01	4.49E+01		4.49E+01	4.49E+01
13966295	U-234	pCi/g		6.25E+01	6.25E+01		6.25E+01	6.25E+01		6.25E+01	6.25E+01
15117961	U-235+D	pCi/g		9.12E-01	9.12E-01		9.12E-01	9.12E-01		9.12E-01	9.12E-01
7440611	U-238+D	pCi/g		4.02E+00	4.02E+00		4.02E+00	4.02E+00		4.02E+00	4.02E+00

Hazard-based value calculated using target HI of 0.1.
Cancer-based value calculated using target ELCR of 1E-06.
Action value is the less of the hazard- and cancer- based value.

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

(Values calculated on 01/07/2011 and are based on best available information.)

			Adult Resident			Child Resident		
Parameter	**Chemical**	**Units**	**Hazard**	**Cancer**	**No Action**	**Hazard**	**Cancer**	**No Action**
127184	Tetrachloroethylene	mg/kg	2.43E+01	1.13E-01	1.13E-01	6.59E+00	1.13E-01	1.13E-01
79016	Trichloroethylene	mg/kg	1.19E+00	2.34E-02	2.34E-02	3.87E-01	2.34E-02	2.34E-02
75014	Vinyl Chloride	mg/kg	5.59E+00	8.24E-02	8.24E-02	1.43E+00	8.24E-02	8.24E-02
108383	Xylene, m-	mg/kg	1.99E+02		1.99E+02	4.67E+01		4.67E+01
1330207	Xylene, Mixture	mg/kg	3.66E+01		3.66E+01	7.96E+00		7.96E+00
95476	Xylene, o-	mg/kg	2.26E+02		2.26E+02	5.35E+01		5.35E+01
106423	Xylene, P-	mg/kg	2.03E+02		2.03E+02	4.75E+01		4.75E+01
14596102	Am-241	pCi/g		1.50E+00	1.50E+00		1.50E+00	1.50E+00
10198400	Co-60	pCi/g		5.47E-03	5.47E-03		5.47E-03	5.47E-03
10045973	Cs-137+D	pCi/g		2.67E-02	2.67E-02		2.67E-02	2.67E-02
13994202	Np-237+D	pCi/g		8.39E-02	8.39E-02		8.39E-02	8.39E-02
13981163	Pu-238	pCi/g		3.21E+00	3.21E+00		3.21E+00	3.21E+00
15117483	Pu-239	pCi/g		3.15E+00	3.15E+00		3.15E+00	3.15E+00
14119336	Pu-240	pCi/g		3.16E+00	3.16E+00		3.16E+00	3.16E+00
14133767	Tc-99	pCi/g		1.01E+02	1.01E+02		1.01E+02	1.01E+02
14269637	Th-230	pCi/g		4.10E+00	4.10E+00		4.10E+00	4.10E+00
13966295	U-234	pCi/g		5.47E+00	5.47E+00		5.47E+00	5.47E+00
15117961	U-235+D	pCi/g		1.22E-01	1.22E-01		1.22E-01	1.22E-01
7440611	U-238+D	pCi/g		5.17E-01	5.17E-01		5.17E-01	5.17E-01

Values in this table were calculated using the best available information in December 2010. 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.

[a] The parameters for the outdoor worker/gardener scenario can be used for a construction/excavation worker, but using an ED of from 1-5 years [based on guidance in the Exposure Factors Handbook (EPA 1993)]

Hazard-based value calculated using target HI of 0.1.
Cancer-based value calculated using target ELCR of 1E-06.
Action value is the less of the hazard- and cancer- based value.

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

(Values calculated on 01/07/2011 and are based on the best available information.)

			Adult Resident			Child Resident		
Parameter	**Chemical**	**Units**	**Hazard**	**Cancer**	**No Action**	**Hazard**	**Cancer**	**No Action**
7429905	Aluminum	mg/L	3.64E+00		3.64E+00	1.04E+00		1.04E+00
7440360	Antimony (metallic)	mg/L	1.44E-03		1.44E-03	4.15E-04		4.15E-04
7440382	Arsenic, Inorganic	mg/L	1.09E-03	3.80E-05	3.80E-05	3.13E-04	3.80E-05	3.80E-05
7440393	Barium	mg/L	7.12E-01		7.12E-01	2.06E-01		2.06E-01
7440417	Beryllium and compounds	mg/L	5.80E-03	1.12E-05	1.12E-05	1.86E-03	1.12E-05	1.12E-05
7440428	Boron And Borates Only	mg/L	7.29E-01		7.29E-01	2.08E-01		2.08E-01
7440439	Cadmium (Water)	mg/L	1.76E-03	1.46E-04	1.46E-04	5.13E-04	1.46E-04	1.46E-04
16065831	Chromium (III) (Insoluble Salts)	mg/L	4.80E+00		4.80E+00	1.47E+00		1.47E+00
7440473	Chromium (Total)	mg/L	4.80E+00		4.80E+00	1.47E+00		1.47E+00
18540299	Chromium VI (chromic acid mists)	mg/L	1.09E-02		1.09E-02	3.12E-03		3.12E-03
18540299	Chromium VI (particulates)	mg/L	9.56E-03	0.000103	1.03E-04	2.93E-03	0.000103	1.03E-04
7440484	Cobalt	mg/L	1.09E-03		1.09E-03	3.13E-04		3.13E-04
7440508	Copper	mg/L	1.46E-01		1.46E-01	4.17E-02		4.17E-02
7439896	Iron	mg/L	2.55E+00		2.55E+00	7.29E-01		7.29E-01
7439921	Lead And Compounds	mg/L			1.50E-02			1.50E-02
7439965	Manganese (Water)	mg/L	8.38E-02		8.38E-02	2.45E-02		2.45E-02
7439976	Mercury, Inorganic Salts	mg/L	1.07E-03		1.07E-03	3.09E-04		3.09E-04
7439987	Molybdenum	mg/L	1.82E-02		1.82E-02	5.21E-03		5.21E-03
7440020	Nickel Soluble Salts	mg/L	7.23E-02		7.23E-02	2.08E-02		2.08E-02
7782492	Selenium	mg/L	1.82E-02		1.82E-02	5.21E-03		5.21E-03
7440224	Silver	mg/L	1.78E-02		1.78E-02	5.15E-03		5.15E-03
7791120	Thallium Chloride	mg/L	2.91E-04		2.91E-04	8.34E-05		8.34E-05
	Uranium (Soluble Salts)	mg/L	1.09E-02		1.09E-02	3.13E-03		3.13E-03
7440622	Vanadium, Metallic	mg/L	2.39E-04		2.39E-04	7.06E-05		7.06E-05
7440666	Zinc (Metallic)	mg/L	1.09E+00		1.09E+00	3.13E-01		3.13E-01
83329	Acenaphthene	mg/L	5.22E-02		5.22E-02	1.38E-02		1.38E-02
208968	Acenaphthylene	mg/L						
107131	Acrylonitrile	mg/L	8.80E-04	4.77E-05	4.77E-05	1.89E-04	4.77E-05	4.77E-05
120127	Anthracene	mg/L	2.22E-01		2.22E-01	6.39E-02		6.39E-02
12674112	Aroclor 1016 (exposure to water)	mg/L	3.87E-05	3.08E-05	3.08E-05	1.99E-05	3.08E-05	1.99E-05
11104282	Aroclor 1221 (exposure to water)	mg/L		6.73E-05	6.73E-05		6.73E-05	6.73E-05
11141165	Aroclor 1232 (exposure to water)	mg/L		6.73E-05	6.73E-05		6.73E-05	6.73E-05
53469219	Aroclor 1242 (exposure to water)	mg/L		1.59E-05	1.59E-05		1.59E-05	1.59E-05
12672296	Aroclor 1248 (exposure to water)	mg/L		1.49E-05	1.49E-05		1.49E-05	1.49E-05
11097691	Aroclor 1254 (exposure to water)	mg/L	3.28E-06	9.80E-06	3.28E-06	1.87E-06	9.80E-06	1.87E-06
11096825	Aroclor 1260 (exposure to water)	mg/L		1.72E-06	1.72E-06		1.72E-06	1.72E-06
56553	Benz[a]anthracene	mg/L		1.22E-05	1.22E-05		1.22E-05	1.22E-05
71432	Benzene	mg/L	6.67E-03	4.27E-04	4.27E-04	1.66E-03	4.27E-04	4.27E-04

Hazard-based value calculated using target HI of 0.1.
Cancer-based value calculated using target ELCR of 1E-06.
Action value is the less of the hazard- and cancer- based value.

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

(Values calculated on 01/07/2011 and are based on best available information.)

			Adult Resident			Child Resident		
Parameter	**Chemical**	**Units**	**Hazard**	**Cancer**	**No Action**	**Hazard**	**Cancer**	**No Action**
50328	Benzo[a]pyrene	mg/L		8.63E-07	8.63E-07		8.63E-07	8.63E-07
205992	Benzo[b]fluoranthene	mg/L		1.35E-05	1.35E-05		1.35E-05	1.35E-05
207089	Benzo[k]fluoranthene	mg/L		8.86E-05	8.86E-05		8.86E-05	8.86E-05
86748	Carbazole	mg/L		2.05E-03	2.05E-03		2.05E-03	2.05E-03
56235	Carbon Tetrachloride	mg/L	9.82E-03	4.19E-04	4.19E-04	2.75E-03	4.19E-04	4.19E-04
67663	Chloroform	mg/L	1.92E-02	2.27E-04	2.27E-04	4.85E-03	2.27E-04	2.27E-04
218019	Chrysene	mg/L		1.15E-03	1.15E-03		1.15E-03	1.15E-03
53703	Dibenz[a,h]anthracene	mg/L		5.73E-07	5.73E-07		5.73E-07	5.73E-07
75354	Dichloroethylene, 1,1-	mg/L	5.81E-02	5.11E-05	5.11E-05	1.38E-02	5.11E-05	5.11E-05
540590	Dichloroethylene, 1,2- (Mixed Isomers)	mg/L	9.56E-03		9.56E-03	2.24E-03		2.24E-03
156592	Dichloroethylene, 1,2-cis-	mg/L	4.72E-03		4.72E-03	1.25E-03		1.25E-03
156605	Dichloroethylene, 1,2-trans-	mg/L	1.91E-02		1.91E-02	4.44E-03		4.44E-03
60571	Dieldrin	mg/L	7.81E-05	1.87E-06	1.87E-06	3.18E-05	1.87E-06	1.87E-06
1746016	Dioxins/Furans (Total)	mg/L	1.57E-10	2.90E-11	2.90E-11	8.98E-11	2.90E-11	2.90E-11
100414	Ethylbenzene	mg/L	1.68E-01	1.51E-03	1.51E-03	4.60E-02	1.51E-03	1.51E-03
206440	Fluoranthene	mg/L	2.93E-02		2.93E-02	1.44E-02		1.44E-02
86737	Fluorene	mg/L	3.25E-02		3.25E-02	8.91E-03		8.91E-03
118741	Hexachlorobenzene	mg/L	4.45E-04	7.74E-06	7.74E-06	2.28E-04	7.74E-06	7.74E-06
37871004	HpCDD, 2,3,7,8-	mg/L	3.77E-09	7.12E-10	7.12E-10	2.23E-09	7.12E-10	7.12E-10
38998753	HpCDF, 2,3,7,8-	mg/L	5.18E-09	9.76E-10	9.76E-10	3.05E-09	9.76E-10	9.76E-10
34465468	HxCDD, 2,3,7,8-	mg/L	2.98E-10	5.63E-11	5.63E-11	1.77E-10	5.63E-11	5.63E-11
55684941	HxCDF, 2,3,7,8-	mg/L	6.92E-10	1.30E-10	1.30E-10	4.06E-10	1.30E-10	1.30E-10
193395	Indeno[1,2,3-cd]pyrene	mg/L		4.52E-06	4.52E-06		4.52E-06	4.52E-06
91203	Naphthalene	mg/L	1.30E-03	0.000176	1.76E-04	2.80E-04	0.000176	1.76E-04
88744	Nitroaniline, 2-	mg/L	3.51E-02		3.51E-02	1.02E-02		1.02E-02
621647	Nitroso-di-N-propylamine, N-	mg/L		8.03E-06	8.03E-06		8.03E-06	8.03E-06
3268879	OCDD	mg/L	2.19E-08	4.17E-09	4.17E-09	1.31E-08	4.17E-09	4.17E-09
39001020	OCDF	mg/L	7.73E-08	1.47E-08	1.47E-08	4.59E-08	1.47E-08	1.47E-08
36088229	PeCDD, 2,3,7,8-	mg/L	3.91E-10	6.90E-11	6.90E-11	2.10E-10	6.90E-11	6.90E-11
57117416	PeCDF, 1,2,3,7,8-	mg/L	5.95E-09	1.09E-09	1.09E-09	3.38E-09	1.09E-09	1.09E-09
57117314	PeCDF, 2,3,4,7,8-	mg/L	4.92E-10	9.10E-11	9.10E-11	2.82E-10	9.1E-11	9.10E-11
85018	Phenanthrene	mg/L						
1336363	Polychlorinated Biphenyls (Total) (high risk)	mg/L		3.18E-06	3.18E-06		3.18E-06	3.18E-06
1336363	Polychlorinated Biphenyls (Total) (low risk)	mg/L		1.59E-05	1.59E-05		1.59E-05	1.59E-05
1336363	Polychlorinated Biphenyls (Total) (lowest risk)	mg/L		9.10E-05	9.10E-05		9.10E-05	9.10E-05
50328	Polynuclear Aromatic Hydrocarbons (Total)	mg/L		8.63E-07	8.63E-07		8.63E-07	8.63E-07
129000	Pyrene	mg/L	1.84E-02		1.84E-02	5.81E-03		5.81E-03
1746016	TCDD, 2,3,7,8-	mg/L	1.57E-10	2.90E-11	2.90E-11	8.98E-11	2.90E-11	2.90E-11
51207319	TCDF, 2,3,7,8-	mg/L	2.10E-09	3.84E-10	3.84E-10	1.18E-09	3.84E-10	3.84E-10

Hazard-based value calculated using target HI of 0.1.
Cancer-based value calculated using target ELCR of 1E-06.
Action value is the less of the hazard- and cancer- based value.

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

(Values calculated on 01/07/2011 and are based on best available information.)

			Adult Resident			Child Resident		
Parameter	**Chemical**	**Units**	**Hazard**	**Cancer**	**No Action**	**Hazard**	**Cancer**	**No Action**
127184	Tetrachloroethylene	mg/L	2.21E-02	7.81E-05	7.81E-05	6.64E-03	7.81E-05	7.81E-05
79016	Trichloroethylene	mg/L	9.44E-04	4.65E-05	4.65E-05	2.77E-04	4.65E-05	4.65E-05
75014	Vinyl Chloride	mg/L	8.47E-03	7.25E-05	7.25E-05	2.31E-03	7.25E-05	7.25E-05
108383	Xylene, m-	mg/L	1.96E-01		1.96E-01	4.83E-02		4.83E-02
1330207	Xylene, Mixture	mg/L	4.09E-02		4.09E-02	9.01E-03		9.01E-03
95476	Xylene, o-	mg/L	1.98E-01		1.98E-01	4.85E-02		4.85E-02
106423	Xylene, P-	mg/L	1.97E-01		1.97E-01	4.84E-02		4.84E-02
14596102	Am-241	pCi/L		9.06E-01	9.06E-01		9.06E-01	9.06E-01
10198400	Co-60	pCi/L		6.00E+00	6.00E+00		6.00E+00	6.00E+00
10045973	Cs-137+D	pCi/L		3.10E+00	3.10E+00		3.10E+00	3.10E+00
13994202	Np-237+D	pCi/L		1.40E+00	1.40E+00		1.40E+00	1.40E+00
13981163	Pu-238	pCi/L		7.19E-01	7.19E-01		7.19E-01	7.19E-01
15117483	Pu-239	pCi/L		6.98E-01	6.98E-01		6.98E-01	6.98E-01
14119336	Pu-240	pCi/L		6.98E-01	6.98E-01		6.98E-01	6.98E-01
14133767	Tc-99	pCi/L		3.43E+01	3.43E+01		3.43E+01	3.43E+01
14269637	Th-230	pCi/L		1.04E+00	1.04E+00		1.04E+00	1.04E+00
13966295	U-234	pCi/L		1.33E+00	1.33E+00		1.33E+00	1.33E+00
15117961	U-235+D	pCi/L		1.31E+00	1.31E+00		1.31E+00	1.31E+00
7440611	U-238+D	pCi/L		1.08E+00	1.08E+00		1.08E+00	1.08E+00

Values in this table were calculated using the best available information in December 2010. 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.

Hazard-based value calculated using target HI of 0.1.
Cancer-based value calculated using target ELCR of 1E-06.
Action value is the less of the hazard- and cancer- based value.

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

(Values calculated on 01/07/2011 and are based on the best available information.)

			Outdoor Worker/Gardener[a]			Industrial Worker		
Parameter	**Chemical**	**Units**	**Hazard**	**Cancer**	**No Action**	**Hazard**	**Cancer**	**No Action**
7429905	Aluminum	mg/L	3.40E+03		3.40E+03	8.36E+02		8.36E+02
7440360	Antimony (metallic)	mg/L	2.04E-01		2.04E-01	5.02E-02		5.02E-02
7440382	Arsenic, Inorganic	mg/L	1.02E+00	6.34E-02	6.34E-02	2.51E-01	1.56E-02	1.56E-02
7440393	Barium	mg/L	4.76E+01		4.76E+01	1.17E+01		1.17E+01
7440417	Beryllium and compounds	mg/L	4.76E-02	1.55E-04	1.55E-04	1.17E-02	3.81E-05	3.81E-05
7440428	Boron And Borates Only	mg/L	6.80E+02		6.80E+02	1.67E+02		1.67E+02
7440439	Cadmium (Water)	mg/L	8.49E-02	1.25E-02	1.25E-02	2.09E-02	3.08E-03	3.08E-03
16065831	Chromium (III) (Insoluble Salts)	mg/L	6.63E+01		6.63E+01	1.63E+01		1.63E+01
7440473	Chromium (Total)	mg/L	6.63E+01		6.63E+01	1.63E+01		1.63E+01
18540299	Chromium VI (chromic acid mists)	mg/L	5.10E+00		5.10E+00	1.25E+00		1.25E+00
18540299	Chromium VI (particulates)	mg/L	1.27E-01	2.38E-03	2.38E-03	3.14E-02	5.85E-04	5.85E-04
7440484	Cobalt	mg/L	2.55E+00		2.55E+00	6.27E-01		6.27E-01
7440508	Copper	mg/L	1.36E+02		1.36E+02	3.35E+01		3.35E+01
7439896	Iron	mg/L	2.38E+03		2.38E+03	5.85E+02		5.85E+02
7439921	Lead And Compounds	mg/L			1.50E-02			1.50E-02
7439965	Manganese (Water)	mg/L	3.26E+00		3.26E+00	8.03E-01		8.03E-01
7439976	Mercury, Inorganic Salts	mg/L	7.13E-02		7.13E-02	1.76E-02		1.76E-02
7439987	Molybdenum	mg/L	1.70E+01		1.70E+01	4.18E+00		4.18E+00
7440020	Nickel Soluble Salts	mg/L	1.36E+01		1.36E+01	3.35E+00		3.35E+00
7782492	Selenium	mg/L	1.70E+01		1.70E+01	4.18E+00		4.18E+00
7440224	Silver	mg/L	1.13E+00		1.13E+00	2.79E-01		2.79E-01
7791120	Thallium Chloride	mg/L	2.72E-01		2.72E-01	6.69E-02		6.69E-02
	Uranium (Soluble Salts)	mg/L	1.02E+01		1.02E+01	2.51E+00		2.51E+00
7440622	Vanadium, Metallic	mg/L	6.18E-03		6.18E-03	1.52E-03		1.52E-03
7440666	Zinc (Metallic)	mg/L	1.70E+03		1.70E+03	4.18E+02		4.18E+02
83329	Acenaphthene	mg/L	4.92E+00		4.92E+00	3.93E-01		3.93E-01
208968	Acenaphthylene	mg/L						
107131	Acrylonitrile	mg/L	3.09E+02	4.01E-01	4.01E-01	2.47E+01	3.20E-02	3.20E-02
120127	Anthracene	mg/L	1.30E+01		1.30E+01	1.04E+00		1.04E+00
12674112	Aroclor 1016 (exposure to water)	mg/L	8.54E-04	8.54E-04	8.54E-04	6.84E-05	6.84E-05	6.84E-05
11104282	Aroclor 1221 (exposure to water)	mg/L		2.87E-03	2.87E-03		2.30E-04	2.30E-04
11141165	Aroclor 1232 (exposure to water)	mg/L		2.87E-03	2.87E-03		2.30E-04	2.30E-04
53469219	Aroclor 1242 (exposure to water)	mg/L		3.85E-04	3.85E-04		3.08E-05	3.08E-05
12672296	Aroclor 1248 (exposure to water)	mg/L		3.57E-04	3.57E-04		2.86E-05	2.86E-05
11097691	Aroclor 1254 (exposure to water)	mg/L	6.43E-05	2.25E-04	6.43E-05	5.15E-06	1.80E-05	5.15E-06
11096825	Aroclor 1260 (exposure to water)	mg/L		3.70E-05	3.70E-05		2.96E-06	2.96E-06
56553	Benz[a]anthracene	mg/L		3.13E-04	3.13E-04		2.51E-05	2.51E-05
71432	Benzene	mg/L	2.40E+00	3.05E-01	3.05E-01	1.92E-01	2.44E-02	2.44E-02

Hazard-based value calculated using target HI of 0.1.
Cancer-based value calculated using target ELCR of 1E-06.
Action value is the less of the hazard- and cancer- based value.

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

(Values calculated on 01/07/2011 and are based on best available information.)

		Adult Recreational (Swimming)			Adult Recreational (Wading)		
Parameter	Chemical	Hazard	Cancer	No Action	Hazard	Cancer	No Action
7429905	Aluminum	3.20E+02		3.20E+02	1.78E+03		1.78E+03
7440360	Antimony (metallic)	5.11E-02		5.11E-02	1.07E-01		1.07E-01
7440382	Arsenic, Inorganic	9.61E-02	3.02E-03	3.02E-03	5.35E-01	1.41E-02	1.41E-02
7440393	Barium	1.41E+01		1.41E+01	2.50E+01		2.50E+01
7440417	Beryllium and compounds	1.65E-02	3.74E-05	3.74E-05	2.50E-02	3.45E-05	3.45E-05
7440428	Boron And Borates Only	6.41E+01		6.41E+01	3.57E+02		3.57E+02
7440439	Cadmium (Water)	2.64E-02	2.52E-03	2.52E-03	4.46E-02	2.79E-03	2.79E-03
16065831	Chromium (III) (Insoluble Salts)	2.27E+01		2.27E+01	3.48E+01		3.48E+01
7440473	Chromium (Total)	2.27E+01		2.27E+01	3.48E+01		3.48E+01
18540299	Chromium VI (chromic acid mists)	7.59E-01		7.59E-01	2.67E+00		2.67E+00
18540299	Chromium VI (particulates)	4.36E-02	5.60E-04	5.60E-04	6.69E-02	5.30E-04	5.30E-04
7440484	Cobalt	1.14E-01		1.14E-01	1.34E+00		1.34E+00
7440508	Copper	1.28E+01		1.28E+01	7.13E+01		7.13E+01
7439896	Iron	2.24E+02		2.24E+02	1.25E+03		1.25E+03
7439921	Lead And Compounds			1.50E-02			1.50E-02
7439965	Manganese (Water)	1.04E+00		1.04E+00	1.71E+00		1.71E+00
7439976	Mercury, Inorganic Salts	2.12E-02		2.12E-02	3.74E-02		3.74E-02
7439987	Molybdenum	1.60E+00		1.60E+00	8.91E+00		8.91E+00
7440020	Nickel Soluble Salts	3.10E+00		3.10E+00	7.13E+00		7.13E+00
7782492	Selenium	1.60E+00		1.60E+00	8.91E+00		8.91E+00
7440224	Silver	3.39E-01		3.39E-01	5.94E-01		5.94E-01
7791120	Thallium Chloride	2.56E-02		2.56E-02	1.43E-01		1.43E-01
	Uranium (Soluble Salts)	9.61E-01		9.61E-01	5.35E+00		5.35E+00
7440622	Vanadium, Metallic	2.04E-03		2.04E-03	3.24E-03		3.24E-03
7440666	Zinc (Metallic)	1.08E+02		1.08E+02	8.91E+02		8.91E+02
83329	Acenaphthene	5.54E-01		5.54E-01	8.39E-01		8.39E-01
208968	Acenaphthylene						
107131	Acrylonitrile	1.17E+01	7.80E-03	7.80E-03	5.27E+01	2.90E-02	2.90E-02
120127	Anthracene	1.48E+00		1.48E+00	2.22E+00		2.22E+00
12674112	Aroclor 1016 (exposure to water)	9.80E-05	6.90E-05	6.90E-05	1.46E-04	6.19E-05	6.19E-05
11104282	Aroclor 1221 (exposure to water)		2.29E-04	2.29E-04		2.08E-04	2.08E-04
11141165	Aroclor 1232 (exposure to water)		2.29E-04	2.29E-04		2.08E-04	2.08E-04
53469219	Aroclor 1242 (exposure to water)		3.12E-05	3.12E-05		2.79E-05	2.79E-05
12672296	Aroclor 1248 (exposure to water)		2.89E-05	2.89E-05		2.59E-05	2.59E-05
11097691	Aroclor 1254 (exposure to water)	7.40E-06	1.82E-05	7.40E-06	1.10E-05	1.63E-05	1.10E-05
11096825	Aroclor 1260 (exposure to water)		3.01E-06	3.01E-06		2.68E-06	2.68E-06
56553	Benz[a]anthracene		2.53E-05	2.53E-05		2.27E-05	2.27E-05
71432	Benzene	2.38E-01	1.94E-02	1.94E-02	4.09E-01	2.21E-02	2.21E-02

Hazard-based value calculated using target HI of 0.1.
Cancer-based value calculated using target ELCR of 1E-06.
Action value is the less of the hazard- and cancer- based value.

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

(Values calculated on 01/07/2011 and are based on best available information.)

		Child Recreational (Swimming)			Child Recreational (Wading)		
Parameter	**Chemical**	**Hazard**	**Cancer**	**No Action**	**Hazard**	**Cancer**	**No Action**
7429905	Aluminum	8.28E+01		8.28E+01	4.56E+02		4.56E+02
7440360	Antimony (metallic)	2.01E-02		2.01E-02	2.73E-02		2.73E-02
7440382	Arsenic, Inorganic	2.48E-02	3.02E-03	3.02E-03	1.37E-01	1.41E-02	1.41E-02
7440393	Barium	6.55E+00		6.55E+00	6.38E+00		6.38E+00
7440417	Beryllium and compounds	9.56E-03	3.74E-05	3.74E-05	6.38E-03	3.45E-05	3.45E-05
7440428	Boron And Borates Only	1.66E+01		1.66E+01	9.12E+01		9.12E+01
7440439	Cadmium (Water)	1.30E-02	2.52E-03	2.52E-03	1.14E-02	2.79E-03	2.79E-03
16065831	Chromium (III) (Insoluble Salts)	1.28E+01		1.28E+01	8.89E+00		8.89E+00
7440473	Chromium (Total)	1.28E+01		1.28E+01	8.89E+00		8.89E+00
18540299	Chromium VI (chromic acid mists)	2.23E-01		2.23E-01	6.84E-01		6.84E-01
18540299	Chromium VI (particulates)	2.46E-02	5.60E-04	5.60E-04	1.71E-02	5.30E-04	5.30E-04
7440484	Cobalt	2.67E-02		2.67E-02	3.42E-01		3.42E-01
7440508	Copper	3.31E+00		3.31E+00	1.82E+01		1.82E+01
7439896	Iron	5.80E+01		5.80E+01	3.19E+02		3.19E+02
7439921	Lead And Compounds			1.50E-02			1.50E-02
7439965	Manganese (Water)	5.29E-01		5.29E-01	4.38E-01		4.38E-01
7439976	Mercury, Inorganic Salts	9.83E-03		9.83E-03	9.57E-03		9.57E-03
7439987	Molybdenum	4.14E-01		4.14E-01	2.28E+00		2.28E+00
7440020	Nickel Soluble Salts	1.13E+00		1.13E+00	1.82E+00		1.82E+00
7782492	Selenium	4.14E-01		4.14E-01	2.28E+00		2.28E+00
7440224	Silver	1.59E-01		1.59E-01	1.52E-01		1.52E-01
7791120	Thallium Chloride	6.63E-03		6.63E-03	3.65E-02		3.65E-02
	Uranium (Soluble Salts)	2.48E-01		2.48E-01	1.37E+00		1.37E+00
7440622	Vanadium, Metallic	1.09E-03		1.09E-03	8.30E-04		8.30E-04
7440666	Zinc (Metallic)	2.60E+01		2.60E+01	2.28E+02		2.28E+02
83329	Acenaphthene	3.19E-01		3.19E-01	2.14E-01		2.14E-01
208968	Acenaphthylene						
107131	Acrylonitrile	3.18E+00	7.80E-03	7.80E-03	1.35E+01	2.90E-02	2.90E-02
120127	Anthracene	8.67E-01		8.67E-01	5.67E-01		5.67E-01
12674112	Aroclor 1016 (exposure to water)	5.83E-05	6.90E-05	5.83E-05	3.73E-05	6.19E-05	3.73E-05
11104282	Aroclor 1221 (exposure to water)		2.29E-04	2.29E-04		2.08E-04	2.08E-04
11141165	Aroclor 1232 (exposure to water)		2.29E-04	2.29E-04		2.08E-04	2.08E-04
53469219	Aroclor 1242 (exposure to water)		3.12E-05	3.12E-05		2.79E-05	2.79E-05
12672296	Aroclor 1248 (exposure to water)		2.89E-05	2.89E-05		2.59E-05	2.59E-05
11097691	Aroclor 1254 (exposure to water)	4.42E-06	1.82E-05	4.42E-06	2.80E-06	1.63E-05	2.80E-06
11096825	Aroclor 1260 (exposure to water)		3.01E-06	3.01E-06		2.68E-06	2.68E-06
56553	Benz[a]anthracene		2.53E-05	2.53E-05		2.27E-05	2.27E-05
71432	Benzene	1.15E-01	1.94E-02	1.94E-02	1.04E-01	2.21E-02	2.21E-02

Hazard-based value calculated using target HI of 0.1.
Cancer-based value calculated using target ELCR of 1E-06.
Action value is the less of the hazard- and cancer- based value.

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

(Values calculated on 01/07/2011 and are based on best available information.)

		Teen Recreational (Swimming)			Teen Recreational (Wading)		
Parameter	**Chemical**	**Hazard**	**Cancer**	**No Action**	**Hazard**	**Cancer**	**No Action**
7429905	Aluminum	2.13E+02		2.13E+02	5.75E+02		5.75E+02
7440360	Antimony (metallic)	3.91E-02		3.91E-02	3.45E-02		3.45E-02
7440382	Arsenic, Inorganic	6.38E-02	3.02E-03	3.02E-03	1.72E-01	1.41E-02	1.41E-02
7440393	Barium	1.13E+01		1.13E+01	8.05E+00		8.05E+00
7440417	Beryllium and compounds	1.40E-02	3.74E-05	3.74E-05	8.05E-03	3.45E-05	3.45E-05
7440428	Boron And Borates Only	4.25E+01		4.25E+01	1.15E+02		1.15E+02
7440439	Cadmium (Water)	2.15E-02	2.52E-03	2.52E-03	1.44E-02	2.79E-03	2.79E-03
16065831	Chromium (III) (Insoluble Salts)	1.90E+01		1.90E+01	1.12E+01		1.12E+01
7440473	Chromium (Total)	1.90E+01		1.90E+01	1.12E+01		1.12E+01
18540299	Chromium VI (chromic acid mists)	5.28E-01		5.28E-01	8.62E-01		8.62E-01
18540299	Chromium VI (particulates)	3.67E-02	5.60E-04	5.60E-04	2.16E-02	5.30E-04	5.30E-04
7440484	Cobalt	7.29E-02		7.29E-02	4.31E-01		4.31E-01
7440508	Copper	8.50E+00		8.50E+00	2.30E+01		2.30E+01
7439896	Iron	1.49E+02		1.49E+02	4.02E+02		4.02E+02
7439921	Lead And Compounds			1.50E-02			1.50E-02
7439965	Manganese (Water)	8.53E-01		8.53E-01	5.52E-01		5.52E-01
7439976	Mercury, Inorganic Salts	1.70E-02		1.70E-02	1.21E-02		1.21E-02
7439987	Molybdenum	1.06E+00		1.06E+00	2.87E+00		2.87E+00
7440020	Nickel Soluble Salts	2.32E+00		2.32E+00	2.30E+00		2.30E+00
7782492	Selenium	1.06E+00		1.06E+00	2.87E+00		2.87E+00
7440224	Silver	2.72E-01		2.72E-01	1.92E-01		1.92E-01
7791120	Thallium Chloride	1.70E-02		1.70E-02	4.60E-02		4.60E-02
	Uranium (Soluble Salts)	6.38E-01		6.38E-01	1.72E+00		1.72E+00
7440622	Vanadium, Metallic	1.70E-03		1.70E-03	1.05E-03		1.05E-03
7440666	Zinc (Metallic)	6.96E+01		6.96E+01	2.87E+02		2.87E+02
83329	Acenaphthene	4.68E-01		4.68E-01	2.70E-01		2.70E-01
208968	Acenaphthylene						
107131	Acrylonitrile	7.92E+00	7.80E-03	7.80E-03	1.70E+01	2.90E-02	2.90E-02
120127	Anthracene	1.25E+00		1.25E+00	7.15E-01		7.15E-01
12674112	Aroclor 1016 (exposure to water)	8.33E-05	6.90E-05	6.90E-05	4.70E-05	6.19E-05	4.70E-05
11104282	Aroclor 1221 (exposure to water)		2.29E-04	2.29E-04		2.08E-04	2.08E-04
11141165	Aroclor 1232 (exposure to water)		2.29E-04	2.29E-04		2.08E-04	2.08E-04
53469219	Aroclor 1242 (exposure to water)		3.12E-05	3.12E-05		2.79E-05	2.79E-05
12672296	Aroclor 1248 (exposure to water)		2.89E-05	2.89E-05		2.59E-05	2.59E-05
11097691	Aroclor 1254 (exposure to water)	6.29E-06	1.82E-05	6.29E-06	3.54E-06	1.63E-05	3.54E-06
11096825	Aroclor 1260 (exposure to water)		3.01E-06	3.01E-06		2.68E-06	2.68E-06
56553	Benz[a]anthracene		2.53E-05	2.53E-05		2.27E-05	2.27E-05
71432	Benzene	1.93E-01	1.94E-02	1.94E-02	1.32E-01	2.21E-02	2.21E-02

Hazard-based value calculated using target HI of 0.1.
Cancer-based value calculated using target ELCR of 1E-06.
Action value is the less of the hazard- and cancer- based value.

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

(Values calculated on 01/07/2011 and are based on best available information.)

			Outdoor Worker/Gardener[a]			Industrial Worker		
Parameter	**Chemical**	**Units**	**Hazard**	**Cancer**	**No Action**	**Hazard**	**Cancer**	**No Action**
50328	Benzo[a]pyrene	mg/L		2.09E-05	2.09E-05		1.67E-06	1.67E-06
205992	Benzo[b]fluoranthene	mg/L		3.55E-04	3.55E-04		2.84E-05	2.84E-05
207089	Benzo[k]fluoranthene	mg/L		2.15E-03	2.15E-03		1.72E-04	1.72E-04
86748	Carbazole	mg/L		1.68E-01	1.68E-01		1.34E-02	1.34E-02
56235	Carbon Tetrachloride	mg/L	1.67E+00	1.67E-01	1.67E-01	1.33E-01	1.33E-02	1.33E-02
67663	Chloroform	mg/L	1.13E+01	1.02E+00	1.02E+00	9.06E-01	8.19E-02	8.19E-02
218019	Chrysene	mg/L		2.90E-02	2.90E-02		2.32E-03	2.32E-03
53703	Dibenz[a,h]anthracene	mg/L		1.32E-05	1.32E-05		1.06E-06	1.06E-06
75354	Dichloroethylene, 1,1-	mg/L	3.61E+01	3.37E-02	3.37E-02	2.89E+00	2.70E-03	2.70E-03
540590	Dichloroethylene, 1,2- (Mixed Isomers)	mg/L	6.90E+00		6.90E+00	5.52E-01		5.52E-01
156592	Dichloroethylene, 1,2-cis-	mg/L	1.53E+00		1.53E+00	1.23E-01		1.23E-01
156605	Dichloroethylene, 1,2-trans-	mg/L	1.53E+01		1.53E+01	1.23E+00		1.23E+00
60571	Dieldrin	mg/L	2.56E-03	8.96E-05	8.96E-05	2.05E-04	7.17E-06	7.17E-06
1746016	Dioxins/Furans (Total)	mg/L	3.08E-09	6.63E-10	6.63E-10	2.46E-10	5.30E-11	5.30E-11
100414	Ethylbenzene	mg/L	1.78E+01	4.53E-01	4.53E-01	1.42E+00	3.62E-02	3.62E-02
206440	Fluoranthene	mg/L	6.88E-01		6.88E-01	5.50E-02		5.50E-02
86737	Fluorene	mg/L	2.36E+00		2.36E+00	1.89E-01		1.89E-01
118741	Hexachlorobenzene	mg/L	9.85E-03	2.15E-04	2.15E-04	7.88E-04	1.72E-05	1.72E-05
37871004	HpCDD, 2,3,7,8-	mg/L	7.14E-08	1.54E-08	1.54E-08	5.71E-09	1.23E-09	1.23E-09
38998753	HpCDF, 2,3,7,8-	mg/L	9.85E-08	2.12E-08	2.12E-08	7.88E-09	1.70E-09	1.70E-09
34465468	HxCDD, 2,3,7,8-	mg/L	5.63E-09	1.21E-09	1.21E-09	4.50E-10	9.70E-11	9.70E-11
55684941	HxCDF, 2,3,7,8-	mg/L	1.32E-08	2.85E-09	2.85E-09	1.06E-09	2.28E-10	2.28E-10
193395	Indeno[1,2,3-cd]pyrene	mg/L		1.02E-04	1.02E-04		8.19E-06	8.19E-06
91203	Naphthalene	mg/L	3.42E+00		3.42E+00	2.74E-01		2.74E-01
88744	Nitroaniline, 2-	mg/L	1.60E+01		1.60E+01	1.28E+00		1.28E+00
621647	Nitroso-di-N-propylamine, N-	mg/L		1.25E-02	1.25E-02		1.00E-03	1.00E-03
3268879	OCDD	mg/L	4.12E-07	8.87E-08	8.87E-08	3.29E-08	7.10E-09	7.10E-09
39001020	OCDF	mg/L	1.46E-06	3.14E-07	3.14E-07	1.17E-07	2.51E-08	2.51E-08
36088229	PeCDD, 2,3,7,8-	mg/L	8.22E-09	1.77E-09	1.77E-09	6.57E-10	1.42E-10	1.42E-10
57117416	PeCDF, 1,2,3,7,8-	mg/L	1.17E-07	2.53E-08	2.53E-08	9.37E-09	2.02E-09	2.02E-09
57117314	PeCDF, 2,3,4,7,8-	mg/L	9.62E-09	2.07E-09	2.07E-09	7.69E-10	1.66E-10	1.66E-10
85018	Phenanthrene	mg/L						
1336363	Polychlorinated Biphenyls (Total) (high risk)	mg/L		7.71E-05	7.71E-05		6.17E-06	6.17E-06
1336363	Polychlorinated Biphenyls (Total) (low risk)	mg/L		3.85E-04	3.85E-04		3.08E-05	3.08E-05
1336363	Polychlorinated Biphenyls (Total) (lowest risk)	mg/L		2.20E-03	2.20E-03		1.76E-04	1.76E-04
50328	Polynuclear Aromatic Hydrocarbons (Total)	mg/L		2.09E-05	2.09E-05		1.67E-06	1.67E-06
129000	Pyrene	mg/L	7.89E-01		7.89E-01	6.32E-02		6.32E-02
1746016	TCDD, 2,3,7,8-	mg/L	3.08E-09	6.63E-10	6.63E-10	2.46E-10	5.30E-11	5.30E-11
51207319	TCDF, 2,3,7,8-	mg/L	4.18E-08	9.01E-09	9.01E-09	3.35E-09	7.21E-10	7.21E-10

Hazard-based value calculated using target HI of 0.1.
Cancer-based value calculated using target ELCR of 1E-06.
Action value is the less of the hazard- and cancer- based value.

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

(Values calculated on 01/07/2011 and are based on best available information.)

		Adult Recreational (Swimming)			Adult Recreational (Wading)		
Parameter	**Chemical**	**Hazard**	**Cancer**	**No Action**	**Hazard**	**Cancer**	**No Action**
50328	Benzo[a]pyrene		1.69E-06	1.69E-06		1.51E-06	1.51E-06
205992	Benzo[b]fluoranthene		2.87E-05	2.87E-05		2.57E-05	2.57E-05
207089	Benzo[k]fluoranthene		1.74E-04	1.74E-04		1.56E-04	1.56E-04
86748	Carbazole		1.29E-02	1.29E-02		1.22E-02	1.22E-02
56235	Carbon Tetrachloride	1.73E-01	1.13E-02	1.13E-02	2.84E-01	1.21E-02	1.21E-02
67663	Chloroform	1.00E+00	5.52E-02	5.52E-02	1.93E+00	7.41E-02	7.41E-02
218019	Chrysene		2.35E-03	2.35E-03		2.10E-03	2.10E-03
53703	Dibenz[a,h]anthracene		1.07E-06	1.07E-06		9.58E-07	9.58E-07
75354	Dichloroethylene, 1,1-	3.49E+00	2.06E-03	2.06E-03	6.16E+00	2.44E-03	2.44E-03
540590	Dichloroethylene, 1,2- (Mixed Isomers)	6.60E-01		6.60E-01	1.18E+00		1.18E+00
156592	Dichloroethylene, 1,2-cis-	1.47E-01		1.47E-01	2.61E-01		2.61E-01
156605	Dichloroethylene, 1,2-trans-	1.47E+00		1.47E+00	2.61E+00		2.61E+00
60571	Dieldrin	2.91E-04	7.10E-06	7.10E-06	4.37E-04	6.49E-06	6.49E-06
1746016	Dioxins/Furans (Total)	3.54E-10	5.37E-11	5.37E-11	5.25E-10	4.80E-11	4.80E-11
100414	Ethylbenzene	1.95E+00	3.39E-02	3.39E-02	3.03E+00	3.28E-02	3.28E-02
206440	Fluoranthene	7.88E-02		7.88E-02	1.17E-01		1.17E-01
86737	Fluorene	2.67E-01		2.67E-01	4.02E-01		4.02E-01
118741	Hexachlorobenzene	1.13E-03	1.74E-05	1.74E-05	1.68E-03	1.56E-05	1.56E-05
37871004	HpCDD, 2,3,7,8-	8.21E-09	1.25E-09	1.25E-09	1.22E-08	1.11E-09	1.11E-09
38998753	HpCDF, 2,3,7,8-	1.13E-08	1.72E-09	1.72E-09	1.68E-08	1.54E-09	1.54E-09
34465468	HxCDD, 2,3,7,8-	6.48E-10	9.84E-11	9.84E-11	9.60E-10	8.78E-11	8.78E-11
55684941	HxCDF, 2,3,7,8-	1.52E-09	2.31E-10	2.31E-10	2.26E-09	2.06E-10	2.06E-10
193395	Indeno[1,2,3-cd]pyrene		8.30E-06	8.30E-06		7.41E-06	7.41E-06
91203	Naphthalene	3.77E-01		3.77E-01	5.83E-01		5.83E-01
88744	Nitroaniline, 2-	1.30E+00		1.30E+00	2.73E+00		2.73E+00
621647	Nitroso-di-N-propylamine, N-		4.36E-04	4.36E-04		9.08E-04	9.08E-04
3268879	OCDD	4.74E-08	7.20E-09	7.20E-09	7.02E-08	6.42E-09	6.42E-09
39001020	OCDF	1.68E-07	2.55E-08	2.55E-08	2.49E-07	2.27E-08	2.27E-08
36088229	PeCDD, 2,3,7,8-	9.43E-10	1.43E-10	1.43E-10	1.40E-09	1.28E-10	1.28E-10
57117416	PeCDF, 1,2,3,7,8-	1.35E-08	2.05E-09	2.05E-09	2.00E-08	1.83E-09	1.83E-09
57117314	PeCDF, 2,3,4,7,8-	1.11E-09	1.68E-10	1.68E-10	1.64E-09	1.50E-10	1.50E-10
85018	Phenanthrene						
1336363	Polychlorinated Biphenyls (Total) (high risk)		6.24E-06	6.24E-06		5.58E-06	5.58E-06
1336363	Polychlorinated Biphenyls (Total) (low risk)		3.12E-05	3.12E-05		2.79E-05	2.79E-05
1336363	Polychlorinated Biphenyls (Total) (lowest risk)		1.78E-04	1.78E-04		1.59E-04	1.59E-04
50328	Polynuclear Aromatic Hydrocarbons (Total)		1.69E-06	1.69E-06		1.51E-06	1.51E-06
129000	Pyrene	9.02E-02		9.02E-02	1.35E-01		1.35E-01
1746016	TCDD, 2,3,7,8-	3.54E-10	5.37E-11	5.37E-11	5.25E-10	4.80E-11	4.80E-11
51207319	TCDF, 2,3,7,8-	4.81E-09	7.30E-10	7.30E-10	7.14E-09	6.52E-10	6.52E-10

Hazard-based value calculated using target HI of 0.1.
Cancer-based value calculated using target ELCR of 1E-06.
Action value is the less of the hazard- and cancer- based value.

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

(Values calculated on 01/07/2011 and are based on best available information.)

		Child Recreational (Swimming)			Child Recreational (Wading)		
Parameter	Chemical	Hazard	Cancer	No Action	Hazard	Cancer	No Action
50328	Benzo[a]pyrene		1.69E-06	1.69E-06		1.51E-06	1.51E-06
205992	Benzo[b]fluoranthene		2.87E-05	2.87E-05		2.57E-05	2.57E-05
207089	Benzo[k]fluoranthene		1.74E-04	1.74E-04		1.56E-04	1.56E-04
86748	Carbazole		1.29E-02	1.29E-02		1.22E-02	1.22E-02
56235	Carbon Tetrachloride	8.78E-02	1.13E-02	1.13E-02	7.26E-02	1.21E-02	1.21E-02
67663	Chloroform	4.26E-01	5.52E-02	5.52E-02	4.94E-01	7.41E-02	7.41E-02
218019	Chrysene		2.35E-03	2.35E-03		2.10E-03	2.10E-03
53703	Dibenz[a,h]anthracene		1.07E-06	1.07E-06		9.58E-07	9.58E-07
75354	Dichloroethylene, 1,1-	1.62E+00	2.06E-03	2.06E-03	1.57E+00	2.44E-03	2.44E-03
540590	Dichloroethylene, 1,2- (Mixed Isomers)	3.04E-01		3.04E-01	3.01E-01		3.01E-01
156592	Dichloroethylene, 1,2-cis-	6.75E-02		6.75E-02	6.68E-02		6.68E-02
156605	Dichloroethylene, 1,2-trans-	6.75E-01		6.75E-01	6.68E-01		6.68E-01
60571	Dieldrin	1.70E-04	7.10E-06	7.10E-06	1.12E-04	6.49E-06	6.49E-06
1746016	Dioxins/Furans (Total)	2.11E-10	5.37E-11	5.37E-11	1.34E-10	4.80E-11	4.80E-11
100414	Ethylbenzene	1.08E+00	3.39E-02	3.39E-02	7.75E-01	3.28E-02	3.28E-02
206440	Fluoranthene	4.68E-02		4.68E-02	3.00E-02		3.00E-02
86737	Fluorene	1.56E-01		1.56E-01	1.03E-01		1.03E-01
118741	Hexachlorobenzene	6.72E-04	1.74E-05	1.74E-05	4.29E-04	1.56E-05	1.56E-05
37871004	HpCDD, 2,3,7,8-	4.91E-09	1.25E-09	1.25E-09	3.11E-09	1.11E-09	1.11E-09
38998753	HpCDF, 2,3,7,8-	6.78E-09	1.72E-09	1.72E-09	4.30E-09	1.54E-09	1.54E-09
34465468	HxCDD, 2,3,7,8-	3.88E-10	9.84E-11	9.84E-11	2.45E-10	8.78E-11	8.78E-11
55684941	HxCDF, 2,3,7,8-	9.10E-10	2.31E-10	2.31E-10	5.77E-10	2.06E-10	2.06E-10
193395	Indeno[1,2,3-cd]pyrene		8.30E-06	8.30E-06		7.41E-06	7.41E-06
91203	Naphthalene	2.09E-01		2.09E-01	1.49E-01		1.49E-01
88744	Nitroaniline, 2-	5.06E-01		5.06E-01	6.98E-01		6.98E-01
621647	Nitroso-di-N-propylamine, N-		4.36E-04	4.36E-04		9.08E-04	9.08E-04
3268879	OCDD	2.83E-08	7.20E-09	7.20E-09	1.79E-08	6.42E-09	6.42E-09
39001020	OCDF	1.00E-07	2.55E-08	2.55E-08	6.35E-08	2.27E-08	2.27E-08
36088229	PeCDD, 2,3,7,8-	5.62E-10	1.43E-10	1.43E-10	3.58E-10	1.28E-10	1.28E-10
57117416	PeCDF, 1,2,3,7,8-	8.05E-09	2.05E-09	2.05E-09	5.11E-09	1.83E-09	1.83E-09
57117314	PeCDF, 2,3,4,7,8-	6.61E-10	1.68E-10	1.68E-10	4.19E-10	1.50E-10	1.50E-10
85018	Phenanthrene						
1336363	Polychlorinated Biphenyls (Total) (high risk)		6.24E-06	6.24E-06		5.58E-06	5.58E-06
1336363	Polychlorinated Biphenyls (Total) (low risk)		3.12E-05	3.12E-05		2.79E-05	2.79E-05
1336363	Polychlorinated Biphenyls (Total) (lowest risk)		1.78E-04	1.78E-04		1.59E-04	1.59E-04
50328	Polynuclear Aromatic Hydrocarbons (Total)		1.69E-06	1.69E-06		1.51E-06	1.51E-06
129000	Pyrene	5.33E-02		5.33E-02	3.44E-02		3.44E-02
1746016	TCDD, 2,3,7,8-	2.11E-10	5.37E-11	5.37E-11	1.34E-10	4.80E-11	4.80E-11
51207319	TCDF, 2,3,7,8-	2.87E-09	7.30E-10	7.30E-10	1.82E-09	6.52E-10	6.52E-10

Hazard-based value calculated using target HI of 0.1.
Cancer-based value calculated using target ELCR of 1E-06.
Action value is the less of the hazard- and cancer- based value.

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

(Values calculated on 01/07/2011 and are based on best available information.)

		Teen Recreational (Swimming)			Teen Recreational (Wading)		
Parameter	Chemical	Hazard	Cancer	No Action	Hazard	Cancer	No Action
50328	Benzo[a]pyrene		1.69E-06	1.69E-06		1.51E-06	1.51E-06
205992	Benzo[b]fluoranthene		2.87E-05	2.87E-05		2.57E-05	2.57E-05
207089	Benzo[k]fluoranthene		1.74E-04	1.74E-04		1.56E-04	1.56E-04
86748	Carbazole		1.29E-02	1.29E-02		1.22E-02	1.22E-02
56235	Carbon Tetrachloride	1.42E-01	1.13E-02	1.13E-02	9.16E-02	1.21E-02	1.21E-02
67663	Chloroform	7.85E-01	5.52E-02	5.52E-02	6.23E-01	7.41E-02	7.41E-02
218019	Chrysene		2.35E-03	2.35E-03		2.10E-03	2.10E-03
53703	Dibenz[a,h]anthracene		1.07E-06	1.07E-06		9.58E-07	9.58E-07
75354	Dichloroethylene, 1,1-	2.80E+00	2.06E-03	2.06E-03	1.99E+00	2.44E-03	2.44E-03
540590	Dichloroethylene, 1,2- (Mixed Isomers)	5.28E-01		5.28E-01	3.79E-01		3.79E-01
156592	Dichloroethylene, 1,2-cis-	1.17E-01		1.17E-01	8.43E-02		8.43E-02
156605	Dichloroethylene, 1,2-trans-	1.17E+00		1.17E+00	8.43E-01		8.43E-01
60571	Dieldrin	2.46E-04	7.10E-06	7.10E-06	1.41E-04	6.49E-06	6.49E-06
1746016	Dioxins/Furans (Total)	3.01E-10	5.37E-11	5.37E-11	1.69E-10	4.80E-11	4.80E-11
100414	Ethylbenzene	1.64E+00	3.39E-02	3.39E-02	9.78E-01	3.28E-02	3.28E-02
206440	Fluoranthene	6.69E-02		6.69E-02	3.78E-02		3.78E-02
86737	Fluorene	2.26E-01		2.26E-01	1.30E-01		1.30E-01
118741	Hexachlorobenzene	9.60E-04	1.74E-05	1.74E-05	5.42E-04	1.56E-05	1.56E-05
37871004	HpCDD, 2,3,7,8-	6.99E-09	1.25E-09	1.25E-09	3.92E-09	1.11E-09	1.11E-09
38998753	HpCDF, 2,3,7,8-	9.65E-09	1.72E-09	1.72E-09	5.42E-09	1.54E-09	1.54E-09
34465468	HxCDD, 2,3,7,8-	5.51E-10	9.84E-11	9.84E-11	3.10E-10	8.78E-11	8.78E-11
55684941	HxCDF, 2,3,7,8-	1.30E-09	2.31E-10	2.31E-10	7.27E-10	2.06E-10	2.06E-10
193395	Indeno[1,2,3-cd]pyrene		8.30E-06	8.30E-06		7.41E-06	7.41E-06
91203	Naphthalene	3.15E-01		3.15E-01	1.88E-01		1.88E-01
88744	Nitroaniline, 2-	9.90E-01		9.90E-01	8.81E-01		8.81E-01
621647	Nitroso-di-N-propylamine, N-		4.36E-04	4.36E-04		9.08E-04	9.08E-04
3268879	OCDD	4.03E-08	7.20E-09	7.20E-09	2.26E-08	6.42E-09	6.42E-09
39001020	OCDF	1.43E-07	2.55E-08	2.55E-08	8.02E-08	2.27E-08	2.27E-08
36088229	PeCDD, 2,3,7,8-	8.02E-10	1.43E-10	1.43E-10	4.52E-10	1.28E-10	1.28E-10
57117416	PeCDF, 1,2,3,7,8-	1.15E-08	2.05E-09	2.05E-09	6.44E-09	1.83E-09	1.83E-09
57117314	PeCDF, 2,3,4,7,8-	9.41E-10	1.68E-10	1.68E-10	5.29E-10	1.50E-10	1.50E-10
85018	Phenanthrene						
1336363	Polychlorinated Biphenyls (Total) (high risk)		6.24E-06	6.24E-06		5.58E-06	5.58E-06
1336363	Polychlorinated Biphenyls (Total) (low risk)		3.12E-05	3.12E-05		2.79E-05	2.79E-05
1336363	Polychlorinated Biphenyls (Total) (lowest risk)		1.78E-04	1.78E-04		1.59E-04	1.59E-04
50328	Polynuclear Aromatic Hydrocarbons (Total)		1.69E-06	1.69E-06		1.51E-06	1.51E-06
129000	Pyrene	7.66E-02		7.66E-02	4.34E-02		4.34E-02
1746016	TCDD, 2,3,7,8-	3.01E-10	5.37E-11	5.37E-11	1.69E-10	4.80E-11	4.80E-11
51207319	TCDF, 2,3,7,8-	4.09E-09	7.30E-10	7.30E-10	2.30E-09	6.52E-10	6.52E-10

Hazard-based value calculated using target HI of 0.1.
Cancer-based value calculated using target ELCR of 1E-06.
Action value is the less of the hazard- and cancer- based value.

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

(Values calculated on 01/07/2011 and are based on best available information.)

		Outdoor Worker/Gardener[a]			Industrial Worker		
Chemical	**Units**	**Hazard**	**Cancer**	**No Action**	**Hazard**	**Cancer**	**No Action**
Tetrachloroethylene	mg/L	1.93E+00	1.00E-02	1.00E-02	1.54E-01	8.00E-04	8.00E-04
Trichloroethylene	mg/L	1.93E-01	5.58E-02	5.58E-02	1.54E-02	4.47E-03	4.47E-03
Vinyl Chloride	mg/L	3.25E+00	4.22E-02	4.22E-02	2.60E-01	3.37E-03	3.37E-03
Xylene, m-	mg/L	3.31E+01		3.31E+01	2.65E+00		2.65E+00
Xylene, Mixture	mg/L	3.71E+01		3.71E+01	2.97E+00		2.97E+00
Xylene, o-	mg/L	3.71E+01		3.71E+01	2.97E+00		2.97E+00
Xylene, P-	mg/L	3.56E+01		3.56E+01	2.84E+00		2.84E+00
Am-241	pCi/L						
Co-60	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						

Hazard-based value calculated using target HI of 0.1.
Cancer-based value calculated using target ELCR of 1E-06.
Action value is the less of the hazard- and cancer- based value.

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

(Values calculated on 01/07/2011 and are based on best available information.)

	Adult Recreational (Swimming)			Adult Recreational (Wading)		
Chemical	**Hazard**	**Cancer**	**No Action**	**Hazard**	**Cancer**	**No Action**
Tetrachloroethylene	2.11E-01	7.45E-04	7.45E-04	3.29E-01	7.24E-04	7.24E-04
Trichloroethylene	1.90E-02	3.51E-03	3.51E-03	3.28E-02	4.04E-03	4.04E-03
Vinyl Chloride	2.91E-01	2.31E-03	2.31E-03	5.55E-01	3.05E-03	3.05E-03
Xylene, m-	3.65E+00		3.65E+00	5.65E+00		5.65E+00
Xylene, Mixture	4.07E+00		4.07E+00	6.33E+00		6.33E+00
Xylene, o-	4.07E+00		4.07E+00	6.33E+00		6.33E+00
Xylene, P-	3.91E+00		3.91E+00	6.06E+00		6.06E+00
Am-241		6.09E+01	6.09E+01			
Co-60		4.03E+02	4.03E+02			
Cs-137+D		2.08E+02	2.08E+02			
Np-237+D		9.39E+01	9.39E+01			
Pu-238		4.83E+01	4.83E+01			
Pu-239		4.69E+01	4.69E+01			
Pu-240		4.69E+01	4.69E+01			
Tc-99		2.30E+03	2.30E+03			
Th-230		6.96E+01	6.96E+01			
U-234		8.95E+01	8.95E+01			
U-235+D		8.82E+01	8.82E+01			
U-238+D		7.27E+01	7.27E+01			

Hazard-based value calculated using target HI of 0.1.
Cancer-based value calculated using target ELCR of 1E-06.
Action value is the less of the hazard- and cancer- based value.

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

(Values calculated on 01/07/2011 and are based on best available information.)

	Child Recreational (Swimming)			Child Recreational (Wading)		
Chemical	**Hazard**	**Cancer**	**No Action**	**Hazard**	**Cancer**	**No Action**
Tetrachloroethylene	1.16E-01	7.45E-04	7.45E-04	8.41E-02	7.24E-04	7.24E-04
Trichloroethylene	9.01E-03	3.51E-03	3.51E-03	8.40E-03	4.04E-03	4.04E-03
Vinyl Chloride	1.25E-01	2.31E-03	2.31E-03	1.42E-01	3.05E-03	3.05E-03
Xylene, m-	2.03E+00		2.03E+00	1.44E+00		1.44E+00
Xylene, Mixture	2.25E+00		2.25E+00	1.62E+00		1.62E+00
Xylene, o-	2.25E+00		2.25E+00	1.62E+00		1.62E+00
Xylene, P-	2.17E+00		2.17E+00	1.55E+00		1.55E+00
Am-241		6.09E+01	6.09E+01			
Co-60		4.03E+02	4.03E+02			
Cs-137+D		2.08E+02	2.08E+02			
Np-237+D		9.39E+01	9.39E+01			
Pu-238		4.83E+01	4.83E+01			
Pu-239		4.69E+01	4.69E+01			
Pu-240		4.69E+01	4.69E+01			
Tc-99		2.30E+03	2.30E+03			
Th-230		6.96E+01	6.96E+01			
U-234		8.95E+01	8.95E+01			
U-235+D		8.82E+01	8.82E+01			
U-238+D		7.27E+01	7.27E+01			

Hazard-based value calculated using target HI of 0.1.
Cancer-based value calculated using target ELCR of 1E-06.
Action value is the less of the hazard- and cancer- based value.

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

(Values calculated on 01/07/2011 and are based on best available information.)

	Teen Recreational (Swimming)			Teen Recreational (Wading)		
Chemical	**Hazard**	**Cancer**	**No Action**	**Hazard**	**Cancer**	**No Action**
Tetrachloroethylene	1.76E-01	7.45E-04	7.45E-04	1.06E-01	7.24E-04	7.24E-04
Trichloroethylene	1.53E-02	3.51E-03	3.51E-03	1.06E-02	4.04E-03	4.04E-03
Vinyl Chloride	2.28E-01	2.31E-03	2.31E-03	1.79E-01	3.05E-03	3.05E-03
Xylene, m-	3.06E+00		3.06E+00	1.82E+00		1.82E+00
Xylene, Mixture	3.40E+00		3.40E+00	2.04E+00		2.04E+00
Xylene, o-	3.40E+00		3.40E+00	2.04E+00		2.04E+00
Xylene, P-	3.27E+00		3.27E+00	1.96E+00		1.96E+00
Am-241		6.09E+01	6.09E+01			
Co-60		4.03E+02	4.03E+02			
Cs-137+D		2.08E+02	2.08E+02			
Np-237+D		9.39E+01	9.39E+01			
Pu-238		4.83E+01	4.83E+01			
Pu-239		4.69E+01	4.69E+01			
Pu-240		4.69E+01	4.69E+01			
Tc-99		2.30E+03	2.30E+03			
Th-230		6.96E+01	6.96E+01			
U-234		8.95E+01	8.95E+01			
U-235+D		8.82E+01	8.82E+01			
U-238+D		7.27E+01	7.27E+01			

Values in this table were calculated using the best available information in December 2010. 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.

[a] The parameters for the outdoor worker/gardener scenario can be used for a construction/excavation worker, but using an ED of from 1-5 years [based on guidance in the Exposure Factors Handbook (EPA 1993)]

Hazard-based value calculated using target HI of 0.1.
Cancer-based value calculated using target ELCR of 1E-06.
Action value is the less of the hazard- and cancer- based value.

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

		SSLs from EPA Web Site downloaded 12/29/2010			
CAS Number	**Chemical**	**SSL 1 (mg/kg)**	**SSL 20 (mg/kg)**	**GW Conc. (ug/L)**	**GW Conc. Source**
7429-90-5	Aluminum	5.48E+04	1.10E+06	3.65E+04	HBL
7440-36-0	Antimony (metallic)	2.71E-01	5.42E+00	6.00E+00	MCL
7440-38-2	Arsenic, Inorganic	2.92E-01	5.84E+00	1.00E+01	MCL
7440-39-3	Barium	8.24E+01	1.65E+03	2.00E+03	MCL
7440-41-7	Beryllium and compounds	3.16E+00	6.32E+01	4.00E+00	MCL
7440-42-8	Boron And Borates Only	2.34E+01	4.67E+02	7.30E+03	HBL
7440-43-9	Cadmium (Water)	3.76E-01	7.52E+00	5.00E+00	MCL
16065-83-1	Chromium(III), Insoluble Salts	9.86E+07	1.97E+09	5.48E+04	HBL
18540-29-9	Chromium(VI)	8.27E-04	1.65E-02	4.31E-02	HBL
7440-48-4	Cobalt	4.95E-01	9.90E+00	1.10E+01	HBL
7440-50-8	Copper	4.58E+01	9.15E+02	1.30E+03	MCL
7439-96-5	Manganese (Water)	5.71E+01	1.14E+03	8.76E+02	HBL
7439-98-7	Molybdenum	3.69E+00	7.37E+01	1.83E+02	HBL
NA	Mercury, Inorganic Salts[b]	1.04E-01	2.09E+00	2.00E+00	MCL
7440-02-0	Nickel Soluble Salts	4.76E+01	9.52E+02	7.30E+02	HBL
7782-49-2	Selenium	2.60E-01	5.20E+00	5.00E+01	MCL
7440-22-4	Silver	1.55E+00	3.10E+01	1.83E+02	HBL
7440-28-0	Thallium (Soluble Salts)	1.42E-01	2.85E+00	2.00E+00	MCL
NA	Uranium (Soluble Salts)	1.35E+01	2.70E+02	3.00E+01	MCL
NA	Vanadium and Compounds	1.84E+02	3.68E+03	1.84E+02	HBL
7440-66-6	Zinc (Metallic)	6.81E+02	1.36E+04	1.10E+04	HBL
71-43-2	Benzene	2.56E-03	5.12E-02	5.00E+00	MCL
56-23-5	Carbon Tetrachloride	1.94E-03	3.89E-02	5.00E+00	MCL
67-66-3	Chloroform	2.22E-02	4.43E-01	8.00E+01	MCL
75-35-4	Dichloroethylene, 1,1-	2.51E-03	5.03E-02	7.00E+00	MCL
540-59-0	Dichloroethylene, 1,2- (Mixed Isomers)	9.66E-02	1.93E+00	3.29E+02	HBL
156-59-2	Dichloroethylene, 1,2-cis-	2.06E-02	4.12E-01	7.00E+01	MCL
156-60-5	Dichloroethylene, 1,2-trans-	2.94E-02	5.88E-01	1.00E+02	MCL
60-57-1	Dieldrin	1.70E-04	3.39E-03	4.20E-03	HBL
1746-01-6	TCDD, 2,3,7,8-	1.50E-05	2.99E-04	3.00E-05	MCL
100-41-4	Ethylbenzene	7.85E-01	1.57E+01	7.00E+02	MCL
118-74-1	Hexachlorobenzene	1.26E-02	2.52E-01	1.00E+00	MCL
88-74-4	Nitroaniline, 2-	1.54E-01	3.08E+00	3.65E+02	HBL
621-64-7	Nitroso-di-N-propylamine, N-	7.21E-06	1.44E-04	9.61E-03	HBL
12674-11-2	Aroclor 1016	9.18E-02	1.84E+00	9.61E-01	HBL
11104-28-2	Aroclor 1221	1.15E-04	2.31E-03	6.80E-03	HBL
11141-16-5	Aroclor 1232	1.15E-04	2.31E-03	6.80E-03	HBL
53469-21-9	Aroclor 1242	5.26E-03	1.05E-01	3.36E-02	HBL
12672-29-6	Aroclor 1248	5.15E-03	1.03E-01	3.36E-02	HBL
11097-69-1	Aroclor 1254	8.78E-03	1.76E-01	3.36E-02	HBL
11096-82-5	Aroclor 1260	2.35E-02	4.70E-01	3.36E-02	HBL
1336-36-3	Polychlorinated Biphenyls (low risk)	7.82E-02	1.56E+00	5.00E-01	MCL

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

		SSLs Calculated Using PGDP No Action Values (See Table A.5) Calculated 12/29/2010				
CAS Number	Chemical	SSL 1 (mg/kg)	SSL 20 (mg/kg)	Chemical	GW Conc. (ug/L)	GW Conc. Source
7429-90-5	Aluminum	1.56E+03	3.12E+04	Aluminum	1.04E+03	child resident
7440-36-0	Antimony (metallic)	1.88E-02	3.75E-01	Antimony (metallic)	4.15E-01	child resident
7440-38-2	Arsenic, Inorganic	1.11E-03	2.22E-02	Arsenic, Inorganic	3.80E-02	child resident
7440-39-3	Barium	8.49E+00	1.70E+02	Barium	2.06E+02	child resident
7440-41-7	Beryllium and compounds	8.85E-03	1.77E-01	Beryllium and compounds	1.12E-02	child resident
7440-42-8	Boron And Borates Only	6.66E-01	1.33E+01	Boron And Borates Only	2.08E+02	child resident
7440-43-9	Cadmium (Water)	1.10E-02	2.20E-01	Cadmium (Water)	1.46E-01	child resident
16065-83-1	Chromium(III), Insoluble Salts	2.65E+06	5.29E+07	Chromium (III) (Insoluble Salts)	1.47E+03	child resident
18540-29-9	Chromium(VI)	1.98E-03	3.96E-02	Chromium VI (particulates)	1.03E-01	child resident
7440-48-4	Cobalt	1.41E-02	2.83E-01	Cobalt	3.13E-01	child resident
7440-50-8	Copper	1.47E+00	2.94E+01	Copper	4.17E+01	child resident
7439-96-5	Manganese (Water)	1.60E+00	3.19E+01	Manganese (Water)	2.45E+01	child resident
7439-98-7	Molybdenum	1.05E-01	2.10E+00	Molybdenum	5.21E+00	child resident
NA	Mercury, Inorganic Salts	1.61E-02	3.23E-01	Mercury, Inorganic Salts	3.09E-01	child resident
7440-02-0	Nickel Soluble Salts	1.36E+00	2.71E+01	Nickel Soluble Salts	2.08E+01	child resident
7782-49-2	Selenium	2.71E-02	5.42E-01	Selenium	5.21E+00	child resident
7440-22-4	Silver	4.38E-02	8.76E-01	Silver	5.15E+00	child resident
7440-28-0	Thallium (Soluble Salts)	5.94E-03	1.19E-01	Thallium Chloride	8.34E-02	child resident
NA	Uranium (Soluble Salts)	1.41E+00	2.82E+01	Uranium (Soluble Salts)	3.13E+00	child resident
NA	Vanadium and Compounds	7.06E-02	1.41E+00	Vanadium, Metallic	7.06E-02	child resident
7440-66-6	Zinc (Metallic)	1.95E+01	3.89E+02	Zinc (Metallic)	3.13E+02	child resident
71-43-2	Benzene	2.18E-04	4.37E-03	Benzene	4.27E-01	child resident
56-23-5	Carbon Tetrachloride	1.62E-04	3.23E-03	Carbon Tetrachloride	4.19E-01	child resident
67-66-3	Chloroform	6.28E-05	1.26E-03	Chloroform	2.27E-01	child resident
75-35-4	Dichloroethylene, 1,1-	1.82E-05	3.64E-04	Dichloroethylene, 1,1-	5.11E-02	child resident
540-59-0	Dichloroethylene, 1,2- (Mixed Isomers)	6.58E-04	1.32E-02	Dichloroethylene, 1,2- (Mixed Isomers)	2.24E+00	child resident
156-59-2	Dichloroethylene, 1,2-cis-	3.67E-04	7.34E-03	Dichloroethylene, 1,2-cis-	1.25E+00	child resident
156-60-5	Dichloroethylene, 1,2-trans-	1.30E-03	2.61E-02	Dichloroethylene, 1,2-trans-	4.44E+00	child resident
60-57-1	Dieldrin	7.55E-05	1.51E-03	Dieldrin	1.87E-03	child resident
1746-01-6	TCDD, 2,3,7,8-	1.45E-08	2.89E-07	TCDD, 2,3,7,8-	2.90E-08	child resident
100-41-4	Ethylbenzene	1.69E-03	3.38E-02	Ethylbenzene	1.51E+00	child resident
118-74-1	Hexachlorobenzene	9.75E-05	1.95E-03	Hexachlorobenzene	7.74E-03	child resident
88-74-4	Nitroaniline, 2-	4.31E-03	8.62E-02	Nitroaniline, 2-	1.02E+01	child resident
621-64-7	Nitroso-di-N-propylamine, N-	6.03E-06	1.21E-04	Nitroso-di-N-propylamine, N-	8.03E-03	child resident
12674-11-2	Aroclor 1016	1.90E-03	3.80E-02	Aroclor 1016 (exposure to water)	1.99E-02	child resident
11104-28-2	Aroclor 1221	1.14E-03	2.29E-02	Aroclor 1221 (exposure to water)	6.73E-02	child resident
11141-16-5	Aroclor 1232	1.14E-03	2.29E-02	Aroclor 1232 (exposure to water)	6.73E-02	child resident
53469-21-9	Aroclor 1242	2.49E-03	4.97E-02	Aroclor 1242 (exposure to water)	1.59E-02	child resident
12672-29-6	Aroclor 1248	2.28E-03	4.57E-02	Aroclor 1248 (exposure to water)	1.49E-02	child resident
11097-69-1	Aroclor 1254	4.88E-04	9.77E-03	Aroclor 1254 (exposure to water)	1.87E-03	child resident
11096-82-5	Aroclor 1260	1.20E-03	2.41E-02	Aroclor 1260 (exposure to water)	1.72E-03	child resident
1336-36-3	Polychlorinated Biphenyls (low risk)	2.49E-03	4.97E-02	Polychlorinated Biphenyls (Total) (low risk)	1.59E-02	child resident

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

		SSLs from EPA Web Site downloaded 12/29/2010			
CAS Number	**Chemical**	**SSL 1 (mg/kg)**	**SSL 20 (mg/kg)**	**GW Conc. (ug/L)**	**GW Conc. Source**
83-32-9	Acenaphthene	2.25E+01	4.49E+02	2.19E+03	HBL
120-12-7	Anthracene	3.60E+02	7.21E+03	1.10E+04	HBL
56-55-3	Benz[a]anthracene	1.04E-02	2.09E-01	2.95E-02	HBL
50-32-8	Benzo[a]pyrene	2.35E-01	4.70E+00	2.00E-01	MCL
205-99-2	Benzo[b]fluoranthene	3.54E-02	7.07E-01	2.95E-02	HBL
207-08-9	Benzo[k]fluoranthene	3.47E-01	6.93E+00	2.95E-01	HBL
218-01-9	Chrysene	1.07E+00	2.13E+01	2.95E+00	HBL
53-70-3	Dibenz[a,h]anthracene	1.13E-02	2.26E-01	2.95E-03	HBL
206-44-0	Fluoranthene	1.62E+02	3.24E+03	1.46E+03	HBL
86-73-7	Fluorene	2.70E+01	5.41E+02	1.46E+03	HBL
193-39-5	Indeno[1,2,3-cd]pyrene	1.15E-01	2.30E+00	2.95E-02	HBL
91-20-3	Naphthalene	4.71E-04	9.42E-03	1.43E-01	HBL
129-00-0	Pyrene	1.19E+02	2.38E+03	1.10E+03	HBL
127-18-4	Tetrachloroethylene	2.27E-03	4.55E-02	5.00E+00	MCL
79-01-6	Trichloroethylene	1.79E-03	3.57E-02	5.00E+00	MCL
75-01-4	Vinyl Chloride	6.90E-04	1.38E-02	2.00E+00	MCL
1330-20-7	Xylene, Mixture	9.85E+00	1.97E+02	1.00E+04	MCL
106-42-3	Xylene, P-	1.19E+00	2.37E+01	1.22E+03	HBL
108-38-3	Xylene, m-	1.19E+00	2.38E+01	1.22E+03	HBL
95-47-6	Xylene, o-	1.20E+00	2.40E+01	1.22E+03	HBL

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

		SSLs Calculated Using PGDP No Action Values (See Table A.5)				
		Calculated 12/29/2010				
CAS Number	Chemical	SSL 1 (mg/kg)	SSL 20 (mg/kg)	Chemical	GW Conc. (ug/L)	GW Conc. Source
83-32-9	Acenaphthene	1.42E-01	2.83E+00	Acenaphthene	1.38E+01	child resident
120-12-7	Anthracene	2.10E+00	4.21E+01	Anthracene	6.39E+01	child resident
56-55-3	Benz[a]anthracene	4.32E-03	8.64E-02	Benz[a]anthracene	1.22E-02	child resident
50-32-8	Benzo[a]pyrene	1.01E-03	2.03E-02	Benzo[a]pyrene	8.63E-04	child resident
205-99-2	Benzo[b]fluoranthene	1.62E-02	3.24E-01	Benzo[b]fluoranthene	1.35E-02	child resident
207-08-9	Benzo[k]fluoranthene	1.04E-01	2.08E+00	Benzo[k]fluoranthene	8.86E-02	child resident
218-01-9	Chrysene	4.15E-01	8.31E+00	Chrysene	1.15E+00	child resident
53-70-3	Dibenz[a,h]anthracene	2.19E-03	4.38E-02	Dibenz[a,h]anthracene	5.73E-04	child resident
206-44-0	Fluoranthene	1.60E+00	3.20E+01	Fluoranthene	1.44E+01	child resident
86-73-7	Fluorene	1.65E-01	3.30E+00	Fluorene	8.91E+00	child resident
193-39-5	Indeno[1,2,3-cd]pyrene	1.76E-02	3.53E-01	Indeno[1,2,3-cd]pyrene	4.52E-03	child resident
91-20-3	Naphthalene	5.79E-04	1.16E-02	Naphthalene	1.76E-01	child resident
129-00-0	Pyrene	6.33E-01	1.27E+01	Pyrene	5.81E+00	child resident
127-18-4	Tetrachloroethylene	3.53E-05	7.07E-04	Tetrachloroethylene	7.81E-02	child resident
79-01-6	Trichloroethylene	1.66E-05	3.31E-04	Trichloroethylene	4.65E-02	child resident
75-01-4	Vinyl Chloride	2.48E-05	4.96E-04	Vinyl Chloride	7.25E-02	child resident
1330-20-7	Xylene, Mixture	8.87E-03	1.77E-01	Xylene, Mixture	9.01E+00	child resident
106-42-3	Xylene, P-	4.72E-02	9.44E-01	Xylene, P-	4.84E+01	child resident
108-38-3	Xylene, m-	4.71E-02	9.43E-01	Xylene, m-	4.83E+01	child resident
95-47-6	Xylene, o-	4.77E-02	9.55E-01	Xylene, o-	4.85E+01	child resident

Values in this table were calculated using the best available information in December 2010. 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.

[a] Values identified as being from the EPA website are from http://epa-prgs.ornl.gov/cgi-bin/chemicals/csl_search
[b] H' for elemental mercury was used for SSL calculation to be conservative.
Only significant COPCs listed on the websites are shown. SSLs for other chemicals will be derived using similar methods as needed.
GW = Groundwater; MCL = Maximum Contaminant Level; HBL = Heath-based Level
Method 1 on Website used to calculate all values. Default parameters from http://epa-prgs.ornl.gov/cgi-bin/chemicals/csl_search used are as follows:

Dilution factor (unitless)	1 or 20
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 Significant Radionuclide COPCs at PGDP

			Resident Adult		Resident Child		
Parameter	**Radionuclide**	**Units**	**10^{-6}**	**10^{-4}**	**10^{-6}**	**10^{-4}**	**Year**
14596102	Americium-241	pCi/g	3.24E+06	3.24E+08	3.89E+07	3.89E+09	3108
10198400	Cobalt-60	pCi/g	2.81E+13	2.81E+15	3.38E+14	3.38E+16	228
10045973	Cesium-137	pCi/g	NA	NA	NA	NA	NA
13994202	Neptunium-237+D	pCi/g	5.16E+02	5.16E+04	6.20E+03	6.20E+05	2277
13981163	Plutonium-238	pCi/g	3.85E+03	3.85E+05	4.62E+04	4.62E+06	1129
15117483	Plutonium-239	pCi/g	3.71E-01	3.71E+01	4.46E+00	4.46E+02	2871
14119336	Plutonium-240	pCi/g	4.64E-01	4.64E+01	5.57E+00	5.57E+02	2871
14133767	Technetium-99	pCi/g	2.19E+00	2.19E+02	2.63E+01	2.63E+03	7.6
14269637	Thorium-230	pCi/g	NA	NA	NA	NA	NA
13966295	Uranium-234	pCi/g	1.02E+00	1.02E+02	1.22E+01	1.22E+03	976
15117961	Uranium-235+D	pCi/g	9.49E-01	9.49E+01	1.14E+01	1.14E+03	975
7440611	Uranium-238+D	pCi/g	7.18E-01	7.18E+01	8.62E+00	8.62E+02	976

Values in this table were calculated using the best available information in December 2010. 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.

"Year" = year that radionuclide is estimated to produce maximum dose over the 10,000-year evaluation period.

"NA" = not applicable. That is, the radionuclide does not reach groundwater within 10,000 years precluding receptor uptake.

SSLs estimated using the RESRAD code version 6.0.

Table A.8. Dose Based SSLs for Site Related Radionuclides at PGDP

Parameter	Radionuclide	Units	Outdoor worker/gardener 1 mrem/yr	Outdoor worker/gardener 15 mrem/yr	Outdoor worker/gardener 25 mrem/yr	Industrial Worker 1 mrem/yr	Industrial Worker 15 mrem/yr	Industrial Worker 25 mrem/yr	Adult Recreator 1 mrem/yr	Adult Recreator 15 mrem/yr	Adult Recreator 25 mrem/yr
14596102	Americium-241	pCi/g	3.04E+00	4.56E+01	7.59E+01	1.87E+01	2.80E+02	4.67E+02	100	1500	2510
10045973	Cesium-137	pCi/g	2.15	32.2	53.7	1.6	24.1	40.1	6.17	92.6	154
10198400	Cobalt-60	pCi/g	0.456	6.84	11.4	0.338	5.07	8.45	1.3	19.5	32.5
13994202	Neptunium-237+D	pCi/g	1.84	27.6	46	3.9	58.5	97.5	16.2	242	404
13981163	Plutonium-238	pCi/g	3.52	52.8	88	24.9	374	624	144	2160	3590
15117483	Plutonium-239	pCi/g	3.18	47.7	79.5	22.5	338	563	130	1950	3250
14119336	Plutonium-240	pCi/g	3.18	47.7	79.5	22.6	338	564	130	1950	3250
14133767	Technetium-99	pCi/g	6820	102000	170000	24200	364000	606000	109000	1640000	2730000
14269637	Thorium-230	pCi/g	20.5	307	512	140	2110	3510	795	11900	19900
13966295	Uranium-234	pCi/g	39.7	595	992	275	4130	6880	1570	23500	39200
15117961	Uranium-235+D	pCi/g	7.93	119	198	7.06	106	177	27.4	411	684
7440611	Uranium-238+D*	pCi/g	22	330	548	27.7	410	685	95	1435	2400

Values in this table were calculated using the best available information in December 2010. 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.

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

Pathways include ingestion, inhalation, and external gamma.

* The values for U-238+D were calculated on 9/24 07. RESRAD 6.3 revised the External DCF for U-238+D on 5/31/02. RESRAD version history @ http://web.ead.anl.gov/resrad/home2/reshstry.cfm

Table A.8. Dose Based SSLs for Site Related Radionuclides at PGDP (Continued)

Parameter	Radionuclide	Units	Child Recreator			Teen Recreator			Adult Resident		
			1 mrem/yr	15 mrem/yr	25 mrem/yr	1 mrem/yr	15 mrem/yr	25 mrem/yr	1 mrem/yr	15 mrem/yr	25 mrem/yr
14596102	Americium-241	pCi/g	4.16E+01	6.24E+02	1.04E+03	74.4	1120	1860	6.21	93.2	155
10045973	Cesium-137	pCi/g	4.58	68.7	115	4.58	68.8	115	0.382	5.73	9.55
10198400	Cobalt-60	pCi/g	0.965	14.5	24.1	0.966	14.5	24.1	0.0805	1.21	2.01
13994202	Neptunium-237+D	pCi/g	10.4	156	260	12	180	300	1	15	25
13981163	Plutonium-238	pCi/g	53.5	802	1340	107	1600	2670	8.91	134	223
15117483	Plutonium-239	pCi/g	48.3	725	1210	96.5	1450	2410	8.05	121	201
14119336	Plutonium-240	pCi/g	48.3	725	1210	96.5	1450	2410	8.06	121	201
14133767	Technetium-99	pCi/g	60300	905000	1510000	81200	1220000	2030000	6770	102000	169000
14269637	Thorium-230	pCi/g	304	4560	7590	591	8860	14800	49.6	743	1240
13966295	Uranium-234	pCi/g	594	8910	14800	1170	17500	29100	97.6	1460	2440
15117961	Uranium-235+D	pCi/g	20	300	500	20.3	305	508	1.69	25.4	42.4
7440611	Uranium-238+D*	pCi/g	69	1025	1701	80	1140	1905	8.1	120	200

Values in this table were calculated using the best available information in December 2010. 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.

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

Pathways include ingestion, inhalation, and external gamma.

* The values for U-238+D were calculated on 9/24 07. RESRAD 6.3 revised the External DCF for U-238+D on 5/31/02. RESRAD version history @ http://web.ead.anl.gov/resrad/home2/reshstry.cfm

Table A.8. Dose Based SSLs for Site Related Radionuclides at PGDP (Continued)

Parameter	Radionuclide	Units	Child Resident		
			1 mrem/yr	15 mrem/yr	25 mrem/yr
14596102	Americium-241	pCi/g	3.47E+00	5.20E+01	8.67E+01
10045973	Cesium-137	pCi/g	0.382	5.73	9.54
10198400	Cobalt-60	pCi/g	0.0805	1.21	2.01
13994202	Neptunium-237+D	pCi/g	0.866	13	21.6
13981163	Plutonium-238	pCi/g	4.46	66.9	112
15117483	Plutonium-239	pCi/g	4.03	60.5	101
14119336	Plutonium-240	pCi/g	4.03	60.5	101
14133767	Technetium-99	pCi/g	5030	75400	126000
14269637	Thorium-230	pCi/g	25.4	381	635
13966295	Uranium-234	pCi/g	49.6	745	1240
15117961	Uranium-235+D	pCi/g	1.67	25	41.7
7440611	Uranium-238+D*	pCi/g	7.5	113	187.5

Values in this table were calculated using the best available information in December 2010. 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.

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

Pathways include ingestion, inhalation and external gamma

* The values for U-238+D were calculated on 9/24 07. RESRAD 6.3 revised the External DCF for U-238+D on 5/31/02. RESRAD version history @ http://web.ead.anl.gov/resrad/home2/reshstry.cfm

Table A.9 Dose-Based Groundwater Screening Levels for Site-Related Radionuclides at PGDP

			Industrial Worker				Adult Resident				Child Resident			
Parameter	Radionuclides	Units	1 mrem/yr	4 mrem/yr	15 mrem/yr	25 mrem/yr	1 mrem/yr	4 mrem/yr	15 mrem/yr	25 mrem/yr	1 mrem/yr	4 mrem/yr	15 mrem/yr	25 mrem/yr
14596102	Americium-241	pCi/L	1.1	4.4	16.5	27.5	0.392	1.57	5.89	9.81	7.85E-01	3.14E+00	1.18E+01	19.6
10045973	Cesium-137	pCi/L	80	320	1200	2000	28.6	114	429	714	57.1	229	857	1430
10198400	Cobalt-60	pCi/L	149	595	2230	3720	53.1	212	797	1330	106	425	1590	2660
13994202	Neptunium-237+D	pCi/L	0.901	3.6	13.5	22.5	0.322	1.29	4.83	8.04	0.644	2.57	9.65	16.1
13981163	Plutonium-238	pCi/L	1.25	5	18.8	31.3	0.446	1.79	6.7	11.2	0.893	3.57	13.4	22.3
15117483	Plutonium-239	pCi/L	1.13	4.52	16.9	28.2	0.404	1.61	6.05	10.1	0.807	3.23	12.1	20.2
14119336	Plutonium-240	pCi/L	1.13	4.52	16.9	28.2	0.404	1.61	6.05	10.1	0.807	3.23	12.1	20.2
14133767	Technetium-99	pCi/L	2740	11000	41100	68500	978	3910	14700	24500	1960	7830	29400	48900
14269637	Thorium-230	pCi/L	7.3	29.2	109	182	2.61	10.4	39.1	65.2	5.21	20.9	78.2	130
13966295	Uranium-234	pCi/L	14.1	56.5	212	353	5.05	20.2	75.7	126	10.1	40.4	151	252
15117961	Uranium-235+D	pCi/L	15	59.9	225	375	5.35	21.4	80.3	134	10.7	42.8	161	268
7440611	Uranium-238+D	pCi/L	14.9	59.5	223	372	5.31	21.2	79.7	133	10.6	42.5	159	266

Values in this table were calculated using the best available information in December 2010. 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.

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

			Recreational User (Child and Adult)			
Parameter	**Radionuclide**	**Units**	**1 mrem/yr**	**4 mrem/yr**	**15 mrem/yr**	**25 mrem/yr**
14596102	Americium-241	pCi/L	47	188	704	1170
10045973	Cesium-137	pCi/L	3420	13700	51300	85500
10198400	Cobalt-60	pCi/L	6350	25400	95300	159000
13994202	Neptunium-237+D	pCi/L	38.5	154	578	963
13981163	Plutonium-238	pCi/L	53.4	214	801	1340
15117483	Plutonium-239	pCi/L	48.3	193	724	1210
14119336	Plutonium-240	pCi/L	48.3	193	724	1210
14133767	Technetium-99	pCi/L	117000	468000	1760000	2930000
14269637	Thorium-230	pCi/L	312	1250	4680	7800
13966295	Uranium-234	pCi/L	604	2420	9060	15100
15117961	Uranium-235+D	pCi/L	640	2560	9600	16000
7440611	Uranium-238+D	pCi/L	635	2540	9530	15900

Values in this table were calculated using the best available information in December 2010. 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.

Table A.11. Dose-Based Soil Screening Levels for Protection of RGA Groundwater for Site-Related Radionuclides at PGDP

Parameter	Radionuclide	Units	Resident Adult				Resident Child				
			1 mrem/yr	4 mrem/yr	15 mrem/yr	25 mrem/yr	1 mrem/yr	4 mrem/yr	15 mrem/yr	25 mrem/yr	Year
14596102	Americium-241	pCi/g	1.70E+07	6.80E+07	2.55E+08	4.25E+08	3.40E+07	1.36E+08	5.10E+08	8.50E+08	3108
10045973	Cesium-137	pCi/g	NA	NA	NA	NA	NA	NA	NA	NA	NA
10198400	Cobalt-60	pCi/g	1.94E+14	7.77E+14	2.91E+15	4.86E+15	3.89E+14	1.55E+15	5.83E+15	9.71E+15	228
13994202	Neptunium-237+D	pCi/g	2720	10900	40700	67900	5430	21700	81500	136000	2277
13981163	Plutonium-238	pCi/g	20300	81100	304000	507000	40600	162000	609000	1010000	1129
15117483	Plutonium-239	pCi/g	1.13	4.5	16.9	28.1	2.25	9.01	33.8	56.3	2871
14119336	Plutonium-240	pCi/g	1.4	5.62	21.1	35.1	2.81	11.2	42.1	70.2	2871
14133767	Technetium-99	pCi/g	9.63	38.5	145	241	19.3	77.1	289	482	7.6
14269637	Thorium-230	pCi/g	NA	NA	NA	NA	NA	NA	NA	NA	NA
13966295	Uranium-234	pCi/g	5.19	20.8	77.8	130	10.4	41.5	156	259	976
15117961	Uranium-235+D	pCi/g	5.47	21.9	82	137	10.9	43.7	164	273	975
7440611	Uranium-238+D	pCi/g	5.43	21.7	81.4	136	10.9	43.4	163	271	976

Values in this table were calculated using the best available information in December 2010. 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.

“Year” = year that radionuclide is estimated to produce maximum dose over the 10,000-year evaluation period.

“NA” = not applicable. That is, the radionuclide does not reach groundwater within 10,000 years precluding receptor uptake.

SSLs estimated using the RESRAD code version 6.0.

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

	Background Value[b]	
Analyte	**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 "---" indicated 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 1997a. Details on the derivation of the background concentration for all other inorganic chemicals are in DOE 1996a.

[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

	Over All Observations		Over Wells	
Analyte	**RGA**	**McNairy**	**RGA**	**McNairy**
Inorganic Chemicals (mg/L)				
Aluminum	2.189	0.687	1.64	0.75
Aluminum, Dissolved	0.311	0.579	0.201	0.587
Antimony	0.060[a]	0.060[a]	0.060[a]	0.060[a]
Antimony, Dissolved	0.060[a]	0.060[a]	0.060[a]	0.060[a]
Arsenic	0.005[a]	0.005[a]	0.005[a]	0.005[a]
Arsenic, Dissolved	0.005[a]	0.005[a]	0.005[a]	0.005[a]
Barium	0.235	0.296	0.202	0.265
Barium, Dissolved	0.2	0.268	0.179	0.266
Beryllium	0.004[a]	0.017[a]	0.004[a]	0.017[a]
Beryllium, Dissolved	0.004[a]	0.004[a]	0.004[a]	0.004[a]
Cadmium	0.010[a]	0.010[a]	0.010[a]	0.010[a]
Cadmium, Dissolved	0.010[a]	0.010[a]	0.010[a]	0.010[a]
Calcium	41.238	38.858	40	39.47
Calcium, Dissolved	38.166	38.829	35.8	40.27
Chloride	91.021	19.708	89.2	20.23
Chromium	0.144	0.060[a]	0.134	0.060[a]
Chromium, Dissolved	0.050[a]	0.050[a]	0.050[a]	0.050[a]
Cobalt	0.045[a]	0.096	0.045[a]	0.072
Cobalt, Dissolved	0.045[a]	0.045[a]	0.045[a]	0.045[a]
Copper	0.036	0.057	0.034	0.033
Copper, Dissolved	0.02	0.013[a]	0.018	0.013[a]
Flouride	0.27	0.33	0.245	0.298
Iron	5.03	18.36	3.72	15.83
Iron, Dissolved	0.267	12.372	0.164	9.446
Lead	0.129	0.050[a]	0.25	0.050[a]
Lead, Dissolved	0.098	0.050[a]	0.25	0.050[a]
Magnesium	16.262	13.418	15.7	16.457
Magnesium, Dissolved	16.215	14.171	15.4	16.533
Manganese	0.119	0.941	0.082	0.729
Manganese, Dissolved	0.068	0.894	0.048	0.682
Mercury	0.0002[a]	0.0002[a]	0.0002[a]	0.0002[a]
Mercury, Dissolved	0.0002[a]	0.0002[a]	0.0002[a]	0.0002[a]
Molybdenum	0.050[a]	0.050[a]	0.050[a]	0.050[a]
Molybdenum, Dissolved	0.050[a]	0.050[a]	0.050[a]	0.050[a]
Nickel	0.682	0.109[a]	.682	0.109[a]
Nickel, Dissolved	0.305	0.050[a]	.305	0.050[a]
Nitrate as Nitrogen	15.561	1.474	13.5	1.43
Potassium	5.195	55.752	4.47	64.08
Potassium, Dissolved	4.096	51.205	3.7	58.75
Selenium	0.005[a]	0.005[a]	0.005[a]	0.005[a]
Selenium, Dissolved	0.005[a]	0.005[a]	0.005[a]	0.005[a]
Silica	26.401	36	21.1	29.4

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

Analyte	Over All Observations		Over Wells	
	RGA	McNairy	RGA	McNairy
Silver	0.011[a]	0.050[a]	0.011[a]	0.050[a]
Silver, Dissolved	0.060[a]	0.050[a]	0.060[a]	0.050[a]
Sodium	59.45	29.2	63.5	24.92
Sodium, Dissolved	60.433	27.98	65.7	25.9
Sulfate	19.947	28.9	19.1	27.27
Thallium	0.056[a]	0.644	0.056[a]	0.255
Thallium, Dissolved	0.056[a]	0.056[a]	0.056[a]	0.056[a]
Uranium	0.002[a]	0.001[a]	0.002[a]	0.001[a]
Uranium, Dissolved	0.002[a]	0.001	0.002[a]	0.001
Vanadium	0.134	0.126	0.139	0.119
Vanadium, Dissolved	0.134	0.126	0.131	0.107
Zinc	0.054	0.142	0.025	0.104
Zinc, Dissolved	0.049	0.116	0.026	0.08
Radionuclides (pCi/L)				
Gross Alpha	5.8	11.9	2.36	5.3
Gross Beta	13.8	144.5	7.3	125.4
Neptunium-237	0.8	0.5	0.21	0.13
Plutonium-239	0.1	0.2	0.03	0.04
Radium-226	0.6	1.2	0.1	0.29
Radon-222	626	295	555.3	228.3
Technetium-99	22.3	20.6	10.8	7.8
Thorium-230	1.1	1.5	0.54	0.4
Total Radium	1.3	0.7	0.46	0.36
Uranium-234[b]	0.7	0.3	0.7	0.3
Uranium-235[b]	0.3	0.2	0.3	0.2
Uranium-238[b]	0.7	0.3	0.7	0.3

Notes: Values taken from Volume 5 *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, Paducah, Kentucky* (DOE 2000a).

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. Issues to be resolved in forthcoming meetings include the data set from which these values were derived and the statistical methods used to analyze the data set.

For all projects where averages within wells over time are considered, the values derived over wells should be used. For all other projects, the values derived 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] Uranium isotopic concentrations were derived from the mass concentration of uranium.

Table A.14. Regulatory Action Levels for PGDP

(Verified 12/30/2010)

Parameter	Chemical	Units	Primary MCLs[a]	Primary MCLGs[a]	Secondary MCLs[a]	State Water Supply WQC[b]	State Fish Consump. WQC[b]	Fed. Combined WQC[c]	PGDP Significant List
83329	Acenaphthene	mg/l				6.70E-01	9.90E-01	6.70E-01	Y
107028	Acrolein	mg/l				1.90E-01	2.90E-01	6.00E-03	
79061	Acrylamide	mg/l		0					
107131	Acrylonitrile	mg/l				5.10E-05	2.50E-04	5.10E-05	Y
15972608	Alachlor	mg/l	0.002	0					
309002	Aldrin	mg/l				4.90E-08	5.00E-08	4.90E-08	
7429905	Aluminum	mg/l			0.05 -0.2				Y
120127	Anthracene	mg/l				8.30E+00	4.00E+01	8.30E+00	Y
7440360	Antimony	mg/l	0.006	0.006		5.60E-03	6.40E-01	5.60E-03	Y
12674112	Aroclor 1016	mg/l							Y
11104282	Aroclor 1221	mg/l							Y
11141165	Aroclor 1232	mg/l							Y
53469219	Aroclor 1242	mg/l							Y
12672296	Aroclor 1248	mg/l							Y
11097691	Aroclor 1254	mg/l							Y
11096825	Aroclor 1260	mg/l							Y
7440382	Arsenic	mg/l	0.01	0		1.00E-02		1.80E-05	Y
1332214	Asbestos	MFL	7	7		7.00E+00		7.00E+00	
1912249	Atrazine	mg/l	0.003	0.003					
319846	BHC, alpha-	mg/l				2.60E-06	4.90E-06	2.60E-06	
319857	BHC, beta-	mg/l				9.10E-06	1.70E-05	9.10E-06	
7440393	Barium	mg/l	2	2		1.00E+00		1.00E+00	Y
71432	Benzene	mg/l	0.005	0		2.20E-03	5.10E-02	2.20E-03	Y
92875	Benzidine	mg/l				8.60E-08	2.00E-07	8.60E-08	
56553	Benzo(a)anthracene	mg/l				3.80E-06	1.80E-05	3.80E-06	Y
50328	Benzo(a)pyrene	mg/l	0.0002	0		3.80E-06	1.80E-05	3.80E-06	Y
205992	Benzo(b)fluoranthene	mg/l				3.80E-06	1.80E-05	3.80E-06	Y
207089	Benzo(k)fluoranthene	mg/l				3.80E-06	1.80E-05	3.80E-06	Y
7440417	Beryllium	mg/l	0.004	0.004		4.00E-03		[f]	Y
542881	Bis(chloromethyl)ether	mg/l				1.00E-07	2.90E-07	1.00E-07	

Table A.14. Regulatory Action Levels for PGDP (Continued)

Parameter	Chemical	Units	Primary MCLs[a]	Primary MCLGs[a]	Secondary MCLs[a]	State Water Supply WQC[b]	State Fish Consump. WQC[b]	Fed. Combined WQC[c]	PGDP Significant List
111444	Bis(2-chloroethyl)ether	mg/l				3.00E-05	5.30E-04	3.00E-05	
108601	Bis(2-chloroisopropyl)ether	mg/l				1.40E+00	6.50E+01	1.40E+00	
15541454	Bromate	mg/l	0.01	0					
79083	Bromoacetic acid	mg/l	0.06[d]						
75274	Bromodichloromethane	mg/l	0.08[e]	0		5.50E-04	1.70E-02	5.50E-04	
75252	Bromoform	mg/l	0.08[e]	0		4.30E-03	1.40E-01	4.30E-03	
85687	Butylbenzyl phthalate	mg/l				1.50E+00	1.90E+00	1.50E+00	
7440439	Cadmium	mg/l	0.005	0.005		5.00E-03		[f]	Y
1563662	Carbofuran	mg/l	0.04	0.04					
56235	Carbon tetrachloride	mg/l	0.005	0		2.30E-04	1.60E-03	2.30E-04	Y
57749	Chlordane	mg/l	0.002	0		8.00E-07	8.10E-07	8.00E-07	
16887006	Chloride	mg/l			250	2.50E+02			
14998277	Chlorite	mg/l	1	0.8					
67663	Chloroform	mg/l	0.08[e]	0.07		5.70E-03	4.70E-01	5.70E-03	Y
91587	Chloronaphthalene, 2-	mg/l				1.00E+00	1.60E+00	1.00E+00	
95578	Chlorophenol, 2-	mg/l				8.10E-02	1.50E-01	8.10E-02	
7440473	Chromium (Total)	mg/l	0.1	0.1		1.00E-01			
16065831	Chromium (III)	mg/l						[f]	Y
18540299	Chromium (VI)	mg/l						[f]	Y
218019	Chrysene	mg/l				3.80E-06	1.80E-05	3.80E-06	Y
7440508	Copper	mg/l	1.3	1.3	1	1.30E+00		1.30E+00	Y
57125	Cyanide	mg/l	0.2	0.2		1.40E-01	1.40E-01	1.40E-01	
72548	DDD	mg/l				3.10E-07	3.10E-07	3.10E-07	Y
72559	DDE	mg/l				2.20E-07	2.20E-07	2.20E-07	
50293	DDT	mg/l				2.20E-07	2.20E-07	2.20E-07	
75990	Dalapon	mg/l	0.2	0.2					
613641	Dibromoacetic acid	mg/l	0.06[d]						
103231	Di(ethylhexyl)adipate	mg/l	0.4	0.4					
117817	Di(ethylhexyl)phthalate	mg/l	0.006	0		1.20E-03	2.20E-03	1.20E-03	
53703	Dibenz(a,h)anthracene	mg/l				3.80E-06	1.80E-05	3.80E-06	Y
96128	Dibromo-3-chloropropane, 1,2-	mg/l	0.0002	0					
124481	Dibromochloromethane	mg/l	0.08[e]	0.06		4.00E-04	1.30E-02	4.00E-04	
84742	Dibutyl phthalate	mg/l				2.00E+00	4.50E+00	2.00E+00	

Table A.14. Regulatory Action Levels for PGDP (Continued)

Parameter	Chemical	Units	Primary MCLs[a]	Primary MCLGs[a]	Secondary MCLs[a]	State Water Supply WQC[b]	State Fish Consump. WQC[b]	Fed. Combined WQC[c]	PGDP Significant List
79436	Dichloroacetic acid	mg/l	0.06[d]	0					
541731	Dichlorobenzene, m-	mg/l				3.20E-01	9.60E-01	3.20E-01	
95501	Dichlorobenzene, o-	mg/l	0.6	0.6		4.20E-01	1.30E+00	4.20E-01	
106467	Dichlorobenzene, p-	mg/l	0.075	0.075		6.30E-02	1.90E-01	6.30E-02	
91941	Dichlorobenzidine, 3,3-	mg/l				2.10E-05	2.80E-05	2.10E-05	
107062	Dichloroethane, 1,2-	mg/l	0.005	0		3.80E-04	3.70E-02	3.80E-04	
75354	Dichloroethylene, 1,1-	mg/l	0.007	0.007		3.30E-01	7.10E+00	3.30E-01	Y
156592	Dichloroethylene, *cis*-1,2-	mg/l	0.07	0.07					Y
156605	Dichloroethylene, *trans*-1,2-	mg/l	0.1	0.1		1.40E-01	1.00E+01	1.40E-01	Y
120832	Dichlorophenol, 2,4-	mg/l				7.70E-02	2.90E-01	7.70E-02	
94757	Dichlorophenoxyacetic acid, 2,4-	mg/l	0.07	0.07		1.00E-01		1.00E-01	
78875	Dichloropropane, 1,2-	mg/l	0.005	0		5.00E-04	1.50E-02	5.00E-04	
542756	Dichloropropene, 1,3-	mg/l				3.40E-04	2.10E-02	3.40E-04	
60571	Dieldrin	mg/l				5.20E-08	5.40E-08	5.20E-08	Y
84662	Diethyl phthalate	mg/l				1.70E+01	4.40E+01	1.70E+01	
131113	Dimethyl phthalate	mg/l				2.70E+02	1.10E+03	2.70E+02	
105679	Dimethylphenol, 2,4-	mg/l				3.80E-01	8.50E-01	3.80E-01	
534521	Dinitro-o-cresol, 4,6-	mg/l				1.30E-02	2.80E-01	1.30E-02	
51285	Dinitrophenol, 2,4-	mg/l				6.90E-02	5.30E+00	6.90E-02	
25550587	Dinitrophenols	mg/l				6.90E-02	5.30E+00	6.90E-02	
121142	Dinitrotoluene, 2,4-	mg/l				1.10E-04	3.40E-03	1.10E-04	
88857	Dinoseb	mg/l	0.007	0.007					
122667	Diphenylhydrazine, 1,2-	mg/l				3.60E-05	2.00E-04	3.60E-05	
85007	Diquat	mg/l	0.02	0.02					
1031078	Endosulfan sulfate	mg/l				6.20E-02	8.90E-02	6.20E-02	
959988	Endosulfan, alpha-	mg/l				6.20E-02	8.90E-02	6.20E-02	
33213659	Endosulfan, beta-	mg/l				6.20E-02	8.90E-02	6.20E-02	
145733	Endothall	mg/l	0.1	0.1					
72208	Endrin	mg/l	0.002	0.002		5.90E-05	6.00E-05	5.90E-05	
7421934	Endrin aldehyde	mg/l				2.90E-04	3.00E-04	2.90E-04	
106898	Epichlorohydrin	mg/l		0					
100414	Ethylbenzene	mg/l	0.7	0.7		5.30E-01	2.10E+00	5.30E-01	Y
106934	Ethylene dibromide	mg/l	0.00005	0					

Table A.14. Regulatory Action Levels for PGDP (Continued)

Parameter	Chemical	Units	Primary MCLs[a]	Primary MCLGs[a]	Secondary MCLs[a]	State Water Supply WQC[b]	State Fish Consump. WQC[b]	Fed. Combined WQC[c]	PGDP Significant List
206440	Fluoranthene	mg/l				1.30E-01	1.40E-01	1.30E-01	Y
86737	Fluorene	mg/l				1.10E+00	5.30E+00	1.10E+00	Y
7782414	Fluoride	mg/l	4	4	2	4.00E+00			
1071836	Glyphosate	mg/l	0.7	0.7					
76448	Heptachlor	mg/l	0.0004	0		7.90E-08	7.90E-08	7.90E-08	
1024573	Heptachlor epoxide	mg/l	0.0002	0		3.90E-08	3.90E-08	3.90E-08	
118741	Hexachlorobenzene	mg/l	0.001	0		2.80E-07	2.90E-07	2.80E-07	Y
87683	Hexachlorobutadiene	mg/l				4.40E-04	1.80E-02	4.40E-04	
319868	Hexachlorocyclo-hexane	mg/l				1.23E-05	4.14E-05	1.23E-05	
77474	Hexachlorocyclopentadiene	mg/l	0.05	0.05		4.00E-02	1.10E+00	4.00E-02	
67721	Hexachloroethane	mg/l				1.40E-03	3.30E-03	1.40E-03	
193395	Indeno(1,2,3-cd)pyrene	mg/l				3.80E-06	1.80E-05	3.80E-06	Y
7439896	Iron	mg/l			0.3	3.00E-01		3.00E-01	Y
78591	Isophorone	mg/l				3.50E-02	9.60E-01	3.50E-02	
7439921	Lead	mg/l	0.015	0		1.50E-02			Y
58899	Lindane	mg/l	0.0002	0.0002		9.80E-04	1.80E-03	9.80E-04	
7439965	Manganese	mg/l			0.05			5.00E-02	Y
7439976	Mercury	mg/l	0.002	0.002		2.00E-03	5.10E-05		Y
72435	Methoxychlor	mg/l	0.04	0.04		1.00E-01		1.00E-01	
74839	Methyl bromide	mg/l				4.70E-02	1.50E+00	4.70E-02	
75092	Methylene chloride	mg/l	0.005	0		4.60E-03	5.90E-01	4.60E-03	
22967926	Methylmercury	mg/kg					3.00E-01		
79118	Monochloroacetic acid	mg/l	0.06[d]	0.07					
108907	Monochlorobenzene	mg/l	0.1	0.1		1.30E-01	1.60E+00	1.30E-01	
621647	N-Nitrosodi-n-propylamine	mg/l				5.00E-06	5.10E-04	5.00E-06	Y
924163	N-Nitrosodibutylamine	mg/l				6.30E-06	2.20E-04	6.30E-06	
55185	N-Nitrosodiethylamine	mg/l				8.00E-07	1.24E-03	8.00E-07	
62759	N-Nitrosodimethylamine	mg/l				6.90E-07	3.00E-03	6.90E-07	
86306	N-Nitrosodiphenylamine	mg/l				3.30E-03	6.00E-03	3.30E-03	
930552	N-Nitrosopyrrolidine	mg/l				1.60E-05	3.40E-02	1.60E-05	
7440020	Nickel	mg/l				6.10E-01	4.60E+00	6.10E-01	Y
14797558	Nitrate (as N)	mg/l	10	10		1.00E+01		1.00E+01	
14797650	Nitrite (as N)	mg/l	1	1					

Table A.14. Regulatory Action Levels for PGDP (Continued)

Parameter	Chemical	Units	Primary MCLs[a]	Primary MCLGs[a]	Secondary MCLs[a]	State Water Supply WQC[b]	State Fish Consump. WQC[b]	Fed. Combined WQC[c]	PGDP Significant List
98953	Nitrobenzene	mg/l				1.70E-02	6.90E-01	1.70E-02	
35576911	Nitrosamines	mg/l				8.00E-07	1.24E-03	8.00E-07	
23135220	Oxamyl	mg/l	0.2	0.2					
608935	Pentachlorobenzene	mg/l				1.40E-03	1.50E-03	1.40E-03	
87865	Pentachlorophenol	mg/l	0.001	0		2.70E-04	3.00E-03	2.70E-04	
108952	Phenol	mg/l				2.10E+01	1.70E+03	1.00E+01	
1918021	Picloram	mg/l	0.5	0.5					
1336363	Polychlorinated biphenyls (PCBs)	mg/l	0.0005	0		6.40E-08	6.40E-08	6.40E-08	Y
129000	Pyrene	mg/l				8.30E-01	4.00E+00	8.30E-01	Y
7782492	Selenium	mg/l	0.05	0.05		1.70E-01	4.20E+00	1.70E-01	Y
7440224	Silver	mg/l			0.1				Y
122349	Simazine	mg/l	0.004	0.004					
100425	Styrene	mg/l	0.1	0.1					
12143452	Sulfate	mg/l			250	2.50E+02			
1746016	TCDD, 2,3,7,8-	mg/l	0.00000003	0		5.00E-12	5.10E-12	5.00E-12	Y
95943	Tetrachlorobenzene, 1,2,4,5-	mg/l				9.70E-04	1.10E-03	9.70E-04	
79345	Tetrachloroethane, 1,1,2,2-	mg/l				1.70E-04	4.00E-03	1.70E-04	
127184	Tetrachloroethene	mg/l	0.005	0		6.90E-04	3.30E-03	6.90E-04	
7440280	Thallium	mg/l	0.002	0.0005		2.40E-04	4.70E-04	2.40E-04	
108883	Toluene	mg/l	1	1		1.30E+00	1.50E+01	1.30E+00	
8001352	Toxaphene	mg/l	0.003	0		2.80E-07	2.80E-07	2.80E-07	Y
76039	Trichloroacetic acid	mg/l	0.06[d]	0.02					Y
120821	Trichlorobenzene, 1,2,4-	mg/l	0.07	0.07		3.50E-02	7.00E-02	3.50E-02	
71556	Trichloroethane, 1,1,1-	mg/l	0.2	0.2		2.00E-01			
79005	Trichloroethane, 1,1,2-	mg/l	0.005	0.003		5.90E-04	1.60E-02	5.90E-04	
79016	Trichloroethene	mg/l	0.005	0		2.50E-03	3.00E-02	2.50E-03	Y
95954	Trichlorophenol, 2,4,5-	mg/l				1.80E+00	3.60E+00	1.80E+00	
88062	Trichlorophenol, 2,4,6-	mg/l				1.40E-03	2.40E-03	1.40E-03	
93721	Trichlorophenoxypropionic acid, 2,4,5-	mg/l	0.05	0.05		1.00E-02		1.00E-02	
	Trihalomethanes, total	mg/l	0.08						
7440611	Uranium	mg/l	0.03	0					Y
75014	Vinyl chloride	mg/l	0.002	0		2.50E-05	2.40E-03	2.50E-05	Y
1330207	Xylenes, total	mg/l	10	10					Y

Table A.14. Regulatory Action Levels for PGDP (Continued)

Parameter	Chemical	Units	Primary MCLs[a]	Primary MCLGs[a]	Secondary MCLs[a]	State Water Supply WQC[b]	State Fish Consump. WQC[b]	Fed. Combined WQC[c]	PGDP Significant List
7440666	Zinc	mg/l			5	7.40E+00	2.60E+01	7.40E+00	Y
12587461	Gross alpha	pCi/L	15	0					
12587472	Gross beta	mrem/yr	4	0					
	Ra-226 + Ra-228 Combined	pCi/L	5	0					
10028178	Tritium	pCi/L	20,000[g]						
13982633	Ra-226	pCi/L	5[g]						Y
13982633	Ra-226+D	pCi/L	5[g]						Y
15262201	Ra-228	pCi/L	5[g]						
15262201	Ra-228+D	pCi/L	5[g]						
14859677	Rn-222+D	pCi/L	300[g]						Y
10098972	Sr-90	pCi/L	8[g]						
10098972	Sr-90+D	pCi/L	8[g]						
14133767	Tc-99	pCi/L	900[g]						Y
14158293	U-232	pCi/L	20[g]						
13968553	U-233	pCi/L	20[g]						
13966295	U-234	pCi/L	20[g]						Y
15117961	U-235	pCi/L	20[g]						Y
15117961	U-235+D	pCi/L	20[g]						Y
13982702	U-236	pCi/L	20[g]						
14269751	U-237	pCi/L	20[g]						
744061	U-238	pCi/L	20[g]						Y
744061	U-238+D	pCi/L	20[g]						Y
15687533	U-240	pCi/L	20[g]						

Notes:

Values in this table were calculated using the best available information in December 2010. 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. Please see source materials for complete discussions of these values. Only values for water are provided. Values are for planning purposes only.

[a] From http://water.epa.gov/drink/contaminants/index.cfm

[b] From 401 KAR § 10:031 recodified from 401 KAR § 5:031

[c] From http://water.epa.gov/scitech/swguidance/waterquality/standards/current/index.cfm /

[d] MCL is for the sum of the concentrations for haloacetic acids.

[e] MCL is for the sum of the concentrations for trihalomethanes.

[f] http://water.epa.gov/scitech/swguidance/waterquality/standards/current/index.cfm indicates more stringent MCL has been issued.

[g] Calculated value at 4 mrem/yr per radionuclide

MFL = millions fibers per liter

APPENDIX B

DERIVATION OF PRELIMINARY REMEDIATION GOALS

PART 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)]. Methods used to derive the groundwater protection soil screening levels (SSLs) are not discussed because these are taken from a United States Environmental Protection Agency (EPA)-sponsored site on the World Wide Web (http://rais.ornl.gov/epa/ssl1.shtml).

1.1 INTRODUCTION

No action and action direct contact risk-based PRGs were derived using a modification of methods described in Risk Assessment Guidance for Superfund (RAGS), Part B. 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 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 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.

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.

1.2.1 Receptors

Table B.1 provides a matrix of 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, the recreational user, and the outdoor worker/gardener. The outdoor worker/gardener scenario replaces the "excavation worker" in the 2001 version of this document. The outdoor worker/gardener uses the same exposure parameters as the former excavation worker; the receptor name was changed to better reflect that the exposure parameters are designed to assess a long-term plant worker conducting outdoor maintenance activities. The 25-year exposure duration for the outdoor worker/gardener can be modified to a value between one and five years to generate site-specific values for exposures during excavation. 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 clean-up priority for the various areas and units at PGDP.

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 Derived for PGDP by Medium

Scenario/Receptor	Medium		
	Groundwater	Surface Water	Soil/Sediment
Outdoor worker/gardener	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. All groundwater screening is to be performed using the resident. Of the two receptors (i.e., child and adult), use of the child is more "conservative." Note that values for soil deemed protective of groundwater are also available and are based on the resident only.
2. The surface water screening value selected is 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 recreator values available, the child recreator values are most "conservative." Note, that two 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 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. Use of the recreator values for the resident is deemed appropriate because rates of contact for the recreator were selected assuming that the individual would be a local resident.
3. Determining which soil and sediment screening value is appropriate is a location-specific decision. For all areas inside the industrialized areas at PGDP where surface soil contamination is of concern, use of the industrial worker values is appropriate. For areas inside the industrialized areas at PGDP where subsurface soil of concern (i.e., soil down to 16 ft bgs), use of the outdoor worker/gardener values is appropriate. Site-specific values should be developed for sites at which excavation is expected (see Section 1.2.1.). For areas, outside the industrialized area, use of the recreator and/or resident values is appropriate. As with the surface water values, the child values are the most "conservative." Generally, the recreator values are more appropriate for areas along ditches and creeks (i.e., for bank soils), and the resident values are more appropriate for grassy fields. Also, note that the recreator and resident values are actually only applicable to surface soil.
4. As mentioned above, values for soil for protection of groundwater are also available. These should be used in all areas.

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 in the PRG derivation. The sources for these exposure parameters are provided in the tables in Appendix D. These exposure parameters are summarized in Table B-4 presented at the end of this appendix.

- Residential Scenario (Child and Adult)—Groundwater, Chemicals
  Ingestion of water (Table D.1), inhalation of vapors emitted from water during showering (Table D.2), inhalation of vapors emitted from water during household use (Table D.3), dermal contact with water during showering (Table D.4).

- Residential Scenario (Child and Adult)—Soil and Sediment, Chemicals
  Incidental ingestion of contaminated soil or sediment (Table D.5), dermal contact with contaminated soil or sediment (Table D.6), inhalation of particulates emitted from soil or sediment (Table D.7), inhalation of vapors emitted from soil or sediment (Table D.7).

- Residential Scenario (Child and Adult)—Soil and Sediment, Radionuclides
  Incidental ingestion of contaminated soil or sediment (Table D.5), inhalation of particulates emitted from soil or sediment (Table D.7), inhalation of vapors emitted from soil or sediment (Table D.7), external exposure to ionizing radiation from soil or sediment (Table D.18).

- Industrial Worker Scenario—Surface Water, Chemicals
  Dermal contact with contaminated surface water (Table D.33).

- Industrial Worker Scenario—Soil, Chemicals
  Incidental ingestion of contaminated soil (Table D.29), inhalation of particulates emitted from soil (Tables D.31), inhalation of vapors emitted from soil (Table D.31), dermal contact with contaminated soil (Table D.33).

- Industrial Worker Scenario—Soil, Radionuclides
  Incidental ingestion of contaminated soil (Table D.29), inhalation of particulates emitted from soil (Table D.31), inhalation of vapors emitted from soil (Table D.31), external exposure to ionizing radiation from soil (Table D.34).

- Outdoor worker/gardener Scenario—Surface Water, Chemicals
  Dermal contact with contaminated surface water (Table D.36).

- Outdoor worker/gardener Scenario—Soil and Sediment, Chemicals
  Incidental ingestion of contaminated soil or sediment (Table D.37), inhalation of particulates emitted from soil or sediment (Tables D.38), inhalation of vapors emitted from soil or sediment (Table D.38), dermal contact with contaminated soil or sediment (Table D.39).

- Outdoor worker/gardener Scenario—Soil and Sediment, Radionuclides
  Incidental ingestion of contaminated soil or sediment (Table D.37), inhalation of particulates emitted from soil or sediment (Table D.38), inhalation of vapors emitted from soil or sediment (Table D.38), external exposure to ionizing radiation from soil or sediment (Table D.40).

- Recreational User Scenario (Child, Teen, and Adult)—Sediment, Chemicals
  Incidental ingestion of contaminated sediment (Table D.15), dermal contact with contaminated sediment (Table D.16), inhalation of particulates emitted from sediment (Tables D.17), inhalation of vapors emitted from sediment (Table D.17).

- Recreational User Scenario (Child, Teen, and Adult)—Sediment, Radionuclides
  Incidental ingestion of contaminated sediment (Table D.15), inhalation of particulates emitted from sediment (Tables D.17), inhalation of vapors emitted from sediment (Table D.17), external exposure to ionizing radiation from soil or sediment (Table D.18).

- Recreational User Scenario (Child, Teen, and Adult)—Surface Water (Swimming), Chemicals
  Incidental ingestion of contaminated surface water (Table D.19), dermal contact with surface water (Table D.21).

- Recreational User Scenario (Child, Teen, and Adult)—Surface Water (Wading), Chemicals
  Dermal contact with surface water (Table D.20).

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.

“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. ”

Also 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."

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 Table B.5 of this appendix.

1.2.4 Values for Volatilization Factors

Derivation of PRGs requires that volatilization factors (VFs) be developed for each chemical based on its physical properties. The soil parameters used in the calculation of VFs are presented in Table B.6. The chemical-specific parameters used in the calculation of VFs and the VF values are presented in Table B.7.

1.2.5 Target Risk and Hazard Values

The target risk and hazard values used when deriving the risk-based concentrations for no action are 1×10^{-6} and 0.1, respectively. The target risk and hazard values used when deriving the risk-based concentrations for action are 1×10^{-4} and 3, respectively. 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 to no action.

1.3. METHOD OF DERIVATION

Each risk-based PRG is calculated using the same method. In the following, the method is first presented generally. An example derivation for trichloroethene in groundwater follows.

1.3.1 General

The general equation used to calculate all goals reflects the direct, linear relationship between the environmental concentrations and the risk or hazard estimate. This is shown in Eq. 1.

$$\frac{C}{TR} = \frac{UC}{UR} \qquad \textbf{Eq. 1}$$

where:

	C	The risk-based concentration (i.e., calculated value)
	TR	The target risks (see Sect. 1.2.4)
	UC	Unit concentration or activity (i.e., 1 mg/kg, 1 pCi/g, 1 mg/l, or 1 pCi/l)
	UR	Unit risk or hazard calculated for the unit concentration or activity

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$$C = \frac{UC \times TR}{UR} \qquad \textbf{Eq. 2}$$

This equation can be rearranged to solve for "C" as shown in Eq. 2.

As can be seen, the only unknown in Eq. 2 is "UR" or the unit risk or hazard posed by the analyte at the unit concentration or activity. This unknown is calculated using the equations and toxicity values discussed earlier. The calculation is shown in the following.

$$UR = \sum_{r=1}^{n} (CDI_r \times TV_r) \qquad \textbf{Eq. 3}$$

where:

UR	Unit risk or hazard
CDI_r	The chronic daily intake or absorbed dose for exposure route r. (See Eq. 4.)
TV_r	The chronic toxicity value for exposure route r. Note, this value varies for cancer and hazard calculations. For cancer calculations, TV_r is the cancer slope factor appropriate to exposure route r. For hazard calculations, TV_r is the inverse of the reference dose (RfD) appropriate to exposure route r.

$$CDI_r = UC \times EXP_r \qquad \textbf{Eq. 4}$$

where:

CDI_r	The chronic daily intake or absorbed dose for exposure route r
UC	The unit concentrations described earlier
Exp_r	The product of the exposure parameters included in the exposure equation for exposure route r shown in Appendix 4. Note, for some exposure equations, this solution requires chemical-specific parameters beyond the concentration of the chemical in the environmental medium.

Equations 1 through 4 can be combined as shown in Eq. 5 where all parameters are as previously defined.

$$C = \frac{UC \times TR}{\sum_{r=1}^{n} (UC \times Exp_r) \times TV_r} \qquad \textbf{Eq. 5}$$

where: All parameters are as previously defined.

1.3.2 Example Derivation for Trichloroethene in Groundwater

The following is an example calculation for the derivation of the risk-based concentration for trichloroethene in groundwater. The end-point considered in this example is cancer risk.

General Equation:

$$C = \frac{UC \times TR}{\sum_{r=1}^{n} (UC \times Exp_r) \times TV_r} \qquad \textbf{Eq. 6}$$

Expanding this for all exposure routes:

$$C = \frac{UC \times TR}{(UC \times Exp_o \times TV_o) + (UC \times Exp_{is} \times TV_i) + (UC \times Exp_{ih} \times TV_i) + (UC \times Exp_d \times TV_d)} \qquad \textbf{Eq. 7}$$

where:

C	Risk-based PRG for trichloroethene (lifetime = 4.70× 10^{-5} mg/l)
UC	Unit concentrations (1 mg/l)
TR	Target risk (1 × 10^{-6})
Exp_o	Exposure factor for ingestion of water [0.0176 liter/(kg × day)] (see Eq. 8)
TV_o	Oral cancer slope factor {3.22 × 10^{-1} [(mg/(kg × day)]$^{-1}$}
Exp_{is}	Exposure factor for inhalation in shower [0.0077 liter/(kg × day)] (see Eq. 9)
TV_i	Inhalation cancer slope factor {3.22 × 10^{-1} [(mg/(kg × day)]$^{-1}$}
Exp_{ih}	Exposure factor for inhalation in home [0.0403 liter/(kg × day)] (see Eq. 11)
Exp_d	Exposure factor for dermal exposure while showering [4.57 × 10^{-4} liter/(kg × day)] (see Eq. 13)
TV_d	Absorbed dose cancer slope factor {0.322 [(mg/(kg × day)]$^{-1}$} (based on a GI absorption of 100%)

$$Exp_o = \left(\frac{IR_a \times EF \times ED_a}{BW_a \times AT} \right) + \left(\frac{IR_c \times EF \times ED_c}{BW_c \times AT} \right) \qquad \textbf{Eq. 8}$$

where:

Exp_o	Exposure factor for ingestion of water [0.0176 liter/(kg × day)]
IR_a	Intake rate of water by adult (2 liter/day)
EF	Exposure frequency (350 days/year)
ED_a	Exposure duration (24 years)
BW_a	Body weight of adult (70 kg)
AT	Averaging time (25,550 days)
IR_c	Intake rate of child (1.5 liter/day)
ED_c	Exposure duration (6 years)
BW_c	Body weight of child (15 kg)

$$Exp_{is} = \left(\frac{C_{shower} \times IR \ \times EF \times ED_a \times ET}{BW_a \times AT} \right) + \left(\frac{C_{shower} \times IR \ \times EF \times ED_c \times ET}{BW_c \times AT} \right) \tag{Eq. 9}$$

where:	Exp_{is}	Exposure factor for inhalation in shower [0.0077 liter/(kg × day)]
	C_{shower}	Chemical-specific parameters that are used to convert UC to concentration of TCE in air (4.55 liter/m^3) (see Eq. 10)
	IR	Inhalation rate (0.833 m^3/hour)
	EF	Exposure frequency (350 days/year)
	ED_a	Exposure duration for adult (24 years)
	ET	Exposure time (0.2 hours/day)
	BW_a	Body weight of adult (70 kg)
	AT	Averaging time (25,550 days)
	ED_c	Exposure duration for child (6 years)
	BW_c	Body weight of child (15 kg)

$$C_{shower} = \frac{\left[\frac{\left(\frac{f \times F_w \times t_1}{2} \right)}{V_a} \times t_1 \right] + \left(\frac{f \times F_w \times t_1 \times t_2}{V_a} \right)}{t_1 + t_2} \tag{Eq. 10}$$

where:	C_{shower}	Chemical-specific parameters that are used to convert UC to concentration of TCE in air (4.55 liter/m^3)
	f	Fraction volatilized (0.75)
	F_w	Water flow rate (890 liters/hour)
	t_1	Time of shower (0.1 hour)
	t_2	Time spent in bath after shower (0.1 hour)
	V_a	Volume of bathroom (11 m^3)

$$Exp_{ih} = \left(\frac{C_{house} \times IR \ \times EF \times ED_a \times ET}{BW_a \times AT} \right) + \left(\frac{C_{house} \times IR \ \times EF \times ED_c \times ET}{BW_c \times AT} \right) \tag{Eq. 11}$$

where:	Exp_{ih}	Exposure factor for inhalation in home [0.0403 liter/(kg × day)]
	C_{house}	Chemical-specific parameters that are used to convert UC to concentration of TCE in air (0.198 liter/m^3) (see Eq. 12)
	IR	Inhalation rate (0.833 m^3/hour)
	EF	Exposure frequency (350 days/year)
	ED_a	Exposure duration for adult (24 years)
	ET	Exposure time (24 hours/day)
	BW_a	Body weight of adult (70 kg)
	AT	Averaging time (25,550 days)
	ED_c	Exposure duration for child (6 years)
	BW_c	Body weight of child (15 kg)

$$C_{house} = \frac{WHF \times f}{HV \times ER \times MC}$$ **Eq. 12**

where:	C_{house}	Chemical-specific parameters that are used to convert UC to concentration of TCE in air (0.198 liter/m^3)
	WHF	Water flow rate (890 liters/day)
	f	Fraction volatilized (0.5)
	HV	House volume (450 m^3/change)
	ER	Exchange rate (10 changes/day)
	MC	Mixing coefficient (0.5)

$$Exp_d = \left(\frac{SA_a \times DAevent \times CFxCF1 \times EF \times ED_a \times EV}{BW_a \times AT} \right) + \left(\frac{SA_c \times DAevent \times CFxCF1 \times EF \times ED_c \times EV}{BW_c \times AT} \right)$$

Eq. 13

where:	Exp_d	Exposure factor for dermal exposure while showering [4.57 × 10^{-4} liter/(kg×day)]
	SA_a	Surface area exposed by adult during shower (1.815 m^2)
	DAevent	(1.08 × 10^{-5} L/cm^2-event) (Chemical-specific for TCE)
	CF	Conversion factor [10 (liters × m)/(cm × m^3)]
	CF1	Conversion factor for organics (1000 cm^3/L
	ED_a	Exposure duration for adult (24 years)
	EF	Exposure frequency (350 days/year)
	EV	Event/day
	BW_a	Body weight of an adult (70 kg)
	AT	Averaging time (25,550 days)
	SA_c	Surface area exposed by child during shower (0.62 m^2)
	ED_c	Exposure duration for child (6 years)
	BW_c	Body weight of child (15 kg)

1.3.3 Example Derivation for ^{99}Tc in Groundwater

The following is an example calculation for the derivation of the risk-based concentration for ^{99}Tc in groundwater. The end-point considered in this example is cancer risk. Note that only one exposure route, ingestion, is relevant to this derivation because ^{99}Tc is not volatile at ambient temperatures.

General Equation:

$$C = \frac{UC \times TR}{\sum_{r=1}^{n} (UC \times Exp_r) \times TV_r}$$ **Eq. 14**

Expanding this for the single exposure routes:

$$C = \frac{UC \times TR}{(UC \times Exp_o \times TV_o)} \qquad \textbf{Eq. 15}$$

where:	C	Risk-based PRG for ^{99}Tc (lifetime = 35.8 pCi/l)
	UC	Unit concentrations (1 pCi/l)
	TR	Target risk (1×10^{-6})
	Exp_o	Exposure factor for ingestion of water [19950 liter] (see Eq. 16)
	TV_o	Oral cancer slope factor $\{1.4 \times 10^{-12}$ [(risk/(liter)]}

$$Exp_o = \left(IR_a \times EF \times ED_a\right) + \left(IR_c \times EF \times ED_c\right) \qquad \textbf{Eq. 16}$$

where:	Exp_o	Exposure factor for ingestion of water (19950 liter)
	IR_a	Intake rate of water by adult (2 liter/day)
	EF	Exposure frequency (350 days/year)
	ED_o	Exposure duration (24 years)
	IR_c	Intake rate of child (1.5 liter/day)
	ED_c	Exposure duration (6 years)

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PART 2: DERIVATION OF DOSE-BASED PRELIMINARY REMEDIATION GOALS

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

2.1. INTRODUCTION

Direct contact dose-based PRGs 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 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). Additionally, dose-based SSLs for the protection of groundwater were derived using the Residual Radioactivity Materials Model (RESRAD) computer code, version 6.4. Note that risk-based SSLs were not derived, but were extracted from existing tables provided by the EPA.

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- or concentration-to-dose conversion factors, and target dose values. Each of these is discussed in the following.

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 exposure duration 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 the yield 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), and the outdoor worker/gardener. 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 clean-up 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 2-1 varies slightly from the version used in non radiological 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 Derived for PGDP by Medium

Scenario/Receptor	**Medium**		
	Groundwater	**Surface Water**	**Soil/Sediment**
Outdoor worker/gardener	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. All groundwater screening is to be performed using the resident. Note that values for soil deemed protective of groundwater are also available and are based on the resident only.
2. Dose-based values for surface water are only available for recreators.
3. Determining which soil and sediment screening value is appropriate is a location-specific decision. For all areas inside the industrialized areas at PGDP where surface soil contamination is of concern, use of the industrial worker values is appropriate. For areas inside the industrialized areas at PGDP where subsurface soil of concern (i.e., soil down to 16 ft bgs), use of the outdoor worker/gardener values is appropriate. Site-specific values should be developed for sites at which excavation is expected (see Section 1.2.1.). For areas, outside the industrialized area, use of the recreator and/or resident values is appropriate. Generally, the recreator values are more appropriate for areas along ditches and creeks (i.e., for bank soils), and the resident values are more appropriate for grassy fields. Also, note that the recreator and resident values are actually only applicable to surface soil.
4. As mentioned above, values for soil for protection of groundwater are also available. These should be used in all areas.

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. 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 are 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 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.

2.2.3 Toxicity Values

The toxicity values (DCFs) used in the derivation of the dose-based concentrations are taken from RESRAD output. The DCFs used in newer versions of RESRAD (6.1 to 6.4) are the same as those used in version 6.0. 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

Radionuclide	Pathway (units) Ingestion[a] (mrem/pCi)	Inhalation[a] (mrem/pCi)	External Gamma[b] (mrem/yr per pCi/g)
Americium-241	3.64E-03	4.44E-01	4.37E-02
Cesium-137	5.00E-05	3.19E-05	3.41E+00
Cobalt-60	2.69E-05	2.19E-04	1.62E+01
Neptunium-237+D	4.44E-03	5.40E-01	1.10E+00
Plutonium-238	3.20E-03	3.92E-01	1.51E-04
Plutonium-239	3.54E-03	4.29E-01	2.95E-04
Plutonium-240	3.54E-03	4.29E-01	1.47E-04
Radium-226+D	1.33E-03	8.60E-03	1.12E+01
Strontium-90+D	1.53E-04	1.31E-03	2.46E-02
Technetium-99	1.46E-06	8.33E-06	1.26E-04
Thorium-228+D	8.08E-04	3.45E-01	1.02E+01
Thorium-230	5.48E-04	3.26E-01	1.21E-03
Thorium-232	2.73E-03	1.64E+00	5.21E-04
Uranium-234	2.83E-04	1.32E-01	4.02E-04
Uranium-235+D	2.67E-04	1.23E-01	7.57E-01
Uranium-238+D	2.69E-04	1.18E-01	1.37E-01

Notes:
[a] From RESRAD version 6.4 output
[b] From RESRAD 6 Manual at http://web.ead.anl.gov/resrad/documents/
"D" stands for short-lived decay product (i.e., radioactive decay product with a half-life less than 6 months).

2.2.4 Target Dose Values

The target dose values used when deriving the dose-based concentrations in soil and sediment are 1.0, 15 and 25 mrem/yr. An additional target dose of 4.0 mrem/yr was added for the surface water and groundwater media in consideration of the federal drinking water standard (standards available at http://www.epa.gov/safewater/contaminants/index.html#listmcl).

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.

SSLs were calculated for each radionuclide of interest using the RESRAD code version 6.0, site-specific information related to geophysical characteristics at PGDP, and the same exposure parameter values used in risk-based calculations. The model included five distinct soil strata and distribution coefficients; the site-specific coefficients are generally and conservatively similar to the defaults for a sandy soil type (sandy soil shows the least retardation of downward migration). Exceptions include plutonium (100 cm^3/g was used instead of the 550 cm^3/g default) and neptunium (RESRAD assigned a value based on the soil-to-plant transfer factor). The model assumed a 10,000-year evaluation period, but some radionuclides still did not "break though" to groundwater where it could be ingested by a receptor.

Table B.4 includes list of exposure parameters using in calculation of human health PRGs. Table B.5 includes the toxicity values and information used in PRG derivation.

$$C_i = \frac{TD}{\sum_{i,j}\left(DCF_i \times A_{ij}\right)} \qquad \textbf{Eq. 1}$$

where:	C_i	The dose-based concentration for radionuclide "i" (i.e., calculated screening level)
	TD	The target doses (see Sect. 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"

Table B.4 Exposure Parameters Used in Calculation of Human Health PRGs (Compiled 3/17/2010)

RECEPTOR	LANDUSE	MEDIUM	MEDIA	PATHWAY	Exposure Frequency EF (days/year)	Exposure Duration ED (years)	Body Weight BW (kg)	Averaging Time for Cancer Risk AT_C (days)
Adult Resident	Residential	Water	Groundwater	Ingestion	350	24	70.0	25550
Child Resident	Residential	Water	Groundwater	Ingestion	350	6	15.0	25550
Adult Resident	Residential	Water	Groundwater	Inhalation/Showering	350	24	70.0	25550
Child Resident	Residential	Water	Groundwater	Inhalation/Showering	350	6	15.0	25550
Adult Resident	Residential	Water	Groundwater	Inhalation/Household Use	350	24	70.0	25550
Child Resident	Residential	Water	Groundwater	Inhalation/Household Use	350	6	15.0	25550
Adult Resident	Residential	Water	Groundwater	Dermal	350	24	70.0	25550
Child Resident	Residential	Water	Groundwater	Dermal	350	6	15.0	25550
Adult Resident	Residential	Soil	Soil	Ingestion	350	24	70.0	25550
Child Resident	Residential	Soil	Soil	Ingestion	350	6	15.0	25550
Adult Resident	Residential	Soil	Soil	Inhalation	350	24	70.0	25550
Child Resident	Residential	Soil	Soil	Inhalation	350	6	15.0	25550
Adult Resident	Residential	Soil	Soil	Dermal	350	24	70.0	25550
Child Resident	Residential	Soil	Soil	Dermal	350	6	15.0	25550
Adult Resident	Residential	Soil	Soil	External Exposure	350	24		
Child Resident	Residential	Soil	Soil	External Exposure	350	6		
Industrial Worker Default	Industrial	Water	Surface Water	Dermal	250	25	70.0	25550
Industrial Worker Default	Industrial	Soil	Soil	Ingestion	250	25	70.0	25550
Industrial Worker Default	Industrial	Soil	Soil	Inhalation	250	25	70.0	25550
Industrial Worker Default	Industrial	Soil	Soil	Dermal	250	25	70.0	25550
Industrial Worker Default	Industrial	Soil	Soil	External Exposure	250	25		
Industrial Worker Default	Industrial	Water	Groundwater	Ingestion	250	25	70.0	25550
Industrial Worker Default	Industrial	Water	Groundwater	Inhalation/Showering	250	25	70.0	25550
Industrial Worker Default	Industrial	Water	Groundwater	Dermal	250	25	70.0	25550
Industrial Worker Current	Industrial	Water	Surface Water	Dermal	250	25	70.0	25550
Industrial Worker Current	Industrial	Soil	Soil	Ingestion	250	25	70.0	25550
Industrial Worker Current	Industrial	Soil	Soil	Inhalation	250	25	70.0	25550
Industrial Worker Current	Industrial	Soil	Soil	Dermal	250	25	70.0	25550

Table B.4 Exposure Parameters Used in Calculation of Human Health PRGs (Compiled 3/17/2010) (Continued)

RECEPTOR	LANDUSE	MEDIUM	MEDIA	PATHWAY	Averaging Time for Noncancer Risk AT_N (days)	Correction Factor CF (units vary)	Correction Factor 2 CF2 (units vary)	Intake Rate of Medium IR (L/d water) or (mg/d soil)	Exposure Time ET (hours/day)
Adult Resident	Residential	Water	Groundwater	Ingestion	8760			2.0	
Child Resident	Residential	Water	Groundwater	Ingestion	2190			1.5	
Adult Resident	Residential	Water	Groundwater	Inhalation/Showering	8760				0.2
Child Resident	Residential	Water	Groundwater	Inhalation/Showering	2190				0.2
Adult Resident	Residential	Water	Groundwater	Inhalation/Household Use	8760				24.0
Child Resident	Residential	Water	Groundwater	Inhalation/Household Use	2190				24.0
Adult Resident	Residential	Water	Groundwater	Dermal	8760	10.00			0.2
Child Resident	Residential	Water	Groundwater	Dermal	2190	10.00			0.2
Adult Resident	Residential	Soil	Soil	Ingestion	8760	0.000001		100	
Child Resident	Residential	Soil	Soil	Ingestion	2190	0.000001		200	
Adult Resident	Residential	Soil	Soil	Inhalation	8760	1000.00			24.0
Child Resident	Residential	Soil	Soil	Inhalation	2190	1000.00			24.0
Adult Resident	Residential	Soil	Soil	Dermal	8760	0.01			
Child Resident	Residential	Soil	Soil	Dermal	2190	0.01			
Adult Resident	Residential	Soil	Soil	External Exposure					
Child Resident	Residential	Soil	Soil	External Exposure					
Industrial Worker Default	Industrial	Water	Surface Water	Dermal	9125	10.00			2.6
Industrial Worker Default	Industrial	Soil	Soil	Ingestion	9125	0.000001		50	
Industrial Worker Default	Industrial	Soil	Soil	Inhalation	9125	1000.00			8.0
Industrial Worker Default	Industrial	Soil	Soil	Dermal	9125	0.01			
Industrial Worker Default	Industrial	Soil	Soil	External Exposure					
Industrial Worker Default	Industrial	Water	Groundwater	Ingestion	9125			1.0	
Industrial Worker Default	Industrial	Water	Groundwater	Inhalation/Showering	9125				0.2
Industrial Worker Default	Industrial	Water	Groundwater	Dermal	9125	10.00			0.2
Industrial Worker Current	Industrial	Water	Surface Water	Dermal	9125	10.00			2.6
Industrial Worker Current	Industrial	Soil	Soil	Ingestion	9125	1000.00		50	
Industrial Worker Current	Industrial	Soil	Soil	Inhalation	9125	1000.00			
Industrial Worker Current	Industrial	Soil	Soil	Dermal	9125	0.01			

Table B.4 Exposure Parameters Used in Calculation of Human Health PRGs (Compiled 3/17/2010) (Continued)

RECEPTOR	LANDUSE	MEDIUM	MEDIA	PATHWAY	Fraction Ingested from Source FI (unitless)	Intake Rate of Air IR_AIR (m3/hr) or (m3/day)	Exposure Frequency for Rads EF_X (fraction of year; unitless)	Exposure Time for Rads TE (fraction of day; unitless)	Gamma Shielding Factor SE (unitless)
Adult Resident	Residential	Water	Groundwater	Ingestion					
Child Resident	Residential	Water	Groundwater	Ingestion					
Adult Resident	Residential	Water	Groundwater	Inhalation/Showering		0.833			
Child Resident	Residential	Water	Groundwater	Inhalation/Showering		0.833			
Adult Resident	Residential	Water	Groundwater	Inhalation/Household Use		0.833			
Child Resident	Residential	Water	Groundwater	Inhalation/Household Use		0.833			
Adult Resident	Residential	Water	Groundwater	Dermal					
Child Resident	Residential	Water	Groundwater	Dermal					
Adult Resident	Residential	Soil	Soil	Ingestion	1.00				
Child Resident	Residential	Soil	Soil	Ingestion	1.00				
Adult Resident	Residential	Soil	Soil	Inhalation		0.833			
Child Resident	Residential	Soil	Soil	Inhalation		0.833			
Adult Resident	Residential	Soil	Soil	Dermal					
Child Resident	Residential	Soil	Soil	Dermal					
Adult Resident	Residential	Soil	Soil	External Exposure			0.959	1.000	0.2
Child Resident	Residential	Soil	Soil	External Exposure			0.959	1.000	0.2
Industrial Worker Default	Industrial	Water	Surface Water	Dermal					
Industrial Worker Default	Industrial	Soil	Soil	Ingestion	1.00				
Industrial Worker Default	Industrial	Soil	Soil	Inhalation		2.5			
Industrial Worker Default	Industrial	Soil	Soil	Dermal					
Industrial Worker Default	Industrial	Soil	Soil	External Exposure			0.685	0.333	0.2
Industrial Worker Default	Industrial	Water	Groundwater	Ingestion					
Industrial Worker Default	Industrial	Water	Groundwater	Inhalation/Showering		0.6			
Industrial Worker Default	Industrial	Water	Groundwater	Dermal					
Industrial Worker Current	Industrial	Water	Surface Water	Dermal					
Industrial Worker Current	Industrial	Soil	Soil	Ingestion	1.00				
Industrial Worker Current	Industrial	Soil	Soil	Inhalation		20.0			
Industrial Worker Current	Industrial	Soil	Soil	Dermal					

Table B.4 Exposure Parameters Used in Calculation of Human Health PRGs (Compiled 3/17/2010) (Continued)

RECEPTOR	LANDUSE	MEDIUM	MEDIA	PATHWAY	Surface Area of Body Exposed SA (meters^2)	Adherence Factor AF (mg/cm^2)	Fraction Volatilized from Water F (unitless)	Flow Rate of Shower FW (l/hr)	Time Taken for Shower T1 (hour)
Adult Resident	Residential	Water	Groundwater	Ingestion					
Child Resident	Residential	Water	Groundwater	Ingestion					
Adult Resident	Residential	Water	Groundwater	Inhalation/Showering			0.75	890	0.1
Child Resident	Residential	Water	Groundwater	Inhalation/Showering			0.75	890	0.1
Adult Resident	Residential	Water	Groundwater	Inhalation/Household Use			0.75	890	
Child Resident	Residential	Water	Groundwater	Inhalation/Household Use			0.75	890	
Adult Resident	Residential	Water	Groundwater	Dermal	1.815				
Child Resident	Residential	Water	Groundwater	Dermal	0.650				
Adult Resident	Residential	Soil	Soil	Ingestion					
Child Resident	Residential	Soil	Soil	Ingestion					
Adult Resident	Residential	Soil	Soil	Inhalation					
Child Resident	Residential	Soil	Soil	Inhalation					
Adult Resident	Residential	Soil	Soil	Dermal	0.570	1.00			
Child Resident	Residential	Soil	Soil	Dermal	0.280	1.00			
Adult Resident	Residential	Soil	Soil	External Exposure					
Child Resident	Residential	Soil	Soil	External Exposure					
Industrial Worker Default	Industrial	Water	Surface Water	Dermal	0.470				
Industrial Worker Default	Industrial	Soil	Soil	Ingestion					
Industrial Worker Default	Industrial	Soil	Soil	Inhalation					
Industrial Worker Default	Industrial	Soil	Soil	Dermal	0.470	1.00			
Industrial Worker Default	Industrial	Soil	Soil	External Exposure					
Industrial Worker Default	Industrial	Water	Groundwater	Ingestion					
Industrial Worker Default	Industrial	Water	Groundwater	Inhalation/Showering			0.75	890	0.1
Industrial Worker Default	Industrial	Water	Groundwater	Dermal	1.815				
Industrial Worker Current	Industrial	Water	Surface Water	Dermal	0.470				
Industrial Worker Current	Industrial	Soil	Soil	Ingestion					
Industrial Worker Current	Industrial	Soil	Soil	Inhalation					
Industrial Worker Current	Industrial	Soil	Soil	Dermal	0.470	1.00			

Table B.4 Exposure Parameters Used in Calculation of Human Health PRGs (Compiled 3/17/2010) (Continued)

RECEPTOR	LANDUSE	MEDIUM	MEDIA	PATHWAY	Time in Bathroom After Shower T2 (hour)	Volume of Bathroom VA (m3)	House Volume HV (m^3/change)	Exchange Rate ER (changes/day)	Mixing Coefficient MC (unitless)
Adult Resident	Residential	Water	Groundwater	Ingestion					
Child Resident	Residential	Water	Groundwater	Ingestion					
Adult Resident	Residential	Water	Groundwater	Inhalation/Showering	0.1	11			
Child Resident	Residential	Water	Groundwater	Inhalation/Showering	0.1	11			
Adult Resident	Residential	Water	Groundwater	Inhalation/Household Use			450	10	0.5
Child Resident	Residential	Water	Groundwater	Inhalation/Household Use			450	10	0.5
Adult Resident	Residential	Water	Groundwater	Dermal					
Child Resident	Residential	Water	Groundwater	Dermal					
Adult Resident	Residential	Soil	Soil	Ingestion					
Child Resident	Residential	Soil	Soil	Ingestion					
Adult Resident	Residential	Soil	Soil	Inhalation					
Child Resident	Residential	Soil	Soil	Inhalation					
Adult Resident	Residential	Soil	Soil	Dermal					
Child Resident	Residential	Soil	Soil	Dermal					
Adult Resident	Residential	Soil	Soil	External Exposure					
Child Resident	Residential	Soil	Soil	External Exposure					
Industrial Worker Default	Industrial	Water	Surface Water	Dermal					
Industrial Worker Default	Industrial	Soil	Soil	Ingestion					
Industrial Worker Default	Industrial	Soil	Soil	Inhalation					
Industrial Worker Default	Industrial	Soil	Soil	Dermal					
Industrial Worker Default	Industrial	Soil	Soil	External Exposure					
Industrial Worker Default	Industrial	Water	Groundwater	Ingestion					
Industrial Worker Default	Industrial	Water	Groundwater	Inhalation/Showering	0.1	11			
Industrial Worker Default	Industrial	Water	Groundwater	Dermal					
Industrial Worker Current	Industrial	Water	Surface Water	Dermal					
Industrial Worker Current	Industrial	Soil	Soil	Ingestion					
Industrial Worker Current	Industrial	Soil	Soil	Inhalation					
Industrial Worker Current	Industrial	Soil	Soil	Dermal					

Table B.4 Exposure Parameters Used in Calculation of Human Health PRGs (Compiled 3/17/2010) (Continued)

RECEPTOR	LANDUSE	MEDIUM	MEDIA	PATHWAY	Exposure Frequency EF (days/year)	Exposure Duration ED (years)	Body Weight BW (kg)	Averaging Time for Cancer Risk AT_C (days)
Industrial Worker Current	Industrial	Soil	Soil	External Exposure	250	25	70.0	
Outdoor worker/gardener Default	Industrial	Soil	Soil	Ingestion	185	25	70.0	25550
Outdoor worker/gardener Default	Industrial	Soil	Soil	Inhalation	185	25	70.0	25550
Outdoor worker/gardener Default	Industrial	Soil	Soil	Dermal	185	25	70.0	25550
Outdoor worker/gardener Default	Industrial	Soil	Soil	External Exposure	185	25	70.0	25550
Outdoor worker/gardener Default	Industrial	Water	Surface Water	Dermal	20	25	70.0	25550
Outdoor worker/gardener Current	Industrial	Soil	Soil	Ingestion	20	1	70.0	25550
Outdoor worker/gardener Current	Industrial	Soil	Soil	Inhalation	20	1	70.0	25550
Outdoor worker/gardener Current	Industrial	Soil	Soil	Dermal	20	1	70.0	25550
Outdoor worker/gardener Current	Industrial	Soil	Soil	External Exposure	185	1		
Outdoor worker/gardener Current	Industrial	Water	Surface Water	Dermal	20	1	70.0	25550
Adult Recreator	Recreational	Soil	Soil	Ingestion	104	12	70.0	25550
Teen Recreator	Recreational	Soil	Soil	Ingestion	140	12	43.0	25550
Child Recreator	Recreational	Soil	Soil	Ingestion	140	6	15.0	25550
Adult Recreator	Recreational	Soil	Soil	Inhalation	104	12	70.0	25550
Teen Recreator	Recreational	Soil	Soil	Inhalation	140	12	43.0	25550
Child Recreator	Recreational	Soil	Soil	Inhalation	140	6	15.0	25550
Adult Recreator	Recreational	Soil	Soil	Dermal	104	12	70.0	25550
Teen Recreator	Recreational	Soil	Soil	Dermal	140	12	43.0	25550
Child Recreator	Recreational	Soil	Soil	Dermal	140	6	15.0	25550
Adult Recreator	Recreational	Soil	Soil	External Exposure	104	12		
Teen Recreator	Recreational	Soil	Soil	External Exposure	140	12		
Child Recreator	Recreational	Soil	Soil	External Exposure	140	6		
Adult Recreator	Recreational	Water	Surface Water	Ingestion	45	12	70.0	25550
Teen Recreator	Recreational	Water	Surface Water	Ingestion	45	12	43.0	25550
Child Recreator	Recreational	Water	Surface Water	Ingestion	45	6	15.0	25550
Adult Recreator/Swimming	Recreational	Water	Surface Water	Dermal	45	12	70.0	25550
Teen Recreator/Swimming	Recreational	Water	Surface Water	Dermal	45	12	43.0	25550
Child Recreator/Swimming	Recreational	Water	Surface Water	Dermal	45	6	15.0	25550

Table B.4 Exposure Parameters Used in Calculation of Human Health PRGs (Compiled 3/17/2010) (Continued)

RECEPTOR	LANDUSE	MEDIUM	MEDIA	PATHWAY	Averaging Time for Noncancer Risk AT_N (days)	Correction Factor CF (units vary)	Correction Factor 2 CF2 (units vary)	Intake Rate of Medium IR (L/d water) or (mg/d soil)	Exposure Time ET (hours/day)
Industrial Worker Current	Industrial	Soil	Soil	External Exposure					
Outdoor worker/gardener Default	Industrial	Soil	Soil	Ingestion	9125	0.000001		480	
Outdoor worker/gardener Default	Industrial	Soil	Soil	Inhalation	9125	1000.00			8.0
Outdoor worker/gardener Default	Industrial	Soil	Soil	Dermal	9125	0.01			
Outdoor worker/gardener Default	Industrial	Soil	Soil	External Exposure					
Outdoor worker/gardener Default	Industrial	Water	Surface Water	Dermal	9125	10.00			8.0
Outdoor worker/gardener Current	Industrial	Soil	Soil	Ingestion	365	1000.00		480	
Outdoor worker/gardener Current	Industrial	Soil	Soil	Inhalation	365	1000.00			
Outdoor worker/gardener Current	Industrial	Soil	Soil	Dermal	365	0.01			
Outdoor worker/gardener Current	Industrial	Soil	Soil	External Exposure					
Outdoor worker/gardener Current	Industrial	Water	Surface Water	Dermal	365	10.00			8.0
Adult Recreator	Recreational	Soil	Soil	Ingestion	4380	0.000001	0.0417	100	5.0
Teen Recreator	Recreational	Soil	Soil	Ingestion	4380	0.000001	0.0417	100.	5.0
Child Recreator	Recreational	Soil	Soil	Ingestion	2190	0.000001	0.0417	200	5.0
Adult Recreator	Recreational	Soil	Soil	Inhalation	4380	1000.00			5.0
Teen Recreator	Recreational	Soil	Soil	Inhalation	4380	1000.00			5.0
Child Recreator	Recreational	Soil	Soil	Inhalation	2190	1000.00			5.0
Adult Recreator	Recreational	Soil	Soil	Dermal	4380	0.01			
Teen Recreator	Recreational	Soil	Soil	Dermal	4380	0.01			
Child Recreator	Recreational	Soil	Soil	Dermal	2190	0.01			
Adult Recreator	Recreational	Soil	Soil	External Exposure					
Teen Recreator	Recreational	Soil	Soil	External Exposure					
Child Recreator	Recreational	Soil	Soil	External Exposure					
Adult Recreator	Recreational	Water	Surface Water	Ingestion	4380			0. 13	2.6
Teen Recreator	Recreational	Water	Surface Water	Ingestion	4380			0.13	2.6
Child Recreator	Recreational	Water	Surface Water	Ingestion	2190			0.13	2.6
Adult Recreator/Swimming	Recreational	Water	Surface Water	Dermal	4380	10.00			2.6
Teen Recreator/Swimming	Recreational	Water	Surface Water	Dermal	4380	10.00			2.6
Child Recreator/Swimming	Recreational	Water	Surface Water	Dermal	2190	10.00			2.6

Table B.4 Exposure Parameters Used in Calculation of Human Health PRGs (Compiled 3/17/2010) (Continued)

RECEPTOR	LANDUSE	MEDIUM	MEDIA	PATHWAY	Fraction Ingested from Source FI (unitless)	Intake Rate of Air IR_AIR (m3/hr) or (m3/day)	Exposure Frequency for Rads EF_X (fraction of year; unitless)	Exposure Time for Rads TE (fraction of day; unitless)	Gamma Shielding Factor SE (unitless)
Industrial Worker Current	Industrial	Soil	Soil	External Exposure			0.685	0.333	0.2
Outdoor worker/gardener Default	Industrial	Soil	Soil	Ingestion	1.00				
Outdoor worker/gardener Default	Industrial	Soil	Soil	Inhalation		2.5			
Outdoor worker/gardener Default	Industrial	Soil	Soil	Dermal					
Outdoor worker/gardener Default	Industrial	Soil	Soil	External Exposure			0.507	0.333	0.2
Outdoor worker/gardener Default	Industrial	Water	Surface Water	Dermal					
Outdoor worker/gardener Current	Industrial	Soil	Soil	Ingestion	1.00				
Outdoor worker/gardener Current	Industrial	Soil	Soil	Inhalation		20.0			
Outdoor worker/gardener Current	Industrial	Soil	Soil	Dermal					
Outdoor worker/gardener Current	Industrial	Soil	Soil	External Exposure			0.055	0.333	0.2
Outdoor worker/gardener Current	Industrial	Water	Surface Water	Dermal					
Adult Recreator	Recreational	Soil	Soil	Ingestion	1.00				
Teen Recreator	Recreational	Soil	Soil	Ingestion	1.00				
Child Recreator	Recreational	Soil	Soil	Ingestion	1.00				
Adult Recreator	Recreational	Soil	Soil	Inhalation		2.5			
Teen Recreator	Recreational	Soil	Soil	Inhalation		2.5			
Child Recreator	Recreational	Soil	Soil	Inhalation		2.5			
Adult Recreator	Recreational	Soil	Soil	Dermal					
Teen Recreator	Recreational	Soil	Soil	Dermal					
Child Recreator	Recreational	Soil	Soil	Dermal					
Adult Recreator	Recreational	Soil	Soil	External Exposure			0.285	0.208	0
Teen Recreator	Recreational	Soil	Soil	External Exposure			0.384	0.208	0
Child Recreator	Recreational	Soil	Soil	External Exposure			0.384	0.208	0
Adult Recreator	Recreational	Water	Surface Water	Ingestion					
Teen Recreator	Recreational	Water	Surface Water	Ingestion					
Child Recreator	Recreational	Water	Surface Water	Ingestion					
Adult Recreator/Swimming	Recreational	Water	Surface Water	Dermal					
Teen Recreator/Swimming	Recreational	Water	Surface Water	Dermal					
Child Recreator/Swimming	Recreational	Water	Surface Water	Dermal					

Table B.4 Exposure Parameters Used in Calculation of Human Health PRGs (Compiled 3/17/2010) (Continued)

RECEPTOR	LANDUSE	MEDIUM	MEDIA	PATHWAY	Surface Area of Body Exposed SA (meters^2)	Adherence Factor AF (mg/cm^2)	Fraction Volatilized from Water F (unitless)	Flow Rate of Shower FW (l/hr)	Time Taken for Shower T1 (hour)
Industrial Worker Current	Industrial	Soil	Soil	External Exposure					
Outdoor worker/gardener Default	Industrial	Soil	Soil	Ingestion					
Outdoor worker/gardener Default	Industrial	Soil	Soil	Inhalation					
Outdoor worker/gardener Default	Industrial	Soil	Soil	Dermal	0.470	1.00			
Outdoor worker/gardener Default	Industrial	Soil	Soil	External Exposure					
Outdoor worker/gardener Default	Industrial	Water	Surface Water	Dermal	0.470				
Outdoor worker/gardener Current	Industrial	Soil	Soil	Ingestion					
Outdoor worker/gardener Current	Industrial	Soil	Soil	Inhalation					
Outdoor worker/gardener Current	Industrial	Soil	Soil	Dermal	0.470	1.00			
Outdoor worker/gardener Current	Industrial	Soil	Soil	External Exposure					
Outdoor worker/gardener Current	Industrial	Water	Surface Water	Dermal	0.470				
Adult Recreator	Recreational	Soil	Soil	Ingestion					
Teen Recreator	Recreational	Soil	Soil	Ingestion					
Child Recreator	Recreational	Soil	Soil	Ingestion					
Adult Recreator	Recreational	Soil	Soil	Inhalation					
Teen Recreator	Recreational	Soil	Soil	Inhalation					
Child Recreator	Recreational	Soil	Soil	Inhalation					
Adult Recreator	Recreational	Soil	Soil	Dermal	0.570	1.00			
Teen Recreator	Recreational	Soil	Soil	Dermal	0.750	1.00			
Child Recreator	Recreational	Soil	Soil	Dermal	0.280	1.00			
Adult Recreator	Recreational	Soil	Soil	External Exposure					
Teen Recreator	Recreational	Soil	Soil	External Exposure					
Child Recreator	Recreational	Soil	Soil	External Exposure					
Adult Recreator	Recreational	Water	Surface Water	Ingestion					
Teen Recreator	Recreational	Water	Surface Water	Ingestion					
Child Recreator	Recreational	Water	Surface Water	Ingestion					
Adult Recreator/Swimming	Recreational	Water	Surface Water	Dermal	1.815				
Teen Recreator/Swimming	Recreational	Water	Surface Water	Dermal	1.310				
Child Recreator/Swimming	Recreational	Water	Surface Water	Dermal	0.650				

Table B.4 Exposure Parameters Used in Calculation of Human Health PRGs (Compiled 3/17/2010) (Continued)

RECEPTOR	LANDUSE	MEDIUM	MEDIA	PATHWAY	Time in Bathroom After Shower T2 (hour)	Volume of Bathroom VA (m3)	House Volume HV (m^3/change)	Exchange Rate ER (changes/day)	Mixing Coefficient MC (unitless)
Industrial Worker Current	Industrial	Soil	Soil	External Exposure					
Outdoor worker/gardener Default	Industrial	Soil	Soil	Ingestion					
Outdoor worker/gardener Default	Industrial	Soil	Soil	Inhalation					
Outdoor worker/gardener Default	Industrial	Soil	Soil	Dermal					
Outdoor worker/gardener Default	Industrial	Soil	Soil	External Exposure					
Outdoor worker/gardener Default	Industrial	Water	Surface Water	Dermal					
Outdoor worker/gardener Current	Industrial	Soil	Soil	Ingestion					
Outdoor worker/gardener Current	Industrial	Soil	Soil	Inhalation					
Outdoor worker/gardener Current	Industrial	Soil	Soil	Dermal					
Outdoor worker/gardener Current	Industrial	Soil	Soil	External Exposure					
Outdoor worker/gardener Current	Industrial	Water	Surface Water	Dermal					
Adult Recreator	Recreational	Soil	Soil	Ingestion					
Teen Recreator	Recreational	Soil	Soil	Ingestion					
Child Recreator	Recreational	Soil	Soil	Ingestion					
Adult Recreator	Recreational	Soil	Soil	Inhalation					
Teen Recreator	Recreational	Soil	Soil	Inhalation					
Child Recreator	Recreational	Soil	Soil	Inhalation					
Adult Recreator	Recreational	Soil	Soil	Dermal					
Teen Recreator	Recreational	Soil	Soil	Dermal					
Child Recreator	Recreational	Soil	Soil	Dermal					
Adult Recreator	Recreational	Soil	Soil	External Exposure					
Teen Recreator	Recreational	Soil	Soil	External Exposure					
Child Recreator	Recreational	Soil	Soil	External Exposure					
Adult Recreator	Recreational	Water	Surface Water	Ingestion					
Teen Recreator	Recreational	Water	Surface Water	Ingestion					
Child Recreator	Recreational	Water	Surface Water	Ingestion					
Adult Recreator/Swimming	Recreational	Water	Surface Water	Dermal					
Teen Recreator/Swimming	Recreational	Water	Surface Water	Dermal					
Child Recreator/Swimming	Recreational	Water	Surface Water	Dermal					

Table B.4 Exposure Parameters Used in Calculation of Human Health PRGs (Compiled 3/17/2010) (Continued)

RECEPTOR	LANDUSE	MEDIUM	MEDIA	PATHWAY	Exposure Frequency EF (days/year)	Exposure Duration ED (years)	Body Weight BW (kg)	Averaging Time for Cancer Risk AT_C (days)
Adult Recreator/Wading	Recreational	Water	Surface Water	Dermal	52	12	70.0	25550
Teen Recreator/Wading	Recreational	Water	Surface Water	Dermal	140	12	43.0	25550
Child Recreator/Wading	Recreational	Water	Surface Water	Dermal	140	6	15.0	25550

Table B.4 Exposure Parameters Used in Calculation of Human Health PRGs (Compiled 3/17/2010) (Continued)

RECEPTOR	LANDUSE	MEDIUM	MEDIA	PATHWAY	Averaging Time for Noncancer Risk AT_N (days)	Correction Factor CF (units vary)	Correction Factor 2 CF2 (units vary)	Intake Rate of Medium IR (mg/l water) or (kg/kg soil)	Exposure Time ET (hours/day)
Adult Recreator/Wading	Recreational	Water	Surface Water	Dermal	4380	10.00			2.6
Teen Recreator/Wading	Recreational	Water	Surface Water	Dermal	4380	10.00			2.6
Child Recreator/Wading	Recreational	Water	Surface Water	Dermal	2190	10.00			2.6

Table B.4 Exposure Parameters Used in Calculation of Human Health PRGs (Compiled 3/17/2010) (Continued)

RECEPTOR	LANDUSE	MEDIUM	MEDIA	PATHWAY	Fraction Ingested from Source FI (unitless)	Intake Rate of Air IR_AIR (m3/hr) or (m3/day)	Exposure Frequency for Rads EF_X (fraction of year; unitless)	Exposure Time for Rads TE (fraction of day; unitless)	Gamma Shielding Factor SE (unitless)
Adult Recreator/Wading	Recreational	Water	Surface Water	Dermal					
Teen Recreator/Wading	Recreational	Water	Surface Water	Dermal					
Child Recreator/Wading	Recreational	Water	Surface Water	Dermal					

Table B.4 Exposure Parameters Used in Calculation of Human Health PRGs (Compiled 3/17/2010) (Continued)

RECEPTOR	LANDUSE	MEDIUM	MEDIA	PATHWAY	Surface Area of Body Exposed SA (meters^2)	Adherence Factor AF (mg/cm^2)	Fraction Volatilized from Water F (unitless)	Flow Rate of Shower FW (l/hr)	Time Taken for Shower T1 (hour)
Adult Recreator/Wading	Recreational	Water	Surface Water	Dermal	1.060				
Teen Recreator/Wading	Recreational	Water	Surface Water	Dermal	0.750				
Child Recreator/Wading	Recreational	Water	Surface Water	Dermal	0.330				

Table B.4 Exposure Parameters Used in Calculation of Human Health PRGs (Compiled 3/17/2010) (Continued)

RECEPTOR	LANDUSE	MEDIUM	MEDIA	PATHWAY	Time in Bathroom After Shower T2 (hour)	Volume of Bathroom VA (m3)	House Volume HV (m^3/change)	Exchange Rate ER (changes/day)	Mixing Coefficient MC (unitless)
Adult Recreator/Wading	Recreational	Water	Surface Water	Dermal					
Teen Recreator/Wading	Recreational	Water	Surface Water	Dermal					
Child Recreator/Wading	Recreational	Water	Surface Water	Dermal					

Table B.5. Toxicity Values and Information Used in PRG Derivation

Chemical Abstract Number	Analyte	COPC	Primary	Tier	Used for Soil?	Used for Water?	Used for Food?	GI Absorption Factor (Unitless)	Reference for GI Absorption Factor	Oral RfD (RfDo)	Reference for RfDo
7429905	Aluminum	Y	Y		Y	Y	Y	1.00E+00	RAGS Part E	1.00E+00	PPRTV
7440360	Antimony (metallic)	Y	Y		Y	Y	Y	1.50E-01	RAGS Part E	4.00E-04	IRIS
7440382	Arsenic, Inorganic	Y	Y		Y	Y	Y	1.00E+00	RAGS Part E	3.00E-04	IRIS
7440393	Barium	Y	Y		Y	Y	Y	7.00E-02	RAGS Part E	2.00E-01	IRIS
7440417	Beryllium and compounds	Y	Y		Y	Y	Y	7.00E-03	RAGS Part E	2.00E-03	IRIS
7440428	Boron And Borates Only	Y	Y		Y	Y	Y	1.00E+00	RAGS Part E	2.00E-01	IRIS
7440439	Cadmium (Diet)	Y	Y		Y	N	Y	2.50E-02	RAGS Part E	1.00E-03	IRIS, a
7440439	Cadmium (Water)	Y	Y		N	Y	N	5.00E-02	RAGS Part E	5.00E-04	IRIS
16065831	Chromium(III), Insoluble Salts	Y	Y		Y	Y	Y	1.30E-02	RAGS Part E	1.50E+00	IRIS
1333820	Chromium VI (chromic acid mists)	Y	Y		N	Y	N	1.00E+00	RAGS Part E	3.00E-03	IRIS
18540299	Chromium(VI)	Y	Y		Y	N	Y	2.50E-02	RAGS Part E	3.00E-03	IRIS
7440473	Chromium (Total)	Y	Y		Y	Y	Y	0.013	RAGS Part E	1.50E+00	b
7440484	Cobalt	Y	Y		Y	Y	Y	1.00E+00	RAGS Part E	3.00E-04	PPRTV
7440508	Copper	Y	Y		Y	Y	Y	1.00E+00	RAGS Part E	4.00E-02	HEAST
7439896	Iron	Y	Y		Y	Y	Y	1.00E+00	RAGS Part E	7.00E-01	PPRTV
7439965	Manganese (Diet)	Y	Y		Y	Y	Y	1.00E+00	RAGS Part E	1.40E-01	IRIS
7439965	Manganese (Water)	Y	Y		Y	Y	Y	4.00E-02	RAGS Part E	2.40E-02	IRIS
7439976	Mercury, Inorganic Salts	Y	Y		Y	Y	Y	7.00E-02	RAGS Part E	3.00E-04	SURROGATE
7439987	Molybdenum	Y	Y		Y	Y	Y	1.00E+00	RAGS Part E	5.00E-03	IRIS
7440020	Nickel Soluble Salts	Y	Y		Y	Y	Y	4.00E-02	RAGS Part E	2.00E-02	IRIS
7782492	Selenium	Y	Y		Y	Y	Y	1.00E+00	RAGS Part E	5.00E-03	IRIS
7440224	Silver	Y	Y		Y	Y	Y	4.00E-02	RAGS Part E	5.00E-03	IRIS
7791120	Thallium Chloride	Y	Y		Y	Y	Y	1.00E+00	RAGS Part E	8.00E-05	IRIS, c
238	Uranium (Soluble Salts)	Y	Y		Y	Y	Y	1.00E+00	RAGS Part E	3.00E-03	IRIS
7440622	Vanadium, Metallic	Y	Y		Y	Y	Y	2.60E-02	RAGS Part E	7.00E-05	PPRTV
7440666	Zinc (Metallic)	Y	Y		Y	Y	Y	1.00E+00	RAGS Part E	3.00E-01	IRIS
83329	Acenaphthene	Y	Y		Y	Y	Y	1.00E+00	RAGS Part E	6.00E-02	IRIS
208968	Acenaphthylene	Y	Y		Y	Y	Y	1.00E+00	RAGS Part E		
107131	Acrylonitrile	Y	Y		Y	Y	Y	1.00E+00	RAGS Part E	4.00E-02	ATSDR
120127	Anthracene	Y	Y		Y	Y	Y	1.00E+00	RAGS Part E	3.00E-01	IRIS
12674112	Aroclor 1016 (exposure to soil or food)	Y	Y	High	Y	N	Y	1.00E+00	RAGS Part E	7.00E-05	IRIS
12674112	Aroclor 1016 (exposure to water)	Y	Y	Low	N	Y	N	1.00E+00	RAGS Part E	7.00E-05	IRIS
11104282	Aroclor 1221 (exposure to soil or food)	Y	Y	High	Y	N	Y	1.00E+00	RAGS Part E		
11104282	Aroclor 1221 (exposure to water)	Y	Y	Low	N	Y	N	1.00E+00	RAGS Part E		
11141165	Aroclor 1232 (exposure to soil or food)	Y	Y	High	Y	N	Y	1.00E+00	RAGS Part E		
11141165	Aroclor 1232 (exposure to water)	Y	Y	Low	N	Y	N	1.00E+00	RAGS Part E		
53469219	Aroclor 1242 (exposure to soil or food)	Y	Y	High	Y	N	Y	1.00E+00	RAGS Part E		
53469219	Aroclor 1242 (exposure to water)	Y	Y	Low	N	Y	N	1.00E+00	RAGS Part E		
12672296	Aroclor 1248 (exposure to soil or food)	Y	Y	High	Y	N	Y	1.00E+00	RAGS Part E		
12672296	Aroclor 1248 (exposure to water)	Y	Y	Low	N	Y	N	1.00E+00	RAGS Part E		
11097691	Aroclor 1254 (exposure to soil or food)	Y	Y	High	Y	N	Y	1.00E+00	RAGS Part E	2.00E-05	IRIS
11097691	Aroclor 1254 (exposure to water)	Y	Y	Low	N	Y	N	1.00E+00	RAGS Part E	2.00E-05	IRIS
11096825	Aroclor 1260 (exposure to soil or food)	Y	Y	High	Y	N	Y	1.00E+00	RAGS Part E		
11096825	Aroclor 1260 (exposure to water)	Y	Y	Low	N	Y	N	1.00E+00	RAGS Part E		

Table B.5. Toxicity Values and Information Used in PRG Derivation (Continued)

Chemical Abstract Number	Analyte	COPC	Primary	Tier	Used for Soil?	Used for Water?	Used for Food?	GI Absorption Factor (Unitless)	Reference for GI Absorption Factor	Oral RfD (RfDo)	Reference for RfDo
56553	Benz[a]anthracene	Y	Y		Y	Y	Y	1.00E+00	RAGS Part E		
71432	Benzene	Y	Y		Y	Y	Y	1.00E+00	RAGS Part E	4.00E-03	IRIS
50328	Benzo[a]pyrene	Y	Y		Y	Y	Y	1.00E+00	RAGS Part E		
205992	Benzo[b]fluoranthene	Y	Y		Y	Y	Y	1.00E+00	RAGS Part E		
207089	Benzo[k]fluoranthene	Y	Y		Y	Y	Y	1.00E+00	RAGS Part E		
86748	Carbazole	Y	Y		Y	Y	Y	1.00E+00	RAGS Part E		
56235	Carbon Tetrachloride	Y	Y		Y	Y	Y	1.00E+00	RAGS Part E	4.00E-03	IRIS
67663	Chloroform	Y	Y		Y	Y	Y	1.00E+00	RAGS Part E	1.00E-02	IRIS
218019	Chrysene	Y	Y		Y	Y	Y	1.00E+00	RAGS Part E		
53703	Dibenz[a,h]anthracene	Y	Y		Y	Y	Y	1.00E+00	RAGS Part E		
75354	Dichloroethylene, 1,1-	Y	Y		Y	Y	Y	1.00E+00	RAGS Part E	5.00E-02	IRIS
540590	Dichloroethylene, 1,2- (Mixed Isomers)	Y	Y		Y	Y	Y	1.00E+00	RAGS Part E	9.00E-03	HEAST
156592	Dichloroethylene, 1,2-cis-	Y	Y		Y	Y	Y	1.00E+00	RAGS Part E	2.00E-03	IRIS
156605	Dichloroethylene, 1,2-trans-	Y	Y		Y	Y	Y	1.00E+00	RAGS Part E	2.00E-02	IRIS
60571	Dieldrin	Y	Y		Y	Y	Y	1.00E+00	RAGS Part E	5.00E-05	IRIS
1746016	Dioxins/Furans (Total)	Y	Y		Y	Y	Y	1.00E+00	RAGS Part E	1.00E-09	ATSDR
100414	Ethylbenzene	Y	Y		Y	Y	Y	1.00E+00	RAGS Part E	1.00E-01	IRIS
206440	Fluoranthene	Y	Y		Y	Y	Y	1.00E+00	RAGS Part E	4.00E-02	IRIS
86737	Fluorene	Y	Y		Y	Y	Y	1.00E+00	RAGS Part E	4.00E-02	IRIS
118741	Hexachlorobenzene	Y	Y		Y	Y	Y	1.00E+00	RAGS Part E	8.00E-04	IRIS
37871004	HpCDD, 2,3,7,8-	Y	Y		Y	Y	Y	1.00E+00	RAGS Part E	1.00E-07	WHO/TEF
38998753	HpCDF, 2,3,7,8-	Y	Y		Y	Y	Y	1.00E+00	RAGS Part E	1.00E-07	WHO/TEF
34465468	HxCDD, 2,3,7,8-	Y	Y		Y	Y	Y	1.00E+00	RAGS Part E	1.00E-08	WHO/TEF
55684941	HxCDF, 2,3,7,8-	Y	Y		Y	Y	Y	1.00E+00	RAGS Part E	1.00E-08	WHO/TEF
193395	Indeno[1,2,3-cd]pyrene	Y	Y		Y	Y	Y	1.00E+00	RAGS Part E		
91203	Naphthalene	Y	Y		Y	Y	Y	1.00E+00	RAGS Part E	2.00E-02	IRIS
88744	Nitroaniline, 2-	Y	Y		Y	Y	Y	1.00E+00	RAGS Part E	1.00E-02	SCREEN
621647	Nitroso-di-N-propylamine, N-	Y	Y		Y	Y	Y	1.00E+00	RAGS Part E		
3268879	OCDD	Y	Y		Y	Y	Y	1.00E+00	RAGS Part E	3.33E-06	WHO/TEF
39001020	OCDF	Y	Y		Y	Y	Y	1.00E+00	RAGS Part E	3.33E-06	WHO/TEF
36088229	PeCDD, 2,3,7,8-	Y	Y		Y	Y	Y	1.00E+00	RAGS Part E	1.00E-09	WHO/TEF
57117416	PeCDF, 1,2,3,7,8-	Y	Y		Y	Y	Y	1.00E+00	RAGS Part E	3.33E-08	WHO/TEF
57117314	PeCDF, 2,3,4,7,8-	Y	Y		Y	Y	Y	1.00E+00	RAGS Part E	3.33E-09	WHO/TEF
85018	Phenanthrene	Y	Y		Y	Y	Y	1.00E+00	RAGS Part E		
1336363	Polychlorinated Biphenyls (high risk)	Y	Y	High	Y	N	Y	1.00E+00	RAGS Part E		
1336363	Polychlorinated Biphenyls (low risk)	Y	Y	Low	N	Y	N	1.00E+00	RAGS Part E		
1336363	Polychlorinated Biphenyls (lowest risk)	Y	Y	Lowest	Y	Y	N	1.00E+00	RAGS Part E		
50328	Polynuclear Aromatic Hydrocarbons (Total)	Y	Y		Y	Y	Y	1.00E+00			
129000	Pyrene	Y	Y		Y	Y	Y	1.00E+00	RAGS Part E	3.00E-02	IRIS
1746016	TCDD, 2,3,7,8-	Y	Y		Y	Y	Y	1.00E+00	RAGS Part E	1.00E-09	ATSDR
51207319	TCDF, 2,3,7,8-	Y	Y		Y	Y	Y	1.00E+00	RAGS Part E	1.00E-08	WHO/TEF
127184	Tetrachloroethylene	Y	Y		Y	Y	Y	1.00E+00	RAGS Part E	1.00E-02	IRIS
79016	Trichloroethylene	Y	Y		Y	Y	Y	1.00E+00	RAGS Part E	3.00E-04	PPRTV
75014	Vinyl Chloride	Y	Y		Y	Y	Y	1.00E+00	RAGS Part E	3.00E-03	IRIS

Table B.5. Toxicity Values and Information Used in PRG Derivation (Continued)

Chemical Abstract Number	Analyte	COPC	Primary	Tier	Used for Soil?	Used for Water?	Used for Food?	GI Absorption Factor (Unitless)	Reference for GI Absorption Factor	Oral RfD (RfDo)	Reference for RfDo
1330207	Xylene, Mixture	Y	Y		Y	Y	Y	1.00E+00	RAGS Part E	2.00E-01	IRIS
106423	Xylene, P-	Y	Y		Y	Y	Y	1.00E+00	RAGS Part E	2.00E-01	IRIS
108383	Xylene, m-	Y	Y		Y	Y	Y	1.00E+00	RAGS Part E	2.00E-01	IRIS
95476	Xylene, o-	Y	Y		Y	Y	Y	1.00E+00	RAGS Part E	2.00E-01	IRIS
14596102	Am-241	Y	Y		Y	Y	Y	5.00E-04	HEAST		
10198400	Co-60	Y	Y		Y	Y	Y	1.00E-01	HEAST		
10045973	Cs-137+D	Y	Y		Y	Y	Y	1.00E+00	HEAST		
13994202	Np-237+D	Y	Y		Y	Y	Y	5.00E-04	HEAST		
13981163	Pu-238	Y	Y		Y	Y	Y	5.00E-04	HEAST		
15117483	Pu-239	Y	Y		Y	Y	Y	5.00E-04	HEAST		
14119336	Pu-240	Y	Y		Y	Y	Y	5.00E-04	HEAST		
14133767	Tc-99	Y	Y		Y	Y	Y	5.00E-01	HEAST		
14269637	Th-230	Y	Y		Y	Y	Y	5.00E-04	HEAST		
13966295	U-234	Y	Y		Y	Y	Y	2.00E-02	HEAST		
15117961	U-235+D	Y	Y		Y	Y	Y	2.00E-02	HEAST		
7440611	U-238+D	Y	Y		Y	Y	Y	2.00E-02	HEAST		

Table B.5. Toxicity Values and Information Used in PRG Derivation (Continued)

Chemical Abstract Number	Analyte	Absorbed Dose (RfDd)	Reference for RfDd	Inhalation (RfCi)	Reference for RfCi	Inhalation (RfDi)	Reference for RfDi	Oral Slope Factor (SFo)	Reference for Sfo
7429905	Aluminum	1.00E+00	CALC	5.00E-03	PPRTV	1.43E-03	CALC		
7440360	Antimony (metallic)	6.00E-05	CALC						
7440382	Arsenic, Inorganic	3.00E-04	CALC	1.50E-05	CALEPA	4.29E-06	CALC	1.50E+00	IRIS
7440393	Barium	1.40E-02	CALC	5.00E-04	HEAST	1.43E-04	CALC		
7440417	Beryllium and compounds	1.40E-05	CALC	2.00E-05	IRIS	5.71E-06	CALC	4.30E+00	prev. RAIS, e
7440428	Boron And Borates Only	2.00E-01	CALC	2.00E-02	HEAST	5.71E-03	CALC		
7440439	Cadmium (Diet)	2.50E-05	CALC	1.00E-05	ATSDR	2.86E-06	CALC	3.80E-01	CALOEHHA
7440439	Cadmium (Water)	2.50E-05	CALC	1.00E-05	ATSDR	2.86E-06	CALC	3.80E-01	CALOEHHA
16065831	Chromium(III), Insoluble Salts	1.95E-02	CALC						
1333820	Chromium VI (chromic acid mists)	3.00E-03	CALC	8.00E-06	IRIS	2.29E-06	CALC		
18540299	Chromium(VI)	7.50E-05	CALC	1.00E-04	IRIS	2.86E-05	CALC	5.00E-01	NJEPA
7440473	Chromium (Total)	1.95E-02	CALC		a				a
7440484	Cobalt	3.00E-04	CALC	6.00E-06	PPRTV	1.71E-06	CALC		
7440508	Copper	4.00E-02	CALC						
7439896	Iron	7.00E-01	CALC						
7439965	Manganese (Diet)	1.40E-01	CALC	5.00E-05	IRIS	1.43E-05	CALC		
7439965	Manganese (Water)	9.60E-04	CALC	5.00E-05	IRIS	1.43E-05	CALC		
7439976	Mercury, Inorganic Salts	2.10E-05	CALC						
7439987	Molybdenum	5.00E-03	CALC						
7440020	Nickel Soluble Salts	8.00E-04	CALC	9.00E-05	ATSDR	2.57E-05	CALC		
7782492	Selenium	5.00E-03	CALC	2.00E-02	CALEPA	5.71E-03	CALC		
7440224	Silver	2.00E-04	CALC						
7791120	Thallium Chloride	8.00E-05	CALC						
238	Uranium (Soluble Salts)	3.00E-03	CALC	3.00E-04	ATSDR	8.57E-05	CALC		
7440622	Vanadium, Metallic	1.82E-06	CALC	1.00E-04	ATSDR	2.86E-05	CALC		
7440666	Zinc (Metallic)	3.00E-01	CALC						
83329	Acenaphthene	6.00E-02	CALC	2.09E-01	b	5.97E-02	CALC		
208968	Acenaphthylene								
107131	Acrylonitrile	4.00E-02	CALC	2.00E-03	IRIS	5.71E-04	CALC	5.40E-01	IRIS
120127	Anthracene	3.00E-01	CALC	1.05E+00	b	3.00E-01	CALC		
12674112	Aroclor 1016 (exposure to soil or food)	7.00E-05	CALC	2.44E-04	b	6.97E-05	CALC	2.00E+00	RAIS, b
12674112	Aroclor 1016 (exposure to water)	7.00E-05	CALC	2.44E-04	b	6.97E-05	CALC	4.00E-01	RAIS, c
11104282	Aroclor 1221 (exposure to soil or food)							2.00E+00	RAIS, b
11104282	Aroclor 1221 (exposure to water)							4.00E-01	RAIS, c
11141165	Aroclor 1232 (exposure to soil or food)							2.00E+00	RAIS, b
11141165	Aroclor 1232 (exposure to water)							4.00E-01	RAIS, c
53469219	Aroclor 1242 (exposure to soil or food)							2.00E+00	RAIS, b
53469219	Aroclor 1242 (exposure to water)							4.00E-01	RAIS, c
12672296	Aroclor 1248 (exposure to soil or food)							2.00E+00	RAIS, b
12672296	Aroclor 1248 (exposure to water)							4.00E-01	RAIS, c
11097691	Aroclor 1254 (exposure to soil or food)	2.00E-05	CALC	6.98E-05	b	1.99E-05	CALC	2.00E+00	RAIS, b
11097691	Aroclor 1254 (exposure to water)	2.00E-05	CALC	6.98E-05	b	1.99E-05	CALC	4.00E-01	RAIS, c
11096825	Aroclor 1260 (exposure to soil or food)							2.00E+00	RAIS, b
11096825	Aroclor 1260 (exposure to water)							4.00E-01	RAIS, c

Table B.5. Toxicity Values and Information Used in PRG Derivation (Continued)

Chemical Abstract Number	Analyte	Absorbed Dose (RfDd)	Reference for RfDd	Inhalation (RfCi)	Reference for RfCi	Inhalation (RfDi)	Reference for RfDi	Oral Slope Factor (SFo)	Reference for Sfo
56553	Benz[a]anthracene							7.30E-01	WHO/TEF
71432	Benzene	4.00E-03	CALC	3.00E-02	IRIS	8.57E-03	CALC	5.50E-02	IRIS
50328	Benzo[a]pyrene							7.30E+00	IRIS
205992	Benzo[b]fluoranthene							7.30E-01	WHO/TEF
207089	Benzo[k]fluoranthene							7.30E-02	WHO/TEF
86748	Carbazole							2.00E-02	HEAST
56235	Carbon Tetrachloride	4.00E-03	CALC	1.00E-01	IRIS	2.86E-02	CALC	7.00E-02	IRIS
67663	Chloroform	1.00E-02	CALC	9.77E-02	ATSDR	2.79E-02	CALC	3.10E-02	CALEPA
218019	Chrysene							7.30E-03	WHO/TEF
53703	Dibenz[a,h]anthracene							7.30E+00	WHO/TEF
75354	Dichloroethylene, 1,1-	5.00E-02	CALC	2.00E-01	IRIS	5.71E-02	CALC	6.00E-01	RAIS
540590	Dichloroethylene, 1,2- (Mixed Isomers)	9.00E-03	CALC	3.14E-02	b	8.97E-03	CALC		
156592	Dichloroethylene, 1,2-cis-	2.00E-03	CALC	3.49E-02	b	9.97E-03	CALC		
156605	Dichloroethylene, 1,2-trans-	2.00E-02	CALC	6.00E-02	PPRTV	1.71E-02	CALC		
60571	Dieldrin	5.00E-05	CALC					1.60E+01	IRIS
1746016	Dioxins/Furans (Total)	1.00E-09	CALC	4.00E-08	CALEPA	1.14E-08	CALC	1.30E+05	CALEPA
100414	Ethylbenzene	1.00E-01	CALC	1.00E+00	IRIS	2.86E-01	CALC	1.10E-02	CALEPA
206440	Fluoranthene	4.00E-02	CALC	1.40E-01	b	4.00E-02	CALC		
86737	Fluorene	4.00E-02	CALC	1.40E-01	b	4.00E-02	CALC		
118741	Hexachlorobenzene	8.00E-04	CALC					1.60E+00	IRIS
37871004	HpCDD, 2,3,7,8-	1.00E-07	CALC	4.00E-06	WHO/TEF	1.14E-06	CALC	1.30E+03	RAIS, d
38998753	HpCDF, 2,3,7,8-	1.00E-07	CALC	4.00E-06	WHO/TEF	1.14E-06	CALC	1.30E+03	RAIS, d
34465468	HxCDD, 2,3,7,8-	1.00E-08	CALC	4.00E-07	WHO/TEF	1.14E-07	CALC	1.30E+04	RAIS, d
55684941	HxCDF, 2,3,7,8-	1.00E-08	CALC	4.00E-07	WHO/TEF	1.14E-07	CALC	1.30E+04	RAIS, d
193395	Indeno[1,2,3-cd]pyrene							7.30E-01	WHO/TEF
91203	Naphthalene	2.00E-02	CALC	3.00E-03	IRIS	8.57E-04	CALC		
88744	Nitroaniline, 2-	1.00E-02	CALC	5.00E-05	SCREEN	1.43E-05	CALC		
621647	Nitroso-di-N-propylamine, N-							7.00E+00	IRIS
3268879	OCDD	3.33E-06	CALC	1.33E-04	WHO/TEF	3.80E-05	CALC	3.90E+01	WHO/TEF
39001020	OCDF	3.33E-06	CALC	1.33E-04	WHO/TEF	3.80E-05	CALC	3.90E+01	WHO/TEF
36088229	PeCDD, 2,3,7,8-	1.00E-09	CALC	4.00E-08	WHO/TEF	1.14E-08	CALC	1.30E+05	WHO/TEF
57117416	PeCDF, 1,2,3,7,8-	3.33E-08	CALC	1.33E-06	WHO/TEF	3.80E-07	CALC	3.90E+03	WHO/TEF
57117314	PeCDF, 2,3,4,7,8-	3.33E-09	CALC	1.33E-07	WHO/TEF	3.80E-08	CALC	3.90E+04	WHO/TEF
85018	Phenanthrene								
1336363	Polychlorinated Biphenyls (high risk)							2.00E+00	IRIS
1336363	Polychlorinated Biphenyls (low risk)							4.00E-01	IRIS
1336363	Polychlorinated Biphenyls (lowest risk)							7.00E-02	IRIS
50328	Polynuclear Aromatic Hydrocarbons (Total)							7.30E+00	IRIS
129000	Pyrene	3.00E-02	CALC	1.05E-01	b	3.00E-02	CALC		
1746016	TCDD, 2,3,7,8-	1.00E-09	CALC	4.00E-08	CALEPA	1.14E-08	CALC	1.30E+05	CALEPA
51207319	TCDF, 2,3,7,8-	1.00E-08	CALC	4.00E-07	WHO/TEF	1.14E-07	CALC	1.30E+04	WHO/TEF
127184	Tetrachloroethylene	1.00E-02	CALC	2.71E-01	ATSDR	7.74E-02	CALC	5.40E-01	CALEPA
79016	Trichloroethylene	3.00E-04	CALC	4.00E-02	PPRTV	1.14E-02	CALC	3.22E-01	KRAG
75014	Vinyl Chloride	3.00E-03	CALC	1.00E-01	IRIS	2.86E-02	CALC	7.20E-01	IRIS

Table B.5. Toxicity Values and Information Used in PRG Derivation (Continued)

Chemical Abstract Number	Analyte	Absorbed Dose (RfDd)	Reference for RfDd	Inhalation (RfCi)	Reference for RfCi	Inhalation (RfDi)	Reference for RfDi	Oral Slope Factor (SFo)	Reference for Sfo
1330207	Xylene, Mixture	2.00E-01	CALC	1.00E-01	IRIS	2.86E-02	CALC		
106423	Xylene, P-	2.00E-01	CALC	7.00E-01	CALEPA	2.00E-01	CALC		
108383	Xylene, m-	2.00E-01	CALC	7.00E-01	CALEPA	2.00E-01	CALC		
95476	Xylene, o-	2.00E-01	CALC	7.00E-01	CALEPA	2.00E-01	CALC		
14596102	Am-241								
10198400	Co-60								
10045973	Cs-137+D								
13994202	Np-237+D								
13981163	Pu-238								
15117483	Pu-239								
14119336	Pu-240								
14133767	Tc-99								
14269637	Th-230								
13966295	U-234								
15117961	U-235+D								
7440611	U-238+D								

Table B.5. Toxicity Values and Information Used in PRG Derivation (Continued)

Chemical Abstract Number	Analyte	Oral Slope Factor for Water (SFow)	Oral Slope Factor for Soil (SFos)	Oral Slope Factor for Food (SFof)	Absorbed Dose Slope Factor (SFd)	Reference for SFd	Inhalation Slope Factor (SFi)	Reference for SFi	External Exposure Slope Factor (SFe)	Reference for SFe
7429905	Aluminum									
7440360	Antimony (metallic)									
7440382	Arsenic, Inorganic				1.50E+00	CALC	1.51E+01	CALC		
7440393	Barium									
7440417	Beryllium and compounds				6.14E+02	CALC, a	8.40E+00	CALC		
7440428	Boron And Borates Only									
7440439	Cadmium (Diet)				1.52E+01	CALC	6.30E+00	CALC		
7440439	Cadmium (Water)				7.60E+00	CALC	6.30E+00	CALC		
16065831	Chromium(III), Insoluble Salts									
1333820	Chromium VI (chromic acid mists)						2.94E+02	CALC		
18540299	Chromium(VI)				2.00E+01	CALC	2.94E+02	CALC		
7440473	Chromium (Total)						2.94E+02	CALC		
7440484	Cobalt						3.15E+01	CALC		
7440508	Copper									
7439896	Iron									
7439965	Manganese (Diet)									
7439965	Manganese (Water)									
7439976	Mercury, Inorganic Salts									
7439987	Molybdenum									
7440020	Nickel Soluble Salts						9.10E-01	CALC		
7782492	Selenium									
7440224	Silver									
7791120	Thallium Chloride									
238	Uranium (Soluble Salts)									
7440622	Vanadium, Metallic									
7440666	Zinc (Metallic)									
83329	Acenaphthene									
208968	Acenaphthylene									
107131	Acrylonitrile				5.40E-01	CALC	2.38E-01	CALC		
120127	Anthracene									
12674112	Aroclor 1016 (exposure to soil or food)				2.00E+00	CALC	2.00E+00	CALC		
12674112	Aroclor 1016 (exposure to water)				4.00E-01	CALC	3.50E-01	CALC		
11104282	Aroclor 1221 (exposure to soil or food)				2.00E+00	CALC	2.00E+00	CALC		
11104282	Aroclor 1221 (exposure to water)				4.00E-01	CALC	3.50E-01	CALC		
11141165	Aroclor 1232 (exposure to soil or food)				2.00E+00	CALC	2.00E+00	CALC		
11141165	Aroclor 1232 (exposure to water)				4.00E-01	CALC	3.50E-01	CALC		
53469219	Aroclor 1242 (exposure to soil or food)				2.00E+00	CALC	2.00E+00	CALC		
53469219	Aroclor 1242 (exposure to water)				4.00E-01	CALC	3.50E-01	CALC		
12672296	Aroclor 1248 (exposure to soil or food)				2.00E+00	CALC	2.00E+00	CALC		
12672296	Aroclor 1248 (exposure to water)				4.00E-01	CALC	3.50E-01	CALC		
11097691	Aroclor 1254 (exposure to soil or food)				2.00E+00	CALC	2.00E+00	CALC		
11097691	Aroclor 1254 (exposure to water)				4.00E-01	CALC	3.50E-01	CALC		
11096825	Aroclor 1260 (exposure to soil or food)				2.00E+00	CALC	2.00E+00	CALC		
11096825	Aroclor 1260 (exposure to water)				4.00E-01	CALC	3.50E-01	CALC		

Table B.5. Toxicity Values and Information Used in PRG Derivation (Continued)

Chemical Abstract Number	Analyte	Oral Slope Factor for Water (SFow)	Oral Slope Factor for Soil (SFos)	Oral Slope Factor for Food (SFof)	Absorbed Dose Slope Factor (SFd)	Reference for SFd	Inhalation Slope Factor (SFi)	Reference for SFi	External Exposure Slope Factor (SFe)	Reference for SFe
56553	Benz[a]anthracene				7.30E-01	CALC	3.85E-01	CALC		
71432	Benzene				5.50E-02	CALC	2.73E-02	CALC		
50328	Benzo[a]pyrene				7.30E+00	CALC	3.85E+00	CALC		
205992	Benzo[b]fluoranthene				7.30E-01	CALC	3.85E-01	CALC		
207089	Benzo[k]fluoranthene				7.30E-02	CALC	3.85E-01	CALC		
86748	Carbazole				2.00E-02	CALC				
56235	Carbon Tetrachloride				7.00E-02	CALC	2.10E-02	CALC		
67663	Chloroform				3.10E-02	CALC, a	8.05E-02	CALC		
218019	Chrysene				7.30E-03	CALC	3.85E-02	CALC		
53703	Dibenz[a,h]anthracene				7.30E+00	CALC	4.20E+00	CALC		
75354	Dichloroethylene, 1,1-				6.00E-01	CALC, a	1.75E-01	CALC		
540590	Dichloroethylene, 1,2- (Mixed Isomers)									
156592	Dichloroethylene, 1,2-cis-									
156605	Dichloroethylene, 1,2-trans-									
60571	Dieldrin				1.60E+01	CALC	1.61E+01	CALC		
1746016	Dioxins/Furans (Total)				1.30E+05	CALC	1.33E+05	CALC		
100414	Ethylbenzene				1.10E-02	CALC	8.75E-03	CALC		
206440	Fluoranthene									
86737	Fluorene									
118741	Hexachlorobenzene				1.60E+00	CALC	1.61E+00	CALC		
37871004	HpCDD, 2,3,7,8-				1.30E+03	CALC	1.33E+03	CALC		
38998753	HpCDF, 2,3,7,8-				1.30E+03	CALC	1.33E+03	CALC		
34465468	HxCDD, 2,3,7,8-				1.30E+04	CALC	1.33E+04	CALC		
55684941	HxCDF, 2,3,7,8-				1.30E+04	CALC	1.33E+04	CALC		
193395	Indeno[1,2,3-cd]pyrene				7.30E-01	CALC	3.85E-01	CALC		
91203	Naphthalene						1.19E-01	CALC		
88744	Nitroaniline, 2-									
621647	Nitroso-di-N-propylamine, N-				7.00E+00	CALC	7.00E+00	CALC		
3268879	OCDD				3.90E+01	CALC	3.99E+01	CALC		
39001020	OCDF				3.90E+01	CALC	3.99E+01	CALC		
36088229	PeCDD, 2,3,7,8-				1.30E+05	CALC	1.33E+05	CALC		
57117416	PeCDF, 1,2,3,7,8-				3.90E+03	CALC	3.99E+03	CALC		
57117314	PeCDF, 2,3,4,7,8-				3.90E+04	CALC	3.99E+04	CALC		
85018	Phenanthrene									
1336363	Polychlorinated Biphenyls (high risk)				2.00E+00	CALC	2.00E+00	CALC		
1336363	Polychlorinated Biphenyls (low risk)				4.00E-01	CALC	3.50E-01	CALC		
1336363	Polychlorinated Biphenyls (lowest risk)				7.00E-02	CALC	7.00E-02	CALC		
50328	Polynuclear Aromatic Hydrocarbons (Total)				7.30E+00	CALC	3.10E+00	PPRTV		
129000	Pyrene									
1746016	TCDD, 2,3,7,8-				1.30E+05	CALC	1.33E+05	CALC		
51207319	TCDF, 2,3,7,8-				1.30E+04	CALC	1.33E+04	CALC		
127184	Tetrachloroethylene				5.40E-01	CALC	2.07E-02	CALC		
79016	Trichloroethylene				3.22E-01	CALC	3.22E-01	KRAG		
75014	Vinyl Chloride				7.20E-01	CALC	1.54E-02	CALC		

Table B.5. Toxicity Values and Information Used in PRG Derivation (Continued)

Chemical Abstract Number	Analyte	Oral Slope Factor for Water (SFow)	Oral Slope Factor for Soil (SFos)	Oral Slope Factor for Food (SFof)	Absorbed Dose Slope Factor (SFd)	Reference for SFd	Inhalation Slope Factor (SFi)	Reference for SFi	External Exposure Slope Factor (SFe)	Reference for SFe
1330207	Xylene, Mixture									
106423	Xylene, P-									
108383	Xylene, m-									
95476	Xylene, o-									
14596102	Am-241	1.04E-10	2.17E-10	1.34E-10			2.81E-08	HEAST	2.76E-08	FGR12
10198400	Co-60	1.57E-11	4.03E-11	2.23E-11			3.58E-11	HEAST	1.24E-05	FGR12
10045973	Cs-137+D	3.04E-11	4.33E-11	3.74E-11			1.19E-11	HEAST	2.54E-06	FGR12
13994202	Np-237+D	6.74E-11	1.62E-10	9.10E-11			1.77E-08	HEAST	7.96E-07	FGR12
13981163	Pu-238	1.31E-10	2.72E-10	1.69E-10			3.36E-08	HEAST	7.22E-11	FGR12
15117483	Pu-239	1.35E-10	2.76E-10	1.74E-10			3.33E-08	HEAST	2.00E-10	FGR12
14119336	Pu-240	1.35E-10	2.77E-10	1.74E-10			3.33E-08	HEAST	6.98E-11	FGR12
14133767	Tc-99	2.75E-12	7.66E-12	4.00E-12			1.41E-11	HEAST	8.14E-11	FGR12
14269637	Th-230	9.10E-11	2.02E-10	1.19E-10			2.85E-08	HEAST	8.19E-10	FGR12
13966295	U-234	7.07E-11	1.58E-10	9.55E-11			1.14E-08	HEAST	2.52E-10	FGR12
15117961	U-235+D	7.18E-11	1.63E-10	9.76E-11			1.01E-08	HEAST	5.43E-07	HEAST
7440611	U-238+D	8.71E-11	2.10E-10	1.21E-10			9.35E-09	HEAST	1.14E-07	FGR12

Table B.5. Toxicity Values and Information Used in PRG Derivation (Continued)

Chemical Abstract Number	Analyte	EPA Cancer Class	Reference for EPA Cancer Class	Date With-drawn	Radionuclide Half-life (day)	Reference for Radionuclide Half-life	Volatile Organic?	PEF Res.	PEF Ind./ Comm.	Reference for PEF	VF Res.
7429905	Aluminum	NA						9.30E+08	6.20E+08	KRAG	
7440360	Antimony (metallic)	NA						9.30E+08	6.20E+08	KRAG	
7440382	Arsenic, Inorganic	A	IRIS	Jan-98				9.30E+08	6.20E+08	KRAG	
7440393	Barium	D	IRIS					9.30E+08	6.20E+08	KRAG	
7440417	Beryllium and compounds	B1	IRIS	Apr-98				9.30E+08	6.20E+08	KRAG	
7440428	Boron And Borates Only	NA		Apr-98				9.30E+08	6.20E+08	KRAG	
7440439	Cadmium (Diet)	B1	IRIS	Jul-97				9.30E+08	6.20E+08	KRAG	
7440439	Cadmium (Water)	B1	IRIS	Jul-97				9.30E+08	6.20E+08	KRAG	
16065831	Chromium(III), Insoluble Salts	D	IRIS					9.30E+08	6.20E+08	KRAG	
1333820	Chromium VI (chromic acid mists)	A	IRIS					9.30E+08	6.20E+08	KRAG	
18540299	Chromium(VI)	A	IRIS					9.30E+08	6.20E+08	KRAG	
7440473	Chromium (Total)	D	IRIS					9.30E+08	6.20E+08	KRAG	
7440484	Cobalt	NA						9.30E+08	6.20E+08	KRAG	
7440508	Copper	D	IRIS					9.30E+08	6.20E+08	KRAG	
7439896	Iron	NA						9.30E+08	6.20E+08	KRAG	
7439965	Manganese (Diet)	D	IRIS	Jan-98				9.30E+08	6.20E+08	KRAG	
7439965	Manganese (Water)	D	IRIS	Jan-98				9.30E+08	6.20E+08	KRAG	
7439976	Mercury, Inorganic Salts	D	IRIS	Sep-95				9.30E+08	6.20E+08	KRAG	3.10E+04
7439987	Molybdenum	NA						9.30E+08	6.20E+08	KRAG	
7440020	Nickel Soluble Salts	A, B2	CALOEHHA					9.30E+08	6.20E+08	KRAG	
7782492	Selenium	D	IRIS					9.30E+08	6.20E+08	KRAG	
7440224	Silver	D	IRIS					9.30E+08	6.20E+08	KRAG	
7791120	Thallium Chloride	D	IRIS	Sep-09				9.30E+08	6.20E+08	KRAG	
238	Uranium (Soluble Salts)	NA						9.30E+08	6.20E+08	KRAG	
7440622	Vanadium, Metallic	NA						9.30E+08	6.20E+08	KRAG	
7440666	Zinc (Metallic)	D	IRIS					9.30E+08	6.20E+08	KRAG	
83329	Acenaphthene	NA					YES	9.30E+08	6.20E+08	KRAG	8.38E+04
208968	Acenaphthylene	NA					YES	9.30E+08	6.20E+08	KRAG	1.13E+05
107131	Acrylonitrile	B1	IRIS				YES	9.30E+08	6.20E+08	KRAG	6.95E+03
120127	Anthracene	D	IRIS				YES	9.30E+08	6.20E+08	KRAG	3.11E+05
12674112	Aroclor 1016 (exposure to soil or food)	B2	IRIS					9.30E+08	6.20E+08	KRAG	3.72E+05
12674112	Aroclor 1016 (exposure to water)	B2	IRIS					9.30E+08	6.20E+08	KRAG	3.72E+05
11104282	Aroclor 1221 (exposure to soil or food)	B2	Region 6					9.30E+08	6.20E+08	KRAG	5.06E+04
11104282	Aroclor 1221 (exposure to water)	B2	Region 6					9.30E+08	6.20E+08	KRAG	5.06E+04
11141165	Aroclor 1232 (exposure to soil or food)	B2	Region 6					9.30E+08	6.20E+08	KRAG	5.06E+04
11141165	Aroclor 1232 (exposure to water)	B2	Region 6					9.30E+08	6.20E+08	KRAG	5.06E+04
53469219	Aroclor 1242 (exposure to soil or food)	B2	IRIS					9.30E+08	6.20E+08	KRAG	4.97E+05
53469219	Aroclor 1242 (exposure to water)	B2	IRIS					9.30E+08	6.20E+08	KRAG	4.97E+05
12672296	Aroclor 1248 (exposure to soil or food)	B2	Region 6					9.30E+08	6.20E+08	KRAG	
12672296	Aroclor 1248 (exposure to water)	B2	Region 6					9.30E+08	6.20E+08	KRAG	
11097691	Aroclor 1254 (exposure to soil or food)	B2	IRIS					9.30E+08	6.20E+08	KRAG	6.17E+05
11097691	Aroclor 1254 (exposure to water)	B2	IRIS					9.30E+08	6.20E+08	KRAG	6.17E+05
11096825	Aroclor 1260 (exposure to soil or food)	B2	IRIS					9.30E+08	6.20E+08	KRAG	9.87E+05
11096825	Aroclor 1260 (exposure to water)	B2	IRIS					9.30E+08	6.20E+08	KRAG	9.87E+05

Table B.5. Toxicity Values and Information Used in PRG Derivation (Continued)

Chemical Abstract Number	Analyte	EPA Cancer Class	Reference for EPA Cancer Class	Date With-drawn	Radionuclide Half-life (day)	Reference for Radionuclide Half-life	Volatile Organic?	PEF Res.	PEF Ind./ Comm.	Reference for PEF	VF Res.
56553	Benz[a]anthracene	B2	IRIS					9.30E+08	6.20E+08	KRAG	1.89E+06
71432	Benzene	A	IRIS				YES	9.30E+08	6.20E+08	KRAG	2.37E+03
50328	Benzo[a]pyrene	B2	IRIS					9.30E+08	6.20E+08	KRAG	1.27E+07
205992	Benzo[b]fluoranthene	B2	IRIS					9.30E+08	6.20E+08	KRAG	1.56E+07
207089	Benzo[k]fluoranthene	B2	IRIS					9.30E+08	6.20E+08	KRAG	1.58E+07
86748	Carbazole	NA						9.30E+08	6.20E+08	KRAG	2.00E+06
56235	Carbon Tetrachloride	B2	IRIS				YES	9.30E+08	6.20E+08	KRAG	1.28E+03
67663	Chloroform	B2	IRIS	Oct-07			YES	9.30E+08	6.20E+08	KRAG	2.09E+03
218019	Chrysene	B2	IRIS					9.30E+08	6.20E+08	KRAG	3.96E+06
53703	Dibenz[a,h]anthracene	B2	IRIS					9.30E+08	6.20E+08	KRAG	3.63E+07
75354	Dichloroethylene, 1,1-	C	IRIS				YES	9.30E+08	6.20E+08	KRAG	1.02E+03
540590	Dichloroethylene, 1,2- (Mixed Isomers)	NA					YES	9.30E+08	6.20E+08	KRAG	1.92E+03
156592	Dichloroethylene, 1,2-cis-	D	IRIS				YES	9.30E+08	6.20E+08	KRAG	1.94E+03
156605	Dichloroethylene, 1,2-trans-	NA					YES	9.30E+08	6.20E+08	KRAG	1.95E+03
60571	Dieldrin	B2	Region 6					9.30E+08	6.20E+08	KRAG	1.36E+06
1746016	Dioxins/Furans (Total)	B2	HEAST					9.30E+08	6.20E+08	KRAG	1.61E+06
100414	Ethylbenzene	D	IRIS				YES	9.30E+08	6.20E+08	KRAG	3.55E+03
206440	Fluoranthene	D	IRIS					9.30E+08	6.20E+08	KRAG	1.58E+06
86737	Fluorene	D	IRIS				YES	9.30E+08	6.20E+08	KRAG	1.67E+05
118741	Hexachlorobenzene	B2	Region 6					9.30E+08	6.20E+08	KRAG	2.96E+04
37871004	HpCDD, 2,3,7,8-	B2	r					9.30E+08	6.20E+08	KRAG	
38998753	HpCDF, 2,3,7,8-	B2	r					9.30E+08	6.20E+08	KRAG	
34465468	HxCDD, 2,3,7,8-	B2	r					9.30E+08	6.20E+08	KRAG	
55684941	HxCDF, 2,3,7,8-	B2	r					9.30E+08	6.20E+08	KRAG	
193395	Indeno[1,2,3-cd]pyrene	B2	IRIS					9.30E+08	6.20E+08	KRAG	3.24E+07
91203	Naphthalene	C	IRIS				YES	9.30E+08	6.20E+08	KRAG	2.77E+04
88744	Nitroaniline, 2-	NA						9.30E+08	6.20E+08	KRAG	2.68E+05
621647	Nitroso-di-N-propylamine, N-	B2	Region 6					9.30E+08	6.20E+08	KRAG	1.13E+05
3268879	OCDD	B2	r					9.30E+08	6.20E+08	KRAG	
39001020	OCDF	B2	r					9.30E+08	6.20E+08	KRAG	
36088229	PeCDD, 2,3,7,8-	B2	r					9.30E+08	6.20E+08	KRAG	
57117416	PeCDF, 1,2,3,7,8-	B2	r					9.30E+08	6.20E+08	KRAG	
57117314	PeCDF, 2,3,4,7,8-	B2	r					9.30E+08	6.20E+08	KRAG	
85018	Phenanthrene	D	IRIS				YES	9.30E+08	6.20E+08	KRAG	3.82E+05
1336363	Polychlorinated Biphenyls (high risk)	B2	IRIS					9.30E+08	6.20E+08	KRAG	5.48E+05
1336363	Polychlorinated Biphenyls (low risk)	B2	IRIS					9.30E+08	6.20E+08	KRAG	5.48E+05
1336363	Polychlorinated Biphenyls (lowest risk)	B2	IRIS					9.30E+08	6.20E+08	KRAG	5.48E+05
50328	Polynuclear Aromatic Hydrocarbons (Total)	B2	IRIS					9.30E+08	6.20E+08	KRAG	1.27E+07
129000	Pyrene	D	IRIS				YES	9.30E+08	6.20E+08	KRAG	1.41E+06
1746016	TCDD, 2,3,7,8-	B2	HEAST					9.30E+08	6.20E+08	KRAG	1.61E+06
51207319	TCDF, 2,3,7,8-	B2	r					9.30E+08	6.20E+08	KRAG	
127184	Tetrachloroethylene	NA	e				YES	9.30E+08	6.20E+08	KRAG	1.75E+03
79016	Trichloroethylene	NA					YES	9.30E+08	6.20E+08	KRAG	1.68E+03
75014	Vinyl Chloride	A	HEAST				YES	9.30E+08	6.20E+08	KRAG	8.77E+02

Table B.5. Toxicity Values and Information Used in PRG Derivation (Continued)

Chemical Abstract Number	Analyte	EPA Cancer Class	Reference for EPA Cancer Class	Date With-drawn	Radionuclide Half-life (day)	Reference for Radionuclide Half-life	Volatile Organic?	PEF Res.	PEF Ind./ Comm.	Reference for PEF	VF Res.
1330207	Xylene, Mixture	D	IRIS				YES	9.30E+08	6.20E+08	KRAG	3.65E+03
106423	Xylene, P-	NA					YES	9.30E+08	6.20E+08	KRAG	3.52E+03
108383	Xylene, m-	NA					YES	9.30E+08	6.20E+08	KRAG	3.44E+03
95476	Xylene, o-	NA					YES	9.30E+08	6.20E+08	KRAG	4.04E+03
14596102	Am-241	A	HEAST		1.58E+05	HEAST		9.30E+08	6.20E+08	KRAG	
10198400	Co-60	A	HEAST		1.92E+03	HEAST		9.30E+08	6.20E+08	KRAG	
10045973	Cs-137+D	A	HEAST		1.10E+04	HEAST		9.30E+08	6.20E+08	KRAG	
13994202	Np-237+D	A	HEAST		7.81E+08	HEAST		9.30E+08	6.20E+08	KRAG	
13981163	Pu-238	A	HEAST		3.20E+04	HEAST		9.30E+08	6.20E+08	KRAG	
15117483	Pu-239	A	HEAST		8.80E+06	HEAST		9.30E+08	6.20E+08	KRAG	
14119336	Pu-240	A	HEAST		2.39E+06	HEAST		9.30E+08	6.20E+08	KRAG	
14133767	Tc-99	A	HEAST		7.77E+07	HEAST		9.30E+08	6.20E+08	KRAG	
14269637	Th-230	A	HEAST		2.81E+07	HEAST		9.30E+08	6.20E+08	KRAG	
13966295	U-234	A	HEAST		8.94E+07	HEAST		9.30E+08	6.20E+08	KRAG	
15117961	U-235+D	A	HEAST		2.57E+11	HEAST		9.30E+08	6.20E+08	KRAG	
7440611	U-238+D	A	HEAST		1.63E+12	HEAST		9.30E+08	6.20E+08	KRAG	

Table B.5. Toxicity Values and Information Used in PRG Derivation (Continued)

Chemical Abstract Number	Analyte	VF Ind./ Comm.	Reference for VF	EPA Default ABS (Unitless)	Reference for EPA ABS	KY Default ABS (Unitless)	Reference for KY ABS	Permeability Constant	Reference for Permeability Constant
7429905	Aluminum			0.001	a	0.05	KRAG	1.00E-03	RAGS PART E
7440360	Antimony (metallic)			0.001	a	0.05	KRAG	1.00E-03	RAGS PART E
7440382	Arsenic, Inorganic			3.00E-02	b	0.03	KRAG, a	1.00E-03	RAGS PART E
7440393	Barium			0.001	a	0.05	KRAG	1.00E-03	RAGS PART E
7440417	Beryllium and compounds			0.001	c	0.007	KDEP	1.00E-03	RAGS PART E
7440428	Boron And Borates Only			0.001	a	0.05	KRAG	1.00E-03	RAGS PART E
7440439	Cadmium (Diet)			1.00E-03	b	0.001	KRAG, a	1.00E-03	RAGS PART E
7440439	Cadmium (Water)			1.00E-03	b	0.001	KRAG, a	1.00E-03	RAGS PART E
16065831	Chromium(III), Insoluble Salts			0.001	a	0.013	KDEP	1.00E-03	RAGS PART E
1333820	Chromium VI (chromic acid mists)			0.001	a	0.025	KDEP	2.00E-03	RAGS PART E
18540299	Chromium(VI)			0.001	a	0.025	KDEP	2.00E-03	RAGS PART E
7440473	Chromium (Total)			0.001	a	0.05	KRAG	1.00E-03	RAGS PART E
7440484	Cobalt			0.001	a	0.05	KRAG	4.00E-04	RAGS PART E
7440508	Copper			0.001	a	0.05	KRAG	1.00E-03	RAGS PART E
7439896	Iron			0.001	a	0.05	KRAG	1.00E-03	RAGS PART E
7439965	Manganese (Diet)			0.001	a	0.04	KDEP	1.00E-03	RAGS PART E
7439965	Manganese (Water)			0.001	a	0.04	KDEP	1.00E-03	RAGS PART E
7439976	Mercury, Inorganic Salts	2.08E+04	CALC	0.001	a	0.05	KRAG	1.00E-03	RAGS PART E
7439987	Molybdenum			0.001	a	0.05	KRAG	1.00E-03	RAGS PART E
7440020	Nickel Soluble Salts			0.001	a	0.04	KDEP	2.00E-04	RAGS PART E
7782492	Selenium			0.001	a	0.05	KRAG	1.00E-03	RAGS PART E
7440224	Silver			0.001	a	0.04	KDEP	6.00E-04	RAGS PART E
7791120	Thallium Chloride			0.001	a	0.05	KRAG	1.00E-03	RAGS PART E
238	Uranium (Soluble Salts)			0.001	a	0.05	KRAG	1.00E-03	RAGS PART E
7440622	Vanadium, Metallic			0.001	a	0.026	KDEP	1.00E-03	RAGS PART E
7440666	Zinc (Metallic)			0.001	a	0.05	KRAG	6.00E-04	RAGS PART E
83329	Acenaphthene	5.62E+04	CALC	1.30E-01	b	0.13	KRAG, a	8.60E-02	EPI Dermwin v2.0
208968	Acenaphthylene	7.57E+04	CALC	1.30E-01	b	0.25	KRAG	9.11E-02	EPI Dermwin v2.0
107131	Acrylonitrile	4.66E+03	CALC	0.01	a	0.25	KRAG	1.16E-03	EPI Dermwin v2.0
120127	Anthracene	2.09E+05	CALC	1.30E-01	b	0.13	KRAG, a	1.42E-01	EPI Dermwin v2.0
12674112	Aroclor 1016 (exposure to soil or food)	2.49E+05	CALC	0.14	b	0.14	KRAG, a	3.05E-01	EPI Dermwin v2.0
12674112	Aroclor 1016 (exposure to water)	2.49E+05	CALC	0.14	b	0.14	KRAG, a	3.05E-01	EPI Dermwin v2.0
11104282	Aroclor 1221 (exposure to soil or food)	3.40E+04		0.14	b	0.14	KRAG, a	1.40E-01	EPI Dermwin v2.0
11104282	Aroclor 1221 (exposure to water)	3.40E+04		0.14	b	0.14	KRAG, a	1.40E-01	EPI Dermwin v2.0
11141165	Aroclor 1232 (exposure to soil or food)	3.40E+04		0.14	b	0.14	KRAG, a	1.40E-01	EPI Dermwin v2.0
11141165	Aroclor 1232 (exposure to water)	3.40E+04		0.14	b	0.14	KRAG, a	1.40E-01	EPI Dermwin v2.0
53469219	Aroclor 1242 (exposure to soil or food)	3.33E+05	CALC	0.14	b	0.14	KRAG, a	5.45E-01	EPI Dermwin v2.0
53469219	Aroclor 1242 (exposure to water)	3.33E+05	CALC	0.14	b	0.14	KRAG, a	5.45E-01	EPI Dermwin v2.0
12672296	Aroclor 1248 (exposure to soil or food)			0.14	b	0.14	KRAG, a	5.84E-01	EPI Dermwin v2.0
12672296	Aroclor 1248 (exposure to water)			0.14	b	0.14	KRAG, a	5.84E-01	EPI Dermwin v2.0
11097691	Aroclor 1254 (exposure to soil or food)	4.14E+05	CALC	0.14	b	0.14	KRAG, a	7.51E-01	EPI Dermwin v2.0
11097691	Aroclor 1254 (exposure to water)	4.14E+05	CALC	0.14	b	0.14	KRAG, a	7.51E-01	EPI Dermwin v2.0
11096825	Aroclor 1260 (exposure to soil or food)	6.62E+05	CALC	0.14	b	0.14	KRAG, a	2.96E+00	EPI Dermwin v2.0
11096825	Aroclor 1260 (exposure to water)	6.62E+05	CALC	0.14	b	0.14	KRAG, a	2.96E+00	EPI Dermwin v2.0

Table B.5. Toxicity Values and Information Used in PRG Derivation (Continued)

Chemical Abstract Number	Analyte	VF Ind./ Comm.	Reference for VF	EPA Default ABS (Unitless)	Reference for EPA ABS	KY Default ABS (Unitless)	Reference for KY ABS	Permeability Constant	Reference for Permeability Constant
56553	Benz[a]anthracene	1.27E+06	CALC	1.30E-01	b	0.13	KRAG, a	5.52E-01	EPI Dermwin v2.0
71432	Benzene	1.59E+03	CALC	0.01	a	0.25	KRAG	1.49E-02	EPI Dermwin v2.0
50328	Benzo[a]pyrene	8.50E+06	CALC	1.30E-01	b	0.13	KRAG, a	7.13E-01	EPI Dermwin v2.0
205992	Benzo[b]fluoranthene	1.05E+07	CALC	1.30E-01	b	0.13	KRAG, a	4.17E-01	EPI Dermwin v2.0
207089	Benzo[k]fluoranthene	1.06E+07	CALC	1.30E-01	b	0.13	KRAG, a	6.91E-01	EPI Dermwin v2.0
86748	Carbazole	1.34E+06	CALC	1.00E-01	b	0.1	KRAG	5.36E-02	EPI Dermwin v2.0
56235	Carbon Tetrachloride	8.57E+02	CALC	0.01	a	0.25	KRAG	1.63E-02	EPI Dermwin v2.0
67663	Chloroform	1.40E+03	CALC	0.01	a	0.25	KRAG	6.83E-03	EPI Dermwin v2.0
218019	Chrysene	2.66E+06	CALC	1.30E-01	b	0.13	KRAG, a	5.96E-01	EPI Dermwin v2.0
53703	Dibenz[a,h]anthracene	2.44E+07	CALC	1.30E-01	b	0.13	KRAG, a	9.53E-01	EPI Dermwin v2.0
75354	Dichloroethylene, 1,1-	6.84E+02	CALC	0.01	a	0.25	KRAG	1.17E-02	EPI Dermwin v2.0
540590	Dichloroethylene, 1,2- (Mixed Isomers)	1.29E+03		0.01	a	0.25	KRAG	1.10E-02	EPI Dermwin v2.0
156592	Dichloroethylene, 1,2-cis-	1.30E+03	CALC	0.01	a	0.25	KRAG	1.10E-02	EPI Dermwin v2.0
156605	Dichloroethylene, 1,2-trans-	1.31E+03	CALC	0.01	a	0.25	KRAG	1.10E-02	EPI Dermwin v2.0
60571	Dieldrin	9.16E+05	CALC	1.00E-01	b	0.1	KRAG	3.26E-02	EPI Dermwin v2.0
1746016	Dioxins/Furans (Total)	1.08E+06	CALC	0.03	b	0.03	KRAG, a	8.08E-01	EPI Dermwin v2.0
100414	Ethylbenzene	2.38E+03	CALC	0.01	a	0.25	KRAG	4.93E-02	EPI Dermwin v2.0
206440	Fluoranthene	1.06E+06	CALC	1.30E-01	b	0.13	KRAG, a	3.08E-01	EPI Dermwin v2.0
86737	Fluorene	1.12E+05	CALC	1.30E-01	b	0.13	KRAG, a	1.10E-01	EPI Dermwin v2.0
118741	Hexachlorobenzene	1.99E+04	CALC	1.00E-01	b	0.1	KRAG	2.54E-01	EPI Dermwin v2.0
37871004	HpCDD, 2,3,7,8-			3.00E-02	b	0.03	KRAG,a	1.81E+00	EPI Dermwin v2.0
38998753	HpCDF, 2,3,7,8-			1.00E-01	b	0.1	KRAG	1.45E+00	EPI Dermwin v2.0
34465468	HxCDD, 2,3,7,8-			0.03	b	0.03	KRAG, a	2.86E+00	EPI Dermwin v2.0
55684941	HxCDF, 2,3,7,8-			1.00E-01	b	0.1	KRAG	1.35E+00	EPI Dermwin v2.0
193395	Indeno[1,2,3-cd]pyrene	2.18E+07	CALC	1.30E-01	b	0.13	KRAG, a	1.24E+00	EPI Dermwin v2.0
91203	Naphthalene	1.86E+04	CALC	1.30E-01	b	0.25	KRAG	4.66E-02	EPI Dermwin v2.0
88744	Nitroaniline, 2-	1.80E+05	CALC	1.00E-01	b	0.1	KRAG	4.46E-03	EPI Dermwin v2.0
621647	Nitroso-di-N-propylamine, N-	7.60E+04	CALC	1.00E-01	b	0.1	KRAG	2.33E-03	EPI Dermwin v2.0
3268879	OCDD			3.00E-02	b	0.03	KRAG, a	1.16E+00	EPI Dermwin v2.0
39001020	OCDF			1.00E-01	b	0.1	KRAG	2.63E+00	EPI Dermwin v2.0
36088229	PeCDD, 2,3,7,8-			3.00E-02	b	0.03	KRAG, a	2.41E-01	EPI Dermwin v2.0
57117416	PeCDF, 1,2,3,7,8-			1.00E-01	b	0.1	KRAG	6.27E-01	EPI Dermwin v2.0
57117314	PeCDF, 2,3,4,7,8-			1.00E-01	b	0.1	KRAG	6.27E-01	EPI Dermwin v2.0
85018	Phenanthrene	2.56E+05		1.30E-01	b	0.25	KRAG	1.44E-01	EPI Dermwin v2.0
1336363	Polychlorinated Biphenyls (high risk)	3.68E+05	CALC	1.40E-01	b	0.14	KRAG, a	5.45E-01	EPI Dermwin v2.0
1336363	Polychlorinated Biphenyls (low risk)	3.68E+05	CALC	1.40E-01	b	0.14	KRAG, a	5.45E-01	EPI Dermwin v2.0
1336363	Polychlorinated Biphenyls (lowest risk)	3.68E+05	CALC	1.40E-01	b	0.14	KRAG, a	5.45E-01	EPI Dermwin v2.0
50328	Polynuclear Aromatic Hydrocarbons (Total)	8.50E+06	CALC	0.13	b	0.13	KRAG, a		
129000	Pyrene	9.45E+05	CALC	1.30E-01	b	0.13	KRAG, a	2.01E-01	EPI Dermwin v2.0
1746016	TCDD, 2,3,7,8-	1.08E+06	CALC	3.00E-02	b	0.03	KRAG, a	8.08E-01	EPI Dermwin v2.0
51207319	TCDF, 2,3,7,8-			1.00E-01	b	0.1	KRAG	6.57E-01	EPI Dermwin v2.0
127184	Tetrachloroethylene	1.17E+03	CALC	0.01	a	0.25	KRAG	3.34E-02	EPI Dermwin v2.0
79016	Trichloroethylene	1.13E+03	CALC	0.01	a	0.25	KRAG	1.16E-02	EPI Dermwin v2.0
75014	Vinyl Chloride	5.89E+02	CALC	0.01	a	0.25	KRAG	8.38E-03	EPI Dermwin v2.0

Table B.5. Toxicity Values and Information Used in PRG Derivation (Continued)

Chemical Abstract Number	Analyte	VF Ind./ Comm.	Reference for VF	EPA Default ABS (Unitless)	Reference for EPA ABS	KY Default ABS (Unitless)	Reference for KY ABS	Permeability Constant	Reference for Permeability Constant
1330207	Xylene, Mixture	2.45E+03	CALC	0.01	a	0.25	KRAG	4.71E-02	EPI Dermwin v2.0
106423	Xylene, P-	2.36E+03	CALC	0.01	a	0.25	KRAG	4.93E-02	EPI Dermwin v2.0
108383	Xylene, m-	2.31E+03	CALC	0.01	a	0.25	KRAG	5.32E-02	EPI Dermwin v2.0
95476	Xylene, o-	2.71E+03	CALC	0.01	a	0.25	KRAG	4.71E-02	EPI Dermwin v2.0
14596102	Am-241								
10198400	Co-60								
10045973	Cs-137+D								
13994202	Np-237+D								
13981163	Pu-238								
15117483	Pu-239								
14119336	Pu-240								
14133767	Tc-99								
14269637	Th-230								
13966295	U-234								
15117961	U-235+D								
7440611	U-238+D								

Table B.5. Toxicity Values and Information Used in PRG Derivation (Continued)

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. “Primary” is a flag used to identify the significant COPCs for the PGDP.
3. “Tier” indicates the “risk level” used for PCB mixtures. The “high” risk level is used to derive action and no action levels for the PGDP.
4. “Used for Soil?”, “Used for Water?”, and “Used for Food?” are flags describing how individual values reported in later columns are used in risk analyses.
5. The “GI Absorption Factor” is a unitless value that is an estimate of the fraction of chemical absorbed from the gastrointestinal tract. This value is used with the Oral RfD and Oral Slope Factor to develop absorbed dose RFDs and Slope factors, respectively.
6. The references for the GI Absorption Factor are as follows:
   RAIS –RAGS Part E
   HEAST – Value taken from EPA’s HEAST database.
7. 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).
8. The references for the Oral RfDs are as follows:
   IRIS – Value taken from EPA’s IRIS database.
   HEAST – Value taken from EPA’s HEAST database.
   ATSDR – Value taken from Agency for Toxic Substances and Disease Registry.
   PPRTV – Provisional Peer Reviewed Toxicity Value.
   CALEPA – California Environmental Protection Agency.
   SURROGATE – toxicity value for a different but structurally similar chemical was used
   SCREEN – screening toxicity value in an appendix to certain PPRTV assessments used (see US EPA Region 3 screening table for details)
   a – As discussed in EPA’s IRIS, the oral toxicity values for “Cadmium (Diet)” are to be used for soil and food and the oral toxicity values for “Cadmium (Water)” are to be used for water.
   b – The toxicity values for Chromium (Total) are the Chromium (III) values for all but inhalation slope factor. The inhalation slope factor is that for Chromium (VI).
   c – This value has been withdrawn from IRIS or HEAST. The date withdrawn is provided later in the table.
9. The “Absorbed Dose RfD” calculated by multiplying the Oral RfD by the GI Absorption factor. The units for Absorbed Dose RfD are mg/(kg x day). This value is only applicable to chemical exposures. Absorbed Dose RfD value withdrawn from IRIS or HEAST is indicated as “CALC, a.” The date withdrawn is provided later in the table.
10. The “Inhalation RfC” is the chronic inhalation concentration used for inhalation routes of exposure. The units for Inhalation RfC are mg/m3.
11. The references for the Inhalation RfCs are as follows:
    IRIS – Value taken from EPA’s IRIS database.
    HEAST – Value taken from EPA’s HEAST database.
    ATSDR – Value taken from Agency for Toxic Substances and Disease Registry.
    CALEPA – California Environmental Protection Agency.
    PPRTV - Provisional Peer Reviewed Toxicity Value..
    SCREEN – screening toxicity value in an appendix to certain PPRTV assessments used (see US EPA Region 3 screening table for details)
    a – The toxicity values for Chromium (Total) are the Chromium (III) values for all but inhalation slope factor. The inhalation slope factor is that for Chromium (VI).

Table B.5. Toxicity Values and Information Used in PRG Derivation (Continued)

b – Value is extrapolated from Oral RfD consistent with methods used by EPA's Region 9.

12. The "Inhalation RfD" is the chronic inhalation reference dose derived from the Inhalation RfC using the formula below. The units for Inhalation RfD are mg/(kg x day).

$$\mathbf{RfD\,[mg/(kg \times day)] = \frac{RfC\,(mg/m^{3}) \times 20\,m^{3}\,/\,day}{70\,kg}}$$

13. 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 $[\text{mg}/(\text{kg} \times \text{day})]^{-1}$. The units on this value for radionuclides is $(\text{pCi})^{-1}$.

14. The references for the Oral Slope Factor are as follows:

IRIS – Value taken from EPA's IRIS database.
HEAST – Value taken from EPA's HEAST database.
CALOEHHA – Value taken from the California Office of Environmental Health Hazard Assessment.
CALEPA – California Environmental Protection Agency.
NJEPA – New Jersey Environmental Protection boundary.PPRTV - Provisional Peer Reviewed Toxicity Value.
Prev. RAIS – Value listed in previous version of ORNL's RAIS database.
R9/NC – Value listed is provisional and are taken from NCEA and EPA Region 9.
WHO/TEF – Value listed in the World Health Organization's toxic equivalency factors.

a – The toxicity values for Chromium (Total) are the Chromium (III) values for all but inhalation slope factor. The inhalation cancer slope factor reported is the inhalation slope factor for Chromium VI reported in EPA's IRIS data base. This inhalation slope factor is used here because a cancer slope factor for total chromium does not exist and because its use is consistent with the Commonwealth of Kentucky's interpretation of the study upon which the inhalation slope factor is based.

b – The cancer potency of PCB mixtures is determined using a three tiered approach that depends on the information available. Criteria for use of the High Risk and Persistence Tier include: food chain exposure; sediment or soil ingestion; dust or aerosol inhalation; dermal exposure if an absorption factor has been applied; any early-life exposure; and the presence of dioxin-like, tumor-promoting, or persistent congeners. This value, 2.00E+00 per (mg/kg)/day, is the upper-bound slope factor for the High Risk and Persistence Tier. The central-estimate slope factor for this tier is 1.00E+00 per (mg/kg)/day.

c – Criteria for use of the Low Risk and Persistence Tier includes: ingestion of water-soluble congeners; inhalation of evaporated congeners; and dermal exposure if no absorption factor has been applied. The value of 4.00E-01 per (mg/kg/day) is the upper-bound Oral Slope Factor for the Low Risk and Persistence Tier. The central-estimate Oral Slope Factor for the Low Risk and Persistence Tier is 3.00E-01 per (mg/kg/day). For ingestion of water-soluble congeners, the middle tier upper-bound slope factor can be converted to a unit risk of 1.00E-05 per (ug/L/day).

d – Van den Berg et al. (2006) presents the WHO 2005 TEFs for carcinogenic dioxins and furans and polychlorinated biphenyls. Ahlborg et al. (1994) presents the WHO 1994 TEFs for carcinogenic polychlorinated biphenyls 170 and 180 in *Toxic equivalency factors for dioxin-like PCBs: Report on a WHO-ECEH and IPCS consultation, December 1993. Chemosphere, Vol. 28, No. 6, 1049-1067*. Polycyclic aromatic hydrocarbon TEFs are presented in *Provisional Guidance for Quantitative Risk Assessment of Polycyclic Aromatic Hydrocarbons*.

e – This value has been withdrawn from IRIS or HEAST. The date withdrawn is provided later in the table.

15. "Oral Slope Factor for Water," "Oral Slope Factor for Soil," and "Oral Slope Factor for Food" are the indicated values for radionuclides. These medium-specific values were introduced for use since the last iteration of this table. The units for these factors are $(\text{pCi})^{-1}$.

16. The "Absorbed Dose Slope Factor" calculated by dividing the Oral Slope Factor by the GI Absorption factor. This value is only applicable to chemical exposures. Absorbed Dose Slope Factor value withdrawn from IRIS or HEAST is indicated as "CALC, a." The date withdrawn is provided later in the table. The units for Absorbed Dose Slope Factor are $[\text{mg}/(\text{kg x day})]^{-1}$ or $(\text{pCi})^{-1}$.

Table B.5. Toxicity Values and Information Used in PRG Derivation (Continued)

17. The “Inhalation Slope Factor” is the chronic inhalation slope factor used for inhalation routes of exposure. The units on this value for chemicals is $[\mathrm{mg}/(\mathrm{kg} \times \mathrm{day})]^{-1}$. The units on this value for radionuclides is $(\mathrm{pCi})^{-1}$. For chemicals, this value was calculated from the inhalation unit risks (when required) using the following formula:

$$\mathrm{SFI}\,[(\mathrm{mg/kg} \times \mathrm{day})]^{-1} = \frac{\mathit{Unit}\ \mathrm{Risk}\ (\mathit{mg}/\mathrm{m}^3)^{-1} \times 70\ \mathrm{kg}}{20\ \mathrm{m}^3\ /\ \mathit{day}}$$

HEAST - Value taken from EPA’s HEAST database.
KRAG- value is from Kentucky DEP Risk Assessment Guidance
PPRTV - Provisional Peer Reviewed Toxicity Value.

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 $[(\mathrm{pCi\ x\ year})/\mathrm{g}]^{-1}$.

19. The references for the External Exposure Slope Factor are as follows:
HEAST – Value taken from EPA’s HEAST website.

20. The “EPA Cancer Class” is the classification into which EPA has placed the chemical. These classes are defined as follows:
A – human carcinogen.
B – probable human carcinogen. There are two subclassification.
B1 – agents for which there is limited human data from epidemiologic studies.
B2 – agents for which there is sufficient evidence from animal studies and for which there is inadequate or no evidence from human epidemiologic studies.
C – possible human carcinogen.
D – not classifiable as to human carcinogenicity.
E – evidence of noncarcinogenicity for humans.
NA – No classification available.

21. The references for the EPA Cancer Class are as follows:
IRIS – Value taken from EPA’s IRIS database.
HEAST – Value taken from EPA’s HEAST database.
CALOEHHA – Taken from California OEHHA’s Cancer Potency Value table
Region 6 – Taken from Human Health Screening Values table for Region 6
r – The cancer class is “extrapolated” from that for the 2,3,7,8-TCDD base chemical.
All radionuclides are assumed to be Class A carcinogens as discussed in HEAST.

22. “Date Withdrawn” is the date on which the specified value was withdrawn from an EPA database.

23. “Radionuclide Half-life” and “Radionuclide Half-life Units” are the indicated physical properties for the radionclides listed.

24. “Volatile Organic?” is a flag used to specify if the chemical should be assessed as a vapor.

25. The “Particle Emission Factor” is a value used to assess inhalation routes of exposure. The particle emission factor is in units of m3/kg. The values for residential and industrial/commercial scenario listed are taken from the 2002 *Kentucky Risk Assessment Guidance.*

26. The “Volatilization Factor” is a value used to assess inhalation routes of exposure. The volatilization factor is in units of m3/kg. As indicated in the 2002 *Kentucky Risk Assessment Guidance,* the chemical-specific values for residential and industrial/commercial scenario listed here are calculated using Equation (8) of the EPA’s *Soil Screening Level Guidance User’s Guide* (1996).

27. The “EPA Default ABS” is the dermal absorption value recommended by EPA Region 4 in their guidance material. This value was used to derive dose from dermal absorption from soil used in calculation of Action PRGs. The dermal absorption value is unitless.

Table B.5. Toxicity Values and Information Used in PRG Derivation (Continued)

28. The references for EPA Default ABS are as follows:
ATSDR – Value taken from Agency for Toxic Substances and Disease Registry.
a – RAIS, values were taken from: United States Environmental Protection Agency. 1995. Supplemental *Guidance to RAGS: Region 4 Bulletins, Human Health Risk Assessment (Interim Guidance)*. Waste Management Division, Office of Health Assessment.
b – RAIS, values were taken from: *Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) Final*. July 2004. Exhibit 3-4.
c – RAIS, values were taken from: United States Environmental Protection Agency. 1992. Dermal *Exposure Assessment: Principles and Application. Interim Report*. EPA/600/8-91/011B. Office of Research and Development, Washington, D.C.

29. The “KY Default 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. This value was used to derive dose from dermal absorption from soil used in calculation of No Action PRGs. The dermal absorption value is unitless.

30. 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.

31. The references for Permeability Constant are as follows:
RAGS Part E – values were taken from: EPA 2004. *Risk Assessment Guidance for Superfund. Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) Final*. EPA/540/R/99/005. Exhibit 3-1, page 3-5. Available online at http://www.epa.gov/oswer/riskassessment/ragse/pdf/2004_1101_part_e.pdf
EPI Dermwin v2.0 – Values were taken from the RAIS website on January 3, 2011. Values on the website are estimated using EPA’s Estimation Program Interface Suite™ (EPA Dermwin v2.0).

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. The PGDP mean value for lead in surface soil from DOE 1995 (17 mg/kg) and the value for lead in RGA groundwater from Table A.13 (0.129 mg/L) should be used in place of the model default value.

Table B.6. 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$^{3)}$	res.	64.177
		ind./com.	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 (Lpore/Lsoil)		0.43
θw	Water-filled soil porosity (Lwater/Lsoil)		0.15

The revised diet values for the model are available at
http://www.epa.gov/superfund/health/contaminants/lead/ieubkfaq.htm.

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/gardener 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. The default soil ingestion value of 50 mg/kg can also be altered if there is a reliable basis for substituting a site-specific value.

Table B.7. Volatilaztion Parameters and VF Values

CAS #	Chemical	D_i (cm^2/s) from RAIS	D_i Ref in RAIS	D_w (cm^2/s) from RAIS	D_w Ref in RAIS	Unitless H' from RAIS	H Ref in RAIS
83329	Acenaphthene	5.06E-02	USEPA 2001	8.33E-06	USEPA 2001	7.52E-03	EPI HenryWin v3.2
208968	Acenaphthylene	4.50E-02	USEPA 2001	6.98E-06	USEPA 2001	4.66E-03	EPI HenryWin v3.2
107131	Acrylonitrile	1.14E-01	USEPA 2001	1.23E-05	USEPA 2001	5.64E-03	EPI HenryWin v3.2
120127	Anthracene	3.90E-02	USEPA 2001	7.85E-06	USEPA 2001	2.27E-03	EPI HenryWin v3.2
12674112	Aroclor 1016 (exposure to soil or food)	2.22E-02	15_2	5.42E-06	16_2	8.18E-03	2_16
12674112	Aroclor 1016 (exposure to water)	2.22E-02	15_2	5.42E-06	16_2	8.18E-03	2_16
11104282	Aroclor 1221 (exposure to soil or food)	5.78E-02	USEPA 1987	6.75E-06	USEPA 1987	3.01E-02	EPI HenryWin v3.2
11104282	Aroclor 1221 (exposure to water)	5.78E-02	USEPA 1987	6.75E-06	USEPA 1987	3.01E-02	EPI HenryWin v3.3
11141165	Aroclor 1232 (exposure to soil or food)	5.78E-02	USEPA 1987	6.75E-06	USEPA 1987	3.01E-02	EPI HenryWin v3.4
11141165	Aroclor 1232 (exposure to water)	5.78E-02	USEPA 1987	6.75E-06	USEPA 1987	3.01E-02	EPI HenryWin v3.5
53469219	Aroclor 1242 (exposure to soil or food)	2.14E-02	15_2	5.31E-06	16_2	7.77E-03	2_16
53469219	Aroclor 1242 (exposure to water)	2.14E-02	15_2	5.31E-06	16_2	7.77E-03	2_16
11097691	Aroclor 1254 (exposure to soil or food)	1.56E-02	15_2	5.00E-06	16_2	1.16E-02	2_16
11097691	Aroclor 1254 (exposure to water)	1.56E-02	15_2	5.00E-06	16_2	1.16E-02	2_16
11096825	Aroclor 1260 (exposure to soil or food)	1.38E-02	15_2	4.32E-06	16_2	1.37E-02	2_16
11096825	Aroclor 1260 (exposure to water)	1.38E-02	15_2	4.32E-06	16_2	1.37E-02	2_16
56553	Benz[a]anthracene	5.10E-02	15_1	9.00E-06	16_1	4.91E-04	EPI HenryWin v3.2
71432	Benzene	8.95E-02	USEPA 2001	1.03E-05	USEPA 2001	2.27E-01	EPI HenryWin v3.2
50328	Benzo[a]pyrene	4.30E-02	15_1	9.00E-06	16_1	1.87E-05	EPI HenryWin v3.2
205992	Benzo[b]fluoranthene	2.26E-02	15_1	5.56E-06	16_1	2.69E-05	EPI HenryWin v3.2
207089	Benzo[k]fluoranthene	2.26E-02	15_1	5.56E-06	16_1	2.39E-05	EPI HenryWin v3.2
86748	Carbazole	6.26E-02	USEPA 1987	7.31E-06	USEPA 1987	4.74E-06	EPI HenryWin v3.2
56235	Carbon Tetrachloride	5.71E-02	USEPA 2001	9.78E-06	USEPA 2001	1.13E+00	EPI HenryWin v3.2
67663	Chloroform	7.69E-02	USEPA 2001	1.09E-05	USEPA 2001	1.50E-01	EPI HenryWin v3.2
218019	Chrysene	2.48E-02	15_1	6.21E-06	16_1	2.14E-04	EPI HenryWin v3.2
53703	Dibenz[a,h]anthracene	2.02E-02	15_1	5.18E-06	16_1	5.76E-06	EPI HenryWin v3.2
75354	Dichloroethylene, 1,1-	8.63E-02	USEPA 2001	1.10E-05	USEPA 2001	1.07E+00	EPI HenryWin v3.2
540590	Dichloroethylene, 1,2- (Mixed Isomers)	9.00E-02	USEPA 1987	1.05E-05	USEPA 1987	1.67E-01	EPI HenryWin v3.2
156592	Dichloroethylene, 1,2-cis-	8.84E-02	USEPA 2001	1.13E-05	USEPA 2001	1.67E-01	EPI HenryWin v3.2
156605	Dichloroethylene, 1,2-trans-	8.76E-02	USEPA 2001	1.12E-05	USEPA 2001	1.67E-01	EPI HenryWin v3.2
60571	Dieldrin	1.25E-02	15_1	4.74E-06	16_1	4.09E-04	EPI HenryWin v3.2
100414	Ethylbenzene	6.85E-02	USEPA 2001	8.46E-06	USEPA 2001	3.22E-01	EPI HenryWin v3.2
206440	Fluoranthene	3.02E-02	15_1	6.35E-06	16_1	3.62E-04	EPI HenryWin v3.2
86737	Fluorene	4.40E-02	USEPA 2001	7.89E-06	USEPA 2001	3.93E-03	EPI HenryWin v3.2
118741	Hexachlorobenzene	5.42E-02	15_1	5.91E-06	16_1	6.95E-02	EPI HenryWin v3.2
193395	Indeno[1,2,3-cd]pyrene	1.90E-02	15_1	5.66E-06	16_1	1.42E-05	EPI HenryWin v3.2
7439976	Mercury, Inorganic Salts	0.0307	15_1	6.30E-06	16_1	0.4674	EPA 2001
91203	Naphthalene	6.05E-02	USEPA 2001	8.38E-06	USEPA 2001	1.80E-02	EPI HenryWin v3.2
88744	Nitroaniline, 2-	4.73E-02	15_2	8.58E-06	16_2	2.41E-06	EPI HenryWin v3.2
621647	Nitroso-di-N-propylamine, N-	5.64E-02	IWAIR	7.76E-06	IWAIR	2.20E-04	EPI HenryWin v3.2

Table B.7. Volatilaztion Parameters and VF Values (Continued)

CAS #	Chemical	K_{oc} (cm^3/g) from RAIS	K_{oc} Ref in RAIS	K_d (cm^3/g)* K_{oc} x 0.2%	D_A (cm^2/sec) calculated	VF (m^3/kg), calculated residential	industrial
83329	Acenaphthene	5.03E+03	EPI KOCWIN v2.0	1.01E+01	1.94E-06	8.38E+04	5.62E+04
208968	Acenaphthylene	5.03E+03	EPI KOCWIN v2.0	1.01E+01	1.07E-06	1.13E+05	7.57E+04
107131	Acrylonitrile	8.51E+00	EPI KOCWIN v2.0	1.70E-02	2.83E-04	6.95E+03	4.66E+03
120127	Anthracene	1.64E+04	EPI KOCWIN v2.0	3.28E+01	1.41E-07	3.11E+05	2.09E+05
12674112	Aroclor 1016 (exposure to soil or food)	4.77E+04	EPI KOCWIN v2.0	9.54E+01	9.88E-08	3.72E+05	2.49E+05
12674112	Aroclor 1016 (exposure to water)	4.77E+04	EPI KOCWIN v2.1	9.54E+01	9.88E-08	3.72E+05	2.49E+05
11104282	Aroclor 1221 (exposure to soil or food)	8.40E+03	EPI KOCWIN v2.2	1.68E+01	5.33E-06	5.06E+04	3.40E+04
11104282	Aroclor 1221 (exposure to water)	8.40E+03	EPI KOCWIN v2.3	1.68E+01	5.33E-06	5.06E+04	3.40E+04
11141165	Aroclor 1232 (exposure to soil or food)	8.40E+03	EPI KOCWIN v2.4	1.68E+01	5.33E-06	5.06E+04	3.40E+04
11141165	Aroclor 1232 (exposure to water)	8.40E+03	EPI KOCWIN v2.5	1.68E+01	5.33E-06	5.06E+04	3.40E+04
53469219	Aroclor 1242 (exposure to soil or food)	7.81E+04	EPI KOCWIN v2.6	1.56E+02	5.53E-08	4.97E+05	3.33E+05
53469219	Aroclor 1242 (exposure to water)	7.81E+04	EPI KOCWIN v2.7	1.56E+02	5.53E-08	4.97E+05	3.33E+05
11097691	Aroclor 1254 (exposure to soil or food)	1.31E+05	EPI KOCWIN v2.10	2.62E+02	3.59E-08	6.17E+05	4.14E+05
11097691	Aroclor 1254 (exposure to water)	1.31E+05	EPI KOCWIN v2.11	2.62E+02	3.59E-08	6.17E+05	4.14E+05
11096825	Aroclor 1260 (exposure to soil or food)	3.50E+05	EPI KOCWIN v2.12	7.00E+02	1.40E-08	9.87E+05	6.62E+05
11096825	Aroclor 1260 (exposure to water)	3.50E+05	EPI KOCWIN v2.13	7.00E+02	1.40E-08	9.87E+05	6.62E+05
56553	Benz[a]anthracene	1.77E+05	EPI KOCWIN v2.0	3.54E+02	3.83E-09	1.89E+06	1.27E+06
71432	Benzene	1.46E+02	EPI KOCWIN v2.0	2.92E-01	2.42E-03	2.37E+03	1.59E+03
50328	Benzo[a]pyrene	5.87E+05	EPI KOCWIN v2.0	1.17E+03	8.50E-11	1.27E+07	8.50E+06
205992	Benzo[b]fluoranthene	5.99E+05	EPI KOCWIN v2.0	1.20E+03	5.63E-11	1.56E+07	1.05E+07
207089	Benzo[k]fluoranthene	5.87E+05	EPI KOCWIN v2.0	1.17E+03	5.44E-11	1.58E+07	1.06E+07
86748	Carbazole	9.16E+03	EPI KOCWIN v2.0	1.83E+01	3.40E-09	2.00E+06	1.34E+06
56235	Carbon Tetrachloride	4.39E+01	EPI KOCWIN v2.0	8.78E-02	8.38E-03	1.28E+03	8.57E+02
67663	Chloroform	3.18E+01	EPI KOCWIN v2.0	6.36E-02	3.12E-03	2.09E+03	1.40E+03
218019	Chrysene	1.81E+05	EPI KOCWIN v2.0	3.62E+02	8.70E-10	3.96E+06	2.66E+06
53703	Dibenz[a,h]anthracene	1.91E+06	EPI KOCWIN v2.0	3.82E+03	1.03E-11	3.63E+07	2.44E+07
75354	Dichloroethylene, 1,1-	3.18E+01	EPI KOCWIN v2.0	6.36E-02	1.32E-02	1.02E+03	6.84E+02
540590	Dichloroethylene, 1,2- (Mixed Isomers)	3.96E+01	EPI KOCWIN v2.0	7.92E-02	3.70E-03	1.92E+03	1.29E+03
156592	Dichloroethylene, 1,2-cis-	3.96E+01	EPI KOCWIN v2.0	7.92E-02	3.63E-03	1.94E+03	1.30E+03
156605	Dichloroethylene, 1,2-trans-	3.96E+01	EPI KOCWIN v2.0	7.92E-02	3.60E-03	1.95E+03	1.31E+03
60571	Dieldrin	2.01E+04	EPI KOCWIN v2.0	4.02E+01	7.33E-09	1.36E+06	9.16E+05
100414	Ethylbenzene	4.46E+02	EPI KOCWIN v2.0	8.92E-01	1.09E-03	3.55E+03	2.38E+03
206440	Fluoranthene	5.55E+04	EPI KOCWIN v2.0	1.11E+02	5.46E-09	1.58E+06	1.06E+06
86737	Fluorene	9.16E+03	EPI KOCWIN v2.0	1.83E+01	4.89E-07	1.67E+05	1.12E+05
118741	Hexachlorobenzene	6.20E+03	EPI KOCWIN v2.0	1.24E+01	1.56E-05	2.96E+04	1.99E+04
193395	Indeno[1,2,3-cd]pyrene	1.95E+06	EPI KOCWIN v2.0	3.90E+03	1.30E-11	3.24E+07	2.18E+07
7439976	Mercury, Inorganic Salts	52	1_1	n/a	1.42E-05	3.10E+04	2.08E+04
91203	Naphthalene	1.54E+03	EPI KOCWIN v2.0	3.08E+00	1.77E-05	2.77E+04	1.86E+04
88744	Nitroaniline, 2-	1.11E+02	EPI KOCWIN v2.0	2.22E-01	1.91E-07	2.68E+05	1.80E+05
621647	Nitroso-di-N-propylamine, N-	2.75E+02	EPI KOCWIN v2.0	5.50E-01	1.07E-06	1.13E+05	7.60E+04

Table B.7. Volatilaztion Parameters and VF Values (Continued)

CAS #	Chemical	D_i (cm^2/s) from RAIS	D_i Ref in RAIS	D_w (cm^2/s) from RAIS	D_w Ref in RAIS	Unitless H' from RAIS	H Ref in RAIS
85018	Phenanthrene	3.45E-02	USEPA 2001	6.69E-06	USEPA 2001	1.73E-03	EPI HenryWin v3.2
1336363	Polychlorinated Biphenyls (high risk)	1.75E-02	15_2	8.00E-06	16_2	7.77E-03	EPI HenryWin v3.2
129000	Pyrene	2.78E-02	IWAIR	7.25E-06	IWAIR	4.87E-04	EPI HenryWin v3.2
1746016	Dioxins/Furans (Total)	1.43E-02	15_2	5.83E-06	16_2	2.04E-03	2_16
127184	Tetrachloroethylene	5.05E-02	USEPA 2001	9.46E-06	USEPA 2001	7.24E-01	EPI HenryWin v3.2
79016	Trichloroethylene	6.87E-02	USEPA 2001	1.02E-05	USEPA 2001	4.03E-01	EPI HenryWin v3.2
75014	Vinyl Chloride	1.07E-01	USEPA 2001	1.20E-05	USEPA 2001	1.14E+00	EPI HenryWin v3.2
1330207	Xylene, Mixture	8.47E-02	USEPA 1987	9.90E-06	USEPA 1987	2.12E-01	EPI HenryWin v3.2
106423	Xylene, P-	6.82E-02	USEPA 2001	8.42E-06	USEPA 2001	2.82E-01	EPI HenryWin v3.2
108383	Xylene, m-	6.84E-02	USEPA 2001	8.44E-06	USEPA 2001	2.94E-01	EPI HenryWin v3.2
95476	Xylene, o-	6.89E-02	USEPA 2001	8.53E-06	USEPA 2001	2.12E-01	EPI HenryWin v3.2

Table B.7. Volatilaztion Parameters and VF Values (Continued)

CAS #	Chemical	K_{oc} (cm^3/g) from RAIS	K_{oc} Ref in RAIS	K_d (cm^3/g)* K_{oc} x 0.2%	D_A (cm^2/sec) calculated	VF (m^3/kg), calculated	
						residential	industrial
85018	Phenanthrene	1.67E+04	EPI KOCWIN v2.0	3.34E+01	9.35E-08	3.82E+05	2.56E+05
1336363	Polychlorinated Biphenyls (high risk)	7.81E+04	EPI KOCWIN v2.0	1.56E+02	4.54E-08	5.48E+05	3.68E+05
129000	Pyrene	5.43E+04	EPI KOCWIN v2.0	1.09E+02	6.88E-09	1.41E+06	9.45E+05
1746016	Dioxins/Furans (Total)	1.46E+05	7_38	2.92E+02	5.29E-09	1.61E+06	1.08E+06
127184	Tetrachloroethylene	9.49E+01	EPI KOCWIN v2.0	1.90E-01	4.46E-03	1.75E+03	1.17E+03
79016	Trichloroethylene	6.07E+01	EPI KOCWIN v2.0	1.21E-01	4.83E-03	1.68E+03	1.13E+03
75014	Vinyl Chloride	2.17E+01	EPI KOCWIN v2.0	4.34E-02	1.77E-02	8.77E+02	5.89E+02
1330207	Xylene, Mixture	3.83E+02	EPI KOCWIN v2.0	7.66E-01	1.03E-03	3.65E+03	2.45E+03
106423	Xylene, P-	3.75E+02	EPI KOCWIN v2.0	7.50E-01	1.10E-03	3.52E+03	2.36E+03
108383	Xylene, m-	3.75E+02	EPI KOCWIN v2.0	7.50E-01	1.15E-03	3.44E+03	2.31E+03
95476	Xylene, o-	3.83E+02	EPI KOCWIN v2.0	7.66E-01	8.35E-04	4.04E+03	2.71E+03

* RAIS does not provide Kd for organic chemicals, therefore, Kd values used in the calculation are taken from PRG Region 9 physical chemical data.

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EPA 1994a. *Guidance manual for the IEUBK Model for Lead in Children*. Office of Solid Waste and Emergency Response, Washington, DC, OSWER # 9285.7-15-1.

EPA 1994b. *Technical Support Document: Parameters and Equations Used in the Integrated Exposure Uptake Biokinetic Model for Lead in Children*. Office of Solid Waste and Emergency Response, Washington, DC, OSWER # 9285.7-22, EPA 540/R-94/040.

EPA 1999. *Short Sheet: IEUBK Model Bioavailability Variable*. Office of Solid Waste and Emergency Response. Washington D.C, OSWER #9285.7-32, EPA #540-F-00-006.

EPA 2000. *Review of Human Health Risk Assessment for the Coeur D'Alene Basin*. Technical Review Workgroup for Lead. Prepared for US EPA, Region 10, Seattle, WA, October 2000.

EPA 2002. *Blood Lead Concentrations of U.S. Adult Females: Summary Statistics from Phases 1 and 2 of the National Health and Nutrition Evaluation Study (NHANES III)*. Office of Solid Waste and Emergency Response, Washington, DC, OSWER # 9285.7-52.

EPA 2003. *Recommendations of the Technical Review Workgroup for Lead for an Approach to Assessing Risks Associated with Adult Exposures to Lead in Soil*, Technical Review Workgroup for Lead.

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 AND SELECTED CHEMICAL-SPECIFIC VALUES

EXPOSURE EQUATIONS AND SELECTED CHEMICAL-SPECIFIC VALUES

This appendix is presented in two parts. Part 1 contains the exposure equations used in environmental human health risk assessments for Department of Energy sites located at the Paducah Gaseous Diffusion Plant (PGDP). Part 2 contains a table presenting selected chemical-specific values used in the calculation of chemical and radionuclide concentrations in biota and calculation of chemical and radionuclide intakes.

The equations in Part 1 are consistent with all Region 4 U.S. Environmental Protection Agency (EPA) and Commonwealth of Kentucky guidance materials. However, the exposure parameters shown are those used to produce daily intakes and absorbed doses used to complete environmental risk assessments performed for PGDP only. While these exposure parameters generally are consistent with the exposure parameters recommended by Region 4 EPA, they do differ in some cases where Kentucky Department for Environmental Protection (KDEP) values were used. The source of each value is provided under 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.

The chemical-specific values presented in the tables in Part 2 are based upon the best available information as of Decmber 2010; however, these values and their sources are subject to change as better or additional information becomes available.

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PART 1: EXPOSURE EQUATIONS

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List of Tables for Part 1

Table D.1. Reasonable Maximum Exposure Assumptions and Human Intake Factors for Ingestion of Water by a Rural Resident[a]

Equations:

$$\text{Chemical Intake}\,[\text{mg/(kg}\times\text{day)}] = \frac{C_w \times IR \times EF \times ED}{BW \times AT}$$

$$\text{Radionuclide Intake (pCi)} = A_w \times IR \times E\text{F} \times ED$$

Parameter	Units	Value used	References[b]
Chemical concentration in water = $\mathbf{C_w}$	mg/L	Chemical-specific	-----
Radiological activity = $\mathbf{A_w}$	pCi/L	Chemical-specific	-----
Ingestion Rate = **IR**	L/d	2 (adult) 1.5 (child)	[14]
Exposure frequency = **EF**	d/year	350	[14]
Exposure duration = **ED**	years	24 (adult) 6 (child)	[14]
Body weight = **BW**	kg	70 (adult) 15 (child)	[14]
Averaging time = **AT**	yr × day/yr.	70 × 365 (carcinogen) ED × 365 (noncarcinogen)	[14]

[a] Equation from [1].

[b] References follow Table D.50.

Table D.2. Reasonable Maximum Exposure Assumptions and Human Intake Factors for Inhalation of Volatile Organic Compounds in Water while Showering by a Rural Resident[a]

Equations:

$$\text{Chemical Intake}\,[\text{mg/(kg}\times\text{day)}] = \frac{C_{shower} \times IR_{air} \times EF \times ED \times ET}{BW \times AT}$$

$$C_{shower}\ (\text{mg/m}^3) = \frac{\left[\left(C_{a\max}/2\right)\times t_1\right] + \left[C_{a\max}\times t_2\right]}{t_1 + t_2} \qquad C_{a\max}\ (\text{mg/m}^3) = \frac{C_{gw}\times f \times F_w \times t_1}{V_a}$$

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	0.833	[14]
Exposure frequency = **EF**	day/year	350	[14]
Exposure duration = **ED**	years	24 (adult) 6 (child)	[14]
Exposure Time = **ET**	hours/day	0.2	[14]
Body weight = **BW**	kg	70 (adult) 15 (child)	[14]
Averaging time = **AT**	yr × day/yr	70 × 365 (carcinogen) ED × 365 (noncarcinogen)	[14]
Activity in groundwater = $\mathbf{A_{gw}}$	pCi/L	Chemical-specific	-----
Maximum air concentration = $\mathbf{C_{amax}}$	mg/m^3	Chemical-specific	Calculated
Time of shower = $\mathbf{t_1}$	hour	0.1	[14]
Time after shower = $\mathbf{t_2}$	hour	0.1	[14]
Concentration in groundwater = $\mathbf{C_{gw}}$	mg/L	Chemical-specific	-----
Fraction volatilized = **f**	unitless	0.75	----- [C]
Water flow rate = $\mathbf{F_w}$	L/h	890	[14]
Bathroom volume = $\mathbf{V_a}$	m^3	11	[14]

[a] Equation from [37].

[b] References follow Table D.50.

[c] Value selected by 2009 work group because KDEP (2002) does not specify this value for showering.

Table D.3. Reasonable Maximum Exposure Assumptions and Human Intake Factors for Inhalation of Volatile Organic Compounds in Water during Household Use by a Rural Resident[a]

Equations:

$$\text{Chemical Intake}\,[\text{mg/(kg}\times\text{day)}] = \frac{C_{house} \times IR_{air} \times EF \times ED \times ET}{BW \times AT}$$

$$C_{house}\ (\text{mg/m}^3) = \frac{C_{gw} \times WHF \times f}{HV \times ER \times MC}$$

Parameter	Units	Value used	References[b]
Concentration in household air = **C_{house}**	mg/m^3	Chemical-specific	Calculated
Indoor inhalation rate = **IR_{air}**	m^3/hour	0.833	[14]
Exposure frequency = **EF**	day/year	350	[14]
Exposure duration = **ED**	years	24 (adult) 6 (child)	[14]
Exposure time = **ET**	hours/day	24	[14]
Body weight = **BW**	kg	70 (adult) 15 (child)	[14]
Averaging time = **AT**	yr × day/yr	70 × 365 (carcinogen) ED × 365 (noncarcinogen)	[14]
Activity in groundwater = **A_{gw}**	pCi/L	Chemical-specific	-----
Concentration in groundwater = **C_{gw}**	mg/L	Chemical-specific	-----
Water flow rate = **WHF**	L/day	890	[14]
Fraction volatilized = **f**	unitless	0.5	[14]
House volume = **HV**	m^3/change	450	[14]
Exchange rate = **ER**	changes/day	10	[14]
Mixing coefficient = **MC**	unitless	0.5	[14]

[a] Equation from [1] and [14].

[b] References follow Table D.50.

Table D.4. Reasonable Maximum Exposure Assumptions and Human Intake Factors for Dermal Contact with Water while Showering by a Rural Resident[a]

Equation:

$$\text{Absorbed Dose Inorganic } [\text{mg/(kg} \times \text{day)}] = \frac{C_w \times SA \times K_p \times CF \times ED \times EF \times ET}{BW \times AT}$$

$$\text{Absorbed Dose Organic}[\text{mg/(kg} \times \text{day)}] = \frac{DA_{event} \times SA \times CF \times CF_1 \times ED \times EF \times EV}{BW \times AT}$$

Parameter	Units	Value used	References[b]
Concentration in water = $\mathbf{C_w}$	mg/L	Chemical-specific	-----
Skin surface area exposed = **SA**[c]	m^2	1.815 (adult) 0.65 (child)	[14]
Skin permeability constant = $\mathbf{K_p}$	cm/hr	Chemical-specific	-----
Absorbed dose per event = DA_{event}	Mg/cm^2-event	Chemical-specific* $\mathbf{C_w}$ [d]	-----
Conversion Factor = **CF**	(L-m)/(cm-m^3)	10	-----
Conversion Factor = $\mathbf{CF_1}$	Cm^3/L	1000	-----
Exposure duration = **ED**	years	24 (adult) 6 (child)	[14]
Exposure frequency = **EF**	days/yr	350	[14]
Exposure time = **ET**	hrs/bath	0.2	[14]
Event = **EV**	bath/day	1	[14]
Body weight = **BW**	kg	70 (adult) 15 (child)	[14]
Averaging time = **AT**	yr × day/yr	70 × 365 (carcinogen) ED × 365 (noncarcinogen)	[14]

[a] Equation from [1].

[b] References follow Table D.50.

[c] Entire surface area of body for both adult and child.

[d] Part 2 of this appendix gives a factor for each organic chemical that is to be multiplied by the water concentration (C_w) to obtain the term DA*event* for the equation shown above.

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Table D.5. Reasonable Maximum Exposure Assumptions and Human Intake Factors for Incidental Ingestion of Soil by a Rural Resident[a]

Equations:

$$\text{Chemical Intake}\,[\text{mg/(kg} \times \text{day}] = \frac{C_s \times CF \times EF \times FI \times ED \times IR}{BW \times AT}$$

$$\text{Radionuclide Intake}\,(\text{pCi}) = A_s \times CF_{rad} \times EF \times FI \times ED \times IR$$

Parameter	**Units**	**Value used**	**References[b]**
Chemical concentration in soil = $\mathbf{C_s}$	mg/kg	Chemical-specific	-----
Radiological activity = $\mathbf{A_s}$	pCi/g	Chemical-specific	-----
Conversion factor = **CF**	kg/mg	10^{-6}	-----
Conversion factor = $\mathbf{CF_{rad}}$	g/mg	10^{-3}	-----
Exposure frequency = **EF**	days/yr	350	[14]
Fraction ingested = **FI**	unitless	1	[14]
Exposure duration = **ED**	years	24 (adult) 6 (child)	[14]
Ingestion rate of soil = **IR**	mg/d	100 (adult) 200 (child)	[14]
Body weight = **BW**	kg	70 (adult) 15 (child)	[14]
Averaging time = **AT**	yr × day/yr	70 × 365 (carcinogen) ED × 365 (noncarcinogen)	[14]

[a] Equation from [1].

[b] References follow Table D.50.

Table D.6. Reasonable Maximum Exposure Assumptions and Human Intake Factors for Dermal Contact with Soil by a Rural Resident[a]

Equation:

$$\text{Absorbed Dose } [(\text{mg}/(\text{kg}\times\text{day})] = \frac{C_s \times CF_d \times SA \times AF \times ABS \times EF \times ED}{BW \times AT}$$

Parameter	Units	Value used	References[b]
Concentration in soil = $\mathbf{C_s}$	mg/kg	Chemical-specific	-----
Conversion factor = $\mathbf{CF_d}$	(kg-cm^2)/(mg-m^2)	0.01	-----
Surface area[c] = **SA**	m^2/day	0.57 (adult) 0.28 (child)	[14]
Adherence factor = **AF**	mg/cm^2	1	[14]
Absorption factor[d] = **ABS**	unitless	Chemical-specific	[14]
Exposure frequency = **EF**	day/yr	350	[14]
Exposure duration = **ED**	years	24 (adult) 6 (child)	[14]
Body weight = **BW**	kg	70 (adult) 15 (child)	[14]
Averaging time = **AT**	yr × day/yr	70 × 365 (carcinogen) ED × 365 (noncarcinogen)	[14]

[a] Equation from [1].

[b] References follow Table D.50.

[c] Includes face, forearms, hands and lower legs for adult; face, forearms, hands, lower legs and feet for children.

[d] The default factors are used unless chemical-specific absorption factors are available. These defaults are 0.25 (volatile organic compounds), 0.10 (semi-volatile organic compounds), and 0.05 (inorganic chemical). Chemical-specific absorption factors available are listed in Table B.5 [38].

Notes:

Dermal absorbed dose is not applicable to radionuclides per guidance found in [1].

Table D.7. Reasonable Maximum Exposure Assumptions and Human Intake Factors for Inhalation of Vapors and Particulates Emitted from Soil by a Rural Resident[a]

Equations:

$$\text{Chemical Intake}\,[\text{mg/(kg}\times\text{day)}] = \frac{C_s \times EF \times ED \times ET \times \left(\frac{1}{VF} + \frac{1}{PEF}\right) \times IR_{air}}{BW \times AT}$$

$$\text{Radionuclide Intake (pCi)} = A_s \times EF \times ED \times ET \times CF \times \left(\frac{1}{PEF}\right) \times IR_{air}$$

Parameter	Units	Value used	References[b]
Concentration in soil = $\mathbf{C_s}$	mg/kg	Chemical-specific	-----
Activity in soil = $\mathbf{A_s}$	pCi/g	Chemical-specific	-----
Exposure frequency = **EF**	day/year	350	[14]
Exposure duration = **ED**	years	24 (adult) 6 (child)	[14]
Exposure time = **ET**	hours/day	24	[14]
Conversion factor = **CF**	g/kg	10^3	-----
Volatilization factor = **VF**	m^3/kg	Chemical-specific	[19]
Particulate emission factor[c] = **PEF**	m^3/kg	9.3×10^8	[14]
Total inhalation rate = $\mathbf{IR_{air}}$	m^3/hour	0.833	[14]
Body weight = **BW**	kg	70 (adult) 15 (child)	[14]
Averaging time = **AT**	yr × day/yr	70 × 365 (carcinogen) ED × 365 (noncarcinogen)	[14]

[a] Equation from [20].

[b] References follow Table D.50.

[c] PEFs from KRAGS 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 the SSL Technical Background document [41].

Table D.8. Reasonable Maximum Exposure Assumptions and Human Intake Factors for External Exposure to Ionizing Radiation from Soil by a Rural Resident[a]

Equation:

$$\text{Absorbed Dose } [(\text{pCi} \times \text{year})/\text{g}] = A_s \times ED \times EF \times (1 - S_e) \times T_e$$

Parameter	Units	Value used	References[b]
Activity in soil = $\mathbf{A_s}$	pCi/g	Chemical-specific	-----
Exposure duration = **ED**	year	24 (adult) 6 (child)	[14]
Exposure frequency = **EF**	day/day	350/365	[14]
Gamma shielding factor = $\mathbf{S_e}$	unitless	0.2	[20]
Gamma exposure time factor = $\mathbf{T_e}$	hr/hr	24/24	[20]

[a] Equation from [20].

[b] References follow Table D.50.

[c] AC cannot be greater than 1.

Table D.9. Reasonable Maximum Exposure Assumptions and Human Intake Factors for Consumption of Home-Ggrown Vegetables by a Rural Resident[a]

Equations:

$$\text{Chemical Intake}\,[\text{mg/(kg}\times\text{day)}] = \frac{\text{C}_{\text{vegetables}} \times FI_v \times IR_v \times EF \times ED}{BW \times AT}$$

$$\text{Radionuclide Intake (pCi)} = A_{vegetables} \times FI_v \times IR_v \times EF \times ED \times CF$$

Parameter	Units	Value used	References[b]
Chemical concentration in vegetables = $\mathbf{C}_{\mathbf{vegetables}}$	mg/kg	Chemical-specific	See Table D.42
Radiological activity = $\mathbf{A}_{\mathbf{vegetables}}$	pCi/g	Chemical-specific	See Table D.42
Diet fraction = $\mathbf{FI}_{\mathbf{v}}$	unitless	0.4	[21]
Ingestion rate[c] = $\mathbf{IR}_{\mathbf{v}}$	kg/d	0.29 (child 1-7) 0.72 (adult 8 – 41)	[23]
Exposure frequency = **EF**	d/year	350	[14]
Exposure duration = **ED**	years	6(child) 24 (adult)	[14]
Body weight (adult) = **BW**	kg	15 (child) 70 (adult)	[14]
Averaging time = **AT**	yr × day/yr	70 × 365 (carcinogen) ED × 365 (noncarcinogen)	[14]
Conversion factor = **CF**	g/kg	1000	-----

[a] Equation from [1].

[b] References follow Table D.50.

[c] Ingestion values represent the 95th percentile of individuals who consume this food group.

Table D.10. Reasonable Maximum Exposure Assumptions and Human Intake Factors for Consumption of Beef by a Rural Resident[a]

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[b]
Chemical concentration in beef = $\mathbf{C_{beef}}$	mg/kg	Chemical-specific	See Table D.46
Radiological activity in beef = $\mathbf{A_{beef}}$	pCi/kg	Chemical-specific	See Table D.46
Beef ingestion rate[c] = $\mathbf{IR_b}$	kg/day	0.07 (child 1 –7) 0.19 (adult 8 – 41)	[23]
Diet fraction = $\mathbf{FI_b}$	unitless	1	[21]
Exposure frequency = **EF**	d/year	350	[14]
Exposure duration = **ED**	years	6 (child) 24 (adult)	[14]
Body weight (adult) = **BW**	kg	15 (child) 70 (adult)	[14]
Averaging time = **AT**	yr × day/yr	70 × 365 (carcinogen) ED × 365 (noncarcinogen)	[14]

[a] Equation from [1].

[b] References follow Table D.50.

[c] Ingestion values represent the 95th percentile of individuals who consume this food group.

Table D.11. Reasonable Maximum Exposure Assumptions and Human Intake Factors for Consumption of Milk by a Rural Resident[a]

Equations:

$$\text{Chemical Intake}\,[\text{mg/(kg} \times \text{day)}] = \frac{C_{milk} \times FI_m \times IR_m \times EF \times ED}{BW \times AT}$$

$$\text{Radionuclide Intake (pCi)} = A_{milk} \times FI_m \times IR_m \times EF \times ED$$

Parameter	Units	Value used	References[b]
Chemical concentration in milk = $\mathbf{C_{milk}}$	mg/kg	Chemical-specific	See Table D.47
Radiological activity in milk = $\mathbf{A_{milk}}$	pCi/kg	Chemical-specific	See Table D.47
Milk ingestion rate[c] = $\mathbf{IR_m}$	kg/day	0.9 (child 1 – 7) 1.25(adult 8 – 41)	[23]
Diet fraction = $\mathbf{FI_m}$	unitless	1	[21]
Exposure frequency = **EF**	d/year	350	[14]
Exposure duration = **ED**	years	6 (child) 24 (adult)	[14]
Body weight (adult) = **BW**	kg	15 (child) 70 (adult)	[14]
Averaging time = **AT**	yr × day/yr	70 × 365 (carcinogen) ED × 365 (noncarcinogen)	[14]

[a] Equation from [1].

[b] References follow Table D.50.

[c] Ingestion values represent the 95th percentile of individuals who consume this food group.

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Table D.12. Reasonable Maximum Exposure Assumptions and Human Intake Factors for Consumption of Poultry by a Rural Resident[a]

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[b]
Chemical concentration in poultry = $\mathbf{C_{poultry}}$	mg/kg	Chemical-specific	See Table D.48
Radiological activity in poultry = $\mathbf{A_{poultry}}$	pCi/kg	Chemical-specific	See Table D.48
Ingestion rate[c] = $\mathbf{IR_p}$	kg/day	0.07 (child 1 – 7) 0.17 (adult 8 – 41)	[23]
Diet fraction = $\mathbf{FI_p}$	unitless	1	[5]
Exposure frequency = **EF**	day/year	350	
Exposure duration = **ED**	years	6 (child) 24 (adult)	[14]
Body weight = **BW**	kg	15 (child) 70 (adult)	[14]
Averaging time = **AT**	yr × day/yr	70 × 365 (carcinogen) ED × 365 (noncarcinogen)	[14]

[a] Equation from [1].

[b] References follow Table D.50.

[c] Ingestion values represent the 95th percentile of individuals who consume this food group.

Table D.13. Reasonable Maximum Exposure Assumptions and Human Intake Factors for Consumption of Pork by a Rural Resident[a]

Equations:

$$\text{Chemical Intake}\,[\text{mg/(kg}\times\text{day)}] = \frac{C_{pork}\times FI_{pork}\times IR_{pork}\times EF\times ED}{BW\times AT}$$

$$\text{Radionuclide Intake (pCi)} = A_{pork}\times FI_{pork}\times IR_{pork}\times EF\times ED$$

Parameter	Units	Value used	References[b]
Chemical concentration in pork = $\mathbf{C_{pork}}$	mg/kg	Chemical-specific	See Table D.49
Radiological activity in pork = $\mathbf{A_{pork}}$	pCi/kg	Chemical-specific	See Table D.49
Pork ingestion rate[c] = $\mathbf{IR_{pork}}$	kg/day	0.03 (child 1 –7) 0.08 (adult 8 – 41)	[23]
Diet fraction = $\mathbf{FI_{pork}}$	unitless	1	[21]
Exposure frequency = **EF**	d/year	350	[14]
Exposure duration = **ED**	years	6 (child) 24 (adult)	[14]
Body weight (adult) = **BW**	kg	15 (child) 70 (adult)	[14]
Averaging time = **AT**	yr × day/yr	70 × 365 (carcinogen) ED × 365 (noncarcinogen)	[14]

[a] Equation from [1].

[b] References follow Table D.50.

[c] Ingestion values represent the 95th percentile of individuals who consume this food group.

Table D.14. Reasonable Maximum Exposure Assumptions and Human Intake Factors for Consumption of Eggs by a Rural Resident[a]

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[b]
Chemical concentration in egg = $\mathbf{C_{egg}}$	mg/kg	Chemical-specific	See Table D.50
Radiological activity in egg = $\mathbf{A_{egg}}$	pCi/kg	Chemical-specific	See Table D.50
Egg ingestion rate[c] = $\mathbf{IR_e}$	kg/day	0.06 (child 1 –7) 0.11 (adult 8 - 41)	[23]
Diet fraction = $\mathbf{FI_e}$	unitless	1	[21]
Exposure frequency = **EF**	d/year	350	[14]
Exposure duration = **ED**	years	6 (child) 24 (adult)	[14]
Body weight (adult) = **BW**	kg	15 (child) 70 (adult)	[14]
Averaging time = **AT**	yr × day/yr	70 × 365 (carcinogen) ED × 365 (noncarcinogen)	[14]

[a] Equation from [1].

[b] References follow Table D.50.

[c] Ingestion values represent the 95th percentile of individuals who consume this food group.

Table D.15. Reasonable Maximum Exposure Assumptions and Human Intake Factors for Incidental Ingestion of Sediment by a Recreational User[a]

Equations:

$$\text{Chemical Intake}\,[\text{mg/(kg} \times \text{day]} = \frac{C_{sed} \times CF \times EF \times ED \times ET \times CF_2 \times IR \times FI}{BW \times AT}$$

$$\text{Radionuclide Intake (pCi)} = A_{sed} \times CF_{rad} \times EF \times ED \times ET \times CF_2 \times IR \times FI$$

Parameter	Units	Value used	References[b]
Concentration in sediment = $\mathbf{C_{sed}}$	mg/kg	Chemical-specific	-----
Conversion factor = **CF**	kg/mg	10^{-6}	-----
Activity in soil = $\mathbf{A_{sed}}$	pCi/g	Chemical-specific	-----
Conversion factor = $\mathbf{CF_{rad}}$	g/mg	10^{-3}	-----
Exposure frequency = **EF**	day/yr	104 (adult) 140 (child and teen)	[14]
Exposure duration = **ED**	year	12 (adult) 12 (teen) 6 (child)	[14]
Exposure time = **ET**	hr/day	5	[14]
Conversion factor = $\mathbf{CF_2}$	day/hr	1/24	-----
Ingestion rate = **IR**	mg/day	100 (adult) 100 (teen) 200 (child)	[14]
Fraction ingested = **FI**	unitless	1	[14]
Body weight = **BW**	kg	70 (adult) 43 (teen) 15 (child)	[14]
Averaging time = **AT**	yr × day/yr	70 × 365 (carcinogen) ED × 365 (noncarcinogen)	[14]

[a] Equation after [1].

[b] References follow Table D.50.

Table D.16. Reasonable Maximum Exposure Assumptions and Human Intake Factors for Dermal Contact with Sediment by a Recreational User[a]

Equation:

$$\text{Absorbed Dose } [(\text{mg}/(\text{kg}\times\text{day})] = \frac{C_{sed} \times CF_d \times SA \times AF \times ABS \times EF \times ED}{BW \times AT}$$

Parameter	Units	Value used	References[b]
Concentration in sediment = $\mathbf{C_{sed}}$	mg/kg	Chemical-specific	-----
Conversion factor-dermal = $\mathbf{CF_d}$	(kg-cm^2)/(mg-m^2)	0.01	-----
Surface area[c] = **SA**	m^2/day	0.57 (adult) 0.75 (teen) 0.28 (child)	[14]
Adherence factor = **AF**	mg/cm^2	1	[14]
Absorption factor[d] = **ABS**	unitless	Chemical-specific	[14]
Exposure frequency = **EF**	day/yr	104 (adult) 140 (teen) 140 (child)	[14]
Exposure duration = **ED**	years	12 (adult) 12 (teen) 6 (child)	[14]
Body weight = **BW**	kg	70 (adult) 43 (teen) 15 (child	[14]
Averaging time = **AT**	yr × day/yr	70 × 365 (carcinogen) ED × 365 (noncarcinogen)	[14]

[a] Equation from [1].

[b] References follow Table D.50.

[c] Includes face, forearms, lower legs and hands for adults; arms, hands, legs, and feet for teens; and face, forearms, hands, lower legs, and feet for children.

[d] The default factors are used unless chemical-specific absorption factors are available. These defaults are 0.25 (volatile organic compounds), 0.10 (semi-volatile organic compounds), and 0.05 (inorganic chemical). Chemical-specific absorption factors available are listed in Table B.5 [38].

Table D.17. Reasonable Maximum Exposure Assumptions and Human Intake Factors for Inhalation of Vapors or Particulates Emitted from Sediment by a Recreational User[a]

Equations:

$$\text{Chemical Intake}\,[\text{mg/(kg}\times\text{day)}] = \frac{C_{sed}\times EF\times ED\times ET\times\left(\frac{1}{VF}+\frac{1}{PEF}\right)\times IR_{air}}{BW\times AT}$$

$$\text{Radionuclide Intake (pCi)} = A_{sed}\times EF\times ED\times ET\times CF\times\left(\frac{1}{PEF}\right)\times IR_{air}$$

Parameter	Units	Value used	References[b]
Concentration in sediment = $\mathbf{C_{sed}}$	mg/kg	Chemical-specific	-----
Activity in sediment = $\mathbf{A_{sed}}$	pCi/g	Chemical-specific	-----
Exposure frequency = **EF**	day/year	104 (adult) 140 (teen) 140 (child)	[14]
Exposure duration = **ED**	years	12 (adult) 12 (teen) 6 (child)	[14]
Exposure time = **ET**	hour/day	5	[14]
Conversion factor = **CF**	g/kg	10^3	-----
Volatilization factor = **VF**	m^3/kg	Chemical-specific	-----
Particulate emission factor[c] = **PEF**	m^3/kg	9.3×10^8	[14]
Total inhalation rate = $\mathbf{IR_{air}}$	m^3/hour	2.5	[14]
Body weight = **BW**	kg	70 (adult) 43 (teen) 15 (child)	[14]
Averaging time = **AT**	yr × day/yr	70 × 365 (carcinogen) ED × 365 (noncarcinogen)	[14]

[a] Equation after [1].

[b] References follow Table D.50.

[c] PEFs from KRAGS 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 the SSL Technical Background document [41].

Table D.18. Reasonable Maximum Exposure Assumptions and Human Intake Factors for External Exposure to Ionizing Radiation from Sediment by a Recreational User[a]

Equation:

$$\text{Absorbed Dose } [(\text{pCi} \times \text{year})/\text{g}] = A_{sed} \times ED \times EF \times (1 - S_e) \times T_e$$

Parameter	**Units**	**Value used**	**References[b]**
Activity in soil = $\mathbf{A_{sed}}$	pCi/g	Chemical-specific	-----
Exposure duration = **ED**	year	12 (adult) 12 (teen) 6 (child)	[14]
Exposure frequency = **EF**	day/day	104/365 (adult) 140/365 (teen) 140/365 (child)	[14]
Gamma shielding factor = $\mathbf{S_e}$	unitless	0.0	[40]
Gamma exposure time factor = $\mathbf{T_e}$	hr/hr	5/24	[20]

[a] Equation from [20].

[b] References follow Table D.50.

Table D.19. Reasonable Maximum Exposure Assumptions and Human Intake Factors for Incidental Ingestion of Surface Water while Swimming by a Recreational User[a]

Equations:

$$\text{Chemical Intake}\,[\text{mg/(kg}\times\text{day)}] = \frac{C_{sw} \times IR \times \text{ET} \times EF \times ED}{BW \times AT}$$

$$\text{Radionuclide Intake}\,(\text{pCi}) = A_{sw} \times \text{IR} \times ET \times \text{EF} \times \text{ED}$$

Parameter	Units	Value used	References[b]
Chemical concentration in water = $\mathbf{C_{sw}}$	mg/L	Chemical-specific	-----
Radiological activity = $\mathbf{A_{sw}}$	pCi/L	Chemical-specific	-----
Ingestion Rate = **IR**	L/hr	0.05	[14]
Exposure time = **ET**	hr/day	2.6	[14]
Exposure frequency = **EF**	d/year	45	[14]
Exposure duration = **ED**	years	12 (adult) 12 (teen) 6 (child)	[14]
Body weight = **BW**	kg	70 (adult) 43 (teen) 15 (child)	[14]
Averaging time = **AT**	yr × day/yr	70 × 365 (carcinogen) ED × 365 (noncarcinogen)	[14]

[a] Equation from [1].

[b] References follow Table D.50.

Notes:

Chemical concentration in surface water (mg/L) times intake factor [L/(kg X day)] yields default RME dose for associated endpoint.

Radionuclide activity in surface water (pCi/L) times intake factor (L) yields default RME dose.

Table D.20. Reasonable Maximum Exposure Assumptions and Human Intake Factors for Dermal Contact with Surface Water (Wading) by a Recreational User[a]

Equation:

$$\text{Absorbed Dose Inorganic } [\text{mg/(kg} \times \text{day)}] = \frac{C_w \times SA \times K_p \times CF \times ED \times EF \times ET}{BW \times AT}$$

$$\text{Absorbed Dose Organic}[\text{mg/(kg} \times \text{day)}] = \frac{DA_{event} \times SA \times CF \times CF_1 \times ED \times EF \times EV}{BW \times AT}$$

Parameter	Units	Value used	References[b]
Concentration in surface water = $\mathbf{C_{sw}}$	mg/L	Chemical-specific	-----
Adult surface area[c] = **SA**	m^2	1.06 (adult) 0.75 (teen) 0.33 (child)	[14]
Conversion factor = **CF**	L/(cm - m^2)	10	-----
Conversion factor 1	cm^3/L	1000	-----
Skin permeability constant = $\mathbf{K_p}$	cm/hr	Chemical-specific	-----
Absorbed dose per event = $\mathbf{DA_{event}}$	Mg/cm^2-event	Chemical-specific* $\mathbf{C_w}$ [d]	-----
Exposure duration = **ED**	Years	12 (adult) 12 (teen) 6 (child)	[14]
Exposure Frequency = **EF**	d/yr	52 (adult) 140 (teen) 140 (child)	[14]
Exposure time = **ET**	hr/day	2.6	[14]
Event = **EV**	Events/day	1	[14]
Body weight = **BW**	kg	70 (adult) 43 (teen) 15 (child)	[14]
Averaging time = **AT**	yr × day/yr	70 × 365 (carcinogen) ED × 365 (noncarcinogen)	[14]

[a] Equation from [1].

[b] References follow Table D.50.

[c] Includes arms, hands, legs, and feet for adult, teen, and child.

[d] Part 2 of this appendix gives a factor for each organic chemical that is to be multiplied by the water concentration (C_w) to obtain the term DA*event* for the equation shown above.

Note: Dermal absorbed dose is not applicable to radionuclides per guidance found in [1].

Table D.21. Reasonable Maximum Exposure Assumptions and Human Intake Factors for Dermal Contact with Surface Water (Swimming) by a Recreational User[a]

Equation:

$$\text{Absorbed Dose Inorganic } [\text{mg/(kg} \times \text{day)}] = \frac{\mathrm{C_w} \times SA \times K_p \times CF \times ED \times EF \times ET}{BW \times AT}$$

$$\text{Absorbed Dose Organic}[\text{mg/(kg} \times \text{day)}] = \frac{DA_{event} \times SA \times CF \times CF_1 \times ED \times EF \times EV}{BW \times AT}$$

Parameter	Units	Value used	References[b]
Concentration in surface water = $\mathbf{C_{sw}}$	mg/L	Chemical-specific	-----
Surface area[c] = **SA**	m^2	1.815 (adult) 1.31 (teen) 0.65 (child)	[14]
Conversion factor = **CF**	L/(cm - m^2)	10	-----
Conversion factor 1 = $\mathbf{CF_1}$	Cm^3/L	1000	-----
Skin permeability constant = $\mathbf{K_p}$	cm/hr	Chemical-specific	-----
Absorbed dose per event = $\mathbf{DA_{event}}$	Mg/cm^2-event	Chemical-specific* $\mathbf{C_w}$ [d]	-----
Exposure duration = **ED**	years	12 (adult) 12 (teen) 6 (child)	[14]
Exposure Frequency = **EF**	d/yr	45	[14]
Exposure time = **ET**	hr/day	2.6	[14]
Event **= EV**	Event/day	1	-----
Body weight = **BW**	kg	70 (adult) 43 (teen) 15 (child)	[14]
Averaging time = **AT**	yr × day/yr	70 × 365 (carcinogen) ED × 365 (noncarcinogen)	[14]

[a] Equation from [1].

[b] References follow Table D.50.

[c] Includes whole body for adult, teen, and child.

[d] Part 2 of this appendix gives a factor for each organic chemical that is to be multiplied by the water concentration (C_w) to obtain the term DA*event* for the equation shown above.

Note: Dermal absorbed dose is not applicable to radionuclides per guidance found in [1].

Table D.22. Reasonable Maximum Exposure Assumptions and Human Intake Factors for Consumption of Fish by a Recreational User[a]

Equations:

$$\text{Chemical Intake}\,[\text{mg/(kg}\times\text{day)}] = \frac{\text{C}_{\text{fish}} \times FI_f \times IR_f \times EF \times ED}{BW \times AT}$$

$$\text{Radionuclide Intake (pCi)} = A_{fish} \times FI_f \times IR_f \times EF \times ED$$

Parameter	**Units**	**Value used**	**References[b]**
Chemical concentration in fish = $\mathbf{C_{fish}}$	mg/kg	Chemical-specific	See Table D.43
Radiological activity = $\mathbf{A_{fish}}$	pCi/kg	Chemical-specific	See Table D.43
Ingestion ratec = $\mathbf{IR_f}$	kg/day	0.029(adult) 0.029 (teen) 0.029 (child)	[39]
Diet fraction = $\mathbf{FI_f}$	unitless	1	[5]
Exposure frequency = **EF**	days/yr	365	[X]
Exposure duration = **ED**	years	12 (adult) 12 (teen) 6 (child)	[14]
Body weight = **BW**	kg	70 (adult) 43 (teen) 15 (child)	[14]
Averaging time = **AT**	yr × day/yr	70 × 365 (carcinogen) ED × 365 (noncarcinogen)	[14]

---

[a] Equation from [1].

[b] References follow Table D.50.

Table D.23. Reasonable Maximum Exposure Assumptions and Human Intake Factors for Consumption of Venison by a Recreational User[a]

Equations:

$$\text{Chemical Intake}\,[\text{mg/(kg} \times \text{day)}] = \frac{C_{deer} \times FI_d \times IR_d \times EF \times ED}{BW \times AT}$$

$$\text{Radionuclide Intake (pCi)} = A_{deer} \times FI_d \times IR_d \times EF \times ED \times CF$$

Parameter	**Units**	**Value used**	**References[b]**
Chemical concentration in venison = $\mathbf{C_{deer}}$	mg/kg	Chemical-specific	See Table D.41
Radiological activity in venison = $\mathbf{A_{deer}}$	pCi/g	Chemical-specific	See Table D.41
Ingestion ratec = $\mathbf{IR_d}$	kg/day	0.032 (adult) 0.032 (teen) 0.007 (child)	See footnote c
Conversion factor = **CF**	g/kg	1000	-----
Diet fraction = $\mathbf{FI_d}$	unitless	1	[5]
Exposure frequency = **EF**	day/yr	350	See footnote c
Exposure duration = **ED**	years	12 (adult) 12 (teen) 6 (child)	[14]
Body weight = **BW**	kg	70 (adult) 43 (teen) 15 (child)	[14]
Averaging time = **AT**	yr × day/yr	70 × 365 (carcinogen) ED × 365 (noncarcinogen)	[14]

[a] Equation from [1].

[b] References follow Table D.50.

[c] 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.

Table D.24. Reasonable Maximum Exposure Assumptions and Human Intake Factors for Consumption of Rabbit by a Recreational User[a]

Equations:

$$\text{Chemical Intake}\,[\text{mg/(kg} \times \text{day)}] = \frac{C_{rabbit} \times FI_r \times IR_r \times EF \times ED}{BW \times AT}$$

$$\text{Radionuclide Intake}\,(\text{pCi}) = A_{rabbit} \times FI_r \times IR_r \times EF \times ED \times CF$$

Parameter	**Units**	**Value used**	**References[b]**
Chemical concentration in rabbit = $\mathbf{C_{rabbit}}$	mg/kg	Chemical-specific	See Table D.45
Radiological activity in rabbit = $\mathbf{A_{rabbit}}$	pCi/g	Chemical-specific	See Table D.45
Ingestion ratec = $\mathbf{IR_r}$	kg/meal	0.0165 (adult) 0.0082 (teen) 0.0033 (child)	See footnote c
Conversion factor = **CF**	g/kg	1000	-----
Diet fraction = $\mathbf{FI_r}$	unitless	1	[5]
Exposure frequency = **EF**	meals/yr	350	See footnote c
Exposure duration = **ED**	years	12 (adult) 12 (teen) 6 (child)	[14]
Body weight = **BW**	kg	70 (adult) 43 (teen) 15 (child)	[14]
Averaging time = **AT**	yr × day/yr	70 × 365 (carcinogen) ED × 365 (noncarcinogen)	[14]

[a] Equation from [1].

[b] References follow Table D.50.

[c] Based on 20 rabbits bagged per year at WKWMA, 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.

Table D.25. Reasonable Maximum Exposure Assumptions and Human Intake Factors for Consumption of Quail by a Recreational User[a]

Equations:

$$\text{Chemical Intake}\,[\text{mg/(kg}\times\text{day)}] = \frac{C_{quail} \times FI_q \times IR_q \times EF \times ED}{BW \times AT}$$

$$\text{Radionuclide Intake (pCi)} = A_{quail} \times FI_q \times IR_q \times EF \times ED \times CF$$

Parameter	Units	Value used	References[b]
Chemical concentration in quail = $\mathbf{C_{quail}}$	mg/kg	Chemical-specific	See Table D.44
Radiological activity in quail = $\mathbf{A_{quail}}$	pCi/g	Chemical-specific	See Table D.44
Ingestion ratec = $\mathbf{IR_q}$	kg/meal	0.0047 (adult) 0.0024 (teen) 0.00094 (child)	See footnote c
Conversion factor = **CF**	g/kg	1000	-----
Diet fraction = $\mathbf{FI_q}$	unitless	1	[5]
Exposure frequency = **EF**	meals/yr	350	See footnote c
Exposure duration = **ED**	years	12 (adult) 12 (teen) 6 (child)	[14]
Body weight = **BW**	kg	70 (adult) 43 (teen) 15 (child)	[14]
Averaging time = **AT**	yr × day/yr	70 × 365 (carcinogen) ED × 365 (noncarcinogen)	[14]

[a] Equation from [1].

[b] References follow Table D.50.

[c] Based on 20 quail bagged per year at WKWMA, 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.

Table D.26. Reasonable Maximum Exposure Assumptions and Human Intake Factors for Ingestion of Water by an Industrial Worker[a]

Equations:

$$\text{Chemical Intake}\,[\text{mg/(kg}\times\text{day)}] = \frac{C_w \times IR_w \times EF \times ED}{BW \times AT}$$

$$\text{Radionuclide Intake}\,(\text{pCi}) = A_w \times \text{IR}_\text{w} \times \text{EF} \times \text{ED}$$

Parameter	Units	Value used	References[b]
Concentration in groundwater = $\mathbf{C_w}$	mg/L	Chemical-specific	-----
Activity in groundwater = $\mathbf{A_w}$	pCi/L	Chemical-specific	-----
Ingestion rate = $\mathbf{IR_w}$	L/day	1	[14]
Exposure frequency = **EF**	day/yr	250	[14]
Exposure duration = **ED**	year	25	[14]
Body weight = **BW**	kg	70	[14]
Averaging time = **AT**	yr × day/yr	70 × 365 (carcinogen) ED × 365 (noncarcinogen)	[14]

---

[a] Equation from [1].

[b] References follow Table D.50.

Table D.27. Reasonable Maximum Exposure Assumptions and Human Intake Factors for Inhalation of Volatile Organic Compounds in Water while Showering by an Industrial Worker[a]

Equations:

$$\text{Chemical Intake}\,[\text{mg/(kg}\times\text{day)}] = \frac{C_{shower} \times IR_{air} \times EF \times ED \times ET}{BW \times AT}$$

$$\text{Radionuclide Intake (pCi)} = A_{gw} \times IR_{air} \times EF \times ED \times IEF$$

$$C_{shower}\ (\text{mg/m}^3) = \frac{[(C_{a\max}/2)\times t_1] + [C_{a\max}\times t_2]}{t_1 + t_2} \qquad C_{a\max}\ (\text{mg/m}^3) = \frac{C_{gw} \times f \times F_w \times t_1}{V_a}$$

Parameter	Units	Value used	References[b]
Concentration in shower = **C**$\mathbf{C_{shower}}$	mg/m^3	Chemical-specific	Calculated
Indoor inhalation rate = $\mathbf{IR_{air}}$	m^3/hour	0.833	[14]
Exposure frequency = **EF**	day/year	250	[14]
Exposure duration = **ED**	years	25	[14]
Exposure time = **ET**	hours/day	0.2	[14]
Body weight = **BW**	kg	70	[14]
Averaging time = **AT**	yr × day/yr	70 × 365 (carcinogen) ED × 365 (noncarcinogen)	[14]
Activity in groundwater = $\mathbf{A_{gw}}$	pCi/L	Chemical-specific	-----
Inhalation exposure factor = **IEF**[c]	(L-hr)/(m^3-day)	Chemical-specific	[15]
Maximum concentration = $\mathbf{C_{amax}}$	mg/m^3	Chemical-specific	
Time of shower = $\mathbf{t_1}$	hours	0.1	[14]
Time after shower = $\mathbf{t_2}$	hours	0.1	[14]
Concentration in groundwater = $\mathbf{C_{gw}}$	mg/L	Chemical-specific	
Fraction volatilized = ***f***	unitless	0.75	[14]
Water flow rate = $\mathbf{F_w}$	L/h	890	[14]
Bathroom volume = $\mathbf{V_a}$	m^3	11	[14]

[a] Equation after [14] and [37].

[b] References follow Table D.50.

[c] Default value is 0. Values for tritium and radon are 0.2064 and 5.6, respectively.

Table D.28. Reasonable Maximum Exposure Assumptions and Human Intake Factors for Dermal Contact with Water while Showering by an Industrial Worker[a]

Equation:

$$\text{Absorbed Dose Inorganic } [\text{mg/(kg}\times\text{day)}] = \frac{C_w \times SA \times K_p \times CF \times ED \times EF \times ET}{BW \times AT}$$

$$\text{Absorbed Dose Organic}[\text{mg/(kg}\times\text{day)}] = \frac{DA_{event} \times SA \times CF \times CF_1 \times ED \times EF \times EV}{BW \times AT}$$

Parameter	Units	Value used	References[b]
Concentration in water = $\mathbf{C_w}$	mg/L	Chemical-specific	-----
Skin permeability constant = $\mathbf{K_p}$	cm/hr	Chemical-specific	-----
Absorbed dose per event = $\mathbf{DA_{event}}$	Mg/cm^2-event	Chemical-specific* $\mathbf{C_w}$ [d]	______________
Skin Surface Area **= SA**	m^2	1.815	[14]
Exposure frequency = **EF**	baths/yr	250	[14]
Exposure duration = **ED**	years	25	[14]
Exposure time = **ET**	hrs/bath	0.2	[14]
Event = **EV**	Bath/day	1	[14]
Conversion factor = **CF**	(L-m)/(cm-m^3)	10	-----
Conversion factor = $\mathbf{CF_1}$	Cm^3/L	1000	-----
Body weight = **BW**	kg	70	[14]
Averaging time = **AT**	yr × day/yr	70 × 365 (carcinogen) ED × 365 (noncarcinogen)	[14]

[a] Equation from [1].

[b] References follow Table D.50.

[c] Entire surface area of body.

[d] Part 2 of this appendix gives a factor for each organic chemical that is to be multiplied by the water concentration (C_w) to obtain the term DA*event* for the equation shown above.

Table D.29. Reasonable Maximum Exposure Assumptions and Human Intake Factors for Incidental Ingestion of Soil by an Industrial Worker[a]

Equations:

$$\text{Chemical Intake}\,[\text{mg/(kg} \times \text{day}] = \frac{C_s \times CF \times EF \times FI \times ED \times IR}{BW \times AT}$$

$$\text{Radionuclide Intake}\,(\text{pCi}) = A_s \times CF_{rad} \times EF \times FI \times ED \times IR$$

Parameter	Units	Value used	References[b]
Concentration in soil = $\mathbf{C_s}$	mg/kg	Chemical-specific	-----
Activity in soil = $\mathbf{A_s}$	pCi/g	Chemical-specific	-----
Ingestion rate = **IR**	mg/day	50 (indoor)	[14]
		480 (outdoor)	[14]
Fraction ingested = **FI**	unitless	1	[14]
Exposure frequency = **EF**	day/yr	250	[14]
Exposure duration = **ED**	year	25	[14]
Conversion factor = **CF**	kg/mg	10^{-6}	-----
Conversion factor = $\mathbf{CF_{rad}}$	g/mg	10^{-3}	-----
Body weight = **BW**	kg	70	[14]
Averaging time = **AT**	yr × day/yr	70 × 365 (carcinogen)	[14]
		ED × 365 (noncarcinogen)	

[a] Equation from [1].

[b] References follow Table D.50.

Table D.30. Reasonable Maximum Exposure Assumptions and Human Intake Factors for Incidental Ingestion of Sediment by an Industrial Worker[a]

Equations:

$$\text{Chemical Intake}\,[\text{mg/(kg}\times\text{day}] = \frac{C_{sed}\times CF\times IR\times EF\times ED\times ET\times CF_2}{BW\times AT}$$

$$\text{Radionuclide Intake}\,(\text{pCi}) = A_{sed}\times CF_{rad}\times IR\times EF\times ED\times ET\times CF_2$$

Parameter	Units	Value used	References[b]
Concentration in sediment = $\mathbf{C_{sed}}$	mg/kg	Chemical-specific	-----
Conversion factor = **CF**	kg/mg	10^{-6}	-----
Activity in sediment = $\mathbf{A_{sed}}$	pCi/g	Chemical-specific	-----
Conversion factor = $\mathbf{CF_{rad}}$	g/mg	10^{-3}	-----
Ingestion rate = **IR**	mg/day	50 (indoor)	[14]
		480 (outdoor)	[14]
Exposure frequency = **EF**	day/yr	250	[14]
Exposure duration = **ED**	year	25	[14]
Exposure time for sediment = **ET**	hour/day	2.6	[14]
Conversion factor = $\mathbf{CF_2}$	worker day/hour	1/8	-----
Body weight = **BW**	kg	70	[14]
Averaging time = **AT**	yr × day/yr	70 × 365 (carcinogen)	[14]
		ED × 365 (noncarcinogen)	

[a] Equation after [1].

[b] References follow Table D.50.

Table D.31. Reasonable Maximum Exposure Assumptions and Human Intake Factors for Inhalation of Vapors and Particulates Emitted from Soil by an Industrial Worker[a]

Equations:

$$\text{Chemical Intake}\,[\text{mg/(kg}\times\text{day)}] = \frac{C_s \times EF \times ED \times ET \times \left(\dfrac{1}{VF} + \dfrac{1}{PEF}\right) \times IR_{air}}{BW \times AT}$$

$$\text{Radionuclide Intake (pCi)} = A_s \times EF \times ED \times ET \times CF \times \left(\frac{1}{PEF}\right) \times IR_{air}$$

Parameter	Units	Value used	References[b]
Concentration in soil = **C$_s$**	mg/kg	Chemical-specific	-----
Activity in soil or = **A$_s$**	pCi/g	Chemical-specific	-----
Conversion factor = **CF**	g/kg	10^3	-----
Exposure frequency = **EF**	day/year	250	[14]
Exposure duration = **ED**	years	25	[14]
Exposure time = **ET**	hour/day	8	[14]
Volatilization factor = **VF**	m^3/kg	Chemical-specific	[19]
Particulate emission factor[c] = **PEF**	m^3/kg	6.2×10^8	[14]
Total inhalation rate = **IR$_{air}$**	m^3/hour	2.5	[14]
Body weight = **BW**	kg	70	[14]
Averaging time = **AT**	yr × day/yr	70 × 365 (carcinogen) ED × 365 (noncarcinogen)	[14]

[a] Equation from [20].

[b] References follow Table D.50.

[c] PEFs from KRAGS 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 the SSL Technical Background document [41].

Table D.32. Reasonable Maximum Exposure Assumptions and Human Intake Factors for Inhalation of Vapors and Particulates Emitted from Sediment by an Industrial Worker[a]

Equations:

$$\text{Chemical Intake}\,[\text{mg/(kg} \times \text{day)}] = \frac{C_{sed} \times EF \times ED \times ET \times \left(\dfrac{1}{VF} + \dfrac{1}{PEF}\right) \times IR_{air}}{BW \times AT}$$

$$\text{Radionuclide Intake}\,(\text{pCi}) = A_{sed} \times EF \times ED \times ET \times CF \times \left(\frac{1}{PEF}\right) \times IR_{air}$$

Parameter	Units	Value used	References[b]
Concentration in sediment = **C_{sed}**	mg/kg	Chemical-specific	-----
Activity in sediment = **A_{sed}**	pCi/g	Chemical-specific	-----
Conversion factor = **CF**	g/kg	10^3	-----
Exposure frequency = **EF**	day/year	250	[14]
Exposure duration = **ED**	years	25	[14]
Exposure time for sediment = **ET**	hours/day	2.6	[14]
Volatilization factor = **VF**	m^3/kg	Chemical-specific	[19]
Particulate emission factor[c] = **PEF**	m^3/kg	6.2×10^8	[14]
Total inhalation rate = **IR_{air}**	m^3/hour	2.5	[14]
Body weight = **BW**	kg	70	[14]
Averaging time = **AT**	yr × day/yr	70 × 365 (carcinogen) ED × 365 (noncarcinogen)	[14]

[a] Equations after [20].

[b] References follow Table D.50.

[c] PEFs from KRAGS 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 the SSL Technical Background document [41].

Table D.33. Reasonable Maximum Exposure Assumptions and Human Intake Factors for Dermal Contact with Soil or Sediment by an Industrial Worker[a]

Equation:

$$\text{Absorbed Dose } [(\text{mg}/(\text{kg}\times\text{day})] = \frac{C_s \times CF_d \times SA \times AF \times ABS \times EF \times ED}{BW \times AT}$$

Parameter	**Units**	**Value used**	**References**[b]
Concentration in soil or sediment = $\mathbf{C_s}$	mg/kg	Chemical-specific	-----
Conversion factor-dermal = $\mathbf{CF_d}$	(kg-cm^2)/(mg-m^2)	0.01	-----
Surface area[c] = **SA**	m^2/day	0.47	[14]
Adherence factor = **AF**	mg/cm^2	1	[14]
Absorption factor[d] = **ABS**	unitless	Chemical-specific	[14]
Exposure frequency = **EF**	day/yr	250	[14]
Exposure duration = **ED**	years	25	[14]
Body weight = **BW**	kg	70	[14]
Averaging time = **AT**	yr × day/yr	70 × 365 (carcinogen) ED × 365 (noncarcinogen)	[14]

[a] Equation after [1].

[b] References follow Table D.50.

[c] Area of hands, arms, and head.

[d] The default factors are used unless chemical-specific absorption factors are available. These defaults are 0.25 (volatile organic compounds), 0.10 (semi-volatile organic compounds), and 0.05 (inorganic chemical). Chemical-specific absorption factors available are listed in Table B.5 [38].

Note: Dermal absorbed dose is not applicable to radionuclides per guidance found in [1].

Table D.34. Reasonable Maximum Exposure Assumptions and Human Intake Factors for External Exposure to Ionizing Radiation from Soil by an Industrial Worker[a]

Equation:

$$\text{Absorbed Dose } [(\text{pCi} \times \text{year})/\text{g}] = A_s \times ED \times EF \times (1 - S_e) \times T_e$$

Parameter	**Units**	**Value used**	**References[b]**
Activity in soil = $\mathbf{A_s}$	pCi/g	Chemical-specific	-----
Exposure frequency = **EF**	day/day	250/365	[14]
Exposure duration = **ED**	year	25	[14]
Gamma shielding factor = $\mathbf{S_e}$	unitless	0.2	[20]
Gamma exposure time factor = $\mathbf{T_e}$	hr/hr	8/24	[20]

[a] Equation after [20].

[b] References follow Table D.50.

Table D.35. Reasonable Maximum Exposure Assumptions and Human Intake Factors for External Exposure to Ionizing Radiation from Sediment by an Industrial Worker[a]

Equation:

$$\text{Absorbed Dose } [(\text{pCi} \times \text{year})/\text{g}] = A_{sed} \times ED \times EF \times (1 - S_e) \times T_e$$

Parameter	**Units**	**Value used**	**References[b]**
Activity in sediment = $\mathbf{A_{sed}}$	pCi/g	Chemical-specific	-----
Exposure frequency = **EF**	day/day	250/365	[14]
Exposure duration = **ED**	year	25	[14]
Gamma shielding factor = $\mathbf{S_e}$	unitless	0.2	[20]
Gamma exposure time factor = $\mathbf{T_e}$	hr/hr	2.6/24	[20]

[a] Equation from [20].

[b] References follow Table D.50.

Table D.36. Reasonable Maximum Exposure Assumptions and Human Intake Factors for Dermal Contact with Surface Water by an Industrial or Outdoor Worker/Gardener[a]

Equation:

$$\text{Absorbed Dose Inorganic } [\text{mg}/(\text{kg} \times \text{day})] = \frac{C_w \times SA \times K_p \times CF \times ED \times EF \times ET}{BW \times AT}$$

$$\text{Absorbed Dose Organic}[\text{mg}/(\text{kg} \times \text{day})] = \frac{DA_{event} \times SA \times CF \times CF_1 \times ED \times EF \times EV}{BW \times AT}$$

Parameter	**Units**	**Value used**	**Reference s[b]**
Concentration in surface water = $\mathbf{C_{sw}}$	mg/L	Chemical-specific	-----
Adult surface area[c] = **SA**	m^2	0.47	[14]
Skin permeability constant = $\mathbf{K_p}$	cm/hr	Chemical-specific	-----
Absorbed dose per event = $\mathbf{DA_{event}}$	Mg/cm^2-event	Chemical-specific* $\mathbf{C_w}$[d]	-----
Exposure frequency = **EF**	day/yr	250 (industrial)	[14]
		20 (excavation)	-----
Exposure duration = **ED**	years	25	[14]
Event = **EV**	event/day	1	[14]
Exposure Time = **ET**	Hr/day	2.6 (industrial)	-----
		8 (excavation)	-----
Conversion factor = **CF**	L/(cm - m^2)	10	-----
Conversion factor = **CF**	Cm^3/L	1000	-----
Body weight = **BW**	kg	70	[14]
Averaging time = **AT**	yr × day/yr	70 × 365 (carcinogen)	[14]
		ED × 365 (noncarcinogen)	

[a] Equation from [1].

[b] References follow Table D-50.

[c] Includes area of arms, hands, and head.

[d] Part 2 of this appendix gives a factor for each organic chemical that is to be multiplied by the water concentration (C_w) to obtain the term DA*event* for the equation shown above.

Note: Dermal absorbed dose is not applicable to radionuclides per guidance found in [1].

Table D.37. Reasonable Maximum Exposure Assumptions and Human Intake Factors for Incidental Ingestion of Soil by an Outdoor Worker/Gardener[a]

Equations:

$$\text{Chemical Intake}\,[\text{mg/(kg}\times\text{day}] = \frac{C_s \times CF \times EF \times FI \times ED \times IR}{BW \times AT}$$

$$\text{Radionuclide Intake}\,(\text{pCi}) = A_s \times CF_{rad} \times EF \times FI \times ED \times IR$$

Parameter	Units	Value used	References[b]
Concentration in soil or sediment = **C$_s$**	mg/kg	Chemical-specific	-----
Conversion factor = **CF**	kg/mg	10^{-6}	-----
Activity in soil or sediment = **A$_s$**	pCi/g	Chemical-specific	-----
Conversion factor = **CF$_{rad}$**	g/mg	10^{-3}	-----
Ingestion rate = **IR**	mg/day	480	[14]
Exposure frequency = **EF**	day/yr	185	[14]
Exposure duration = **ED**	year	25	[20]
Fraction ingested = **FI**	unitless	1	[14]
Body weight = **BW**	kg	70	[14]
Averaging time = **AT**	yr × day/yr	70 × 365 (carcinogen) ED × 365 (noncarcinogen)	[14]

---

[a] Equation after [1].

[b] References follow Table D.50.

Table D.38. Reasonable Maximum Exposure Assumptions and Human Intake Factors for Inhalation of Vapors and Particulates Emitted from Soil by an Outdoor Worker/Gardener[a]

Equations:

$$\text{Chemical Intake}\,[\text{mg/(kg} \times \text{day)}] = \frac{C_s \times EF \times ED \times ET \times \left(\frac{1}{VF} + \frac{1}{PEF}\right) \times IR_{air}}{BW \times AT}$$

$$\text{Radionuclide Intake (pCi)} = A_s \times EF \times ED \times ET \times CF \times \left(\frac{1}{PEF}\right) \times IR_{air}$$

Parameter	Units	Value used	References[b]
Concentration in soil or sediment = $\mathbf{C_s}$	mg/kg	Chemical-specific	-----
Activity in soil or sediment = $\mathbf{A_s}$	pCi/g	Chemical-specific	-----
Conversion factor = **CF**	g/kg	10^3	-----
Exposure frequency = **EF**	day/yr	185	[14]
Exposure duration = **ED**	years	25	[20]
Exposure time = **ET**	hours/day	8	[14]
Volatilization factor = **VF**	m^3/kg	Chemical-specific	[19]
Particulate emission factor[c] = **PEF**	m^3/kg	6.2×10^8	[14]
Inhalation rate = $\mathbf{IR_{air}}$	m^3/hour	2.5	[14]
Averaging time = **AT**	yr × day/yr	70 × 365 (carcinogen) ED × 365 (noncarcinogen)	[14]

[a] Equation from [20].

[b] References follow Table D.50.

[c] PEFs from KRAGS 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 the SSL Technical Background document [41].

Table D.39. Reasonable Maximum Exposure Assumptions and Human Intake Factors for Dermal Contact with Soil by an Outdoor Worker/Gardener[a]

Equation:

$$\text{Absorbed Dose } [(\text{mg}/(\text{kg}\times\text{day})] = \frac{C_s \times CF_d \times SA \times AF \times ABS \times EF \times ED}{BW \times AT}$$

Parameter	**Units**	**Value used**	**References[b]**
Concentration in soil or sediment = $\mathbf{C_s}$	mg/kg	Chemical-specific	-----
Conversion factor-dermal = $\mathbf{CF_d}$	(kg-cm^2)/(mg-m^2)	0.01	-----
Surface area[c] = **SA**	m^2/day	0.47	[14]
Adherence factor = **AF**	mg/cm^2	1	[14]
Absorption factor[d] = **ABS**	unitless	Chemical-specific	[14]
Exposure frequency = **EF**	day/yr	185	[14]
Exposure duration = **ED**	years	25	[20]
Body weight = **BW**	kg	70	[14]
Averaging time = **AT**	yr × day/yr	70 × 365 (carcinogen) ED × 365 (noncarcinogen)	[14]

[a] Equation from [1].

[b] References follow Table D.50.

[c] Includes skin area of arms, hands, and head.

[d] The default factors are used unless chemical-specific absorption factors are available. These defaults are 0.25 (volatile organic compounds), 0.10 (semi-volatile organic compounds), and 0.05 (inorganic chemical). Chemical-specific absorption factors available are listed in Table B.5 [38].

Note: Dermal absorbed dose is not applicable to radionuclides per guidance found in [1].

Table D.40. Reasonable Maximum Exposure Assumptions and Human Intake Factors for External Exposure to Ionizing Radiation from Soil by an Outdoor Worker/Gardener[a]

Equation:

$$\text{Absorbed Dose } [(\text{pCi} \times \text{year})/\text{g}] = A_s \times ED \times EF \times (1 - S_e) \times T_e$$

Parameter	**Units**	**Value used**	**References[b]**
Activity in soil or sediment = $\mathbf{A_s}$	pCi/g	Chemical-specific	-----
Exposure frequency = **EF**	day/day	185/365	[14], [20]
Exposure duration = **ED**	year	25	[20]
Gamma shielding factor = $\mathbf{S_e}$	unitless	0.2	[20]
Gamma exposure time factor = $\mathbf{T_e}$	hr/hr	8/24	[20]

[a] Equation from [20].

[b] References follow Table D.50.

Table D.41. Reasonable Maximum Exposure Assumptions for Concentration or Activity of COPCs in Deer[a]

Equations:

$$C_{deer} = F_{deer} \times [(\mathrm{C}_{\mathrm{forage}} \times AC \times f_s \times Q_f) + (C_s \times AC \times Q_s) + (C_{sw} \times CF_{rad} \times Q_{sw})]$$

$$C_{forage} = (C_s \times R_{upp}) + (C_s \times R_{es})$$

Parameter	Units	Value used	References[b]
Chemical concentration in deer = $\mathbf{C_{deer}}$	mg/kg or pCi/g	Chemical-specific	Calculated
Forage-deer transfer factor = $\mathbf{F_{deer}}$	day/kg	Chemical-specific	-----
Chemical 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	[34]
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 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 in surface water = $\mathbf{C_{sw}}$	mg/L or pCi/L	Chemical-specific	-----
Conversion factor for radionuclides = $\mathbf{CF_{rad}}$	kg/g	10^{-3}	-----
Quantity of surface water ingested daily by deer = $\mathbf{Q_{sw}}$	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 follow Table D.50.

[c] AC cannot be greater than 1.

[d] All ingested water is assumed to be from SWMU or SWMU area.

Table D.42. Reasonable Maximum Exposure Assumptions for Concentration or Activity of COPCs in Home-grown Vegetables[a]

Equations:

$$C_{vegetables} = (C_w \times Irr_{rup} \times CF_{rad}) + (C_s \times AC \times R_{upv}) + (C_w \times Irr_{res} \times CF_{rad}) + (C_s \times AC \times R_{es}) + (C_w \times Irr_{dep} \times CF_{rad})$$

$$Irr_{rup} = \frac{Ir \times F \times Bv_{wet} \times [1 - \exp(-\lambda_B \times t_b)]}{P \times \lambda_B}$$

$$Irr_{dep} = \frac{Ir \times F \times I_f \times T \times [1 - \exp(-\lambda_E \times t_v)]}{Y_v \times \lambda_E}$$

$$Irr_{res} = \frac{Ir \times F \times MLF \times [1 - \exp(-\lambda_B \times t_b)]}{P \times \lambda_B}$$

Parameter	Units	Value used	References[b]
Concentration in vegetable = $\mathbf{C_{vegetables}}$	mg/kg or pCi/g	Chemical-specific	Calculated
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 = $\mathbf{CF_{rad}}$	kg/g	10^{-3}	-----
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	[33]
Wet root uptake for leafy vegetables = $\mathbf{R_{upv}}$	kg/kg	Chemical-specific	-----
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	-----
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 follow Table D.50.

[c] AC cannot be greater than 1.

Table D.43. Reasonable Maximum Exposure Assumptions for Concentration or Activity of COPCs in Fish

Equation:

$$C_{fish} = C_{sw} \times BAF_{fish}$$

Parameter	Units	Value used	References
Contaminant concentration in fish = $\mathbf{C_{fish}}$	mg/kg or pCi/kg	Chemical-specific	Calculated
Contaminant concentration in water = $\mathbf{C_{sw}}$	mg/L or pCi/L	Chemical-specific	-----
Bioaccumulation factor = $\mathbf{BAF_{fish}}$	L/kg	Chemical-specific	-----

Table D.44. Reasonable Maximum Exposure Assumptions for Concentration or Activity of COPCs in Quail[a]

Equations:

$$C_{quail} = F_{quail} \times [(C_{forage} \times AC \times f_s \times Q_f) + (C_s \times AC \times Q_s) + (C_{sw} \times CF_{rad} \times Q_{sw}) + (C_i + AC + Q_i)]$$

$$C_{forage} = (C_s \times R_{upp}) + (C_s \times R_{es}) \qquad C_i = (C_s \times BAF_i)$$

Parameter	Units	Value used	References[b]
Chemical concentration in quail = $\mathbf{C_{quail}}$	mg/kg or pCi/g	Chemical-specific	Calculated
Forage-quail transfer factor = $\mathbf{F_{quail}}$	day/kg	Chemical-specific	use $\mathbf{F_{poultry}}$ **values**
Chemical 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	[30]
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	[30] 88.2% of total food
Chemical 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	[30] 11.8 % of total food
Chemical 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	0.00158	[32] 9.3% of total food (same as turkey)
Contaminant concentration in surface water = $\mathbf{C_{sw}}$	mg/L or pCi/L	Chemical-specific	-----
Conversion factor for radionuclides = $\mathbf{CF_{rad}}$	kg/g	10^{-3}	-----
Quantity of surface water ingested daily by quail = $\mathbf{Q_{sw}}$	L/day	0.024	[30]
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 follow Table D.50.

[c] AC cannot be greater than 1.

[d] All ingested water is considered to be from SWMU or SWMU area.

Table D.45. Reasonable Maximum Exposure Assumptions for Concentration or Activity of COPCs in Rabbits[a]

Equations:

$$C_{rabbit} = F_{rabbit} \times [(\mathrm{C}_{\mathrm{forage}} \times AC \times f_s \times Q_f) + (C_s \times AC \times Q_s) + (C_{sw} \times CF_{rad} \times Q_{sw})]$$

$$C_{forage} = (C_s \times R_{upp}) + (C_s \times R_{es})$$

Parameter	Units	Value used	References[b]
Chemical concentration in rabbit = $\mathbf{C_{rabbit}}$	mg/kg or pCi/g	Chemical-specific	Calculated
Forage-rabbit transfer factor = $\mathbf{F_{rabbit}}$	day/kg	Chemical-specific	use $\mathbf{F_{beef}}$ values
Chemical 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	[30]
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	[31]
Chemical 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	[31] 6.3% of forage
Contaminant concentration in surface water = $\mathbf{C_{sw}}$	mg/L or pCi/L	Chemical-specific	-----
Conversion factor for radionuclides = $\mathbf{CF_{rad}}$	kg/g	10^{-3}	-----
Quantity of surface water ingested daily by rabbit = $\mathbf{Q_{sw}}$	L/day	0.116	[31]
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 follow Table D.50.

[c] AC cannot be greater than 1.

[d] All ingested water is considered to be from SWMU or SWMU area.

Table D.46. Reasonable Maximum Exposure Assumptions for Concentration or Activity of COPCs in Beef[a]

Equations:

$$C_{beef} = F_{beef} \times [(C_{forage} \times AC \times f_s \times Q_f) + (C_s \times AC \times Q_s) + (C_{sw} \times CF_{rad} \times Q_{sw})]$$

$$C_{forage} = (C_s \times R_{upp}) + (C_s \times R_{es})$$

Parameter	Units	Value used	References[b]
Chemical concentration in beef = $\mathbf{C_{beef}}$	mg/kg or pCi/g	Chemical-specific	Calculated
Forage-beef transfer factor = $\mathbf{F_{beef}}$	day/kg	Chemical-specific	-----
Chemical 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	[29]
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	[25]
Chemical 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	[26]
Contaminant concentration in water = $\mathbf{C_w}$	mg/L or pCi/L	Chemical-specific	-----
Conversion factor for radionuclides = $\mathbf{CF_{rad}}$	kg/g	10^{-3}	-----
Quantity of water ingested daily by beef = $\mathbf{Q_w}$	L/day	50	[25]
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 follow Table D.50.

[c] AC cannot be greater than 1.

[d] All ingested water is considered to be from SWMU or SWMU area.

Table D.47. Reasonable Maximum Exposure Assumptions for Concentration or Activity of COPCs in Milk[a]

Equations:

$$C_{milk} = F_{milk} \times [(C_{forage} \times AC \times f_s \times Q_f) + (C_s \times AC \times Q_s) + (C_w \times CF_{rad} \times Q_{sw})]$$

$$C_{forage} = (C_s \times R_{upp}) + (C_s \times R_{es})$$

Parameter	Units	Value used	References[b]
Chemical concentration in milk = $\mathbf{C_{milk}}$	mg/kg or pCi/g	Chemical-specific	Calculated
Forage-milk transfer factor = $\mathbf{F_{milk}}$	day/kg	Chemical-specific	-----
Chemical 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	[29]
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	[25]
Chemical 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	[26]
Contaminant concentration in water = $\mathbf{C_w}$	mg/L or pCi/L	Chemical-specific	-----
Conversion factor for radionuclides = $\mathbf{CF_{rad}}$	kg/g	10^{-3}	-----
Quantity of water ingested daily by dairy = $\mathbf{Q_w}$	L/day	60	[25]
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 follow Table D.50.

[c] AC cannot be greater than 1.

[d] All ingested water is considered to be from SWMU or SWMU area.

Table D.48. Reasonable Maximum Exposure Assumptions for Concentration or Activity of COPCs in Poultry[a]

Equations:

$$C_{poultry} = F_{poultry} \times [(C_{forage} \times AC \times f_s \times Q_f) + (C_s \times AC \times Q_s) + (C_w \times CF_{rad} \times Q_w)]$$

$$C_{forage} = (C_s \times R_{upp}) + (C_s \times R_{es})$$

Parameter	Units	Value used	References[b]
Chemical concentration in poultry = $\mathbf{C_{poultry}}$	mg/kg or pCi/g	Chemical-specific	Calculated
Forage-poultry transfer factor = $\mathbf{F_{poultry}}$	day/kg	Chemical-specific	-----
Chemical 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	[29]
Fraction of poultry's food from site = $\mathbf{f_s}$	unitless	.5	[29] assumes broilers get 50% bought grain
Quantity of pasture ingested daily by poultry = $\mathbf{Q_f}$	kg/day	0.12 (chicken) 0.35 (turkey)	[24] 20 wk old male turkey
Chemical 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 = $\mathbf{CF_{rad}}$	kg/g	10^{-3}	-----
Quantity of water ingested daily by poultry = $\mathbf{Q_w}$	L/day	0.24 (chicken) 1.0 (turkey)	[24] 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 follow Table D.50.

[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.49. Reasonable Maximum Exposure Assumptions for Concentration or Activity of COPCs in Pork[a]

Equations:

$$C_{pork} = F_{pork} \times [(C_{forage} \times AC \times f_s \times Q_f) + (C_s \times AC \times Q_s) + (C_w \times CF_{rad} \times Q_w)]$$

$$C_{forage} = (C_s \times R_{upp}) + (C_s \times R_{es})$$

Parameter	Units	Value used	References[b]
Chemical concentration in pork = $\mathbf{C_{pork}}$	mg/kg or pCi/g	Chemical-specific	Calculated
Forage-pork transfer factor = $\mathbf{F_{pork}}$	day/kg	Chemical-specific	-----
Chemical 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	[29]
Fraction of swine's food from site = $\mathbf{f_s}$	unitless	0.4	[29]
Quantity of pasture ingested daily by swine = $\mathbf{Q_f}$	kg/day	2.4	[36]
Chemical 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	[28]
Contaminant concentration in water = $\mathbf{C_w}$	mg/L or pCi/L	Chemical-specific	-----
Conversion factor for radionuclides = $\mathbf{CF_{rad}}$	kg/g	10^{-3}	-----
Quantity of water ingested daily by swine = $\mathbf{Q_w}$	L/day	6.14	[27] 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 follow Table D.50.
[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 percent of the swine's diet to come from pasture while the remaining comes from store bought grain.

Table D.50. Reasonable Maximum Exposure Assumptions for Concentration or Activity of COPCs in Egg[a]

Equations:

$$C_{egg} = F_{egg} \times (C_w \times CF_{rad} \times Q_w)]$$

Parameter	Units	Value used	References[b]
Chemical concentration in egg = $\mathbf{C_{egg}}$	mg/kg or pCi/g	Chemical-specific	Calculated
Forage-egg transfer factor = $\mathbf{F_{egg}}$	day/kg	Chemical-specific	-----
Contaminant concentration in water = $\mathbf{C_w}$	mg/L or pCi/L	Chemical-specific	-----
Conversion factor for radionuclides = $\mathbf{CF_{rad}}$	kg/g	10^{-3}	-----
Quantity of water ingested daily by poultry = $\mathbf{Q_w}$	L/day	0.24 (chicken) 1.0 (turkey)	[24] 1:2 ratio of 20 wk old male turkey

[a] Equations after [1], [2], [3], [4].

[b] All references follow Table 50.

[c] AC cannot be greater than 1.

[d] All ingested water is considered to be from SWMU or SWMU area.

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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PART 2: CHEMICAL-SPECIFIC VALUES

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Appendix D: Part 2 Chemical-Specific Values

Reviewed 12/30/2010			Molecular Weight		Half-life (Radionuclides)		Pathway Indicators (from DOE 2001)			
CAS Number (RAIS)	Analyte Name (RAIS)	Notes	MW (g/mol)	MW Reference	T_r (days)	T_r Reference	Water Use Flag	Soil Use Flag	Food Use Flag	Volatile Organic Flag
7429905	Aluminum		30.01	RAIS 3_1			Yes	Yes	Yes	No
7440360	Antimony (metallic)		124.78	RAIS 3_1			Yes	Yes	Yes	No
7440382	Arsenic, Inorganic		77.95	RAIS 3_1			Yes	Yes	Yes	No
7440393	Barium		137.33	RAIS 3_1			Yes	Yes	Yes	No
7440417	Beryllium and compounds		9.01	RAIS 3_1			Yes	Yes	Yes	No
7440428	Boron And Borates Only		13.84	RAIS 3_1			Yes	Yes	Yes	No
7440439	Cadmium (Diet)		112.41	RAIS 3_1			No	Yes	Yes	No
7440439	Cadmium (Water)		112.41	RAIS 3_1			Yes	No	No	No
16065831	Chromium (III) (Insoluble Salts)	note e	52	SRS			Yes	Yes	Yes	No
7440473	Chromium (total)	note f	52	SRS			Yes	Yes	Yes	No
18540299	Chromium VI (chromic acid mists)		52	SRS			Yes	No	No	No
18540299	Chromium VI (particulates)		52	SRS			No	Yes	Yes	No
7440484	Cobalt		58.93	RAIS 3_1			Yes	Yes	Yes	No
7440508	Copper		63.55	RAIS 3_1			Yes	Yes	Yes	No
7439896	Iron		55.85	RAIS 3_1			Yes	Yes	Yes	No
7439921	Lead and compounds		207.2	RAIS 3_1			Yes	Yes	Yes	No
7439965	Manganese (Diet)		54.94	RAIS 3_1			No	No	Yes	No
7439965	Manganese (Water)		54.94	RAIS 3_1			Yes	Yes	No	No
7439976	Mercury, Inorganic Salts	note g	200.59	RAIS 3_1			Yes	Yes	Yes	No
7439987	Molybdenum		95.94	RAIS 3_1			Yes	Yes	Yes	No
7440020	Nickel Soluble Salts		58.69	RAIS 3_1			Yes	Yes	Yes	No
7782492	Selenium		80.98	RAIS 3_1			Yes	Yes	Yes	No
7440224	Silver		107.87	RAIS 3_1			Yes	Yes	Yes	No
7791120	Thallium Chloride		239.84	RAIS 3_1			Yes	Yes	Yes	No
	Uranium (Soluble Salts)						Yes	Yes	Yes	No
7440622	Vanadium, Metallic		50.94	RAIS 3_1			Yes	Yes	Yes	No
7440666	Zinc (Metallic)		67.41	RAIS 3_1			Yes	Yes	Yes	No
83329	Acenaphthene		154.21	RAIS 3_1			Yes	Yes	Yes	Yes
208968	Acenaphthylene		152.2	RAIS 3_1			Yes	Yes	Yes	Yes
107131	Acrylonitrile		53.06	RAIS 3_1			Yes	Yes	Yes	Yes
120127	Anthracene		178.24	RAIS 3_1			Yes	Yes	Yes	Yes
12674112	Aroclor 1016 (exposure to soil or food)		257.55	RAIS 3_1			No	Yes	Yes	No
12674112	Aroclor 1016 (exposure to water)		257.55	RAIS 3_1			Yes	No	No	No
11104282	Aroclor 1221 (exposure to soil or food)		188.66	RAIS 3_1			No	Yes	Yes	No
11104282	Aroclor 1221 (exposure to water)		188.66	RAIS 3_1			Yes	No	No	No
11141165	Aroclor 1232 (exposure to soil or food)		188.66	RAIS 3_1			No	Yes	Yes	No
11141165	Aroclor 1232 (exposure to water)		188.66	RAIS 3_1			Yes	No	No	No
53469219	Aroclor 1242 (exposure to soil or food)		291.99	RAIS 3_1			No	Yes	Yes	No

Blank cells indicate no value available.

Appendix D: Part 2 Chemical-Specific Values (Continued)

Reviewed 12/30/2010		Permeability Coefficient (Inorganics)		Permeability Coefficient (Organics)			Octanol-Water Partition Coefficient			
CAS Number (RAIS)	Analyte Name (RAIS)	K_p (cm/hr)	K_p Reference	DAevent factor-shower (L/cm2-event)	DAevent factor-swim/wade (L/cm2-event)	DA event reference	logKow	logKow reference	Kow	Kow reference
7429905	Aluminum	0.001	RAIS 6_6							
7440360	Antimony (metallic)	0.001	RAIS 6_6							
7440382	Arsenic, Inorganic	0.001	RAIS 6_6							
7440393	Barium	0.001	RAIS 6_6							
7440417	Beryllium and compounds	0.001	RAIS 6_6							
7440428	Boron And Borates Only	0.001	RAIS 6_6							
7440439	Cadmium (Diet)	0.001	RAIS 6_6							
7440439	Cadmium (Water)	0.001	RAIS 6_6							
16065831	Chromium (III) (Insoluble Salts)	0.001	RAIS 6_6							
7440473	Chromium (total)	0.001	RAIS 6_6							
18540299	Chromium VI (chromic acid mists)	0.002	RAIS 6_6							
18540299	Chromium VI (particulates)	0.002	RAIS 6_6							
7440484	Cobalt	0.0004	RAIS 6_6							
7440508	Copper	0.001	RAIS 6_6							
7439896	Iron	0.001	RAIS 6_6					RAIS 8_60		
7439921	Lead and compounds	0.0001	RAIS 6_6					RAIS 8_60		
7439965	Manganese (Diet)	0.001	RAIS 6_6					RAIS 8_60		
7439965	Manganese (Water)	0.001	RAIS 6_6					RAIS 8_60		
7439976	Mercury, Inorganic Salts	0.001	RAIS 6_6				0.62	RAIS 8_60	4.2E+00	
7439987	Molybdenum	0.001	RAIS 6_6					RAIS 8_60		
7440020	Nickel Soluble Salts	0.0002	RAIS 6_6					RAIS 8_60		
7782492	Selenium	0.001	RAIS 6_6					RAIS 8_60		
7440224	Silver	0.0006	RAIS 6_6					RAIS 8_60		
7791120	Thallium Chloride	0.001	RAIS 6_6					RAIS 8_60		
	Uranium (Soluble Salts)	0.001	RAIS 6_6					RAIS 8_60		
7440622	Vanadium, Metallic	0.001	RAIS 6_6					RAIS 8_60		
7440666	Zinc (Metallic)	0.0006	RAIS 6_6					RAIS 8_60		
83329	Acenaphthene			9.08E-05	3.32E-04	EPA 2004	3.92	RAIS 8_60	8.3E+03	
208968	Acenaphthylene			9.48E-05	3.46E-04	EPA 2004	3.94	RAIS 8_60	8.7E+03	
107131	Acrylonitrile			6.59E-07	3.52E-06	EPA 2004	0.25	RAIS 8_60	1.8E+00	
120127	Anthracene			1.74E-04	6.27E-04	EPA 2004	4.45	RAIS 8_60	2.8E+04	
12674112	Aroclor 1016 (exposure to soil or food)			6.18E-04	2.23E-03	EPA 2004	5.62	RAIS 8_60	4.2E+05	
12674112	Aroclor 1016 (exposure to water)			6.18E-04	2.23E-03	EPA 2004	5.62	RAIS 8_60	4.2E+05	
11104282	Aroclor 1221 (exposure to soil or food)			1.84E-04	6.62E-04	EPA 2004	4.53	RAIS 8_60	3.4E+04	
11104282	Aroclor 1221 (exposure to water)			1.84E-04	6.62E-04	EPA 2004	4.53	RAIS 8_60	3.4E+04	
11141165	Aroclor 1232 (exposure to soil or food)			1.84E-04	6.62E-04	EPA 2004	4.53	RAIS 8_60	3.4E+04	
11141165	Aroclor 1232 (exposure to water)			1.84E-04	6.62E-04	EPA 2004	4.53	RAIS 8_60	3.4E+04	
53469219	Aroclor 1242 (exposure to soil or food)			1.37E-03	4.94E-03	EPA 2004	6.29	RAIS 8_60	1.9E+06	

Blank cells indicate no value available.

Appendix D: Part 2 Chemical-Specific Values (Continued)

Reviewed 12/30/2010		Soil to Plant Uptake (dry)		Soil to Plant Uptake (wet)		Wet Root Uptake for Leafy Vegetables (same as B_{vwet})		Forage Beef Biotransfer Factor and Forage Rabbit Biotransfer Factor	
CAS Number (RAIS)	Analyte Name (RAIS)	R_{upp}	R_{upp} reference	B_{vwet}	B_{vwet} reference	R_{upv}	R_{upv} reference	F_{beef} (day/kg)	F_{beef} reference
7429905	Aluminum	0.004	RAIS 12_2	0.001	RAIS 11_2	0.001	RAIS 11_2	0.0015	RAIS 13_2
7440360	Antimony (metallic)	0.05	RAIS 12_4	0.01	RAIS 11_4	0.01	RAIS 11_4	0.00004	RAIS 13_3
7440382	Arsenic, Inorganic	0.04	RAIS 12_2	0.01	RAIS 11_2	0.01	RAIS 11_2	0.002	RAIS 13_2
7440393	Barium	0.1	RAIS 12_4	0.003	RAIS 11_3	0.003	RAIS 11_3	0.0002	RAIS 13_3
7440417	Beryllium and compounds	0.01	RAIS 12_2	0.0025	RAIS 11_2	0.0025	RAIS 11_2	0.001	RAIS 13_2
7440428	Boron And Borates Only	4	RAIS 12_2	1	RAIS 11_2	1	RAIS 11_2	0.0008	RAIS 13_2
7440439	Cadmium (Diet)	0.55	RAIS 12_2	0.14	RAIS 11_2	0.14	RAIS 11_2	0.0004	RAIS 13_3
7440439	Cadmium (Water)	0.55	RAIS 12_2	0.14	RAIS 11_2	0.14	RAIS 11_2	0.0004	RAIS 13_3
16065831	Chromium (III) (Insoluble Salts)	0.04	RAIS 12_4	0.0001	RAIS 11_3	0.0001	RAIS 11_3	0.009	RAIS 13_3
7440473	Chromium (total)	0.04	RAIS 12_4	0.0001	RAIS 11_3	0.0001	RAIS 11_3	0.009	RAIS 13_3
18540299	Chromium VI (chromic acid mists)	0.04	RAIS (no addl ref)	0.0001	RAIS (no addl ref)	0.0001	RAIS (no addl ref)	0.009	RAIS (no addl ref)
18540299	Chromium VI (particulates)	0.04	RAIS (no addl ref)	0.0001	RAIS (no addl ref)	0.0001	RAIS (no addl ref)	0.009	RAIS (no addl ref)
7440484	Cobalt	0.054	RAIS 12_3	0.023	RAIS 11_3	0.023	RAIS 11_3	0.0001	RAIS 13_3
7440508	Copper	0.8	RAIS 12_3	0.08	RAIS 11_3	0.08	RAIS 11_3	0.009	RAIS 13_3
7439896	Iron	0.01	RAIS 12_4	0.0004	RAIS 11_3	0.0004	RAIS 11_3	0.02	RAIS 13_3
7439921	Lead and compounds	0.09	RAIS 12_4	0.00076	RAIS 11_3	0.00076	RAIS 11_3	0.0004	RAIS 13_3
7439965	Manganese (Diet)	0.68	RAIS 12_3	0.069	RAIS 11_3	0.069	RAIS 11_3	0.0005	RAIS 13_3
7439965	Manganese (Water)	0.68	RAIS 12_3	0.069	RAIS 11_3	0.069	RAIS 11_3	0.0005	RAIS 13_3
7439976	Mercury, Inorganic Salts	1	RAIS 12_4	0.3	RAIS 11_4	0.3	RAIS 11_4	0.01	RAIS 13_4
7439987	Molybdenum	0.4	RAIS 12_4	0.08	RAIS 11_3	0.08	RAIS 11_3	0.001	RAIS 13_3
7440020	Nickel Soluble Salts	0.18	RAIS 12_3	0.05	RAIS 11_4	0.05	RAIS 11_4	0.005	RAIS 13_3
7782492	Selenium	0.5	RAIS 12_4	0.1	RAIS 11_4	0.1	RAIS 11_4	0.1	RAIS 13_4
7440224	Silver	1	RAIS 12_4	0.0000216	RAIS 11_3	0.000022	RAIS 11_3	0.003	RAIS 13_3
7791120	Thallium Chloride								
	Uranium (Soluble Salts)	0.023	RAIS 12_3	0.00063	RAIS 11_3	0.00063	RAIS 11_3	0.0003	RAIS 13_3
7440622	Vanadium, Metallic	0.0055	RAIS 12_2	0.00138	RAIS 11_2	0.0014	RAIS 11_2	0.0025	RAIS 13_2
7440666	Zinc (Metallic)	0.99	RAIS 12_3	0.264	RAIS 11_3	0.26	RAIS 11_3	0.1	RAIS 13_3
83329	Acenaphthene	0.205	RAIS 12_1	0.041	RAIS 11_1	0.025	RAIS 11_1	0.000208	RAIS 13_1
208968	Acenaphthylene	0.2	RAIS 12_1	0.0399	RAIS 11_1	0.055	RAIS 11_1	0.000218	RAIS 13_1
107131	Acrylonitrile	27.6	RAIS 12_1	5.51	RAIS 11_1	5.5	RAIS 11_1	4.45E-08	RAIS 13_1
120127	Anthracene	0.101	RAIS 12_1	0.0202	RAIS 11_1	0.022	RAIS 11_1	0.000705	RAIS 13_1
12674112	Aroclor 1016 (exposure to soil or food)	0.0212	RAIS 12_1	0.00424	RAIS 11_1	0.0029	RAIS 11_1	0.0104	RAIS 13_1
12674112	Aroclor 1016 (exposure to water)	0.0212	RAIS 12_1	0.00424	RAIS 11_1	0.0029	RAIS 11_1	0.0104	RAIS 13_1
11104282	Aroclor 1221 (exposure to soil or food)	0.0908	RAIS 12_1	0.0182	RAIS 11_1	0.032	RAIS 11_1	0.000847	RAIS 13_1
11104282	Aroclor 1221 (exposure to water)	0.0908	RAIS 12_1	0.0182	RAIS 11_1	0.032	RAIS 11_1	0.000847	RAIS 13_1
11141165	Aroclor 1232 (exposure to soil or food)	0.0908	RAIS 12_1	0.0182	RAIS 11_1	0.11	RAIS 11_1	0.000847	RAIS 13_1
11141165	Aroclor 1232 (exposure to water)	0.0908	RAIS 12_1	0.0182	RAIS 11_1	0.11	RAIS 11_1	0.000847	RAIS 13_1
53469219	Aroclor 1242 (exposure to soil or food)	0.00865	RAIS 12_1	0.00173	RAIS 11_1	0.032	RAIS 11_1	0.0487	RAIS 13_1

Blank cells indicate no value available.

Appendix D: Part 2 Chemical-Specific Values (Continued)

Reviewed 12/30/2010		Forage Deer Biotransfer Factor (note b)		Forage Egg Biotransfer Factor		Forage Milk Biotransfer Factor		Forage Pork Biotransfer Factor	
CAS Number (RAIS)	**Analyte Name (RAIS)**	**F_{deer} (day/kg)**	**F_{deer} reference**	**F_{egg} (day/kg)**	**F_{egg} reference**	**F_{milk} (day/kg)**	**F_{milk} reference**	**F_{pork} (day/kg)**	**F_{pork} reference**
7429905	Aluminum	0.0015	RAIS 13_2			0.0002	RAIS 5_4		
7440360	Antimony (metallic)	0.00004	RAIS 13_3			0.000025	RAIS 5_3		
7440382	Arsenic, Inorganic	0.002	RAIS 13_2			0.00006	RAIS 5_4		
7440393	Barium	0.0002	RAIS 13_3	0.9	IAEA 1994	0.00048	RAIS 5_3		
7440417	Beryllium and compounds	0.001	RAIS 13_2			0.0000009	RAIS 5_4		
7440428	Boron And Borates Only	0.0008	RAIS 13_2			0.0015	RAIS 5_4		
7440439	Cadmium (Diet)	0.0004	RAIS 13_3	0.0025	EPA 2005	0.001	RAIS 5_4	0.000191489	EPA 2005
7440439	Cadmium (Water)	0.0004	RAIS 13_3	0.0025	EPA 2005	0.001	RAIS 5_4	0.000191489	EPA 2005
16065831	Chromium (III) (Insoluble Salts)	0.009	RAIS 13_3			0.00001	RAIS 5_3		
7440473	Chromium (total)	0.009	RAIS 13_3			0.00001	RAIS 5_3		
18540299	Chromium VI (chromic acid mists)	0.009	RAIS (no addl ref)			0.00001	RAIS (no addl ref)		
18540299	Chromium VI (particulates)	0.009	RAIS (no addl ref)			0.00001	RAIS (no addl ref)		
7440484	Cobalt	0.0001	RAIS 13_3	0.1	IAEA 1994	0.00007	RAIS 5_3	0.002	IAEA 1994
7440508	Copper	0.009	RAIS 13_3	0.5	IAEA 1994	0.0015	RAIS 5_4	0.022	IAEA 1994
7439896	Iron	0.02	RAIS 13_3	1	IAEA 1994	0.00003	RAIS 5_3	0.026	IAEA 1994
7439921	Lead and compounds	0.0004	RAIS 13_3			0.0003	RAIS 5_2		
7439965	Manganese (Diet)	0.0005	RAIS 13_3	0.06	IAEA 1994	0.00003	RAIS 5_3	0.0036	IAEA 1994
7439965	Manganese (Water)	0.0005	RAIS 13_3	0.06	IAEA 1994	0.00003	RAIS 5_3	0.0036	IAEA 1994
7439976	Mercury, Inorganic Salts	0.01	RAIS 13_4			0.00047	RAIS 5_3		
7439987	Molybdenum	0.001	RAIS 13_3	0.9	IAEA 1994	0.0017	RAIS 5_3		
7440020	Nickel Soluble Salts	0.005	RAIS 13_3			0.016	RAIS 5_3		
7782492	Selenium	0.1	RAIS 13_4	1.12625	EPA 2005	0.01	RAIS 5_2	0.187659574	EPA 2005
7440224	Silver	0.003	RAIS 13_3			0.00005	RAIS 5_3	0.02	IAEA 1994
7791120	Thallium Chloride								
	Uranium (Soluble Salts)	0.0003	RAIS 13_3	1	IAEA 1994	0.0004	RAIS 5_3	0.062	IAEA 1994
7440622	Vanadium, Metallic	0.0025	RAIS 13_2			0.00002	RAIS 5_4		
7440666	Zinc (Metallic)	0.1	RAIS 13_3	0.00875	EPA 2005	0.01	RAIS 5_2	0.00012766	EPA 2005
83329	Acenaphthene	0.0005	RAIS 13_1	0.010240001	EPA 2005	6.57E-05	RAIS 5_1	0.029440002	EPA 2005
208968	Acenaphthylene	0.00013	RAIS 13_1			6.88E-05	RAIS 5_1		
107131	Acrylonitrile	0.000000044	RAIS 13_1	4.02163E-05	EPA 2005	1.40E-08	RAIS 5_1	0.000115622	EPA 2005
120127	Anthracene	0.00063	RAIS 13_1	0.014234427	EPA 2005	0.000223	RAIS 5_1	0.040923977	EPA 2005
12674112	Aroclor 1016 (exposure to soil or food)	0.02	RAIS 13_1	0.016832789	EPA 2005	0.00329	RAIS 5_1	0.048394269	EPA 2005
12674112	Aroclor 1016 (exposure to water)	0.02	RAIS 13_1	0.016832789	EPA 2005	0.00329	RAIS 5_1	0.048394269	EPA 2005
11104282	Aroclor 1221 (exposure to soil or food)	0.00031	RAIS 13_1			0.000268	RAIS 5_1		
11104282	Aroclor 1221 (exposure to water)	0.00031	RAIS 13_1			0.000268	RAIS 5_1		
11141165	Aroclor 1232 (exposure to soil or food)	0.00004	RAIS 13_1			0.000268	RAIS 5_1		
11141165	Aroclor 1232 (exposure to water)	0.00004	RAIS 13_1			0.000268	RAIS 5_1		
53469219	Aroclor 1242 (exposure to soil or food)	0.00031	RAIS 13_1			0.0154	RAIS 5_1		

Blank cells indicate no value available.

Appendix D: Part 2 Chemical-Specific Values (Continued)

Reviewed 12/30/2010		Forage Poultry Biotransfer Factor and Forage Quail		Fish Bioaccumulation Factor		Insect Bioaccumulation Factor (note d)		
CAS Number (RAIS)	Analyte Name (RAIS)	$F_{poultry}$ (day/kg)	$F_{poultry}$ reference	BAF_{fish} (L/kg)	BAF_{fish} reference	BAF_i [(L/kg worm dw)/ (L/kg soil dw)]	BAF_i reference	Analyte type
7429905	Aluminum			500	RAIS 10_6	0.054	DOE 2001	Inorganic
7440360	Antimony (metallic)			100	RAIS 10_6	1	EPA 2007 Table 4a	Inorganic
7440382	Arsenic, Inorganic			300	RAIS 10_6	$e^{(0.706*\ln(Cs)-1.421)}$	EPA 2007 Table 4a	Inorganic
7440393	Barium	0.009	IAEA 1994	4	RAIS 10_6	0.091	EPA 2007 Table 4a	Inorganic
7440417	Beryllium and compounds			100	RAIS 10_6	0.045	EPA 2007 Table 4a	Inorganic
7440428	Boron And Borates Only							Inorganic
7440439	Cadmium (Diet)	0.10625	EPA 2005	200	RAIS 10_6, 10_7	$e^{(0.795 * \ln(Cs) + 2.114)}$	EPA 2007 Table 4a	Inorganic
7440439	Cadmium (Water)	0.10625	EPA 2005	200	RAIS 10_6, 10_7	$e^{(0.795 * \ln(Cs) + 2.114)}$	EPA 2007 Table 4a	Inorganic
16065831	Chromium (III) (Insoluble Salts)			200	RAIS 10_6	0.306	EPA 2007 Table 4a	Inorganic
7440473	Chromium (total)			200	RAIS 10_6	0.306	EPA 2007 Table 4a	Inorganic
18540299	Chromium VI (chromic acid mists)			200	RAIS 10_6	0.306	EPA 2007 Table 4a	Inorganic
18540299	Chromium VI (particulates)			200	RAIS 10_6	0.306	EPA 2007 Table 4a	Inorganic
7440484	Cobalt	2	IAEA 1994	300	RAIS 10_6	0.122	EPA 2007 Table 4a	Inorganic
7440508	Copper	0.5	IAEA 1994	200	RAIS 10_6	0.515	EPA 2007 Table 4a	Inorganic
7439896	Iron	1	IAEA 1994	200	RAIS 10_6	0.061	DOE 2001	Inorganic
7439921	Lead and compounds			300	RAIS 10_6	$e^{(0.807 * \ln(Cs) - 0.218)}$	EPA 2007 Table 4a	Inorganic
7439965	Manganese (Diet)	0.05	IAEA 1994	400	10_6, 10_12	$e^{(0.682 * \ln(Cs) - 0.809)}$	EPA 2007 Table 4a	Inorganic
7439965	Manganese (Water)	0.05	IAEA 1994	400	10_6, 10_12	$e^{(0.682 * \ln(Cs) - 0.809)}$	EPA 2007 Table 4a	Inorganic
7439976	Mercury, Inorganic Salts	0.03	IAEA 1994	1000	RAIS 10_6	0.15	DOE 2001	Inorganic
7439987	Molybdenum	1	IAEA 1994	10	RAIS 10_6			Inorganic
7440020	Nickel Soluble Salts			100	RAIS 10_6			Inorganic
7782492	Selenium	1.12625	EPA 2005	200	RAIS 10_6	$e^{(0.733 * \ln(Cs) - 0.075)}$	EPA 2007 Table 4a	Inorganic
7440224	Silver	2	IAEA 1994	5	RAIS 10_6	2.045	EPA 2007 Table 4a	Inorganic
7791120	Thallium Chloride			10000	RAIS 10_6			Inorganic
	Uranium (Soluble Salts)	1	IAEA 1994	10	RAIS 10_6	0.092	DOE 2001	Inorganic
7440622	Vanadium, Metallic					0.042	EPA 2007 Table 4a	Inorganic
7440666	Zinc (Metallic)	0.00875	EPA 2005	1000	RAIS 10_6	$e^{(0.328 * \ln(Cs) + 4.449)}$	EPA 2007 Table 4a	Inorganic
83329	Acenaphthene	0.017920001	EPA 2005	755	RAIS 10_5	1.47	EPA 2007 Table 5	Organic
208968	Acenaphthylene			271	RAIS 10_5	22.9	EPA 2007 Table 5	Organic
107131	Acrylonitrile	7.03786E-05	EPA 2005	3.16	RAIS 10_5			Organic
120127	Anthracene	0.024910247	EPA 2005	1800	RAIS 10_5	2.42	EPA 2007 Table 5	Organic
12674112	Aroclor 1016 (exposure to soil or food)	0.029457381	EPA 2005	9140	RAIS 10_5	1.20	DOE 2001	Organic
12674112	Aroclor 1016 (exposure to water)	0.029457381	EPA 2005	9140	RAIS 10_5	1.20	DOE 2001	Organic
11104282	Aroclor 1221 (exposure to soil or food)			453	RAIS 10_5	1.20	DOE 2001	Organic
11104282	Aroclor 1221 (exposure to water)			453	RAIS 10_5	1.20	DOE 2001	Organic
11141165	Aroclor 1232 (exposure to soil or food)			453	RAIS 10_5	1.20	DOE 2001	Organic
11141165	Aroclor 1232 (exposure to water)			453	RAIS 10_5	1.20	DOE 2001	Organic
53469219	Aroclor 1242 (exposure to soil or food)			25300	RAIS 10_5	1.20	DOE 2001	Organic

Blank cells indicate no value available.

Appendix D: Part 2 Chemical-Specific Values (Continued)

Reviewed 12/30/2010			Molecular Weight		Half-life (Radionuclides)		Pathway Indicators (from DOE 2001)			
CAS Number (RAIS)	Analyte Name (RAIS)	Notes	MW (g/mol)	MW Reference	T_r (days)	T_r Reference	Water Use Flag	Soil Use Flag	Food Use Flag	Volatile Organic Flag
53469219	Aroclor 1242 (exposure to water)		291.99	RAIS 3_1			Yes	No	No	No
12672296	Aroclor 1248 (exposure to soil or food)		291.99	RAIS 3_1			No	Yes	Yes	No
12672296	Aroclor 1248 (exposure to water)		291.99	RAIS 3_1			Yes	No	No	No
11097691	Aroclor 1254 (exposure to soil or food)		326.44	RAIS 3_1			No	Yes	Yes	No
11097691	Aroclor 1254 (exposure to water)		326.44	RAIS 3_1			Yes	No	No	No
11096825	Aroclor 1260 (exposure to soil or food)		395.33	RAIS 3_1			No	Yes	Yes	No
11096825	Aroclor 1260 (exposure to water)		395.33	RAIS 3_1			Yes	No	No	No
56553	Benz[a]anthracene		228.3	RAIS 3_1			Yes	Yes	Yes	No
71432	Benzene		78.11	RAIS 3_1			Yes	Yes	Yes	Yes
50328	Benzo[a]pyrene		252.32	RAIS 3_1			Yes	Yes	Yes	No
205992	Benzo[b]fluoranthene		252.32	RAIS 3_1			Yes	Yes	Yes	No
207089	Benzo[k]fluoranthene		252.32	RAIS 3_1			Yes	Yes	Yes	No
86748	Carbazole		167.21	RAIS 3_1			Yes	Yes	Yes	No
56235	Carbon Tetrachloride		153.82	RAIS 3_1			Yes	Yes	Yes	Yes
67663	Chloroform		119.38	RAIS 3_1			Yes	Yes	Yes	Yes
218019	Chrysene		228.3	RAIS 3_1			Yes	Yes	Yes	No
53703	Dibenz[a,h]anthracene		278.36	RAIS 3_1			Yes	Yes	Yes	No
75354	Dichloroethylene, 1,1-		96.94	RAIS 3_1			Yes	Yes	Yes	Yes
540590	Dichloroethylene, 1,2- (Mixed Isomers)		96.94	RAIS 3_1			Yes	Yes	Yes	Yes
156592	Dichloroethylene, 1,2-cis-		96.94	RAIS 3_1			Yes	Yes	Yes	Yes
156605	Dichloroethylene, 1,2-trans-		96.94	RAIS 3_1			Yes	Yes	Yes	Yes
60571	Dieldrin		380.91	RAIS 3_1			Yes	Yes	Yes	No
1746016	Dioxins/Furans (total)	note h	321.98	RAIS 3_1			Yes	Yes	Yes	No
100414	Ethylbenzene		106.17	RAIS 3_1			Yes	Yes	Yes	Yes
206440	Fluoranthene		202.26	RAIS 3_1			Yes	Yes	Yes	No
86737	Fluorene		166.22	RAIS 3_1			Yes	Yes	Yes	Yes
118741	Hexachlorobenzene		284.78	RAIS 3_1			Yes	Yes	Yes	No
37871004	HpCDD, 2,3,7,8-		425.31	RAIS 3_1			Yes	Yes	Yes	No
38998753	HpCDF, 2,3,7,8-		409.31	RAIS 3_1			Yes	Yes	Yes	No
34465468	HxCDD, 2,3,7,8-		390.87	RAIS 3_1			Yes	Yes	Yes	No
55684941	HxCDF, 2,3,7,8-		374.87	RAIS 3_1			Yes	Yes	Yes	No
193395	Indeno[1,2,3-cd]pyrene		276.34	RAIS 3_1			Yes	Yes	Yes	No
91203	Naphthalene		128.18	RAIS 3_1			Yes	Yes	Yes	Yes
88744	Nitroaniline, 2-	note i	138.13	RAIS 3_1			Yes	Yes	Yes	No
621647	Nitroso-di-N-propylamine, N-		130.19	RAIS 3_1			Yes	Yes	Yes	No
3268879	OCDD		459.76	RAIS 3_1			Yes	Yes	Yes	No
39001020	OCDF		443.76	RAIS 3_1			Yes	Yes	Yes	No
36088229	PeCDD, 2,3,7,8-		356.42	RAIS 3_1			Yes	Yes	Yes	No

Blank cells indicate no value available.

Appendix D: Part 2 Chemical-Specific Values (Continued)

Reviewed 12/30/2010		Permeability Coefficient (Inorganics)		Permeability Coefficient (Organics)			Octanol-Water Partition Coefficient			
CAS Number (RAIS)	Analyte Name (RAIS)	K_p (cm/hr)	K_p Reference	DAevent factor-shower (L/cm2-event)	DAevent factor-swim/wade (L/cm2-event)	DA event reference	logKow	logKow reference	Kow	Kow reference
53469219	Aroclor 1242 (exposure to water)			1.37E-03	4.94E-03	EPA 2004	6.29	RAIS 8_60	1.9E+06	
12672296	Aroclor 1248 (exposure to soil or food)			1.48E-03	5.33E-03	EPA 2004	6.34	RAIS 8_60	2.2E+06	
12672296	Aroclor 1248 (exposure to water)			1.48E-03	5.33E-03	EPA 2004	6.34	RAIS 8_60	2.2E+06	
11097691	Aroclor 1254 (exposure to soil or food)			2.34E-03	8.45E-03	EPA 2004	6.79	RAIS 8_60	6.2E+06	
11097691	Aroclor 1254 (exposure to water)			2.34E-03	8.45E-03	EPA 2004	6.79	RAIS 8_60	6.2E+06	
11096825	Aroclor 1260 (exposure to soil or food)			1.43E-02	5.14E-02	EPA 2004	8.27	RAIS 8_60	1.9E+08	
11096825	Aroclor 1260 (exposure to water)			1.43E-02	5.14E-02	EPA 2004	8.27	RAIS 8_60	1.9E+08	
56553	Benz[a]anthracene			9.23E-04	3.33E-03	EPA 2004	5.76	RAIS 8_60	5.8E+05	
71432	Benzene			9.77E-06	4.54E-05	EPA 2004	2.13	RAIS 8_60	1.3E+02	
50328	Benzo[a]pyrene			1.39E-03	5.00E-03	EPA 2004	6.13	RAIS 8_60	1.3E+06	
205992	Benzo[b]fluoranthene			8.15E-04	2.94E-03	EPA 2004	5.78	RAIS 8_60	6.0E+05	
207089	Benzo[k]fluoranthene			1.35E-03	4.85E-03	EPA 2004	6.11	RAIS 8_60	1.3E+06	
86748	Carbazole			6.16E-05	2.27E-04	EPA 2004	3.72	RAIS 8_60	5.2E+03	
56235	Carbon Tetrachloride			1.74E-05	6.53E-05	EPA 2004	2.83	RAIS 8_60	6.8E+02	
67663	Chloroform			5.87E-06	2.40E-05	EPA 2004	1.97	RAIS 8_60	9.3E+01	
218019	Chrysene			9.95E-04	3.59E-03	EPA 2004	5.81	RAIS 8_60	6.5E+05	
53703	Dibenz[a,h]anthracene			2.19E-03	7.88E-03	EPA 2004	6.75	RAIS 8_60	5.6E+06	
75354	Dichloroethylene, 1,1-			8.65E-06	3.76E-05	EPA 2004	2.13	RAIS 8_60	1.3E+02	
540590	Dichloroethylene, 1,2- (Mixed Isomers)			8.14E-06	3.55E-05	EPA 2004	2.09	RAIS 8_60	1E+02	
156592	Dichloroethylene, 1,2-cis-			8.14E-06	3.55E-05	EPA 2004	1.86	RAIS 8_60	7E+01	
156605	Dichloroethylene, 1,2-trans-			8.14E-06	3.55E-05	EPA 2004	2.09	RAIS 8_60	1E+02	
60571	Dieldrin			1.47E-04	5.31E-04	EPA 2004	5.4	RAIS 8_60	3E+05	
1746016	Dioxins/Furans (total)			2.45E-03	8.83E-03	EPA 2004	6.8	RAIS 8_60	6E+06	
100414	Ethylbenzene			3.84E-05	1.53E-04	EPA 2004	3.15	RAIS 8_60	1.4E+03	
206440	Fluoranthene			4.38E-04	1.58E-03	EPA 2004	5.16	RAIS 8_60	1.4E+05	
86737	Fluorene			1.25E-04	4.61E-04	EPA 2004	4.18	RAIS 8_60	1.5E+04	
118741	Hexachlorobenzene			6.12E-04	2.21E-03	EPA 2004	5.73	RAIS 8_60	5.4E+05	
37871004	HpCDD, 2,3,7,8-			1.06E-02	3.81E-02	EPA 2004	8.2	RAIS 8_60	2E+08	
38998753	HpCDF, 2,3,7,8-			7.65E-03	2.76E-02	EPA 2004	7.92	RAIS 8_60	8.3E+07	
34465468	HxCDD, 2,3,7,8-			1.34E-02	4.83E-02	EPA 2004	8.21	RAIS 8_60	1.6E+08	
55684941	HxCDF, 2,3,7,8-			5.70E-03	2.05E-02	EPA 2004	7.58	RAIS 8_60	3.8E+07	
193395	Indeno[1,2,3-cd]pyrene			2.82E-03	1.02E-02	EPA 2004	6.7	RAIS 8_60	5E+06	
91203	Naphthalene			4.19E-05	1.59E-04	EPA 2004	3.3	RAIS 8_60	2E+03	
88744	Nitroaniline, 2-			4.33E-06	1.70E-05	EPA 2004	1.85	RAIS 8_60	7.1E+01	
621647	Nitroso-di-N-propylamine, N-			2.17E-06	8.67E-06	EPA 2004	1.36	RAIS 8_60	2.3E+01	
3268879	OCDD			6.10E-02	2.20E-01	EPA 2004	8.2	RAIS 8_60	2E+08	
39001020	OCDF			1.72E-02	6.21E-02	EPA 2004	8.6	RAIS 8_60	4E+08	
36088229	PeCDD, 2,3,7,8-			9.18E-04	3.31E-03	EPA 2004	6.3	RAIS 8_60	2E+06	

Blank cells indicate no value available.

Appendix D: Part 2 Chemical-Specific Values (Continued)

Reviewed 12/30/2010		Soil to Plant Uptake (dry)		Soil to Plant Uptake (wet)		Wet Root Uptake for Leafy Vegetables (same as B_{vwet})		Forage Beef Biotransfer Factor and Forage Rabbit Biotransfer Factor	
CAS Number (RAIS)	Analyte Name (RAIS)	R_{upp}	R_{upp} reference	B_{vwet}	B_{vwet} reference	R_{upv}	R_{upv} reference	F_{beef} (day/kg)	F_{beef} reference
53469219	Aroclor 1242 (exposure to water)	0.00865	RAIS 12_1	0.00173	RAIS 11_1	0.032	RAIS 11_1	0.0487	RAIS 13_1
12672296	Aroclor 1248 (exposure to soil or food)	0.0081	RAIS 12_1	0.00162	RAIS 11_1	0.0033	RAIS 11_1	0.0547	RAIS 13_1
12672296	Aroclor 1248 (exposure to water)	0.0081	RAIS 12_1	0.00162	RAIS 11_1	0.0033	RAIS 11_1	0.0547	RAIS 13_1
11097691	Aroclor 1254 (exposure to soil or food)	0.00444	RAIS 12_1	0.000888	RAIS 11_1	0.0025	RAIS 11_1	0.154	RAIS 13_1
11097691	Aroclor 1254 (exposure to water)	0.00444	RAIS 12_1	0.000888	RAIS 11_1	0.0025	RAIS 11_1	0.154	RAIS 13_1
11096825	Aroclor 1260 (exposure to soil or food)	0.000615	RAIS 12_1	0.000123	RAIS 11_1	0.00059	RAIS 11_1	4.66	RAIS 13_1
11096825	Aroclor 1260 (exposure to water)	0.000615	RAIS 12_1	0.000123	RAIS 11_1	0.00059	RAIS 11_1	4.66	RAIS 13_1
56553	Benz[a]anthracene	0.0176	RAIS 12_1	0.00351	RAIS 11_1	0.0038	RAIS 11_1	0.0144	RAIS 13_1
71432	Benzene	2.24	RAIS 12_1	0.448	RAIS 11_1	0.47	RAIS 11_1	3.37E-06	RAIS 13_1
50328	Benzo[a]pyrene	0.0107	RAIS 12_1	0.00214	RAIS 11_1	0.0022	RAIS 11_1	0.0337	RAIS 13_1
205992	Benzo[b]fluoranthene	0.0171	RAIS 12_1	0.00342	RAIS 11_1	0.0022	RAIS 11_1	0.0151	RAIS 13_1
207089	Benzo[k]fluoranthene	0.011	RAIS 12_1	0.0022	RAIS 11_1	0.00088	RAIS 11_1	0.0322	RAIS 13_1
86748	Carbazole	0.268	RAIS 12_1	0.0536	RAIS 11_1	0.048	RAIS 11_1	1.31E-04	RAIS 13_1
56235	Carbon Tetrachloride	0.879	RAIS 12_1	0.176	RAIS 11_1	0.18	RAIS 11_1	0.0000169	RAIS 13_1
67663	Chloroform	2.77	RAIS 12_1	0.554	RAIS 11_1	0.53	RAIS 11_1	2.33E-06	RAIS 13_1
218019	Chrysene	0.0164	RAIS 12_1	0.00329	RAIS 11_1	0.0038	RAIS 11_1	0.0161	RAIS 13_1
53703	Dibenz[a,h]anthracene	0.00468	RAIS 12_1	0.000936	RAIS 11_1	0.00088	RAIS 11_1	0.141	RAIS 13_1
75354	Dichloroethylene, 1,1-	2.24	RAIS 12_1	0.448	RAIS 11_1	0.7	RAIS 11_1	3.37E-06	RAIS 13_1
540590	Dichloroethylene, 1,2- (Mixed Isomers)	2.36	RAIS 12_1	0.472	RAIS 11_1	4.1	RAIS 11_1	3.08E-06	RAIS 13_1
156592	Dichloroethylene, 1,2-cis-	3.21	RAIS 12_1	0.642	RAIS 11_1	0.61	RAIS 11_1	1.81E-06	RAIS 13_1
156605	Dichloroethylene, 1,2-trans-	2.36	RAIS 12_1	0.472	RAIS 11_1	4.1	RAIS 11_1	3.08E-06	RAIS 13_1
60571	Dieldrin	0.0284	RAIS 12_1	0.00568	RAIS 11_1	0.017	RAIS 11_1	0.00628	RAIS 13_1
1746016	Dioxins/Furans (total)	0.00438	RAIS 12_1	0.000876	RAIS 11_1	0.00088	RAIS 11_1	0.158	RAIS 13_1
100414	Ethylbenzene	0.573	RAIS 12_1	0.115	RAIS 11_1	0.12	RAIS 11_1	0.0000353	RAIS 13_1
206440	Fluoranthene	0.0391	RAIS 12_1	0.00783	RAIS 11_1	0.011	RAIS 11_1	0.00361	RAIS 13_1
86737	Fluorene	0.145	RAIS 12_1	0.029	RAIS 11_1	0.022	RAIS 11_1	0.000378	RAIS 13_1
118741	Hexachlorobenzene	0.0183	RAIS 12_1	0.00366	RAIS 11_1	0.0065	RAIS 11_1	0.0134	RAIS 13_1
37871004	HpCDD, 2,3,7,8-	0.000675	RAIS 12_1	0.000135	RAIS 11_1	0.00024	RAIS 11_1	3.96	RAIS 13_1
38998753	HpCDF, 2,3,7,8-	0.000981	RAIS (no addl ref)	0.000196	RAIS (no addl ref)			2.08	RAIS (no addl ref)
34465468	HxCDD, 2,3,7,8-	0.000666	RAIS (no addl ref)	0.000133	RAIS (no addl ref)			4.05	RAIS (no addl ref)
55684941	HxCDF, 2,3,7,8-	0.00155	RAIS (no addl ref)	0.000309	RAIS (no addl ref)			0.95	RAIS (no addl ref)
193395	Indeno[1,2,3-cd]pyrene	0.00501	RAIS 12_1	0.001	RAIS 11_1	0.0011	RAIS 11_1	0.125	RAIS 13_1
91203	Naphthalene	0.469	RAIS 12_1	0.0939	RAIS 11_1	0.094	RAIS 11_1	0.0000499	RAIS 13_1
88744	Nitroaniline, 2-	3.25	RAIS 12_1	0.651	RAIS 11_1	0.7	RAIS 11_1	1.77E-06	RAIS 13_1
621647	Nitroso-di-N-propylamine, N-	6.26	RAIS 12_1	1.25	RAIS 11_1	1.2	RAIS 11_1	5.73E-07	RAIS 13_1
3268879	OCDD	0.000675	RAIS 12_1	0.000135	RAIS 11_1	0.000062	RAIS 11_1	3.96	RAIS 13_1
39001020	OCDF	0.000396	RAIS 12_1	0.0000792	RAIS 11_1	0.000079	RAIS 11_1	9.95	RAIS 13_1
36088229	PeCDD, 2,3,7,8-	0.00854	RAIS 12_1	0.00171	RAIS 11_1	0.0013	RAIS 11_1	0.0499	RAIS 13_1

Blank cells indicate no value available.

Appendix D: Part 2 Chemical-Specific Values (Continued)

Reviewed 12/30/2010		Forage Deer Biotransfer Factor (note b)		Forage Egg Biotransfer Factor		Forage Milk Biotransfer Factor		Forage Pork Biotransfer Factor	
CAS Number (RAIS)	Analyte Name (RAIS)	F_{deer} (day/kg)	F_{deer} reference	F_{egg} (day/kg)	F_{egg} reference	F_{milk} (day/kg)	F_{milk} reference	F_{pork} (day/kg)	F_{pork} reference
53469219	Aroclor 1242 (exposure to water)	0.00031	RAIS 13_1			0.0154	RAIS 5_1		
12672296	Aroclor 1248 (exposure to soil or food)	0.016	RAIS 13_1			0.0173	RAIS 5_1		
12672296	Aroclor 1248 (exposure to water)	0.016	RAIS 13_1			0.0173	RAIS 5_1		
11097691	Aroclor 1254 (exposure to soil or food)	0.025	RAIS 13_1	0.013041874	EPA 2005	0.0487	RAIS 5_1	0.037495387	EPA 2005
11097691	Aroclor 1254 (exposure to water)	0.025	RAIS 13_1	0.013041874	EPA 2005	0.0487	RAIS 5_1	0.037495387	EPA 2005
11096825	Aroclor 1260 (exposure to soil or food)	0.31	RAIS 13_1			1.47	RAIS 5_1		
11096825	Aroclor 1260 (exposure to water)	0.31	RAIS 13_1			1.47	RAIS 5_1		
56553	Benz[a]anthracene	0.013	RAIS 13_1	0.016810475	EPA 2005	0.00455	RAIS 5_1	0.048330116	EPA 2005
71432	Benzene	0.0000031	RAIS 13_1	0.001423967	EPA 2005	1.07E-06	RAIS 5_1	0.004093906	EPA 2005
50328	Benzo[a]pyrene	0.031	RAIS 13_1	0.015815757	EPA 2005	0.0107	RAIS 5_1	0.045470302	EPA 2005
205992	Benzo[b]fluoranthene	0.031	RAIS 13_1	0.015238273	EPA 2005	0.00476	RAIS 5_1	0.043810036	EPA 2005
207089	Benzo[k]fluoranthene	0.16	RAIS 13_1	0.015356774	EPA 2005	0.0102	RAIS 5_1	0.044150725	EPA 2005
86748	Carbazole	0.00016	RAIS 13_1			0.0000415	RAIS 5_1		
56235	Carbon Tetrachloride	0.000016	RAIS 13_1	0.003655359	EPA 2005	5.34E-06	RAIS 5_1	0.010509156	EPA 2005
67663	Chloroform	0.0000025	RAIS 13_1	0.001222053	EPA 2005	7.37E-07	RAIS 5_1	0.003513402	EPA 2005
218019	Chrysene	0.013	RAIS 13_1	0.016810475	EPA 2005	0.0051	RAIS 5_1	0.048330116	EPA 2005
53703	Dibenz[a,h]anthracene	0.16	RAIS 13_1	0.013041874	EPA 2005	0.0444	RAIS 5_1	0.037495387	EPA 2005
75354	Dichloroethylene, 1,1-	0.0000016	RAIS 13_1	0.001423967	EPA 2005	1.07E-06	RAIS 5_1	0.004093906	EPA 2005
540590	Dichloroethylene, 1,2- (Mixed Isomers)	0.000000075	RAIS 13_1			9.72E-07	RAIS 5_1		
156592	Dichloroethylene, 1,2-cis-	0.000002	RAIS 13_1	0.001043999	EPA 2005	5.72E-07	RAIS 5_1	0.003001496	EPA 2005
156605	Dichloroethylene, 1,2-trans-	0.000000075	RAIS 13_1	0.001423967	EPA 2005	9.72E-07	RAIS 5_1	0.004093906	EPA 2005
60571	Dieldrin	0.001	RAIS 13_1	0.014234427	EPA 2005	0.00198	RAIS 5_1	0.040923977	EPA 2005
1746016	Dioxins/Furans (total)	0.16	RAIS 13_1	0.010998412	EPA 2005	0.0498	RAIS 5_1	0.031620435	EPA 2005
100414	Ethylbenzene	0.000031	RAIS 13_1	0.005113285	EPA 2005	0.0000112	RAIS 5_1	0.014700694	EPA 2005
206440	Fluoranthene	0.002	RAIS 13_1	0.016523041	EPA 2005	0.00114	RAIS 5_1	0.047503744	EPA 2005
86737	Fluorene	0.00063	RAIS 13_1	0.012323384	EPA 2005	0.00012	RAIS 5_1	0.035429729	EPA 2005
118741	Hexachlorobenzene	0.005	RAIS 13_1	0.017107242	EPA 2005	0.00424	RAIS 5_1	0.049183319	EPA 2005
37871004	HpCDD, 2,3,7,8-	1.5	RAIS 13_1			1.25	RAIS 5_1		
38998753	HpCDF, 2,3,7,8-					0.657	RAIS (no addl ref)		
34465468	HxCDD, 2,3,7,8-					1.28	RAIS (no addl ref)		
55684941	HxCDF, 2,3,7,8-					0.3	RAIS (no addl ref)		
193395	Indeno[1,2,3-cd]pyrene	0.1	RAIS 13_1	0.012377986	EPA 2005	0.0396	RAIS 5_1	0.03558671	EPA 2005
91203	Naphthalene	0.00005	RAIS 13_1	0.006251439	EPA 2005	0.0000158	RAIS 5_1	0.017972887	EPA 2005
88744	Nitroaniline, 2-	0.0000016	RAIS 13_1	0.000963302	EPA 2005	5.59E-07	RAIS 5_1	0.002769493	EPA 2005
621647	Nitroso-di-N-propylamine, N-	0.00000063	RAIS 13_1	0.000412268	EPA 2005	1.81E-07	RAIS 5_1	0.00118527	EPA 2005
3268879	OCDD	15	RAIS 13_1	0.002886224	EPA 2005	1.25	RAIS 5_1	0.008297893	EPA 2005
39001020	OCDF	10	RAIS 13_1	0.003690541	EPA 2005	3.15	RAIS 5_1	0.010610304	EPA 2005
36088229	PeCDD, 2,3,7,8-	0.079	RAIS 13_1			0.0158	RAIS 5_1		

Blank cells indicate no value available.

Appendix D: Part 2 Chemical-Specific Values (Continued)

Reviewed 12/30/2010		Forage Poultry Biotransfer Factor and Forage Quail		Fish Bioaccumulation Factor		Insect Bioaccumulation Factor (note d)		
CAS Number (RAIS)	Analyte Name (RAIS)	$F_{poultry}$ (day/kg)	$F_{poultry}$ reference	BAF_{fish} (L/kg)	BAF_{fish} reference	BAF_i [(L/kg worm dw)/ (L/kg soil dw)]	BAF_i reference	Analyte type
53469219	Aroclor 1242 (exposure to water)			25300	RAIS 10_5	1.20	DOE 2001	Organic
12672296	Aroclor 1248 (exposure to soil or food)			27100	RAIS 10_5	1.20	DOE 2001	Organic
12672296	Aroclor 1248 (exposure to water)			27100	RAIS 10_5	1.20	DOE 2001	Organic
11097691	Aroclor 1254 (exposure to soil or food)	0.022823279	EPA 2005	54100	RAIS 10_5	1.20	DOE 2001	Organic
11097691	Aroclor 1254 (exposure to water)	0.022823279	EPA 2005	54100	RAIS 10_5	1.20	DOE 2001	Organic
11096825	Aroclor 1260 (exposure to soil or food)			12300	RAIS 10_5	1.20	DOE 2001	Organic
11096825	Aroclor 1260 (exposure to water)			12300	RAIS 10_5	1.20	DOE 2001	Organic
56553	Benz[a]anthracene	0.029418331	EPA 2005	260	RAIS 10_5	1.59	EPA 2007 Table 5	Organic
71432	Benzene	0.002491943	EPA 2005	4.27	RAIS 10_5			Organic
50328	Benzo[a]pyrene	0.027677575	EPA 2005	5150	RAIS 10_5	1.33	EPA 2007 Table 5	Organic
205992	Benzo[b]fluoranthene	0.026666979	EPA 2005	3020	RAIS 10_5	2.6	EPA 2007 Table 5	Organic
207089	Benzo[k]fluoranthene	0.026874354	EPA 2005	4990	RAIS 10_5	2.6	EPA 2007 Table 5	Organic
86748	Carbazole			170	RAIS 10_5			Organic
56235	Carbon Tetrachloride	0.006396878	EPA 2005	7.4	RAIS 10_5			Organic
67663	Chloroform	0.002138592	EPA 2005	13	RAIS 10_5			Organic
218019	Chrysene	0.029418331	EPA 2005	3170	RAIS 10_5	2.29	EPA 2007 Table 5	Organic
53703	Dibenz[a,h]anthracene	0.022823279	EPA 2005	9600	RAIS 10_5	2.31	EPA 2007 Table 5	Organic
75354	Dichloroethylene, 1,1-	0.002491943	EPA 2005	13	RAIS 10_5			Organic
540590	Dichloroethylene, 1,2- (Mixed Isomers)			11.1	RAIS 10_5			Organic
156592	Dichloroethylene, 1,2-cis-	0.001826998	EPA 2005	11.1	RAIS 10_5			Organic
156605	Dichloroethylene, 1,2-trans-	0.002491943	EPA 2005	11.1	RAIS 10_5			Organic
60571	Dieldrin	0.024910247	EPA 2005	7480	RAIS 10_5	$e^{(0.8756 * \ln(Cs) + 2.2757)}$	EPA 2007 Table 4b	Organic
1746016	Dioxins/Furans (total)	0.019247221	EPA 2005	97000	RAIS 10_5			Organic
100414	Ethylbenzene	0.008948248	EPA 2005	55.6	RAIS 10_5			Organic
206440	Fluoranthene	0.028915322	EPA 2005	3630	RAIS 10_5	3.04	EPA 2007 Table 5	Organic
86737	Fluorene	0.021565922	EPA 2005	525	RAIS 10_5	9.57	EPA 2007 Table 5	Organic
118741	Hexachlorobenzene	0.029937673	EPA 2005	21400	RAIS 10_5			Organic
37871004	HpCDD, 2,3,7,8-			4640	RAIS 10_5			Organic
38998753	HpCDF, 2,3,7,8-			2800	RAIS 10_5			Organic
34465468	HxCDD, 2,3,7,8-			3400	RAIS 10_5			Organic
55684941	HxCDF, 2,3,7,8-			598	RAIS 10_5			Organic
193395	Indeno[1,2,3-cd]pyrene	0.021661475	EPA 2005	12200	RAIS 10_5	2.86	EPA 2007 Table 5	Organic
91203	Naphthalene	0.010940018	EPA 2005	84.5	RAIS 10_5	4.4	EPA 2007 Table 5	Organic
88744	Nitroaniline, 2-	0.001685779	EPA 2005	10	RAIS 10_5			Organic
621647	Nitroso-di-N-propylamine, N-	0.000721469	EPA 2005	3.67	RAIS 10_5	0.049	DOE 2001	Organic
3268879	OCDD	0.005050891	EPA 2005	1310	RAIS 10_5			Organic
39001020	OCDF	0.006458446	EPA 2005	771	RAIS 10_5			Organic
36088229	PeCDD, 2,3,7,8-			6660	RAIS 10_5			Organic

Blank cells indicate no value available.

Appendix D: Part 2 Chemical-Specific Values (Continued)

Reviewed 12/30/2010			Molecular Weight		Half-life (Radionuclides)		Pathway Indicators (from DOE 2001)			
CAS Number (RAIS)	**Analyte Name (RAIS)**	**Notes**	**MW (g/mol)**	**MW Reference**	**T_r (days)**	**T_r Reference**	**Water Use Flag**	**Soil Use Flag**	**Food Use Flag**	**Volatile Organic Flag**
57117416	PeCDF, 1,2,3,7,8-		340.42	RAIS 3_1			Yes	Yes	Yes	No
57117314	PeCDF, 2,3,4,7,8-		340.42	RAIS 3_1			Yes	Yes	Yes	No
85018	Phenanthrene		178.24	RAIS 3_1			Yes	Yes	Yes	Yes
1336363	Polychlorinated Biphenyls (high risk)		291.99	RAIS 3_1			No	Yes	Yes	No
1336363	Polychlorinated Biphenyls (low risk)		291.99	RAIS 3_1			Yes	No	No	No
1336363	Polychlorinated Biphenyls (lowest risk)		291.99	RAIS 3_1			No	No	No	No
50328	Polynuclear Aromatic Hydrocarbons (total)	note j	252.32	RAIS 3_1			Yes	Yes	Yes	No
129000	Pyrene		202.26	RAIS 3_1			Yes	Yes	Yes	No
1746016	TCDD, 2,3,7,8-		321.98	RAIS 3_1			Yes	Yes	Yes	No
51207319	TCDF, 2,3,7,8-		305.98	RAIS 3_1			Yes	Yes	Yes	No
127184	Tetrachloroethylene		165.83	RAIS 3_1			Yes	Yes	Yes	Yes
79016	Trichloroethylene		131.39	RAIS 3_1			Yes	Yes	Yes	Yes
75014	Vinyl Chloride		62.5	RAIS 3_1			Yes	Yes	Yes	Yes
108383	Xylene, m-		106.17	RAIS 3_1			Yes	Yes	Yes	Yes
1330207	Xylene, Mixture		106.17	RAIS 3_1			Yes	Yes	Yes	Yes
95476	Xylene, o-		106.17	RAIS 3_1			Yes	Yes	Yes	Yes
106423	Xylene, P-		106.17	RAIS 3_1			Yes	Yes	Yes	Yes
14596102	Am-241				158000	HEAST	Yes	Yes	Yes	No
10198400	Co-60				1920	HEAST	Yes	Yes	Yes	No
10045973	Cs-137+D				11000	HEAST	Yes	Yes	Yes	No
13994202	Np-237+D				781000000	HEAST	Yes	Yes	Yes	No
13981163	Pu-238				32000	HEAST	Yes	Yes	Yes	No
15117483	Pu-239				8800000	HEAST	Yes	Yes	Yes	No
14119336	Pu-240				2390000	HEAST	Yes	Yes	Yes	No
14133767	Tc-99				77700000	HEAST	Yes	Yes	Yes	No
14269637	Th-230				28100000	HEAST	Yes	Yes	Yes	No
13966295	U-234				89400000	HEAST	Yes	Yes	Yes	No
15117961	U-235+D				2.57E+11	HEAST	Yes	Yes	Yes	No
7440611	U-238+D				1.63E+12	HEAST	Yes	Yes	Yes	No

Blank cells indicate no value available.

Appendix D: Part 2 Chemical-Specific Values (Continued)

Reviewed 12/30/2010		Permeability Coefficient (Inorganics)		Permeability Coefficient (Organics)			Octanol-Water Partition Coefficient			
CAS Number (RAIS)	Analyte Name (RAIS)	K_p (cm/hr)	K_p Reference	DAevent factor-shower (L/cm2-event)	DAevent factor-swim/wade (L/cm2-event)	DA event reference	logKow	logKow reference	Kow	Kow reference
57117416	PeCDF, 1,2,3,7,8-			2.14E-03	7.72E-03	EPA 2004	6.79	RAIS 8_60	6.2E+06	
57117314	PeCDF, 2,3,4,7,8-			2.61E-03	9.41E-03	EPA 2004	6.92	RAIS 8_60	8.3E+06	
85018	Phenanthrene			1.77E-04	6.37E-04	EPA 2004	4.46	RAIS 8_60	2.9E+04	
1336363	Polychlorinated Biphenyls (high risk)			1.37E-03	4.94E-03	EPA 2004	6.29	RAIS 8_60	1.9E+06	
1336363	Polychlorinated Biphenyls (low risk)			1.37E-03	4.94E-03	EPA 2004	6.29	RAIS 8_60	1.9E+06	
1336363	Polychlorinated Biphenyls (lowest risk)			1.37E-03	4.94E-03	EPA 2004	6.29	RAIS 8_60	1.9E+06	
50328	Polynuclear Aromatic Hydrocarbons (total)			1.39E-03	5.00E-03	EPA 2004	6.13	RAIS 8_60	1.3E+06	
129000	Pyrene			2.86E-04	1.03E-03	EPA 2004	4.88	RAIS 8_60	7.6E+04	
1746016	TCDD, 2,3,7,8-			2.45E-03	8.83E-03	EPA 2004	6.8	RAIS 8_60	6E+06	
51207319	TCDF, 2,3,7,8-			1.80E-03	6.50E-03	EPA 2004	6.53	RAIS 8_60	3.4E+06	
127184	Tetrachloroethylene			3.82E-05	1.41E-04	EPA 2004	3.4	RAIS 8_60	3E+03	
79016	Trichloroethylene			1.08E-05	4.23E-05	EPA 2004	2.42	RAIS 8_60	2.6E+02	
75014	Vinyl Chloride			4.98E-06	2.51E-05	EPA 2004	1.62	RAIS 8_60	4.2E+01	
108383	Xylene, m-			4.14E-05	1.64E-04	EPA 2004	3.2	RAIS 8_60	2E+03	
1330207	Xylene, Mixture			3.67E-05	1.46E-04	EPA 2004	3.12	RAIS 8_60	1.3E+03	
95476	Xylene, o-			3.67E-05	1.46E-04	EPA 2004	3.12	RAIS 8_60	1.3E+03	
106423	Xylene, P-			3.84E-05	1.53E-04	EPA 2004	3.15	RAIS 8_60	1.4E+03	
14596102	Am-241									
10198400	Co-60									
10045973	Cs-137+D									
13994202	Np-237+D									
13981163	Pu-238									
15117483	Pu-239									
14119336	Pu-240									
14133767	Tc-99									
14269637	Th-230									
13966295	U-234									
15117961	U-235+D									
7440611	U-238+D									

Blank cells indicate no value available.

Appendix D: Part 2 Chemical-Specific Values (Continued)

Reviewed 12/30/2010		Soil to Plant Uptake (dry)		Soil to Plant Uptake (wet)		Wet Root Uptake for Leafy Vegetables (same as B_{vwet})		Forage Beef Biotransfer Factor and Forage Rabbit Biotransfer Factor	
CAS Number (RAIS)	Analyte Name (RAIS)	R_{upp}	R_{upp} reference	B_{vwet}	B_{vwet} reference	R_{upv}	R_{upv} reference	F_{beef} (day/kg)	F_{beef} reference
57117416	PeCDF, 1,2,3,7,8-	0.00444	RAIS 12_1	0.000888	RAIS 11_1	0.00089	RAIS 11_1	0.154	RAIS 13_1
57117314	PeCDF, 2,3,4,7,8-	0.00373	RAIS 12_1	0.000746	RAIS 11_1	0.00075	RAIS 11_1	0.208	RAIS 13_1
85018	Phenanthrene	0.0997	RAIS 12_1	0.0199	RAIS 11_1	0.017	RAIS 11_1	0.000721	RAIS 13_1
1336363	Polychlorinated Biphenyls (high risk)	0.00865	RAIS 12_1	0.00173	RAIS 11_1	0.0025	RAIS 11_1	0.0487	RAIS 13_1
1336363	Polychlorinated Biphenyls (low risk)	0.00865	RAIS 12_1	0.00173	RAIS 11_1	0.0025	RAIS 11_1	0.0487	RAIS 13_1
1336363	Polychlorinated Biphenyls (lowest risk)	0.00865	RAIS 12_1	0.00173	RAIS 11_1	0.0025	RAIS 11_1	0.0487	RAIS 13_1
50328	Polynuclear Aromatic Hydrocarbons (total)	0.0107	RAIS 12_1	0.00214	RAIS 11_1	0.0022	RAIS 11_1	0.0337	RAIS 13_1
129000	Pyrene	0.0569	RAIS 12_1	0.0114	RAIS 11_1	0.011	RAIS 11_1	0.0019	RAIS 13_1
1746016	TCDD, 2,3,7,8-	0.00438	RAIS 12_1	0.000876	RAIS 11_1	0.00088	RAIS 11_1	0.158	RAIS 13_1
51207319	TCDF, 2,3,7,8-	0.00628	RAIS 12_1	0.00126	RAIS 11_1	0.0032	RAIS 11_1	0.0847	RAIS 13_1
127184	Tetrachloroethylene	0.411	RAIS 12_1	0.0821	RAIS 11_1	0.24	RAIS 11_1	0.0000628	RAIS 13_1
79016	Trichloroethylene	1.52	RAIS 12_1	0.304	RAIS 11_1	0.31	RAIS 11_1	6.58E-06	RAIS 13_1
75014	Vinyl Chloride	4.42	RAIS 12_1	0.885	RAIS 11_1	1.2	RAIS 11_1	1.04E-06	RAIS 13_1
108383	Xylene, m-	0.536	RAIS 12_1	0.107	RAIS 11_1	0.11	RAIS 11_1	0.0000396	RAIS 13_1
1330207	Xylene, Mixture	0.597	RAIS 12_1	0.119	RAIS 11_1	0.094	RAIS 11_1	0.000033	RAIS 13_1
95476	Xylene, o-	0.597	RAIS 12_1	0.119	RAIS 11_1	0.11	RAIS 11_1	0.000033	RAIS 13_1
106423	Xylene, P-	0.573	RAIS 12_1	0.115	RAIS 11_1	0.11	RAIS 11_1	0.0000353	RAIS 13_1
14596102	Am-241	5.00E-03	RAIS 14_1	1.00E-03	RAIS 14_1	0.000024	RAIS 11_3	5.00E-05	RAIS 14_1
10198400	Co-60	4.00E-01	RAIS 14_1	8.00E-02	RAIS 14_1	0.023	RAIS 11_3	2.00E-02	RAIS 14_1
10045973	Cs-137+D	2.00E-01	RAIS 14_1	4.00E-02	RAIS 14_1	0.017	RAIS 11_3	3.00E-02	RAIS 14_1
13994202	Np-237+D	1.00E-01	RAIS 14_1	2.00E-02	RAIS 14_1	0.0035	RAIS 11_3	1.00E-03	RAIS 14_1
13981163	Pu-238	5.00E-03	RAIS 14_1	1.00E-03	RAIS 14_1	0.0000049	RAIS 11_3	1.00E-04	RAIS 14_1
15117483	Pu-239	5.00E-03	RAIS 14_1	1.00E-03	RAIS 14_1	0.0000049	RAIS 11_3	1.00E-04	RAIS 14_1
14119336	Pu-240	5.00E-03	RAIS 14_1	1.00E-03	RAIS 14_1	0.0000049	RAIS 11_3	1.00E-04	RAIS 14_1
14133767	Tc-99	2.50E+01	RAIS 14_1	5.00E+00	RAIS 14_1	210	RAIS 11_3	1.00E-04	RAIS 14_1
14269637	Th-230	5.00E-03	RAIS 14_1	1.00E-03	RAIS 14_1	0.00014	RAIS 11_3	1.00E-04	RAIS 14_1
13966295	U-234	1.25E-02	RAIS 14_1	2.50E-03	RAIS 14_1	0.00063	RAIS 11_3	3.40E-04	RAIS 14_1
15117961	U-235+D	1.25E-02	RAIS 14_1	2.50E-03	RAIS 14_1	0.00077	RAIS 11_3	3.40E-04	RAIS 14_1
7440611	U-238+D	1.25E-02	RAIS 14_1	2.50E-03	RAIS 14_1	0.002	RAIS 11_3	3.40E-04	RAIS 14_1

Blank cells indicate no value available.

Appendix D: Part 2 Chemical-Specific Values (Continued)

Reviewed 12/30/2010		**Forage Deer Biotransfer Factor (note b)**		**Forage Egg Biotransfer Factor**		**Forage Milk Biotransfer Factor**		**Forage Pork Biotransfer Factor**	
CAS Number (RAIS)	**Analyte Name (RAIS)**	**F_{deer} (day/kg)**	**F_{deer} reference**	**F_{egg} (day/kg)**	**F_{egg} reference**	**F_{milk} (day/kg)**	**F_{milk} reference**	**F_{pork} (day/kg)**	**F_{pork} reference**
57117416	PeCDF, 1,2,3,7,8-	0.15	RAIS 13_1	0.011068381	EPA 2005	0.0487	RAIS 5_1	0.031821594	EPA 2005
57117314	PeCDF, 2,3,4,7,8-	0.21	RAIS 13_1	0.013041874	EPA 2005	0.0657	RAIS 5_1	0.037495387	EPA 2005
85018	Phenanthrene	0.001	RAIS 13_1	0.014234427	EPA 2005	0.000228	RAIS 5_1	0.040923977	EPA 2005
1336363	Polychlorinated Biphenyls (high risk)	0.0487	RAIS 13_1			0.0154	RAIS 5_1		
1336363	Polychlorinated Biphenyls (low risk)	0.0487	RAIS 13_1			0.0154	RAIS 5_1		
1336363	Polychlorinated Biphenyls (lowest risk)	0.0487	RAIS 13_1			0.0154	RAIS 5_1		
50328	Polynuclear Aromatic Hydrocarbons (total)	0.0337	RAIS 13_1	0.015815757	EPA 2005	0.0107	RAIS 5_1	0.045470302	EPA 2005
129000	Pyrene	0.002	RAIS 13_1	0.016184526	EPA 2005	0.000599	RAIS 5_1	0.046530513	EPA 2005
1746016	TCDD, 2,3,7,8-	0.16	RAIS 13_1	0.010998412	EPA 2005	0.0498	RAIS 5_1	0.031620435	EPA 2005
51207319	TCDF, 2,3,7,8-	0.017	RAIS 13_1	0.015356774	EPA 2005	0.0268	RAIS 5_1	0.044150725	EPA 2005
127184	Tetrachloroethylene	0.00001	RAIS 13_1	0.006865149	EPA 2005	0.0000198	RAIS 5_1	0.019737304	EPA 2005
79016	Trichloroethylene	0.0000063	RAIS 13_1	0.002192048	EPA 2005	2.08E-06	RAIS 5_1	0.006302137	EPA 2005
75014	Vinyl Chloride	0.00000063	RAIS 13_1	0.00044366	EPA 2005	3.29E-07	RAIS 5_1	0.001275522	EPA 2005
108383	Xylene, m-	0.00004	RAIS 13_1	0.005666697	EPA 2005	0.0000125	RAIS 5_1	0.016291754	EPA 2005
1330207	Xylene, Mixture	0.00005	RAIS 13_1			0.0000104	RAIS 5_1		
95476	Xylene, o-	0.00004	RAIS 13_1	0.005113285	EPA 2005	0.0000104	RAIS 5_1	0.014700694	EPA 2005
106423	Xylene, P-	0.00004	RAIS 13_1	0.005113285	EPA 2005	0.0000112	RAIS 5_1	0.014700694	EPA 2005
14596102	Am-241	0.00004	RAIS 13_3	0.004	IAEA 1994	2.00E-06	RAIS 14_1	0.00017	IAEA 1994
10198400	Co-60	0.0001	RAIS 13_3	0.1	IAEA 1994	2.00E-03	RAIS 14_1	0.002	IAEA 1994
10045973	Cs-137+D	0.03	RAIS 13_3	0.4	IAEA 1994	8.00E-03	RAIS 14_1	0.24	IAEA 1994
13994202	Np-237+D	0.001	RAIS 13_3			5.00E-06	RAIS 14_1		
13981163	Pu-238	0.00001	RAIS 13_3	0.0005	IAEA 1994	1.00E-06	RAIS 14_1	0.00008	IAEA 1994
15117483	Pu-239	0.00001	RAIS 13_3	0.0005	IAEA 1994	1.00E-06	RAIS 14_1	0.00008	IAEA 1994
14119336	Pu-240	0.00001	RAIS 13_3	0.0005	IAEA 1994	1.00E-06	RAIS 14_1	0.00008	IAEA 1994
14133767	Tc-99	0.0001	RAIS 13_3	3	IAEA 1994	1.00E-03	RAIS 14_1	0.00015	IAEA 1994
14269637	Th-230	0.0001	RAIS 13_4			5.00E-06	RAIS 14_1		
13966295	U-234	0.0003	RAIS 13_3	1	IAEA 1994	6.00E-04	RAIS 14_1	0.062	IAEA 1994
15117961	U-235+D	0.0004	RAIS 13_3	1	IAEA 1994	6.00E-04	RAIS 14_1	0.062	IAEA 1994
7440611	U-238+D	0.00042	RAIS 13_3	1	IAEA 1994	6.00E-04	RAIS 14_1	0.062	IAEA 1994

Blank cells indicate no value available.

Appendix D: Part 2 Chemical-Specific Values (Continued)

Reviewed 12/30/2010		Forage Poultry Biotransfer Factor and Forage Quail		Fish Bioaccumulation Factor		Insect Bioaccumulation Factor (note d)		
CAS Number (RAIS)	Analyte Name (RAIS)	$F_{poultry}$ (day/kg)	$F_{poultry}$ reference	BAF_{fish} (L/kg)	BAF_{fish} reference	BAF_i [(L/kg worm dw)/ (L/kg soil dw)]	BAF_i reference	Analyte type
57117416	PeCDF, 1,2,3,7,8-	0.019369666	EPA 2005	3770	RAIS 10_5			Organic
57117314	PeCDF, 2,3,4,7,8-	0.022823279	EPA 2005	3770	RAIS 10_5			Organic
85018	Phenanthrene	0.024910247	EPA 2005	2510	RAIS 10_5	1.72	EPA 2007 Table 5	Organic
1336363	Polychlorinated Biphenyls (high risk)			25300	RAIS 10_5			Organic
1336363	Polychlorinated Biphenyls (low risk)			25300	RAIS 10_5			Organic
1336363	Polychlorinated Biphenyls (lowest risk)			25300	RAIS 10_5			Organic
50328	Polynuclear Aromatic Hydrocarbons (total)	0.027677575	EPA 2005	5150	RAIS 10_5	1.33	EPA 2007 Table 5	Organic
129000	Pyrene	0.028322921	EPA 2005	1510	RAIS 10_5	1.75	EPA 2007 Table 5	Organic
1746016	TCDD, 2,3,7,8-	0.019247221	EPA 2005	97000	RAIS 10_5			Organic
51207319	TCDF, 2,3,7,8-	0.026874354	EPA 2005	4060	RAIS 10_5			Organic
127184	Tetrachloroethylene	0.012014011	EPA 2005	52	RAIS 10_5			Organic
79016	Trichloroethylene	0.003836083	EPA 2005	16	RAIS 10_5			Organic
75014	Vinyl Chloride	0.000776404	EPA 2005	5.47	RAIS 10_5			Organic
108383	Xylene, m-	0.00991672	EPA 2005	14.8	RAIS 10_5			Organic
1330207	Xylene, Mixture			14.1	RAIS 10_5			Organic
95476	Xylene, o-	0.008948248	EPA 2005	14.1	RAIS 10_5			Organic
106423	Xylene, P-	0.008948248	EPA 2005	14.8	RAIS 10_5			Organic
14596102	Am-241	0.006	IAEA 1994	3.00E+01	RAIS 14_1			Radionuclide
10198400	Co-60	2	IAEA 1994	3.00E+02	RAIS 14_1			Radionuclide
10045973	Cs-137+D	10	IAEA 1994	2.00E+03	RAIS 14_1			Radionuclide
13994202	Np-237+D			3.00E+01	RAIS 14_1	1	DOE 2001	Radionuclide
13981163	Pu-238	0.003	IAEA 1994	3.00E+01	RAIS 14_1	2.5	DOE 2001	Radionuclide
15117483	Pu-239	0.003	IAEA 1994	3.00E+01	RAIS 14_1	2.5	DOE 2001	Radionuclide
14119336	Pu-240	0.003	IAEA 1994	3.00E+01	RAIS 14_1	2.5	DOE 2001	Radionuclide
14133767	Tc-99	0.03	IAEA 1994	2.00E+01	RAIS 14_1			Radionuclide
14269637	Th-230			1.00E+02	RAIS 14_1	1	DOE 2001	Radionuclide
13966295	U-234	1	IAEA 1994	1.00E+01	RAIS 14_1	0.092	DOE 2001	Radionuclide
15117961	U-235+D	1	IAEA 1994	1.00E+01	RAIS 14_1	0.092	DOE 2001	Radionuclide
7440611	U-238+D	1	IAEA 1994	1.00E+01	RAIS 14_1	0.092	DOE 2001	Radionuclide

Blank cells indicate no value available.

Appendix D: Part 2 Chemical-Specific Values (Continued)

Notes:	
a.	Beef biotransfer factor also is used for rabbit biotransfer factor as discussed in DOE 1999.
b.	Deer biotransfer factor represented by beef biotransfer factor from RAIS.
c.	Poultry biotransfer factor also is used for quail biotransfer factor as discussed in DOE 1999.
d.	Worm bioaccumulation factor used for insect bioaccumulation factor as discussed in DOE 1999.
e.	EPA SRS notes that CAS Number 16065831 represents chromium (III) and that the number is used erroneously in IRIS for chromium (III), insoluble salts. The molecular weight for chromium (III) is provided.
f.	Chromium (total) data not available in RAIS. Information for chromium (III) (insoluble salts) used here.
g.	DOE 2000 data from second entry for mercury in DOE 2000.
h.	Data for TCDD, 2,3,7,8- also used for Dioxins/Furans (total) for consistency with Table B.5.
i.	Changed "Volatile Organic Flag" to match Table B.5 and EPA, Region 6 flag.
j.	Data for Benzo[a]pyrene used for polynuclear aromatic hydrocarbons (total) for consistency with Table B.5.
References:	
DOE 1999	Guidance for Conducting Risk Assessments and Related Risk Activities for the DOE-ORO Environmental Management Program, Appendix F, BJC/OR-271, April 1999.
DOE 2001	Methods for Conducting Risk Assessment and Risk Evaluations at the Paducah Gaseous Diffusion Plant Paducah, Kentucky, Volume 1, Human Health, Appendix D, Part 2, DOE/OR/07-1506&D2, December 2001.
EPA 2004	Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment), EPA/540/R/99/005, OSWER 9285.7-02EP, PB99-963312, July 2004.
EPA 2005	Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities, EPA530-R-05-006, September 2005.
EPA 2007 Table 4a	Guidance for Developing Ecological Soil Screening Levels (Eco-SSLs) Attachment 4-1, OSWER Directive 9285.7-55, Revised April 2007, Table 4a "Uptake Equations for Inorganics."
EPA 2007 Table 5	Guidance for Developing Ecological Soil Screening Levels (Eco-SSLs) Attachment 4-1, OSWER Directive 9285.7-55, Revised April 2007, Table 5 "Estimation of Soil to Earthworm Bioaccumulation Factors for Non-Ionic Organic Contaminants."
IAEA 1994	IAEA (International Atomic Energy Agency). 1994. Handbook of Parameter Values for the Prediction of Radionuclide Transfer in Temperate Environments. Technical Report Series No. 364
RAIS	EPA Risk Assessment Information System (RAIS) Chemical-Specific Factors current as of November 2010, http://rais.ornl.gov/cgi-bin/tox/TOX_select?select=csf, accessed December 30, 2010.
RAIS 3_1	EPA RAIS reference 3_1: molecular weights are taken from Chemifinder, Dermwin version 1.42, or Physprop Database, Values were taken from hppt://www.epa.gov/opptintr/exposure/pubs/episuite.htm. The DERMWIN program has a database of molecular weights.
RAIS 5_1	EPA RAIS reference 5_1: McKone, T. E. 1994, Uncertainty and variability in human exposures to soil contaminants through home-grown food: a Monte Carlo assessment. Risk Anal. 14(4):449-463.
RAIS 5_2	EPA RAIS reference 5_2: National Council on Radiation Protection Measurement, January 1989, Screening Techniques for Determining Compliance with Environmental Standards. Releases of Radionuclides to the Atmosphere, Bethesda, Maryland.
RAIS 5_3	EPA RAIS reference 5_3: International Atomic Energy Agency, 1994, Handbook of parameter values for the prediction of radionuclide transfer in temperate environment. Tech. Rep. Ser. No. 364, Vienna, Austria.
RAIS 5_4	EPA RAIS reference 5_4: Baes, C. F., III, Sharp, R. D., Sjoreen, A. L., and Shor, R. W., 1984, A Review and Analysis of Parameters for Assessing Transport of Environmentally Released Radionuclides through Agriculture, ORNL-5786, Oak Ridge National Laboratory, Oak Ridge, Tennessee.
RAIS 6_6	EPA RAIS reference 6_6: EPA 2004. Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) Final. EPA/540/R/99/005, Exhibit 3-1.
RAIS 8_4	EPA RAIS reference 8_4: MEPAS http://mepas.pnl.gov/earth/mepasmain.html.

Appendix D: Part 2 Chemical-Specific Values (Continued)

RAIS 8_60	EPA RAIS reference 8_60: Values were taken from http://www.epa.gov/opptintr/exposure/pubs/episuite.htm.
RAIS 10_2	EPA RAIS reference 10_2: International Atomic Energy Agency. 1994. Handbook of parameter values for the prediction of radionuclide transfer in temperate environment. Tech. Rep. Ser. No. 364, Vienna, Austria.
RAIS 10_5	EPA RAIS reference 10_5: Values were taken from http://www.epa.gov/opptintr/exposure/pubs/episuite.htm.
RAIS 10_6	EPA RAIS reference 10_6: Obtained from Table D.5 "Aquatic Bioaccumulation Factors (FWR$_{i6k}$) for Fresh Water" from the "Users Manual for RESRAD Version 6, ANL/EAD-4, 2001" by C. Yu, A.J. Zielen, J-J. Cheng, D.J. LePoire, E. Gnanapragasam, S. Kamboj, J. Arnish, A. Wallo III, W.A. Williams, and H. Peterson, Environmental Assessment Division, Argonne National Laboratory, Argonne, Illinois, 60439. Values reported are for the element, regardlss of the chemical speciation in the aquatic system, as L/kg (liters of water per kilogram fish).
RAIS 10_7	EPA RAIS reference 10_7: No distinction was made for the bioaccumulation of cadmium either from the water into fish or from solids into fish (e.g., fish food).
RAIS 10_12	EPA RAIS reference 10_12: No distinction was made for the bioaccumulation of manganese either from the water into fish or from solids into fish (e.g., fish food).
RAIS 11_1	EPA RAIS reference 11_1: Equation modified from McKone, T.E., 1994, Uncertainty and variability in human exposures to soil contaminants through home-grown food: a Monte Carlo assessment. Risk Anal., 14(4):449-463.
RAIS 11_2	EPA RAIS reference 11_2: Baes, C.F., III, Sharp, R.D., Sjoreen, A.L., and Shor, R.W., 1984, A Review and Analysis of Parameters for Assessing Transport of Environmentally Released Radionulcides through Agriculture, ORNL-5786, Oak Ridge National Laboratory, Oak Ridge, Tennessee.
RAIS 11_3	EPA RAIS reference 11_3: International Atomic Energy Agency, 1994, Handbook of parameter values for the prediction of radionuclide transfer in temperate environment. Tech. Rep. Ser. No. 364, Vienna, Austria.
RAIS 11_4	EPA RAIS reference 11_4: National Council on Radiation Protection Measurement, January 1989, Screening Techniques for Determining Compliance with Environmental Standards. Releases of Radionuclides to the Atmosphere, Bethesda, Maryland.
RAIS 12_1	EPA RAIS reference 12_1: Equation modified from McKone, T.E., 1994, Uncertainty and variability in human exposures to soil contaminants through home-grown food: a Monte Carlo assessment. Risk Anal., 14(4):449-463.
RAIS 12_2	EPA RAIS reference 12_2: Baes, C.F., III, Sharp, R.D., Sjoreen, A.L., and Shor, R.W., 1984, A Review and Analysis of Parameters for Assessing Transport of Environmentally Released Radionulcides through Agriculture, ORNL-5786, Oak Ridge National Laboratory, Oak Ridge, Tennessee.
RAIS 12_3	EPA RAIS reference 12_3: International Atomic Energy Agency, 1994, Handbook of parameter values for the prediction of radionuclide transfer in temperate environment. Tech. Rep, Ser. No. 364, Vienna, Austria.
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RAIS 13_1	EPA RAIS reference 13_1: McKone, T. E., 1994, Uncertainty and variability in human exposures to soil contaminants through home-grown food: a Monte Carlo assessment. Risk Anal., 14(4):449-463.
RAIS 13_2	EPA RAIS reference 13_2: Baes, C. F., III, Sharp, R. D., Sjoreen, A. L., and Shor, R. W., 1984, A Review and Analysis of Parameters for Assessing Transport of Environmentally Released Radionuclides through Agriculture, ORNL-5786, Oak Ridge National Laboratory, Oak Ridge, Tennessee.
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RAIS 13_4	EPA RAIS reference 13_4: National Council on Radiation Protection Measurement, January 1989, Screening Techniques for Determining Compliance with Environmental Standards, Releases of Radionuclides to the Atmosphere, Bethesda, Maryland.
RAIS 14_1	EPA RAIS reference 14_1: ANL. 1993. Manual for Implementing Residual Radioactive Materials Guidelines Using RESRAD, Version 5.0. Argonne National Laboratory, Argonne, IL. ANL/EAD/LD-2 NCRP. 1996 Screening Models for Releases of Radionuclides to Atmosphere, Surface Water, and Ground, Vols. 1 and 2, NCRP Report No. 123. National Council on Radiation Protection and Measurements. http://www.ncrp.com/rpt123.html
HEAST	EPA RAIS reference HEAST: EPA Health Effects Assessment Summary Tables (HEAST) at http://www.epa.gov/radiation/heast/index.html
SRS	Substance Registry System, EPA, www.epa.gov/srs/, Web site visited January 5, 2011

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APPENDIX E

ADDITIONAL INFORMATION

CONTENTS

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E.1. DATA AND DOCUMENTS USED TO ESTABLISH BACKGROUND CONCENTRATIONS

As early as the late 1950s, the U.S. Department of Energy (DOE) and its predecessor organization determined the importance of setting background concentrations metals and radionuclides in the environment. Routine monitoring programs were established for air and grass. In 1971, the monitoring program had been expanded to include surface soil samples taken at four locations at the plant perimeter, with the only analyte being total uranium.

In 1973, the locations of sampling were changed from the perimeter locations mentioned herein to four locations five miles from the plant perimeter. The only analyte was total uranium. From 1975 until 1985, the environmental monitoring program for soils continued as described.

In 1986, significant changes were reported to have occurred in the soil monitoring program. The environmental report for that year states that the analyte list for soil samples was expanded from only uranium to thorium-230, neptunium-237, plutonium-239, and isotopic uranium. Starting in 1988, the radionuclide analyte list for soil samples taken as part of the environmental monitoring programs was expanded to include total uranium, uranium-238, cesium-237, potassium-40, neptunium-237, pluntonium-239, thorium-230, and technetium-99. Also beginning in 1988, analyses were performed for 36 metals. Metals included in the analyte list were aluminum, antimony, arsenic, barium, beryllium, bismuth, calcium, cadmium, chromium, cobalt, copper, iron, lead, lithium, magnesium, manganese, mercury, molybdenum, nickel, niobium, phosphorus, potassium, ruthenium, silver, sodium, silicon, strontium, tantalum, thallium, thorium, tin, titanium, tungsten, vanadium, zinc, and zirconium.

Phase I and II Site Investigations Reference Sampling

In 1988, DOE and the U.S. Environmental Protection Agency (EPA) entered into a Consent Order that defined the mutual objectives of the EPA and DOE to study groundwater contamination and the threat of releases from the Paducah Gaseous Diffusion Plant (PGDP).

As part of the effort to address the Consent Order, a Site Investigation was performed in two phases. The Phase I and II Site Investigation Reports were completed in 1992. During the completion of Phase I and II Site Investigations, the need for background or reference concentrations for inorganic analytes and reference activities radionuclides was recognized. To meet this need, the Site Investigations included the collection of soil samples from areas outside known plant influence. To establish reference activities for radionuclides, 33 surface soil samples (from 0 to 12 inches in depth) were collected from areas at least 5 miles east and southeast of PGDP in May and June of 1990. The analytes for this sampling effort included gross alpha and gross beta, neptunium-237, technetium-99, plutonium-239, thorium-230, uranium-238, uranium-234, and uranium-235.

To establish reference concentrations for inorganic and metals, 5 surface samples (from 0 to 6 inches in depth) were taken during the Phase II Site Investigation in areas near the PGDP, but outside areas suspected to be influenced by the plant operations. The metals included aluminum, antimony, arsenic, barium, beryllium, cadmium, calcium, chromium, cobalt, copper, cyanide, iron, lead, magnesium, manganese, mercury, nickel, potassium, selenium, silver, sodium, thallium, vanadium and zinc. A report *entitled Inorganic Soil and Groundwater Chemistry Near Paducah Gaseous Diffusion Plant; Paducah, Kentucky,* ORNL/TM-

12897, was prepared and sent to the regulatory agencies for information purposes. While this report was not prepared to establish background groundwater and soil concentrations, it did discuss potential background concentrations for soil and groundwater at PGDP.

In response to comments on *Soil and Groundwater Chemistry Near Paducah Gaseous Diffusion Plant; Paducah, Kentucky,* ORNL/TM-12897, (1996), DOE prepared another internal report with a more extensive evaluation of existing data (primarily data from the Phase I and II Site Investigations, entitled *Background Concentrations and Human Health Risk-based Screening Criteria for Metals in Soil at the Paducah Gaseous Diffusion Plant,* KY/EM-77&D1. The report contained data for 146 surface sampling locations and 597 samples for subsurface soils for metals analysis. The metals included all of those analyzed in the Phase II report with the exception of cyanide in surface and subsurface soils and thallium in subsurface soils. A consensuses of reviewers believed that the data evaluation in this report was not sufficient to establish background of metals in soil and requested that the document be revised.

In response, a revised report, *Background Concentrations and Human Health Risk-based Screening Criteria for Metals in Soil at the Paducah Gaseous Diffusion Plant,* DOE/OR/07-1417&D2, was prepared (DOE 1996). EPA conditionally approved this revised document. The conditions included the reanalysis of four metals including antimony, beryllium, cadmium, and thallium. Also in 1996, the Commonwealth of Kentucky accepted the revised report. The Commonwealth also called for additional sampling to verify the background concentrations of antimony, beryllium, cadmium, and thallium.

DOE issued the final revision of a work plan entitled *Project Plan for the Background Soils Project for the Paducah Gaseous Diffusion Plant, Paducah, Kentucky,* DOE/OR/07-1414&D2 (DOE 1996). As described in this work plan, DOE was to verify with additional sampling the background concentrations for the four metals listed in the conditional approval letters for DOE/OR/07-1417&D2 and to determine the background concentrations of selected radionuclides.

DOE issued the final revision of the report for the background soils project entitled *Background Levels of Selected Radionuclides and Metals in Soils and Geologic Media at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky,* DOE/OR/07-1586&D2. In this report, the values selected by DOE as background concentrations for soil in the DOE/OR/07-1417 report were combined with the background concentrations analyzed for antimony, beryllium, cadmium, thallium, and selected radionuclides, and final background concentration data sets were established. This report included 15 surface soil and 41 subsurface soil sampling locations for the four metals listed above. In addition the significant radionuclides included cesium-137, neptunium-237, plutonium-239, plutonium-238, potassium-40, radium-226, strontium-90, technetium-99, thorium-238, thorium-230, thorium-232, uranium-238, uranium-234, and uranium-235. A variety of statistical methods as described in *Background Levels of Selected Radionuclides and Metals in Soils and Geologic Media at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky,* DOE/OR/07-1586&B2, were used to evaluate the data and ultimately these data were used with data from previous investigations to establish the background values for soils at PGDP. The background values are presented in Appendix A.

E.2. SITE-SPECIFIC EXPOSURE INFORMATION

This section of the appendix contains copies of reports, memoranda, and articles that are useful in developing exposure assessments for the PGDP and justifying various assumptions made when completing risk assessments and analyses. These include the following:

- Letter and survey form used during the Phase I Site Investigation (CH2M Hill 1991) to determine groundwater use near PGDP;

- Summary of the interview with Mr. Kenny E. Perry, Agricultural Extension Agent, Ballard County, Kentucky, regarding agricultural practices in Ballard County held in February 1994;

- Summary of the interview with Mr. Douglas A. Wilson, Agricultural Extension Agent, McCracken County, Kentucky, regarding agricultural practices in McCracken County held in February 1994;

- Letter dated February 24, 1994, from Mr. Douglas A. Wilson, Agriculture Extension Agent, McCracken County, Kentucky, to Mr. Fred Dolislager, Risk Analyst, Oak Ridge National Laboratory, regarding area of crop land in McCracken County;

- Questionnaire dated October 26, 1995, sent to Mr. Charles Logsdon, Kentucky Department of Fish and Wildlife, by FMSM Engineers, Inc. regarding recreational use of Little and Big Bayou Creeks near PGDP;

- Facsimile dated November 8, 1995, sent to Mr. Stephen Scott, FMSM Engineers, Inc., containing responses from Mr. Charles Logsdon, Kentucky Department of Fish and Wildlife, to the aforementioned questionnaire;

- Letter dated April 5, 1994, from Kentucky Department of Fish and Wildlife to Mr. Fred Dolislager, Risk Analyst, Oak Ridge National Laboratory, containing annual harvests of geese, ducks, turkeys, and deer in McCracken and Ballard Counties, Kentucky; and

- 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.

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APPENDIX E
ATTACHMENT 1

ADDITIONAL REFERENCE INFORMATION

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CH2M HILL
Engineers
Planners
Economists
Scientists

February 7, 1990

SED28178

Dear Resident:

The discovery of groundwater contamination occurring at the Paducah Gaseous Diffusion Plant has prompted an extensive environmental study in and around the plant. The study is being done by the U.S. Department of Energy (DOE) and Martin Marietta Energy Systems (Energy Systems) under an agreement between DOE and the U.S. Environmental Protection Agency (EPA). The DOE owns the Paducah Gaseous Diffusion Plant; Energy Systems manages the plant for DOE.

Energy Systems contracted CH2M HILL, an international environmental engineering firm, to conduct the main study of the groundwater contamination. CH2M HILL is implementing a "Work Plan" that spells out details of the study. The Work Plan was agreed to and approved by DOE and EPA.

One part of the Work Plan is to determine the location and number of residents within four miles of the plant boundary who use groundwater for drinking water or other reasons such as irrigation. To fulfill this portion of the Work Plan, we are asking people who may live within four miles of the plant boundary to complete the attached Water Users Survey as soon as possible and return it to CH2M HILL in the enclosed stamped, self-addressed envelope.

Questions on the survey include the source of your water supply and, if you have a private well, the particular construction of your well. Many residents may not have all of the information requested, but any information you can provide will be extremely helpful. Your information will be used in reports describing the findings of the environmental study, but your name and address will be kept confidential.

If you have any questions regarding the Water Users Survey, please contact Debbie Wattier, Manager, Public Relations Department, Paducah Gaseous Diffusion Plant, at (502) 441-6271, or Lori Kincaid, CH2M HILL, at (615) 483-9032. Your cooperation in completing the survey is greatly appreciated and will help in the ongoing efforts to remedy the groundwater contamination occurring at the plant.

Sincerely,

CH2M HILL

James B Moore

James B. Moore

OROC1/078.50

WATER USERS SURVEY
for the
PADUCAH GASEOUS DIFFUSION PLANT
PADUCAH, KENTUCKY

Name ______________________________
(for surveys mailed to businesses, please include name of business)

Address ______________________________

1. If your residence (or business) is located in the area shown on the attached map, please mark its approximate location with an "X."

2. What is the source of your water supply? (Check all that apply)

   Private well ______
   Municipal water ______ supplied by ______________________
   Other (explain) ______________________________

3. Do you have a well on your property that is not in use?

   Yes ______ No ______

   If yes, when was the well last used? ______________________

4. If you do not use well water for any purpose, you need not complete the rest of the survey. Thank you for your help.

5. Is your water supply well located at the address listed above?

   Yes ______ No ______

   If not, where is the well located?

   ____

6. Does anyone else (other than residents at your address or employees of your business) use the same well?

   Yes ______ No ______

   If yes, please identify the other users in the space provided on the back of this form.

7. What do you use well water for? (Check all that apply)

   Drinking water ______
   Irrigation ______
   Industrial use ______
   Domestic use (laundry, etc.) ______
   Watering livestock ______
   Other (explain) ______

8. How is your well constructed?

   Depth (feet) ______
   Material (steel, plastic, tile, etc.) ______
   Diameter (inches) ______
   Screened interval (feet): From ______ to ______

9. Do you have a holding tank?

   Yes ______ No ______

   If yes, what size? ______ gallons

Additional Users of the Well Described in this Survey

Name ______________________________

Address ______________________________

Name ______________________________

Address ______________________________

Name ______________________________

Address ______________________________

Name ______________________________

Address ______________________________

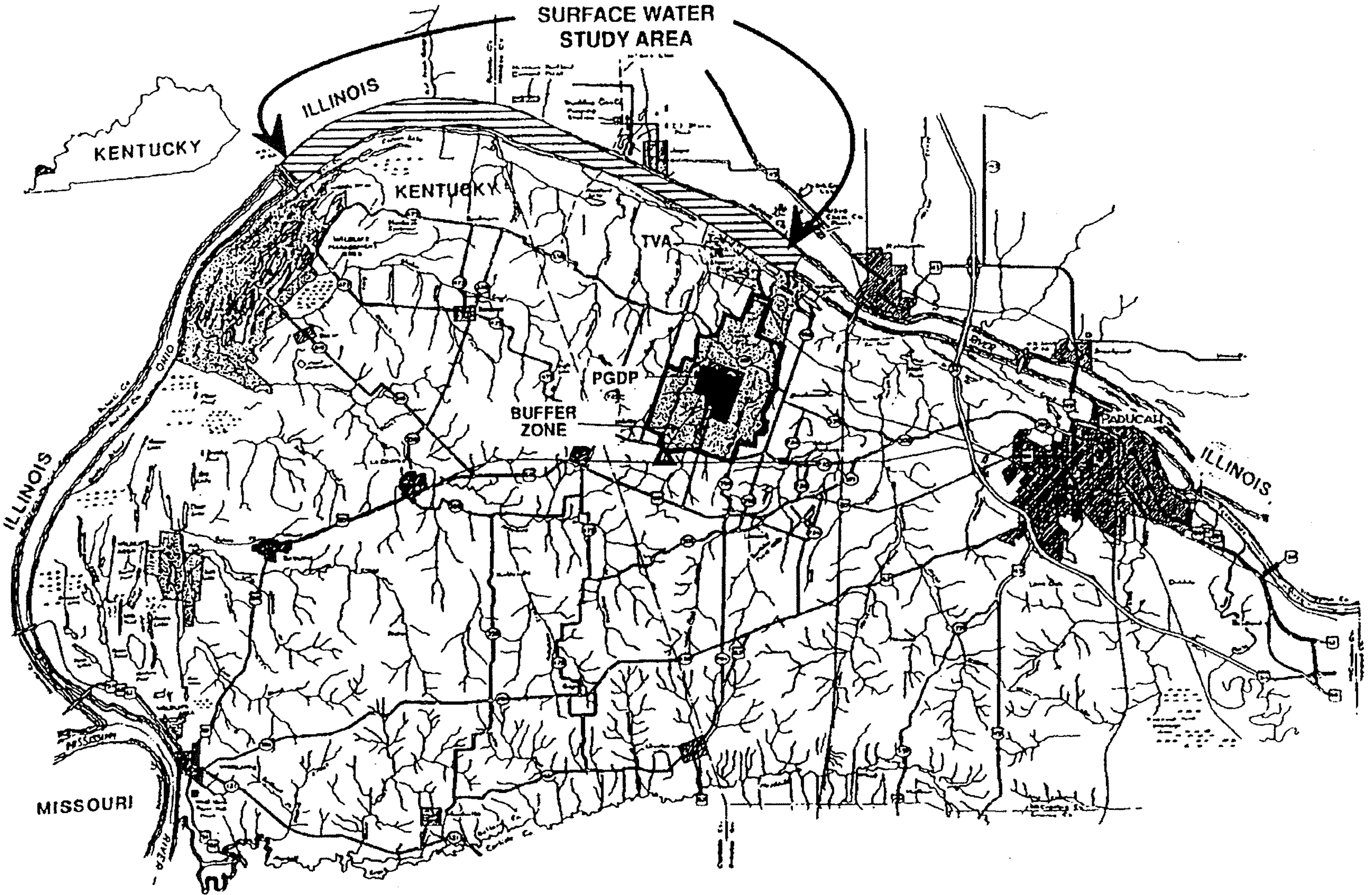
Name ______________________________

Address ______________________________

If you do not know the names or addresses of other users, please estimate how many other homes or businesses may be using the same well:

Number of homes ______
Number of businesses ______

Do you have any additional comments?

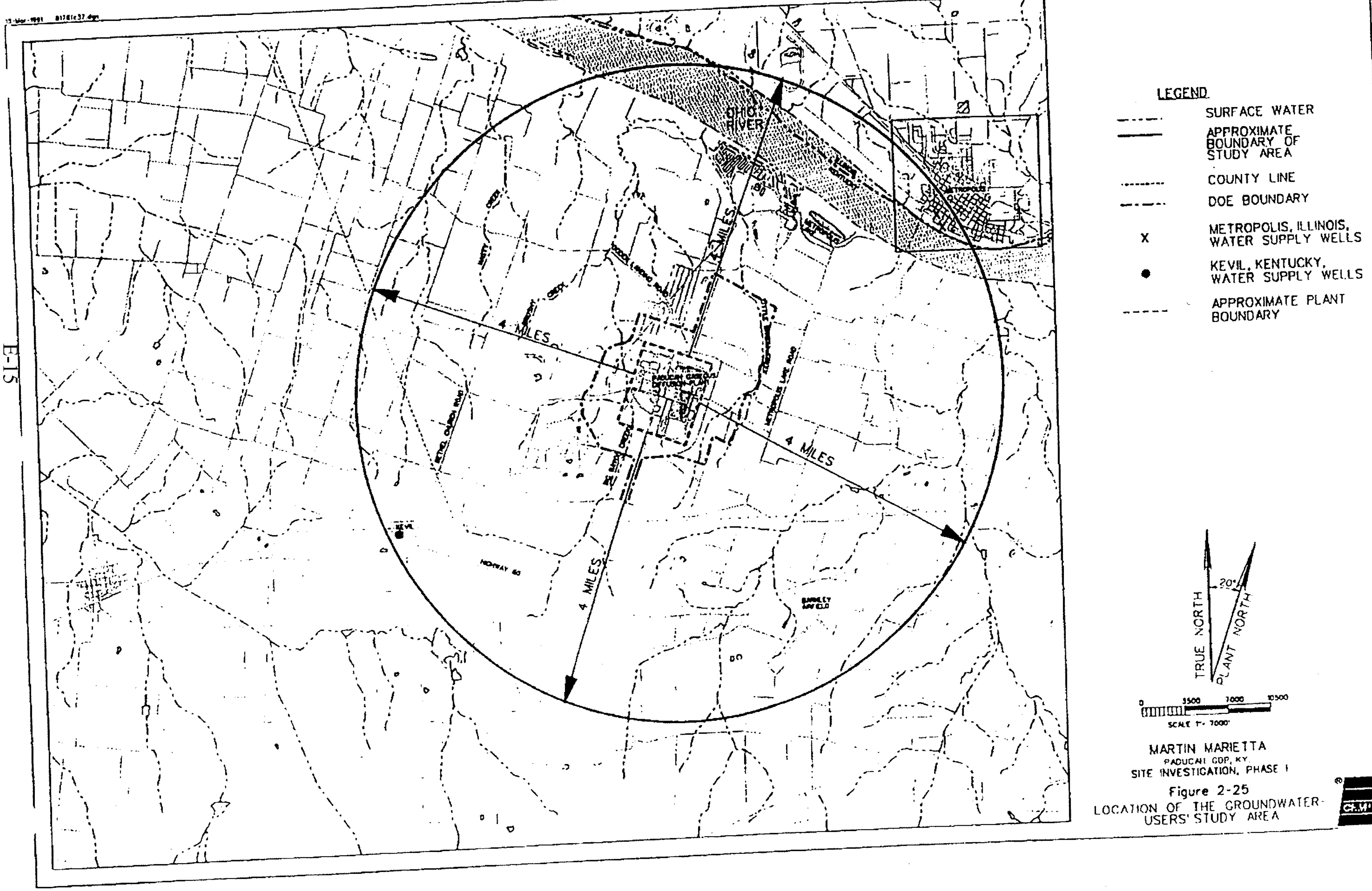


NOT TO SCALE

MARTIN MARIETTA
PADUCAH GDP, KY.
SITE INVESTIGATION, PHASE I

Figure 2-26
LOCATION OF STUDY AREA FOR
SURFACE WATER INTAKE, MARCH 1989

Source: I .i Marietta Energy Systems (1973)



MARTIN MARIETTA
PADUCAH GDP, KY
SITE INVESTIGATION, PHASE I

Figure 2-25
LOCATION OF THE GROUNDWATER-USERS' STUDY AREA

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Ballard County Residential and Agricultural Information

Population

1) 8,000 population
2) 2.6 people per family

Gardening

1) 50% of the population has a garden
2) common grown garden vegetables are squash, corn, tomatoes, green beans, and peas
3) the average garden size is ¼ acre
4) approximately .1to .2 pounds of garden grown vegetables are consumed per individual per day
5) approximately 80% of gardeners can their produce
6) growing season is april 5 to october 12; 4560 hours

Crop Farming

1) 65,000 tillable acres in the county; 160,000 total acres
2) north of HWY 60 logging has been occurring for 20 years
3) 5% acres tobacco, 25% acres corn, 25% acres wheat and soybeans (double cropped) , [25% timber, and 20% pasture]- not considered tillable
4) 1% of the crops receive overhead irrigation; 90% from surface water; 1 in 5 tobacco plots are irrigated
5) approximately 5 inches of water per year is deposited as irrigation
6) 900 tobacco plots in the county
7) the average plot is 1.5 acres; 10 acres dark tobacco and rest burley
8) 2400 pounds are produced per acre
9) 35 acres of cucumbers are farmed with drip irrigation
10) One roadside stand

Livestock Farming

1) beef, dairy, swine and poultry farming was valued at $10,000,000 in the county
2) 11,000 cattle are in the county; 100 dairy cows per farm, 8 farms
3) commercial dairy farms use silage, homegrown hay, rotational grazing, and 13% is improved pasture
4) 15% get meat locally but 60% of total consumption is store bought
5) approximately 13,125 pounds of milk are produced per cow per year
6) there are 40 poultry barns with 20-30,000 broilers; turn around is approximately 6x/year
7) poultry are fed bought feed
8) there are 12 hog farms averaging 1,700/farm; 12-18 small farms have around 3 sows/farm
9) swine are fed locally grown corn and additives

Ballard County Residential and Agricultural Information cont.

Fish Farming

1) there are several catfish ponds in the county of which 0 are pay lakes
2) channel catfish fingerlings are the fish stocked
3) the ponds average 2 acres
4) approximately 4000 pounds of catfish are harvested per year in the county
5) building ponds is not economically feasible; 1 pond uses a groundwater pump
6) harvested weights of the catfish range from 1.5 to 2 pounds
7) a pond can be turned over in 1.5 years
8) fish are generally fed bought food.

The above information is a correct representation of Ballard County

Kenny Perry
signature

Kenny E. Perry
Ballard county extension agent for agriculture
P.O. Box 237
200 Broadway
La Center, KY 42056

McCracken County Residential and Agricultural Information

Population

1) 60,000 population
2) 2.5 people per family

Gardening

1) 35-40% of the population has a garden
2) common grown garden vegetables are squash, corn, tomatoes, green beans, and lettuce
3) the average garden size is ¼ acre
4) during harvest season (3 months) approximately 2 pounds of garden grown vegetables are consumed per individual per day
5) approximately all gardeners can their produce

Crop Farming

1) 65,000 tillable acres in the county
2) since 1984 there has been a steady decrease in the number of acres farmed for corn, wheat, soybeans, and tobacco from 58,711 in 1984 to 39,900 in 1993
3) 440 acres tobacco, 15,000 acres corn, 7000 acres wheat, and 22,000 acres soybeans
4) horticulture crops are trickle irrigated (20 acres)
5) 150 tobacco plots in the county
6) the average plot is 2 acres
7) 2500 pounds are produced per acre
8) plots are spray irrigated very infrequently and mainly flooded

Livestock Farming

1) beef, dairy, swine and poultry farming are only of minor importance to the county
2) 3 commercial beef farms(6,200 head), 3 commercial dairy farms (500 head holsteins), 2 commercial swine farms (3600 head), 14 broiler barns (28000 birds with a 6x/year turn-around, and approximately 25 farms have 2 hogs or 2 cows
3) stored feed usage is rare, mostly hay and unimproved pasture
4) home slaughtering of cattle, chickens, and swine is insignificant
5) ingestion of home milk and eggs is insignificant
6) total milk production was 3,600,000 pounds in 1992
7) 5% of farms consume 60% of their beef from homegrown livestock

McCracken County Residential and Agricultural Information cont.

Fish Farming

1) there are 5-10 catfish ponds in the county of which 2 are pay lakes
2) channel catfish fingerlings are the fish stocked
3) the ponds average 1 acre and 4 feet deep
4) approximately 4000 pounds of catfish are harvested per year
5) approximately 100% of the fish harvested stay in the county
6) harvested weights of the catfish range from 1 to 2 pounds
7) a pond can be turned over in 2 years
8) fish are generally fed bought food.

The above information is a correct representation of McCracken County

Doug Wilson
signature

Douglas A. Wilson
McCracken county extension agent for agriculture
2705 Olivet Church Road
Paducah, KY 42001-9755

UNIVERSITY OF KENTUCKY
COLLEGE OF AGRICULTURE
Lexington, Kentucky 40546

RESIDENT INSTRUCTION
AGRICULTURAL EXPERIMENT STATION
COOPERATIVE EXTENSION SERVICE

COOPERATIVE EXTENSION SERVICE

REPLY TO:
McCracken Co. Extension Center
2705 Olivet Church Road
Paducah KY 42001-9755
Phone: (502)554-9520/554-9522
Fax: (502) 554-8283

February 24, 1994

Fred Dolislager
2924 Williams Road
Knoxville, TN 37932

Dear Fred:

Following the information you requested regarding crop land use in McCracken County since 1984:

YEAR	ACRES IN CROP
1984	58711
1985	58071
1986	58000
1987	57401
1988	54000
1989	41800
1990	40800
1991	39792
1992	40245
1993	39900

This is a total of corn-wheat-soybeans and tobacco.

Sincerely,

Doug Wilson

Douglas A. Wilson
County Extension Agent
for Agriculture

DW/mh

409
North Forbes Road
Lexington, Kentucky
40511-2050

606-233-0574
606-254-4600 FAX

Fuller Mossbarger Scott & May
FMSM
ENGINEERS

October 26, 1995

O.1.1.94355L05

Mr. Charles Logsdon
Kentucky Department of Fish and Wildlife Resources
10535 Ogden Landing Road
Kevil, Kentucky 42053

Re: PCB Risk Calculations
Paducah Gaseous Diffusion Plant

Dear Mr. Logsdon:

FMSM is conducting a preliminary risk calculation for the Little Bayou and Big Bayou areas around the Paducah Gaseous Diffusion Plant. This subject was discussed at a meeting in which you attended on September 7, 1995. During that meeting you indicated that your office could provide information on the recreational use of these areas. In response to your suggestion, we have developed the following list of questions. Please try to research your site use data and answer as many of these questions as possible. If data is not directly available to answer these questions we would appreciate an estimate based on your best professional judgment.

Big Bayou

1. What is the average number of visitors per year to Big Bayou?

2. Of this number, how many are adults and how many are children?

3. Are most of your visitors repeat or one-time visitors on a yearly basis?

4. What is the average time (hours) spent in Big Bayou? Is there a difference in average time spent between adult and child usage?

5. What are the common recreational usages in the area? What is the percentage breakdown of usages by the visitors (i.e. what percentage of visitors fish, hunt, hike, swim, etc.)?

6. What is the number of repeat visits per year by any one individual or group of individuals? What is the average time spent (hours) in the area by the higher frequency visitors?

FULLER, MOSSBARGER, SCOTT & MAY ENGINEERS, INC
OFFICES IN LEXINGTON, CINCINNATI & LOUISVILLE

7. For individuals who are fishing in the area. are they mostly bank fishing or wade fishing? Can you estimate the percentage breakdown between the two? What is the average time spent in the area by a fisherman?

8. Is there a harvestable fish population in Big Bayou? If there is, is there enough to support subsistence fishing (i.e., 0.284 kilograms of meat flesh/meal) for one person to eat 128 meals a year? If not, how much fish, and how often could a person best expect to harvest a meal for consumption?

Little Bayou

I realize that during the September 7th meeting, you stated there is little to no recreational use of the Little Bayou areas. However, it would be helpful if you could answer the same questions about Little Bayou, as asked of Little Bayou. Therefore, we are repeating the following questions.

1. What is the average number of visitors per year to Little Bayou?

2. Of this number, how many are adults and how many are children?

3. Are most of your visitors repeat or one-time visitors on a yearly basis?

4. What is the average time (hours) spent in Little Bayou? Is there a difference in average time spent between adult and child usage?

5. What are the common recreational usages in the area? What is the percentage breakdown of usages by the visitors (i.e. what percentage of visitors fish, hunt, hike, swim, etc.)?

6. What is the number of repeat visits per year by any one individual or group of individuals? What is the average time spent (hours) in the area by the higher frequency visitors?

7. For individuals who are fishing in the area, are they mostly bank fishing or wade fishing? Can you estimate the percentage breakdown between the two? What is the average time spent in the area by a fisherman?

8. Is there a harvestable fish population in Little Bayou? If there is, is there enough to support subsistence fishing (i.e., 0.284 kilograms of meat flesh/meal) for one person to eat 128 meals a year? If not, how much fish, and how often could a person best expect to harvest a meal for consumption?

We appreciate your help in answering these questions. After you have reviewed these, if you have any questions, or if the questions need clarification, please call.

Sincerely,

FULLER, MOSSBARGER, SCOTT AND MAY
ENGINEERS, INC.

Stephen L. Scott, P.E.
Project Manager

/esh

c: David Asburn ✓
Tom McGee ✓
Bob Sneed ✓
David Brancato ✓

facsimile
TRANSMITTAL

to: Stephen Soott, P.E.
fax #: 606-254-4800
re: Big Bayou & Little Bayou
date: November 8, 1995
pages: 4, including this cover sheet.

From the desk of...

Charlie Logsdon
WMA Supervisor
Ky. Dept. Of Fish & Wildlife Resources
10535 Ogden Landing Rd.
Kevil, KY. 42053

(502)488-3233
Fax

Stephen Scott, P.E.
Fuller, Mossbarger, Scott and May
Engineers, Inc.
1409 North Forbes Road
Lexington, Ky. 40511-2050

Dear Mr. Scott:

I have answered these question as accurately as possible. If you have any other questions, or questions about my answers feel free to contact me. Sorry about the delay, but you're letter came during some of our deer hunting seasons.

Sincerely,

Charlie Logsdon

Charlie Logsdon

cc: Wayne Davis
Don Walker

Little Bayou

1. The number of people visiting Little Bayou is essentially zero, with the exception of PGDP personnel and a few fishermen(maybe, 20 visits annually) that fish a large beaver pond above the outfalls of the plant. A few people (bowhunters and dog trainers) may cross the creek occasionally, but these visits would be brief(the majority would be measured in seconds or minutes). Field trial galleries do cross the creek(over a large dirt-covered culvert) north of McCaw Road, however, they do not enter the creek and the whole process takes seconds.

2. The visitors would be adults.

3. Refer to Big Bayou question 3. Visitors to Little Bayou would be repeat users, probably less than 10 visits per year and most of them in the brief encounter scenario described in question 1.

4. Most encounters with Little Bayou would be measured in seconds. Fishermen that use the beaver pond above the outfalls, may fish on average 2 hours.

5. See Big Bayou question 5.

6. Field trials that cross the creek may occur 12-15 weekends of the year. Most of the participants would be repeat users. The sum of all the encounters with Little Bayou would be measured in minutes for the most frequent user and most would only cross the creek on the culvert and dirt crossings.

7. All fishermen in the beaver pond would be bank fishermen as the pond is too deep to wade.

8. Other than the beaver pond above the outfalls, it would be nearly impossible to catch 0.284 kgs of fish from Little Bayou. There is a fish population, but most would fall in the minnow category and are not desirable by fishermen. In the beaver pond, it would be possible to catch this amount, but it would not support subsistence fishing(128 meals/year).

Big Bayou

Question 1: The number of visits by people using Big Bayou specifically, is estimated to be 150 visits. This is for a specific activity involving Big Bayou, such as fishing. More people may be in the vicinity while using the WKWMA, but their use of Big Bayou maybe for only an instant(i.e., using a log to cross Big Bayou to hunt on the other side of the creek).

Question 2: Of the 150 visits of people using Big Bayou, 100 are adults and 50 are children. This is an estimate based on our observations of people using the area.

Question 3: Most of these people would be one time users. However, 10% of the total number of users could be classified as repeat users. The highest number of visits by one person specifically using Big Bayou, would probably be <10.

Question 4: The average time spent in Big Bayou by users is unknown. However, I feel the amount of time spent/trip would be similar to other activities. During 1994, the average number of hours spent/trip for the following activities were: Quail hunting - 3.49 hrs/trip(n= 158), rabbit hunting - 3.25(n=168), bowhunting for deer - 3.48(n=1115), duck hunting - 2.4(n=69), and racooon hunting - 2.63(n=20). Raccoon hunting and duck hunting would be the activities most likely associated with Big Bayou. There would be little, if any, difference between adult and child usage of the area.

Question 5: This question is difficult to answer. Do you mean for WKWMA or Big Bayou? WKWMA is heavily used by a wide variety of users. Annually, the estimated number of visits for the following activities are: fishing - 5000 visits/year, hunting and dog training 4-6000, field trials - 1500, hiking - 100, berry & nut picking - 200, driving through for a variety of reasons - 50,000.
For activities involving Big Bayou alone: fishing - 150, hunting - ?(explained in question 1).

Question 6: Refer to questions 3 and 4.

Question 7. Most, if not all would be bank fishermen. Most of the fishing would occur at 3 points: 1) where the iron bridge in tract 4 crosses Big Bayou, 2) where the collapsed bridge in tract 4 crosses Big Bayou(by weir constructed by PGDP), and 3) where the concrete crossing bridges Big Bayou in tract 6. While it may occur, no wade fishing has been observed. No actual data is available, but should be similar to the length of visits noted in question 4.

Question 8: There is a harvestable fish population in Big Bayou. A person could potentially expect to catch 0.284 kgs of fish on a regular basis(depending on the skill of the fisherman), however, this is assuming that the person is not culling(throwing back extremely small fish). The frequency of being able to catch 0.248 kgs of fish would increase as one approaches the mouth of Big Bayou. Also, the only way the creek could support 128 meals a year is if there was major influx of fish from the Ohio River. This does occur when there is a backwater. During the backwater periods catches of 50 to several hundred pounds of catfish can be taken(this has been observed) on trotlines. This would not be indicative of risks associated with the plant.

COMMONWEALTH OF KENTUCKY
DEPARTMENT OF FISH AND WILDLIFE RESOURCES
C. THOMAS BENNETT, COMMISSIONER

April 5, 1994

Mr. Fred Dolislager
2924 William Road
Knoxville, TN 37932

Dear Mr Dolislager:

Enclosed is the information you requested. I created some graphs of annual harvest for ducks and geese in each county. Harvest estimates were used for the last 11 years because this is most representative of current hunting activities in Ballard and McCracken counties. Mean annual duck harvest in Ballard and McCracken counties is 2,834 and 396 birds, respectively. Mean annual goose harvest is 7,623 and 233 for Ballard and McCracken counties, respectively. This does not include 1993-94 harvest estimates which have not been tabulated yet. Below is a table of duck and goose harvests for each county by year.

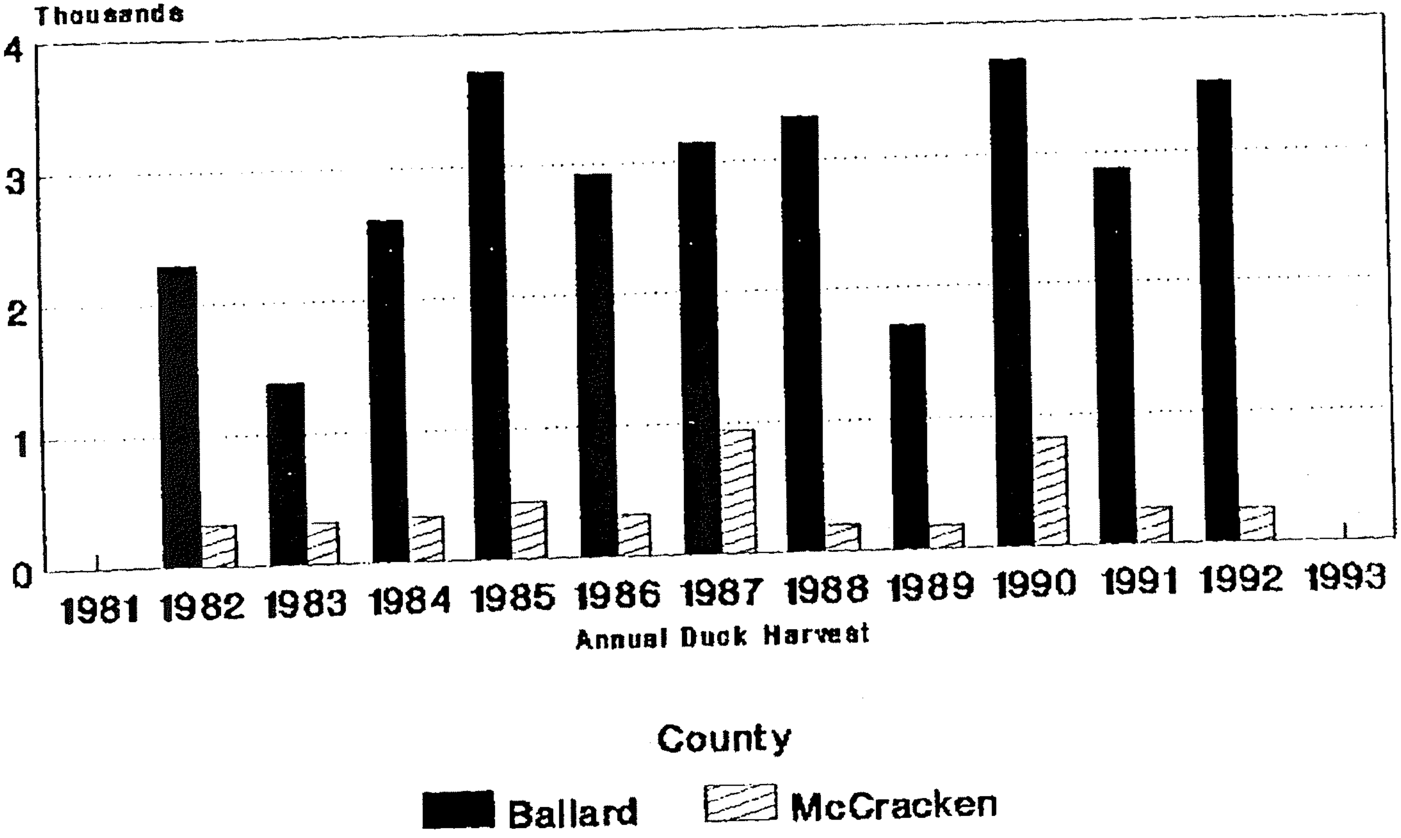
	McCracken		Ballard	
Year	Ducks	Geese	Ducks	Geese
1982	311	171	2,293	5,272
1983	311	171	1,378	7,214
1984	339	188	2,600	6,095
1985	436	69	3,711	6,567
1986	311	171	2,918	6,956
1987	937	580	3,147	8,698
1988	197	160	3,316	13,119
1989	179	178	1,710	17,228
1990	815	245	3,712	4,574
1991	263	463	2,869	4,712
1992	259	171	3,518	2,959
1982-92 Mean	396	233	2,834	7,623

I hope this information is what you need. If you need anything else feel free to give me a call.

Sincerely,

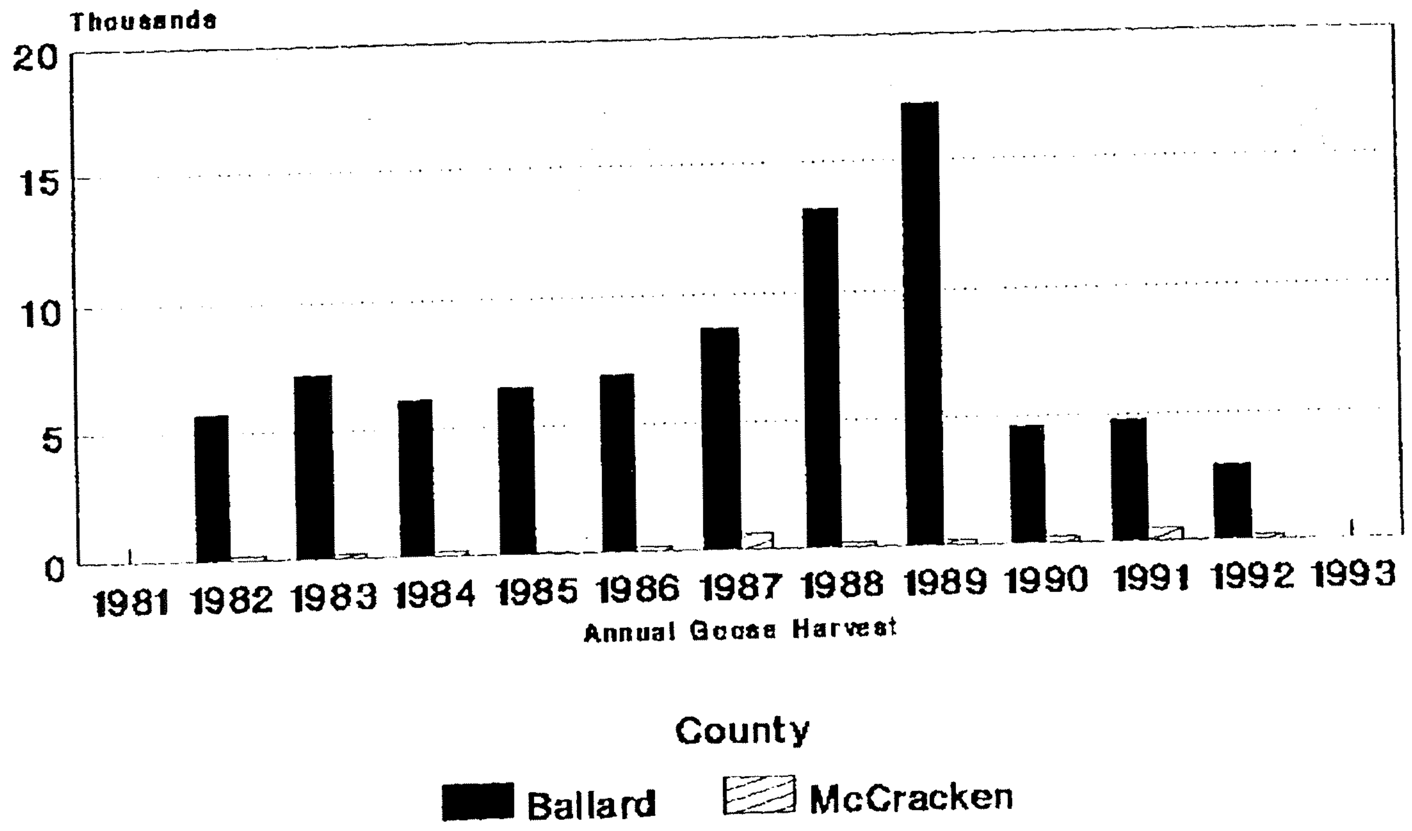
Arnold L. Mitchell Bldg. #1 Game Farm Road Frankfort, Ky 40601
An Equal Opportunity Employer M/F/D

TOTAL DUCK HARVEST IN BALLARD AND McCRACKEN COUNTIES FROM 1982 - 1992.



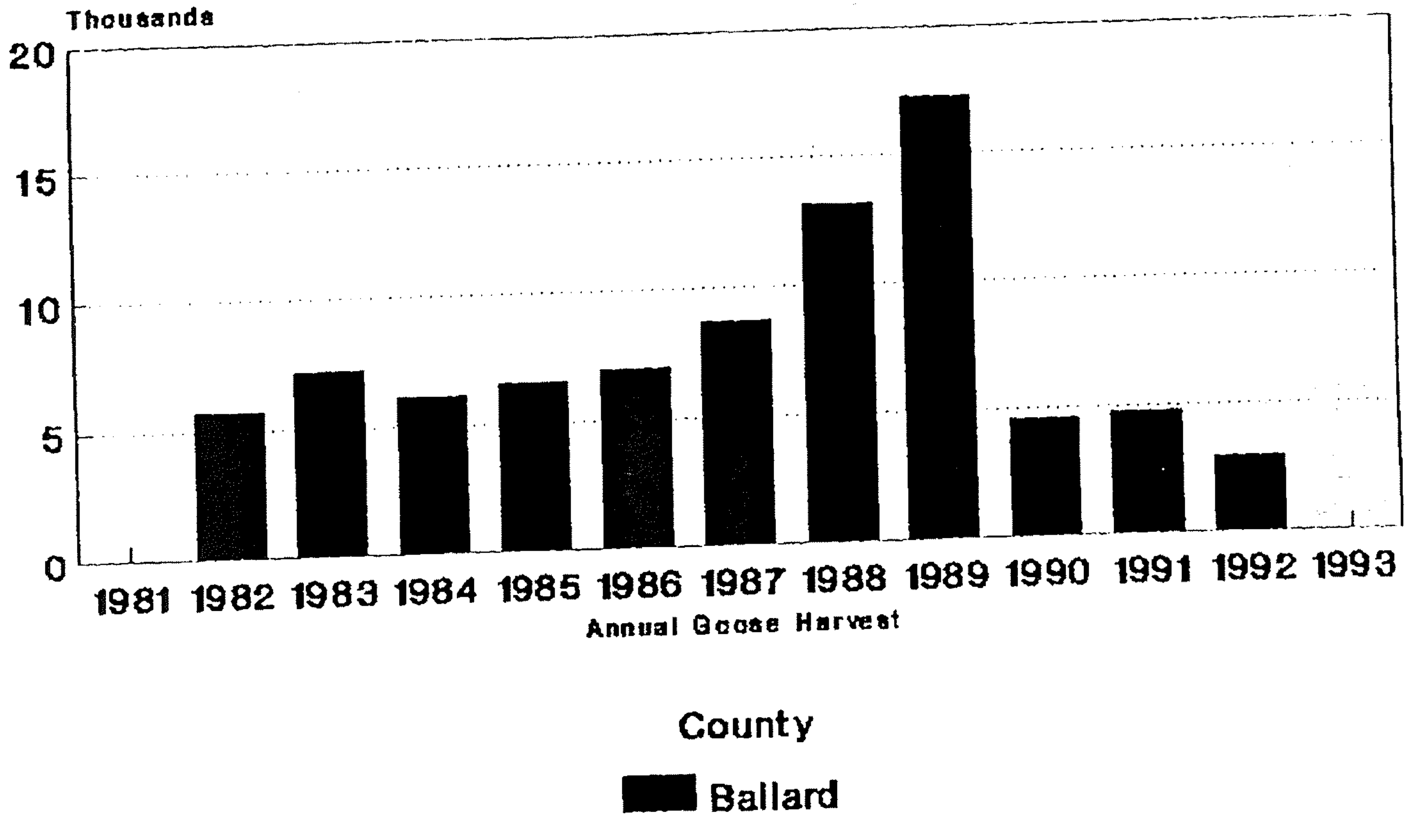
McCracken totals for 1982, 1983 and 1986 were estimated from averaging 11 years of annual harvest for the county

TOTAL GOOSE HARVEST IN BALLARD AND McCRACKEN COUNTIES FROM 1982 - 1992.



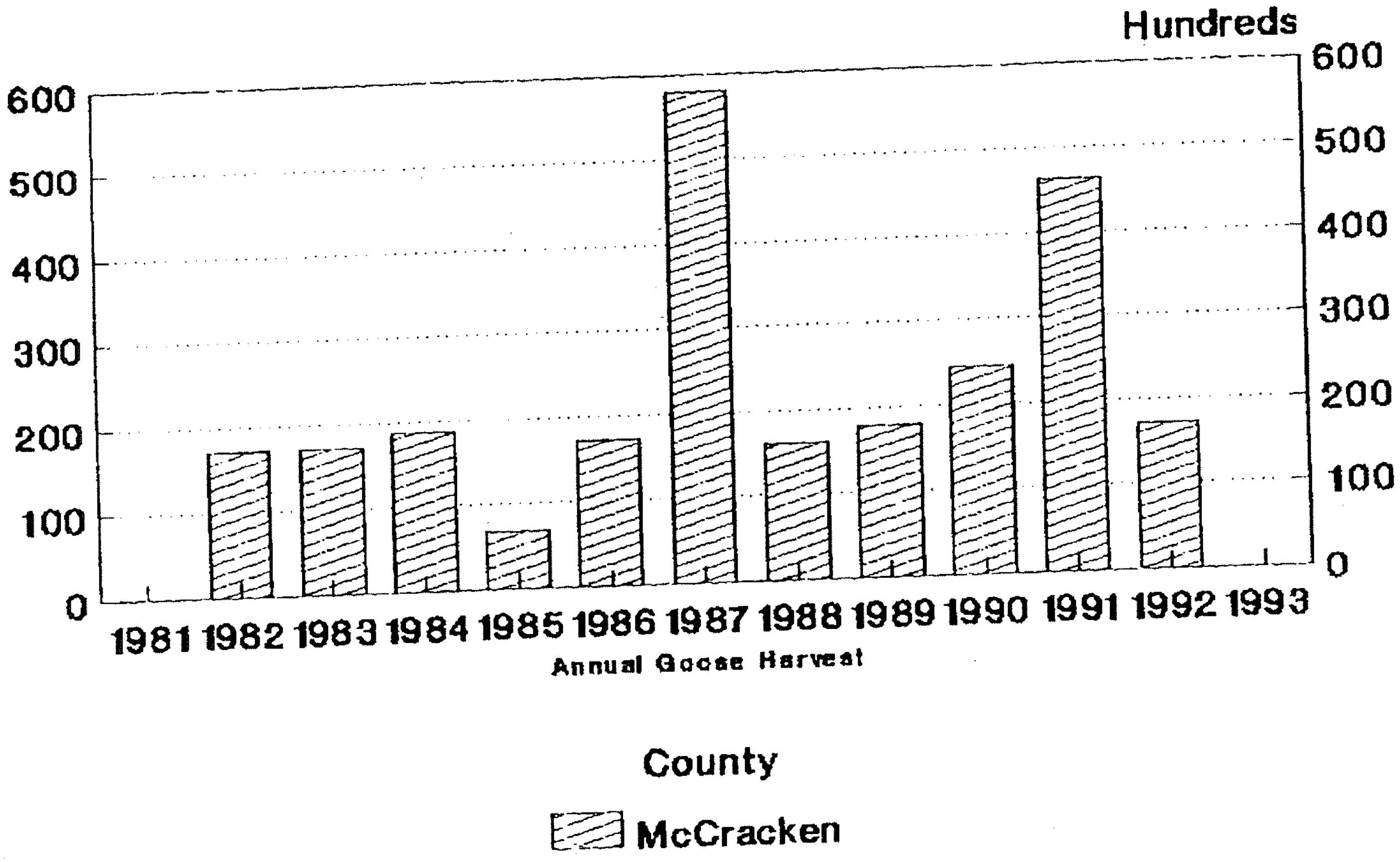
McCracken totals for 1982, 83, 88 & 92

TOTAL GOOSE HARVEST IN BALLARD AND McCRACKEN COUNTIES FROM 1982 - 1992.



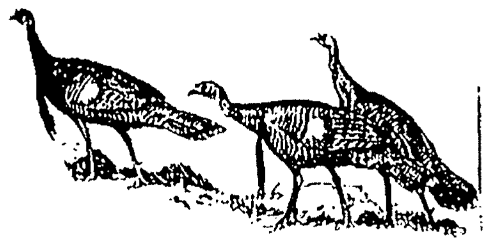
McCracken totals for 1982, 83, 88 & 92
were estimated from averaging 11 years
of annual harvest for the county

TOTAL GOOSE HARVEST IN BALLARD AND McCRACKEN COUNTIES FROM 1982 - 1992.



McCracken totals for 1982, 83, 88 & 92
were estimated from averaging 11 years
of annual harvest for the county

KENTUCKY
WILD TURKEY HARVEST
BY COUNTY
1995

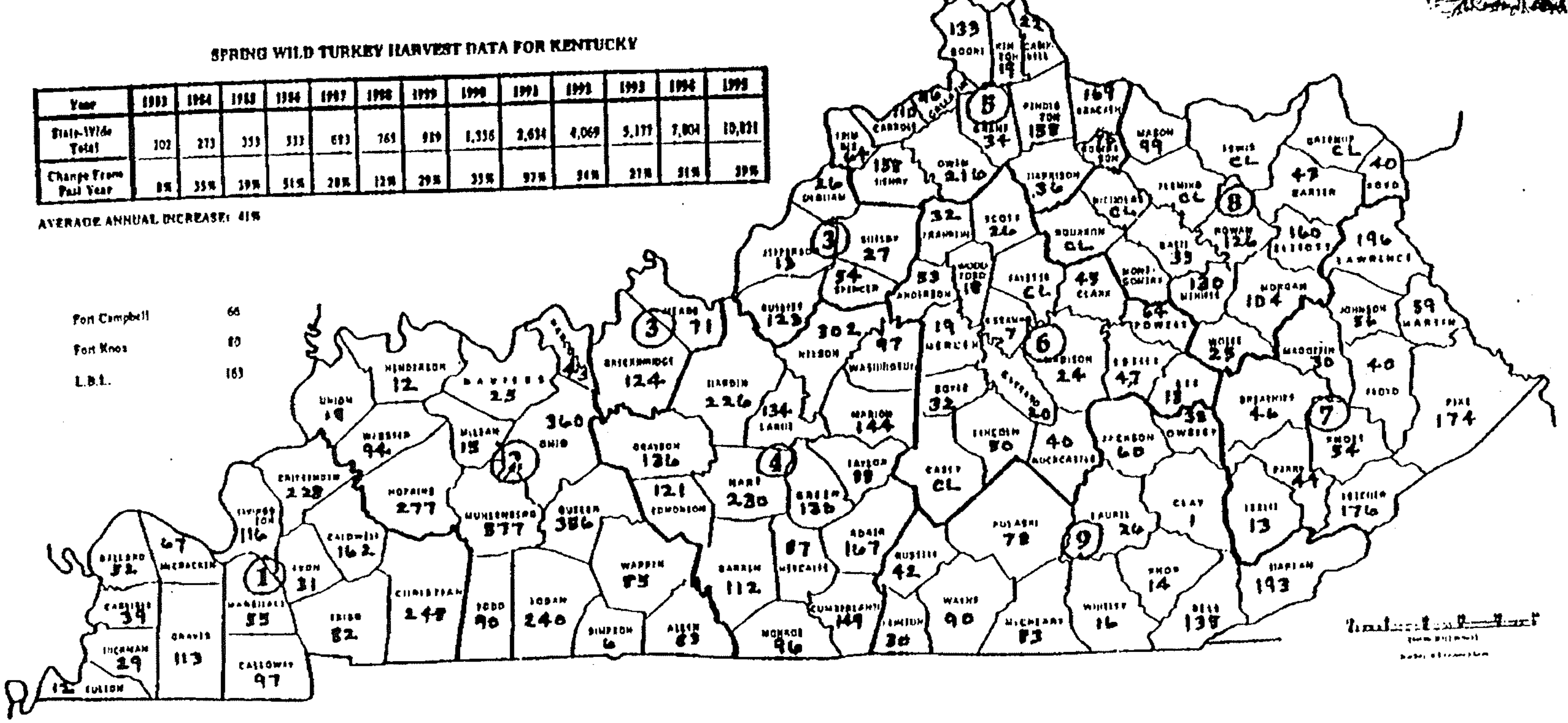


SPRING WILD TURKEY HARVEST DATA FOR KENTUCKY

Year	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
State-Wide Total	102	273	353	533	673	765	989	1,336	2,634	4,069	5,177	7,804	10,831
Change From Past Year	8%	35%	39%	51%	20%	12%	29%	35%	97%	54%	27%	51%	39%

AVERAGE ANNUAL INCREASE: 41%

Fort Campbell	66
Fort Knox	80
L.B.L.	163



This data was provided by the Kentucky Department of Fish and Wildlife Resources, and compiled in the present form by:

909 Bolls Fork Road
Rush, KY 41168

(606) 928-6975

DR. ROLAND L. BURNS
8TH DISTRICT COMMISSION MEMBER

Table 7b. Kentucky Antlered Buck Harvest 1986-1994.

	YEAR								
COUNTY	1986	1987	1988	1989	1990	1991	1992	1993	1994
ADAIR	303	358	666	484	580	517	653	581	489
ALLEN	408	582	661	478	512	534	534	497	310
ANDERSON	360	465	570	499	414	450	496	390	528
BALLARD	289	451	441	264	411	311	287	331	420
BARREN	174	265	407	322	309	328	379	369	345
BATH	139	188	246	287	351	281	337	422	309
BELL	17	24	37	57	114	98	102	135	174
BOONE	415	514	555	503	614	653	475	471	665
BOURBON	8	4	9	16	12	21	38	46	51
BOYD	172	331	385	469	488	439	420	562	472
BOYLE	96	145	175	160	110	299	177	156	148
BRACKEN	264	370	479	348	411	493	366	309	422
BREATHITT	33	40	57	80	80	66	123	157	124
BRECKINRIDGE	657	997	737	831	818	806	799	604	735
BULLITT	160	192	248	249	273	255	310	301	297
BUTLER	604	804	557	650	664	567	574	541	733
CALDWELL	520	707	502	499	588	508	545	460	556
CALLOWAY	208	304	292	370	447	384	300	303	357
CAMPBELL	83	153	180	173	218	199	244	204	194
CARLISLE	208	268	319	247	214	198	181	281	239
CARROLL	205	369	306	304	348	372	274	253	331
CARTER	245	363	493	600	619	1032	838	827	788
CASEY	370	508	495	606	518	518	648	418	485
CHRISTIAN	896	1046	908	904	958	1037	863	850	953
CLARK	50	99	127	123	176	182	204	176	231
CLAY	0	0	104	114	98	130	191	165	200
CLINTON	33	57	38	45	120	112	170	163	124
CRITTENDEN	654	1040	883	903	944	706	877	847	820
CUMBERLAND	188	275	299	343	386	388	469	418	463
DAVIESS	241	221	386	354	314	282	333	327	420
EDMONSON	119	141	124	213	150	185	164	197	214
ELLIOTT	171	231	282	322	352	609	325	316	312
ESTILL	0	0	0	0	0	0	0	84	90
FAYETTE	1	4	4	7	8	14	19	15	29
FLEMING	64	82	79	146	155	126	208	203	275
FLOYD	16	53	39	113	152	134	171	133	199
FRANKLIN	451	421	487	459	440	611	467	557	475
FULTON	120	120	165	165	126	121	167	153	173
GALLATIN	233	324	330	278	317	382	261	233	283
GARRARD	11	13	20	30	53	65	87	96	107
GRANT	281	311	416	382	466	451	387	400	457
GRAVES	469	683	689	498	580	468	527	552	608
GRAYSON	332	387	513	451	499	591	530	574	674
GREEN	220	325	415	359	324	385	388	434	388
GREENUP	144	262	338	369	543	687	597	618	559
HANCOCK	406	366	359	394	384	380	413	371	321
HARDIN	356	452	540	581	586	591	710	704	719
HARLAN	45	55	68	117	63	131	135	134	195
HARRISON	194	251	262	333	231	354	238	270	325
HART	98	105	98	255	258	325	375	365	425
HENDERSON	420	515	511	437	460	417	423	429	535
HENRY	502	348	591	556	602	747	492	447	539

.ble 7b. Kentucky Antlered Buck Harvest 1986-1994.

	YEAR								
OUNTY	1986	1987	1988	1989	1990	1991	1992	1993	1994
ICKMAN	190	330	329	257	242	227	220	346	287
OPKINS	940	983	936	987	1028	779	908	591	992
ACKSON	60	98	144	130	142	205	208	209	295
EFFERSON	100	153	194	183	207	256	241	261	287
ESSAMINE	16	13	21	36	35	73	53	33	102
OHNSON	11	27	29	79	108	154	184	160	233
ENTON	45	92	95	86	114	144	132	128	165
NOTT	55	78	57	110	119	133	149	168	185
NOX	0	0	0	0	0	218	149	139	178
ARUE	231	321	352	370	384	322	341	314	321
AUREL	57	79	135	131	112	184	158	179	258
AWRENCE	322	632	792	1034	1165	1098	935	928	822
EE	22	36	31	55	79	81	85	52	92
ESLIE	39	52	60	121	46	65	59	37	121
ETCHER	0	0	0	0	48	61	81	88	112
LEWIS	72	83	66	122	208	277	338	341	420
LINCOLN	49	68	71	137	135	169	205	157	180
LIVINGSTON	431	653	541	496	587	467	483	453	484
LOGAN	618	847	608	624	710	555	561	627	695
LYON	94	63	228	161	145	149	152	125	185
MACCRACKEN	170	175	365	250	189	225	229	190	202
MACCREARY	126	181	164	252	192	143	212	249	232
MACLEAN	339	334	455	278	404	259	289	347	347
MADISON	30	32	41	112	191	339	228	170	183
MAGOFFIN	9	12	18	0	0	0	0	173	192
MARION	335	506	486	508	468	475	440	423	486
MARSHALL	59	129	157	158	157	165	138	147	168
MARTIN	16	34	47	87	108	149	217	213	273
MASON	156	191	123	196	284	317	243	287	287
MEADE	234	203	396	327	393	356	343	332	382
MENIFEE	115	150	138	271	319	362	283	248	277
MERCER	103	183	203	210	238	182	211	179	207
METCALFE	164	263	285	299	355	271	317	380	420
MONROE	123	142	149	259	283	286	339	302	327
MONTGOMERY	8	16	18	32	61	55	81	84	110
MORGAN	123	183	235	289	332	364	533	428	551
MUHLENBURG	760	738	542	640	725	738	817	462	875
NELSON	446	580	639	685	630	580	634	552	683
NICHOLAS	85	140	127	177	189	205	170	164	175
OHIO	867	1266	893	908	874	1042	1029	1083	1325
OLDHAM	252	324	403	361	411	462	360	383	309
OWEN	670	600	912	812	864	901	676	889	810
OWSLEY	24	30	35	50	53	60	67	60	144
PENDLETON	399	460	514	516	511	481	463	513	542
PERRY	0	0	0	0	50	74	67	58	62
PIKE	23	37	28	55	64	100	0	0	0
POWELL	21	35	34	43	73	89	106	93	104
PULASKI	174	248	282	424	455	383	486	450	491
ROBERTSON	128	114	242	186	143	195	202	215	213
ROCKCASTLE	37	37	36	49	70	81	86	91	108
ROWAN	136	159	241	294	386	299	432	393	456
RUSSELL	144	218	111	241	228	247	246	128	273

ble 7b. Kentucky Antlered Buck Harvest 1986-1994.

				YEAR					
COUNTY	1986	1987	1988	1989	1990	1991	1992	1993	1994
SCOTT	287	382	398	511	407	412	351	266	586
SHELBY	321	404	522	401	584	611	520	496	538
SIMPSON	50	59	55	92	89	88	103	105	139
SPENCER	230	276	346	371	328	303	241	303	369
TAYLOR	185	289	275	349	351	321	328	311	254
TODD	497	633	487	571	549	419	472	509	704
TRIGG	189	192	337	235	328	330	309	248	311
TRIMBLE	241	245	298	277	310	351	272	303	289
UNION	257	336	338	371	396	317	186	245	302
WARREN	275	285	440	383	379	255	343	341	346
WASHINGTON	298	349	445	430	339	459	336	236	432
WAYNE	156	201	206	293	288	264	299	301	348
WEBSTER	553	855	777	823	872	775	655	690	680
WHITLEY	66	110	91	153	205	221	232	252	271
WOLFE	23	46	33	70	124	191	159	122	176
WOODFORD	99	92	141	189	221	172	210	191	258
TOTALS	26022	33671	36065	37303	39910	40929	39868	38781	43848

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According to two reports received by the risk analysis section, industrial workers range 0.5 acres a day. This area is where the worker may be exposed to contamination. This area is called an exposure unit. In this risk assessment, it was reasoned an exposure unit of 0.5 acres is consistent with the activities at PGDP. Exposure was weighted based on the size of the SWMU and the 0.5 acre exposure unit. If the size of the SWMU was smaller than the 0.5 acre exposure unit, then the fraction was introduced into the CDI equation. The fraction; however, cannot exceed 1. Copies of the two reports are provided as references.

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PLANNING ISSUES FOR SUPERFUND SITE REMEDIATION

Randall T. Ryti
Dean Neptune

Abandoned drums located behind the "burn shed" at the site

One function of the Superfund program is to assess the risk posed by hazardous waste sites. Sites that merit inclusion on the National Priorities List (NPL) are analyzed intensively through the Remedial Investigation/Feasibility Studies (RI/FS) process, which provides estimates of the risk posed by the site and the cost of cleanup. In this article we will review the planning issues for RI/FS through a case study of a specific Superfund site—a former transformer storage and rehabilitation facility in North Carolina.

The planning process used for this example is the Data Quality Objectives (DQO) process, which consists of the following steps: define the problem, define the question, define the data needs (the domain and decision rule), and define the data performance for the main question (*1,2*).

The planning approach is flexible; we have successfully applied the DQO process to two other Superfund sites. This site differed in the complexity of the problem, as well as the time frame within the Superfund assessment and cleanup process. We have observed that using the DQO process has not increased the resources expended (either time or money). Indeed, the process has resulted in substantial savings at a dioxin site in Missouri (*3,4*).

Another advantage of the planning process is that data collection can be focused. If one or a few contaminants are of interest, then more specific tests can be used. The planning process also sets goals for data collection, so that a criterion for the adequacy of data collection can be specified. The question of "how much is enough" develops naturally during the planning process.

Site history

The site is a former transformer storage and rehabilitation facility located on 4.8 acres of swampy terrain. The site lies within the 100 year floodplain of the Cape Fear River. Rebuilding of transformers was discontinued in 1982, but storage of transformers continued until 1986 when the site was abandoned. The initial sampling in 1978 found chlorobenzene in the well water on the site. Adjacent residences were placed on city water at that time. In 1979, PCBs were found in both the soil and well water, but no other action was taken. An Emergency Removal Action (ERA) was conducted in 1984 to remove contaminated soil. Sampling after the ERA detected PCBs at up to 140 ppm in the sub-surface soil.

The United States Environmental Protection Agency (EPA) Region 4 is administering the assessment and cleanup activities at the site. Discussions with the Region indicated that there were two phases to these activities. In Phase 1, the short list of contaminants of concern (COCs) and the general location of these COCs are determined. In Phase 2, the locations of the COCs are determined more precisely and the costs of various remedial alternatives are estimated. Through the steps of the DQO process, these general statements were refined and quantitative error tolerances were specified.

Phase 1

Discussion with EPA Region 4 indicated that Phase 1 of the assessment should answer two questions: What is the list of COCs at the Carolina Transformer site, and what is the x, y and z location of these contaminants?

Determining the list of COCs and the spatial scale of the contamination are essentially interrelated. For example, a "hot spot" of dioxin at a concentration of 10 ppb, but only in a few grams of soil at one location is not a threat to human health. Thus a contaminant causes concern if it exists above a specific concentration over an area where exposure is possible.

What logic can be used to define the area and concentration that makes a particular contaminant a concern? One approach is to compute the concentration and exposure area from a risk perspective. A second approach is to consider the way that the contaminant came to be distributed on the site.

EPA policy puts an acceptable risk level between 1 in 10,000 and 1 in 10,000,000 additional cancers (*5*). In this case, Region 4 decided that an acceptable risk is an additional 1 in 1,000,000 cancer incidence.

For PCBs in soil, the likely exposure route is through ingestion of contaminated soil. Exposure scenarios were investigated for adult workers on the site or children trespassers.

A risk scenario is based on assumptions about the absorption rate of the contaminant, the soil ingestion rate, and the length of the exposure. For example, a 70 kg adult is assumed to absorb 30% of the PCBs ingested. Adults are assumed to ingest a total of 100 mg of soil per day. These PCBs accumulate over 30 years, where the worker is present at the site 5 days a week for 50 weeks a year. Based on laboratory models and these exposure assumptions, an additional one in one million risk is equivalent to a PCB concentration of 1 ppm in the soil. For children trespassers, the end concentration is roughly the same, although the assumptions are different.

Over what area is this exposure accumulated? Some construction workers work over (and thus integrate exposure) an area of 1/2 acre. Children playing on a baseball field would also cover about 1/2 acre. We define an exposure unit (EU) as 1/2 acre. Since exposure is integrated over a large area (1/2 acre), small "hot spots" are only important if the overall average in a 1/2 acre area is greater than 1 ppm.

The preceding scenario was based on ingestion of surface soil. Based on CFR guidelines (an ARAR for PCBs), subsurface soil can be backfilled with clean soil if the concentration of PCBs are less than 10 ppm at a depth of 10 inches; thus <1 ppm PCBs is acceptable for soil in the 0–10 in. layer, and <10 ppm PCBs is acceptable below 10 in.

The likely source of the contamination was from leaking transformers. Thus a "hot spot" could result from a single leaking transformer. The Region decided that a leaking transformer would likely result in a 10 ft by 10 ft footprint. This implies that the smallest area that should need remediation is also a 10-ft square. The spatial scale is now bounded between 100 ft^2 and 22,500 ft^2. (1/2 acre). What concentration of PCBs in 100 ft^2 would result in an average of 1 ppm over 1/2 acre? If the remainder of the 1/2 acre were clean, then a single hot spot would have to measure more than 225 ppm for that EU to pose an unacceptable risk.

The main goal of Phase 1 is to define the list of COCs for the site and estimate the risk posed to the public. To address these goals, some information on the spatial distribution of the contaminants must be collected. Based on the historical use of the site and aerial photos, the site was divided into three areas: administration, operations and storage: PCB contamination was expected to be lowest in administration, intermediate in storage, and highest in operations. This stratification should lead to a more precise estimate of the average P concentration on the site. The lis COCs was confirmed on a subset samples submitted for the full scan analysis. Region 4 had expected that PCBs would be the sole COC on the site. The initial data also indicated that PCBs were much greater than 1 ppm in the surface soil. If these expectations are met, then the data collected in Phase 1 will only have to describe the general location of PCBs across the site.

Because no reliable information on the distribution of PCBs and the presence of other contaminants was available, a pilot study was recommended. In the case that the problem was truly as simple as described above, the pilot study could give enough information to lead to the second phase of the RI/FS.

Before describing the development of the pilot and the results obtained, let us consider the decision rule and the data quality required in Phase 1. The decision is to find if any area of the Carolina Transformer site poses an unacceptable health risk to the public. The data quality for the decision are the acceptable probabilities of maki e positive or false negative errors. e positive is where the actual risk posed by the site is less than 1 in 1,000,000 addi-

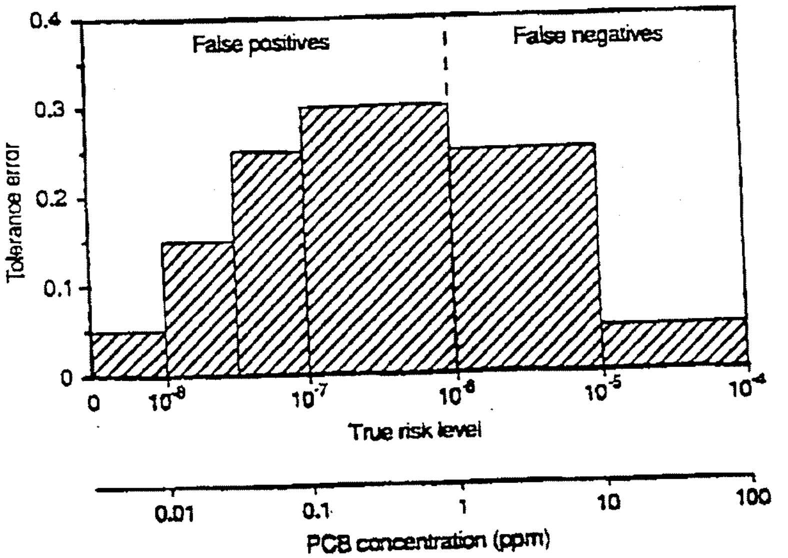
TABLE 1

ssumptions about the site used to design the pilot

Sub-unit	Area/acres	Probability 10' x 10' is contaminated	Number of samples
Administration	0.75	0.05	5
Storage	1.5	0.25	15
Operations	0.75	0.50	25

FIGURE 1

"Discomfort curve," or acceptable error rate for decision



onal cancers, but the risk is measured as being greater than 1 in 1,000,000 additional cancers. The consequences of a false positive are that resources (time and money) are diverted to sites that do not pose a significant risk. The possible consequences of a false negative (actual risk posed by the site is greater than 1 in 1,000,000 additional cancers but is measured as less) are additional cancers. Region 4 stated their quantitative discomfort with various magnitudes of false negatives and false positives (Figure 1).

The pilot survey was designed by using simple assumptions about the site. Based on the historical activities at the site, PCBs were assumed to be the most important (or only) contaminants on the site. Thus the Region agreed to run most of the soil samples through a quick-turnaround (QT) analysis procedure for PCBs. In addition to providing results more quickly, the QT method was also less expensive per analysis than the total contaminant list (TCL) scan ($150 vs. $1250). Based on the amount of data collected in other RI/FS Phase 1 surveys, approximately 45 QT soil samples could be analyzed. This amount is based on $30,000 total for Phase 1 analyses; spending one-half of the total in the pilot at $350 per analysis. An additional 10 samples were run by the TCL method to search for other contaminants. The 45 QT samples were allocated based on simple assumptions of the distribution of PCBs. PCB presence or absence was assumed to follow a binomial distribution on the scale of 10 ft by 10 ft areas (with no spatial correlation beyond 10 ft). The probability of presence was assumed to vary according to the sub-units of the site (Table 1).

The TCL samples taken in the pilot confirmed that PCBs were the only significant COC. The QT samples showed that the magnitude of PCB concentration did vary in the predicted manner among the three sub-units of the site. Table 2 shows these concentrations.

The concentration of PCBs was variable both within and between sub-units of the site. For example, stations close to a hot spot (e.g., 10 ppm) were not likely to measure 10 ppm. The spatial pattern of PCBs fits a "hot spot model"; the contamination is located in a binomial fashion, either contaminated or not contaminated. The most important result is that 41 of 45 samples were greater than 1 ppm PCBs; nearly the entire site is a "hot spot" from a risk perspective. Thus the initial assumptions about the frequency of "hot spots" were not correct.

Because the pilot identified PCBs as the only significant contaminant, we can restate the decision as: do any 1/2-acre areas of the site exceed 1 ppm PCBs? What is the approximate location of the contaminated soil? The Region had two options at this point: accept the results of the pilot survey for Phase 1, or conduct a Phase 1 survey where the number of samples is based on the results of the pilot.

Based on the laboratory measurement error for PCBs and the spatial sampling variation, the number of samples taken in the pilot did not meet all of the error constraints set by the Region. The false negative error rate for the Phase 1 decision based on the pilot data was slightly larger than the rate specified by the discomfort curve (7.5% vs. 5%). The advantage of accepting the pilot for the Phase 1 results is that Phase 2 can be started more quickly. False negatives are not important since all 1/2 acre units were positives (i.e., PCBs >1 ppm), the Region decided to accept the results of the pilot in making the preliminary risk assessment for the site.

Phase 2

The purpose of the Phase 2 RI/FS survey is to define the location of the contamination and the cleanup costs. The cleanup costs are based on two components: a per unit volume cost and the total volume to remediate. The per volume remedial cost is dependent on the particular remedial sequence selected (for example: excavation, incineration, disposal, and back-filling with clean soil). We assume that the per volume remedial cost can be estimated exactly, so the only error is in the estimate of the volume of soil to be remediated. Thus the total volume can be computed from the location estimate.

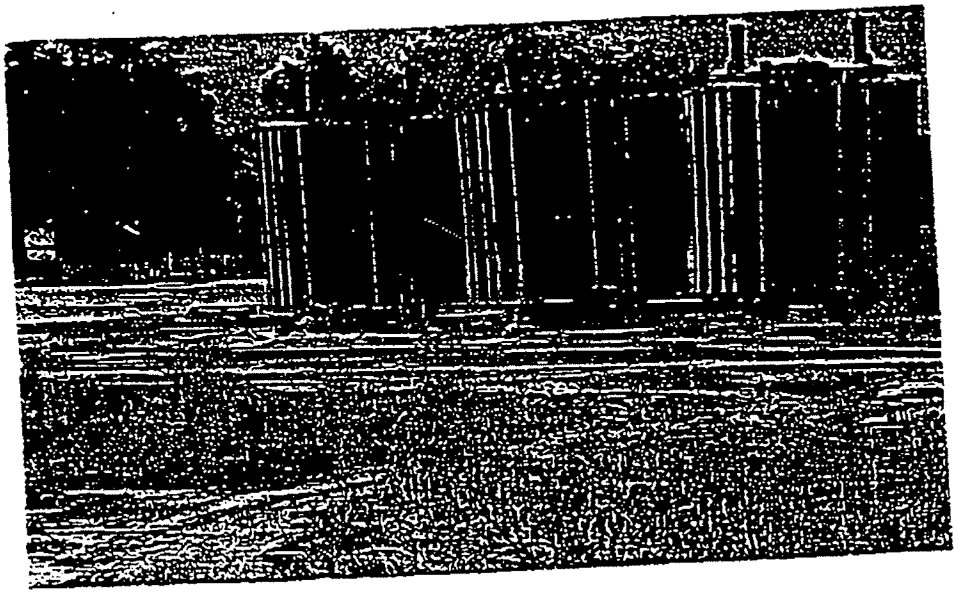
EPA policy states that the cost should be estimated to within +30% and -50% of the actual RD/RA cost. To simplify the problem, the Region wanted the Phase 2 survey to be designed to estimate the cleanup cost to within 30% with 90% or greater probability. An obvious difficulty is that sub-surface contamination must be estimated before the surface soil is remediated. A simplifying assumption is that two discrete soil layers will be sampled. Soil above 1 ppm PCBs in the top 10 in. and soil below 10 in. and containing more than 10 ppm PCBs will be remediated.

TABLE 2

Results of the pilot survey

Sub-unit	Mean concentration (standard deviation, n)	Median
Administration	7.5 (10.7, 5)	1.1
Storage	19.3 (21.4, 15)	11.3
Operations	34.7 (24.5, 25)	32.4

The data resolution needed for the location question is dependent on the spatial distribution of the contaminant within the exposure units (EU) (1/2 acres units in this example). Should an all-or-none approach be used for EU cleanup, or should remediation units (RUs) be defined as sub-units of EUs? In some cases, the additional sampling is cost-effective in that a "surgical" cleanup can remove hot spots of contamination (4). At a dioxin contaminated site in Missouri, the lowest total cost for sampling and cleanup was for RUs that were 1/24th the size of EUs (4). But in the present case, the pilot data indicated that there was little local pattern in the contamination, and that PCBs were nearly uniformly above 1 ppm. Field sampling and laboratory analysis costs were estimated for four sizes of RUs (1/2 acre, 1/8 acre, 1/18 acre, and 1/32 acre). Designs were evaluated by a Monte Carlo simulation approach (see Ref. 6 for additional examples; contact Dean Neptune for details on the simulations). Based on cost considerations, Region 4 selected 50 ft by 50 ft (about 1/18th acre) as the remedial unit size. This design has a cost of about $50,000 for sampling and laboratory analyses.



Large electrical transformers at the site—a former transformer rehabilitation and storage facility

Each EU (or 1/2 acre) contains a three by three grid of RUs. Partial RUs (containing less than 1250 ft^2) are lumped with an adjacent RU. Sixty-two RUs were sampled in the legal boundaries of the site. Two soil samples were taken: a 0–2 in. sample that represented the 0–8 in. soil layer, and a 8–10 in. sample that represented the 8–16 in. soil layer. For each layer, 14 grab samples were taken in the Administration area, and 4 grabs in the elsewhere (Storage/Operations). The grabs were homogenized, and a single aliquot was bagged for laboratory analysis. Each aliquot contained enough material for four laboratory analyses. Two laboratory analyses were made of each aliquot in the Administration area and one analysis elsewhere.

The results of the Phase 2 RI/FS survey showed that PCBs are highly variable over the site (Table 3).

PCB concentration varied over four orders of magnitude in both soil layers. There was greater contamination in the 0–2 in. layer on average, as compared with the 8–10 in. layer (compare Figures 2,3). But in 13 of 61 RUs the 8–10 in. layer was more contaminated (in many locations, by an order of magnitude) than the 0–2 in. layer. We would expect that PCBs would ordinarily migrate slowly down through the soil profile, without some kind of mechanical disturbance (or churning) of the soil. To what extent the soil was churned as a result of the operations at the facility or by the actions taken during the Emergency Removal Action is not known.

To estimate the volume of contaminated soil, the following cleanup strategy (Figure 4) was developed. It was based on the depth that can excavated by a backhoe (about 8 and the two cleanup criteria. The surface soil is considered to be clean if the PCB concentration is less than 1 ppm. An excavated area can be backfilled with clean soil if the PCB concentration is less than 10 ppm at a depth below 10 inches. Three different depths are excavated (8, 10 or 16 in.), or no soil is removed based on the PCB concentration (Table 4). The total amount of soil to be excavated is estimated at 5389 yd^3.

In the Administration area, 6 of 16 RUs (62.5%) were greater than 1 ppm in the 0–2 in. layer, and in the Operations/Storage all 46 RUs measured greater than 1 ppm in the 0–2 in. layer. These numbers are similar to the assumptions used in the volume estimation design computations (50% contaminated assumed for Administration and 90% contaminated assumed for Operations/Storage).

Fifteen quality assessment (QA) samples were analyzed. The QA samples were laboratory sub-samples of the core composites. The relative standard deviation of these QA samples was 15%, excluding one outlier.

Discussion

The goal of Superfund program is to

remediate sites that pose an unacceptable health hazard. Because resources nited, the Superfund program must be able to rank sites and to rank the hazards within sites. The information for these rankings becomes more detailed at each step in the process. Three main questions about sites are: Does the site pose a hazard? What remedial plan will remove the hazard? How will I verify the site is "clean?"

The Data Quality Objectives (DQO) process provides a way for managers to define a general question about a site that is later refined to a quantitative decision rule. The other parallel effort in the DQO process is to define error tolerances. The initial error tolerances are qualitative, and these are later quantified. These two components (decision rule and error tolerances), are the building blocks for a statistically-based design.

In the case of the North Carolina transformer site, the managers in Region 4 asked for the lowest cost designs that would meet their error tolerances for selected cleanup unit (RU) sizes. They were able to compare the cost of these rveys against a survey that would es-ate the volume of soil that was contaminated. In this way they could balance the importance of these main questions in the Phase 2 survey.

The advantage of the DQO process is that the decision constraints (the decision rule and the error tolerances) are based on the initial responses of the decision-maker. The decision-maker can see how different ways of stating the decision rule can have profound implications on the proposed survey design. Where no proposed sampling design is within budget, then the decision-maker has the option to either increase the budget or modify some of the constraints (look at larger RUs).

Conclusions

We have shown that the Data Quality Objectives process can help define questions and the data quality in ways that can lead to statistically-based sampling designs. The DQO process allowed Region 4 to collect the right data at the right time. It should be noted that at each step from the pilot survey to the Phase 1 design, and finally for the Phase 2 study design, the question was further clarified and more information was gathered about PCB distribution across the site. One problem with the Superfund program in general has been to decide when enough data has been collected.

TABLE 3

Results of Phase 2 survey

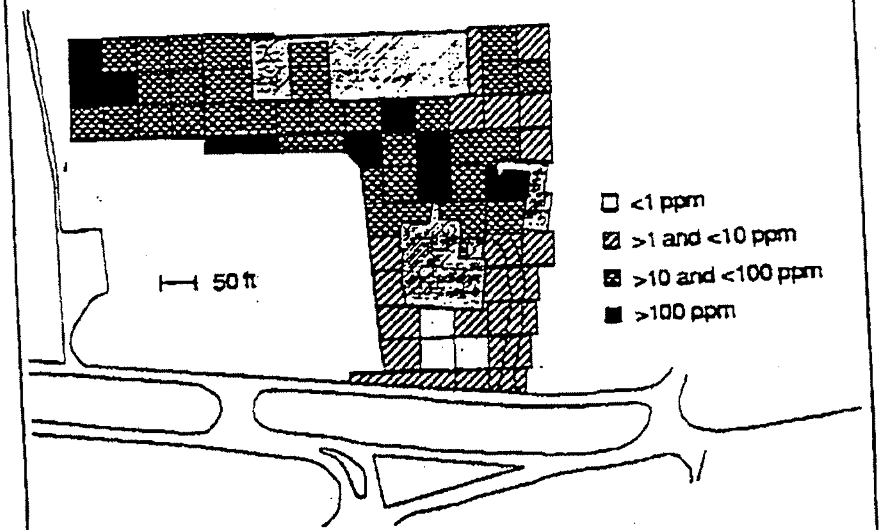
		Range		Number of RUs	
Soil layer	Median	low	high	<1 ppm	<10 ppm
0–2"[1]	21	0.4	2500	3	21
8–10"[2]	7.25	0.2	1100	18	36

[1] n=62

[2] n=61, one RU was concrete below the top 8"

FIGURE 2

PCB concentrations in 0–2 in. soil layer



Hatched areas represent buildings or concrete pads

FIGURE 3

PCB concentrations in 8–10 in. soil layer

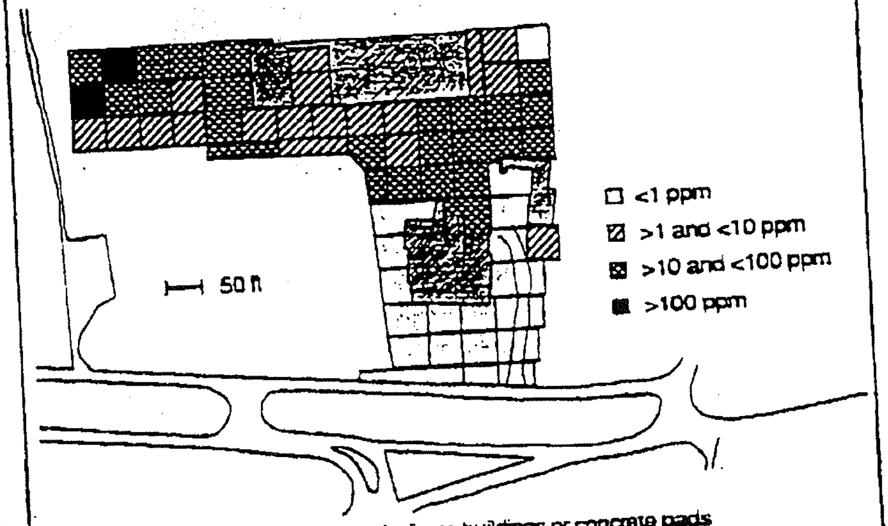


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TABLE 4

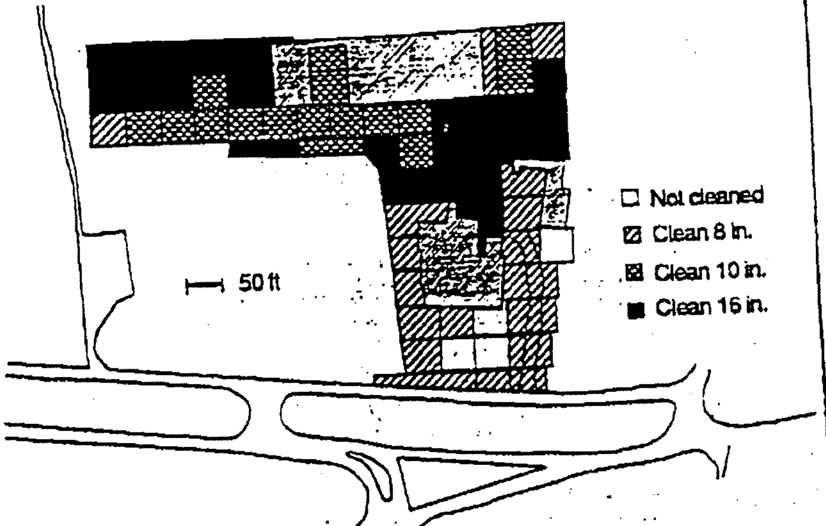
Summary of cleanup strategy

Soil depth and concentration	Depth to excavate	Number of RUs	Volume cubic yards
0–2" <1 ppm	0"	3	—
6–10" <1 ppm	8"	18	969
8–10" < 10 ppm	10"	18	1297
8–10" >10 ppm[1]	16"	22	3123

[1] These RUs need to be sampled at 16–18" to verify PCBs are <10 ppm

FIGURE 4

Cleanup strategy for the site



Hatched areas represent buildings or concrete pads

It is through the steps of the DQO process that the data user specifies the stopping point (the decision rule with error tolerances).

Acknowledgments

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Making in Superfund:

A Data Quality Objectives CASE STUDY

What type and quality of data are needed to answer key questions and how do we know when we have enough? Data quality objectives (DQOs) offer decision makers a tool to answer both questions. DQOs provide a qualitative and quantitative framework around which data collection surveys are designed, and can serve as performance criteria for assessing ongoing or completed remedial investigation/feasibility studies (RI/FSs). DQOs allow remedial project managers to make decisions based on RI/FS data with a predetermined and acceptable level of confidence.

Here we present a case study demonstrating the practicality and benefits of using the DQO process as an up-front planning tool for designing RI/FS data collection activities. The RI/FS decision maker and technical support staff (typically including environmental toxicologists and field and laboratory scientists) must work together to develop DQOs and associated RI/FS survey designs. With these individuals in mind, this article illustrates the issues raised during the DQO process, and demonstrates how the process can help resolve them at a Superfund site before an RI survey design is developed.

Development of DQOs involves a step-wise planning process (see box, "Data quality objectives") that may be applied to any problem involving the collection and use of environmental data (*1*). We begin the DQO process by carefully stating the environmental problem to be addressed or the decision to be made; then we identify the information required to select an appropriate course of action and carefully articulate the specific role data will play in making the selection. Specifications regarding the type of data needed, the way data will be used, and the desired degree of certainty in conclusions to be derived from the data are then developed through an iterative process that involves the decision maker and data generators (technical support staff).

When applied to Superfund sites, the DQO process provides a quantitative basis for designing rigorous, defensible, and cost-effective remedial investigations. The DQO planning process recognizes that decision making in Superfund is driven by risks to public health and that the uncertainty in decisions will be affected by the type and quality of data collected. The focus on planning, as presented here, is consistent with ideas developed as part of Superfund's endeavor to streamline its remedial process (*2*).

The case study was developed cooperatively by EPA's Region IV Waste Management Division and Environmental Services Division, and the Quality Assurance Management Staff. Our study involved a retrospective application of the DQO process to an actual Superfund site that had already been studied and the remedial investigation design already implemented. (The RI designs reported here were not actually implemented.) By using a completed site, Region IV expects to compare and contrast the DQO process with the current approach to planning such investigations. All decisions regarding the DQOs were made by Region IV personnel, just as they would for other sites where RIs are planned. We chose an actual site for several reasons: to avoid a purely hypothetical exercise; to ensure that realistic issues were confronted; and to facilitate an objective assessment of the practicality of implementing the DQO process for Superfund problems. Here we report the results of our planning efforts, following the generic structure illustrated in the box "Data quality objectives."

Problem statement

The starting point for any planning process is gathering background information on the specific problem at hand. The site addressed in this case study was used for storing and burning railroad ties and creosote-soaked timbers (*3*) (see photo). Information collected at various times (e.g., during previous site studies and during the Superfund site listing process) suggested that a logical exposure scenario consistent with future use of the site includes site workers and visitors as hazard targets.

Toxicologists determined that the exposure route of greatest concern for these targets is direct ingestion of contaminated surface soils; other routes of exposure are not addressed in the case study. Existing data from preliminary investigations and site visits also suggested that while several contaminants are to be expected in such surface soils, the most toxic are polyaromatic hydrocarbons (PAHs) associated with creosote.

Decisions and decision elements

The key decision posed by the RI/FS is: "What remedial actions, if any, must be taken to reduce the risk posed by the site to an acceptable level?" A logical starting point, and the focus of this study, is to determine whether the site poses an unacceptable risk in its current state—whether it is a problem.

The next step is to work logically toward increasingly specific and hence focused questions that will require environmental data for resolution. We know that PAH contamination of soil is the most likely source of public health risk from the site. Thus, the element of interest can be restated as a question: "Which, if any surface soil areas have PAHs at concentrations that pose an unacceptable risk to the hazard targets?"

Domain and logic statement

The next step was to determine the concentrations of PAHs that, if present over some defined area, would pose an unacceptable risk. This approach to the problem raised three related questions:

- What level of public health risk from this site is acceptable to the remedial project manager?
- What concentration of PAHs is associated with the acceptable level of risk, given reasonable assumptions about target exposure?
- What is the smallest area on the site over which we can reasonably assume that the targets' exposure to contaminants may occur?

Addressing these issues required assumptions about the population at risk (people), their activities, exposure routes, and the risks associated with specific contaminants. Recognizing that the number of samples ultimately collected at a site depends in part on the smallest area of concern, we focused attention on defining the size of this area first, and then dealt with the issues of acceptable risk and corresponding concentrations.

To divide the site into discrete areas for study in a manner consistent with our interest in controlling risk, assumptions about exposure and activity patterns were used to define an area called an "exposure unit" (EU). An EU is the area over which people are expected to integrate exposure when routinely working at or visiting the site (see white grid on site photo).

A separate decision will be made for each EU: if an area is found to contain PAHs at a concentration that poses an unacceptable risk, that EU (and thus the site) will be considered a problem. Further investigations and remedial alternatives will address only the EUs found to

Data quality objectives

To build total quality into data operations, EPA quality assurance management staff have developed a planning tool for assuring that key planning steps are taken in a thoughtful, methodical manner. This tool, known as the Data Quality Objectives (DQO) process, begins with a careful statement of the environmental problem and produces a design for collecting the information needed to make an informed decision with a desired degree of confidence. The stepwise structure of the DQO process is to:

- state the problem, then
- identify decisions that address the problem, then
- select elements or factors that affect the decision, then
- specify the domain of the decision.
- Then develop a logic statement,
- establish constraints on uncertainty, and, finally,
- optimize the design for data collection.

The DQO process provides a logical, objective, and quantitative framework for finding an appropriate balance between the time and resources that will be used to generate the product (data) and the quality of that product.

DQOs enable EPA to develop, optimize, and evaluate statistically valid sampling and analysis designs that achieve the constraints on uncertainty. In general several options are developed for a range of costs that will generate the type and quality of data required to make a reliable decision. In the final step of the DQO process, the decision maker selects the design option that best fits his or her needs.

contain PAHs at concentrations posing unacceptable risks. If no such EUs are found, then a "no-action" alternative may be appropriate for the entire site.

Superfund risk assessment guidance stresses the importance of considering future land use and related reasonable exposure scenarios (4). According to the National Utility Contractor's Association, people working at or visiting a site such as this, where light industrial equipment is operated, would typically work within or traverse an area roughly one-half acre in size (about 2,000 m^2) on a given day (5). This is the area in which people can be expected to receive their daily dose of contamination. In a very real sense, people "sample" surface soil contaminants over this half-acre; hence the average concentration of contaminants over each half-acre is a meaningful basis for assessing risk. Thus, for this site, a half-acre area of soil is an EU. Since a separate estimate of the average surface soil concentration will be generated for each EU, and a separate decision made about whether each EU poses an unacceptable risk, the EU defines the spatial domain of the decision.

Based on discussions of the potential risks posed by the site, the EPA Region IV remedial staff decided that remedial action should be taken if the site (i.e., any EU at the site) poses an increased cancer risk greater than 10^{-4}. The 10^{-4} risk level is therefore the decision point between acceptable and unacceptable risk. This decision point is consistent with EPA's policy that 10^{-4} and 10^{-7} is the range for acceptable risk limits (6). (Note: The 10^{-4} level was used specifically for this case study and does not necessarily reflect EPA Region IV policy or standard practice for other sites.)

We used exposure assumptions and standard Superfund risk equations (6) to determine the surface soil contaminant concentration that corresponds to a risk level of 10^{-4}. Region IV typically treats total PAHs as though the sole contaminant is benzo[a]pyrene, the most toxic of the PAH family of compounds. This approach is conservative in that it will generally overestimate the risk posed by total PAHs. Risk calculations indicate that an EU is a problem (i.e., presents a 10^{-4} increased risk of cancer) when the average PAH concentration in the EU is at or above 122 ppm.

A "logic statement" is a concise quantitative summary of how data will be used to reach a decision. The logic statement follows directly from the formulation of the problem above.

Data collected during the remedial investigation will be used to determine the average surface soil concentration of PAHs within each half-acre. Average PAH concentrations will be compared to the risk-derived concentration of concern, 122 ppm, to determine which, if any, surface soil EUs have PAHs at concentrations that would pose an unacceptable risk.

If an EU has an unacceptable average PAH concentration ≥122 ppm, then further study should be undertaken to develop a list of remedial alternatives. This "if-then" logic statement will be applied for each of the EUs, and any EU posing an unacceptable risk will need to be remediated.

Constraints on uncertainty

If the estimates of average PAH concentration within EUs are inaccurate, decisions about whether an EU poses unacceptable risk may be incorrect. The remedial investigation should be designed to limit the probability of incorrect decisions to an acceptable level. After the logic statement was specified, the project manager developed constraints on uncertainty, expressed as acceptable false positive and false negative error rates. These are shown in Figure 1. The y-axis provides the acceptable error rates (probability of making an incorrect decision) given various possible true risk levels, shown on the upper x-axis.

Acceptable error rates were not assigned in the 61–122-ppm range because the manager considered either decision would acceptable in this range. The error rates expressed in Figure 1 provided the statistician with quantitative constraints to be used in developing survey designs, which specify the number, location, and type of samples needed in the remedial investigation.

Stated in terms of the risk-based decision point, decisions about EUs may be incorrect in two ways:

The first type of error occurs when it is decided that an EU does not pose an unacceptable risk when, in fact, the risk posed by the EU exceeds 10^{-4}. This is a false negative error. If the investigation leads to this false conclusion, the project manager may stop further investigations at the EU and people eventually may be exposed to unacceptable risks. The seriousness of this type of error, and therefore the project manager's desire to avoid it, becomes greater as the true level of risk gets larger and larger. To help the manager establish limits on false negatives, a toxicologist was consulted to assess the consequences for three ranges of incremental risk, all of which exceed 10^{-4}:

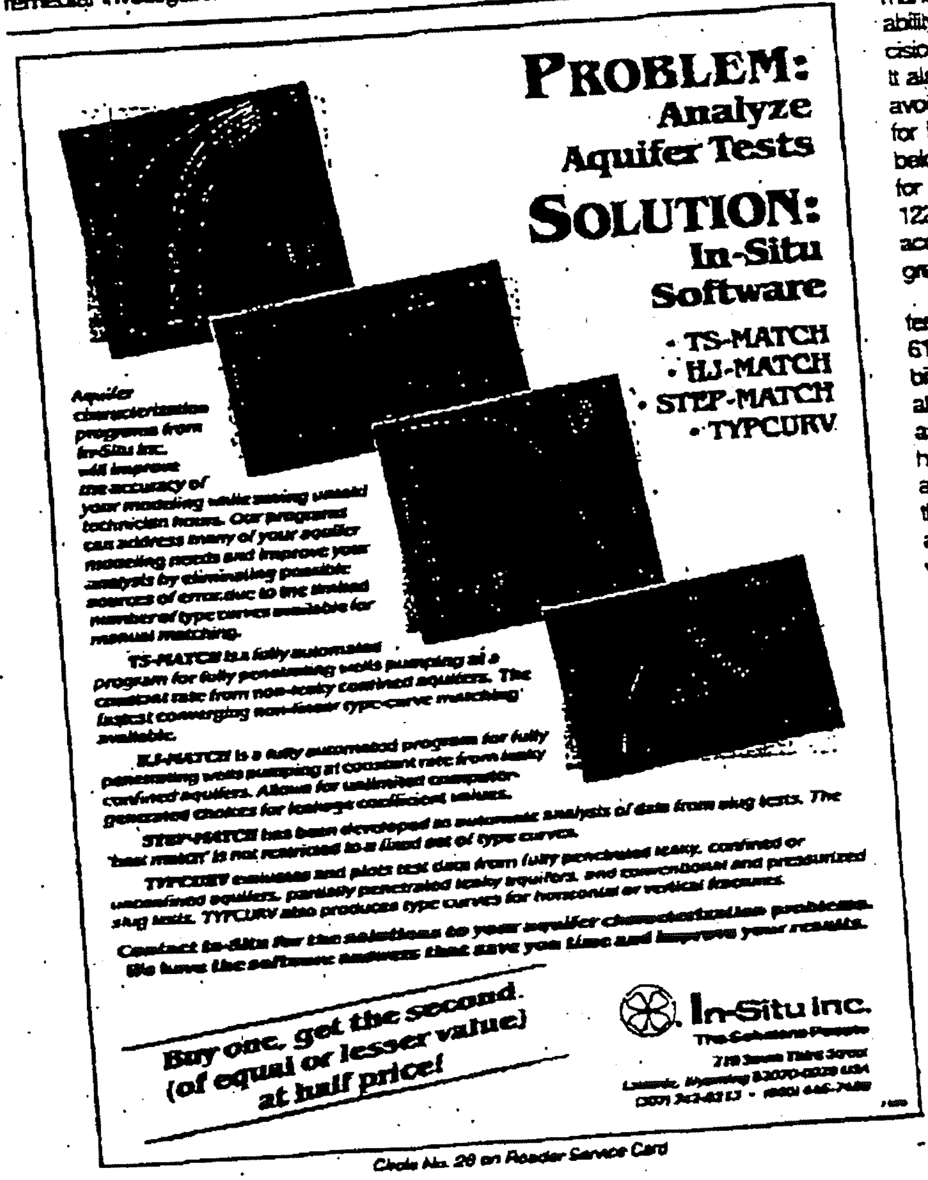
- 1.0×10^{-4} to 5.0×10^{-4};
- 5.0×10^{-4} to 1.0×10^{-3}; and.
- above 1.0×10^{-3}.

After carefully considering the human health consequences, the project manager assigned acceptable probabilities for failing to detect a problem if the risk posed by the EU is actually within each of the above ranges (shown in the right-hand portion of Figure 1). The manager expressed differing levels of acceptable error rates for the three risk ranges. These error rates (probabilities), which reflect the manager's increasing desire to avoid false negative errors at higher and higher contaminant concentrations, are the maximum acceptable rates established for this type of error. Notice that the manager desired lower false negative rates when the true risk is above 1.0×10^{-3} because the consequences to the public and to workers on-site are potentially much more serious than the consequences associated with the other ranges of risk.

The second type of error occurs when it is decided that an EU poses an unacceptable risk when, in fact, the risk posed by the EU is less than 10^{-4}. This is a false positive error. If data collected during the remedial investigation lead to this false conclusion, the manager will decide, unnecessarily, to continue to study the EU. New data may eventually reveal that an EU is not a problem, and hence, correct the false positive error. Otherwise, unnecessary remedial action will be taken. A false positive error results in wasted time, money, and effort on EUs that are actually not a problem. The manager consulted with the toxicologist and site engineers to assess the consequences of such error for three risk ranges, all of which are below 10^{-4}:

- below 5×10^{-6};
- 5.0×10^{-6} to 1.0×10^{-5}; and
- 1.0×10^{-5} to 5.0×10^{-5}.

The project manager stated that the remedial investigation should be designed to have a low probability of false positives when very low risk levels exist at an EU (e.g., when the EU is "clean"). The manager was willing to tolerate higher probabilities of false positives for risk levels near the threshold. The manager assigned acceptable probabilities for determining when an EU is a problem when in reality it is not for each of the above ranges (shown in the left-hand portion of Figure 1). These values are the acceptable rates for this type of error.



Risk equations (6) were used to determine the PAH concentrations that correspond to the risk ranges for which acceptable error rates had been defined. These concentrations are shown on the lower x-axis in Figure 1.

The logic statement, discussed earlier, indicated that we want to conclude that an EU is a problem if the true average PAH concentration in the EU is >122 ppm. Figure 1 indicates that the project manager is willing to accept a 0.15 probability or less for making an incorrect decision at true concentrations of 122 ppm. It also indicates the manager's desire to avoid developing remedial alternatives for EUs that have PAH concentrations below 61 ppm. The figure specifies that for PAH concentrations falling between 122 ppm and 61 ppm, the manager will accept either decision (indicated by the grey region in Figure 1).

Because the project manager is indifferent about the decision in the range of 61–122 ppm, but wants to limit the probability of a false negative at 122 ppm or above, our original question was refined as follows: "Which, if any, surface soil EUs have an average PAH concentration above 61 ppm?" At 122 ppm and above, the manager has specified the false negative error rates that are acceptable. At values below 61 ppm, the manager also specified the false positive error rates that are acceptable. The qualitative and quantitative criteria established for addressing this question are the DQOs for the remedial investigation, and will focus the statistician's search for an optimal design (see box, "DQOs for case study").

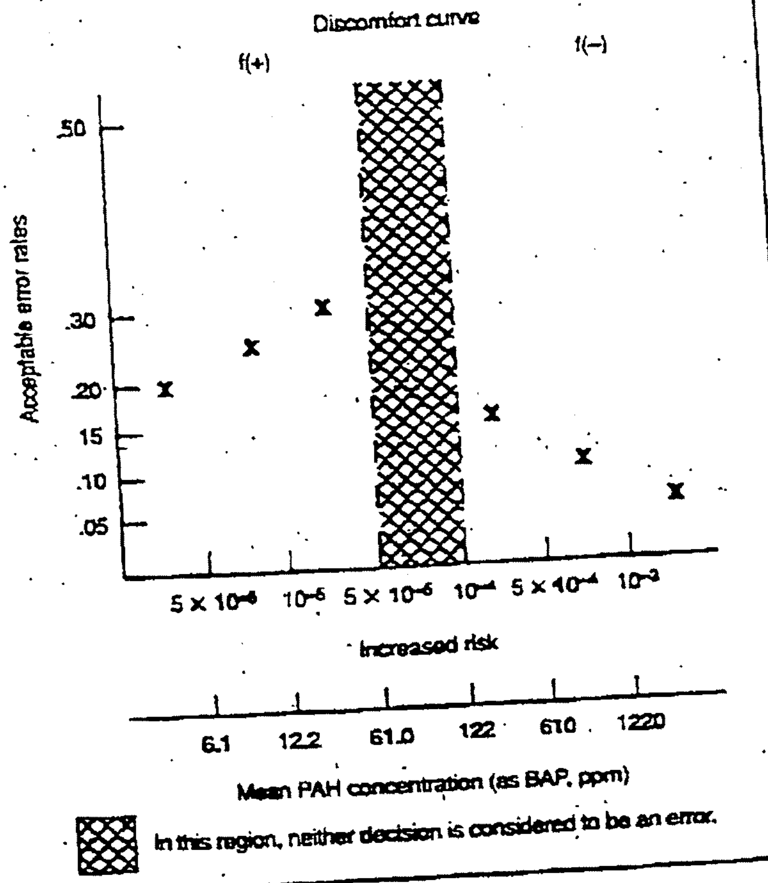
Design and optimization

After the DQOs were established, a statistician applied conventional techniques to explore and evaluate various designs for data collection. The statistician was asked to design a survey that, first, would attempt to identify any EUs that have average PAH concentrations >61 ppm; and second, would be subject to error rates no greater than those specified in the DQO statement from the project manager.

One concern the statistician noted was

FIGURE 1

Acceptable limits for decision error



DQOs for case study

Decision: Determine whether sections of the site pose unacceptable risks to human health or the environment and require remediation.

Domain: Exposure units are half-acre areas of surface soils. (Temporal aspects of the domain are not at issue because the contaminant of concern at this site is stable, not mobile.)

Logic statement: If the mean PAH concentration in an exposure unit exceeds 122 ppm (10^{-4} risk), then the exposure unit will require remediation.

Uncertainty constraints

PAH risk range	Concentration range (ppm)	Acceptable probability for false positives (%)
Below 5×10^{-6}	Below 6.1	20
5×10^{-6} to 1×10^{-6}	6.1–12.2	25
1×10^{-6} to 5×10^{-6}	12.2–61	30

PAH risk range	Concentration range (ppm)	Acceptable probability for false negatives (%)
1×10^{-4} to 5×10^{-4}	122–610	15
5×10^{-4} to 1×10^{-3}	610–1,220	10
Above 1×10^{-3}	Above 1,220	5

Workers collect soil samples at the Superfund site

that any attempt to divide the site into spatially distinct, uniform exposure units for testing runs the risk of missing an unacceptably contaminated area which lies across two or more EUs. This weakness is more than offset by two conservat measures included earlier: the assum tion that the only PAH present is benzo[a]pyrene (the most toxic of the PAHs), and the decision to test for concentrations above 61 ppm when concern for false negative errors begins above 122 ppm.

The statistician framed the if-then logic statement as a statistical test that would allow us to determine whether PAHs within an EU are greater than 61 ppm, and began the search for designs that would control the decision uncertainty to the levels specified in the DQOs. To develop a statistically based sampling and analysis plan (the design), the statistician needed rough estimates of the spatial pattern and variability of the distribution of contaminant concentrations within EUs. He also required an estimate of the additional variability that would be introduced through the process of taking samples and analyzing them in the laboratory. Finally, since the statistician was asked to find the least expensive design that meets all the DQOs (the optimal solution), estimates of the costs of taking and analyzing a sample were required.

Since prior data on averag s across half-acre units were not ava ble, the statistician used prior data from random samples of surface soils across the site (Figure 2). The statistician assumed that point-by-point spatial variability of PAHs within half-acre EUs was identical to the point-by-point variability of samples taken across the entire site, without grouping into half-acre units. This is probably a conservative assumption, since it is likely that there is some degree of similarity within EUs as compared to points that are more widely separated.

These data indicated the form of the distribution of contaminant concentrations (in this case a log-normal distribution) and provided the basis for estimating the variability of contaminant concentrations across the site. An estimate of the most probable total variance (on a log scale) is $\sigma_T^2 = 1.64$ (24 degrees of freedom). Quality control data from analyses of PAHs, using the same analytical methods as those used to generate historical data for this site, indicate that analytical imprecision is on the order of 25% relative standard deviation. If the statistician had determined the historical data were not suitable for estimating the distribution and variability of concentrations within EUs, a pilot study would have been required to obtain these estimates.

Using the above information and the approximate per-sample costs of sampling ($80) and analysis ($800), the statistician began to evaluate various statistical sampling designs that would allow us to achieve the desired control over uncertainty. Recall that uncertainty is measured in terms of the probability of reaching an incorrect conclusion about whether an EU is a problem, i.e., the probability of false positives and false negatives. Among the options considered were uniform random sampling across the site, systematic sampling, stratified sampling, and sample compositing within each EU. After considering these options, the statistician recommended an approach that uses a compositing technique in which 10 or more scoops of soil, taken randomly within each EU, are combined, homogenized, and subsampled for analysis. When the potential difficulties and errors introduced through mixing and subsampling were recognized, five soil scoops were considered to be an efficient, practical number that could be combined routinely.

A statistical evaluation of several different designs, presented in Table 1, led to the following conclusions:

First, the expected performance data indicate that two survey designs have favorable cost and acceptable performance (i.e., were expected to meet or come close to meeting the 0.15 acceptable false negative and 0.3 false positive error rates specified over the range of important concentrations). The most favorable designs involved compositing five scoops per analytical sample. One design required the analysis of two composited samples per EU, while the other required three. Our notation for these designs are (5,2) and (5,3), respectively.

Second, compositing five scoops transformed the underlying log-normal distribution into one that is more like a normal distribution in shape. A computer simulation was needed to assess more accurately the anticipated performance of the two designs, i.e., the "power" or capability of each design to detect EUs with PAH concentrations above the criterion. (Details on the statistical evaluation may be obtained by writing author Dear Neptune.)

The (5,2) and (5,3) designs were eval uated by simulation to determine hov

FIGURE 2
Frequency distribution of soil PAH concentrations

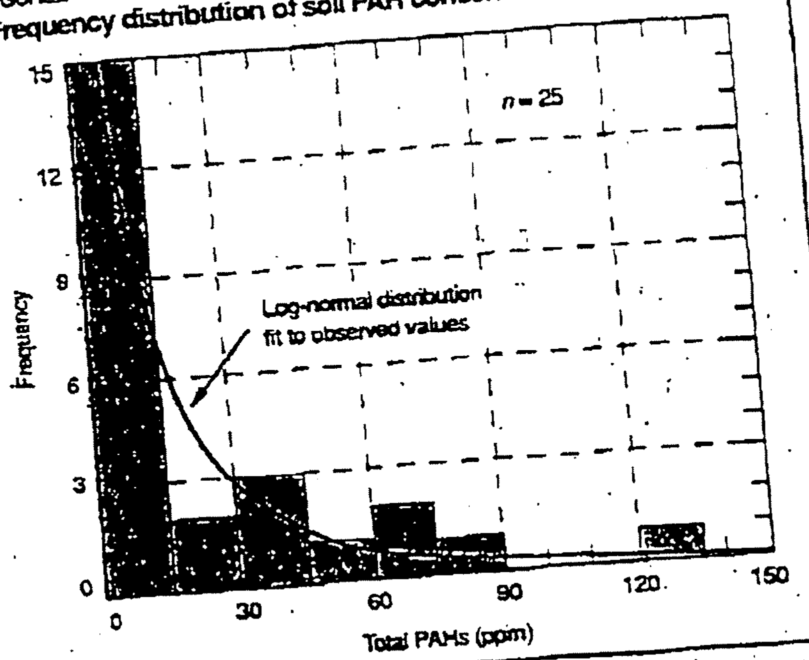


TABLE 1
Results of initial power calculations

No. scoops /analysis	No. analyses/EU	Cost /EU ($)	Probability of error[a]
1	4	3,520	.53
3	5	5,200	.15
4	2	2,240	.27
4	3	3,360	.18
4	4	4,480	.12
5	2	2,400	.20
5	3	3,600	.11

[a] When μ = 122 ppm and α = .20.
Note: α = probability of concluding EU is a problem when μ is 61 ppm.

well they can be expected to perform at the critical values of 122 and 61 ppm, and at other concentrations higher and lower than these values. The rough estimates of performance in Table 1 were based on the assumption that the distribution of total PAHs was log-normal with a total variability of 1.64. The true variability of concentrations within EUs may prove to be greater or less than this estimate. To determine the effect that more or less variability might have on reaching a correct conclusion with either of these designs, the performance of each design was evaluated at three different levels of total variability: 1.64 (most probable—our estimate of variability based on historical data), 1.00 (assumes less variability—a lower 95% confidence limit on the historical estimate), and 3.17 (assumes more variability—an upper 95% confidence limit on the historical estimate).

Figures 3 and 4 show the results of the simulations presented as expected performance curves. The shaded regions of the two figures are areas in which the constraints on uncertainty—control on false negative and false positive error rates—are achieved. In the region between 61 and 122 ppm, the shaded area shows that any amount of error can be tolerated. The shaded regions above 122 and below 61 ppm are those for which the error rates are of concern. A design performance curve that lies entirely in the shaded regions would satisfy all the DQOs (see box, "DQOs for the case study").

The figures show that the two designs can be expected to perform similarly and to achieve most of the constraints on uncertainty (most of the curve appears in the shaded region). If variability is 1.64, the figures reveal that both designs fail slightly when the true average PAH concentrations are between 50 and 60 ppm. Neither of the designs is likely to meet uncertainty constraints if the total variability is high (3.17). Points labeled "A" and "B" are slightly outside the regions of desired performance. Points labeled "A" are of concern if the variability is lower than we anticipate (1.00). Points labeled "B" are of concern if the variability is greater than we anticipate (3.17). Thus, if we use either the (5,2) or (5,3) design, and the variability of PAH concentrations within an EU is substantially lower or higher than assumed (1.64), we can expect slightly higher error rates than specified by the DQOs.

Considering the conservative measures built into the designs, the project manager determined that failing to meet uncertainty constraints at these specific points is not serious. Finally, because the design (5,2) represents a 33% cost savings over the (5,3) design, and its ability to achieve the uncertainty constraints is approximately equal to that of the (5,3) design, the (5,2) design was recommended for the remedial investigation.

Summary

The data quality objectives produced in the manner described do much more than simply guide the survey design. The DQOs provide a focused decision statement, boundaries on the domain of interest (the EU), an "if-then" logic statement that specifies how data will be used in the decision, and constraints on the amount of uncertainty (limits on both false positives and false negatives) acceptable. They provide the information needed to ensure that the number of samples per EU is adequate and the sampling and analysis methods used will provide the

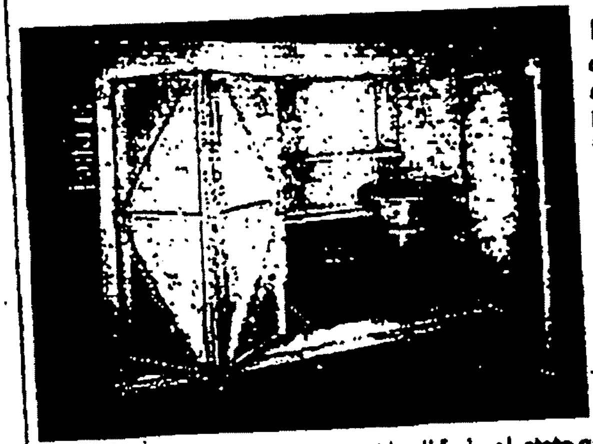


FIGURE 3

Results of simulation for the (5,2) design

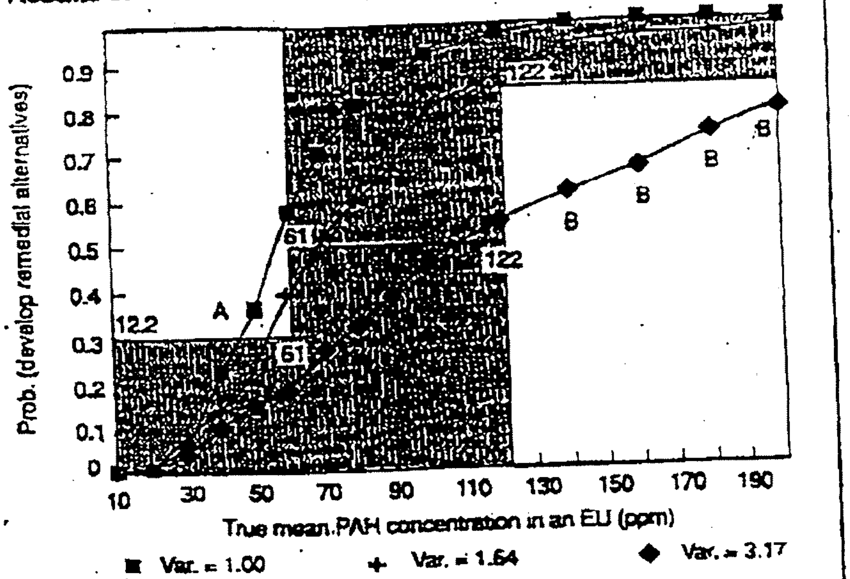
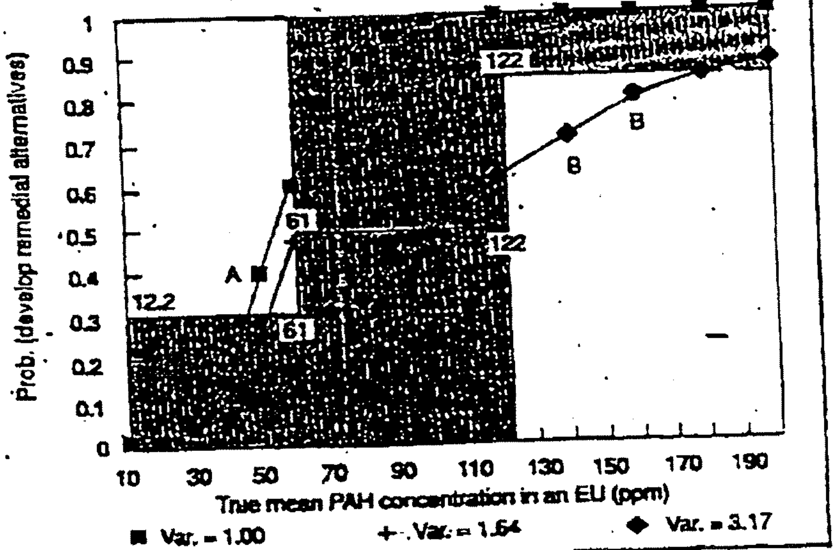


FIGURE 4

Results of simulation for the (5,3) design



quality of data required to support decisions with the desired certainty. The most important benefits of this approach are that the decisions regarding Superfund site remediation can be made at the desired level of certainty, and that the project manager has specific quantitative criteria for deciding how much data is enough.

References

(1) Quality Assurance Management Staff. "Development of Data Quality Objectives: Description of Stages I and II." In *EPA Information Guide*: EPA: Washington, D.C., July 1986.

(2) Environmental Protection Agency Office of Emergency and Remedial Response. "RI/FS Improvements Phase II, Streamlining Recommendations"; EPA: Washington, D.C., January 1989; OSWER Directive No. 9355.3-06.

(3) Environmental Protection Agency. "Region IV Remedial Investigation Report for this Uncontrolled Hazardous Waste Site"; EPA: Washington, D.C., 1988.

(4) Environmental Protection Agency. *Risk Assessment Guidance for Superfund: Human Health Evaluation Manual*; EPA: Washington, D.C., June 30, 1989; draft. *Note:* The calculations used to estimate reasonable maximum exposure in this case study are found in Reference 6.

(5) Connor, B., National Utility Contractors Association, Arlington, Va., personal communication. Reasonableness of this estimate was confirmed by EPA ORD and Region IV risk assessment experts.

(6) Office of Emergency and Remedial Response. *Superfund Public Health Evaluation Manual*; OSWER/EPA: Washington, D.C., October 1986; EPA 540/1-86/060

Acknowledgments

The individuals listed below played a substantive role in the development of the DQOs for this hazardous waste site. Region IV used the planning issues raised through the DQO process to set survey design constraints (the DQOs) for the case study. The DQOs then were used as the basis for optimizing the possible survey designs for this site. The DQO process and its adaptation to Superfund planning issues for the remedial investigation/feasibility study was led by the quality assurance management staff, with DQO application support from Research Triangle Institute, Montana State University, and NUS Corp. The authors of this paper have summarized the outputs of a series of activities in which all of these individuals participated directly: James Pickett, Ph.D., and Randall Ryti, Ph.D., Montana State University; Robert Hubbard, NUS Corp.; Eugene P. Brantly, C. Andrew Clayton, Daniel I. Michael, Michael Messner, Research Triangle Institute; Elmer Akin, Meredith Anderson, William Bokey, Beverly Houston, David Kleusner, M.D. Lair, William Patton, EPA Region IV; Dean Neptune, Ph.D., EPA Headquarters quality assurance management staff.

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E.3. KENTUCKY REGULATORY GUIDANCE

- Kentucky Risk Assessment Guidance, Risk Assessment Branch, Department of Environmental Protection, Commonwealth of Kentucky.

- Kentucky Guidance for Ambient Background Assessment, Risk Assessment Branch, Department of Environmental Protection, Commonwealth of Kentucky, January 8, 2004 .

- Kentucky Guidance for Groundwater Assessment Screening, Risk Assessment Branch, Department of Environmental Protection, Commonwealth of Kentucky, January 15 2004.

- Trichloroethylene Environmental Levels of Concern, Risk Assessment Branch, Department of Environmental Protection, Commonwealth of Kentucky, April 2004.

- PGDP background document (included by reference).

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Kentucky Risk Assessment Guidance

June 8, 2002

Natural Resources and
Environmental Protection Cabinet

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Section 1. Introduction

Risk assessment is a formalized process for evaluating the potential human health and ecological impacts based on the concentration of, exposure to, and toxicity of environmental contaminants. Risk assessment has been used in environmental decision-making since the process was outlined in a publication by the National Research Council – National Academy of Sciences (1983) Red Book. The United States Environmental Protection Agency (U.S. EPA) produced several guidance documents to assist in assessing risks (U.S. EPA, 1989; 1991).

Human health risk assessment, as outlined, is a four-part process. The first step, Data Collection and Evaluation, assesses the available data and identifies chemicals of potential concern (COPCs). The next part, Exposure Assessment, identifies potential receptors and calculates their exposure to the COPCs. Toxicity Assessment, the third process, quantifies the toxicity of the COPCs for carcinogenic and noncarcinogenic effects. The final step, Risk Characterization, is the calculation of the potential effects on the receptors identified in the Exposure Assessment, based on the toxicity of the chemicals identified in the Data Collection and Evaluation step.

Risk assessment procedures are used in several stages of site assessment and closure. During site scoping Preliminary Remediation Goals may be used to determine preferred detection limits and to screen initial data to focus on areas of concern. Data from Site Characterization are often screened against target risk-based concentrations (Preliminary Remediation Goals) to identify whether a baseline risk assessment or further evaluation is needed and, if so, which chemicals should be further assessed. Risk assessment is also used in setting remedial goals, and as an exit criterion for closure of remediation activities. Risk assessment is used as part of activities related to the Resource Conservation and Recovery Act (RCRA), Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), Clean Water Act, and Clean Air Act.

This document details the application of risk assessment to environmental remediation. The document can be used to determine if site conditions are protective of human health and the environment, or that risks are reduced to acceptable levels through removal of contaminants or management. The risk-based procedures for the program are based on a tiered approach allowing for screening against default risk-based screening values in lower tiers and incorporating more site-related data in the higher tiers.

This document outlines the procedures for:

1. Comparing site data against risk-based screening values.
2. Preparing a baseline risk assessment to determine protectiveness of human health and the environment.
3. Evaluating when an ecological assessment is necessary
4. Evaluating when to compare site soil data to Soil Screening Levels for protection of groundwater.
5. Selecting remedial cleanup goals.

The following sections describe the process of evaluating the site data that were collected during the site characterization. The data must be representative and complete. If statistical procedures are used, a sufficient number of samples should be collected to meet the needs of those statistical tests. Human health risk assessment is described in Section 2.0. The subsections within Section 2.0 describe the application of risk assessment to the processes of environmental assessment and remediation including: tiered risk assessment, groundwater evaluation, risk management, selection of remedial goals, and presenting the results of the two tiers of risk assessment. Section 3.0 details the ecological risk assessment procedures.

Section 2. Human Health Risk Assessment

This section provides methods for screening environmental data to identify Contaminants of Concern, performing screening and baseline risk assessment, evaluating groundwater, managing risks, and selecting remedial goals. Figures 1 and 2 outline the process for risk-based procedures for residential and commercial/industrial scenarios in environmental remediation. The remedial options listed in Figures 1 and 2 are those listed in KRS 224.01-400 (18)-(21).

Figure 1. Flowchart for Residential Cleanup Options

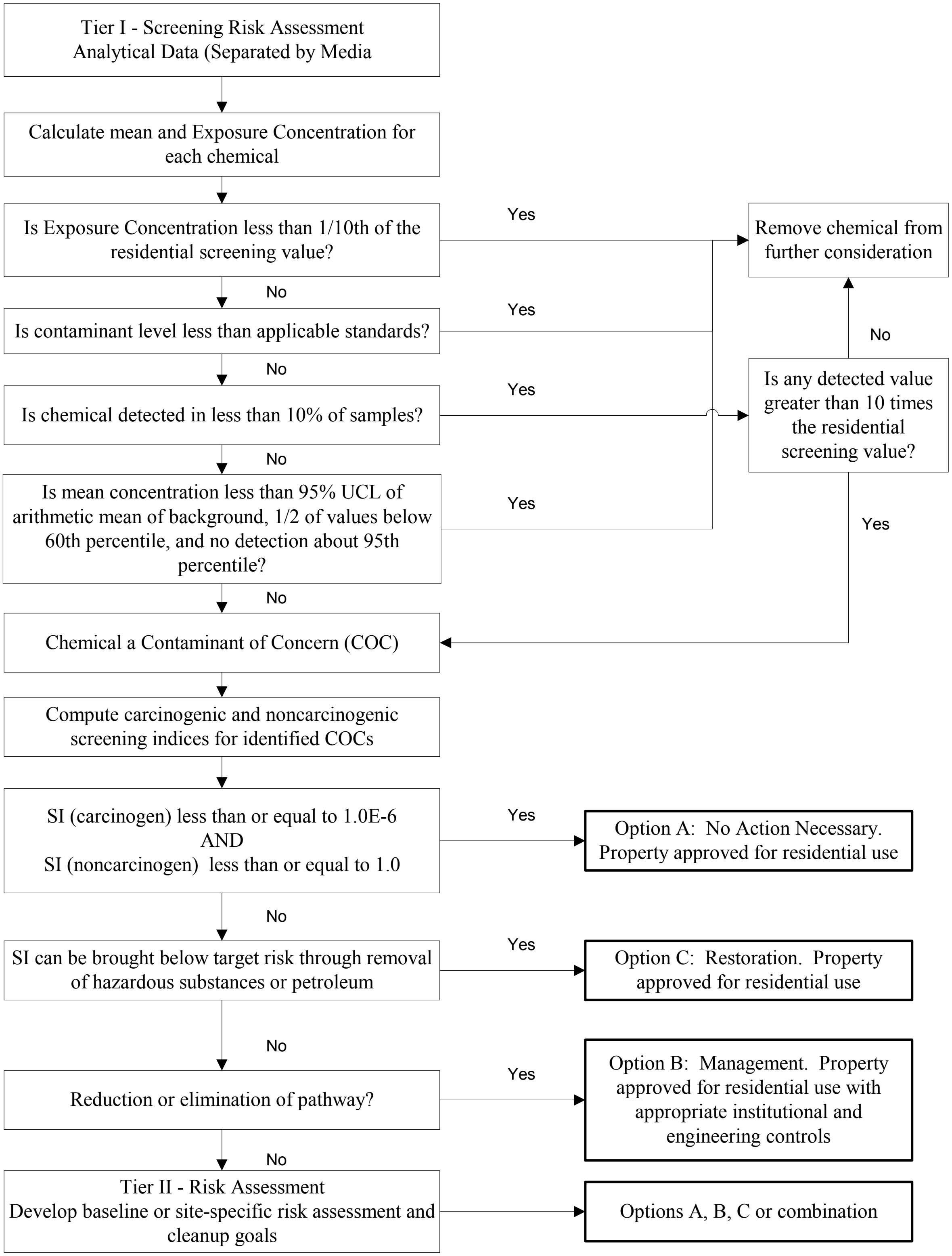
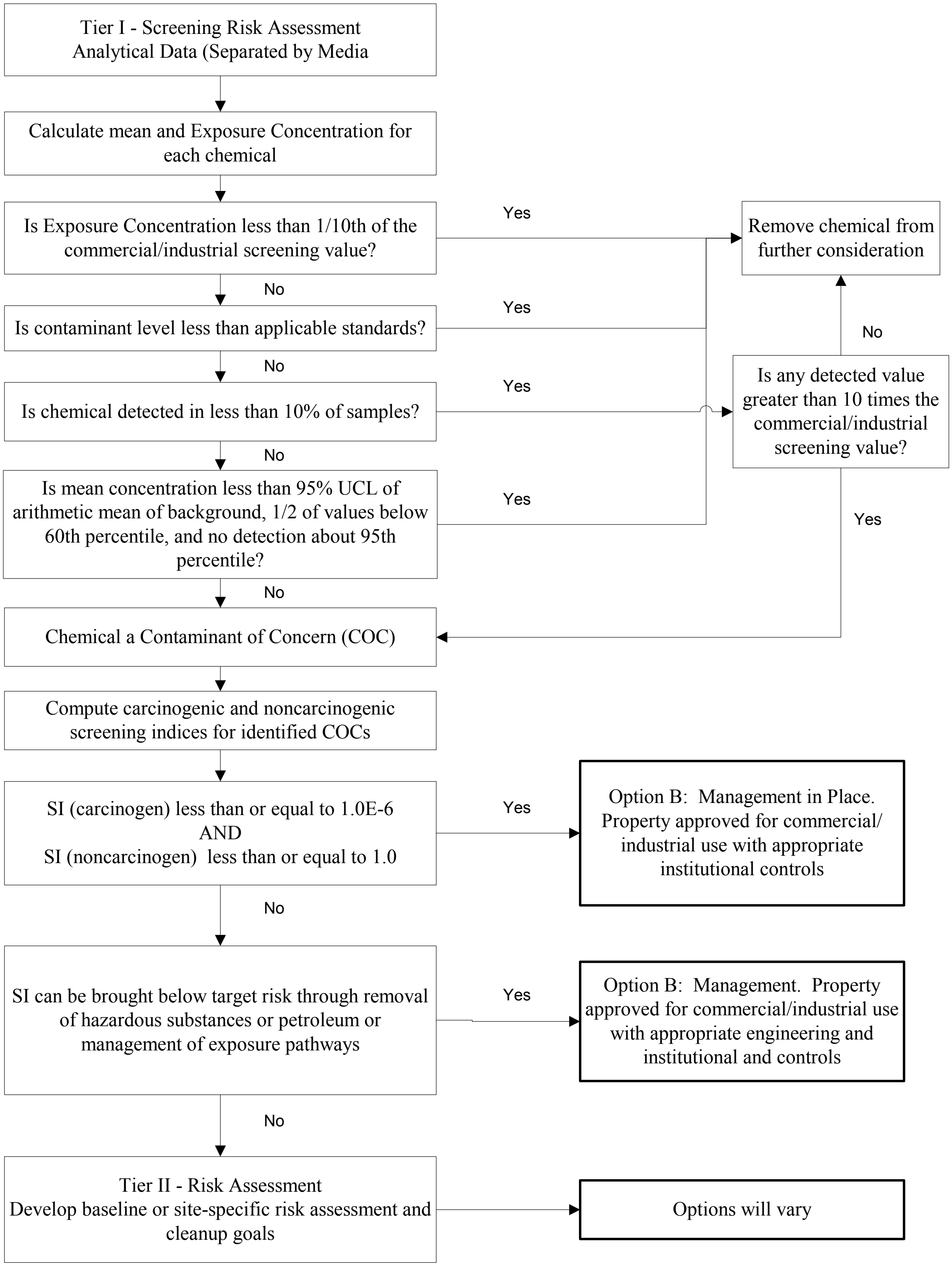


Figure 2. Flowchart for Commerical/Industrial Cleanup Options



Section 2.1. Tier I. Human Health Risk-Based Screening

This initial tier identifies which contaminants contribute significantly to the risks associated with the property and calculates the cumulative risk for all Contaminants of Concern (COCs). For this guidance, hazardous substance or petroleum shall have the meaning as defined in KRS 224.01-512. The screening-level risk assessment should be completed for residential land use as a baseline, and commercial or industrial land use if commercial or industrial use is part of the management plan. The following steps should be followed when completing a screening-level risk assessment for human health.

1. Segregate analytical data by medium. Further segregate soil data into surface (0-1 foot depth) and subsurface (greater than one foot depth).
2. Calculate 95% Upper Confidence Limit (UCL) of the arithmetic mean as described in U.S. EPA, 1992 (Supplemental Guidance to RAGS: Calculating the Concentration Term). Use all samples of the property and site(s). Use one-half of the detection limit for non-detect sample results. The Exposure Concentration shall be the lower of the 95% UCL of the arithmetic mean and the maximum detected value for that medium (and horizon, for soil). Calculate the mean of the site data for inorganic compounds in addition to the 95% UCL.
3. Compare the Exposure Concentration to 1/10th of the residential or commercial/industrial screening value, as appropriate. When screening, use the Total Chromium value for chromium, use carcinogenic effects for arsenic, and use Toxicity Equivalency Factors (TEFs) to calculate a Toxicity Equivalency Quotient (TEQ) for dioxins. Instead of 1/10th of the screening value for lead, use the Kentucky Lead Action Level of 50 mg/kg for soils for residential, and 400 mg/kg for commercial/industrial soils. Appendix E contains the KY Radiological Risk-Based Preliminary Remediation Goals, if applicable. Compare the Exposure Concentration to the following standards when applicable: Maximum Contaminant Levels (MCLs) for surface and ground water (401 KAR 8:250, 401 KAR 8:300, 401 KAR 8:400, 401 KAR 8:420), National Ambient Air Quality Standards (NAAQS) for air, and Surface Water Standards (401 KAR 5:031) for surface water.
4. Calculate the frequency of detection of the hazardous substance or petroleum constituent. Identify those compounds that are detected in at least 10 percent of the samples. If there is any detection above ten times the residential or commercial/industrial screening value, as

appropriate, then the hazardous substance or petroleum should remain a Contaminant of Concern (COC) regardless of the frequency of detection.

5. Compare the mean of the site data to the 95% UCL of background for inorganics. The background value shall be the generic statewide background number listed on Table G-2 in Appendix G, or site-specific background may be determined using the methods described in 401 KAR 100:100 Section 7 (6). In addition to the site mean being less that the 95% UCL of background, at least half of the samples should fall below the 60th percentile on Table G-2 or site-specific background, and no sample should exceed the 95th percentile listed on Table G-2 or site-specific background. The cabinet may approve other statistical methods proposed by the VERP applicant or party.

6. Produce a summary table that lists each hazardous substance or petroleum, site mean, Exposure Concentration, 1/10th of the screening value, frequency of detection (as a fraction), and, for inorganics, 95% UCL of the arithmetic mean of background. Include MCLs, Surface Water Standards, and NAAQS, if applicable. Identify those compounds as Contaminants of Concern (COCs) that exceeds the values in all applicable screens (i.e., is not eliminated by any screen). Highlight or denote with bold text the screen that eliminates the COPC from further evaluation, if applicable. Table 1 is an example of the summary table for soil.

Table 1. Summary of Results of Tier I Screening

Hazardous Substance	Mean	Exposure Concentration	1/10th Screening Value	Frequency of Detection	95% UCL of Background	COC?
Benzene	--	0.8 mg/kg	0.03 mg/kg	(8/30)	---	Yes
Arsenic	7.9 mg/kg	9.3 mg/kg	0.019 mg/kg	(24/30)	**9.4**	No

7. Segregate the COCs into carcinogens and noncarcinogens as described in the Preliminary Remediation Goals table in Appendix C. Radionuclides should be evaluated in the Tier I Screen using the screening values in Appendix E, if applicable. Calculate a Screening Index for all COCs by dividing the Exposure Concentration by the chemical-specific Preliminary Remediation Goal from Appendix C and summing the carcinogens and noncarcinogens:

$$\text{Screening Index (SI)} = \sum \frac{\text{Exposure Concentration x}}{\text{Screening Value x}} + \frac{\text{Exposure Concentration y}}{\text{Screening Value y}} + \frac{\text{Exposure Concentration z}}{\text{Screening Value z}} + \textit{etc.}$$

For noncarcinogens, a Screening Index of less than 1.0 indicates that exposure to all noncarcinogenic contaminants, when summed, do not exceed a HQ of 1.0. Likewise the carcinogenic constituents should also use the SI approach and multiply the result by 10^{-6} to determine the additive risk in the media. This approach should be used for all applicable media at a site and then summing the indices of the individual media. The VERP applicant or party may calculate a site-specific PRG for a Tier I risk assessment screen.

8. Present the results of the Screening Index in the risk assessment report (Section 2.6).
9. If the cumulative Screening Index (SI) exceeds 1.0 for noncarcinogens or 1×10^{-6} for carcinogens, a VERP Applicant or party should select the next course of action. They may select to complete a risk management plan (Section 2.4), initiate remedial action(s) (Section 2.5), or evaluate the risks further through a baseline risk assessment (Section 2.2).

Section 2.2. Tier II. Baseline Human Health Risk Assessment.

1. Based on the COCs that were identified in Tier I (Risk-Based Screening), conduct a baseline risk assessment.
2. Risk assessment guidance documents from the United States Environmental Protection Agency should be used in preparing the risk assessment. Primary guidance is the "Risk Assessment Guidance for Superfund. Volume I. Human Health Evaluation Manual. (Part A)" (RAGS Part A) and RAGS Part B (U.S. EPA, 1989; 1991), the "Soil Screening Guidance: Technical Background Document" (U.S. EPA, 1996a), the "Soil Screening Guidance: Users Guide" (U.S. EPA, 1996b), the "Soil Screening Guidance for Radionuclides: Users Guide" (U.S. EPA, 2000), and the Supplemental Guidance to RAGS: Region 4 Bulletins (U.S. EPA, 2001c). Other supporting guidance documents should be used as needed.
3. Describe the collection of sampling data and the procedures used to evaluate the data that are included in the risk assessment. Evaluation is completed as described in RAGS Part A (U.S. EPA, 1989) and involves evaluating analytical methods, quality of data, quantitation limits, data qualifiers, and blanks.
4. Identify and calculate exposure to current and future receptors. Potential land uses should be identified including, but not limited to: residential, industrial, recreational, commercial, or

agricultural. The baseline risk assessment should address all current and potential future receptors including trespassers and residents. Exposure factors for common receptors are listed in Appendix A. Site-specific factors may be used, subject to cabinet approval. The factors and the rationale for their use should be documented in the risk assessment report.

5. Describe the toxicity of the COCs that were identified in Section 2.1. List the toxicity values that are associated with the COCs. The hierarchy for sources of toxicity values is: (1) U.S. EPA's Integrated Risk Information System (IRIS), (2) U.S. EPA's Health Effects Assessment Summary Tables (HEAST), (3) provisional values from U.S. EPA's National Center for Environmental Assessment (NCEA), and (4) Other sources. Other sources may include Agency for Toxic Substances and Disease Registry (ATSDR) Toxicological Profiles, World Health Organization (WHO) documents, publications in the primary toxicological literature, or values withdrawn from IRIS or HEAST, with cabinet approval.
6. Calculate the risks associated with the receptors that were identified in Step 4.
7. Identify and describe the uncertainties associated with the risk assessment. Potential sources of uncertainty include COC selection, range of values for exposure parameters, characterization of the site, and interaction between chemicals (additivity, synergism). Uncertainty analysis is further discussed in RAGS Part A (U.S. EPA, 1989).

Section 2.3. Groundwater Evaluation.

Groundwater data from monitoring wells are evaluated in Tier I and II risk evaluations. Recoverable water from soil borings can also be evaluated with groundwater numbers (Preliminary Remediation Goals, MCLs) as described in Section 2.1 and 2.2. If no groundwater monitoring data are available, or data are not adequate, then compare Exposure Concentration(s) for soil to the Soil Screening Level(s) from the Preliminary Remediation Goals table in Appendix C as described in 401 KAR 100:100 Section 5 (5). Radionuclides should be evaluated using the Soil Screening Levels in Appendix E, if applicable.

If the bottom two sampling intervals in the soil boring do not exceed the SSL, modified SSL, site-specific SSL, or subsurface background, then further groundwater evaluation of soil as a potential source for groundwater contamination is not necessary. If soil concentrations in the bottom two sampling intervals of the soil boring do exceed the Soil Screening Level, Modified SSLs, or site-specific SSLs for protection of groundwater resources, and subsurface background, then this indicates a need to manage for migration of contaminants to groundwater or for a groundwater investigation. Submit a plan to assess and protect groundwater or provide site-specific information that contamination doesn't pose a threat to groundwater.

Identify if the site is in an area where contamination of a karst aquifer is possible, or the contaminant(s) could result in a dense non-aqueous phase liquid (DNAPL) layer, or any other circumstances exist that would indicate a higher potential for contamination of groundwater. If such conditions exist, submit a plan for groundwater assessment and protection.

Section 2.4. Management of Risks.

1. Property Use. Management of risks can be accomplished by ensuring that a property is only used by a certain receptor. For example, a property that meets criteria for commercial or industrial use, but not residential, must remain commercial or industrial. Alternate land uses can be evaluated by using commercial/industrial screening values in place of the residential screening values that were used in Section 2.1, or in a baseline risk assessment.
2. Physical and Institutional Controls. Management of risks can be accomplished if exposure to contaminated media is controlled using a combination of soil cover, restrictive covenants, dig restrictions, fencing, or other approved methods.
3. Submit Corrective Action Plan for approval as described in 401 KAR 100:100 Section 8.

Section 2.5. Selection of Remedial Goals.

1. The primary goals of remediation is protection of human health at the hazard index of 1.0 and the carcinogenic risk of 1×10^{-6} at the point of exposure, and protection of ecological health. Ecological risks are addressed in Section 3.0.
2. The primary goals of remediation do not excuse compliance with other applicable standards, such as the National Ambient Air Quality Standards and the surface water standards.
3. The intended use must be ensured through physical and institutional controls and described in the Corrective Action Plan. The risk-based Preliminary Remediation Goals are found in the Appendix C table or derived based on approved receptor-specific values. Remedial goals

for radionuclides will be developed on a site-specific basis in consultation with the Kentucky Cabinet for Health Services. Generic inorganic background values are listed in Appendix G or may be derived using the guidance in 401 KAR 100:100 Section 7 (6).

4. The applicable risk-based remedial goals for surface soils are the residential and commercial/industrial soil numbers in the Appendix C Preliminary Remediation Goals table or those calculated based on approved receptor-specific values. Appendix E contains the risk-based concentrations for radionuclides, if applicable. The remedial goal for certain organic chemicals may be based on site-specific concentrations if it can be demonstrated to the cabinet that concentrations are the result of natural sources or are a by-product of combustion of fuels and not the result of activities on the property or site. For subsurface soils, a VERP applicant or party may select ten times the surface soil risk-based concentrations as an initial remedial goal with implementation of the institutional and physical controls and should not be a source of groundwater contamination. If contaminants are in the surface soil horizon, this can be attained through the use of cover (6 inches of pavement (e.g., asphalt or concrete), 12 inches of soil, or other approved method). For example, if the commercial/industrial soil number is 1.3 mg/kg on the risk-based PRGs table in Appendix C, and the contamination is more than a foot below the surface or is covered with a foot of clean soil, then the concentration that is left in place can be 13 mg/kg and the use of the site would need to be restricted to commercial or industrial use with the soil cover maintained in place.

Section 2.6. Human Health Risk Assessment Report Format.

The risk assessment results should be presented as part of the environmental remediation process wherever risk assessment is used for environmental decision-making. This may be included as part of the site characterization report, corrective action completion report, in an appendix to those reports, or as a separate document.

1. Screening. The screening report should consist of a brief description of the property, site characterization activities, a summary of the analytical data along with the statistical calculations of the 95% UCL, the summary table as described in Section 2.1 6., and results of the Screening Index.

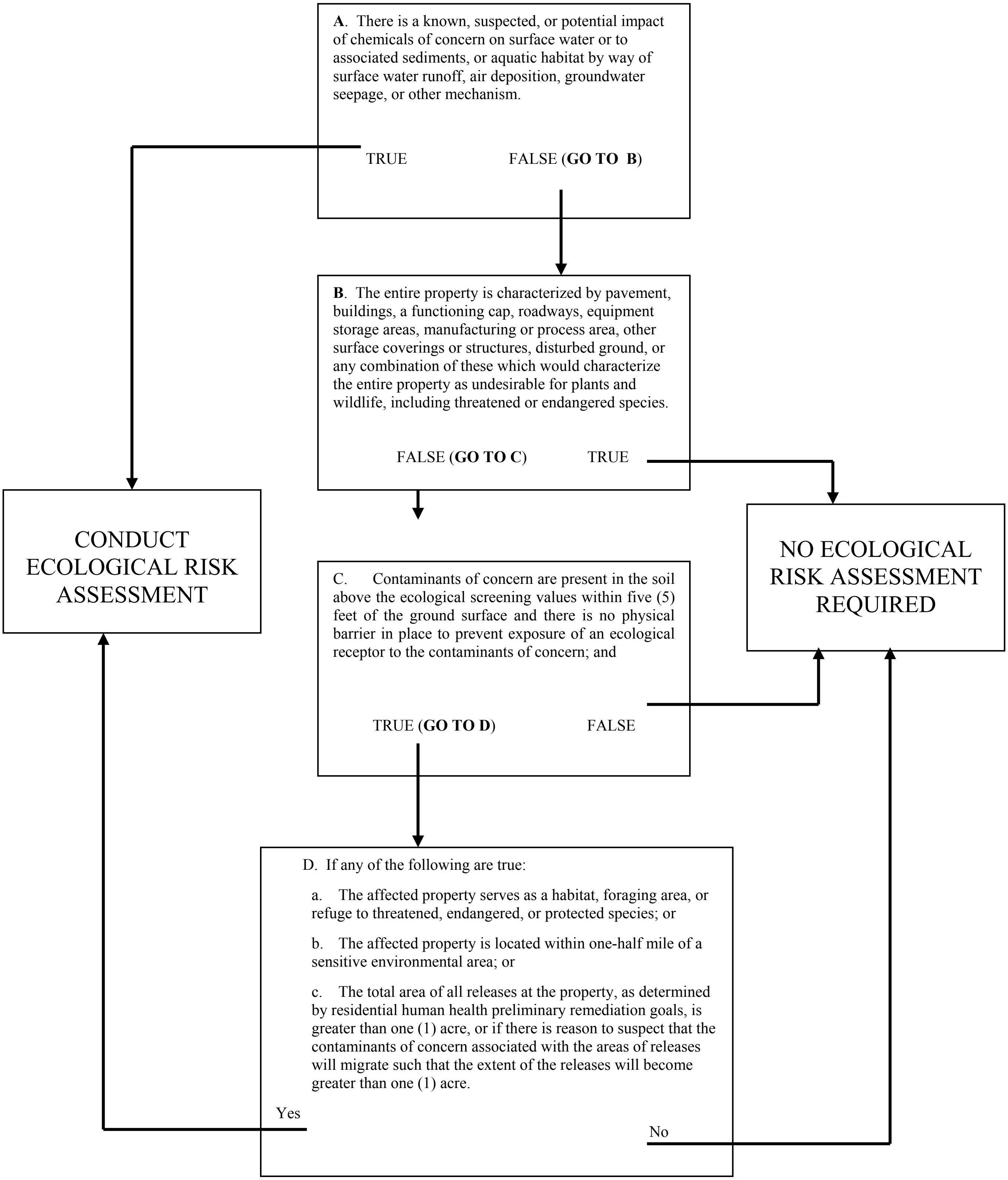
2. Baseline Risk Assessment. The baseline risk assessment report should follow the general outline shown in Appendix B. A copy of the screening risk assessment may be included with the baseline risk assessment to provide information that was used in the baseline risk assessment (selection of COCs, calculation of 95% UCL).

Section 3.0 Ecological Risk Assessment

If it has been determined that an Ecological Risk Assessment (ERA) needs to be conducted (401 KAR 100:100 Section 5 (8)), this document provides the outline for that process. The flowchart in Figure 3 is the process for determining if an ERA needs to be conducted. The checklist in Appendix F can be used to identify features of the environmental setting that are related to ecological receptors.

The phrase “ecological risk assessment” refers to a qualitative and/or quantitative appraisal of the actual or potential impacts from a hazardous compound or physical stressor on plants and animals. Documents from various federal programs (Simini et. al., 2000; USEPA 1993; USEPA 1997a; USEPA 1998) were consulted in the process of developing this document and the procedures used in calculating risk-based concentrations. Figure 4 outlines the process of the ERA.

Figure 3. Flowchart For Determining An Ecological Risk Assessment



A. There is a known, suspected, or potential impact of chemicals of concern on surface water or to associated sediments, or aquatic habitat by way of surface water runoff, air deposition, groundwater seepage, or other mechanism.

B. The entire property is characterized by pavement, buildings, a functioning cap, roadways, equipment storage areas, manufacturing or process area, other surface coverings or structures, disturbed ground, or any combination of these which would characterize the entire property as undesirable for plants and wildlife, including threatened or endangered species.

C. Contaminants of concern are present in the soil above the ecological screening values within five (5) feet of the ground surface and there is no physical barrier in place to prevent exposure of an ecological receptor to the contaminants of concern; and

D. If any of the following are true:

a. The affected property serves as a habitat, foraging area, or refuge to threatened, endangered, or protected species; or

b. The affected property is located within one-half mile of a sensitive environmental area; or

c. The total area of all releases at the property, as determined by residential human health preliminary remediation goals, is greater than one (1) acre, or if there is reason to suspect that the contaminants of concern associated with the areas of releases will migrate such that the extent of the releases will become greater than one (1) acre.

The ERA process is based on two major elements: characterization of effects and characterization of exposure. These provide the focus for conducting the phases of risk assessment: planning, problem formulation, analysis, risk characterization, and risk management.

a) Planning – The Planning phase involves the determination of level-of-effort necessary for the ERA. ERA management goals and objectives are determined (i.e., what plant, animal, or ecosystem is at risk and might need protection), the focus of the ERA is laid out, and the time frame for the assessment is set.

b) Problem Formulation – The overall strategy for estimating risk at a site is developed in Problem Formulation. During this phase, the Conceptual Site Model (CSM) is created, the receptors potentially at risk are defined, and a plan is written that describes the data to be analyzed and the process to be used to calculate risk.

c) Analysis – This component of the ERA consists of data collection, the technical evaluation of the data, the calculation of the existing and potential exposures, and corresponding ecological effects.

d) Risk Characterization – The likelihood and severity of the risk is evaluated for the assessment endpoints, and the ERA's uncertainty is described in the Risk Characterization. A good description of the risk, including the level of adverse effects, is important for interpreting the risk results.

e) Risk Management – In this component, the results of the ERA are integrated with other considerations to make and justify remedial decisions. In a screening level ERA, the risk management decision is whether a baseline ERA is needed.

Section 3.1. Tier 1. Screening-Level Ecological Risk Assessment.

The purpose of the screening-level risk assessment is to evaluate whether existing data justify a decision that site contaminants do not pose a risk to ecological receptors or whether additional evaluation is necessary. If no potential for risk is identified in a screening-level risk assessment, then risk managers can confidently conclude that no further action is required at the site. Tier 1 of ERA consists of two steps:

Step 1. Screening-Level Problem Formulation and Ecological Effects Evaluation.

Step 2. Screening-Level Preliminary Exposure Estimate and Risk Calculation.

Steps 1 and 2 of the ERA process contain the following elements:

- Site visit
- Screening-level problem formulation (preliminary Conceptual Site Model)
- Exposure pathways and endpoints
- Screening-level effects evaluation (toxicity threshold benchmarks)
- Screening-level exposure estimate (site concentration data)
- Screening-level risk calculation (site concentration data screens)
- Documentation

a) Preliminary Conceptual Site Model (CSM). As part of Tier 1, Step 1 of the ERA, use available information to develop a preliminary CSM. Available information may include observations made during site visits, historical documents, existing data, and professional judgement of technical experts who are familiar with the site. The preliminary CSM should describe the environmental setting of the individual site, the site's immediate surroundings, and the contaminants known to exist at the site. The preliminary CSM should identify fate and transport mechanisms of contaminants potentially moving off-site, and briefly discuss the ways that site contaminants act on likely receptors.

b) Exposure Pathways and Endpoints. Based on the preliminary CSM, the ecological risk assessor should identify the potentially complete exposure pathways and endpoints for the screening assessment. The exposure pathways and endpoints for the site specify which ecological effects data are required. The screening-level effects data are screening-level benchmarks and concentrations of substances in the abiotic media (e.g., soil, air or water). If groundwater potentially discharges to surface water, groundwater concentrations are compared to surface water screening benchmarks.

c) Identify Chemicals of Potential Concern. As part of Tier 1, Step 2, determine (COPCs) by eliminating COPCs from further evaluation:

- Background Comparisons**.** Compare the mean concentration for inorganic constituents on-site against the 95% UCL of the mean concentrations of background for inorganic constituents. At least ½ of the data points should be less than the 60th percentile, and no data point above the 95th percentile. Generic inorganic background values are listed in Appendix G or may be derived in accordance with 401 KAR 100:100 Section 7 (6).

- Screening Table Comparison. Compare the lesser of the maximum concentration or 95% UCL on site for substances in a given exposure medium to the screening-level benchmarks (Appendix D) for those substances. Compare site concentrations to screening-level benchmarks for surface soil, sediment, surface water, and groundwater (if site conditions will potentially result in exposure to ecological receptors).

d) Retaining Chemicals of Concern. If any constituent in an abiotic medium to which organisms are potentially exposed is present at a concentration exceeding screening-level benchmark and ambient background or if there is not a screening-level benchmark, then further evaluation of the potential risk will be required. Chemicals with known synergistic effects or that bioaccumulate will be retained as COPCs. If existing data does not have adequate detection limits (i.e., detection limits above screening benchmarks) new data must be collected to replace it.

e) Documentation. The documentation of Steps 1 and 2 should include the following:
   - Brief habitat description, and map;
   - Preliminary CSM;
   - Tables of screening results;
   - List of wildlife species actually or potentially occurring at the site, including threatened and endangered plant and animal species;
   - Discussion of uncertainties. The discussion of the uncertainties should identify constituents for which there are no screening-level benchmarks or analytical chemistry data.

At the end of Tier 1, the decision whether to collect additional data for screening, to proceed with the ERA, or to take no further action can be documented in the report.

Section 3.2. Tier 2 Baseline Ecological Risk Assessment

The baseline ecological risk assessment is a continuation of the screening ERA. It consists of 6 steps:

Step 3. Baseline Risk Assessment Problem Formulation
Step 4. Study Design and Data Quality Objectives
Step 5. Field Verification of Sampling Design
Step 6. Site Investigation and Analysis of Exposure and Effects
Step 7. Risk Characterization
Step 8. Risk Management

a) Step 3. Baseline Risk Assessment Problem Formulation. The Baseline Risk Assessment Problem Formulation should provide sufficient information to support a risk management decision concerning the need for additional evaluation of ecological risk. Further evaluation may mean site-specific ecological investigation at the site. This will require a work plan, documenting Step 4 of the process, and describing how the data will be used in Step 7 to make a remedial decision for the site. Important inputs to this decision are:

- Site concentration data;
- Conceptual Site Model;
- Habitat Description;
- Preliminary Hazard Quotients. The Hazard Quotient should be calculated for COPCs using toxicity values from current literature and intake factors from the Wildlife Exposure Factors Handbook (USEPA 1993) for the species listed below. A Hazard Quotient is calculated by dividing the site concentration (the lessor of the 95% UCL of the mean or maximum) by the No-Observed Adverse Effect Level (NOAEL). If the Hazard Quotient is above 1.0, that compound continues through the baseline ERA.

  For terrestrial habitats, receptors must include (1) earthworm (Lumbricus terrestris), (2) short-tailed shrew (Blarina brevicauda), (3) long-tailed weasel (Mustela frenata), (4) meadow vole (Microtus pennsylvanicus) or prairie vole (Microtus ochrogaster), and (5) American woodcock (Scolopax minor). For aquatic habitats, receptors must include; mink (Mustela vison) little brown bat (Myotis lucifugus), and belted kingfisher (Cerlye alcyon). The above list of species should not be considered exclusive. If there are other species on site that exposure factors, intake rates, and toxicity values are known, those species should be included in the ERA. Species that are on the Federal and/or State Threatened or Endangered Species List and either known to have been on or in the vicinity of the site or if the site contains habitat known to support those species, then they should also be included in the ERA.

- The identification of COPCs that warrant further evaluation.
- An understanding of the effects of COPCs on ecological receptors (including toxicity reference values).
- The identification of complete exposure pathways by which COPCs are brought into contact with ecological receptors (include bioaccumulation factors and ingestion rates for wildlife receptors).
- The identification of assessment endpoints (e.g., protection of fish eating birds from eggshell thinning due to DDT exposure) and measurement endpoints (e.g., natural population structure, feeding, resting, and reproductive cycles).
- Discussion of uncertainties should include the lack of site concentration or toxicity data for COPCs.

b) In Step 4, the process identifies the study design and data quality objectives (DQOs) for the site investigation. The work plan (WP) and the sampling and analysis plan (SAP) are the primary products of Step 4. The WP and SAP must specify the study design in sufficient detail to evaluate its adequacy for collecting the data necessary to answer the risk questions.

The WP or SAP should include the following:

- The number and location of samples of each medium for each purpose
- The comparison of analytical detection limits and threshold concentrations
- The full description of toxicity tests and population/community study designs
- A description of how the results of site investigations will be used in the risk characterization (Step 7) to answer risk questions.

c) In Step 5, the Verification of Field Sampling Design process evaluates the probability of successfully completing the study as designed. The WP or SAP should describe the methods for verifying the study design. The verification process and any remaining uncertainties about the study design should be discussed when the results of the site investigation are reported.

d) Step 6, the Site Investigation and Data Analysis, is the implementation of the site investigation designed in Step 4 and verified in Step 5. Approved alterations in the work plan should be documented in the report containing the risk characterization (i.e., the baseline risk report).

e) Risk Characterization (Step 7) is conducted after data collected during the site investigation have been analyzed. The risk characterization evaluates the exposure and effects data to assess the risk to the assessment endpoints (risk estimation). The risk characterization also presents information necessary to interpret the risk assessment and to decide upon adverse effect thresholds for the assessment endpoints (risk description). This presentation should include a qualitative and quantitative summary of risk results and uncertainties.

   In risk estimation, the lines of evidence, for which data were collected in the site investigation, are integrated in the risk characterization to support a conclusion about the significance of ecological risk. The different possible lines of evidence could be tissue concentration data, toxicity test results, and/or population/community data.

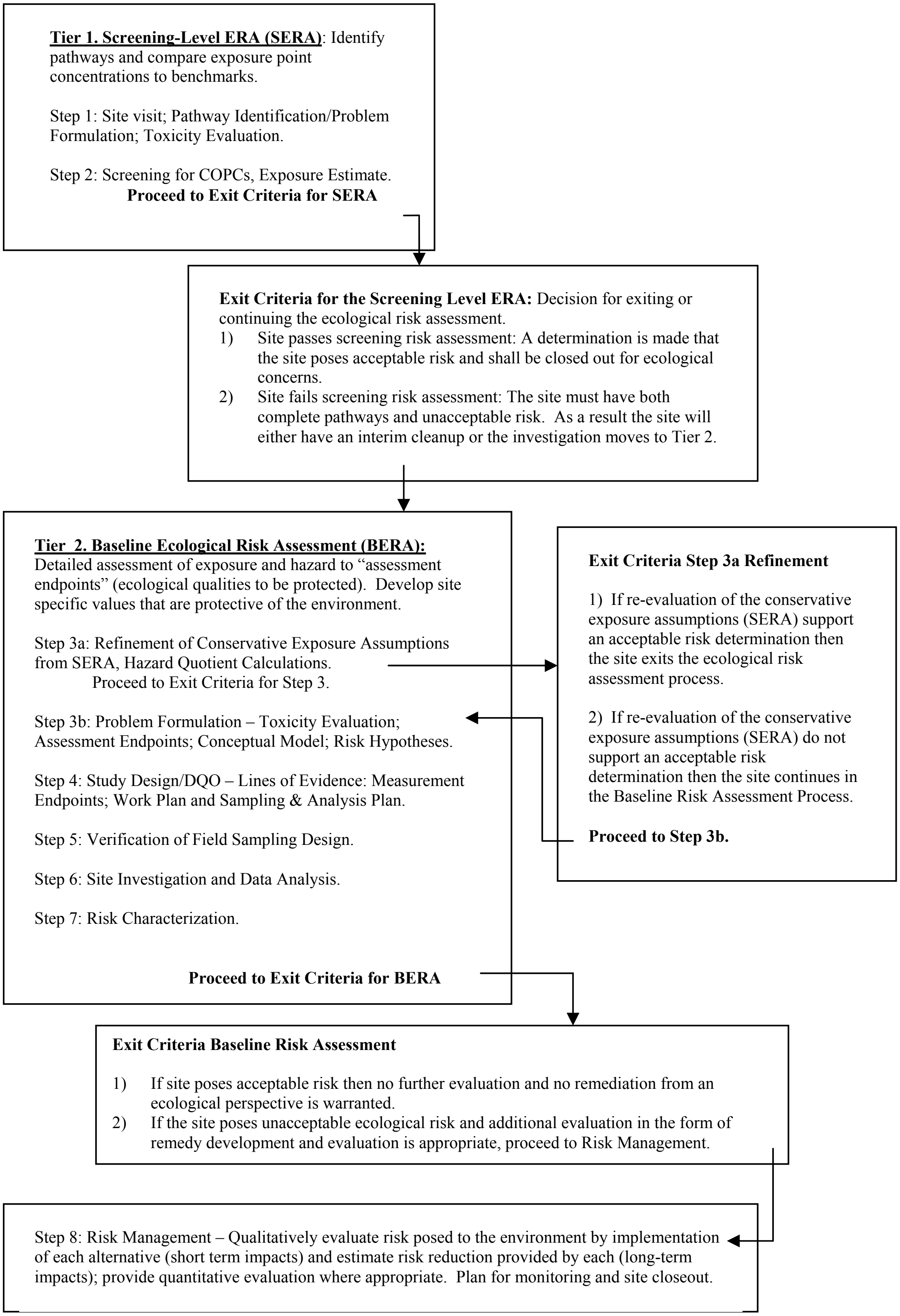
   If site-specific tissue concentration data are available from the site investigation, HQs for wildlife receptors preying on those tissues are calculated. These HQs are calculated using appropriate exposure estimates and toxicity reference values.

   In the ERA, the risk characterization should put the level of risk at the site in context. The risk description should identify threshold concentrations in source or exposure media for effects on the assessment endpoint. All site-specific parameter values used to calculate HQs must be described and the source of the values identified.

   At Step 7, the uncertainty about the risk posed by a substance should have been reduced to a level that allows risk managers to make a technically defensible remedial decision. The risk characterization provides information to judge the ecological significance of the estimated risk to assessment endpoints in the absence of any remedial action.

f) Step 8 of the ERA is Risk Management. The role of ecological risk assessors is to advise the risk managers during the final actions. If the risk characterization concludes there is a risk to ecological receptors, the risk management decision is whether to remediate the site or to leave the constituents of concern in place with controls on exposure and monitoring.

Figure 4. Ecological Risk Assessment Flow Chart



Tier 1. Screening-Level ERA (SERA): Identify pathways and compare exposure point concentrations to benchmarks.

Step 1: Site visit; Pathway Identification/Problem Formulation; Toxicity Evaluation.

Step 2: Screening for COPCs, Exposure Estimate.

Proceed to Exit Criteria for SERA

Exit Criteria for the Screening Level ERA: Decision for exiting or continuing the ecological risk assessment.

1) Site passes screening risk assessment: A determination is made that the site poses acceptable risk and shall be closed out for ecological concerns.
2) Site fails screening risk assessment: The site must have both complete pathways and unacceptable risk. As a result the site will either have an interim cleanup or the investigation moves to Tier 2.

Tier 2. Baseline Ecological Risk Assessment (BERA): Detailed assessment of exposure and hazard to "assessment endpoints" (ecological qualities to be protected). Develop site specific values that are protective of the environment.

Step 3a: Refinement of Conservative Exposure Assumptions from SERA, Hazard Quotient Calculations.

Proceed to Exit Criteria for Step 3.

Step 3b: Problem Formulation – Toxicity Evaluation; Assessment Endpoints; Conceptual Model; Risk Hypotheses.

Step 4: Study Design/DQO – Lines of Evidence: Measurement Endpoints; Work Plan and Sampling & Analysis Plan.

Step 5: Verification of Field Sampling Design.

Step 6: Site Investigation and Data Analysis.

Step 7: Risk Characterization.

Proceed to Exit Criteria for BERA

Exit Criteria Step 3a Refinement

1) If re-evaluation of the conservative exposure assumptions (SERA) support an acceptable risk determination then the site exits the ecological risk assessment process.

2) If re-evaluation of the conservative exposure assumptions (SERA) do not support an acceptable risk determination then the site continues in the Baseline Risk Assessment Process.

Proceed to Step 3b.

Exit Criteria Baseline Risk Assessment

1) If site poses acceptable risk then no further evaluation and no remediation from an ecological perspective is warranted.
2) If the site poses unacceptable ecological risk and additional evaluation in the form of remedy development and evaluation is appropriate, proceed to Risk Management.

Step 8: Risk Management – Qualitatively evaluate risk posed to the environment by implementation of each alternative (short term impacts) and estimate risk reduction provided by each (long-term impacts); provide quantitative evaluation where appropriate. Plan for monitoring and site closeout.

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Appendix A
Exposure Factors

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Table 1 Incidental Soil Ingestion Pathway.

Parameter	Value
Chemical Concentration in Soil	95 % UCL of the mean or maximum
Ingestion Rate:	
Child less that 7 years	200 mg/day
Child 7 through 18 years, and Adult	100 mg/day
Adult Worker (8 hour work day)	50 mg/day
Outdoor Adult (landscaping, construction, Rural outdoor activities, tilling and gardening)	480 mg/day
Exposure Frequency:	
Resident	350 days/year
General Workers	250 days/year
Adult Outdoors (urban)	52 days/year
Adult Outdoors (rural)	104 days/year
Outdoor Worker	185 days/year
Child Outdoors (recreational or trespasser)	140 days/year
Fraction of Soil from a Source Impacted by a Release	1.0 (unitless)
Exposure Duration:	
Child less than 7 years	6 years
Child 7 through 18 years	12 years
Residential Urban Adult	12 years
Residential Rural Adult	22 years
Adult Worker	25 years
Ingestion Absorption Factor	1.0 (unitless) or chemical-specific
Body Weight:	
Child less than 7 years	15 kg
Child 7 through 18 years	43 kg
Adult	70 kg
Exposure Averaging Time	25,550 days for carcinogens Exposure Duration (years) x 365 days/year for noncarcinogens

Table 2 Dermal Contact with Stressors in Soil Pathway.

Parameter	Value
Chemical Concentration in Soil	95 % UCL of the mean or maximum
Skin Surface Area:	
Child less than 7 years	2800 cm^2/day (face, forearms, hands, lower legs, and feet)
Child 7 through 18 years	7500 cm^2/day (arms, hands, legs, and feet)
Residential Adult	5700 cm^2 (face, hands, forearms, and lower legs)
Adult (Industrial)	3300 cm^2/day (face, forearms, and hands)
Outdoor Worker	4700 cm^2/day (arms, hands, and head)
Exposure Frequency:	
Resident	350 days/year
General Workers	250 days/year
Adult Outdoors (urban)	52 days/year
Adult Outdoors (rural)	104 days/year
Outdoor Worker	185 days/year
Child Outdoors (recreational or trespasser)	140 days/year
Fraction of Soil from a Source Impacted by a Release	1.0 (unitless)
Exposure Duration:	
Child less than 7 years	6 years
Child 7 through 18 years	12 years
Residential Urban Adult	12 years
Residential Rural Adult	22 years
Adult Worker	25 years
Dermal Absorption Factor	0.25 Volatile Organics (unitless) 0.1 Semivolatiles (unitless) 0.05 Inorganics (unitless)
Skin Contact Time (fraction of day soil remains on skin):	
Residential	12 hours/24 hours (0.5 unitless)
Worker	8 hours/24 hours (0.33 unitless)
Recreational or Trespasser	12 hours/24 hours (0.5 unitless)
Soil to Skin Adherence Factor	1.0 mg/cm^2
Body Weight:	
Child less than 7 years	15 kg
Child 7 through 18 years	43 kg
Adult	70 kg
Exposure Averaging Time	25,550 days for carcinogens Exposure Duration (years) x 365 days/year for noncarcinogens

Table 3 Inhalation of Particulate-phase Stressors from Soil Pathway.

Parameter	Value
Chemical Concentration in Soil	95 % UCL of the mean or maximum
Inhalation Rate:	
Resident (Children and Adults)	20 m^3/day (0.833m^3/hour, 24 hr/day)
Trespasser	20 m^3/day (2.5 m^3/hour, 8 hr/day)
Worker (Indoor and Outdoor)	12.5 m^3/day (2.5 m^3/hour, 5 hr/day)
Exposure Frequency:	
Resident	350 days/year
General Worker	250 days/year
Adult Outdoors (urban)	52 days/year
Adult Outdoors (rural)	104 days/year
Outdoor Worker	185 days/year
Child Outdoors (recreational or trespasser)	140 days/year
Fraction of Soil from a Source Impacted by a Release	1.0 (unitless)
Exposure Duration:	
Child less than 7 years	6 years
Child 7 through 18 years	12 years
Residential Urban Adults	12 years
Residential Rural Adults	22 years
Adult Worker	25 years
Inhalation Absorption Factor	1.0 (unitless) or chemical-specific
Particulate Emission Factor:	
Residential	9.3 x 10^8 m^3/kg or site-specific
Commercial/Industrial	6.2 x 10^8 m^3/kg or site-specific
Body Weight:	
Child less than 7 years	15 kg
Child 7 through 18 years	43 kg
Adults	70 kg
Exposure Averaging Time	25,550 days for carcinogens Exposure Duration (years) x 365 days/year for noncarcinogens

Table 4 Inhalation of Airborne (Vapor Phase) Stressors from Soil Pathway.

Parameter	Value
Chemical Concentration in Soil	95 % UCL of the mean or maximum
Inhalation Rate:	
Resident (Children and Adults)	20 m^3/day (0.833 m^3/hour, 24 hr/day)
Trespasser	20 m^3/day (2.5 m^3/hour, 8 hr/day)
Worker (Indoor and Outdoor)	12.5 m^3/day (2.5 m^3/hour, 5 hr/day)
Exposure Frequency:	
Resident	350 days/year
General Worker	250 days/year
Adult Outdoors (urban)	52 days/year
Adult Outdoors (rural)	104 days/year
Outdoor Worker	185 days/year
Child Outdoors (recreational or trespasser)	140 days/year
Fraction of Soil from a Source Impacted by a Release	1.0 (unitless)
Exposure Duration:	
Child less than 7 years	6 years
Child 7 through 18 years	12 years
Residential Urban Adult	12 years
Residential Rural Adult	22 years
Adult Worker	25 years
Inhalation Absorption Factor	1.0 (unitless) or chemical-specific
Volatilization Factor	Derived using Equation 8 of the Soil Screening Level Guidance User's Guide (U.S. EPA 1996b)
Body Weight:	
Child less than 7 years	15 kg
Child 7 through 18 years	43 kg
Adult	70 kg
Exposure Averaging Time	25,550 days for carcinogens Exposure Duration (years) x 365 days/year for noncarcinogens

Table 5 Ingestion of Stressors from Water Pathway.

Parameter	Value
Chemical Concentration in Water	95 % UCL of the mean or maximum
Ingestion Rate:	
Child less than 3 years old	1.0 liter/day
Child 3 through 18 years and Adult	2.0 liters/day
Adult Worker (up to an 8 hour work day)	1.0 liter/day
Exposure Frequency:	
Resident	350 days/year
General Worker	250 days/year
Fraction of Soil from a Source Impacted by a Release	1.0 (unitless)
Exposure Duration:	
Child less than 7 years	6 years
Child 7 through 18 years	12 years
Residential Urban Adult	12 years
Residential Rural Adult	22 years
Adult Worker	25 years
Ingestion Absorption Factor	1.0 (unitless) or chemical-specific
Body Weight:	
Child less than 7 years	15 kg
Child 7 through 18 years	43 kg
Adult	70 kg
Exposure Averaging Time	25,550 days for carcinogens Exposure Duration (years) x 365 days/year for noncarcinogens

Table 6 Ingestion of Stressors in Surface Water While Swimming Pathway.

Parameter	Value
Chemical Concentration in Water	95 % UCL of the mean or maximum
Ingestion Rate:	50 milliliters/hour
Exposure Time:	2.6 hours/day
Exposure Frequency:	45 days/year
Fraction of Water from a Source Impacted by a Release	1.0 (unitless)
Exposure Duration:	
Child less than 7 years	6 years
Child 7 through 18 years	12 years
Residential Urban Adult	12 years
Residential Rural Adult	22 years
Ingestion Absorption Factor	1.0 (unitless) or chemical-specific
Body Weight:	
Child less than 7 years	15 kg
Child 7 through 18 years	43 kg
Adults	70 kg
Exposure Averaging Time	25,550 days for carcinogens Exposure Duration (years) x 365 days/year for noncarcinogens

Table 7 Dermal Contact with Stressors in Water while Swimming or Wading Pathway.

Parameter	Value
Chemical Concentration in Water	95 % UCL of the mean or maximum
Skin Surface Area:	
Child swimmer 3 through 6 years	0.6500 m^2/day
Child swimmer 7 through 18 years	1.3100 m^2/day
Adult swimmer	1.8150 m^2/day
Child wader 1 through 6 years	0.3300 m^2/day (arms, hands. legs and feet)
Child wader 7 through 18 years	0.7500 m^2/day (arms, hands. legs and feet)
Adult wader	1.0600 m^2/day (arms, hands. legs and feet)
Exposure Time	2.6 hours/day
Dermal Permeability factor (Kp)	Use RAGS Part E (U.S. EPA 2001b) Appendix B. If measured K_ps are available, then those should be used instead of the modeled values for those chemicals.
Exposure Frequency:	
Swimming	45 days/year
Child and Adolescent Wading	140 days/year
Adult Wading	52 days/year
Fraction of Water from a Source Impacted by a Release	1.0 (unitless)
Exposure Duration:	
Child less than 7 years	6 years
Child 7 through 18 years	12 years
Residential Urban Adult	12 years
Residential Rural Adult	22 years
Dermal Absorbed Dose per Event (DA_{event})	Calculated using RAGS Part E (U.S. EPA, 2001b)
Ingestion Absorption Factor	1.0 (unitless) or chemical-specific
Body Weight:	
Child less than 7 years	15 kg
Child 7 through 18 years	43 kg
Adult	70 kg
Exposure Averaging Time	25,550 days for carcinogens Exposure Duration (years) x 365 days/year for noncarcinogens

Table 8 Dermal Contact with Stressors in Water during Showering or Bathing Pathway.

Parameter	Value
Chemical Concentration in Water	95 % UCL of the mean or maximum
Skin Surface Area: Child 3 through 6 years Child 7 through 18 years Adult	 0.6500 m^2/day 1.3100 m^2/day 1.8150 m^2/day
Exposure Time	0.2 hours/day
Dermal Permeability factor (Kp)	Use RAGS Part E (U.S. EPA 2001b) Appendix B. If measured K_ps are available, then those should be used instead of the modeled values for those chemicals.
Exposure Frequency: Residents Workers in the work place	 350 days/year 250 days/year
Fraction of Water from a Source Impacted by a Release	1.0 (unitless)
Exposure Duration: Child less than 7 years Child 7 through 18 years Residential Urban Adult Residential Rural Adult Adult Worker	 6 years 12 years 12 years 22 years 25 years
Dermal Absorbed Dose per Event (DA_{event})	Calculated using RAGS Part E (U.S. EPA, 2001b)
Ingestion Absorption Factor	1.0 (unitless) or chemical-specific
Body Weight: Child less than 7 years Child 7 through 18 years Adult	 15 kg 43 kg 70 kg
Exposure Averaging Time	25,550 days for carcinogens Exposure Duration (years) x 365 days/year for noncarcinogens

Table 9 Inhalation of Airborne (Vapor Phase) Stressors in Water during Showering Pathway

Parameter	Value
Chemical Concentration in Water	95 % UCL of the mean or maximum
Concentration of Stressor in Air	Use Schaum, et al., 1994, Showering Exposure
Inhalation Rate	0.833 m^3/day
Exposure Time	0.2 hours/day (12 minutes/day)
Exposure Frequency:	
Residents	350 days/year
Workers in the work place	250 days/year
Fraction of Water from a Source Impacted by a Release	1.0 (unitless)
Exposure Duration:	
Child less than 7 years	6 years
Child 7 through 18 years	12 years
Residential Urban Adults	12 years
Residential Rural Adults	22 years
Adult Worker	25 years
Inhalation Absorption Factor	1.0 (unitless) or chemical-specific
Body Weight:	
Child less than 7 years	15 kg
Child 7 through 18 years	43 kg
Adults	70 kg
Exposure Averaging Time	25,550 days for carcinogens Exposure Duration (years) x 365 days/year for noncarcinogens

Table 10 Inhalation of Airborne (Vapor Phase) Stressors in Water during General Home Use Pathway.

Parameter	Value
Chemical Concentration in Water	95 % UCL of the mean or maximum
Concentration of Stressor in Air	Use Schaum et al., 1994, Whole House Model
Inhalation Rate	20 m^3/day
Water Flow Rate	890 L/day
House Volume	450 m^3
Air Exchange Rate	10 changes/day
Fraction Volatilized	0.5 (unitless)
Mixing Coefficient (how well mixed in the home)	0.5 (unitless)
Exposure Frequency:	
Resident	350 days/year
Fraction of Water from a Source Impacted by a Release	1.0 (unitless)
Exposure Duration:	
Child less than 7 years	6 years
Child 7 through 18 years	12 years
Residential Urban Adult	12 years
Residential Rural Adult	22 years
Inhalation Absorption Factor	1.0 (unitless) or chemical-specific
Body Weight:	
Child less than 7 years	15 kg
Child 7 through 18 years	43 kg
Adults	70 kg
Exposure Averaging Time	25,550 days for carcinogens Exposure Duration (years) x 365 days/year for noncarcinogens

Other Pathways. Other pathways may be used at sites that have current or potential future pathways that are not listed in this Appendix. Examples include: consumption of contaminated fish, produce, and livestock. Exposure factors should be based on site-specific conditions and may be obtained from U.S. EPA documents including Exposure Factors Handbook, Risk Assessment Guidance for Superfund (Part A), and Risk Assessment Guidance for Superfund (Part B).

Appendix B

General Outline for Baseline Risk Assessment

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Outline of Components of a Human Health Baseline Risk Assessment

This is a general outline and not all components of the outline are applicable to all sites.

1.0 INTRODUCTION

- 1.1 Overview
  - 1.1.a General Problem at site
  - 1.1.b Site-specific objectives of risk assessment
- 1.2 Scope of Risk Assessment
  - 1.2.a Complexity of risk assessment and rationale
  - 1.2.b Overview of study design

2.0 IDENTIFICATION OF STRESSORS OF POTENTIAL CONCERN

- 2.1 General Site-Specific Data Collection Considerations
  - 2.1.a Preliminary identification of potential human exposure
  - 2.1.b Modeling parameter needs
- 2.2 General Site-Specific Data Evaluation Considerations
  - 2.2.a Steps used (including statistical methods used for evaluation and data selection)
  - 2.2.b Criteria employed in evaluating data
  - 2.2.c Discussion of data uncertainty
- 2.3 Stressor Analytical Data (Complete for All Media)
  - 2.3.a Listing of analytical methods used
  - 2.3.b Evaluation of chemical limits
  - 2.3.c Evaluation of qualified and coded data
  - 2.3.d Contaminants in field and laboratory blanks
  - 2.3.e Tentatively identified compounds
  - 2.3.f Further limitation of number of stressors
  - 2.3.g Uncertainties, limitations, gaps in quality of collection or analysis
- 2.4 Summary of Stressors of Potential Concern

3.0 EXPOSURE ASSESSMENT

- 3.1 Characterization of Exposure Setting
  - 3.1.a Summary of Physical Setting
  - 3.1.b Potentially Exposed Individuals, Populations, and Communities (Human)
    - 3.1.b.1 Relative locations of individuals, populations, and communities with respect to site
    - 3.1.b.2 Current land use

3.1.b.3 Potential alternate future land uses

3.1.b.4 Subpopulations of potential concern

3.2 Identification of Exposure Pathways

3.2.a Sources of the release and receiving media

3.2.b Fate and transport in release media

3.2.c Exposure points and exposure routes

3.2.d Integration of sources, releases, fate and transport mechanisms, exposure points, and exposure routes into complete exposure pathways

3.2.e Summary of exposure pathways to be quantified in this assessment

3.3 Quantification of Exposure

3.3.a Exposure concentrations

3.3.b Estimation of chemical intakes for individual pathways

3.4 Identification of Uncertainties

3.4.a Current and future land-use

3.4.b Environmental sampling and analysis

3.4.c Exposure pathways evaluated

3.4.d Fate and transport modeling

3.4.e Parameter values

3.5 Summary of Exposure Assessment

4.0 TOXICITY ASSESSMENT

4.1 Toxicity Information for Noncarcinogenic Effects (Human Health)

4.1.a Appropriate exposure periods for toxicity values

4.1.b Up-to-date reference doses (RfDs) for all stressors

4.1.c One-and ten-day health advisories for shorter-term oral exposures

4.1.d Overall data base and the critical study on which the toxicity value is based (including the critical effect and the uncertainty and modifying factors used in the calculation)

4.1.e Effects that may appear at doses higher than those required to elicit the critical effect

4.1.f Absorption efficiency considered

4.2 Toxicity Information for Carcinogenic Effects

4.2.a Exposure averaged over a lifetime

4.2.b Up-to-date slope factors for all carcinogens

4.2.c Weight-of-evidence classification for all carcinogens (Groups A, B, and C)

4.2.d Type of cancer for Group A, B, and C carcinogens

4.2.e Concentration above which the dose-response curve is no longer linear, if applicable

4.3 Stressors for Which No EPA Toxicity Values are Available

4.3.a Sources of values

4.3.b Qualitative evaluation

4.3.c Documentation or justification of any new toxicity values developed

4.4 Uncertainties Related to Toxicity Information

4.4.a Quality of the individual studies

4.4.b Completeness of the overall data base

4.5 Summary of Toxicity Information

5.0 RISK CHARACTERIZATION

5.1 Current Land-use Conditions (Human Health)

5.1.a Carcinogenic risk of individual stressors in individual pathways

5.1.b Chronic hazard quotient calculation (individual stressors, individual pathways)

5.1.c Subchronic hazard quotient calculation (individual stressors, individual pathways)

5.1.d Shorter-term hazard quotient calculation (individual stressors, individual pathways)

5.1.e Noncarcinogenic hazard index (individual stressors, all pathways)

5.1.f Carcinogenic risk (individual stressors, all pathways)

5.2 Future Land-Use Conditions (Human Health)

5.2.a Carcinogenic risk of individual stressors in individual pathways

5.2.b Chronic hazard quotient calculation (individual stressors, individual pathways)

5.2.c Subchronic hazard quotient calculation (individual stressors, individual pathways)

5.2.d Noncarcinogenic hazard index (individual stressors, all pathways)

5.2.e Carcinogenic risk (individual stressors, all pathways)

5.3 Uncertainties

5.3.a Site-specific uncertainty factors

5.3.a.1 Definition of physical setting

5.3.a.2 Model applicability and assumptions

5.3.a.3 Parameter values for fate or transport and exposure calculations

5.3.b Summary of toxicity assessment uncertainty

5.3.b.1 Uncertainty and identification of potential human health effects

5.3.b.2 Derivation of toxicity value including completeness of overall database

5.3.b.3 Potential for synergistic or antagonistic interactions

5.3.b.4 Uncertainty in evaluating less-than-lifetime exposures

5.4 Comparison of Risk Characterization Results to Human Studies (if available)

5.4.a Health assessment from the Agency for Toxic Substances and Disease Registry (ATSDR)

5.4.b Site-specific health studies (pilot studies or epidemiological studies)

5.4.c Incorporation of studies into the overall risk characterization

5.5 Summary Discussion and Tabulation of the Risk Characterization

5.5.a Key site-related stressors and key exposure pathways identified

5.5.b Types of health risk of concern

5.5.c Level of confidence in the quantitative information used to estimate risk

5.5.d Presentation of qualitative information on toxicity

5.5.e Confidence in the key exposure estimates for the key exposure pathways

5.5.f Magnitude of the carcinogenic and noncarcinogenic risk estimates

5.5.g Magnitude of chronic and subchronic risk estimates

5.5.h Major factors contributing to risk

5.5.i Major factors (COCs and Pathways) contributing to uncertainty

5.5.j Exposed population and community characteristics

5.5.k Comparison with site-specific health studies

5.5.l Comparison of chemical concentrations with natural background

6.0 SUMMARY AND CONCLUSIONS

6.1 Stressors of Potential Concern

6.2 Exposure Assessment

6.3 Toxicity Assessment

6.4 Risk Characterization

6.5 Uncertainties

Outline of Components of an Ecological Baseline Risk Assessment

This is a general outline and not all components of the outline are applicable to all sites.

STEP 1: SCREENING-LEVEL PROBLEM FORMULATION AND ECOLOGICAL EFFECTS EVALUATION

1.1 INTRODUCTION

1.2 SCREENING-LEVEL PROBLEM FORMULATION

    1.2.1 Environmental Setting and Contaminants at the Site

    1.2.2 Contaminant Fate and Transport

    1.2.3 Ecotoxicity and Potential Receptors

    1.2.4 Complete Exposure Pathways

    1.2.5 Assessment and Measurement Endpoints

1.3 SCREENING-LEVEL ECOLOGICAL EFFECTS EVALUATION

    1.3.1 Preferred Toxicity Data

    1.3.2 Dose Conversions

    1.3.3 Uncertainty Assessment

1.4 SUMMARY

STEP 2: SCREENING-LEVEL EXPOSURE ESTIMATE AND RISK CALCULATION

2.1 INTRODUCTION

2.2 SCREENING-LEVEL EXPOSURE ESTIMATES

    2.2.1 Exposure Parameters

    2.2.2 Uncertainty Assessment

2.3 SCREENING-LEVEL RISK CALCULATION

2.4 SCIENTIFIC/MANAGEMENT DECISION POINT (SMDP)

2.5 SUMMARY

STEP 3: BASELINE RISK ASSESSMENT PROBLEM FORMULATION

3.1 THE PROBLEM-FORMULATION PROCESS

3.2 REFINEMENT OF PRELIMINARY CONTAMINANTS OF CONCERN

3.3 LITERATURE SEARCH ON KNOWN ECOLOGICAL EFFECTS

8.3 SCIENTIFIC/MANAGEMENT DECISION POINT (SMDP)

8.4 SUMMARY

Appendix C
Human Health Screening Values

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Development of Risk Based Concentrations for Environmental Remediation in Kentucky

Introduction

This appendix details the procedures used to develop risk-based concentrations that will be used for the Voluntary Environmental Remediation Program, KRS 224.01-400 and KRS 224.01-405 cleanups, and other programs where risk-based concentrations are needed. Documents from the United States Environmental Protection Agency were consulted in the process of developing this document and the procedures used in calculating risk-based concentrations.

Application

It is intended for this table to have several applications to sites undergoing environmental remediation. Applications include: preliminary screening of site contaminants, closure of small spills, determination of potential toxic conditions, and reduction and refinement of the number of Chemicals of Concern (COCs) at a site during a baseline risk assessment. The values are also one of the factors that should be considered when selecting remedial goals. The values consider the more common exposure routes but if an individual site has other exposure routes that play a major role in the site-related exposures, these values may underestimate the risk.

Calculation of Risk-Based Values

The formulae for calculating the risk-based concentrations are primarily from U.S. EPA guidance including Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part A), commonly referred to as RAGS Part A (U.S. EPA, 1989), RAGS part B (U.S. EPA, 1991), Soil Screening Guidance: Users Guide (U.S. EPA, 1996c), and Soil Screening Guidance: Technical Background Document (U.S. EPA, 1996b). "Estimating Dermal and Inhalation Exposure to Volatile Chemicals in Domestic Water" (Schaum *et al*., 1994) was used to represent the inhalation exposure to water based on the Whole House Dispersion Model. The assumptions that are used in estimating the risk-based concentrations are selected to be protective of sensitive subpopulations.

KYDEP incorporated applicable exposure routes into each medium of exposure. For residential and occupational exposure to soil; ingestion, dermal and inhalation exposure was considered. Dermal exposure to soil used default absorption values of 0.25 for volatiles, 0.1 for semivolatiles, and 0.05 for metals. Default dermal absorption factors were derived from literature reviews of dermal absorption. The Agency for Toxic Substances and Disease Registry

(ATSDR) Toxicological Profiles were a valuable source of absorption and chemical specific data. Ten compounds had chemical-specific dermal absorption rates as listed in RAGS Part E (U.S, EPA, 2000a). Inhalation of contaminants found in soil used two factors: a Volatilization Factor (VF), and a Particulate Emission Factor (PEF). Potential volatilization from soil to air was represented for volatiles by the volatilization factor that was calculated using the formula in the Soil Screening Guidance: User's Guide (U.S. EPA, 1996c). A compound was assumed to be volatile when the molecular weight was less than 200 mg/mol and the Henry's Law Constant (H) was greater than 10^{-5} atm-m^3/mol. The respective default dispersion factor for residential and commercial/industrial exposures were derived for Kentucky sites using exhibit 11 in U.S. EPA, 1996c. Climatic zone VII was used to calculate the dispersion factor term since that is the logical zone for Kentucky sites. For a residential dispersion factor, the 90% lower confidence limit was calculated for a 0.5-acre site size. A commercial/industrial value for dispersion factor was calculated based the 90% lower confidence limit of the values listed under a site size of 5 acres.

Inhalation was the route that was used for air exposures. Tap water exposure used ingestion and inhalation, the latter using the Schaum (1994) Whole House Exposure Model. The model describes the average indoor air concentration as a result of water use throughout the house. This model considers water use such as washing dishes, bathing, washing clothes, and cooking. The formula is:

$$C_a = \frac{WHF \times C_w \times f}{HV \times ER \times MC}$$

where:

Ca = concentration in air, mg/m^3

Cw = concentration in water, mg/L

WHF = water flow rate in whole house, 890 L/day

HV = house volume, 450 m^3

ER = exchange rate, 10 air changes/day

MC = mixing coefficient, 0.5 (unitless)

f = fraction of contaminant that volatilizes, 0.5 (unitless)

The default values for these parameters were selected from the text of the Schaum (1994) chapter and are listed following the description.

Formulae

The formulae for calculation of the risk-based values are the result of taking the standard exposure equations used in risk assessments and solving for the concentration term. Toxicity values were used to represent the potential toxicity of each compound. These values are obtained from several sources. The source is listed next to each toxicity value. The abbreviations in order of preference are: “i” U.S. EPA’s Integrated Risk Information System (IRIS), “h” U.S. EPA’s Health Effects Assessment Summary Tables (HEAST), “n” U.S. EPA’s National Center for Environmental Assessment (NCEA), “w” withdrawn from IRIS or HEAST, “o” other EPA documents, “r” route extrapolation, and “s” when the toxicity value of a surrogate compound was used based on physicochemical characteristics. The Risk-Based Screening Values are based on a target risk of 1 x 10^{-6} for carcinogens and a Hazard Index of 1.0 for noncarcinogens in each media. The carcinogenic risk of 1 x 10^{-6}, or one excess cancer in one million is standard practice in risk assessment for *de minimis* risk. The target Hazard Index of 1.0 indicates that the noncarcinogenic risk is below a toxicity threshold represented by the reference dose. The basis for each screening value in the table is denoted by “ca” for a carcinogenic endpoint, and “nc” for a noncarcinogenic endpoint. A soil saturation limit was derived using the formula in U.S. EPA, 1996c. A ceiling limit was set at 10^{+5} as a maximum soil concentration. If the risk-based screening value exceeded the saturation limit or the maximum, then the soil screening value was set at the saturation limit (denoted as “sat”) or the maximum ceiling limit (denoted as “max”) The following formulae were used to calculate the risk-based screening values for each media.

Noncarcinogenic Effects

Residential Soil

$$\frac{(ED\_c \times BW\_c \times 365 \times THQ)}{(IRA\_c \times (1/VF + 1/PEF\_r) \times EF\_r \times ED\_c \times 1/RfDi) + (SA\_c \times AF \times ABS \times EF\_r \times ED\_c \times 0.000001 \times 1/RfDo) + (IRS\_c \times EF\_r \times ED\_c \times 0.000001 \times 1/RfDo)}$$

Commercial/Industrial Soil

$$\frac{(ED\_a \times BW\_a \times 365 \times THQ)}{(IRA\_a \times (1/VF + 1/PEF\_o) \times EF\_o \times ED\_o \times 1/RfDi) + (SA\_i \times AF \times ABS \times EF\_o \times ED\_o \times 0.000001 \times 1/RfDo) + (IRS\_o \times EF\_o \times ED\_o \times 0.000001 \times 1/RfDo)}$$

Ambient Air

$$\frac{(ED\_c \times BW\_c \times 365 \times THQ \times RfDi \times 1000)}{(IRA\_c \times EF\_r \times ED\_c)}$$

Tap Water

$$\frac{(BW\_c \times ED\_c \times 365 \times THQ \times 1000)}{(\frac{(IRW\_c < 3 \times 3) + (IRW\_c > 3 \times 3)}{ED\_c} \times EF\_r \times ED\_c \times 1/RfDo) + (\frac{(890 \times 0.5)}{(450 \times 10 \times 0.5)} \times IRA\_c \times EF\_r \times ED\_c \times 1/RfDi)}$$

Carcinogenic Effects

Residential Soil

$$\frac{(AT \times 365 \times TR)}{(InF\_adj \times (1/VF + 1/PEF\_r) \times EF\_r \times SFi) + (SFS\_adj \times AF \times ABS \times EF\_r \times 0.000001 \times SFo) + (IFS\_adj \times EF\_r \times 0.000001 \times SFo)}$$

Commercial/Industrial Soil

$$\frac{(AT \times BW\_a \times 365 \times TR)}{(IRA\_a \times (1/VF + 1/PEF\_o) \times EF\_o \times ED\_o \times SFi) + (SA\_i \times AF \times ABS \times EF\_o \times ED\_o \times 0.000001 \times SFo) + (IRS\_o \times EF\_o \times ED\_o \times 0.000001 \times SFo)}$$

Ambient Air

$$\frac{(AT \times 365 \times TR \times 1000)}{(InhF\_adj \times EF\_r \times SFi)}$$

Tap Water

$$\frac{(AT \times 365 \times TR \times 1000)}{(IFW\_adj \times EF\_r \times SFo) + (\frac{(890 \times 0.5)}{(450 \times 10 \times 0.5)} \times InhF\_adj \times EF\_r \times SFi)}$$

Four age adjusted factors were calculated for carcinogenic exposure calculations. The formula for each factor is shown below.

Ingestion Factor for Soil

$$\left(\frac{IRS\_c \times ED\_c}{BW\_c}\right) + \left(\frac{IRS\_a \times ED\_adol}{BW\_adol}\right) + \left(\frac{IRS\_a \times ED\_a}{BW\_a}\right)$$

Skin Contact Factor for Soil

$$\left(\frac{SA\_c \times ED\_c}{BW\_c}\right) + \left(\frac{SA\_adol \times ED\_adol}{BW\_adol}\right) + \left(\frac{SA\_a \times ED\_a}{BW\_a}\right)$$

Inhalation Factor

$$\left(\frac{IRA\_c \times ED\_c}{BW\_c}\right) + \left(\frac{IRA\_a \times ED\_adol}{BW\_adol}\right) + \left(\frac{IRA\_a \times ED\_a}{BW\_a}\right)$$

Ingestion Factor for Water

$$\left(\frac{IRW\_c < 3 \times 3}{BW\_c}\right) + \left(\frac{IRW\_a,c > 3 \times 3}{BW\_c}\right) + \left(\frac{IRW\_a,c > 3 \times ED\_adol}{BW\_adol}\right) + \left(\frac{IRW\_a,c > 3 \times ED\_a}{BW\_a}\right)$$

Table 1 summarizes the exposure factors that were used to calculate the risk-based screening values.

Table 1. Exposure Factors

Parameter (units)	**Value**	**Abbreviation**
Target Cancer Risk	1 x 10^{-6}	TR
Target Hazard Quotient	1	THQ
Body weight, age 1-6 (kg)	15	BW_c
Body weight adolescent (kg)	43	BW_adol
Body weight, adult (kg)	70	BW_a
Surface area , child (cm^2/day)	2800	SA_c
Surface area , adolescent (cm^2/day)	7500	SA_adol
Surface area , adult resident (cm^2/day)	5700	SA_a
Surface area , adult industrial (cm^2/day)	3300	SA_i
Adherence factor (mg/cm^2)	1	AF
Dermal absorption in soil (volatiles)	0.25	ABS_vol
Dermal absorption in soil (semivolatiles)	0.1	ABS_semi
Dermal absorption in soil (metals)	0.05	ABS_met
Averaging time (years)	70	AT
Inhalation rate (m^3/d)	20	IRA_a
	20	IRA_c
Drinking water ingestion (L/d)	2	IRW_a, c>3
	1	IRW_c<3
	1	IRW_o
Volatilization factor - soil (m^3/kg)	Chemical specific	VF_S
Particulate emission factor (m^3/kg)	9.3E+08	PEF_r
	6.2E+08	PEF_o
Soil ingestion - adolescent & adult resident (mg/d)	100	IRS_a
Soil ingestion - age 1-6 (mg/d)	200	IRS_c
Soil ingestion – commercial/industrial (mg/d)	50	IRS_o
Exposure frequency (d/yr)	350	EF_r
Commercial/Industrial Exposure Frequency (d/yr)	250	EF_o
Exposure duration, age 1-6 (yr)	6	ED_c
Exposure duration, age 7-18 (yr)	12	ED_adol
Exposure duration, adult (yr)	12	ED_a
Commercial/Industrial Exposure Duration (yr)	25	ED_o
Total residential duration (yr)	30	ED_total
Age-adjusted factors (for carcinogens only)		
Ingestion factor for soils ([mg*yr]/[kg*d])	125.050	IFS_adj
Skin contact factor for soils ([cm^2*yr]/[kg*d])	4190.166	SFS_adj
Inhalation factor ([m^3*yr]/[kg-d])	17.010	InhF_adj
Ingestion factor for water ([L*yr]/[kg-d])	1.501	IFW_adj

The formulae for calculating the volatilization factor (VF), particulate emission factor (PEF), and soil screening levels (SSL) are contained in the Soil Screening Guidance: Users Guide (U.S. EPA, 1996c) and are listed below. The assumptions for those calculations are listed in the Soil Screening Guidance: Users Guide. The only factors in this document that were different were the dispersion factor (Q/C) values for residential (64.177) and commercial/industrial (43.07). The Kentucky-specific values for Q/C were estimated based on the 90% Lower Confidence Level of the mean dispersion factor of Climatic Zone VII of Table 3 of the SSL Technical Background Document (U.S. EPA, 1996b). Volatilization Factors are used in the soil exposure scenario to estimate partitioning between soil and vapor in the exposure zone, and the particulate emission factor represents the concentration of respirable particulates in air. The chemical specific values of D_i in the VF calculation were obtained from the U.S. EPA Region 9 Preliminary Remediation Goals Table dated November 1, 2000. Region 9 used several sources: Superfund Exposure Assessment Manual (U.S. EPA, 1988), Subsurface Contamination Reference Guide (U.S. EPA, 1990c), Fate and Exposure Data (Howard, 1991), and the Superfund Chemical Data Matrix (U.S. EPA 1994). Some chemicals required the use of a surrogate for physicochemical data based on chemical structure and characteristics.

The Soil Screening Level uses modeling to estimate soil concentrations that are protective of human health exposure to groundwater with a Dilution and Attenuation Factor of 1. The endpoint that was chosen for the SSL was the MCL from U.S. EPA (2001b) or the risk-based tap water concentration as calculated in the table if an MCL was not available.

Volatilization Factor

$$VF(m^3/kg) = \frac{Q/C \times (3.14 \times D_A \times T)^{1/2} \times 10^{-4}(m^2/cm^2)}{2 \times \rho_b \times D_A}$$

where

$$D_A = \frac{\left(\theta_a^{10/3} \times D_i \times H' + \theta_w^{10/3} \times D_w\right)/n^2}{\rho_b \times K_d + \theta_w + \theta_a \times H'}$$

and:

Q/C = *64.177 (residential)*
43.07 (commercial/industrial)
T = *9.5E+8 seconds*
ρ_b = *1.5 g/cm3*
θ_a = *0.28* L_{air}/L_{soil}
D_i = *chemical-specific*
H' = *H x 41*
H = *Henry's Law Constant (chemical-specific)*
θ_w = *0.15* L_{water}/L_{soil}
D_w = *chemical-specific*
n = *0.43* L_{pore}/L_{soil}
K_d = *chemical-specific*

Particulate Emission Factor

$$PEF(m^3 / kg) = Q / C \times \frac{3600s / h}{0.036 \times (1 - V) \times (U_m / U_t)^3 \times F(x)}$$

where:
Q/C = *64.177 (residential)*
43.07 (commercial/industrial)
V = *0.5 (unitless)*
U_m = *4.69 m/s*
U_t = *11.32 m/s*
$F(x)$ = *0.194 (unitless)*

Soil Screening Level

$$SSL(mg / kg) = C_w \left[K_d + \frac{\theta_w + \theta_a \times H'}{\rho_b} \right]$$

where the C_w is the MCL or risk-based tap water value in mg/L from the table.

and:
K_d = *chemical-specific*
θ_w = *0.3* L_{water}/L_{soil}
θ_a = *0.13* L_{air}/L_{soil}
H' = *H x 41*
H = *Henry's Law Constant (chemical-specific)*
ρb = *1.5 g/cm3*

Exceptions

There are a few exceptions to the standard procedures described in this document where modifications in the exposure assumptions or toxicity value were necessary to meet a certain class of chemicals.

Metals. Many of the metals only have oral toxicity values listed in IRIS or HEAST. In order to have complete information, it was necessary to extrapolate the oral toxicity values to inhalation exposures as well. The exposure routes were also modified based on the characteristics of metals. Soil exposure included ingestion, dermal exposure, and particulate inhalation. Exposure to tap water considered only ingestion. Elemental mercury, even though it is a metal, was assumed to be a volatile for exposure to soil and water. These conditions fit typical exposure conditions for tap water. If a site has potential exposure to mists containing metals in water, then exposure via inhalation should be considered in a site-specific tap water screening value calculated for the site using the formulae contained in this document.

Gases. Some of the constituents on the table are considered to be gases or vapors at standard temperature. In consideration of their physical state, both soil and water exposure consider only inhalation since their residence time in soil would not be expected to be long for ingestion or dermal exposure.

Extrapolation. Some chemicals had only oral or inhalation toxicity values listed on the Region IX PRGs Table. In those cases, extrapolation was necessary. Literature reviews were done to verify the potential for effects in other media of exposure.

Lead. U.S. EPA has implemented use of the IEUBK Model to estimate environmental levels that will result in a target blood lead level. KYDEP performed a review of lead issues (KYDEP, 1996) and determined that the most appropriate metric for lead risk assessment was the RfD_o and RfD_i derived based on the LOAEL in laboratory rats. For further discussion of lead see the Lead Issues document (KYDEP, 1996). KYDEP also has an action level of 50 ppm in residential or unrestricted use in soil, 400 ppm in commercial or industrial soils, and a tap water action level of 0.015 mg/L that are listed on the table. The soil value of 50 mg/kg was originally developed in the UST program.

MTBE. Methyl t-Butyl Ether had an oral RfD issued by NCEA, which was withdrawn. The RfD was retained and listed as withdrawn on the table. U.S. EPA has a Drinking Water Advisory: Consumer Acceptability Advisory level in water of 20 µg/L to 40 µg/L based on odor and taste, respectively. This is below the carcinogenic and noncarcinogenic risk-based numbers.

PCBs. PCBs also received special consideration. KYDEP has used the high risk value of 2.0 $(mg/kg\text{-}day)^{-1}$ based on the observation that as a mixture of PCBs weathers, the lower chlorinated biphenyls are more likely to degrade, leaving the higher chlorinated biphenyls in a higher proportion. Since the higher chlorinated biphenyl mixture (Arochlor 1260) exhibit more toxicity, the high-risk value was used for the screening values. For noncarcinogenic effects, the table has two mixtures listed. Arochlor 1254 is applied by KYDEP for the higher chlorinated mixtures (Arochlor 1260, 1254, and 1248) and the Arochlor 1016 value is applied to mixtures that are less chlorinated (1242, 1016).

How To Use the Table

When evaluating an area using the screening values, it is useful to develop a Conceptual Site Model to verify that it fits into the assumptions that were used to derive the screening values. The first step is to identify the areas of potential contamination and analyze grab samples for a broad range of potential contaminants (typically the HSL, TAL/TCL, etc.) in several samples to refine analytical parameters. The contaminants of potential concern are then identified. The potential ecological and human health receptors should be determined and also the potential pathways of exposure.

The screening values table is organized with the toxicity values in the left-hand columns, each one followed by the source of the RfD or Slope Factor. The VOC Column identifies (with "1" being volatile) which compounds use a volatilization factor in the soil exposure. The soil dermal absorption value is shown for each compound, and the Chemical Abstract Service (CAS) registry number and contaminant name are shown. The next four columns represent the risk-based concentration associated with each of the contaminants for soil, air, and water.

The Soil Screening Levels are determined for most volatiles and the compounds listed in the Soil Screening Guidance (U.S. EPA, 1996c). The Dilution and Attenuation Factor (DAF) of 1 is applicable for a screening value where there is the potential for shallow aquifers, karst terranes (a major factor in Kentucky), and areas of significant permeability. It is possible to develop Soil Screening Values for a higher DAF if site-specific information indicates that the depth to groundwater, soil type, and geological formations support that there is significant dilution between the contaminated zone and the groundwater. 401 KAR 100:100 Section 5(5) establishes procedures to modify the SSL based on site-specific conditions.

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Appendix D

Ecological Screening Values

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Appendix E
Radionuclide Screening Values

Available on www.kentucky.gov

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Appendix F

Checklist for Ecological Assessment/Sampling

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Checklist for Ecological Assessment/Sampling

I. SITE DESCRIPTION

1. Site Name: ______________________________

Location: ______________________________

____

County: ____________ City: ____________ State: ____________

2. Latitude: ______________ Longitude: ______________

3. What is the approximate area of the site? ______________________________

4. Please attach to the checklist USGS topographic map(s) of the site, if available.

5. Are aerial or other site photographs available? ☐ yes ☐ no If yes, please attach any available photo(s).

6. What type of facility is located at the site?

☐ Chemical ☐ Manufacturing ☐ Mixing ☐ Waste disposal

☐ Other (specify) ______________________________

7. What are the suspected contaminants of concern at the site? If known, what are the maximum concentration levels?

8. Do any potentially sensitive environmental areas exist adjacent to or in proximity to the site, e.g., Federal and State parks, National and State monuments, wetlands, lakes, streams? *Remember, flood plains and wetlands are not always obvious; do not answer "no" without confirming information.*

9. Please provide the source(s) of information used to identify these sensitive areas, and indicate their general location on the site map.

10.

The land use on the site is:	The area surrounding the site is:
	____________________ mile radius
_____% Urban	_____% Urban
_____% Rural	_____% Rural
_____% Residential	_____% Residential
_____% Industrial (☐ light ☐ heavy)	_____% Industrial (☐ light ☐ heavy)
_____% Agricultural	_____% Agricultural
(*Crops*:______________________)	(*Crops*:______________________)
_____% Recreational	_____% Recreational
(Describe; note if it is a park, etc.)	*(Describe; note if it is a park, etc.)*
____________________________	____________________________
____________________________	____________________________
_____% Undisturbed	_____% Undisturbed
_____% Other	_____% Other

11. If known, what is the approximate depth to the water table? ______________________________

12. Is the direction of surface runoff apparent from site observations? ☐ yes ☐ no If yes, to which of the following does the surface runoff discharge? Indicate all that apply.

☐ Surface water ☐ Groundwater ☐ Sewer ☐ Collection impoundment

13. Is there a navigable waterbody or tributary to a navigable waterbody? ☐ yes ☐ no

14. Is there a waterbody anywhere on or in the vicinity of the site?

☐ yes (approx. distance____________________) ☐ no

15. Is there evidence of flooding? ☐ yes ☐ no *Wetlands and flood plains are not always obvious; do not answer "no" without confirming information.*

16. Are any threatened and/or endangered species (plant or animal) known to inhabit the area of the site?

☐ yes ☐ no

17. Are there any wooded areas at the site? ☐ yes ☐ no.

18. What percentage or area of the site is wooded? (_____% _____ acres). Indicate the wooded area on the site map which is attached to a copy of this checklist.

19. Is shrub/scrub vegetation present at the site? ☐ yes ☐ no.

20. What percentage of the site is covered by scrub/shrub vegetation? (_____% _____ acres). Indicate the areas of shrub/scrub on the site map.

21. Are there open (bare, barren) field areas present at the site? ☐ yes ☐ no

22. What percentage of the site is open field? (_____% _____ acres). Indicate the open fields on the site map.

23. Based on observations and/or available information, are designated or known wetlands definitely present at the site? ☐ yes ☐ no

24. Please note the sources of observations and information used (e.g., USGS Topographic Maps, National Wetland Inventory, Federal or State Agency, etc.) to make this determination.

25. CONTINUE WITH ECOLOGICAL RISK ASSESSMENT. **YES_____** **NO_____**

Record weather conditions at the time this checklist was prepared:

DATE: ______________________

______________Temperature (EC/EF) ______________Normal daily high temperature

______________Wind (direction/speed) ______________Precipitation (rain, snow)

______________Cloud cover

Completed by ____ Affiliation ___________________

Additional Preparers ____

Site Manager____

Date ___

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Appendix G

Development of Generic Background Concentrations for Kentucky Soils

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Development of Generic Background Concentrations for Kentucky Soils

Background, as defined in 401 KAR 42:005 (definitions codified to support the Underground Storage Tank regulations), means the concentration of substances consistently present in the environment at, or regionally proximate to, a release but outside the influence of the release. There are two types of background:

a) Natural background is the amount of naturally occurring substances in the environment, exclusive of that from anthropogenic sources.

b) Ambient background means the concentrations of naturally-occurring inorganic substances and ubiquitous anthropogenic inorganic substances in the environment that are representative of the region surrounding the site and not attributable to activities on the property.

Since sites undergoing environmental assessment are often found in industrialized and potentially contaminated areas, the determination of site-specific background concentrations is difficult. Generic ambient background values applicable to all sites in Kentucky would be useful for comparison to site data for the purpose of identifying those constituents requiring remedial action (i.e., removal or exposure control). These generic ambient background values would provide a party or VERP applicant an alternative to attempting to identify site-specific background soils in areas that are likely contaminated.

To address this issue, the NREPC used background sample values provided by regulated facilities, as well as background sample values collected by cabinet employees. These samples were collected from areas generally considered to be outside of the influence of site activities, but were potentially impacted by regional or citywide activity. Therefore, these samples represent “ambient,” as opposed to “natural,” background. From 400 to over 800 samples for each constituent were used in the analysis. For each constituent, a 95% Upper Confidence Limit (UCL) of the arithmetic mean, 60th Percentile, and 95th percentile were calculated. The 95% UCL is the value that represents that the mean of the data set falls below that value with 95% confidence. The 60th and 95th percentiles indicate that 60 percent and 95 percent of the data falls below those values.

The following methodology was employed to calculate ambient background:

1. Values reported as “non-detected” were retained in the database at ½ the reporting limit (USEPA, 1998).

2. As the data sets came from areas having varied uses (e.g., industrial, commercial, residential, agricultural, woodlands, etc.), the probability that some of the samples were taken in contaminated areas is significant. Data sets were tested for outliers by the Grubb’s test, and individual samples that had a calculated Z-score above 3.8 were generally removed from the background data set. The Grubb’s test formula is as follows:

$$Z = \frac{|population\ mean - value\ of\ individual\ sample|}{standard\ deviation}$$

3. The descriptive statistics of mean and standard deviation were calculated by standard parametric methods assuming normality and are listed in Table G-1. Parametric methods were used to allow for comparisons between NREPC background values and other published values.

   a. Standard deviation was calculated by the “nonbiased” method employing the formula:

$$S.D. = \sqrt{\frac{\sum\left(X_i - \overline{X}\right)^2}{n-1}}$$

   b. Mean was calculated as the sum of all individual scores divided by the total number of observations.

4. The data sets were analyzed with Lillefor’s test for normality. Since the data sets are not normally or log normally distributed, the parameters that are to be used in determining if site samples are consistent with background (i.e. 95% UCL of mean, 60th percentile and 95th percentile) were calculated by nonparametric methods and are listed in Table G-2.

5. The 95% upper confidence limit of the arithmetic mean for each constituent was calculated on the trimmed data set using ProUCL. ProUCL is a statistical package developed by Lockheed Martin under contract with the U.S. EPA.

6. The 60th percentile value is used as the midpoint for each constituent. It was calculated as follows:
   a. The constituent values were ranked in increasing order of magnitude.
   b. The quantity 60(n)/100 was used to identify the measurement with the resulting rank.

7. The 95th percentile value is used as the upper bound value for each constituent and was calculated as follows:
   a. The constituent values were ranked in increasing order of magnitude.
   b. The quantity 95(n)/100 was used to identify the measurement with the resulting rank.

The thallium data were characterized by a large number of non-detects (633 non-detects verses 54 detects). Due to the large number of non-detects, non-detects were not entered as ½ the non-detect concentration. Each non-detect sample was assumed to have a concentration equal to the recorded non-detect concentration. Considering the number of non-detects and the likelihood that the recorded values skew thallium concentrations upward, only the 95th percentile of the total data is cited in table G-2.

Comparison to Background

- The mean site concentration for inorganic constituents must be below the 95% UCL of the mean concentrations of background for inorganic constituents. At least ½ of the data points should be less than the midpoint (60th percentile), and no data point above the upper bound value (95th percentile). The site data should be segregated by surface and subsurface data. The surface and subsurface site data may be compared to the statewide numbers in Table G-2, or to site-specific background samples.

Horizontal and Vertical Extent

401 KAR 100:100 Section 5(4) states that during site characterization, a minimum of two additional sampling locations is required for each sampling point at the edge of an area of concern that exceeds the method detection limit or ambient background and shall be located at a

minimum distance of ten (10) feet from the previous sampling point that had a confirmed exceedance of method detection limits, or ambient background. The following criteria may be used to determine if the sampling point exceeds generic or site-specific ambient background.

- If the value for the individual sample is less than the 95% UCL of the arithmetic mean of background, then no additional samples are required.
- If the sampling point is greater than the 95th percentile of background, then a minimum of two additional sampling points are required.
- If the sampling point is between the 95% UCL of background and the 95th percentile of background, then the complete dataset needs to be evaluated to determine if two additional sampling locations are required. If at least half of all data points at the edge of the AOC are at or below the 95% UCL of background and the remaining data points are between the 95% UCL of background and the 95th percentile of background, then no additional samples are required. If this criteria is not met, then two additional sampling points are required.

The cabinet may require additional sample locations if the data indicate that the extent of contamination has not been determined.

Literature Cited

United States Environmental Protection Agency (USEPA), 1995. Determination of Background Concentrations of Inorganics in Soils and Sediments at Hazardous Waste Sites. Office of Research and Development. Office of Solid Waste and Emergency Response. EPA/540/S-96/500. December, 1995.

United States Environmental Protection Agency (USEPA), 1998. Statistical Tests for Background Comparison at Hazardous Waste Sites. Supplemental Guidance to RAGS: Region 4 Bulletins – Addition #1. Interim Draft. USEPA Region 4, Waste Management Division. Atlanta, Georgia. November, 1998.

Table G-1. Summary Statistics for Ambient Inorganic Chemicals

Element	**Number of Samples**	**Range (mg/kg)**	**Mean (mg/kg)**	**Standard Deviation (mg/kg)**
Aluminum	679	1290 - 38,100	10969	5462.9
Arsenic	539	0.059 - 55.5	8.9	7
Barium	756	6.14 – 1160	111.3	92.4
Beryllium	696	0.061 - 3.57	0.8	0.5
Cadmium	701	0.004 - 9.46	0.68	1.4
Chromium	771	2.83 - 168	20.5	13.9
Cobalt	649	0.29 - 67.6	11.9	8.1
Copper	729	0.49 - 636	18.9	39.7
Iron	697	222 - 86,900	22456	13269.7
Lead	808	0.03 - 284	30	31.3
Manganese	685	8.43 - 5100	1017	854.9
Mercury	459	0.007 - 0.721	0.06	0.1
Nickel	716	0.39 - 83.7	20.9	13.1
Selenium	714	0.001 - 3.93	0.94	0.7
Silver	697	0.006 - 5.2	0.42	0.6
Thallium	633	0.13 - 28		
Vanadium	679	4.82 - 92.1	26.9	11.8
Zinc	721	6 - 470	55	46.3

Table G-2. Generic Statewide Ambient Background for Kentucky

Element	**Mean (mg/kg)**	**95% UCL of Mean (mg/kg)**	**60th Percentile (mg/kg)**	**95th Percentile (mg/kg)**
Aluminum	10969	11314	10800	21000
Arsenic	8.9	9.4	8.3	21.2
Barium	111.3	116.9	100	241
Beryllium	0.8	0.83	0.75	1.8
Cadmium	0.68	0.78	0.27	3.9
Chromium	20.5	21.3	19.3	40
Cobalt	11.9	12.4	13.1	25.1
Copper	18.9	21.3	13.8	41.7
Iron	22456	23284	22000	47600
Lead	30	33	20.9	84.6
Manganese	1017	1071	948	2620
Mercury	0.06	0.07	0.059	0.14
Nickel	20.9	21.7	20.2	46.8
Selenium	0.94	0.99	1.38	2.1
Silver	0.42	0.45	0.257	1.2
Thallium				7.95
Vanadium	26.9	27.7	27.3	48.6
Zinc	55	57	48.6	115

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Kentucky Guidance for Ambient Background Assessment

January 8, 2004

Natural Resources and
Environmental Protection Cabinet

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Introduction

This guidance document is intended to assist in comparing site data and background data for sites undergoing environmental assessment. These procedures provide a simplified statistical procedure for determining if the site data is part of the background population. It also provides generic statewide background values for inorganic chemicals that may be used in lieu of collecting site-specific background samples. The statistical procedures may be used for site-specific data or the generic statewide values in Tables 1 and 2. This guidance does not preclude other appropriate statistical comparisons from being made, but rather a simplified screening method that does not require a deep knowledge of statistics. If the site data set fails the statistical procedures in this guidance, it may be appropriate to perform a more complete statistical comparison.

Background, as defined in 401 KAR 42:005 (definitions codified to support the Underground Storage Tank regulations), means the concentration of substances consistently present in the environment at, or regionally proximate to, a release but outside the influence of the release. There are two types of background:

a) Natural background is the amount of naturally occurring substances in the environment, exclusive of that from anthropogenic sources.

b) Ambient background means the concentrations of naturally occurring inorganic substances and ubiquitous anthropogenic inorganic substances in the environment that are representative of the region surrounding the site and not attributable to an identifiable release.

Since sites undergoing environmental assessment are often found in industrialized and potentially contaminated areas, the determination of site-specific background concentrations is difficult. Generic ambient background values applicable to all sites in Kentucky would be useful for comparison to site data for the purpose of identifying those constituents requiring remedial action (i.e., removal or exposure control). These generic ambient background values would provide an alternative to attempting to identify site-specific background soils in areas that are likely contaminated.

Methodology

To provide an alternative to site-specific background sampling, the NREPC used background sample values provided by regulated facilities, as well as background sample values collected by cabinet employees. These samples were collected from areas generally considered to be outside of the influence of site activities, but were potentially impacted by regional or urban activity. Therefore, these samples represent "ambient," as opposed to "natural," background. From 400 to over 800 samples for each constituent were used in the analysis. For each constituent, a 95% Upper Confidence Limit (UCL) of the arithmetic mean, 60th percentile, and 95th percentile were calculated. The 95% UCL is the value below which the true mean of the data set falls, with 95% confidence. The 60th and 95th percentiles indicate that 60 percent and 95 percent of the data falls below those values.

The following methodology was employed to calculate ambient background:

1. Values reported as "non-detected" were retained in the database at half the reporting limit (USEPA, 1998).

2. As the data sets came from areas having varied uses (e.g., industrial, commercial, residential, agricultural, woodlands, etc.), the probability that some of the samples were taken in contaminated areas is significant. Data sets were tested for outliers by the Grubb's test, and individual samples that had a calculated Z-score above 3.8 were generally removed from the background data set. The Grubb's test formula is as follows:

$$Z = \frac{\left| population\ mean - value\ of\ individual\ sample \right|}{standard\ deviation}$$

3. The descriptive statistics of mean and standard deviation were calculated by standard parametric methods assuming normality and are listed in Table 1. Parametric methods were used to allow for comparisons between these generic ambient background values and the results of other published studies of background.

a. Standard deviation was calculated by the "nonbiased" method employing the formula:

$$S.D. = \sqrt{\frac{\sum\left(X_i - \overline{X}\right)^2}{n-1}}$$

b. Mean was calculated as the sum of all individual scores divided by the total number of observations.

4. The data sets were analyzed with Lillefor's test for normality. Since the data sets are not normally or lognormally distributed, the parameters that are to be used in determining if site samples are consistent with background (i.e. 95% UCL of mean, 60th percentile and 95th percentile) were calculated by nonparametric methods and are listed in Table 2.

5. The 95% UCL of the arithmetic mean for each constituent was calculated on the trimmed data set using ProUCL. ProUCL is a statistical package developed by Lockheed Martin under contract with the U.S. EPA.

6. The 60th percentile value is used as the midpoint for each constituent. It was calculated as follows:
   a. The constituent values were ranked in increasing order of magnitude.
   b. The quantity 60(n)/100 was used to identify the measurement with the resulting rank.

7. The 95th percentile value is used as the upper bound value for each constituent and was calculated as follows:
   a. The constituent values were ranked in increasing order of magnitude.
   b. The quantity 95(n)/100 was used to identify the measurement with the resulting rank.

The thallium data were characterized by a large number of non-detects (633 non-detects verses 54 detects). Due to the large number of non-detects, non-detects were not entered as ½ the non-detect concentration. Each non-detect sample was assumed to have a concentration equal to the recorded non-detect concentration. Considering the number of non-detects and the likelihood that the recorded values skew thallium concentrations upward, only the 95th percentile of the total data is cited in Table 2.

Procedure for Comparison to Background

The site data should be segregated by surface and subsurface data. The surface and subsurface site data may be compared to the statewide numbers in Table 2, or to site-specific background samples. The following three criteria may be used to demonstrate that the site data is background:

1. The mean site concentration for inorganic constituents must be below the 95% UCL of the mean concentrations of background for inorganic constituents.
2. At least half of the data points should be less than the 60th percentile.
3. No data points should be above the upper bound value (95th percentile).

These procedures provide a tool for comparing site data with either generic statewide or site-specific background using the statistical characteristics of the two populations. Other statistical comparisons may be used, if appropriate.

Determining Site-specific Background

Site-specific ambient background levels may be determined at the site. The site-specific ambient background data set shall consist of an appropriate number of samples for the statistical method employed. The number of samples necessary to characterize site-specific background will vary based on the variability of the data. Twenty data points may be used as a minimum number of samples per horizon (surface and subsurface) as a default number, unless other statistical methods can be used to develop a different number. A site-specific determination of the number of required samples may be calculated based on the statistical characteristics of the background population.

Upgradient groundwater samples are to be obtained from the same hydrogeological unit as the groundwater contamination at the site. The background monitoring wells shall be located hydrogeologically upgradient from the release(s) of concern, unless it can be demonstrated to the cabinet that the upgradient location is undefinable or infeasible.

Background soil samples should be collected from native soil in areas of similar soil type as found at the site. Background concentrations should be determined separately for surface and subsurface areas that are consistent with the on-site investigation.

The following areas are inappropriate to sample when determining soil background unless otherwise necessary to reach a corrective action decision or identify potential sources of contamination:

1. Fill areas;
2. Areas in which management, treatment, handling, storage or disposal activities of any of the following are known or suspected to have occurred: hazardous substances or petroleum, solid or hazardous wastes, or waste waters;
3. Areas within three feet of a roadway;
4. Parking lots and areas surrounding parking lots or other paved areas;
5. Railroad tracks or railway areas or other areas affected by their runoff;
6. Areas of concentrated air pollutant depositions or areas affected by their runoff;
7. Storm drains or ditches presently or historically receiving industrial or urban runoff; or
8. Areas within three feet of any current structure, or the former location of any structure, which is likely to have been painted with lead-based paint.

Literature Cited

United States Environmental Protection Agency (USEPA), 1995. Determination of Background Concentrations of Inorganics in Soils and Sediments at Hazardous Waste Sites. Office of Research and Development. Office of Solid Waste and Emergency Response. EPA/540/S-96/500. December, 1995.

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Chromium	771	2.83 - 168	20.5	13.9
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Copper	729	0.49 - 636	18.9	39.7
Iron	697	222 - 86,900	22456	13269.7
Lead	808	0.03 - 284	30	31.3
Manganese	685	8.43 - 5100	1017	854.9
Mercury	459	0.007 - 0.721	0.06	0.1
Nickel	716	0.39 - 83.7	20.9	13.1
Selenium	714	0.001 - 3.93	0.94	0.7
Silver	697	0.006 - 5.2	0.42	0.6
Thallium	633	0.13 - 28		
Vanadium	679	4.82 - 92.1	26.9	11.8
Zinc	721	6 - 470	55	46.3

Table 2. Generic Statewide Ambient Background for Kentucky

Element	**Mean (mg/kg)**	**95% UCL of Mean (mg/kg)**	**60th Percentile (mg/kg)**	**95th Percentile (mg/kg)**
Aluminum	10969	11314	10800	21000
Arsenic	8.9	9.4	8.3	21.2
Barium	111.3	116.9	100	241
Beryllium	0.8	0.83	0.75	1.8
Cadmium	0.68	0.78	0.27	3.9
Chromium	20.5	21.3	19.3	40
Cobalt	11.9	12.4	13.1	25.1
Copper	18.9	21.3	13.8	41.7
Iron	22456	23284	22000	47600
Lead	30	33	20.9	84.6
Manganese	1017	1071	948	2620
Mercury	0.06	0.07	0.059	0.14
Nickel	20.9	21.7	20.2	46.8
Selenium	0.94	0.99	1.38	2.1
Silver	0.42	0.45	0.257	1.2
Thallium				7.95
Vanadium	26.9	27.7	27.3	48.6
Zinc	55	57	48.6	115

Kentucky Guidance for Groundwater Assessment Screening

January 15, 2004

Environmental and
Public Protection Cabinet

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Introduction

This document provides guidance for evaluating contaminated sites to determine whether superficial and shallow contamination in soils indicates an existing or potential groundwater contamination problem, and whether a direct assessment of groundwater conditions is necessary. This method is intended to provide the party or applicant a cost-effective approach using soils data collected as part of the site characterization for determining the need to assess groundwater quality.

Methodology

An assessment of the effect of a release of a hazardous substance or petroleum on groundwater quality may not be necessary at all sites. This process is intended for sites that lack adequate groundwater monitoring data and where the party or applicant anticipates to leave in place contaminants of concern (COCs).

This approach to evaluating impacts and potential impacts of a release on groundwater is based on the attenuation of contaminants moving through the soil profile by means of biodegradation, hydrolysis, volatilization, adsorption, and dilution. Contaminants may not attenuate similarly in all situations, and therefore conservative Dilution Attenuation Factor (DAF) values are applied. However, conditions at some sites may result in contaminant migration through the soil profile in a manner that bypasses physical, chemical, and biological processes in the soils. Caution should be applied to use of this methodology at sites where normal physical, chemical, and biological processes in the soils are bypassed, including sites underlain by soils with large, interconnected pores (macropores) that provide for the rapid transport of water and contaminants through the soil profile, sites underlain by well-developed karst terrane, sites underlain by highly fractured media, or where contamination extends to the soil-bedrock interface. These types of sites may not provide for the soil processes assumed to be in effect in this method. In addition, this process is primarily intended for COCs that are relatively insoluble and are expected, under normal conditions, to remain in the soil profile and not to migrate to groundwater. Therefore, caution should be used in applying this methodology at sites where soluble or mobile COCs such as volatile organic compounds, nitrates, or dense non-aqueous phase liquids (DNAPL) are present; the presence of such COCs in the soils may indicate that a groundwater assessment may be necessary. The cabinet reserves the authority to require a direct assessment of groundwater at sites where it deems such investigation is prudent to understanding the extent of contamination and the risks associated with the release.

To determine whether a direct assessment of groundwater conditions is necessary, analytical data from the soil profile may be evaluated by the methods outlined in this document in combination with an evaluation of other soil conditions, and the geology and hydrology of the site. These data can be used to determine whether groundwater was likely to have been impacted, and whether these soils will serve as a future source of groundwater contamination.

In order to use this method, the horizontal and vertical extent of soil contamination must be known. An adequate number of soil borings with multiple, discreet sampling intervals of sufficient length and spacing to characterize vertical distribution of contamination are also necessary.

If it can be demonstrated using one of the following options that a release has not had and will not have an adverse effect on groundwater quality, a direct assessment of groundwater impacts may not be necessary.

1. An assessment of groundwater for a release may not be necessary if the applicable Soil Screening Levels, or SSL (DAF 1), in the U.S. EPA Region 9 Preliminary Remediation Goals (October 1, 2002) are not exceeded in the bottom two (2) sampling intervals of each soil boring.

2. Rather than using the default SSLs (DAF 1), a modified SSL may be used. This modified SSL takes into account the surface area of the site, the vertical separation between the contamination in the soil profile and groundwater, and the underlying bedrock conditions. The appropriate modified SSL is equivalent to the SSL (DAF 1) referenced in the U.S. EPA Region 9 Preliminary Remediation Goals, (October 1, 2002) multiplied by the applicable value in Table 1, below. An assessment of groundwater for a release may not be necessary if the applicable modified SSLs are not exceeded in samples from the bottom two (2) sampling intervals.

Table 1.

Vertical Separation Between Contamination in the Soil Profile and the Zone of Saturation	**Surface Area of Site and other considerations**		
	< 0.5 acres	**0.5-10 acres**	**> 10 acres, or site underlain by karst or highly fractured media**
0-5 ft	1	1	1
5-10 ft	5	2.5	1
10-15 ft	10	5	1
15-20 ft	15	7.5	2.5
Greater than 20 ft	20	10	5

3. A site-specific SSL may be developed and applied based on site-specific conditions, including soil types, characteristics of COCs, total organic carbon in the soil, soil porosity, infiltration rate, and the vertical separation between the contamination in the soil profile and groundwater. If the analytical results in the bottom two (2) sampling intervals do not exceed the site-specific SSLs, a groundwater assessment may not be necessary for that site.

4. A fate and transport evaluation may be developed to demonstrate that levels of COCs in the soils will not result in groundwater contamination beyond the property boundary. If a fate and transport evaluation adequately demonstrates that levels of COCs in the soils will not result in groundwater contamination beyond the property boundary, a groundwater assessment may not be necessary. However, a direct groundwater assessment will be required to make such a determination in most situations.

5. An analysis of the results of current and historical groundwater monitoring may be used to determine whether groundwater has been adequately characterized. Such an analysis shall contain sufficient information to determine whether groundwater has been affected by any releases at the site. The report of this analysis shall include:

a. The location of monitoring wells relative to the location of the soil contamination at the site, and to groundwater flow direction at the property;

b. Monitoring well construction details, including diameter of the annulus, diameter of the well casing, the depth and length of the screened interval, construction of the sand pack, and the type and manner of sealing materials used;

c. The proximity of wells to one another and to the property boundary; and

d. The results of all groundwater analyses conducted to date on samples collected at the property, including sample dates, the parameters analyzed, and the methods of collection and analysis.

A groundwater assessment is necessary and prudent in some circumstances. Any direct evidence of groundwater contamination, including seeps, contaminated wells and springs, or other similar information is compelling evidence to conduct a thorough groundwater investigation. The cabinet may direct a person or applicant to conduct a groundwater assessment in regards to a known or suspected release, regardless of the results of the methods employed above.

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Trichloroethylene Environmental Levels of Concern

Kentucky Department for Environmental Protection
Division of Environmental Services
Risk Assessment Branch
Jeri W. Higginbotham, Ph.D.

April 21, 2004

Kentucky Risk Based Screening Values for Trichloroethylene

Based on a Slope Factor of 3.22E-01 per mg/kg-d

Ambient Air – 0.013 ug/m^3

Tap Water – 0.046 ug/l

Residential Soil – 0.031 mg/kg

Industrial Soil – 0.077 mg/kg

Rural Residential Soil – 0.027 mg/kg

Recreational Soil – 0.5 mg/kg

Farmer Exposure Soil – 0.089 mg/kg

Outdoor Worker Soil – 0.1 mg/kg

Short-Term Outdoor Worker Soil – 2.5 mg/kg

Ambient Air (Child age 1 to 18) – 0.00084 ug/m^3

Tap Water (Child age 1 to 18) – 0.0018 ug/l

Trichloroethylene (TCE) is a colorless liquid with a somewhat sweet odor (ATSDR 1997a) similar to that of chloroform (Plunkett 1987). Synonyms are 1,1,2-trichloroethylene, trichloroethene, acetylene trichloride, and ethylene trichloride (Proctor, Hughes, and Fischman 1989). Registered trade names include Algylen, Blacosolv, Dow-Tri, Perma-A-Chlor, Trilene, and Vestrol (ATSDR 1997a). It has been produced commercially since the 1920's (IARC 1997) and is commonly used as a cleaning and degreasing agent in the manufacture of furniture and fixtures, fabricated metal products, electric and electronic equipment, transport equipment, and, to a lesser extent, textiles, paper, and glass (HSDB 2004). It is an ingredient in adhesives, paint removers, typewriter correction fluids, and spot removers (ATSDR 2003). Between the 1930's and 1950's, it was used in the dry cleaning industry (IARC 1997). In 1977, the United States Food and Drug Administration (FDA) banned the use of TCE as a grain fumigant, disinfectant, anesthetic, and as an extraction solvent to extract caffeine from coffee, oleoresins from spices, and oil from palm, coconut, and soybean seed (ATSDR 1997a).

Due to its long history of use, TCE is a widespread environmental contaminant. Between 1988 and 2001, total on-site and off-site releases of TCE in the United States decreased from 57,445,582 pounds to 8,484,115 pounds (Table 1). In every year, at least 97% was in the form of air emissions (TRI 2003) but there were also releases to land, surface water discharge, and underground injection. It has been found at 861 Superfund National Priorities List (NPL) sites (ATSDR 1997a). And not surprisingly, by leaching through soil, the rate of which is dependent on organic matter and soil moisture content, it has contaminated underground water sources (ATSDR 1997a).

Table 1. Releases of trichloroethylene by year from 1988 to 2001 in the United States. All values are reported in pounds. Data from TRI, 2003.

total air emissions	surface water discharge	under-ground injection	releases to land	total on-site releases	total off-site releases	total on- and off-site releases	year	air/total
8,249,587	406	98,220	12,609	8,360,822	123,296	8,484,118	2001	0.972356
9,759,536	593	47,877	9,713	9,817,719	159,396	9,977,115	2000	0.978192
10,605,822	1,034	0	148,867	10,755,723	168,374	10,924,097	1999	0.970865
13,265,539	882	593	800	13,267,814	126,053	13,393,867	1998	0.990419
18,224,059	568	986	3,975	18,229,588	182,423	18,412,011	1997	0.989792
21,886,451	541	1,291	9,740	21,898,023	89,527	21,987,550	1996	0.995402
26,282,939	1,477	550	3,577	26,288,543	74,145	26,362,688	1995	0.996975
30,948,761	1,671	288	4,070	30,954,790	96,312	31,051,102	1994	0.996704
31,007,030	5,220	460	8,212	31,020,922	233,561	31,254,483	1993	0.992083
30,838,983	8,606	466	20,726	30,868,781	248,714	31,117,495	1992	0.99105
36,356,277	12,784	800	62,991	36,432,852	115,973	36,548,825	1991	0.994732
40,028,932	14,285	805	12,554	40,056,576	753,864	40,810,440	1990	0.98085
49,798,528	15,849	390	8,686	49,823,453	1,250,933	51,074,386	1989	0.97502
55,943,736	13,801	390	21,186	55,979,113	1,466,469	57,445,582	1988	0.973856

TCE is degraded most rapidly in the air and least rapidly in groundwater. Degradation products depend on the medium and have adverse health effects of their own. In air, TCE persists for 11 to 14 days before decomposing to hydrochloric acid, dichloroacetyl chloride, phosgene, and carbon monoxide (Cal/EPA 1999). It rapidly evaporates from surface water but may persist in groundwater and soil for prolonged periods (ATSDR 2003). There is some evidence for microbiological degradation to cis and trans 1,2-dichloroethylene in soil and groundwater. In one study, a half-life of 1.0 to 1.5 years in groundwater was calculated (Cal/EPA 1999). Other studies have calculated half-lives in groundwater of 10.7 months and 4.5 years (Howard 1991). Rate of degradation depends on the presence of organisms capable of degrading the chemical, the availability of other metabolic requirements, and the amount of chemical present. In the absence of appropriate microflora or appropriate microfloral habitat, TCE may persist for centuries as a dense nonaqueous phase liquid (DNAPL) in subsurface pools and lenses. With a solubility of 1.1 grams per liter (Verschueren 1983), DNAPL TCE slowly dissolves into groundwater over prolonged periods, creating contaminant plumes (Newell and Ross 1992).

In mammals, the liver is the primary site of TCE metabolism with trichloroacetic acid (TCA) being the major end product. Other metabolic products are trichloroethanol, trichloroethanol-glucuronide, dichloroacetic acid, and dichlorovinyl cysteine. In addition to the liver, TCE metabolism occurs in the lungs and kidneys (EPA 2001). Blood and urine tests can detect TCE and many of its metabolic products for up to a week after exposure (ATSDR 2003).

Exposure to TCE has been linked to adverse health effects including liver and neurological dysfunction (ATSDR 1997a) and, accordingly, occupational and drinking water standards have been set. Based on adverse central nervous system effects, the Occupational Safety and Health Administration has established a time-weighted average permissible exposure limit (TWA PEL) of 50 ppm and a short term exposure limit (STEL) of 200 ppm (NIOSH 2001). The maximum contaminant level (MCL) for trichloroethylene in drinking water is 0.005 mg/L and the maximum contaminant level goal (MCLG) is zero. The basis for the MCL and MCLG was its potential to cause liver damage and certain cancers from a lifetime exposure above 0.005 mg/L (EPA 2002a).

However, carcinogenicity data for TCE was withdrawn from the United States Environmental Protection Agency (EPA) Integrated Risk Information System in 1989. The most recent EPA document concerning TCE is a preliminary draft entitled, “Trichloroethylene Health Risk Assessment: Synthesis and Characterization,” from the National Center for Environmental Assessment (EPA 2001). It draws on 16 state-of-the-science papers published as a supplemental issue of Environmental Health Perspectives (volume 108, supplement 2, May 2000) as well as many other papers and was reviewed by a panel of the EPA Science Advisory Board's Environmental Health Committee (EPA 2002b).

In this draft, EPA concludes that TCE is "highly likely to produce cancer in humans" and can be classified as a "probable human carcinogen" (group B1). The International Agency for Research on Cancer (IARC), also, classifies TCE as "probably carcinogenic to humans" (Group 2A). Their evaluation was based on limited evidence in humans and sufficient evidence in experimental animals for the carcinogenicity of trichloroethylene (IARC 1997).

Many epidemiological studies are reported for the effects of TCE, but their quality and informational content vary considerably. One of the less informative studies concerned a cohort of workers at one manufacturing plant in Roscoe, Illinois (Shindell et al. 1985). As compared to the entire U.S. population, fewer individuals than expected died, and this was true for every cause of death (cardiovascular, respiratory cancer, nonrespiratory cancer, stroke, trauma, and other). Statistically significant deficits were in overall mortality, nonrespiratory cancer, and trauma. That there were deficits for every cause of death suggests that other parameters besides TCE exposure were varying between the cohort and the comparison group (healthy worker effect). The authors end by postulating the presence of "some other factor contributing to the favorable experience." Furthermore, cancers were only categorized as respiratory or nonrespiratory and exposure data were not provided. This study is simply not informative and provides no evidence for TCE health effects of any kind. Wartenberg (2000) placed it in his Tier II group of cohort studies, Tier I being composed of the most informative studies. The Science Advisory Board review panel endorsed

Wartenberg's classification system and went on to recommend that EPA weight the Tier I studies more strongly than other studies (EPA 2002b).

Of the four epidemiological studies discussed by EPA (2001), three were Tier I cohort studies and one was community based (Wartenberg 2000). A New Jersey study tracked individuals in a 75-town area affected by drinking water contamination (Cohn et al. 1994). Occupational exposure of Finnish workers to three halogenated hydrocarbons, tetrachloroethylene (PCE), 1,1,1-trichloroethane, and TCE was reported by Anttila et al. (1995). Blair et al. (1998) followed a cohort of workers who were employed at Hill Air Force Base for at least one year and who were exposed by vapour inhalation. A fourth and final study reported on the incidence of kidney cancer in German cardboard workers (EPA 2001).

In the New Jersey study, female residents had statistically significant excesses of leukemia and non-Hodgkin lymphoma where relative risks (RR), 95% confidence intervals (CI), and the number of cases (N) were RR=1.43, 95% CI=1.07-1.90, N=56 and RR=1.36, 95% CI-1.08-1.70, N=87 respectively (Cohn et al. 1994). Epidemiological studies often report data as relative risk where the probability of disease in the study group is divided by the probability of disease in the control group. A RR value above 1.0 indicates an excess of disease in the study group while a RR value below 1.0 indicates a deficit of disease in the study group. If the confidence interval does not contain 1.0, then the relative risk is statistically significant at the stated level of confidence which is usually 95%.

Based on this study, a unit risk estimate and slope factor for non-Hodgkin lymphoma was calculated by EPA (2001) using the following rationale. A relative risk factor of 1.36 is interpreted as a 36% increased risk of getting this disease. (EPA actually rounded up the relative risk to 1.40.) By multiplying the background risk of getting non-Hodgkin lymphoma by 0.36 and dividing by the average concentration of TCE in those homes where the concentration exceeded the MCL of 5 ppb a unit risk estimate was calculated. The background risk was given as 6E-04 (prevalence of the disease in the United States), and the average concentration was 23.4 ug/L. The unit risk is 9.2E-06 per ug/L. The resulting slope factor based on a 70 kg adult drinking 2 L/d is 3.22E-01 per mg/kg-d average lifetime exposure to TCE for non-Hodgkin lymphoma. (EPA, using 1.4 as the relative risk and rounding up, listed 4.00E-01 per mg/kg-d in Table 4-9.) Dividing this slope factor into 10^{-6} yields a risk-specific dose of 3.1E-06 mg/kg-d. For a 70 kg individual, the maximum daily dose is 2.2E-04 mg/d (0.22 ppb) which is well below the routine detection limit of 1.0E-03 mg/l (1.0 ppb) in water (King County 2002).

One weakness of this study was that it was impossible to control for other impurities in the water, some of which might contribute to the risk of developing these two cancers. Though TCE was present in the greatest concentration, PCE was also a common contaminant. Both are thought to exert carcinogenic effects through common metabolites. To that end, it is estimated that only from 1-3% of the absorbed PCE is metabolized (ATSDR 1997b), whereas from 40-75% of the absorbed TCE is metabolized (ATSDR 1997a). Furthermore, very little research has been done to confirm or refute the hypothesis that combinations of compounds act in an additive or greater-than-additive (synergistic) manner. Certain combinations might act in a less-than-additive (antagonistic) manner. And there is one report indicating that PCE inhibits the metabolism of TCE in humans (ATSDR 2002). As for other contaminants, no association was detected between leukemia or non-Hodgkin lymphoma incidence and trihalomethanes, benzene, 1,1,1-trichloroethane, carbon tetrachloride, and trans-1,2-dichloroethylene. The apparent risk seems largely attributable to TCE.

A strength of the study was the socio-economic similarity of the municipalities compared. And, as with any epidemiological study, uncertainties in extrapolating from animal to human effects and from high to low doses are avoided (EPA 2001).

In the Finnish study, the following statistically significant standardized incidence ratios (SIRs) and 95% CI were reported for the entire cohort of 3974 workers: 2.35 for cervical cancer (95% CI-1.08-4.46), 2.13 for non-Hodgkin's lymphoma (95% CI-1.06-3.8), and 1.63 for lymphohematopoietic cancers (95% CI-1.06-2.41). Standardized incidence ratios are the ratio of observed cancer incidence in the cohort to the expected cancer incidence based on the population of Finland adjusted for age and sex. The cohort was subdivided according to exposure and duration of exposure. One subgroup was monitored for urinary TCA, a major metabolite of TCE, and had been followed for at least 19 years since the first measurement. This subgroup had statistically significant SIRs of 1.57 for all cancers (95% CI-1.2-2.02), 2.98 for stomach cancer (95% CI-1.2-6.13), 6.07 for liver cancer (95% CI-1.25-17.7), 3.57 for prostate cancer (95% CI-1.54-7.02), and 2.98 for lymphohematopoietic cancers (95% CI-1.2-6.14). Among a subgroup who were monitored for blood PCE levels, no statistically significant SIRs were reported. By the author's calculations though, exposure was greatest for TCE accounting for 80% of the person-years at risk (Anttila et al. 1995).

Using urinary TCA to quantify exposure, slope factors were calculated for liver cancer (7.0E-02), kidney cancer (2.0E+00), and non-Hodgkin lymphoma (7.0E+00) (EPA 2001). However, only liver cancer was statistically significantly elevated among those workers with known exposure to trichloroethylene. Of the 11 cases of non-Hodgkin lymphoma, 3 were attributed to exposure to PCE resulting in a statistically non-significant excess in those exposed to TCE (SIR=1.81, 95% CI-0.78-3.56). In addition to the small number of cancer cases, exposure duration was uncertain (Anttila et al. 1995). Even though the comparison group was generated from the Finnish population, Anttila (1995) argues that, "It is not probable that chemicals other than solvents, or life-style patterns (such as alcohol consumption, smoking, sexual habits) explain the excesses in the present cohort, because excesses of the same primary sites were not seen in a parallel, in many respects comparable, cohort of workers monitored for lead exposure."

In the Hill Air Force Base study, statistically non-significant excesses of non-Hodgkin lymphoma (RR=2.0, 95% CI=0.9-4.6), multiple myeloma (RR=1.3, 95% CI=0.5-3.4), breast cancer (RR=1.8, 95% CI=0.9-3.3), kidney cancer (RR=1.6, 95% CI=0.5-5.1), and cancer of the liver (RR=1.7, 95% CI=0.2-16.2) and biliary passages (RR=1.3, 95% CI=0.5-3.4) were reported. It is, perhaps, timely to note here that a trend may be biologically significant but not statistically significant. Strengths of this study include it's size (n=14,457), the extended follow up that enables inclusion of effects with long latent periods, and the use of an internal control group to "minimise the potential for selection and socioeconomic problems associated with the use of the general population for comparison." Limitations of the study include the fact that other solvents were used on base, though TCE was the main solvent used historically, and exposure estimates were qualitative rather than quantitative (Blair et al. 1998). Without quantitative exposure estimates, risk estimates cannot be derived.

The fourth study discussed by EPA (2001) tracked German cardboard workers exposed to TCE. This study noted an increased incidence of kidney cancer but may have been initiated after the observation of a cluster (IARC 1997). Problems associated with this study include a lack of exposure data, the use of other solvents in addition to TCE, an unadjusted incidence (EPA 2001), and differing diagnostic methodology between the cohort and comparison group (EPA 2002b).

More recently, Raaschou-Nielsen et al. (2003) reported on a Danish cohort of 40,049 blue-collar workers in 347 Danish companies with documented TCE use. The SIR for all cancers was 1.08 (95% CI-1.04-1.12). Other statistically significant SIRs were:

- 1.8 for esophageal adenocarcinoma (95% CI-1.15-2.73) among men,
- 2.8 for primary liver cancer (95% CI-1.13-5.80) among women,
- 2.8 for gallbladder and biliary passage cancer (95% CI-1.28-5.34) among women,
- 1.4 for lung cancer (95% CI-1.28-1.51) among men and
- 1.9 (95% CI-1.48-2.35) among women,
- 1.9 for cervical cancer (95% CI-1.42-2.37),
- 1.2 for non-Hodgkin's lymphoma (95% CI-1.0-1.5) among the entire cohort, and
- 1.8 for esophageal adenocarcinoma (95% CI-1.2-2.7) among the entire cohort.

A non-significant SIR of 1.7 was noted for leukemia (95% CI-0.89-2.86) in women. An obvious strength of this study is its large cohort size. Unfortunately, it suffers from a poorly chosen control group, the Danish population. The authors admit that their experimental and control groups probably differed in the proportion of individuals in each socio-economic group. Cigarette smoking is known to be higher in the least educated groups in Denmark and may be a confounding factor in this study weakening the association between TCE and lung cancer. The authors note that social class is probably a confounding factor for cervical cancer as well. And because exposure was not quantified, risk estimates cannot be calculated.

Raaschou-Nielsen et al. (2003) as well as the three studies used by EPA (2001) report increased incidence of lymphohematopoietic cancers (non-Hodgkin's lymphoma, multiple myeloma, and leukemia). Three studies noted excesses of liver cancer. Leukemia and myeloma originate in the bone marrow while lymphoma originates in lymphatic tissues. These cancers are considered to be related because they involve the uncontrolled growth of cells with similar functions and origins. The diseases are not thought to be heritable, although a few cases of familial lymphoma have been reported, but rather to result from acquired injury to the cell, which becomes abnormal (malignant) and multiplies continuously (Bock 2004). Lymphohematopoietic cancers are basically environmentally caused diseases. Known environmental risk factors for liver cancer include aflatoxin, anabolic steroids, arsenic, cirrhosis, hepatitis, thorium dioxide, tobacco use, and vinyl chloride (ACS 2003).

Furthermore, three of these cancers have increased in incidence over the last 30 years as reported by the Surveillance, Epidemiology, and End Results (SEER) database. The incidence of non-Hodgkin's lymphoma across all races in the US increased from 11.1 per 100,000 in 1975 to 19.9 per 100,000 in 1994 with a subsequent decline to 19.0 per 100,000 in 2000. Incidence of myeloma followed a similar pattern increasing from 4.65 per 100,000 in 1973 to 6.0 per 100,000 in 1997 with a subsequent decline to 5.47 per 100,000 in 2000. Leukemia incidence actually declined from12.5 per 100,000 in 1973 to 11.9 per 100,000 in 2000, but not by much (SEER 2003). Liver cancer has increased from 2.7 per 100,000 in

1973 to 5.3 per 100,000 in 2000 (SEER 2003). All of the above-mentioned rates are age adjusted with all age groups, 0 to 85+, used.

Genetic toxicity studies using cultured cells from exposed and unexposed individuals lend support to the epidemiological connection between TCE and lymphohematopoietic cancers in humans. As reviewed by the California Environmental Protection Agency (Cal/EPA), in some, but not all, studies using peripheral lymphocyte cultures, genetic effects were noted. These included hyperdiploidy, hypodiploidy, sister chromatid exchanges, and chromosome structural anomalies including breaks, deletions, gaps, inversions, and translocations (Cal/EPA1999).

The epidemiological evidence is, also, supported by studies in rats and mice. Cal/EPA noted, “The principal findings are: 1) liver carcinomas in male mice by inhalation and in both sexes by gavage administration; 2) lung carcinomas in female mice by inhalation; and 3) kidney tubular carcinoma in male rats by inhalation and gavage dosing.” In one study, an increased incidence of malignant lymphoma was observed in TCE-exposed female Han:NMR1 mice and, in another, TCE was associated with the development of testicular interstitial cell tumors in Marshall rats (Cal/EPA 1999).

Cal/EPA (1999) used data from two liver tumor studies in mice to generate slope factors. Using total amount of TCE metabolized by the liver, the lower 95% confidence limit on the dose associated with a 10% tumor incidence (LED_{10}) was calculated (EPA 1996). The following four slope factors were calculated as $0.1/LED_{10}$:

- 2.1E-02 in females by gavage,
- 7.7E-02 in males by gavage,
- 4.7E-03 in females by inhalation, and

- 3.4E-03 in males by inhalation.

The geometric mean of these slope factors is 1.3E-02 per mg/kg-d which is what Cal/EPA used to calculate their public health goal for the concentration of TCE in drinking water. The author admits ignorance as to how an average value can be protective of sensitive populations. On the other hand, their public health goal of 0.8 ppb is below the routine detection limit of 1.0 ppb. Moreover, this is the slope factor which was endorsed by EPA Region 4 last year (email from Ted Simon 2003).

Risk estimates associated with the rat and mice studies were reported by EPA (2001) as well. The slope factor and risk-specific dose for kidney cancer in rats was 3.0E-04 and 3.3E-03 respectively. Slope factors and risk-specific doses for liver cancer in mice using internal TCA as the dose metric ranged from 3.0E-02 to 2.0E-01 per mg/kg-d and from 0.5E-05 to 3.1E-05 mg/kg-d respectively.

Considering both the epidemiological studies and the rat and mice studies, slope factors range from 7.0 to 3.0E-04 per mg/kg-day which is a 23,000 fold difference. EPA proposed ignoring the lowest and highest estimates. The remaining slope factors range from 4.0E-01 (3.22E-01 as calculated here) to 2.0E-02 per mg/kg-d which is a 20 fold difference. This is slightly higher than EPA's previous slope factor of 1.1E-02 and Cal/EPA's, 1.3E-02.

EPA (2001), following National Research Council recommendations, did not consolidate these slope factors into a single estimate. They advise selecting an appropriate slope factor from the range. For example, "Risk assessments involving the presence of risk factors such as diabetes or alcohol consumption, or high background exposure to TCE or its metabolites, would more appropriately choose a higher slope factor." An estimated 6.3% of the population in this country have diabetes (NIDDK 2003) and in Kentucky, 6.8% have been diagnosed with it (CDC 2003). Given that diabetes is so prevalent, the higher slope factor should be chosen all the time.

Historically, EPA (1989) has been protective of sensitive populations and, in calculating reference doses, has recommended an uncertainty factor of 10 to account "for variation in the general population….intended to protect sensitive subpopulations." Moreover, the Science Advisory Board review panel (EPA 2002b) expressed concern "for diseased individuals (diabetes, hepatitis, HIV positive, etc.), who may be especially susceptible to TCE exposure." We are only just beginning to understand the range of human metabolic variation, the frequency of metabolic variants within the population, and what amount and kind of variation would cause susceptibility to the effects of chronic exposure to TCE (see Lipscomb et al. 2003 for an example). Until we know the frequency of metabolic variants susceptible to low level exposure to TCE we must assume that the frequency is greater than 1.0E-06.

The Science Advisory Board review panel (EPA 2002b) recognized the importance of epidemiological studies, stating that they "merit special attention because they may be potentially important in terms of population-attributable risk." Furthermore, the panel recommended that where such studies are the basis of risk estimates, they should be the ones, "among the studies that are well designed, that would generate the most health-protective number."

EPA Region 9 (2002) lists 4.00E-01 per mg/kg-d as both the oral and inhalation slope factor for TCE citing NCEA as the source. In an effort to find the origin of that slope factor, I contacted EPA Environmental Health Scientist, Dr. Weihsueh Chiu, who thought it came from the 2001 draft assessment (EPA 2001 and email from Weihsueh Chiu 2004). EPA

(2001) provides two slope factors using data from Cohn et al. (1994), 4.00E-01 per mg/kg-d in Table 4-9 and 3.5E-01 per mg/kg-d in Section 4.5.1.3. A slope factor of 4.00E-01 per mg/kg-d is not associated with any other study in EPA (2001). Using the original paper (Cohn et al. 1994), it is calculated as 3.22E-01 per mg/kg-d here.

The choice of a higher slope factor (3.22E-01 per mg/kg-d) seems easily justified. It is being used in EPA Region 9 and EPA Region 10 (2004) who uses Region 9's values. The higher risk estimates are protective of sensitive populations. This specific risk estimate is based on an epidemiological study. The epidemiological studies are supported by evidence from rat, mice, and cell culture studies.

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E.4. FLOW CHART FOR UNCERTAINTY MANAGEMENT FOR UNKNOWN AREAS OF CONTAMINATION

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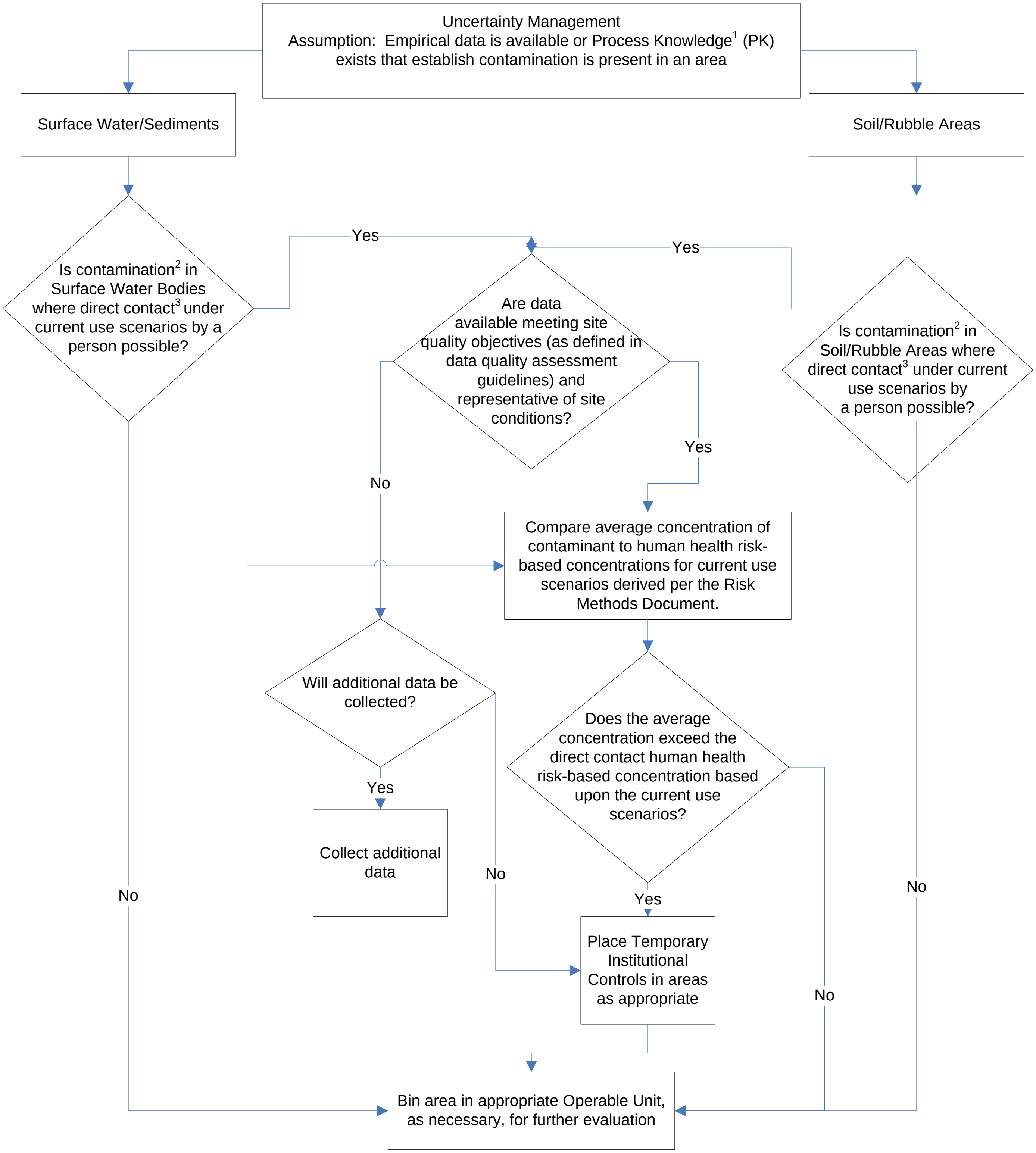
Flow Chart for Uncertainty Management

This flowchart applies to newly identified areas of contamination that may be identified in the future on DOE-owned property licensed for use at the Paducah Gaseous Diffusion Plant, which are outside the controlled area and not currently assigned to an operable unit under the federal Facility Agreement. The flowchart describes uncertainty management for non-worker exposures associated with DOE-owned property described above.



1 “Process Knowledge” is defined as information identifying releases from past or current processes at the PGDP.

2 “Contamination” is defined in the Risk Methods Document as the presence of a constituent at a concentration greater than background.

3 “Direct contact” is exposure by a human to environmental medium [i.e., surface soil, sediment, debris (e.g., rubble), and surface water] through ingestion, dermal contact, inhalation (particulates and vapors), or external exposure.

Enclosure
(Cont)

Further Explanation of Flow Chart Steps

Uncertainty Management Assumption: Empirical data is available or Process Knowledge[1] (PK) exists that establish contamination is present in an area	This flowchart applies to newly identified areas of contamination that may be identified in the future on DOE-owned property licensed for use at the Paducah Gaseous Diffusion Plant, which are outside the controlled area and not currently assigned to an operable unit under the federal Facility Agreement. The flowchart describes uncertainty management for non-worker exposures associated with DOE-owned property described above. Sufficient data or credible Process Knowledge must exist for this process to be activated.
Is contamination[2] in Surface Water Bodies or Soil/Rubble Areas where direct contact[3] under current use scenarios by a person possible?	Contamination definition is identified in Footnote 2. This process focuses on areas of surface soil, sediment, debris (e.g., rubble), and surface water that are located in the licensed area and available for direct contact exposure. Examples of exposure scenarios are riding horses or ATVs in the creek and bank areas, walking or hiking through wildlife habitat, or hunting.
Are data available meeting site quality objectives (as defined in data quality assessment guidelines) and representative of site conditions?	An evaluation of the available data will be performed to determine if data are of sufficient quality to be used for risk assessment. Additional data may be collected to determine appropriate protective actions.
Compare average concentration of contaminant to human health risk-based concentrations for current use scenarios derived per the Risk Methods Document.	Average concentrations (calculated from existing data using protocols defined in the Risk Methods Document and other guidance documents) from existing data will be compared to the human health risk-based concentrations. Risk-based concentrations used will be based on guidance in the current site Risk Methods Document.
Place Temporary Institutional Controls in areas as appropriate	Temporary institutional controls may vary depending on the nature of contamination. DOE may place temporary institutional controls under CERCLA, perform a maintenance action, or post under 10 *CFR* 835.
Bin area in appropriate Operable Unit, as necessary, for further evaluation	DOE, EPA, and KY will determine the appropriate Operable Unit under which the area may be placed for future evaluation in accordance with the FFA. These agencies will determine if immediate actions such as sampling or removal actions are warranted based on potential risk and exposure to the public.

E.5. DATA QUALITY OBJECTIVE MATERIALS

These Data Quality Objective (DQO) materials were obtained from the Hanford DQO website at http://www.hanford.gov/dqo/. Additional materials on the DQO process can be found at that website. The purposes and steps in the DQO process are summarized below; the DQO flowchart, checklists, and example checklists are included in Attachment 2 to this appendix.

E.5.1 DQO Purpose and Goals

The DQO Process is a strategic planning approach based on the Scientific Method to prepare for a data collection activity. It provides a systematic procedure for defining the criteria that a data collection design should satisfy, including when to collect samples, where to collect samples, the tolerable level of decision error for the study, and how many samples to collect, balancing risk and cost in an acceptable manner. Using the DQO Process will assure that the type, quantity, and quality of environmental data used in decision making will be appropriate for the intended application, resulting in environmental decisions that are technically and scientifically sound and legally defensible. In addition, the DQO Process will guard against committing resources to data collection efforts that do not support a defensible decision.

What are DQOs? DQOs are qualitative and quantitative statements derived from the outputs of the first six steps of the DQO Process that do the following:

1. Clarify the study objective;
2. Define the most appropriate type of data to collect;
3. Determine the most appropriate conditions from which to collect the data; and
4. Specify tolerable limits on decision errors which will be used as the basis for establishing the quantity and quality of data needed to support the decision.

The DQOs then are used to develop a scientific and resource-effective data collection design.

By using the DQO Process, decision makers are assured that the type, quantity, and quality of environmental data appropriate for the intended application. In addition, decision makers will guard against committing resources to data collection efforts that do not support a defensible decision.

Each of the seven steps is described briefly below. A more detailed description can be found in the subsequent chapters of this guidance (EPA 1994; EPA 2000a; and EPA 2000b).

- **Step 1: State the Problem**
- Concisely describe the problem to be studied. Review prior studies and existing information to gain a sufficient understanding to define the problem.

- **Step 2: Identify the Decision**

- Identify the Principal Study Questions that need to be answered and what actions may result, in order to resolve the Problem Statement.

- **Step 3: Identify the Inputs to the Decision**
- Identify the information and environmental measurements that are needed to resolve the Principal Study Questions.

- **Step 4: Define the Study Boundaries**

- Specify the time periods and spatial area to which decisions will apply. Determine when and where data should be collected.

- **Step 5: Develop a Decision Rule**

- For each Principal Study Question, define the statistical parameter of interest, specify action levels, and integrate the previous DQO outputs into "if...then" statements that describes the logical basis for choosing among alternative actions.

- **Step 6: Specify Tolerable Limits on Decision Errors**

- Define the decision maker's tolerable decision error rates[1] based on the consequences of making an incorrect decision.

- **Step 7: Optimize the Design**

- Evaluate information from the previous steps and generate alternative data collection designs. Choose the most resource-effective design that meets all DQOs.

[1] *A decision error rate is the probability of making an incorrect decision based on data that inaccurately estimate the true state of nature.*

E.5.2 DQO References

- EPA 1994a: Guidance for the Data Quality Objectives Process, EPA QA/G-4, U.S. EPA, Quality Assurance Management Staff, Washington, DC, Final, September.

- EPA 2000a: Guidance for the Data Quality Objectives Process; Office of Environmental Information, U.S. EPA, Washington, DC, August.

- EPA 2000b: Data Quality Objectives Process for Hazardous Waste Site Investigations; Office of Environmental Information, U.S. EPA, Washington, DC, January.

- EPA 1997. U.S. EPA Office of Inspector General, Report of Audit: Laboratory Data Quality at Federal Facility Superfund Sites, E1SKB6-09-0041-71001.32, March 20.

E.5.3 Summary of Key Elements to the DQO Process

Presented below is a list of key elements that technical reviewers will be looking for when reviewing DQO process summary reports. Prior to issuing a DQO process summary report for review, the document writer should review the key elements listed below to ensure they have been adequately addressed.

Step 1: State the Problem

Key Elements:

- Comprehensive **scoping** effort
- **Conceptual Site Model** based on comprehensive **scoping** effort
- **Concise Statement of the Problem**(s), based on the Conceptual Site Model, that provides unambiguous focus for the Project

General Format:

In order to *[show that lead is contributing to the decrease in duck populations in the wetlands]*, data regarding *[levels of lead in the surface water, sediments, and vegetation in the marshlands]* is needed.

Step 2: Identify Decisions

Key Elements:

- **Decision Statement**(s) designed to address the concerns highlighted in the problem statement
    - **Principal Study Questions** (PSQ) that identify key unknown conditions or unresolved issues requiring environmental data
    - **Alternative Actions** that state all possible actions that might be taken once a PSQ has been resolved

General Format:

Determine whether [unknown environmental condition/issue/criterion from the Problem Statement] requires [choosing between two or more Alternative Actions].

Specific Format:

Determine whether [Principal Study Question #1] requires [Alternative Action A] or [Alternative Action B].

EXAMPLE:

Determine whether [lead is contributing to the decrease in duck populations] and requires [remediation by removal of the lead from the bottom of the ponds] or [regulation on the types of pellets that future hunters may use] or [requires no action].

Step 3: Identify Inputs:

Key Elements:

- **Informational Inputs** required to resolve the PSQs identified in Step 2
  - **Environmental variables** that require measurements
  - **Sources for data**
  - **Level of Quality** needed for the Decision(s)
  - **Usability of Existing Data** sets
    - **Quality Assured**
    - **Statistically valid**
    - **Agrees with Conceptual Site Model**
  - **Information** needed to **establish action levels**
  - Analytical **Methods** and **Detection Limits**

Step 4: Specify Boundaries

Key Elements:

- **Scale of decision** making
  - **Population** of interest
  - **Geographical (Spatial) boundaries** of the decision statement
  - **Temporal boundaries** of the decision statement
  - **Constraints** to sampling

Step 5: Define Decision Rules

Key Elements:

- **Decision Rules** (if/then statements) that combine:
  - **Parameter of interest**
    - Population Parameter
    - Sample Statistic
    - Environmental Variable
    - Chemical/Physical Attribute in the population
    - Quantity
  - **Scale of Decision Making**
    - Geographic Area/Volume
    - Timeframe
    - Population
  - **Action Level**
  - **Alternative Action(s)**

EXAMPLE:

If the *[true mean (as estimated by the 90% UCL of the sample mean) concentration of cadmium]* within *[the fly ash leachate in a container truck for a period of 1000 years]* is greater than *[1 mg/kg]*, then *[the fly ash waste will be considered hazardous and will be disposed of in a RCRA facility]*; or *[the fly ash waste will be disposed of in a municipal landfill]*.

Step 6: Specify Error Tolerances

Key Elements:
- **Expected Range** of data values
- Possible **decision errors**
- **Null** and alternative hypotheses
- **Consequences** of decision errors
- **Severity** of consequences
- **Tolerable limits** on decision errors
- **Gray Region** boundaries

Step 7: Optimize Sample Design

Key Elements:
- **Select a statistical method** (equation) based on the frequency distribution of the COPCs.
- **Calculate the Number of samples needed** to make decision using various tolerable error limits.
- **Develop the AUSCAS** (Aggregate Unit Sample Collection and Analysis Cost) **equation**.
- **Develop a Cost of Sampling versus Uncertainty relationship** (Table).

Select the most resource-effective data collection and analysis design that satisfies the DQOs specified in the proceeding 6 Steps.

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APPENDIX E
ATTACHMENT 2

DQO INFORMATION

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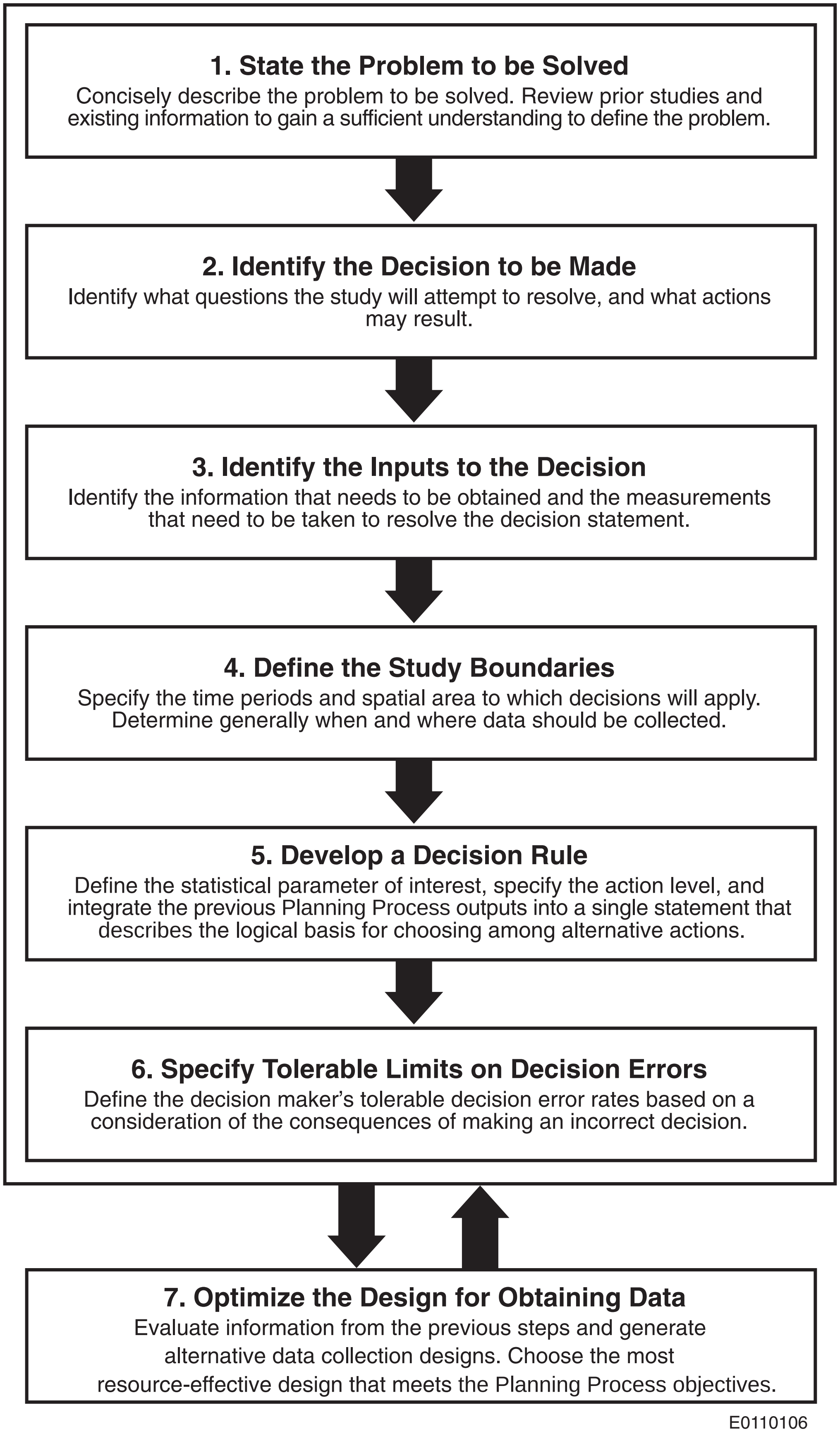
Systematic Planning Process Flowchart



1. State the Problem to be Solved

Concisely describe the problem to be solved. Review prior studies and existing information to gain a sufficient understanding to define the problem.

2. Identify the Decision to be Made

Identify what questions the study will attempt to resolve, and what actions may result.

3. Identify the Inputs to the Decision

Identify the information that needs to be obtained and the measurements that need to be taken to resolve the decision statement.

4. Define the Study Boundaries

Specify the time periods and spatial area to which decisions will apply. Determine generally when and where data should be collected.

5. Develop a Decision Rule

Define the statistical parameter of interest, specify the action level, and integrate the previous Planning Process outputs into a single statement that describes the logical basis for choosing among alternative actions.

6. Specify Tolerable Limits on Decision Errors

Define the decision maker's tolerable decision error rates based on a consideration of the consequences of making an incorrect decision.

7. Optimize the Design for Obtaining Data

Evaluate information from the previous steps and generate alternative data collection designs. Choose the most resource-effective design that meets the Planning Process objectives.

DQA Process Flowchart

1. Review the Data Quality Objectives and Sampling Design

Review the DQO outputs to assure that they are still applicable.
Review the sampling design and data collection
documentation for consistency with the DQOs.

2. Conduct a Preliminary Data Review

Review quality assurance reports, calculate basic statistical quantities and generate graphs of the data. Use this information to learn about the structure of the data and identify patterns, relationships, or potential anomalies.

3. Select the Statistical Test

Select the most appropriate for summarizing and analyzing the data, based on the preliminary data review. Identify the key underlying assumptions that must hold for the statistical procedures to be valid.

4. Verify the Assumptions of the Statistical Test

Evaluate whether the underlying assumptions hold, or whether departures are acceptable, given the actual data and other information about the study.

5. Draw Conclusions from the Data

Perform the calculations required for the statistical test and document
the inferences drawn as a result of these calculations.
If the design is to be used again, evaluate the performance of the sampling design.

Keith, L. H., 1996, *Principles of Environmental Sampling*, 2nd ed., American Chemical Society, Washington, D.C.

PROJECT TITLE: BASIN SEDIMENT CHARACTERIZATION

I	**ASPECT:** Project Scope	**PERSON ASSIGNED RESPONSIBILITY:** Project Engineer

ISSUES: Identify the questions and problems to be resolved through the DQO process. What is the focus of the project? What is/is not important for the resolution of the concerns that are the subject of this DQO? What questions will be resolved through the DQO process?

I(a)	**COMPONENT:** Project Assumptions	**SOURCE:** Project Engineer

SUMMARY:

The Basin received, segregated, and stored spent fuel during reactor operation. The Basin, along with all adjacent facilities, is scheduled for disposition through the decontamination and decommissioning (D&D) process. Before D&D of the structure can begin, all water and sediment in the Basin must be characterized and disposed of. The sediment will be transferred to the adjacent Cask Pit for characterization. Current plans call for disposal in the Disposal Facility. The following issues provide a starting point for this DQO process, which is to address the characterization of the Basin sediment.

∃ Historical data, while providing an indication of what may be expected, are insufficient for final sediment characterization and disposition.

∃ Not enough is known about the sediment distribution in the Basin to support an assumption of homogeneity across the Basin floor. Sampling the sediments in situ, therefore, requires a relatively large number of samples to be representative.

∃ All of the sediment currently in the Basin will be removed to the Cask Pit for characterization prior to disposal. This sediment, along with the existing sediment content of the Cask Pit, will be suitable for disposal at the Disposal Facility.

∃ Although interim sampling is highly desirable, final characterization and selection of a disposition option may not occur prior to final sampling.

Sediments will be dewatered for disposal at Disposal Facility. Water from this process will be sent to the Effluent Treatment Facility for treatment and disposal and is subject to the waste acceptance criteria at that facility. TRU wastes will be evaluated for disposal alternatives if they are found in the sediment.

I(b)	**COMPONENT:** Project Goals	**SOURCE:** Project Engineer

SUMMARY:

Characterize the sediment from the Basin and Cask Pit to verify that it meets the waste acceptance criteria (WAC) for the Disposal Facility.

II	**ASPECT:** Process/Activity Knowledge	**PERSON ASSIGNED RESPONSIBILITY:** Project Task Lead

ISSUES: Describe the processes/activities that took place at the site under consideration in sufficient detail to support this DQO. What processes/activities took place at the site? Which processes/activities are significant for the decisions that are required for this DQO? Are there documents to support this history? Are personnel available to interview regarding this history? Are the process materials (input and output) described in detail?

II(a)	**COMPONENT:** Process/Activity Description	**SOURCE:** Dodson, T.K. - Reactor Area Project Plan

SUMMARY:

The purpose of the Basin was to receive, segregate, and store spent fuel during Reactor operation. The Basin is a reinforced unlined concrete structure 45.7 (150 ft) long by 15.2 m (50 ft) wide and 7.3 m (24 ft) deep. Basin construction materials include concrete, both bare and painted; painted carbon-steel structural components; borated concrete cubicle panels; stainless-steel transport carts (Fast Carts); and aluminum cubicle lids.

Reactor fuel is metallic uranium (^{238}U slightly enriched with ^{235}U) clad in a zirconium alloy. It is of concentric tube-within-a tube design. Outer fuel elements are about 5 cm (2 in.) in diameter and 43 cm (17 in.) to 66 cm (26 in.) in length. Inner elements are the same length as the outer element making up the fuel assembly, and about 2.54 cm (1 in.) in diameter with a small center hole for coolant circulation. Standoffs were used between the inner and outer element and between the outer element and the process tube to maintain annular coolant flow. Carbon-steel perforated spacers of 43 to 55.8 cm (17 to 22 in.) length were placed before and after the fuel to place it within the process tube for flux shaping.

Fuel was supplied to the reactor in either 0.95% or 1.25% ^{235}U enrichments. Depending on defense production requirements, operating cycles ranged from 30 to 90 plus days. Refueling outages replaced about one-third of the core inventory (about 6,000 fuel assemblies). Spent fuel was discharged to and stored in the Basin. Operating contractors have observed that historically about 1% of the fuel was damaged during discharge, most commonly through contact with the top edge of the Fast Carts. Fuel damage consisted of cladding cracks, end-fitting failures, and full breaks. Although operating personnel retrieved and packaged 99+% of the discharged fuel, direct fuel contact with the 420 Basin water and corrosion of broken fuel provided a fissile material input source to basin sediments.

II(b)	**COMPONENT:** Process History	**SOURCE:** Dodson, T.K. - Reactor Area Project Plan

SUMMARY:

The Basin Stabilization Project will remove contaminated hardware, irradiated hardware, sediment, and water from the pool complex. The end state for the Basin is dewatered, with all surfaces either decontaminated or surface treated so that the facility requires no routine maintenance and only infrequent surveillance (to verify no roof leaks or animal intrusion).

The Remotely Operated Sediment Extraction Equipment (ROSEE) system, or a similar system, will be used to vacuum sediments. All sediment debris smaller than 0.63 cm (0.25 in.) will be deposited in the Cask Pit and the water is returned to the Basin. Auxiliary filters added to the design eliminate the flow of sediment back to the Basin.

Although hardware waste was removed and packaged for disposal during several “housekeeping” campaigns, sediment was never vacuumed and removed. Basin sediment consists of metal debris (fuel and structural-steel corrosion), wind blown sand and dirt, and biological debris. Sediment is presumed to be evenly distributed on horizontal surfaces.

II(c)	**COMPONENT:** Process Feed Materials	**SOURCE:** UNI-M-94 - Basin Recirculation Facility

SUMMARY:

Every six weeks 20 to 30% of the fuel elements in the reactor were discharged into a tunnel-like canal at the outlet face of the reactor. Discharge water contained a considerable amount of suspended and soluble metals and metal oxides. Primary circuit water discharged into the basin was initially high pH, deaerated, demineralized water containing 2-3 ppm ammonia. As discharge continued, the water was displaced with lower pH water containing less ammonia. Eventually, demineralized makeup water replaced the discharge water. The document provides additional details regarding the major equipment and details of operations.

II(d)	**COMPONENT:** Process Data	**SOURCE:**

SUMMARY: See component II(a)

II(e)	**COMPONENT:** Process Output Stream(s)	**SOURCE:** SD-CP-TI-135: *Hanford Production Reactor Fuel Storage Basin Sediment Characterization* (Subrahmanvam 1989)

SUMMARY:

The sediment in the Basin potentially has received contributions from the following process streams:

∃ Fuel element debris (fission products, transuranic nuclides, cladding)

∃ Activation products from Reactor operation

∃ Corrosion of metals from the Basin (structural steel rust)

∃ Dust, dirt, sand, insects, algae

∃ Water treatment chemicals (chloride, aluminum sulfate [natural ^{232}thorium]) hydrazine, ammonia, morpholine, sulfuric acid, hydrogen peroxide, and sodium dichromate)

∃ Reactor corrosion products

∃ Lead weights and shielding

∃ Oil sheen on the water surface (short duration, during the period of no water treatment).

∃ Fuel element debris (fission products, transuranic nuclides, cladding).

II(f)	**COMPONENT:** Maps, Diagrams, As-Built Drawings	**SOURCE:** Project Engineer

SUMMARY:

Drawings of the Basin and Cask Pit are available in the Project Files. Basin drawings are not relevant for the purposes of this DQO, however, because this project is addressing only the characterization of sediments after they have been removed from the Basin. Cask Pit drawings will be used to support the sampling program for sediment characterization and are also available in the project files.

II(g)	**COMPONENT:** Site Visits	**SOURCE:** Project Engineer

SUMMARY:

A site visit indicated that the cover of the cask pit has a 2 in. diameter sample access port. Samples are proposed to be collected through this port. If this is not a viable scenario, significant resources will be required to establish an alternative.

II(h)	**COMPONENT:** Other	**SOURCE:**
SUMMARY: Not applicable.		

III	**ASPECT:** Historical Analytical Data	**PERSON ASSIGNED RESPONSIBILITY:** Environmental Lead
ISSUES: What analytical data are available to describe the presence and/or concentrations of constituents of concern at the site under consideration? In what format is the data available? Can existing data be used for decision making?		
III(a)	**COMPONENT:** Soils Analyses	**SOURCE:**
SUMMARY: Not applicable.		

III(b)	**COMPONENT:** Sediment/Debris	**SOURCE:** *Hanford Production Reactor Fuel Storage Basin Sediment - Characterization and Processing for Disposal* (Subrahmanyam 1989)

SUMMARY:

The referenced report investigated the concentrations of constituents in the sediments from a reactor fuel storage basin similar to the one that is the subject of this DQO. The report found that a major fraction of the observed gamma emitter activity is attributable to the activation products Mn-54 and Co-60. Activities of short-lived activation products Fe-59, Zr-95, and Nb-98 at very low levels were also reported. These species, believed to have formed in and due to the corrosion of fuel cladding (zirconium) and fuel support structures (stainless steel), are adsorbed and become part of the sediment.

Fission products and TRU isotope activities found in the sediments could only originate in irradiated fuel. This leads to the conclusion that some of the fuel elements developed cladding defects.

Although other sources of sediment data have been reported, no supporting documentation or other evidence could be found.

III(c)	**COMPONENT:** Air Monitoring	**SOURCE:**
SUMMARY: Not applicable.		

III(d)	**COMPONENT:** Groundwater	**SOURCE:**
SUMMARY: Not applicable.		

III(e)	**COMPONENT:** Surface Water	**SOURCE:**
SUMMARY: Not applicable.		

III(f)	**COMPONENT:** Waste Analysis	**SOURCE:**
SUMMARY: Not applicable.		

III(g)	**COMPONENT:** Radiological Screening/Rad Survey Data	**SOURCE:** *Draft Characterization Plan for Deactivation of the 107N Basin Recirculation Building* (Gamma-XXXX)
SUMMARY: Recent radiological surveys show very little loose contamination, and relatively low dose rates, except for the areas surrounding the sand filters and backwash tank. Sand filters show contact readings up to 900 mR/h. Ion exchange columns show low contamination with a maximum reading of 5,000 dpm/100 cm^2 beta/gamma and no alpha detected. Typical beta/gamma smears were less than 2,000 dpm/100 cm^2.		

III(h)	**COMPONENT:** Field Screening Data	**SOURCE:**
SUMMARY: None available.		

III(I)	**COMPONENT:** Other	**SOURCE:**
SUMMARY: Not applicable.		

IV **ASPECT:** Project Drivers

PERSON ASSIGNED RESPONSIBILITY: Project Environmental Lead

ISSUES: What regulations or other agreements establish the requirements for the project? Are there specific provisions within these regulations that apply? Are there enforceable milestones, deadlines, or permit conditions that are relevant?

IV(a) **COMPONENT:** Lead Agency

SOURCE: RL Area Project Manager/TPA

SUMMARY:

Washington State Department of Ecology is the lead agency for all activities in this area per the TPA. EPA has a supporting role.

IV(b) **COMPONENT:** RCRA

SOURCE: 40 CFR 260

SUMMARY:

The Disposal Facility is a RCRA permitted disposal facility. The Waste Acceptance Criteria for the Disposal Facility are established in the RCRA permit for that facility. Although the Basin itself could be a regulated TSD unit, the regulatory agency has agreed that, because the remediation is proceeding consistent with a compliance order (the TPA), no additional administrative action (e.g., a RCRA permit application) is required for the sediment.

IV(c) **COMPONENT:** CERCLA

SOURCE:

SUMMARY: Not applicable.

IV(d) **COMPONENT:** CAA

SOURCE:

SUMMARY: Not applicable.

IV(e) **COMPONENT:** NPDES

SOURCE:

SUMMARY: Not applicable.

IV(f) **COMPONENT:** SDWA

SOURCE:

SUMMARY: Not applicable.

IV(g) **COMPONENT:** TSCA

SOURCE:

SUMMARY:

Wastes containing more than 50 mg/kg PCBs are regulated under TSCA. In addition, wastes containing more than 1 mg/kg are regulated under the

Washington State Dangerous Waste Code W001. Sediment characterization will include analysis for PCBs, because they have been detected in the sediments at other Basins on site.

IV(h)	**COMPONENT:** NEPA	**SOURCE:** DOE/EA-0984: *Environmental Assessment for the Deactivation of the N Reactor Facilities*
SUMMARY: An environmental assessment (EA) was developed to assess the potential impacts from the deactivation/stabilization activities. The EA resulted in a finding of no significant impact (FONSI). The EA established proposed actions that must be followed during deactivation/stabilization activities.		

IV(I)	**COMPONENT:** Compliance Order/Consent Agreement	**SOURCE:** TPA reference #M-16-01E-T2
SUMMARY: The Tri Party Agreement stipulates that basin sediment characterization is to be completed by 12/97.		

IV(j)	**COMPONENT:** Waste Acceptance Criteria	**SOURCE:** Gamma-XXXX, Rev. 2
SUMMARY: The Disposal Facility WAC establishes specific concentration limits for radionuclides and chemical constituents. WAC can be found in the referenced source document, which is available in the project files. If there is a TRU component to the sediments, the WAC for the relevant disposal facility will be evaluated once the nature of these constituents have been characterized. Water generated during dewatering of the sediments will be sent to the Effluent Treatment Facility and is subject to that facility's WAC.		

IV(k)	**COMPONENT:** Milestones/Schedule	**SOURCE:** Tri-Party Agreement
SUMMARY: Sediment characterization is to be completed by 9/97; stabilization and disposition by 12/97. Internal project schedules show each of these target date as three months earlier than the TPA milestones.		

IV(l)	**COMPONENT:** Other	**SOURCE:** Project Engineer
SUMMARY: Potential need to evaluate waste acceptance criteria for TRU disposal, contingent on the results of characterization.		

V	**ASPECT:** Operational Concerns	**PERSON ASSIGNED RESPONSIBILITY:** Project Engineer

ISSUES: Does the site/material under evaluation present special considerations that affect data collection activities? Are these considerations established through regulations?

V(a) **COMPONENT:** Health and Safety **SOURCE:** Project Engineer

SUMMARY:

All sampling will be performed within the Basin building; there is essentially no risk to the environment or the public associated with sampling the sediment in this facility. As a Radiation Area/Contaminated Area (RA/CA), work in this facility must be in full compliance with Gamma procedures for such work; a work package describing the activity to be performed must be prepared. Radiological requirements will be specified in a Radiation Work Permit (RWP) for the activity; the RWP establishes the ALARA requirements for the project.

V(b) **COMPONENT:** Cultural and Biological Constraints **SOURCE:** Regulatory Support Staff

SUMMARY:

None of the planned activities will affect plants, wildlife, or habitat that would require cultural or biological constraints. All activities will be conducted indoors.

V(c) **COMPONENT:** Nuclear Criticality **SOURCE:**

SUMMARY: Not applicable.

VI **ASPECT:** Project Budget **PERSON ASSIGNED RESPONSIBILITY:** Project Engineer

ISSUES: One aspect of ensuring that a project optimizes its resources is to evaluate costs and the impact of the DQO process. A baseline project cost allows for comparison after completing the DQO process. What are the costs associated with the various project activities? How were these costs derived?

VI(a) **COMPONENT:** DQO/Planning **SOURCE:** Project Engineer

SUMMARY: $60K

VI(b) **COMPONENT:** Sample Collection **SOURCE:** Project Engineer

SUMMARY:

Assume 2 RCTs, 1 Craft Supervisor, 3 Sampling Technicians, and 1 Field Engineer at a cost of $2,800 per day. $3500 per day to generate the work package. Cost for one day sample campaign = $6,300. Number of days sampling to be determined.

VI(c) | **COMPONENT:** Sample Analysis | **SOURCE:** Project Engineer

SUMMARY: TBD based on output from the DQO. Costs for individual analyses are provided below:

Analyses	Unit Price
Rad Analysis	
Gross Alpha	45
Gross Beta	45
U-Isotopic (AEA)	200
Pu-Isotopic (AEA)	1,054
Sr-90	448
GEA	115
Chemical Analysis	
Total Metals	188
TOC	210
TIC	210
pH	19
TCLP Metals	178
Hydroxide Demand	126
Anions by IC	251
Cyanide	57
PCB	350
Physical Properties	
DSC	314
Density	756
% Solids	75
% Moisture	75
Particle Size	144
Viscosity	210

Physical properties are included because this information will be required for sample packaging, not due to limits imposed by the WAC. These figures do not include the cost of quality control samples. Costs will double with shortened turnaround times.

VI(d) | **COMPONENT:** Site Investigation | **SOURCE:**

SUMMARY: Not applicable.

VI(e) | **COMPONENT:** Radiological Survey | **SOURCE:** Project Engineer

SUMMARY:

There are no plans to perform radiological surveys of the sediments. Radiological analysis will be included in the overall sediment characterization.

VI(f)	**COMPONENT:** Remediation	**SOURCE:**
SUMMARY: Not applicable.		

VI(g)	**COMPONENT:** D&D	**SOURCE:**
SUMMARY: Not applicable. (The activities are preliminary to D&D.)		

VI(h)	**COMPONENT:** Data Quality Assessment	**SOURCE:** Project Engineer
SUMMARY: Data Quality Assessment requirements will be determined based on the sampling decisions that are developed during this DQO. Approximately $20 K budget.		

VII	**ASPECT:** COPCs	**PERSON ASSIGNED RESPONSIBILITY:** Project Engineer

ISSUES: For most DQOs, the primary focus will be to determine and quantify the contaminants of concern. Based on available information, what are the contaminants of potential concern (COPCs)? How were these derived? Is there a regulatory limit associated with these COPCs? What are the appropriate sampling/analytical methods for evaluating their presence and concentrations?

VII(a)	**COMPONENT:** Draft List of COPCs	**SOURCE:** Project Engineer

SUMMARY:

COPCs were identified based on the available process history of the Basin, along with available data generated from the sediment found in other basins.

1. Fuel Element Debris

^{3}H
^{36}Cl
^{60}Co
^{93}Zr
^{107}Pd
^{126}Sn
^{135}Cs
^{151}Sm
^{154}Eu
^{226}Ra
^{229}Th
^{232}Th
^{235}U
^{238}Pu
^{241}Pu
^{244}Cm
^{246}Cm
^{63}Ni
^{93}Mo
^{113m}Cd
^{10}Be
^{40}K
^{150}Eu
^{187}Re
^{228}Ra
^{129}I
^{137}Cs
^{236}U
^{239}Pu
^{243}Am
^{230}Th
^{232}U
^{79}Se
^{94}Nb
^{121m}Sn
^{244}Pu
^{247}Cm
^{152}Eu
^{209}Po
^{227}Ac
^{14}C
^{59}Ni
^{237}Np
^{240}Pu
^{243}Cm
^{133}Ba
^{147}Sm
^{90}Sr
^{99}Tc
^{231}Pa
^{234}U
^{152}Gd
^{210}Pb
^{245}Cm
^{248}Cm
^{238}U
^{241}Am

NOTE: These are the radionuclides of concern with respect to solid waste disposal as published in *Hanford Site Solid Waste Acceptance Criteria* (WHC-EP-0063-4). Not all of these are necessarily present in the sediments.

2. Structural material

∃ tin
∃ aluminum
∃ Lead
∃ Iron
∃ carbon steel (which contains iron and carbon)
∃ stainless steel (which contains iron, nickel, chromium, and molybdenum)
∃ concrete (which contains calcium sulphate and silica)
∃ ≈inconel (which contains nickel, iron, and chromium)
∃ zircalloy II (which contains zirconium and tin)
∃ zirconium

3. Miscellaneous COPCs (e.g., dust, dirt, sand, insects, and algae)

∃ total organic carbon (TOC)
∃ asbestos

4. Water treatment chemical COPCs

∃ aluminum
∃ morpholine
∃ sodium hydroxide
∃ ammonia
∃ sulfuric acid
∃ chloride
∃ hydrogen peroxide
∃ hydrazine
∃ sodium dichromate
∃ sulfate
∃ thorium

5. Reactor corrosion product COPCs

∃ iron
∃ lead
∃ cadmium
∃ chromium
∃ cobalt
∃ manganese
∃ arsenic
∃ nickel

6. Lead weights and shielding COPCs

∃ elemental lead

7. Oil sheed on water surface COPCs

∃ cutting oils
∃ lubricants (e.g., grease from crane hook, etc.).

8. Organics from Chemical Constituents in N Reactor Wastewater (Hunacek 1992)

∃ Acetone
∃ Trichloroethane
∃ 1-Butanol
∃ Trichloromethane
∃ 2-Butanone
∃ Tetrachloroethene
∃ Hexone
∃ Methyl Isobutyl Ketone
∃ Toluene

VII(b)	**Component:** Regulatory Limits/Basis	**Source:** Project Engineer

Summary:

The regulatory Limits for the sediments are the Waste Acceptance Criteria for the Disposal Facility, the intended disposal site for the dewatered sediments. The WACs are premised on the permit criteria established for that facility. The WAC limits are available in the project files. Additional limits are established in the WAC for the Effluent Treatment Facility, which will receive the water from dewatering the sediments.

VII(c)	**Component:** Sample Collection Method(s)	**Source:** Project Engineer

Summary:

These will be determined in the course of this DQO process.

VII(d)	**Component:** Analytical Methods/Detection Limits	**Source:** Analytical Support Staff

Summary:

See attached table.

VIII	**ASPECT:** Existing Risk Scenarios/Pathways	**PERSON ASSIGNED RESPONSIBILITY:**

ISSUES: Evaluating the potential exposure of population or environmental receptors will provide a primary basis for data collection. Are there existing studies that evaluate risk scenarios and/or exposure pathways? Are the results of these studies transferable to the project under consideration? Are there fate/transport models/data available?

VIII(a)	**COMPONENT:** Previous Conceptual Models	**SOURCE:**

SUMMARY: Not applicable.

VIII(b)	**COMPONENT:** Previous Risk Assessment	**SOURCE:**

SUMMARY:

Human health and risk assessments associated with this project were addressed in the Risk Management Document. Radiation risk criteria associated with human health exposure is 15 mrem/day above background for the rad contaminants of concern; for ecological risk, 1.0 rad/day is the accepted criteria for external exposure.

VIII(c)	**COMPONENT:** Fate and Transport Information	**SOURCE:**

SUMMARY:

Fate and transport concerns for the sediment disposal alternative(s) will have been evaluated during the siting process for the relevant disposal unit(s).

Analytical Parameters for Sediment Analysis			
Analytical Category	**Analytical Parameter**	**Analytical Method**	**Detection Limit/Soil**[a]
Radionuclides	Gross alpha	gas proportional counting	5 pCi/g
	Gross beta	gas proportional counting	10 pCi/g
	Americium-241[d] Cobalt-60 Sb-125 Cs-134 Cesium-137 Eu-152 Eu-153 Eu-154 Radium-226 Radium-228	Gamma Energy Analysis (GEA)[b]	2 pCi/g 10 pCi/g 10 pCi/g 10 pCi/g 10 pCi/g 10 pCi/g 10 pCi/g 10 pCi/g 2 pCi/g 3 pCi/g
	Ni-63	Chemical separation / liquid scintillation counting	50 pCi/g
	Strontium-90	Chemical separation / beta proportional counting	10 pCi/g
	Technicium-99	Chemical separation / liquid scintillation counting	30 pCi/g
	Thorium-228	Chemical separation / alpha energy analysis	2 pCi/g
	Thorium-230		2 pCi/g
	Thorium-232		2 pCi/g
	Uranium-234	Chemical separation / alpha energy analysis	2 pCi/g
	Uranium-235		2 pCi/g
	Uranium-238		2 pCi/g
	Plutonium-238	Chemical separation / alpha energy analysis[c]	2 pCi/g
	Plutonium-239/240		2 pCi/g
	Americium-241[d]	Chemical separation / alpha energy analysis	2 pCi/g
	Curium-244		2 pCi/g
Chemical Analytical Methods	pH	Ion specific electrode SW-846 / 9045	N/A
	Metals: Aluminum Antimony[e] Arsenic[e] Barium[e] Beryllium[e] Cadmium[e] Chromium[e] Iron Lead [e] Manganese Nickel[e] Selenium[e] Silica Silver[e]	ICP SW-846 / 6010A or SW-846 / 7421(GFAA) or SW-846 / 7740(GFAA)	 20 ppm 40 ppm 100 ppm 150 ppm 0.25 ppm 3.5 ppm 15 ppm 10 ppm 7.0 ppm 2.0 ppm 100 ppm 3.0 ppm 50 ppm 6.0 ppm

Analytical Parameters for Sediment Analysis

Analytical Category	Analytical Parameter	Analytical Method	Detection Limit/Soil[a]
	Sodium Thallium[e] Vanadium[e] Zinc	or SW-846 / 7841(GFAA)	60 ppm 1.5 ppm 4.5 ppm 3.0 ppm
	Mercury[e]	Cold vapor AA SW-846 / 7471	0.5 ppm
	TCLP metals[f] Antimony[g] Arsenic Barium Beryllium[g] Cadmium Chromium Lead Nickel[g] Selenium Silver Thallium[g] Vanadium[g]	Sample extraction / ICP metals SW-846 / 1311 for sediment SW-846 / 6010A for water/leachate	2.1 ppm 5.0 ppm 7.6 ppm 0.014 ppm 0.19 ppm 0.86 ppm 0.37 ppm 5.0 ppm 0.16 ppm 0.30 ppm 0.078 ppm 0.23 ppm
	Mercury	Extraction / cold vapor AA SW-846 / 1311; SW-846 / 7471	0.025 ppm
	Polychlorinated biphenyls Aroclors 1016 1221 1232 1242 1248 1254 1260	Gas chromatography SW-846 / 8080A	10 ppm
Chemical Analytical Methods	Anions Chloride Bromide Fluoride Nitrate Nitrite Phosphate Sulfate	Ion chromatography EPA 300.0	5 ppm
	Ammonia	Distillation , colorimetric EPA 350.2/3	10 ppm
	Total Organic Carbon	Combustion, coulemetric SW-846 / 9060	200 ppm
	Asbestos (105-lift station only)	Polarized light microscopy	N/A
Physical Properties	Particle Size Distribution	10 mm to 10 micron sieve, <10 micron per hydrometer (ASTM Methods)	N/A

Analytical Parameters for Sediment Analysis			
Analytical Category	**Analytical Parameter**	**Analytical Method**	**Detection Limit/Soil**[a]
	Density (in situ and centrifuged)	Gravimetric	N/A
	Viscosity (at 70% F)	Physical measurement	N/A

a. Detection limits are highly matrix-dependent and will be negotiated with the lab. Detection limits for radionuclides are those needed to for radiological release for waste as found in Stickney (1988), Table J-1b. Detection limits for chemicals are those needed to support waste criteria evaluation. Laboratory actual working detection limits will be established to ensure that these limits will be met with sufficient confidence to support waste decisions.

b. Isotopes with half lives less than 1.5 years and naturally occurring isotopes such as K-40 will not be specifically targeted by GEA. The laboratory will report other gamma emitters that are detected by the method.

c. Plutonium-241 will be determined through calculations.

d. Analysis for Cm-244 allows concurrent analysis and reporting of Am-241. GEA for Am-241 will be requested, but may show significant interferences from other gamma emitters.

e. Results must be obtained from TCLP leachate or, in the event dose rates prohibit leaching, decision makers will revisit the use of total metals results.

f. Volume and cost estimates will be finalized after discussions with the laboratory and prior to generation of the sampling & analysis plan. Volumes will be kept to a minimum for ALARA concerns. Volumes for archive will be assessed separately and are separate from those for analysis.

g. Not a TCLP metal - but addressed per Gamma-XXXX, Rev. 2, Table 4-2.

PROJECT TITLE:

I	**ASPECT:** Project Scope	**PERSON ASSIGNED RESPONSIBILITY:**
ISSUES: Identify the questions and problems to be resolved through the DQO process. What is the focus of the project? What is/is not important for the resolution of the concerns that are the subject of this DQO? What questions will be resolved through the DQO process?		
I(a)	**COMPONENT:** Project Assumptions	**SOURCE:**
SUMMARY:		

I(b)	**COMPONENT:** Project Goals	**SOURCE:**
SUMMARY:		

II	**ASPECT:** Process/Activity Knowledge	**PERSON ASSIGNED RESPONSIBILITY:**
ISSUES: Describe the processes/activities that took place at the site under consideration in sufficient detail to support this DQO. What processes/activities took place at the site? Which processes/activities are significant for the decisions that are required for this DQO? Are there documents to support this history? Are personnel available to interview regarding this history? Are the process materials (input and output) described in detail?		
II(a)	**COMPONENT:** Process/Activity Description	**SOURCE:**
SUMMARY:		

II(b)	**COMPONENT:** Process History	**SOURCE:**
SUMMARY:		

II(c)	**COMPONENT:** Process Feed Materials	**SOURCE:**
SUMMARY:		

II(d)	**COMPONENT:** Process Data	**SOURCE:**
SUMMARY:		

II(e)	**COMPONENT:** Process Output Stream(s)	**SOURCE:**
SUMMARY:		

II(f)	**COMPONENT:** Maps, Diagrams, As-Built Drawings	**SOURCE:**
SUMMARY:		

II(g)	**COMPONENT:** Site Visits	**SOURCE:**
SUMMARY:		

II(h)	**COMPONENT:** Other	**SOURCE:**
SUMMARY:		

III	**ASPECT:** Historical Analytical Data	**PERSON ASSIGNED RESPONSIBILITY:**
ISSUES: What analytical data are available to describe the presence and/or concentrations of constituents of concern at the site under consideration? In what format is the data available? Can existing data be used for decision making?		
III(a)	**COMPONENT:** Soils Analyses	**SOURCE:**
SUMMARY:		

III(b)	**COMPONENT:** Sediment/Debris	**SOURCE:**
SUMMARY:		

III(c)	**COMPONENT:** Air Monitoring	**SOURCE:**
SUMMARY:		

III(d)	**COMPONENT:** Groundwater	**SOURCE:**
SUMMARY:		

III(e)	**COMPONENT:** Surface Water	**SOURCE:**
SUMMARY:		

III(f)	**COMPONENT:** Waste Analysis	**SOURCE:**
SUMMARY:		

III(g)	**COMPONENT:** Radiological Screening/Rad Survey Data	**SOURCE:**
SUMMARY:		

III(h)	**COMPONENT:** Field Screening Data	**SOURCE:**
SUMMARY:		

III(i)	**COMPONENT:** Other	**SOURCE:**
SUMMARY:		

IV	**ASPECT:** Project Drivers	**PERSON ASSIGNED RESPONSIBILITY:**
ISSUES: What regulations or other agreements establish the requirements for the project? Are there specific provisions within these regulations that apply? Are there enforceable milestones, deadlines, or permit conditions that are relevant?		
IV(a)	**COMPONENT:** Lead Agency	**SOURCE:**
SUMMARY:		

IV(b)	**COMPONENT:** RCRA	**SOURCE:**
SUMMARY:		

IV(c)	**COMPONENT:** CERCLA	**SOURCE:**
SUMMARY:		

IV(d)	**COMPONENT:** CAA	**SOURCE:**
SUMMARY:		

IV(e)	**COMPONENT:** NPDES	**SOURCE:**
SUMMARY:		

IV(f)	**COMPONENT:** SDWA	**SOURCE:**
SUMMARY:		

IV(g)	**COMPONENT:** TSCA	**SOURCE:**
SUMMARY:		

IV(h)	**COMPONENT:** NEPA	**SOURCE:**
SUMMARY:		

IV(i)	**COMPONENT:** Compliance Order/Consent Agreement	**SOURCE:**
SUMMARY:		

IV(j)	**COMPONENT:** Waste Acceptance Criteria	**SOURCE:**
SUMMARY:		

IV(k)	**COMPONENT:** Milestones/Schedule	**SOURCE:**
SUMMARY:		

IV(l)	**COMPONENT:** Other	**SOURCE:**
SUMMARY:		

V	**ASPECT:** Operational Concerns	**PERSON ASSIGNED RESPONSIBILITY:**
ISSUES: Does the site/material under evaluation present special considerations that affect data collection activities? Are these considerations established through regulations?		
V(a)	**COMPONENT:** Health and Safety	**SOURCE:**
SUMMARY:		

V(b)	**COMPONENT:** Cultural and Biological Constraints	**SOURCE:**
SUMMARY:		

V(c)	**COMPONENT:** Nuclear Criticality	**SOURCE:**
SUMMARY:		

VI	**ASPECT:** Project Budget	**PERSON ASSIGNED RESPONSIBILITY:**
ISSUES: One aspect of ensuring that a project optimizes its resources is to evaluate costs and the impact of the DQO process. A baseline project cost allows for comparison after completing the DQO process. What are the costs associated with the various project activities? How were these costs derived?		
VI(a)	**COMPONENT:** DQO/Planning	**SOURCE:**
SUMMARY:		

VI(b)	**COMPONENT:** Sample Collection	**SOURCE:**
SUMMARY:		

VI(c)	**COMPONENT:** Sample Analysis	**SOURCE:**
SUMMARY:		

VI(d)	**COMPONENT:** Site Investigation	**SOURCE:**
SUMMARY:		

VI(e)	**COMPONENT:** Radiological Survey	**SOURCE:**
SUMMARY:		

VI(f)	**COMPONENT:** Remediation	**SOURCE:**
SUMMARY:		

VI(g)	**COMPONENT:** D&D	**SOURCE:**
SUMMARY:		

VI(h)	**COMPONENT:** Data Quality Assessment	**SOURCE:**
SUMMARY:		

VII	**ASPECT:** COPCs	**PERSON ASSIGNED RESPONSIBILITY:**
ISSUES: For most DQOs, the primary focus will be to determine and quantify the contaminants of concern. Based on available information, what are the contaminants of potential concern (COPCs)? How were these derived? Is there a regulatory limit associated with these COPCs? What are the appropriate sampling/analytical methods for evaluating their presence and concentrations?		
VII(a)	**COMPONENT:** Draft List of COPCs	**SOURCE:**
SUMMARY:		

VII(b)	**COMPONENT:** Regulatory Limits/Basis	**SOURCE:**
SUMMARY:		

VII(c)	**COMPONENT:** Sample Collection Method(s)	**SOURCE:**
SUMMARY:		

VII(d)	**COMPONENT:** Analytical Methods/Detection Limits	**SOURCE:**
SUMMARY:		

VIII	**ASPECT:** Existing Risk Scenarios/ Pathways	**PERSON ASSIGNED RESPONSIBILITY:**
ISSUES: Evaluating the potential exposure of population or environmental receptors will provide a primary basis for data collection. Are there existing studies that evaluate risk scenarios and/or exposure pathways? Are the results of these studies transferable to the project under consideration? Are there fate/transport models/data available?		
VIII(a)	**COMPONENT:** Previous Conceptual Models	**SOURCE:**
SUMMARY:		

VIII(b)	**COMPONENT:** Previous Risk Assessment	**SOURCE:**
SUMMARY:		

VIII(c)	**COMPONENT:** Fate and Transport Information	**SOURCE:**
SUMMARY:		

CONTENTS

LIST OF ACRONYMS

CAA	*Clean Air Act*
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
COPC	contaminants of potential concern
CWA	*Clean Water Act*
DQO	Data Quality Objective
EPA	U.S. Environmental Protection Agency
EPCRA	*Emergency Planning and Community Right to Know Act*
HAP	hazardous air pollutant(s)
LOE	level of effort
MCL	maximum contamination level(s)
MSDS	material safety data sheet
NEPA	*National Environmental Policy Act of 1969*
NPDES	National Pollutant Discharge Elimination System
OSHA	Occupational Safety and Health Administration
PCB	polychlorinated biphenyl(s)
RCRA	*Resource Conservation and Recovery Act of 1976*
RI/FS	remedial investigation/feasibility study
ROD	Record of Decision
SDWA	*Safe Drinking Water Act*
TRU	transuranic
TSCA	*Toxic Substances Control Act*
UST	underground storage tank(s)
VOC	volatile organic compound(s)
WAC	waste acceptance criteria

OVERVIEW AND PURPOSE

Completing the Data Quality Objective (DQO) Scoping process before commencing the DQO process is critical to ensuring that the appropriate project-related issues are addressed during the DQO. The Scoping Checklist is intended to assist the project lead to identify the important project issues early in the process. Completing the checklist also helps to determine where to find information to support decisions for these issues.

This Level 2 link provides guidance for the user of the checklist to assist in its completion. The checklist is divided into aspects; each aspect is further subdivided into components. Aspects provide a grouping for common elements that will likely be considered from a similar perspective during the DQO. Components are the elements of the aspect; not all components will be relevant for all DQOs. The user is to provide summary information for each of the relevant components; summaries should consist of no more than one page of text to support each component. These summaries will be compiled to prepare the DQO Scoping report, which in turn will provide a focus for the DQO process. Additional supporting information may be provided in the scoping binder or other supplemental material.

The following material provides an overview of the subject matter for each aspect; users do not provide summary information at this level within the checklist. A brief description of the relevant information that could be summarized is provided under each component heading. This information must be provided to complete the checklist. Again, every component may not be relevant for every DQO.

Level 3 provides additional supporting information through examples of completed checklists.

PROJECT TITLE: [INSERT THE NAME THAT HAS BEEN ASSIGNED TO THE PROJECT.]

I. PROJECT SCOPE. The purpose of this aspect is to provide an overview of the project. The project lead should give careful consideration to what information gathering activities are the subject of the DQO. The answer to this question will be determined by a review of the project objectives, the available information to support the project, project schedule and budget, and resources available to support the project.

I	**ASPECT:** Project Scope	**PERSON ASSIGNED RESPONSIBILITY:**
ISSUES: Identify the questions and problems to be resolved through the DQO process. What is the focus of the project? What is/is not important for the resolution of the concerns that are the subject of this DQO? What questions will be resolved through the DQO process?		
I(a)	**COMPONENT:** Project Assumptions	**SOURCE:**
SUMMARY: *Once the project lead has made an initial determination as to these issues, a preliminary scope can be developed for the project. If budget, schedule, or manpower are limiting factors, the scope of the DQO may have to be reduced accordingly. Technical assumptions, for example, the process history for the site, accessibility of the site for sample collection within the necessary time frame, or suitability of available data to support decisions, must be evaluated. It is important that resource assumptions, as well as the technical assumptions be documented.* *It sometimes may be as important to define what is not within the scope of the project, so that the resulting information is not used for the wrong purpose or does not disappoint an end user with results that may not fit their expectations. For example, an assumption could be made that the project will support characterization of soil contamination for a given sub-unit of a Superfund cleanup site. An assumption may be that information will be gathered to determine the constituents of concern for that site to support cleanup decisions. It may be appropriate to state that the information will not be intended to support decisions for the balance of the operable unit.* *The project assumptions may be pre-determined by the record of decision, feasibility study, compliance orders, or other relevant project documents or procedures. They may also be established by the project leader or team members early in the project.* *Stage of Project - If investigation phase is complete and in remediation, the Record of Decision governs decisions.*		

I(b)	**COMPONENT:** Project Goals	**SOURCE:**

SUMMARY:

Project goals are the purposes towards which the DQO process is directed. A project goal may be, for example, to enable the unrestricted release of a piece of property. The goal will likely be attained through the achievement of one or more objectives, which will be guided by the results of the DQO process. The objectives for the cited example might include a definition of the existing contamination at the site and identification of strategy to attain cleanup levels that are acceptable by the overseeing agency. The Checklist should provide a fairly definitive goal or goals for the process. Objectives will likely be developed through the DQO process, although preliminary objectives could be established if the project lead has a sufficient understanding of the project at this time.

Project goals generally will be established by the team leader early in the project. Project goals may change over the life of the project due to new information generated over the course of the project, or because of external influences on the project, such as budgetary constraints, schedule, or compliance concerns.

II. PROCESS/ACTIVITY KNOWLEDGE. In order to evaluate a site, an adequate understanding of the site history is required. If there is a history of manufacturing or other industrial processes at a site, knowledge of the material used, the type of process(es), and any treatment of raw, processed, or waste materials, along with methods and location of disposal or spills will contribute valuable information to an understanding of the site. This information can help to focus the location of an investigation as well as the techniques that will be used, both for sampling and analysis of samples. If there are concerns related to non-process activities, such as waste disposal, information on the materials used and the time frame of the disposal operation can be helpful. For transportation issues, knowledge of the material to be transported, packaging techniques, hazards associated with the material, and transportation routes all will provide helpful information for decision makers. In this aspect the user should provide a summary of whatever information is available through written or verbal history that will help the decision makers to determine the characteristics of the site and to develop a strategy for resolving any issues that require additional information.

II	**ASPECT:** Process/Activity Knowledge	**PERSON ASSIGNED RESPONSIBILITY:**
ISSUES: Describe the processes/activities that took place at the site under consideration in sufficient detail to support this DQO. What processes/activities took place at the site? Which processes/activities are significant for the decisions that are required for this DQO? Are there documents to support this history? Are personnel available to interview regarding this history? Are the process materials (input and output) described in detail?		
II(a)	**COMPONENT:** Process/Activity Description	**SOURCE:**
SUMMARY: *Describe the major, relevant, activities that took place at the site. If the site is of interest because of manufacturing or other production-related activities, describe the relevant activities. If the project is related to some other type of activity, for example, waste processing, waste disposal, product storage, or transportation, describe the activity and the features of the facility or site that are relevant. Determine what is relevant based on the project scope, defined above. For example, an investigation to evaluate spills from a process waste tank would be concerned only with the processes that could have contributed to that specific tank during the period of concern, not all processes that ever took place at that facility. Provide sufficient detail so that a reader has a good understanding of where the activity took place, the steps in the process, equipment used, and any information that can support the investigation that is the subject of the DQO.*		

This information can often be obtained from existing site documents or interviews.

II(b)	**COMPONENT:** Process History	**SOURCE:**

SUMMARY:

Determine when the process began operations, any changes in the operations, duration(s) of specific operations or campaigns, and when the operation shut down, if it is no longer in operation. This information should be described in some detail if the site has a history of multiple uses or process changes. If the site history is fairly uniform, this information can be combined with the process history provided in II(a).

II (c)	**COMPONENT:** Process Feed Materials	**SOURCE:**

SUMMARY:

This component is concerned with the raw materials use at the site. Feed materials include not only the raw product materials, but also any chemicals used in the processing of the product and lubricants or other materials used in maintenance of equipment or the facility.

II(d)	**COMPONENT:** Process Data	**SOURCE:**

SUMMARY:

Summarize any process information, such as monitoring of process make up or operating parameters, that can help to define the constituents of concern for the DQO.

II(e)	**COMPONENT:** Process Output Stream(s)	**SOURCE:**

SUMMARY:

Describe the form (e.g., solid, liquid, slurry, gas) and makeup (i.e., constituents and concentrations) of the output from any process operations. This should include both the product output and the byproducts, such as waste streams. As described in component II(b), processes may have changed over time. This summary should include separate summaries for each of the processes that took place over the operational period of concern for the DQO.

II(f)	**COMPONENT:** Maps, Diagrams, As-Built Drawings	**SOURCE:**

SUMMARY:

Include copies of the most useful pictorial materials that can support the DQO. If there are numerous drawings, maps, photographs, or other materials that can aid a user in the DQO process, provide a summary of these materials and reference where the additional materials can be found.

II(g)	**COMPONENT:** Site Visits	**SOURCE:**

SUMMARY:

In may cases, a site visit can provide vital information to assist the DQO team in evaluating the site and structuring decisions for the DQO. A site visit can help the decision makers to grasp the magnitude of a site, limitations on investigative procedures, and safety concerns for samplers, among other conditions that may not be apparent from published reports. If a site visit has been conducted by one or more members of the team, a summary should be provided. If a site visit is considered as a useful component of the process, but has not taken place, summarize what the expectations are for the site visit.

II(h)	**COMPONENT:** Other	**SOURCE:**

SUMMARY:

Include additional information on the site history or process information that may not fit within the above components.

III. ANALYTICAL DATA. Analytical data that has been collected in the past to support operations at the site, as part of a compliance monitoring program, or as part of previous site investigations can help the DQO team to determine the critical constituents, as well as locations that require additional characterization. When reviewing previously collected analytical data, it is important to review the purposes for which the data was collected and what quality assurance/quality control measures governed the sample program. This information will help the DQO team to evaluate the purposes for which the historical data can be used. Information that was collected with the benefit of only limited quality control, for example, may be useful to help focus an investigation, but likely would not be used for final decision-making. Analytical data that was subject to rigorous controls during sampling and analysis may provide sufficient characterization of the site to provide a basis for decisions. The components listed below represent the major media subject to analysis. Not all projects will be concerned with all of these components. If the project is concerned with media not listed below, provide the relevant information in the “other” component.

The information that is requested in the components in this section may appear redundant in some cases; for example, soils analysis (III(a)) could include radiological screening data (III(h)) as well as field screening data (III(I)). The user should select the categories that best describe the data groups for the DQO under development.

Summarizing analytical data is critical to allow decision makers to see the “bottom line.” However, the summary must be accurately gathered. It is recommended that personnel with experience in gathering and evaluating the data also summarize the data. For example, a chemist or laboratory specialist should summarize analytical data, while a hydrogeologist should summarize the groundwater data.

Strategies for summarizing data by media include, but are not limited to:

Soils

- summarize borings by depth, graphically if possible
- summarize surface contamination on surface maps
- provide minimum, maximum, average by depth
- divide data into areas of similar chemical history and geology

Groundwater

- summarize concentration by depth of well per analyte
- provide plume maps
- provide concentration from same well for same analyte over time
- provide minimum, maximum, average by analyte

Surface water

- map surface concentrations by analyte

Process/buildings/equipment

- provide by piece of equipment and content of equipment any concentration of liquid, sludge, solids
- provide radionuclide surface surveys and wipes, for each piece of equipment
- calculate minimum, maximum, average for similar process equipment or building areas housing a particular process

III	**ASPECT:** Historical Analytical Data	**PERSON ASSIGNED RESPONSIBILITY:**
ISSUES: What analytical data are available to describe the presence and/or concentrations of constituents of concern at the site under consideration? In what format is the data available? Can existing data be used for decision making?		
III(a)	COMPONENT: Soils Analyses	**SOURCE:**
SUMMARY: *This component includes unconsolidated and consolidated soils that serve as a medium for plant growth (both actual and potential). For the purposes of this classification, soils can be either native materials or fill. In general, this component is concerned with materials that are external to buildings or other man-made structures.*		

III(b)	**COMPONENT:** Sediment	**SOURCE:**
SUMMARY: *Sediment, for the purposes of this component, is the generally fine organic and/or mineral mater that is deposited by wind or water in stagnant or non-turbulent areas. Examples include the fine materials found on the bottom of settling ponds and storage basins or particulate matter collected by a scrubber from an air emissions control device.*		

III (c)	**COMPONENT:** Equipment/Debris	**SOURCE:**
SUMMARY: *Equipment and debris include any man-made objects that are of concern*		

for the purposes of the study. In general, equipment and debris must be suspect of retaining some form of residual contamination to be of value for the study. Examples of equipment include process equipment, storage tanks, containers, and transfer lines. Equipment will generally be found in its original configuration, if not in its native location. Debris can consist of the remains of equipment, but also includes trash and other material that has outlived its functional life.

III(d)	COMPONENT: Air Monitoring	**SOURCE:**

SUMMARY:

This component includes stack monitoring from process or waste handling sources, as well as ambient conditions for evaluation of health and safety concerns or exposure to external receptors.

III(e)	**COMPONENT:** Groundwater	**SOURCE:**

SUMMARY:

Data to support this component can include analytical data that characterizes the presence, concentration, and distribution of constituents in the groundwater, as well as data that describes groundwater flow and migration pathways. Data also may indicate changes in the groundwater regime over time (e.g., changes in water levels). Data could be available from compliance records from the facility or from modeling conducted to support compliance or other activities.

III(f)	**COMPONENT:** Surface Water	**SOURCE:**

SUMMARY:

Surface water data can include records that may be available from National Pollutant Discharge Elimination System (NPDES) discharge monitoring, characterization of water quality within basins, or monitoring of streams, rivers, or other bodies of water for reasons other than NPDES compliance.

III(g)	**COMPONENT:** Waste Analysis	**SOURCE:**

SUMMARY:

Waste analysis may have been performed to determine the suitability of the waste material for disposal under specific regulatory programs or at specific disposal facilities. This component includes characterization of solid waste; liquid waste that does not discharge to surface water also will be captured in this component. This description should include volumes of waste, form of waste, containment, and identification and concentration of constituents.

III(h)	**COMPONENT:** Radiological Screening/Rad Survey Data	**SOURCE:**

SUMMARY:

Describe any radiological characterization of the facility, raw materials, or waste materials.

III(I)	**COMPONENT:** Field Screening Data	**SOURCE:**

SUMMARY:

III(j)	**COMPONENT:** DQA	**SOURCE:**

SUMMARY:

While the data is being summarized, a review of the analytical quality control and statistical evaluation of the data should be performed. This review must be done by an experienced analyst or chemist with support from a statistical specialist or person with statistical evaluation experience. Typical analytical quality reviews include, but are not limited to evaluation of trip, field, equipment and method blanks, duplicates, matrix spikes and spike duplicates. The effect of the quality control on the usability of the data should be provided and considered in the data summary.

Statistical review includes, but is not limited to:

- *examination of numerical and spatial distribution of the data*
- *examination of data for outliers or anomalous values*
- *review of the data against the conceptual model*
- *data usage to calculate any applicable statistical parameters (mean, median, mode, etc.)*

III(j)	**COMPONENT:** Other	**SOURCE:**

SUMMARY:

IV. PROJECT DRIVERS. This aspect is concerned with the regulatory or other sources of authority that are the driving force behind the project at hand. Rarely will all of these components apply to one project. In the summary sections below, identify those sources of authority, describe why they are important, and summarize the specific provisions that are relevant for the study that is the subject of this DQO.

IV	**ASPECT:** Project Drivers	**PERSON ASSIGNED RESPONSIBILITY:**

ISSUES: What regulations or other agreements establish the requirements for the project? Are there specific provisions within these regulations that apply? Are there enforceable milestones, deadlines, or permit conditions that are relevant?

IV(a)	**COMPONENT:** Lead Agency	**SOURCE:**

SUMMARY:

In many cases, there could be more than one agency involved in regulating a particular site or activity. For example, the U.S. Environmental Protection Agency (EPA) may have authority over cleanup of an abandoned waste site, the state hazardous waste agency could oversee ongoing hazardous waste management activities, and a local air pollution control authority may monitor emissions from a waste processing operation. The study at hand should be defined in sufficient detail that the user can identify which of the various agencies has the lead responsibility for overseeing project activities. If this can not be determined, it may be necessary to revisit the project scope. In some cases, agencies will share regulatory authority. In addition to identifying the lead agency, summarize the source of regulatory authority and whether there are any agreements that are driving the project schedule.

IV(b)	**COMPONENT:** RCRA	**SOURCE:**

SUMMARY:

The Resource Conservation and Recovery Act of 1976 *(RCRA) will govern the management, treatment, and disposal of hazardous materials. The RCRA program is set by EPA in 40 CFR 260 et seq. Authority for implementation of RCRA has been delegated by EPA to many states, who can adopt more stringent requirements than the federal program. RCRA also includes management and cleanup of underground storage tanks (USTs). This component should include a summary whether the facility is managing, treating, and/or disposing of regulated materials; identify the regulated materials; and summarize the provisions of the regulations that are relevant to the study at hand (e.g., land disposal restrictions, UST regulations, state-regulated wastes, compliance monitoring).*

IV (C)	**COMPONENT:** CERCLA	**SOURCE:**

SUMMARY:

The Comprehensive Environmental Response, Compensation and Liability Act of 1980 *(CERCLA) covers the cleanup of sites where waste have been disposed of improperly and/or the site has been abandoned by the parties responsible for disposal. CERCLA sites generally are not subject to other regulatory means of enforcing cleanup actions; many states have adopted a version of CERCLA that is more stringent than the Federal program. The CERCLA process involves a planning stage, in which the party(ies)evaluates the nature and extent of cleanup as* *well as the remedial alternatives (the remedial investigation/feasibility study [RI/FS] process), and a cleanup stage. If data has been generated at the site under either of these stages of the process, it can support the DQO. Are there specific enforceable actions that are the basis for the activities that are the subject of the DQO?*

In addition to cleanup of contaminated sites, the CERCLA legislation contains provisions that require facilities to maintain an inventory of chemicals used or stored on site. This is the Emergency Planning and Community Right to Know Act (EPCRA). Information generated to support EPCRA can help to establish a preliminary list of contaminants of potential concern (COPCs). The Superfund amendments of 1986 contain provision that require industry to communicate to the public chemical emissions from a facility. These are the so-called Title III requirements. This information also can support development of a COPC list.

IV(d)	**COMPONENT:** CAA	**SOURCE:**

SUMMARY:

The Federal Clean Air Act *(CAA) governs both ambient air quality standards and emissions control. The program is implemented through approved State programs. The provisions of the act that are most significant for the DQO process are contained in the operating permit program. Every facility that falls within the scope of the CAA is required to obtain an operating permit, which describes the sources of emissions and establishes control, monitoring, and record-keeping requirements for those emissions. Records relating to volatile organic compounds (VOCs) and hazardous air pollutants (HAPs) that are regulated by the CAA can support an evaluation of COPCs. Is the data that is being collected for this project to support CAA permitting or monitoring activities?*

IV(e)	**COMPONENT:** NPDES	**SOURCE:**

SUMMARY:

The NPDES regulations are established under the authority of the Clean Water Act (CWA). The NPDES program governs discharges into the waters of the United States. As noted for other regulatory programs, many states have adopted programs that parallel the Federal program. State programs can be more stringent than the Federal program and may also include regulation of discharges to groundwater, which the Federal program does not govern. The NPDES requires a permit for discharges from sources such as pipes, ditches, leachate collection systems, and containers. Storm water runoff from industrial facilities also is regulated under the NPDES program. The NPDES permit should include information related to the materials and processes that contribute to wastewater flows. Is the data that is being collected to support waste water discharge or other CWA *compliance activities?*

IV(f)	**COMPONENT:** SDWA	**SOURCE:**

SUMMARY:

The Safe Drinking Water Act *(SDWA) establishes levels of constituents for drinking water sources through adoption of maximum contamination levels (MCLs). In general, the SDWA will be of significance for purposes of a DQO process because the MCLs, in many cases, are the standards that may drive cleanup of contaminated waters. The SDWA also can be of importance to public water supply systems that rely on groundwater as a source of drinking water, because under the wellhead protection provisions of the act these sources should have developed a model of the groundwater system that they rely on, as well as potential sources of contamination. The SDWA also contains provisions that govern underground injection of wastes.*

IV(g)	**COMPONENT:** TSCA	**SOURCE:**

SUMMARY:

The Toxic Substances Control Act *(TSCA) requires companies to conduct testing of chemicals that pose a substantial risk of injury to human health or the environment. The specific chemicals and their testing requirements are specified by EPA and can be shared among members of an industry. TSCA also includes provisions requiring companies to notify EPA of chemicals that they manufacture, process, or import for a commercial purpose; "new chemicals" undergo review by the agency prior to manufacture or import. The information generated under these aspects of TSCA can help to establish the COPCs at a site. The TSCA program that is likely to be relevant for most DQOs, however, establishes regulations for manufacture, use, and disposal of polychlorinated biphenyls (PCBs). Are there TSCA-regulated materials included in the constituents of concern at this site?*

IV(h)	**COMPONENT:** NEPA	**SOURCE:**

SUMMARY:

The National Environmental Policy Act of 1969 *(NEPA) establishes requirements for the evaluation of a project and its potential consequences as an initial step in the planning process. Many states have adopted versions of NEPA that govern activities subject to state approval. NEPA documentation can be useful in providing information relating to the history of a project. Alternatives established through the NEPA process may also direct the course of the DQO process. Are the activities subject to a NEPA-related process or decision?*

IV(I)	**COMPONENT:** Compliance Order/Consent Agreement	**SOURCE:**

SUMMARY:

In some cases a facility may be subject to a formal agreement with a regulatory agency that establishes cleanup goals and schedules. If such an order or agreement exists, the conditions found in this document will provide direction for the DQO. Are the activities that are the subject of this DQO being performed in response to a consent order or compliance agreement?

IV(j)	**COMPONENT:** Waste Acceptance Criteria	**SOURCE:**

SUMMARY:

Waste acceptance criteria (WAC) established by a treatment or disposal facility will determine whether or not material can be sent to that facility. The WAC may establish specific analytical requirements as well as maximum levels of constituents and waste forms for material to be received. WACs should be established early in the process, if they are relevant for the DQO. Identify any relevant waste acceptance criteria for this DQO.

IV(k)	**COMPONENT:** Milestones/Schedule	**SOURCE:**

SUMMARY:

Milestones can be established as part of a permit condition or may be artificially imposed as part of a facility's planning process. Whatever the source of a milestone or schedule for an activity, these should be identified so that planning in the DQO process considers the relevant time frames in the decision-making process.

IV(l)	**COMPONENT:** Other	**SOURCE:**

SUMMARY:

Describe the nature and content of any other drivers for the activities that are the subject of this DQO process.

V. OPERATIONAL CONCERNS. The DQO process should consider concerns that relate to how information is gathered and whether there are specific concerns related to the data gathering operation. These concerns include such things as the safety of workers and historical or biological significance of a site. These issues should receive attention to help guide the development of decision statements.

V	**ASPECT:** Operational Concerns	**PERSON ASSIGNED RESPONSIBILITY:**
ISSUES: Does the site/material under evaluation present special considerations that affect data collection activities? Are these considerations established through regulations?		
V(a)	**COMPONENT:** Health and Safety	**SOURCE:**
SUMMARY: *Limiting exposure of workers to health or safety hazards can be a significant concern when gathering data at sites where hazardous or dangerous waste is present or if the conditions at the site present hazards independent of the materials being investigated (e.g., enclosed spaces, access concerns, inadequate ventilation). Federal and State Occupational Safety and Health Administration (OSHA) programs require employers to establish a worker health and safety program that includes making information available to employees regarding hazards as well as training programs for employees. Material safety data sheets (MSDS) should be available that can assist in determining the potential hazards associated with specific chemicals and compounds. The MSDS will include information regarding explosion hazards, reactions with other materials, health hazards, and precautions for safe handling. In addition to concerns that may be specified in regulations, common sense can play an important role in evaluating worker health and safety. These issues need to be addressed as alternative actions are being evaluated.*		

V(b)	**COMPONENT:** Cultural and Biological Constraints	**SOURCE:**

SUMMARY:

Sites that have significance due to the presence of historical or cultural artifacts may require special procedures in order to preserve the integrity of these resources. In some cases, evaluation of alternatives may require involving parties who traditionally would not be involved in the DQO process in order to ensure that these concerns are addressed adequately. In a similar light, biological constraints can have a significant affect on project planning. The presence of rare or endangered species can impose significant limitations on project activities. Even when the biological concerns are not elevated to such an extreme, site activities can have a significant offsite affect through runoff or disturbance of local populations. Presence of animals, insects, or plants that present a threat to workers also must be considered, although this aspect of the biological community could be addressed in component V(a). Information regarding these concerns can be found in background documents prepared for site activities. State historical, cultural, and wildlife agencies often maintain inventories of populations and locations of concern.

V (c)	**COMPONENT:** Nuclear Criticality	**SOURCE:**

SUMMARY:

In practice criticality is evaluated by evaluation of transuranic radionuclides, spatial analysis, and an evaluation of the material in which the appropriate radionuclides are present (e.g., water is a moderator). Transuranic (TRU) waste may need to be evaluated for criticality in the appropriate concentrations and under the appropriate configuration. TRU is defined as alpha-emitting radionuclides with an atomic number greater than 92. TRU content is typically determined by measurement of total alpha and ^{237}*Np,* ^{238}*Pu,* ^{239}*Pu,* ^{240}*Pu,* ^{241}*Pu,* ^{242}*Pu,* ^{241}*Am,* ^{242}*Cm(*^{242m}*Am,* ^{242}*Am),*$^{243+244}$*Cm and* ^{243}*Am. Any evaluation for TRU and/or criticality should be summarized.*

VI. PROJECT BUDGET. The resources committed to a project will have a definite effect on the decisions that are made for that project. If the resources are extremely limited, the amount of effort that goes into the DQO process will reflect these limitations. A primary role of the DQO process is to ensure that a project maximizes available resources. In order to evaluate the effectiveness of the process, the checklist should incorporate the budget that has been committed to various project activities. Careful evaluation of these items early in the project will help to determine whether adequate resources or the right resources have been dedicated to the project. Once the alternatives have been developed and the sampling plan optimized, these figures will be compared to the costs established based on this revised program as a final step in the DQO process.

VI	**ASPECT:** Project Budget	**PERSON ASSIGNED RESPONSIBILITY:**

ISSUES: One aspect of ensuring that a project optimizes its resources is to evaluate costs and the impact of the DQO process. A baseline project cost allows for comparison after completing the DQO process. What are the costs associated with the various project activities? How were these costs derived?

VI(a)	**COMPONENT:** DQO/Planning	**SOURCE:**

SUMMARY:

Identify the amount of funding and level of effort that has been identified to support the DQO process. This figure should reflect the commitments required by both in-house and other staff who will support the process. The level of effort (LOE) should take into account hours required to gather information, time spent in meetings and off-line preparing for, summarizing, and following-up on meetings, and development of documentation (e.g., risk analysis, regulatory analysis) to support the DQO process, as necessary.

VI(b)	**COMPONENT:** Sample Collection	**SOURCE:**

SUMMARY:

Identify the types, number, and location of samples anticipated to support the decisions that are the subject of the DQO. Provide the sample methodology and reasoning behind the selection of these values. Include a description of the purpose for each sample (i.e., what decision will the results from that sample support). What is the cost associated with this sampling program?

VI(c)	**COMPONENT:** Sample Analysis	**SOURCE:**

SUMMARY:

Identify the analytical methods proposed for each of the sample types *identified in component VI(c). What is the holding time for this analysis? What is the method detection limit associated with this technique? What is the cost associated with this method?*

VI(d)	**COMPONENT:** Site Investigation	**SOURCE:**

SUMMARY:

Site investigation includes more than sample collection and analysis. Determine the level of effort associated with planning and implementing the sampling program, evaluating the results of analyses, and developing alternative actions. Include such items as the QA/QC program, mobilization of staff and resources, and meetings with regulators. What is the cost associated with this level of effort?

VI(e)	**COMPONENT:** Radiological Survey	**SOURCE:**

SUMMARY:

This component is specific to sites where radionuclide contamination may be a concern. It could be considered a subset of sampling. Determine the type and extent of radionuclide survey required to assess the site. What is the LOE required to complete this proposed activity?

VI(f)	**COMPONENT:** Remediation	**SOURCE:**

SUMMARY:

What is the estimated cost associated with remediation of the site, independent of those components identified previously in this aspect (components VI(a) though (e))? This information might be available in an engineering evaluation that has been prepared for a site. Depending on the stage of the project this information may not have been developed. If the information is available, include such items as the cost of treating wastes, waste removal and disposal, and any follow-on monitoring that may be required. Identify the assumptions that went into developing these figures.

VI(g)	**COMPONENT:** D&D	**SOURCE:**

SUMMARY:

Decontamination and demolition (D&D) involves the elimination of contamination concerns at a facility through removal, treatment, or neutralization followed by razing the structure. The demolished structure itself may be disposed of in place or removed for disposal elsewhere. In some cases, it may be possible to recycle the components of a demolished facility. Identify the nature of the D&D activities, assumptions that are behind these activities, and the *costs associated with the various steps in the process.*

VI(h)	**COMPONENT:** Data Quality Assessment	**SOURCE:**

SUMMARY:

DQA cost typically includes statistical and analytical support. These costs should be provided.

VII. COPCs. The focus of most DQOs will be to support the identification and/or characterization of contaminants of potential concern COPCs). In the early stages of most projects the project leader should have a reasonable grasp of what constituents are driving the decisions. The purpose of this aspect is to develop a preliminary listing of the COPC to provide the DQO team with a starting point to work from.

VII	**ASPECT:** COPCs	**PERSON ASSIGNED RESPONSIBILITY:**

ISSUES: For most DQOs, the primary focus will be to determine and quantify the contaminants of concern. Based on available information, what are the contaminants of potential concern (COPCs)? How were these derived? Is there a regulatory limit associated with these COPCs? What are the appropriate sampling/analytical methods for evaluating their presence and concentrations?

VII(a)	**COMPONENT:** Draft List of COPCs	**SOURCE:**

SUMMARY:

Based on the information developed in previous steps (e.g., process description, analytical data, regulatory requirements) identify the COPCs that are interest for this DQO process. This is a preliminary listing that may be added to or reduced during the DQO. It should parallel the constituents that are the subject of the sampling plan provided in Aspect VI.

VII(b)	**COMPONENT:** Regulatory Limits/Basis	**SOURCE:**

SUMMARY:

Identify any limits imposed on the COPCs identified in VII that have an associated limit. Limits may be published or derived via risk assessment/modeling. Typically for clean up risk assessment is used. The DQO will provide the details of a risk scenarios and preliminary modeling results if published regulatory limits do not apply. List and published limits. If existing limits do not apply, not that a risk assessment/modeling must be done to establish the limits. If a previous risk assessment was performed obtain the limits from the risk assessment. If a previous Record of Decision (ROD) exists, obtain limits from the ROD.

VII(c)	**COMPONENT:** Sample Collection Method(s)	**SOURCE:**
SUMMARY: *This information should have been developed to support the costs provided in Aspect VI. Describe the specific methods to be used and the proposed QA/QC program for the sample program.*		

VII(d)	**COMPONENT:** Analytical Methods/Detection Limits	**SOURCE:**
SUMMARY: *This information should have been developed to support the costs provided in Aspect VI. Describe the specific methods to be used and the proposed QA/QC program for the sample program.*		

VIII. RISK SCENARIOS/PATHWAYS. Data may have been previously collected for the site to support the evaluation of risk exposure scenarios. Alternatively, the information generated through this DQO may support the development of risk assessment activities for the facility/site. Existing information can support the development of information through focussing decisions. If data is required to support a site assessment, these needs will help to determine the nature of information to be gathered.

VIII	**ASPECT:** Existing Risk Scenarios/ Pathways	**PERSON ASSIGNED RESPONSIBILITY:**
ISSUES: Evaluating the potential exposure of population or environmental receptors will provide a primary basis for data collection. Are there existing studies that evaluate risk scenarios and/or exposure pathways? Are the results of these studies transferable to the project under consideration? Are there fate/transport models/data available?		
VIII(a)	**COMPONENT:** Previous Conceptual Models	**SOURCE:**
SUMMARY: *A conceptual site model will identify the sources of exposure, contaminants of concern, potential receptors, and pathways to those receptors. If an existing exposure model has developed a site model, many of the COPCs that will be the focus of the DQO will be identified in that model. In addition, the model will provide supporting information to help in the identification of decisions and alternatives. Review and summarize the results of any existing site conceptual models as they relate to the decisions that are the subject of this DQO.*		

VIII(b)	**COMPONENT:** Previous Risk Assessment	**SOURCE:**

SUMMARY:

If a previous risk assessment was performed, obtain and summarize the conceptual model, risk limits for COPCs, risk pathways by media/matrix.

VIII(c)	**COMPONENT:** Fate and Transport Information	**SOURCE:**

SUMMARY:

The fate and transport is the chemical and physical movement of the COPC to the receiver of the risk or receptor. The COPC may be present at concentrations above allowable limits, and may not be mobile enough to reach the receptor and; therefore, present no risk. The mobility of the COPC in the media should be evaluated if a risk assessment is needed. This includes evaluation of pH, partition coefficients, octanol-water coefficient, chemical and biological transformation, flow rate, temperature, degree of water saturation. D&D activities may or may not require risk assessment.

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E.6. COMPILED PARAMETERS FOR PROBABILISTIC RISK ASSESSMENTS

A probabilistic risk assessment (PRA) of migration of contaminants to groundwater was conducted for the *Site Investigation Report for the Southwest Groundwater Plume at the Paducah Gaseous Diffusion Plant*, *Paducah, Kentucky,* DOE/OR/07-2180&D2 (issued May 2006). The parameters used in that modeling effort were presented in Attachment 2 of Appendix F of this site investigation report. A copy of that attachment is provided as Attachment 3 to this appendix. This set of parameter values is appropriate for use in modeling for other PRAs, though the information on these values should be reviewed during the PRA development to ensure the assumptions made in setting the values are appropriate for each site being evaluated. Parameter values should be modified, if necessary, to reflect conditions for the individual site under consideration.

APPENDIX E
ATTACHMENT 3

INPUT PARAMETERS FOR PROBABILISTIC MODELING

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Appendix F of the *Site Investigation Report for the Southwest Groundwater Plume at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE/OR/07-2180&D2)

INPUT PARAMETERS FOR PROBABILISTIC MODELING

1. INTRODUCTION

Probabilistic (stochastic) modeling was performed for the trichloroethene (TCE) sources at (Solid Waste Management Unit (SWMU) 1 and the C-720 Building areas in order to understand better the uncertainties in the transport modeling for these sources, to estimate the likely TCE concentrations at the points of exposure (POEs) using the most likely input parameters, and to determine the error bounds on the predicted TCE concentrations. This modeling was based upon the nature and extent discussion in the Site Investigation (SI) Report and the transport modeling results completed earlier.

The fate and transport modeling was performed using Spatial Analysis/Decision Assistance (SADA) software (UT 2002); Crystal Ball® (Decisioneering, Inc. 2000), an add-in to Microsoft Excel®; Seasonal Soil Compartment Model (SESOIL) (GSC 1996, Bonazountas and Wagner 1984); and Analytical Transient One-, Two-, and Three-Dimensional Simulation Model (AT123D) (GSC 1998, Yeh 1981). The key input parameters for the modeling were developed using SADA and Crystal Ball®, while the modeling itself was performed using SESOIL and AT123D.

2. INPUT PARAMETERS

The input parameters for the modeling were in two groups: fixed and variable. The values of the fixed parameters were from earlier work (DOE 2003). The values of the variable parameters were set considering earlier work and employing a probabilistic method. This was done by developing a distribution for each variable parameter and sampling the distribution using the Monte Carlo sampling technique provided in Crystal Ball®.

3. PARAMETER DISTRIBUTIONS

Several distributions were considered when selecting the best distribution for each of the variable input parameters. A general discussion of each distribution considered is provided below.

1. **Triangular Distribution:** This distribution is used to describe a variable with known minimum, maximum, and most likely values (Decisioneering, Inc. 2000). Three conditions underlying this distribution are as follows:

    - The minimum value of the variable is fixed.
    - The maximum value of the variable is fixed.

- The most likely value of the variable falls between the minimum and maximum values forming a triangular-shaped distribution and showing that values near the minimum and maximum are less likely to occur than those near the most likely values.

2. **Normal Distribution:** This is the most important distribution in the probability theory because it describes many natural phenomena (Decisioneering, Inc. 2000). Three conditions underlying this distribution are as follows:

   - Some value of the variable is the most likely (the mean of the distribution).
   - The value of the variable could as likely be below the mean as it could be above the mean (symmetrical about the mean).
   - The value of the variable is more likely to be near the mean than far away.

   Generally, if the coefficient of variability is less than 30%, a normal distribution is recommended. A skewness value between -0.5 and +0.5 indicates a fairly symmetrical distribution (Decisioneering, Inc. 2000).

3. **Log-Normal Distribution:** This distribution is widely used to describe a variable with values that are positively skewed (Decisioneering, Inc. 2000). The three conditions underlying this distribution are as follows:

   - The variable can increase without limits but cannot fall below zero.
   - The variable is positively skewed with most of the values near the lower limit.
   - The natural logarithm of the variable yields a normal distribution

   Generally, if the coefficient of variability is greater than 30%, a log-normal distribution is recommended. A skewness value less than -1 or greater than +1 indicates a highly skewed distribution (Decisioneering, Inc. 2000).

4. **Uniform Distribution:** This distribution is used to describe a variable when each value of the variable has the same probability of occurrence within a selected range. This distribution is often used when no information about variable’s distribution is available. The three conditions underlying this distribution are as follows:

   - The minimum value of the variable is fixed.
   - The maximum value of the variable is fixed.
   - The probability of any value being selected within the range between the minimum and maximum values is equal.

4. SESOIL PARAMETERS

The SESOIL software was used to simulate contaminant transport through the Upper Continental Recharge System (UCRS) to the Regional Gravel Aquifer (RGA). The parameters used for SESOIL are listed in Tables F.2.1 and F.2.2. As mentioned earlier, there are two groups of parameters. Remarks for each parameter are provided in these tables to clarify the source of the value and the justification for its selected value. Additional remarks for each variable parameter, including the values input into Crystal Ball, are provided in Table F.2.3. Finally, summary statistics for each variable parameter output by

Crystal Ball are provided in Table F.2.4. Histograms of the values output by Crystal Ball for the variable parameters are in Figs. F.2.1 through F.2.18.

1. **Fixed Parameters:** These parameters are summarized in Tables F.2.1 and F.2.2.

    - **Soil Type:** The upper portion of the UCRS is loam, while the bottom portion of it is silty clay (DOE 1999). The soil type was considered to be silty loam for each area.

    - **Bulk Density:** The bulk density of the UCRS is 1.46 g/cm^3 (DOE 1999). The bulk density was set to this value for each area.

    - **Disconnectedness Index:** The disconnected index was set to a site-specific approximate value of 10 used in earlier work. The value was estimated by calibrating the deterministic model to an average recharge of 11.38 cm/yr.

    - **Porosity:** The porosity of the UCRS is 0.45 (DOE 1999). The porosity was set to this value for each area.

    - **Depth to Water Table:** The depth to the water table was estimated for each area considering site-specific data. The depths were estimated as 16.76 m (55 ft), and 18.29 m (60 ft) for SWMU 1 and C-720 areas, respectively.

    - **Freundlich Equation Exponent:** The Freundlich equation exponent typically ranges from 0.9 to 1.4; the default value of 1.0 is recommended if the actual value is not known (GSC 1996). The exponent was set to 1 for each area.

    - **Contaminant of Concern (COC):** The COC of interest was TCE.

    - **Source Area:** The source area was developed analyzing site-specific data for each area. Soil concentration for the area was analyzed layer-by-layer using SADA. A limitation of SESOIL required that all layers have the same area. Source areas and the average soil concentration in each layer were estimated, and the source area with the maximum contaminant mass was identified and set as the “uniform area.” Concentrations within each layer were then normalized against the “uniform area” (discussed later). The “uniform areas” used for SWMU 1 and the C-720 area were 324 m^2 and 1394 m^2, respectively.

    - **Molecular Weight:** The molecular weight was set to 131 g/gm-mol (EPA 1994).

    - **Solubility in Water:** The solubility in water was set to 1100 mg/L (EPA 1996).

    - **Diffusion in Air:** The diffusion in air was set to 0.08 cm^2/sec (EPA 1996).

    - **Henry’s Constant:** The Henry’s constant was set to 0.0103 atm-m^3/mol (EPA 1996).

    - **Soil Organic Carbon/Water Partition coefficient (K_{oc}):** The K_{oc} was set to 94 L/kg (EPA 1996).

2. **Variable Parameters:** These parameters are summarized in Tables F.2.1 through F.2.4.

- **Intrinsic Permeability:** Site-specific data were available for the vertical hydraulic conductivity of the UCRS. Therefore, the intrinsic permeability was estimated from vertical hydraulic conductivity using the following equation.

  $$K = k\frac{g}{\nu} \tag{1}$$

  where K = vertical hydraulic conductivity of soil, k = intrinsic permeability of soil, ν = kinematic viscosity of water, and g = gravitational acceleration (Bear 1979). Taking ν = 0.01 cm^2/sec and g = 981 cm/sec^2 (Mills et al. 1985), and substituting in Equation 1 leads to

  $$k\left(cm^2\right) = \frac{K\left(cm/\sec\right)}{9.81\,x\,10^4\left(1/cm - \sec\right)} \tag{2}$$

  The intrinsic permeability was estimated from the saturated vertical hydraulic conductivity using Equation 2.

  The site-specific vertical hydraulic conductivities measured earlier were assumed to be representative of that expected in the UCRS at each area. Summary statistics for the site-specific data are in Table F.2.3. A set of 13 results was available (DOE 1997a, DOE 1997b). These results ranged from 1.00E-08 cm/sec to 2.00E-04 cm/sec with a likeliest (mean) value of 1.64E-05 cm/sec. The coefficient of variation was estimated as 336%, and the skewness was estimated as 3.6. Next, the statistics were studied. The maximum value, when used in SESOIL produced an unreasonable recharge; therefore, a second estimate of maximum was sought through calibration. The maximum was re-estimated as 3.20E-05 through calibration to a recharge of 22 cm/yr (DOE 2000). Given that a range and a most likely value could be determined from the site-specific data, a triangular distribution was assumed. The vertical hydraulic conductivity was assumed not correlated to any other parameter. The summary statistics for the values output by Crystal Ball are in Table F.2.4. Histograms for the output values for the resulting intrinsic permeabilities for each of the two source areas are in Figs. F.2.1 and F.2.2.

- **Organic Carbon Content:** Site-specific data were available for the organic carbon content of the UCRS. The site-specific organic carbon contents measured earlier were assumed to representative of that expected in the UCRS at each source area. Summary statistics for the site-specific data are in Table F.2.3. A set of 138 results was available. The coefficient of variation was estimated as 66%, and the skewness was estimated as 4.3. Given the coefficient of variation and skewness, a log-normal distribution was assumed. The organic carbon content was assumed not correlated to any other parameter. The summary statistics for the values output by Crystal Ball are in Table F.2.4. Histograms for the output values for organic carbon content for each of the two source areas are in Figs. F.2.3 and F.2.4.

- **Soil Concentration:** Site-specific data were available for the TCE soil concentrations in each source area. Summary statistics for each layer are in Table F.2.3. For SWMU 1, a set of 135 results was available. The coefficient of variation for these results was estimated as 523%, and the skewness was estimated as 6.42. Given the coefficient of variation and skewness, a log-normal distribution was assumed. Using site-specific data, the correlation between Layers 1 and 2 soil concentrations was determined to be 0.92. (Please see Section 4.3 for additional discussion of correlations between layers.) Similar analyses led to choosing the log-normal distribution for Layer 1 at the C-720 area. The correlation coefficients between Layers 1 and 2 for the C-720 area were determined to be 0 and -0.50, respectively. Site-specific data were also available for the soil concentrations in Layer 2 through Layer 6. Summary statistics for each of these layers at each location are in Table F.2.3. For each layer at each location, a log-normal distribution was chosen, and correlations between layers were derived.

As mentioned earlier, a limitation of the SESOIL model required normalization of soil concentrations in each layer at each location to a "uniform area." To accomplish this, the layer with the maximum contaminant mass at each source was used as that source's "uniform area," and a simple ratio was used to normalize each layer's concentration to that of the "uniform area." The summary statistics for the value output by Crystal Ball are in Table F.2.4. Histograms for each layer at each location are in Figs. F.2.5 through F.2.16.

- **Degradation Half-Life/Degradation Rate:** Site-specific data were limited for the degradation half-life of TCE in the UCRS; therefore, a range of half-lives estimated for the RGA (3.2 to 11.3 years) were selected with uniform distribution for the UCRS. (Please see Attachment F.3 of Appendix F for additional information on the estimation of degradation half-life of TCE in the RGA at PGDP.) The degradation half-life was assumed not correlated to any other parameter. Summary statistics for the values output by Crystal Ball are in Table F.2.4. Histograms of the output values for degradation rate for each of the two source areas are in Figs. F.2.17 and F.2.18. Note that only histograms of degradation rate are presented because the rate, and not the half-life, was the value input into SESOIL. Where, the degradation rate is derived from the degradation half-life using the following expression:

  $$\lambda = \frac{\ln 2}{t_{1/2}} \tag{3}$$

  where λ = degradation rate (day^{-1}), and $t_{1/2}$ = degradation half-life (days).

  An additional scenario termed the "fixed degradation scenario" was also assessed in the probabilistic analysis. The degradation half-life was set equal to 26.6 years for these runs, while the remaining parameters listed above were allowed to vary.

5. AT123D PARAMETERS AND SOURCE TERM MODELING PARAMETERS

The AT123D software was used to simulate contaminant transport from the source areas through the RGA to the POEs. The parameters used for AT123D modeling are listed in Tables F.2.5, F.2.6, and F.2.7. Remarks for each parameter are provided in the table to clarify the source and justification of selected values. Additional remarks for each variable parameter are provided in Table F.2.8. Finally, the summary statistics for each variable parameter sampled output by Crystal Ball and used in the runs for AT123D and source term modeling are provided in Table F.2.9. Histograms of the values output by Crystal Ball for the variable parameters are in Figs. F.2.19 through F.2.24.

1. **Fixed Parameters:** These parameters are summarized in Tables F.2.5, F.2.6, and F.2.7.

    - **Dispersivity:** The longitudinal dispersivity was set to 1.5 m for each area (DOE 1999). Similarly, the transverse (lateral) dispersivity and the vertical dispersivity were set to 1.5 m and 0.03 m, respectively, for the area.

    - **Bulk Density:** The bulk density of the RGA is 1670 kg/m^3 (DOE 1999). The bulk density was set to this value for each area.

    - **Density of Water:** The density of water was set to 1000 kg/m^3 (Mills et al. 1985).

    - **COC:** As mentioned earlier, the COC was TCE.

    - **Source Area:** The area used in AT123D modeling for each source was the "uniform area" developed for the source in SESOIL modeling.

    - **Diffusion in Water:** The diffusion in water was set to 3.28E-6 m^2/hr (EPA 1996).

    - **K_{oc}:** As mentioned earlier, the K_{oc} was set to 94 L/kg (EPA 1996).

    - **Distance to POEs:** The distance from the center of each source area to the POEs was estimated from plant maps. Each of the POEs was placed at the centerline of the estimated path of contaminant migration.

2. **Variable Parameter:** These parameters are summarized in Tables F.2.5 through F.2.9.

    - **Aquifer Depth (Thickness):** The aquifer depth was allowed to vary in order to account for changes in the thickness of RGA as a contaminant migrates from a source area to the Ohio River. Site-specific data were available from field measurements, and these data were assumed to be applicable to the RGA at each source area and along the estimated contaminant flow paths. A set of 24 results was available. The coefficient of variation was estimated as 31%, and the skewness was estimated as -0.61. Given the coefficient of variation and skewness, the distribution was assumed to be normal. The aquifer depth was assumed not correlated to any other parameter. Summary statistics for the values output by Crystal Ball® and used in runs for AT123D modeling are provided in Table F.2.9. A histogram of the output values for aquifer depth is in Fig. F.2.19. (Note that each source area used the same set of parameters in AT123D modeling; therefore, only one histogram is presented for each of the AT123D variable parameters.)

    - Hydraulic Conductivity: Site specific data were available for the hydraulic conductivity of the RGA, and these data were assumed to be applicable to the RGA at each source area and along the contaminant flow paths. A set of 62 results was available. The data ranged from 1.00E-04 ft/day to 8.50E+05 ft/day with a likeliest value of 1.93E+04 ft/day. The coefficient of variation was estimated as 563%, and the skewness was estimated as 7.53. A value of 1500 ft/day was used in DOE 1999. During model set-up, the range was judged to be too variable given the site-specific soil condition, and a second estimate was sought from the PGDP groundwater flow model. This estimate was developed using an analysis based upon a plan area from the PGDP site-wide groundwater model and the path of contaminant migration from the source areas to the Ohio River (please see Fig.5.1 of the main report). Based upon this analysis, the minimum, maximum, and most likely values chosen were 75, 1500, and 967 ft/day, respectively. The coefficient of variation was estimated as 65%, and the skewness was estimated as -0.35. Subsequently, the selected most likely value was determined to be inconsistent with probable site conditions, and after consultation with site experts these value was changed to 350 ft/day (i.e., the geometric mean of the minimum and maximum in the plan area). The standard deviation was assumed equal to the likeliest value yielding a coefficient of variation of 100%. Given this coefficient of variation and the skewness from the earlier analyses (i.e., that related to site-specific data and plan area), a log-normal distribution was assumed. In addition, the hydraulic conductivity was assumed correlated to the hydraulic gradient and the porosity. The correlation coefficients selected by site experts were -0.50 and 0.20 for correlating the hydraulic conductivity to the hydraulic gradient and to the porosity, respectively. Summary statistics for the values output by Crystal Ball® and used in runs for AT123D modeling are provided in Table F.2.9. A histogram of the output values for hydraulic conductivity is in Fig. F.2.20.

Hydraulic Gradient: Site-specific data were available for the hydraulic gradient of the RGA, and these data were assumed applicable to the RGA at each source area and along the contaminant flow paths. A set of 12 results was available. The coefficient of variation was estimated as 111%, and the skewness was estimated as 1.95. Given the coefficient of variation and skewness, a log-normal distribution was assumed with minimum, maximum, and most likely values of 1.00E-04, 4.00E-03, and 1.01E-03 m/m, respectively. The standard deviation was set at 1.12E-03 m/m. Additionally, the hydraulic gradient was assumed correlated to the hydraulic conductivity and the porosity. The correlation coefficients were assumed as -0.50 and -0.20 for correlating the hydraulic gradient to the hydraulic conductivity and to the porosity, respectively. Summary statistics for the values output by Crystal Ball® and used in runs for AT123D modeling are provided in Table F.2.9. A histogram of the output values for hydraulic gradient is in Fig. F.2.21.

Effective Porosity: Site-specific data were available for the porosity of the RGA; therefore, the effective porosity was estimated from the porosity using a conversion value of 81% taken from DOE 1999. [In that report, an effective porosity of 0.30 and a porosity of 0.37 were reported (i.e., 0.30/0.37 = 0.81 or 81%).] The data were assumed applicable to the RGA at each source area and along the contaminant flow paths. A set of 28 results was available. The minimum, maximum, and most likely values selected for porosity were 27, 54, and 39%. The coefficient of variation was estimated as 15%, and the skewness was estimated as 0.43. Given the coefficient of variation and skewness, a normal distribution was assumed. Additionally, the porosity was assumed correlated to the hydraulic conductivity and the hydraulic gradient. The correlation coefficients were assumed as 0.20 and -0.20 for correlating the porosity to the hydraulic conductivity and to the hydraulic gradient, respectively. Summary statistics for the values output by Crystal Ball® and the resulting effective porosity values used in runs for AT123D modeling are provided in Table F.2.9. A histogram of the effective porosity values is in Fig. F.2.22[1]. Note that only a histogram of effective porosity is presented because effective porosity and not porosity was the value input into AT123D.

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[1] Future groundwater modeling efforts at PGDP will utilize 35% as a practical upper-bound for effective porosity values.

- **Organic Carbon Content:** Site-specific data were available for the organic carbon content of the RGA, and these data were assumed applicable to the RGA at each source area and along the contaminant flow paths. A set of 38 results was available. The minimum, maximum, and most likely values selected were 3.0E-03, 2.53E-01, and 3.5E-02%, respectively. The coefficient of variation was estimated as 1.05%, and the skewness was estimated as 4.0. Given the coefficient of variation and skewness, a log-normal distribution was assumed. The organic carbon content was assumed not correlated to any other parameter. Summary statistics for the values output by Crystal Ball® and used in runs for AT123D modeling are provided in Table F.2.9. A histogram of the output values for organic carbon content is in Fig. F.2.23.

- **Degradation Half-Life:** Recently, as part of response actions, the U.S. Department of Energy (DOE) has developed revised biodegradation rates that were incorporated into the SI modeling. Attachment F.3 to this appendix presents a detailed discussion of the derivation of the degradation rates. Additionally, the degradation half-life was observed to be correlated with groundwater flow which is a direct function of hydraulic conductivity and hydraulic gradient. However, for this analysis the degradation half-life was assumed 100% correlated to the hydraulic gradient. Summary statistics for the values output by Crystal Ball® and used in runs for AT123D modeling are provided in Table F.2.9. A histogram of the output values for degradation rate is in Fig. F.2.24. Note that only histograms of degradation rate are presented because the rate, and not the half-life, was the value input into AT123D. It should be noted here that although hydraulic gradient assumed a normal distribution, Crystal Ball output for degradation rate presented in Fig. F2.24 does not appear to be normally distributed. An additional scenario termed the "fixed degradation scenario" was also assessed in the probabilistic analysis. No degradation was assumed for these runs, while the remaining parameters listed above were allowed to vary.

6. CORRELATION MATRIX

As mentioned earlier, the soil concentration in each layer was assumed correlated to the adjacent layers for a given area. To estimate the correlation coefficient between two adjacent layers, sets of ordered pairs of concentrations were analyzed. Because data were sparse, ordered pairs were difficult to establish using the sampling date; therefore, the source developed using SADA was used for the estimation. For SADA data, the size and shape of the source areas in the adjacent layers differed; therefore, an ordered pair was formed only in the parts of the source where two layers overlapped.

The correlation values are presented in Table F.2.3.

7. SENSITIVITY ANALYSIS

Although there was not any sensitivity analysis performed under this task to select the parameters that were allowed to vary, previous groundwater modeling efforts at the PGDP have included sensitivity analyses of several of the parameters input into SESOIL and AT123D in order to understand some of the modeling uncertainties. The analyses are included in these documents:

- U-Landfill Design and Analysis (DOE 2002)
- K_d-Sensitivity Analysis (SAIC 2002)
- Northeast and Northwest Plume Groundwater Modeling (BJC 2003)
- Recharge- and Ohio River Stage-Sensitivity Analysis (DOE 2002)

Based on these analyses, the following parameters were determined to be the most sensitive parameters for fate and transport modeling using SESOIL and AT123D:

- Contaminant's concentration in the soil/source term,
- Contaminant's degradation half-life,
- Contaminant's distribution coefficient (K_d) (i.e., directly related to the organic carbon content of source soils for organic compounds)
- Percolation rate (controlled by source vertical permeability)
- Saturated hydraulic conductivity,
- Hydraulic gradient,
- Effective porosity, and
- Aquifer thickness

The contaminant concentration in the source term is one of the most sensitive parameters; increasing the source term concentration increases the predicted groundwater concentration at the POE by increasing contaminant flux and lengthening the time required for depletion of contaminant in the source. The percolation rate is also a very sensitive parameter; increasing the percolation rate results in increased contaminant flux to the RGA and, potentially, a greater peak concentration at the POE. An increased percolation rate, however, is related to faster depletion of contaminant in the source. The contaminant's distribution coefficient, K_d, is a very sensitive parameter for the SESOIL and AT123D models and may rank only behind contaminant concentration in terms of importance. Sensitivity analyses have shown that increasing the K_d of any layer included in the SESOIL model or of the RGA included in the AT123D model decreases contaminant concentrations at the POE because of retardation and attenuation due to sorption. Therefore, with higher K_d's the rate of source depletion is slowed, and the time required for source depletion is increased. Degradation half-life is also important if the time taken for source depletion or required for contaminant migration from the source to the POE is long relative to the contaminant's degradation half-life (i.e., 3 or more times half-life). This is the case because, under this condition, the rate of contaminant degradation in the source or as the contaminant migrates from the source to the POE results in markedly lower contaminant concentrations at the POE.

For AT123D modeling, the earlier sensitivity analyses have identified three additional input parameters. These parameters are hydraulic conductivity, hydraulic gradient, and effective porosity. In the AT123D model, hydraulic conductivity, hydraulic gradient, and effective porosity work together to control seepage velocity (i.e., seepage velocity equals hydraulic conductivity times hydraulic gradient divided by effective porosity), and an increase in seepage velocity increases the rate of contaminant migration to the POE. The values chosen for the Southwest Plume model indicates that the hydraulic gradient varies over a relatively narrow range in the RGA. Therefore, the impact of hydraulic gradient on seepage velocity is expected to be relatively smaller than that of hydraulic conductivity. Table 2.10

presents an overall summary of qualitative sensitivity of modeling results to input parameters for this analysis.

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Table F.2.1. Sil-specific parameters for SESOIL modeling (see Table F.46a)

Input Parameter	Unit	SWMU 1	C-720 Building	Remark
Soil Type	-	Silty Loam	Silty Loam	DOE 1999
Bulk Density	g/cm^3	1.46	1.46	DOE 1999
Intrinsic Permeability	cm^2	Variable	Variable	Probabilistic method
Disconnectedness Index	-	10	10	Site-specific (to PGDP) approximate value used in earlier work
Porosity	-	0.45	0.45	DOE 1999
Depth to Water Table	m	16.76	18.29	Site-specific (to RGA) field data
Organic Carbon Content	%	Variable	Variable	Probabilistic method
Freundlich Equation Exponent	-	1	1	Default

DOE 1999. *Remedial Investigation Report for Waste Area Grouping 27 at the Paducah Gaseous Diffusion Plant Paducah, Kentucky*, DOE/OR/07-1777/V4&D2, June.
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Table F.2.2. Chemical-specific parameters for SESOIL modeling (see Table F.46b)

Input Parameter	Unit	SWMU 1	C-720 Building	Remark
Contaminant of Concern	-	Trichloroethene	Trichloroethene	
Source Area	m^2	324	1394	Site-specific (to TCE) SADA analysis
Soil Concentration - Layer 1	mg/kg	Variable	Variable	Probabilistic method
Soil Concentration - Layer 2	mg/kg	Variable	Variable	Probabilistic method
Soil Concentration - Layer 3	mg/kg	Variable	Variable	Probabilistic method
Soil Concentration - Layer 4	mg/kg	Variable	Variable	Probabilistic method
Soil Concentration - Layer 5	mg/kg	Variable	Variable	Probabilistic method
Soil Concentration - Layer 6	mg/kg	Variable	Variable	Probabilistic method
Molecular Weight	g/gmol	131	131	EPA 1994
Solubility in Water	mg/L	1100	1100	EPA 1996
Diffusion in Air	cm^2/s	0.08	0.08	EPA 1996
Henry's Constant	$atm.m^3/mol$	0.0103	0.0103	EPA 1996
Koc	L/kg	94	94	EPA 1996
Degradation Rate	day^{-1}	Variable	Variable	Probabilistic method

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Table F.2.3. Statistics of variable inputs used in Monte Carlo sampling for SESOIL modeling (see Table F.45)

Input Parameter	Statistics	Unit	SWMU 1	C-720 Building	Remark
Vertical Hydraulic Conductivity[a]	Minimum	cm/sec	1.00E-08	1.00E-08	DOE 1997a, DOE 1997b
	Likeliest	cm/sec	1.64E-05	1.64E-05	DOE 1997a, DOE 1997b
	Maximum	cm/sec	2.00E-04	2.00E-04	[b]DOE 1997a, DOE 1997b
	Standard Deviation	cm/sec	5.52E-05	5.52E-05	DOE 1997a, DOE 1997b
	Count	#	13	13	DOE 1997a, DOE 1997b
	Coefficient of Variation	%	336.49	336.49	DOE 1997a, DOE 1997b
	Skew	-	3.60	3.60	DOE 1997a, DOE 1997b
	Maximum	cm/sec	3.20E-05	3.20E-05	[c,d]Recharge-specific (to RGA) calibration
	Distribution	-	Triangular	Triangular	See Section 4.0, Intrinsic Permeability
	Correlation Pair	-	None	None	None
	Correlation Coefficient	-	NA	NA	NA
Organic Carbon Content	Minimum	%	2.48E-02	2.48E-02	Site-specific (to PGDP) field data
	Likeliest	%	8.01E-02	8.01E-02	Site-specific (to PGDP) field data
	Maximum	%	4.55E-01	4.55E-01	Site-specific (to PGDP) field data
	Standard Deviation	%	5.27E-02	5.27E-02	Site-specific (to PGDP) field data
	Count	#	138	138	Site-specific (to PGDP) field data
	Coefficient of Variation	%	65.82	65.82	Site-specific (to PGDP) field data
	Skew	-	4.30	4.30	Site-specific (to PGDP) field data
	Distribution	-	Log normal	Log normal	Site-specific (to PGDP) field data
	Correlation Pair	-	None	None	See Section 4.0, Organic Carbon Content
	Correlation Coefficient	-	NA	NA	NA
Soil Concentration - Layer 1	Minimum	mg/kg	0.00E+00	0.00E+00	Site-specific (to PGDP) field data
	Likeliest	mg/kg	2.14E+00	1.56E+00	Site-specific (to PGDP) field data
	Maximum	mg/kg	8.70E+01	1.70E+01	Site-specific (to PGDP) field data
	Standard Deviation	mg/kg	1.12E+01	5.12E+00	Site-specific (to PGDP) field data
	Count	#	135	11	Site-specific (to PGDP) field data
	Coefficient of Variation	%	522.90	328.48	Site-specific (to PGDP) field data
	Skew	-	6.42	3.32	Site-specific (to PGDP) field data
	Distribution	-	Log normal	Log normal	Site-specific (to PGDP) field data
	Correlation Pair	-	see Layer 2	see Layer 2	Site-specific (to TCE) SADA analysis
	Correlation Coefficient	-	see Layer 2	see Layer 2	Site-specific (to TCE) SADA analysis

Table F.2.3. Statistics of variable inputs used in Monte Carlo sampling for SESOIL modeling (see Table F.45) (continued)

Input Parameter	Statistics	Unit	SWMU 1	C-720 Building	Remark
Soil Concentration - Layer 2	Minimum	mg/kg	0.00E+00	0.00E+00	Site-specific (to PGDP) field data
	Likeliest	mg/kg	1.59E+01	1.22E+00	Site-specific (to PGDP) field data
	Maximum	mg/kg	4.39E+02	1.90E+01	Site-specific (to PGDP) field data
	Standard Deviation	mg/kg	7.87E+01	4.23E+00	Site-specific (to PGDP) field data
	Count	#	31	36	Site-specific (to PGDP) field data
	Coefficient of Variation	%	494.84	347.17	Site-specific (to PGDP) field data
	Skew	-	5.53	3.81	Site-specific (to PGDP) field data
	Distribution	-	Log normal	Log normal	Site-specific (to PGDP) field data
	Correlation Pair	-	Layer 1 and Layer 2	Layer 1 with Layer 2	Site-specific (to TCE) SADA analysis
	Correlation Coefficient	-	9.20E-01	-5.00E-01	Site-specific (to TCE) SADA analysis
Soil Concentration - Layer 3	Minimum	mg/kg	0.00E+00	0.00E+00	Site-specific (to PGDP) field data
	Likeliest	mg/kg	7.60E+00	5.94E+00	Site-specific (to PGDP) field data
	Maximum	mg/kg	8.50E+01	6.80E+01	Site-specific (to PGDP) field data
	Standard Deviation	mg/kg	1.82E+01	1.54E+01	Site-specific (to PGDP) field data
	Count	#	32	23	Site-specific (to PGDP) field data
	Coefficient of Variation	%	238.82	258.66	Site-specific (to PGDP) field data
	Skew	-	3.15	3.49	Site-specific (to PGDP) field data
	Distribution	-	Log normal	Log normal	Site-specific (to PGDP) field data
	Correlation Pair	-	Layer 2 and Layer 3	Layer 2 with Layer 3	Site-specific (to TCE) SADA analysis
	Correlation Coefficient	-	3.50E-01	5.90E-01	Site-specific (to TCE) SADA analysis
Soil Concentration - Layer 4	Minimum	mg/kg	0.00E+00	0.00E+00	Site-specific (to PGDP) field data
	Likeliest	mg/kg	5.12E+00	3.87E-01	Site-specific (to PGDP) field data
	Maximum	mg/kg	7.40E+01	1.80E+00	Site-specific (to PGDP) field data
	Standard Deviation	mg/kg	1.46E+01	6.50E-01	Site-specific (to PGDP) field data
	Count	#	27	33	Site-specific (to PGDP) field data
	Coefficient of Variation	%	285.55	168.18	Site-specific (to PGDP) field data
	Skew	-	4.37	1.44	Site-specific (to PGDP) field data
	Distribution	-	Log normal	Log normal	Site-specific (to PGDP) field data
	Correlation Pair	-	Layer 3 and Layer 4	Layer 3 with Layer 4	Site-specific (to TCE) SADA analysis
	Correlation Coefficient	-	2.10E-01	1.60E-01	Site-specific (to TCE) SADA analysis

Table F.2.3. Statistics of variable inputs used in Monte Carlo sampling for SESOIL modeling (see Table F.45) (continued)

Input Parameter	Statistics	Unit	SWMU 1	C-720 Building	Remark
Soil Concentration - Layer 5	Minimum	mg/kg	0.00E+00	0.00E+00	Site-specific (to PGDP) field data
	Likeliest	mg/kg	5.95E+00	2.00E-01	Site-specific (to PGDP) field data
	Maximum	mg/kg	6.60E+01	1.30E+00	Site-specific (to PGDP) field data
	Standard Deviation	mg/kg	1.42E+01	3.69E-01	Site-specific (to PGDP) field data
	Count	#	33	30	Site-specific (to PGDP) field data
	Coefficient of Variation	%	238.99	184.61	Site-specific (to PGDP) field data
	Skew	-	3.24	2.04	Site-specific (to PGDP) field data
	Distribution	-	Log normal	Log normal	Site-specific (to PGDP) field data
	Correlation Pair	-	Layer 4 with Layer 5	Layer 4 with Layer 5	Site-specific (to TCE) SADA analysis
	Correlation Coefficient	-	4.00E-01	9.90E-01	Site-specific (to TCE) SADA analysis
Soil Concentration - Layer 6	Minimum	mg/kg	0.00E+00	0.00E+00	Site-specific (to PGDP) field data
	Likeliest	mg/kg	7.20E-01	1.17E-01	Site-specific (to PGDP) field data
	Maximum	mg/kg	3.40E+00	6.30E-01	Site-specific (to PGDP) field data
	Standard Deviation	mg/kg	1.07E+00	2.04E-01	Site-specific (to PGDP) field data
	Count	#	12	16	Site-specific (to PGDP) field data
	Coefficient of Variation	%	148.61	174.34	Site-specific (to PGDP) field data
	Skew	-	1.71	1.61	Site-specific (to PGDP) field data
	Distribution	-	Log normal	Log normal	Site-specific (to PGDP) field data
	Correlation Pair	-	Layer 5 with Layer 6	Layer 5 with Layer 6	Site-specific (to TCE) SADA analysis
	Correlation Coefficient	-	9.20E-01	5.00E-01	Site-specific (to TCE) SADA analysis
Degradation Half-life	Minimum	yr	3.20E+00	3.20E+00	See Attachment F.3
	Likeliest	yr	NA	NA	NA
	Maximum	yr	1.13E+01	1.13E+01	See Attachment F.3
	Standard Deviation	yr	NA	NA	NA
	Distribution	-	Uniform	Uniform	See Section 4.0, Degradation Half-Life
	Correlation Pair	-	None	None	See Section 4.0, Degradation Half-Life
	Correlation Coefficient	-	NA	NA	NA

Table F.2.3. Statistics of variable inputs used in Monte Carlo sampling for SESOIL modeling (see Table F.45) (continued)

[a] Field observation was available for vertical hydraulic conductivity. Therefore, intrinsic permeability was estimated from vertical hydraulic conductivity.
[b] The maximum from DOE 1997a and DOE 1997b was judged to be high and was re-estimated through calibration.
[c] The maximum was estimated through calibration to a recharge of 22 cm/yr (DOE 2000).
[d] The value selected for probabilistic method.

Howard, P.H., R.S. Boethling, W.F. Jarvis, W.M. Meylan, and E.M. Michalenko, *Environmental Degradation Rates*, Lewis Publishers, Inc. Chelsea, MI, 1991.

LMES (Lockheed Martin Energy Systems) 1997. *Evaluation of Natural Attenuation Processes for Trichloroethylene and Technetium-99 in the Northeast and Northwest Plumes at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, KY/EM-113.

DOE, 1997a. *Ground-Water Conceptual Model for the Paducah Gaseous Diffusion Plant Paducah, Kentucky,* DOE/OR/06-1628&D0, August.

DOE, 1997b. *Data Summary and Interpretation Report for Interim Remedial Design at Solid Waste Management Unit 2 of Waste Area Grouping 22 at the PGDP Paducah, Kentucky,* DOE/OR/07-1549&D1, February.

DOE 2000. *Feasibility Study for the Groundwater Operable Unit at Paducah Gaseous Diffusion Plant Paducah, Kentucky,* DOE/OR/07-1857&D1, July.

Table F.2.4. Statistics of variable inputs used in Monte Carlo runs for SESOIL modeling (see Table F.47)

Input Parameter	Statistics	Unit	SWMU 1	C-720 Building
Vertical Hydraulic Conductivity[a]	Minimum	cm/sec	2.75E-06	2.75E-06
	Median	cm/sec	1.64E-05	1.64E-05
	Maximum	cm/sec	2.82E-05	2.83E-05
	Arithmetic Mean	cm/sec	1.60E-05	1.58E-05
	Standard Deviation	cm/sec	6.57E-06	6.73E-06
Intrinsic Permeability[a]	Minimum	cm^2	2.80E-11	2.80E-11
	Median	cm^2	1.67E-10	1.67E-10
	Maximum	cm^2	2.87E-10	2.89E-10
	Arithmetic Mean	cm^2	1.63E-10	1.61E-10
	Standard Deviation	cm^2	6.70E-11	6.86E-11
Organic Carbon Content[b]	Minimum	mg/kg	2.53E+02	2.67E+02
	Median	mg/kg	6.76E+02	6.86E+02
	Maximum	mg/kg	2.78E+03	3.47E+03
	Arithmetic Mean	mg/kg	7.90E+02	8.37E+02
	Standard Deviation	mg/kg	4.71E+02	5.14E+02
Organic Carbon Content (%)[b]	Minimum	%	2.53E-02	2.67E-02
	Median	%	6.76E-02	6.86E-02
	Maximum	%	2.78E-01	3.47E-01
	Arithmetic Mean	%	7.90E-02	8.37E-02
	Standard Deviation	%	4.71E-02	5.14E-02
Soil Concentration - Layer 1[c]	Minimum	mg/kg	2.86E-03	2.33E-03
	Median	mg/kg	5.73E-01	2.37E-01
	Maximum	mg/kg	3.58E+01	4.63E+00
	Arithmetic Mean	mg/kg	2.37E+00	6.46E-01
	Standard Deviation	mg/kg	5.15E+00	1.03E+00
Soil Concentration - Layer 2[c]	Minimum	mg/kg	6.03E-02	5.20E-03
	Median	mg/kg	3.64E+00	2.14E-01
	Maximum	mg/kg	1.88E+02	5.80E+00
	Arithmetic Mean	mg/kg	1.41E+01	5.95E-01
	Standard Deviation	mg/kg	3.09E+01	1.12E+00
Soil Concentration - Layer 3[c]	Minimum	mg/kg	1.28E-01	2.34E-02
	Median	mg/kg	5.80E+00	1.67E+00
	Maximum	mg/kg	1.02E+02	4.82E+01
	Arithmetic Mean	mg/kg	1.14E+01	5.08E+00
	Standard Deviation	mg/kg	1.63E+01	8.66E+00
Soil Concentration - Layer 4[c]	Minimum	mg/kg	1.28E-01	5.11E-03
	Median	mg/kg	2.78E+00	7.76E-02
	Maximum	mg/kg	1.15E+02	5.91E-01
	Arithmetic Mean	mg/kg	8.93E+00	1.24E-01
	Standard Deviation	mg/kg	1.62E+01	1.23E-01
Soil Concentration - Layer 5[c]	Minimum	mg/kg	1.26E-01	1.01E-03
	Median	mg/kg	4.39E+00	3.56E-02
	Maximum	mg/kg	7.50E+01	4.01E-01
	Arithmetic Mean	mg/kg	1.04E+01	6.09E-02
	Standard Deviation	mg/kg	1.44E+01	6.68E-02

Table F.2.4. Statistics of variable inputs used in Monte Carlo runs for SESOIL modeling (see Table F.47) (continued)

Input Parameter	Statistics	Unit	SWMU 1	C-720 Building
Soil Concentration - Layer 6[c]	Minimum	mg/kg	5.30E-02	7.50E-04
	Median	mg/kg	1.04E+00	1.95E-02
	Maximum	mg/kg	6.65E+00	1.92E-01
	Arithmetic Mean	mg/kg	1.55E+00	3.31E-02
	Standard Deviation	mg/kg	1.53E+00	3.63E-02
Degradation Half-Life[d]	Minimum	yr	3.2	3.2
	Median	yr	4.9	4.9
	Maximum	yr	11.3	11.3
	Arithmetic Mean	yr	4.9	4.9
	Standard Deviation	yr	NA	NA
Degradation Rate[d]	Minimum	/hr	7.13E-06	7.21e-06
	Median	/hr	1.22E-05	1.13E-05
	Maximum	/hr	2.43E-05	2.43E-05
	Arithmetic Mean	/hr	1.32E-05	1.30E-05
	Standard Deviation	/hr	NA	NA

[a] Intrinsic permeability (cm^2) was estimated from the vertical hydraulic conductivity (cm/sec) using a conversion factor of 1.019E-5.

[b] Organic carbon content (%) was estimated from organic carbon content (mg/kg) using a conversion factor of 1E-4.

[c] Soil concentrations are normalized using the volume of the layer with the largest mass.

[d] Degradation rate was estimated from degradation half-life in units of days using the formula: rate = [(ln 2)/degradation half-life].

Table F.2.5. Hydrogeology-specific parameters for AT123D modeling (see Table F.49)

Input Parameter	Unit	SWMU 1	C-720 Building	Remark
Aquifer Thickness	m	Variable	Variable	Probabilistic method
Hydraulic Conductivity	m/hr	Variable	Variable	Probabilistic method
Hydraulic Gradient	m/m	Variable	Variable	Probabilistic method
Effective Porosity	-	Variable	Variable	Probabilistic method
Organic Carbon Content	%	Variable	Variable	Probabilistic method
Dispersivity - Longitudinal	m	15	15	DOE 1999
Dispersivity - Transverse	m	1.5	5	DOE 1999
Dispersivity - Vertical	m	0.03	5	DOE 1999
Bulk Density	kg/m^3	1670	1670	DOE 1999
Density of Water	kg/m^3	1000	1000	Mills et al. 1985

DOE 1999. *Remedial Investigation Report for Waste Area Grouping 27 at the Paducah Gaseous Diffusion Plant Paducah, Kentucky,* DOE/OR/07-1777/V4&D2, June.

Mills, W. B., D. B. Porcella, M. J. Ungs, S. A. Gherini, K. V. Summers, Lingfung Mok, G. L. Rupp, G. L. Bowie, and D. A. Hadith, 1985. *Water Quality Assessment: A Screening Procedure for Toxic and Conventional Pollutants, Parts II,* EPA-600/6-85/002b, September, U.S. Environmental Protection Agency, Environmental Research Laboratory, Office of Research and Development, Athens, GA.

Table F.2.6. Chemical-specific parameters for AT123D modeling (see Table F.49)

Input Parameter	Unit	SWMU 1	C-720 Building	Remark
Contaminant of Concern	-	Trichloroethene	Trichloroethene	Selected for analysis
Source Area	m^2	324	1394	Site-specific (to TCE) SADA analysis
Diffusion in Water	m^2/hr	3.28E-06	3.28E-06	EPA 1996
Koc	L/kg	94	94	EPA 1996
Degradation Rate (half-life)[a]	hr^{-1} (year)	Variable	Variable	Attachment F.3

[a] Degradation rate was estimated from degradation half-life (see text).

EPA 1996. *Soil Screening Guidance: Technical Background Document*, Office of Solid Waste and Emergency Response, Washington, D.C.

Table F.2.7. POE-specific parameters for AT123D modeling (see Table F.51)

Input Parameter	Unit	SWMU 1	C-720 Area	Remark
Distance to Plant Boundary	m (ft)	170 (558)	762 (2500)	See Fig. F.20
Distance to Property Boundary	m (ft)	915 (3000)	1460 (4789)	See Fig. F.20
Distance to Ohio River	m (ft)	7317 (24000)	7927 (26000)	See Fig. F.20

Table F.2.8. Statistics of variable inputs used in Monte Carlo sampling for AT123D modeling (see Table F.48)

		SWMU 1 and C-720 Building				
Input Parameter	**Statistics**	**Crystal Ball**	**Unit**	**AT123D**	**Unit**	**Remark**
Aquifer Thickness	Minimum Value	10.00	ft	3.05	m	DOE 1995, DOE 1997a, DOE 1997b, DOE 2000a, DOE 2000b, DOE 2004, KY 1992b
	Likeliest Value	38.71	ft	11.80	m	DOE 1995, DOE 1997a, DOE 1997b, DOE 2000a, DOE 2000b, DOE 2004, KY 1992b
	Maximum Value	63.50	ft	19.36	m	DOE 1995, DOE 1997a, DOE 1997b, DOE 2000a, DOE 2000b, DOE 2004, KY 1992b
	Standard deviation	11.84	ft	3.61	m	DOE 1995, DOE 1997a, DOE 1997b, DOE 2000a, DOE 2000b, DOE 2004, KY 1992b
	Count	24	#	24	#	DOE 1995, DOE 1997a, DOE 1997b, DOE 2000a, DOE 2000b, DOE 2004, KY 1992b
	Coefficient of Variation	30.59	%	30.59	%	DOE 1995, DOE 1997a, DOE 1997b, DOE 2000a, DOE 2000b, DOE 2004, KY 1992b
	Skew	-0.61	-	-0.61	-	DOE 1995, DOE 1997a, DOE 1997b, DOE 2000a, DOE 2000b, DOE 2004, KY 1992b
	Distribution	Normal	-	Normal	-	DOE 1995, DOE 1997a, DOE 1997b, DOE 2000a, DOE 2000b, DOE 2004, KY 1992b
	Correlation pair	None	-	None	-	Assumed none
	Correlation coefficient	NA	-	NA	-	NA
Hydraulic Conductivity	Minimum Value	1.00E-04	ft/day	1.27E-06	m/hr	[a] BJC 2001a, BJC 2001b, DOE 1997a, DOE 1997b, DOE 1999a, DOE 1999b, DOE 1999c, KY 1992a
	Likeliest Value	1.93E+04	ft/day	2.46E+02	m/hr	[a] BJC 2001a, BJC 2001b, DOE 1997a, DOE 1997b, DOE 1999a, DOE 1999b, DOE 1999c, KY 1992a
	Maximum Value	8.50E+05	ft/day	1.08E+04	m/hr	[a] BJC 2001a, BJC 2001b, DOE 1997a, DOE 1997b, DOE 1999a, DOE 1999b, DOE 1999c, KY 1992a
	Standard deviation	1.09E+05	ft/day	1.38E+03	m/hr	[a] BJC 2001a, BJC 2001b, DOE 1997a, DOE 1997b, DOE 1999a, DOE 1999b, DOE 1999c, KY 1992a
	Count	62	#	62	#	[a] BJC 2001a, BJC 2001b, DOE 1997a, DOE 1997b, DOE 1999a, DOE 1999b, DOE 1999c, KY 1992a
	Coefficient of Variation	563.17	%	563.17	%	[a] BJC 2001a, BJC 2001b, DOE 1997a, DOE 1997b, DOE 1999a, DOE 1999b, DOE 1999c, KY 1992a
	Skew	7.53	-	7.53	-	[a] BJC 2001a, BJC 2001b, DOE 1997a, DOE 1997b, DOE 1999a, DOE 1999b, DOE 1999c, KY 1992a

Table F.2.8. Statistics of variable inputs used in Monte Carlo sampling for AT123D modeling (see Table F.48) (continued)

Input Parameter	Statistics	SWMU 1 and C-720 Building				Remark
		Crystal Ball	Unit	AT123D	Unit	
Hydraulic Conductivity	Minimum Value	75.00	ft/day	0.95	m/hr	[a] PGDP Groundwater flow model
	Likeliest Value	966.85	ft/day	12.28	m/hr	[a] PGDP Groundwater flow model
	Maximum Value	1500.00	ft/day	19.05	m/hr	[a] PGDP Groundwater flow model
	Standard deviation	628.74	ft/day	7.99	m/hr	[a] PGDP Groundwater flow model
	Count	12166	#	12166	#	[a] PGDP Groundwater flow model
	Coefficient of Variation	65.03	%	65.03	%	[a] PGDP Groundwater flow model
	Skew	-0.35	-	-0.35	-	[a] PGDP Groundwater flow model
Hydraulic Conductivity	Minimum Value	75.00	ft/day	0.95	m/hr	[a,b] Minimum of the site-specific (to PGDP) groundwater flow model
	Likeliest Value	350.00	ft/day	4.45	m/hr	[a,b] Assumed approximate geomean of the minimum and maximum of the site-specific (to PGDP) groundwater flow model
	Maximum Value	1500.00	ft/day	19.05	m/hr	[a,b] Maximum of the site-specific (to PGDP) groundwater flow model
	Standard deviation	350.00	ft/day	4.45	m/hr	[a,b] Assumed equal to likeliest value
	Coefficient of Variation	100.00	%	100.00	%	[a,b] Assumed equal to likeliest value
	Distribution	Log normal	-	Log normal	-	BJC 2001a, BJC 2001b, DOE 1997a, DOE 1997b, DOE 1999a, DOE 1999b, DOE 1999c, KY 1992a
	Correlation pair	Hydraulic Conductivity and Porosity	-	Hydraulic Conductivity and Porosity	-	Assumed
	Correlation coefficient	NA	-	NA	-	NA
Hydraulic Gradient	Minimum Value	1.00E-04	ft/ft	1.00E-04	m/m	BJC 2001a, DOE 1997a, DOE 1997b, DOE 1997, KY 1992a, KY 1997
	Likeliest Value	1.01E-03	ft/ft	1.01E-03	m/m	BJC 2001a, DOE 1997a, DOE 1997b, DOE 1997, KY 1992a, KY 1997
	Maximum Value	4.00E-03	ft/ft	4.00E-03	m/m	BJC 2001a, DOE 1997a, DOE 1997b, DOE 1997, KY 1992a, KY 1997
	Standard deviation	1.12E-03	ft/ft	1.12E-03	m/m	BJC 2001a, DOE 1997a, DOE 1997b, DOE 1997, KY 1992a, KY 1997
	Count	12	#	12	#	BJC 2001a, DOE 1997a, DOE 1997b, DOE 1997, KY 1992a, KY 1997
	Coefficient of Variation	110.89	%	110.89	%	BJC 2001a, DOE 1997a, DOE 1997b, DOE 1997, KY 1992a, KY 1997
	Skew	1.95	-	1.95	-	BJC 2001a, DOE 1997a, DOE 1997b, DOE 1997, KY 1992a, KY 1997
	Distribution	Normal	-	Normal	-	BJC 2001a, DOE 1997a, DOE 1997b, DOE 1997, KY 1992a, KY 1997
Hydraulic Gradient	Correlation pair	Hydraulic Conductivity and Hydraulic Gradient	-	Hydraulic Conductivity and Hydraulic Gradient	-	Assumed

Table F.2.8. Statistics of variable inputs used in Monte Carlo sampling for AT123D modeling (see Table F.48) (continued)

Input Parameter	Statistics	SWMU 1 and C-720 Building				Remark
		Crystal Ball	Unit	AT123D	Unit	
	Correlation coefficient	-0.50	-	-0.50	-	Assumed
Porosity [c]	Minimum Value	27.00	%	27.00	%	DOE 1997a, DOE 1999a, DOE 1999c
	Likeliest Value	39.11	%	39.11	%	DOE 1997a, DOE 1999a, DOE 1999c
	Maximum Value	54.00	%	54.00	%	DOE 1997a, DOE 1999a, DOE 1999c
	Standard deviation	5.98	%	5.98	%	DOE 1997a, DOE 1999a, DOE 1999c
	Count	28	#	28	#	DOE 1997a, DOE 1999a, DOE 1999c
	Coefficient of Variation	15.29	%	15.29	%	DOE 1997a, DOE 1999a, DOE 1999c
	Skew	0.43	-	0.43	-	DOE 1997a, DOE 1999a, DOE 1999c
	Distribution	Normal	-	Normal	-	DOE 1997a, DOE 1999a, DOE 1999c
	Correlation pair	Hydraulic Gradient and Porosity	-	Hydraulic Gradient and Porosity	-	Assumed
	Correlation coefficient	-0.20	-	-0.20	-	Assumed
Organic Carbon Content	Minimum Value	0.003	%	0.003	%	KY 1992a, DOE 1997a, BJC 2006
	Likeliest Value	0.035	%	0.035	%	KY 1992a, DOE 1997a, BJC 2006
	Maximum Value	0.253	%	0.253	%	KY 1992a, DOE 1997a, BJC 2006
	Standard deviation	0.037	%	0.037	%	KY 1992a, DOE 1997a, BJC 2006
	Count	38	#	38	#	KY 1992a, DOE 1997a, BJC 2006
	Coefficient of Variation	1.05	%	1.05	%	KY 1992a, DOE 1997a, BJC 2006
	Skew	4.00	-	4.00	-	KY 1992a, DOE 1997a, BJC 2006
	Distribution	Log normal	-	Log normal	-	KY 1992a, DOE 1997a, BJC 2006
	Correlation pair	None	-	None	-	Assumed
	Correlation coefficient	NA	-	NA	-	NA

Table F.2.8. Statistics of variable inputs used in Monte Carlo sampling for AT123D modeling (see Table F.48) (continued)

Input Parameter	Statistics	SWMU 1 and C-720 Building				Remark
		Crystal Ball	Unit	AT123D	Unit	
Degradation Half-Life	Minimum Value	3.2	yr	NA	-	[d] See Attachment F.3
	Likeliest Value	NA	-	NA	-	NA
	Maximum Value	11.3	yr	NA	-	[d] See Attachment F.3
	Standard deviation	NA	-	NA	-	NA
	Count	NA	-	NA	-	NA
	Coefficient of Variation	NA	-	NA	-	NA
	Skew	NA	-	NA	-	NA
	Distribution	Uniform	-	NA	-	[d] See Attachment F.3
	Correlation pair	Hydraulic Gradient and Degradation Rate	-	NA	-	Assumed
	Correlation coefficient	-1.00	-	NA	-	[d] See Attachment F.3
Degradation Rate	Minimum Value	NA	-	7.01E-06	/hr	[d] See Attachment F.3
	Likeliest Value	NA	-	NA	-	NA
	Maximum Value	NA	-	2.45E-05	/hr	[d] See Attachment F.3
	Standard deviation	NA	-	NA	-	NA
	Count	NA	-	NA	-	NA
	Coefficient of Variation	NA	-	NA	-	NA
	Skew	NA	-	NA	-	NA
	Distribution	NA	-	Uniform	-	[d] See Attachment F.3
	Correlation pair	NA	-	Hydraulic Gradient and Degradation Rate	-	Assumed
	Correlation coefficient	NA	-	-1.00	-	[d] See Attachment F.3

[a] Multiple values were noted.
[b] The value selected for probabilistic method.
[c] Field observation was available for porosity. Therefore, effective porosity was estimated from porosity.
[d] Degradation rate was estimated from degradation half-life in units of hours using the formula: rate = [(ln 2)/degradation half-life].
BJC 2001a. C-746-U Solid Waste Landfill Groundwater Monitoring Plan Paducah Gaseous Diffusion Plant Paducah, Kentucky. BJC/PAD-205/R1, December.
BJC 2001b. Groundwater Monitoring Plan for the C-746-S Residential Landfill Paducah Gaseous Diffusion Plant Paducah, Kentucky. BJC/PAD-268/R1, December.

Table F.2.8. Statistics of variable inputs used in Monte Carlo sampling for AT123D modeling (see Table F.48) (continued)

		SWMU 1 and C-720 Building				
Input Parameter	**Statistics**	**Crystal Ball**	**Unit**	**AT123D**	**Unit**	**Remark**

BJC 2006.

DOE 1995. *Northeast Plume Preliminary Characterization Summary Report*, DOE/OR/07-1339/V2 & D2, July.

DOE 1997a. *Data Summary and Interpretation Report for Interim Remedial Design at Solid Waste Management Unit 2 of Waste Area Grouping 22 at the PGDP Paducah, Kentucky*, DOE/OR/07-1549&D1, February.

DOE 1997b. *Ground-Water Conceptual Model for the Paducah Gaseous Diffusion Plant Paducah, Kentucky*, DOE/OR/06-1628&D0, August.

DOE 1999a. *Remedial Investigation Report for Waste Area Grouping 6 at Paducah Gaseous Diffusion Plant Paducah, Kentucky*, DOE/OR/07-1727V1&D2, May.

DOE 1999b. R*emedial Investigation Report for Waste Area Grouping 27 at Paducah Gaseous Diffusion Plant Paducah, Kentucky*, DOE/OR/07-1777V1&D2, June.

DOE 1999c. *Remedial Investigation Report for Waste Area Grouping 6 at Paducah Gaseous Diffusion Plant Paducah, Kentucky*, DOE/OR/07-1727V2&D2, May.

DOE 2000a. *Data Report for the Sitewide Remedial Evaluation for Source Areas Contributing to Off-Site Groundwater Contamination at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/OR/07-1845/D1, January.

DOE 2000b. *Remedial Investigation Report for Waste Area Grouping 3 at the Paducah Gaseous Diffusion Plan, Paducah, Kentucky*, DOE/OR/07-1895/V2&D1, September.

DOE 2004. *Site Investigation Report for the Southwest Plume at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/OR/07-2180&D0, October.

KY 1992a. R*eport of the Paducah Gaseous Diffusion Plan Groundwater Investigation Phase III*, KY/E-150, November 25.

KY 1992b. *Results of the Site Investigation, Phase II, at the Paducah Gaseous Diffusion Plant*, KY/SUB/13B-97777C P-03/1991/1, April.

KY 1997. *Analysis and Interpretation of Water Levels in Observations Wells at the Paducah Gaseous Diffusion Plant 1990-1997*, KY/EM-210, June 30.

Table F.2.9. Statistics of variable inputs used in Monte Carlo runs for Source Term development and AT123D modeling (see Table F.50)

Input Parameter	[c] Statistics	Unit	SWMU 1 and C-720 Building
Aquifer Depth	Minimum	m	3.38
	Median	m	11.30
	Maximum	m	18.50
	Arithmetic Mean	m	10.90
	[c] Standard Deviation	m	3.44
Hydraulic Conductivity	Minimum	m/hr	0.97
	Median	m/hr	3.54
	Maximum	m/hr	17.60
	Arithmetic Mean	m/hr	4.77
	[c] Standard Deviation	m/hr	3.70
Hydraulic Gradient	Minimum	m/m	1.63E-04
	Median	m/m	1.37E-03
	Maximum	m/m	3.98E-03
	Arithmetic Mean	m/m	1.49E-03
	[c] Standard Deviation	m/m	9.20E-04
Porosity	[a] Minimum	%	27.16
	Median	%	38.27
	Maximum	%	53.09
	Arithmetic Mean	%	39.51
	[c] Standard Deviation	%	6.17
Effective Porosity	[a] Minimum	-	0.22
	Median	-	0.31
	Maximum	-	0.43
	Arithmetic Mean	-	0.32
	[c] Standard Deviation	-	0.05
Organic Carbon Content	Minimum	%	0.003
	Median	%	0.024
	Maximum	%	0.228
	Arithmetic Mean	%	0.034
	[c] Standard Deviation	%	0.034
Degradation Half-Life	[b] Minimum	yr	3.2
	Median	yr	4.9
	Maximum	yr	11.3
	Arithmetic Mean	yr	4.9
	[c] Standard Deviation	yr	NA
Degradation Rate	[b] Minimum	/hr	7.20E-06
	Median	/hr	1.62E-05
	Maximum	/hr	2.45E-05
	Arithmetic Mean	/hr	1.61E-05
	[c] Standard Deviation	/hr	NA

Table F.2.9. Statistics of variable inputs used in Monte Carlo runs for AT123D modeling (see Table F.50) (continued)

Input Parameter		Statistics	Unit	SWMU 1 and C-720 Building
Groundwater Concentration in the RGA[c]		Minimum	μg/L	2.92
		Median	μg/L	362.7
		Maximum	μg/L	25311
		Arithmetic Mean	μg/L	2138.6
	[c]	Standard Deviation	μg/L	4534.8
Total Soil Concentration Derived from Groundwater Concentrations[c]		Minimum	mg/kg	7.25E-04
		Median	mg/kg	9.73E-02
		Maximum	mg/kg	5.68E+00
		Arithmetic Mean	mg/kg	5.72E-01
	[c]	Standard Deviation	mg/kg	1.18E+00

[a] Effective porosity was estimated from porosity (see text).

[b] Degradation rate was estimated from degradation half-life in units of hours using the formula: rate = [(ln 2)/degradation half-life].

[c] This parameter was only used for secondary source term modeling.

Table F.2.10. Qualitative sensitivity of modeling results to input parameters for the Southwest Plume SI Report

Input Parameter	Degree of sensitivity		
	Low	Medium	High
Bulk density	√		
Effective porosity		√	
Horizontal hydraulic conductivity in the RGA		√	
Vertical hydraulic conductivity in the UCRS	√		
Percolation rate		√	
Horizontal hydraulic gradient in the RGA		√	
Aquifer thickness	√		
Longitudinal dispersivity	√		
Soil-water partition coefficient (K_d)			√
Fraction of organic carbon (%)			√
Biodegradation half-life			√
Molecular diffusion	√		
Source Area		√	
Source term in the UCRS			√

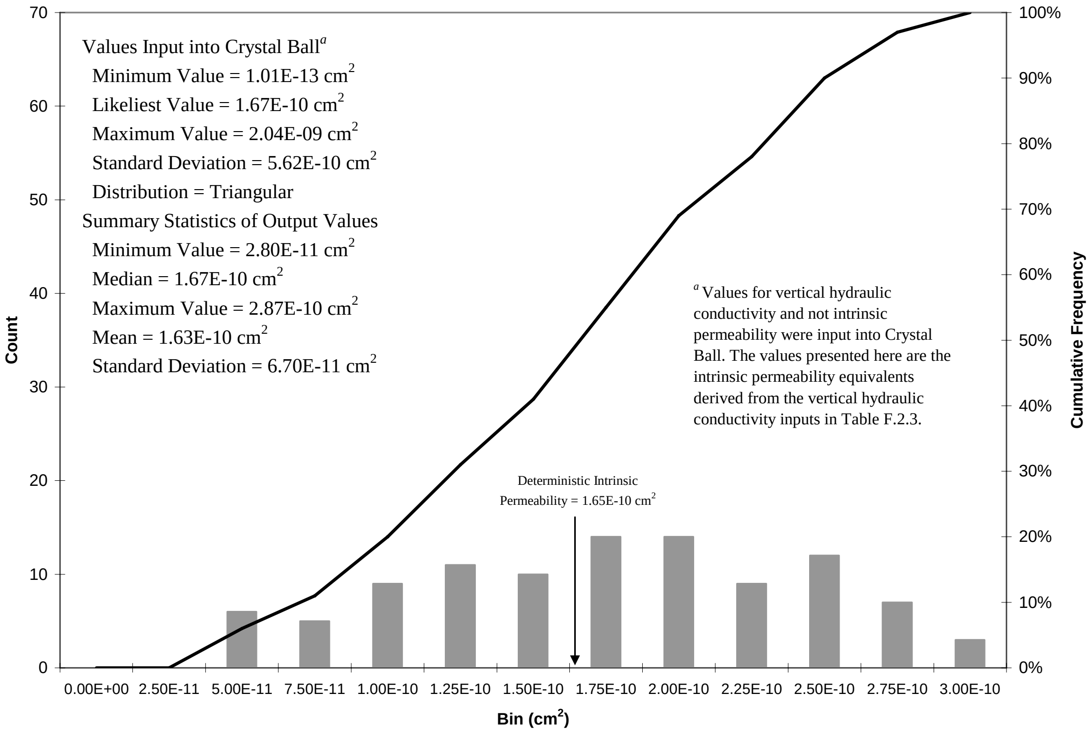


Fig. F.2.1. Histogram of Intrinsic Permeability SESOIL inputs for SWMU 1.

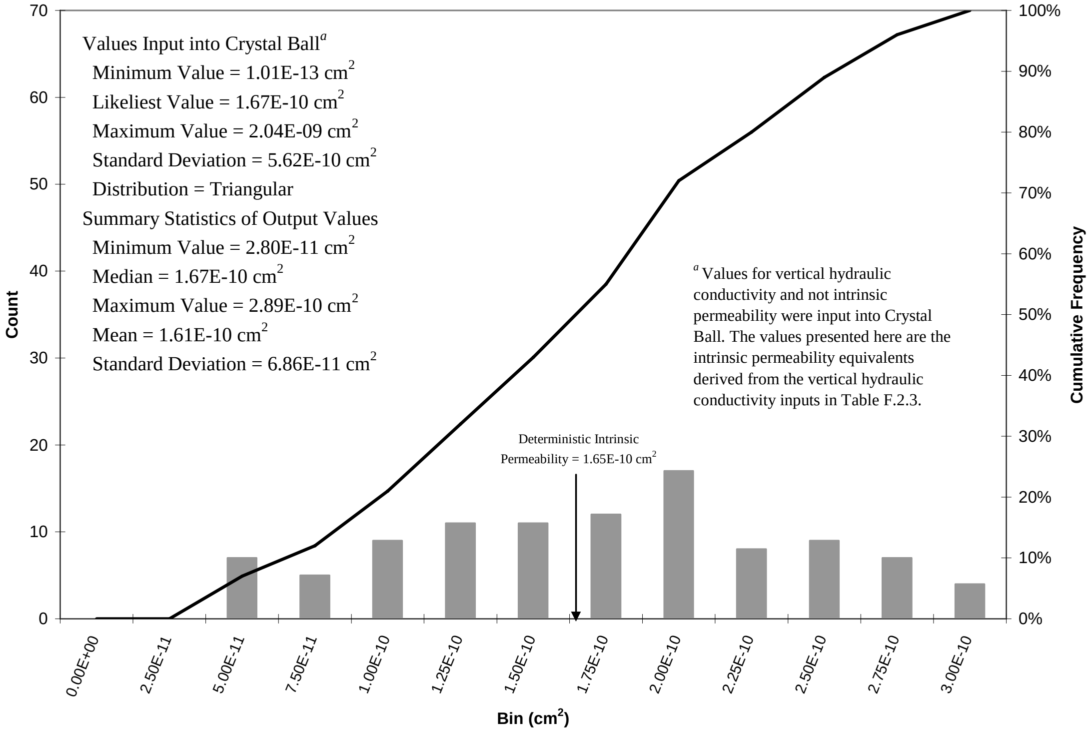


Fig. F.2.2. Histogram of Intrinsic Permeability SESOIL inputs for the C-720 Area.

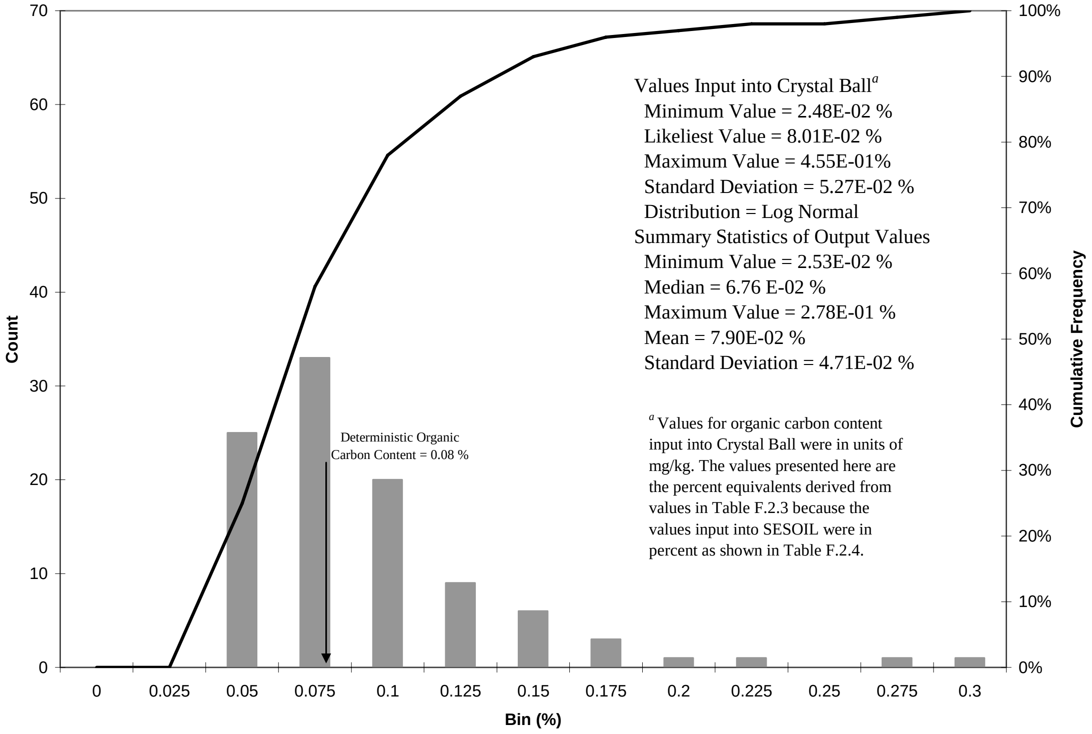
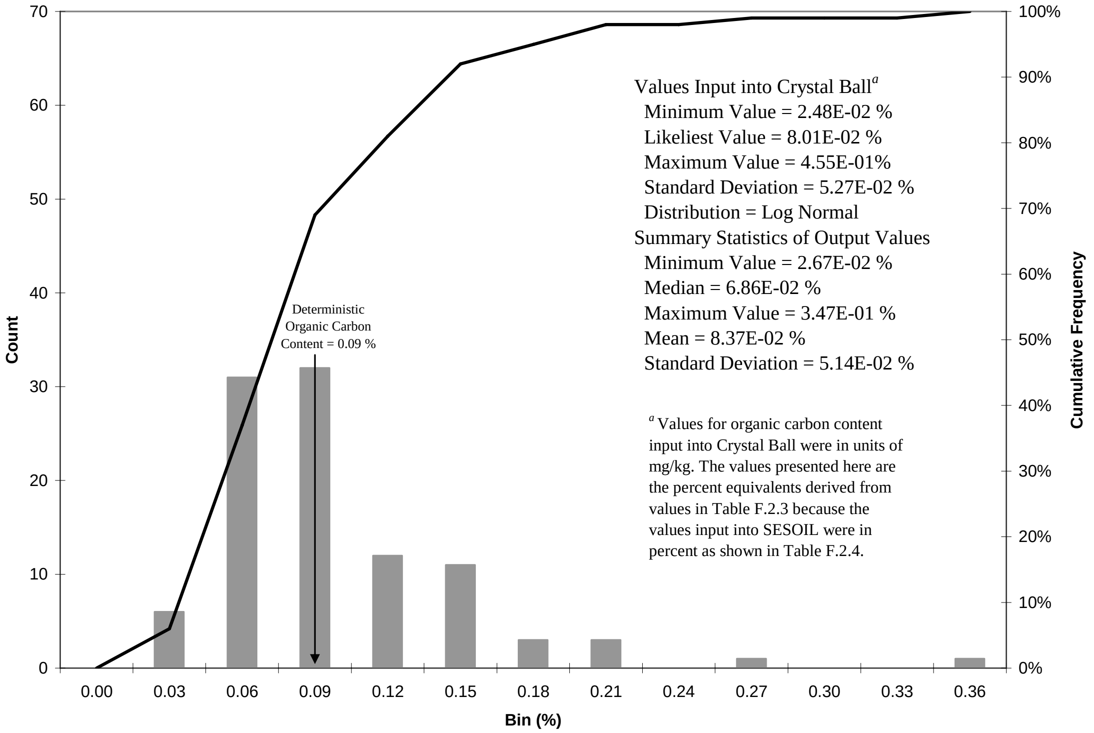


Fig. F.2.3. Histogram of Organic Carbon Content SESOIL inputs for SWMU 1.

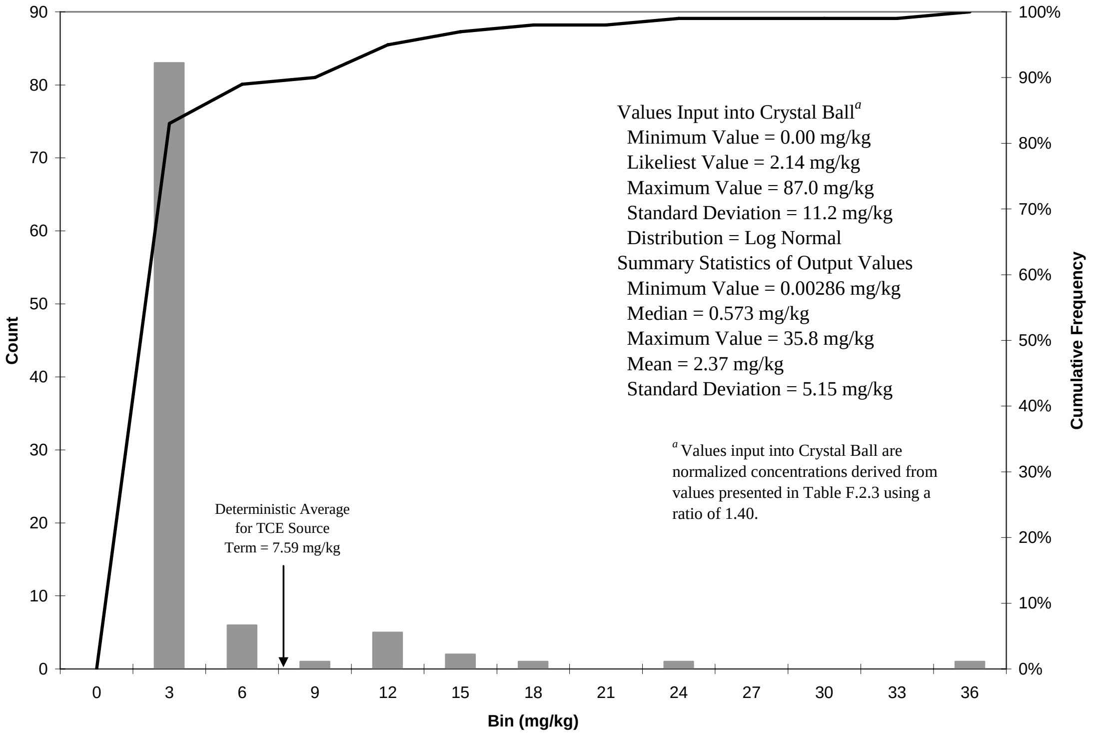


Deterministic Organic Carbon Content = 0.09 %

Values Input into Crystal Ball[a]
Minimum Value = 2.48E-02 %
Likeliest Value = 8.01E-02 %
Maximum Value = 4.55E-01%
Standard Deviation = 5.27E-02 %
Distribution = Log Normal
Summary Statistics of Output Values
Minimum Value = 2.67E-02 %
Median = 6.86E-02 %
Maximum Value = 3.47E-01 %
Mean = 8.37E-02 %
Standard Deviation = 5.14E-02 %

[a] Values for organic carbon content input into Crystal Ball were in units of mg/kg. The values presented here are the percent equivalents derived from values in Table F.2.3 because the values input into SESOIL were in percent as shown in Table F.2.4.

Fig. F.2.4. Histogram of Organic Carbon Content SESOIL inputs for the C-720 Area.

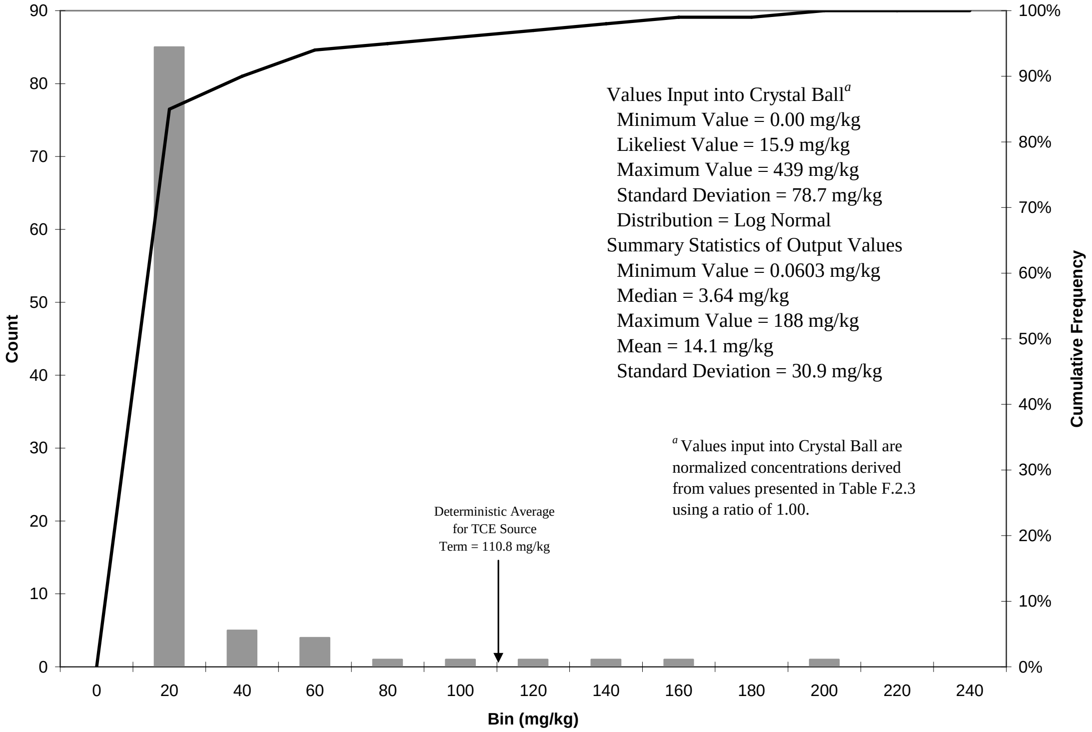


Deterministic Average for TCE Source Term = 7.59 mg/kg

Values Input into Crystal Ball[a]
Minimum Value = 0.00 mg/kg
Likeliest Value = 2.14 mg/kg
Maximum Value = 87.0 mg/kg
Standard Deviation = 11.2 mg/kg
Distribution = Log Normal
Summary Statistics of Output Values
Minimum Value = 0.00286 mg/kg
Median = 0.573 mg/kg
Maximum Value = 35.8 mg/kg
Mean = 2.37 mg/kg
Standard Deviation = 5.15 mg/kg

[a] Values input into Crystal Ball are normalized concentrations derived from values presented in Table F.2.3 using a ratio of 1.40.

Fig. F.2.5. Histogram of Layer 1 TCE concentrations at SWMU 1 used as SESOIL inputs.



Values Input into Crystal Ball[a]
Minimum Value = 0.00 mg/kg
Likeliest Value = 15.9 mg/kg
Maximum Value = 439 mg/kg
Standard Deviation = 78.7 mg/kg
Distribution = Log Normal
Summary Statistics of Output Values
Minimum Value = 0.0603 mg/kg
Median = 3.64 mg/kg
Maximum Value = 188 mg/kg
Mean = 14.1 mg/kg
Standard Deviation = 30.9 mg/kg

[a] Values input into Crystal Ball are normalized concentrations derived from values presented in Table F.2.3 using a ratio of 1.00.

Deterministic Average for TCE Source Term = 110.8 mg/kg

Fig. F.2.6. Histogram of Layer 2 TCE concentrations at SWMU 1 used as SESOIL inputs.

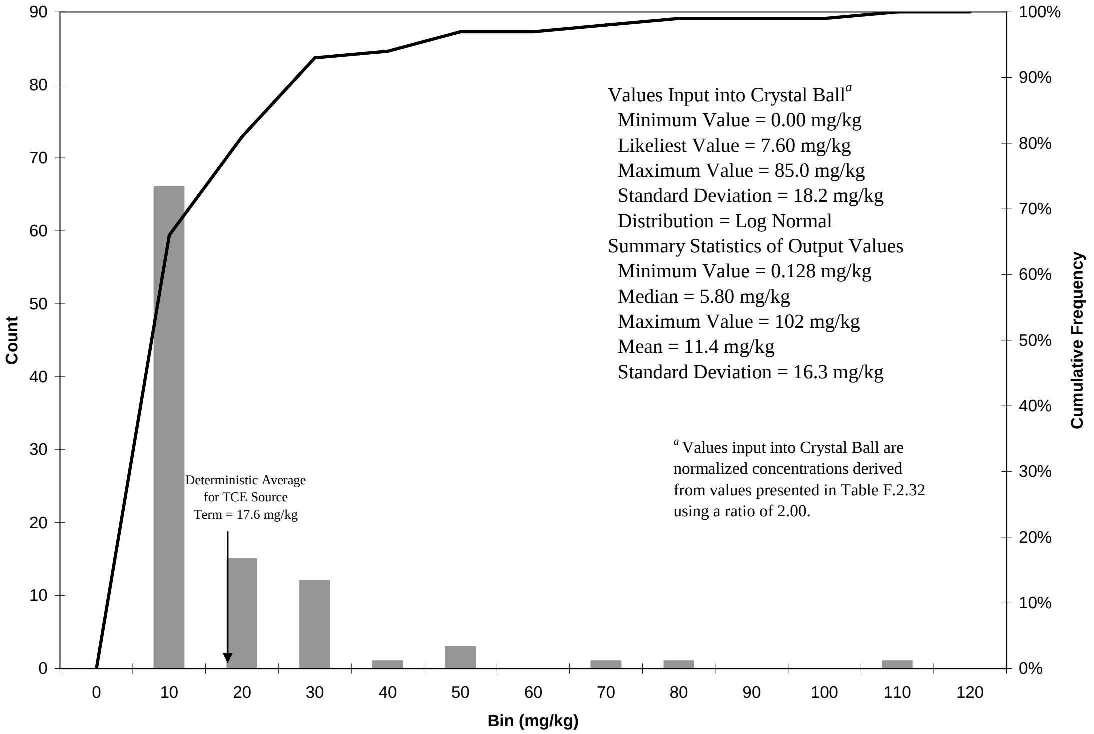


Fig. F.2.7. Histogram of Layer 3 TCE concentrations at SWMU 1 used as SESOIL inputs.

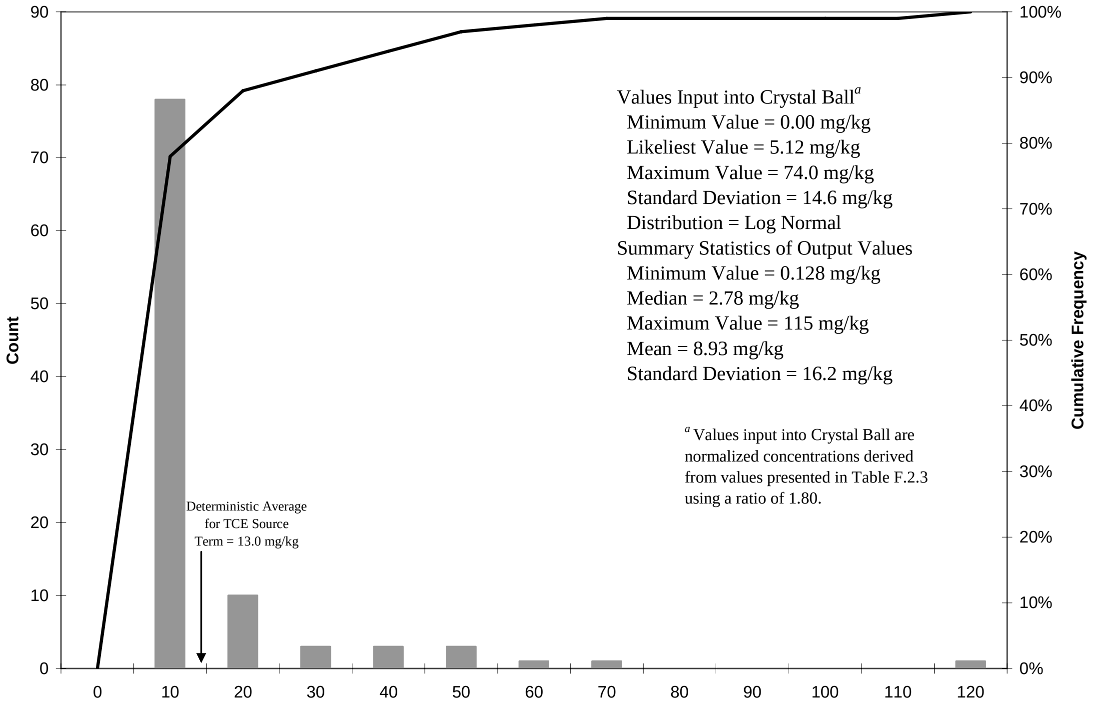


Fig. F.2.8. Histogram of Layer 4 TCE concentrations at SWMU 1 used as SESOIL inputs.

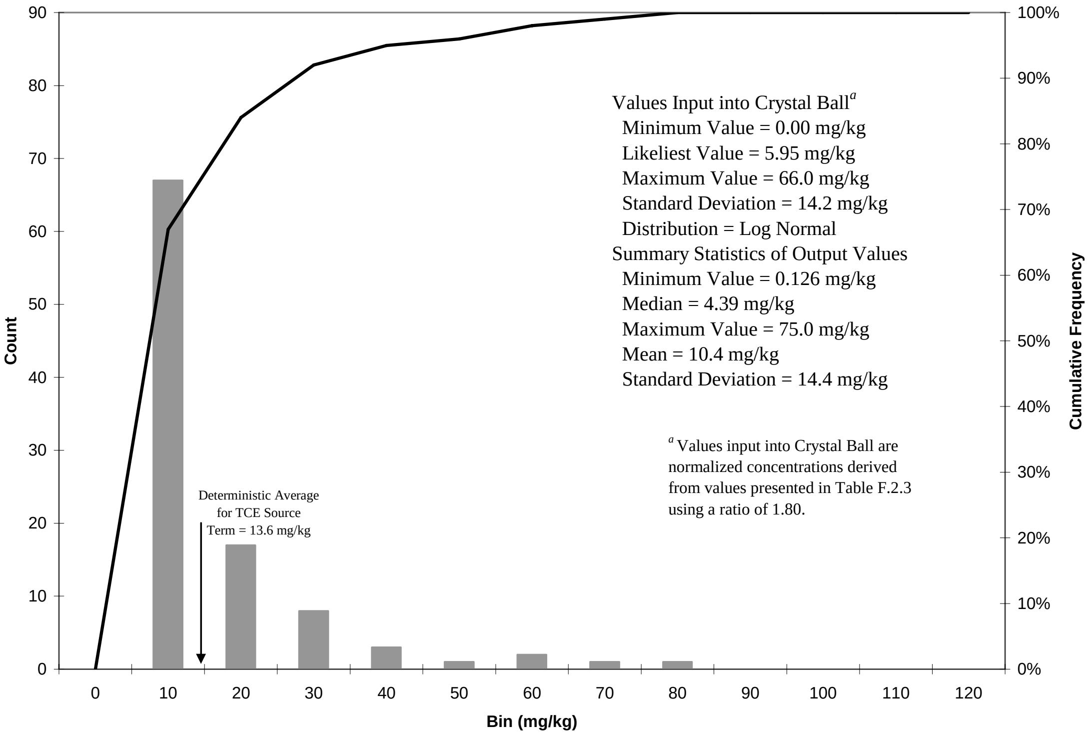


Fig. F.2.9. Histogram of Layer 5 TCE concentrations at SWMU 1 used as SESOIL inputs.

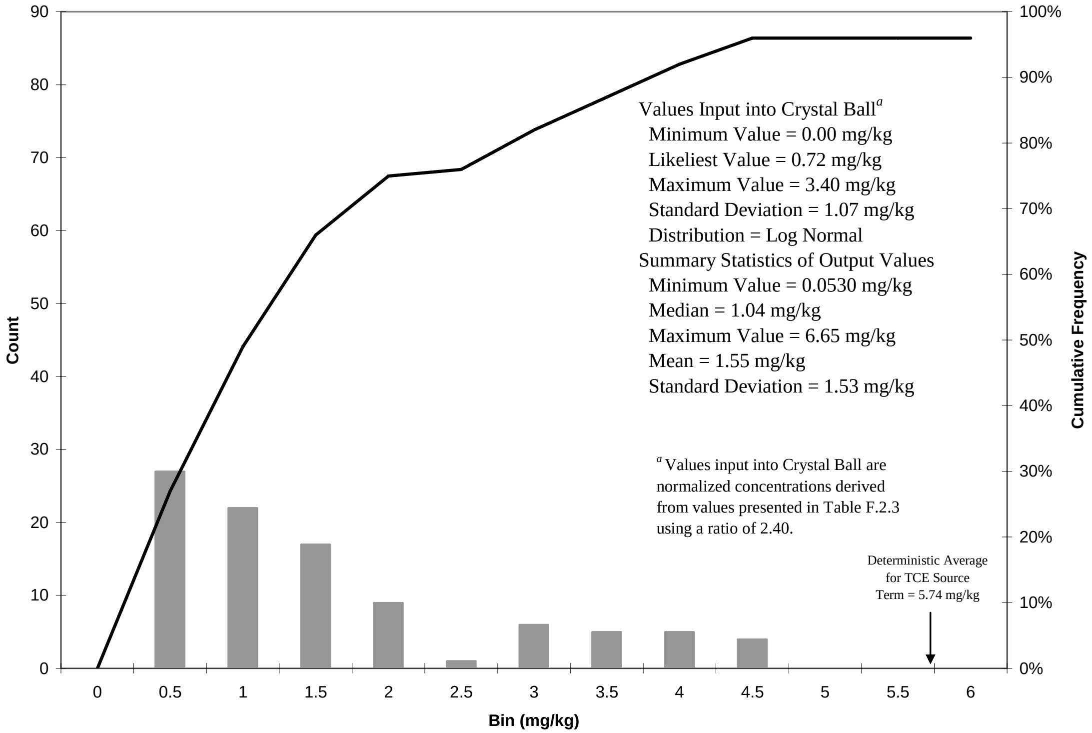
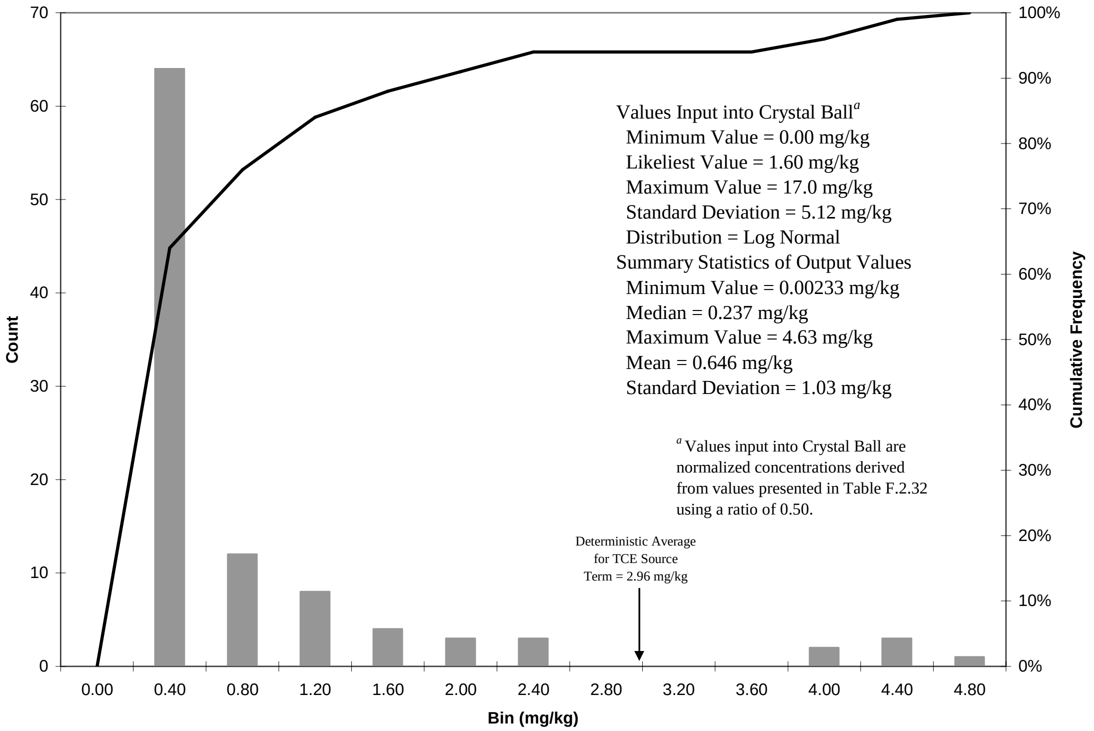


Fig. F.2.10. Histogram of Layer 6 TCE concentrations at SWMU 1 used as SESOIL inputs.

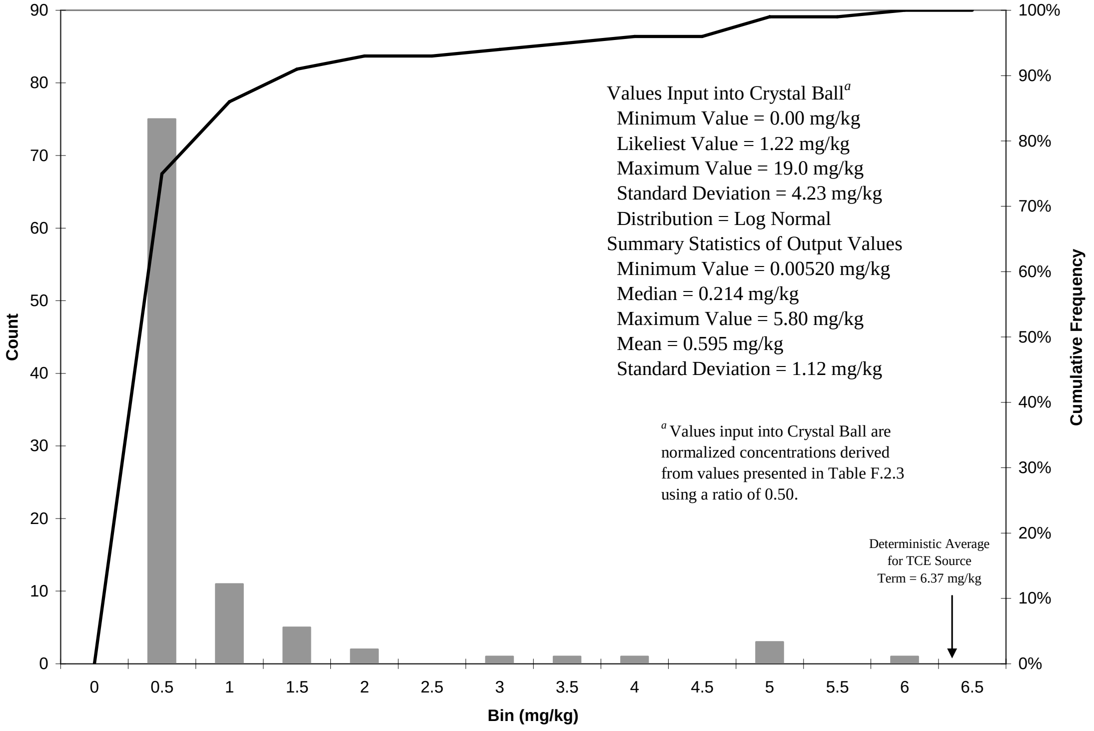


Values Input into Crystal Ball[a]
Minimum Value = 0.00 mg/kg
Likeliest Value = 1.60 mg/kg
Maximum Value = 17.0 mg/kg
Standard Deviation = 5.12 mg/kg
Distribution = Log Normal
Summary Statistics of Output Values
Minimum Value = 0.00233 mg/kg
Median = 0.237 mg/kg
Maximum Value = 4.63 mg/kg
Mean = 0.646 mg/kg
Standard Deviation = 1.03 mg/kg

[a] Values input into Crystal Ball are normalized concentrations derived from values presented in Table F.2.32 using a ratio of 0.50.

Deterministic Average for TCE Source Term = 2.96 mg/kg

Fig. F.2.11. Histogram of Layer 1 TCE concentrations at C-720 Area used as SESOIL inputs.

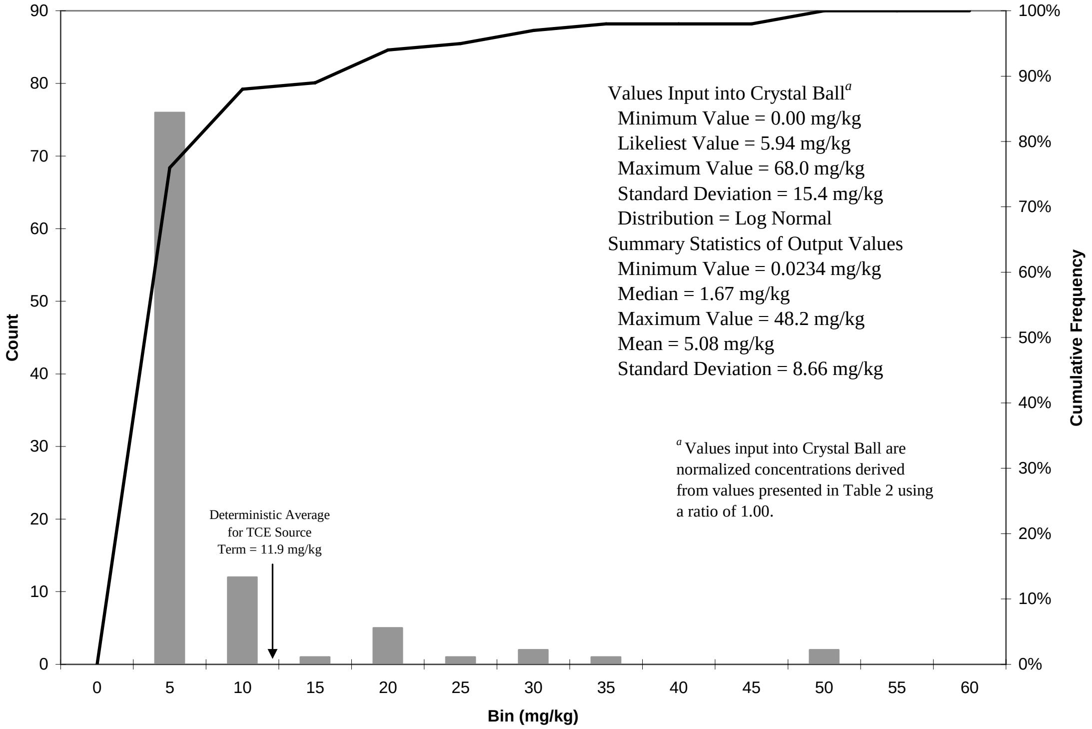


Values Input into Crystal Ball[a]
Minimum Value = 0.00 mg/kg
Likeliest Value = 1.22 mg/kg
Maximum Value = 19.0 mg/kg
Standard Deviation = 4.23 mg/kg
Distribution = Log Normal
Summary Statistics of Output Values
Minimum Value = 0.00520 mg/kg
Median = 0.214 mg/kg
Maximum Value = 5.80 mg/kg
Mean = 0.595 mg/kg
Standard Deviation = 1.12 mg/kg

[a] Values input into Crystal Ball are normalized concentrations derived from values presented in Table F.2.3 using a ratio of 0.50.

Deterministic Average for TCE Source Term = 6.37 mg/kg

Fig. F.2.12. Histogram of Layer 2 TCE concentrations at C-720 Area used as SESOIL inputs.

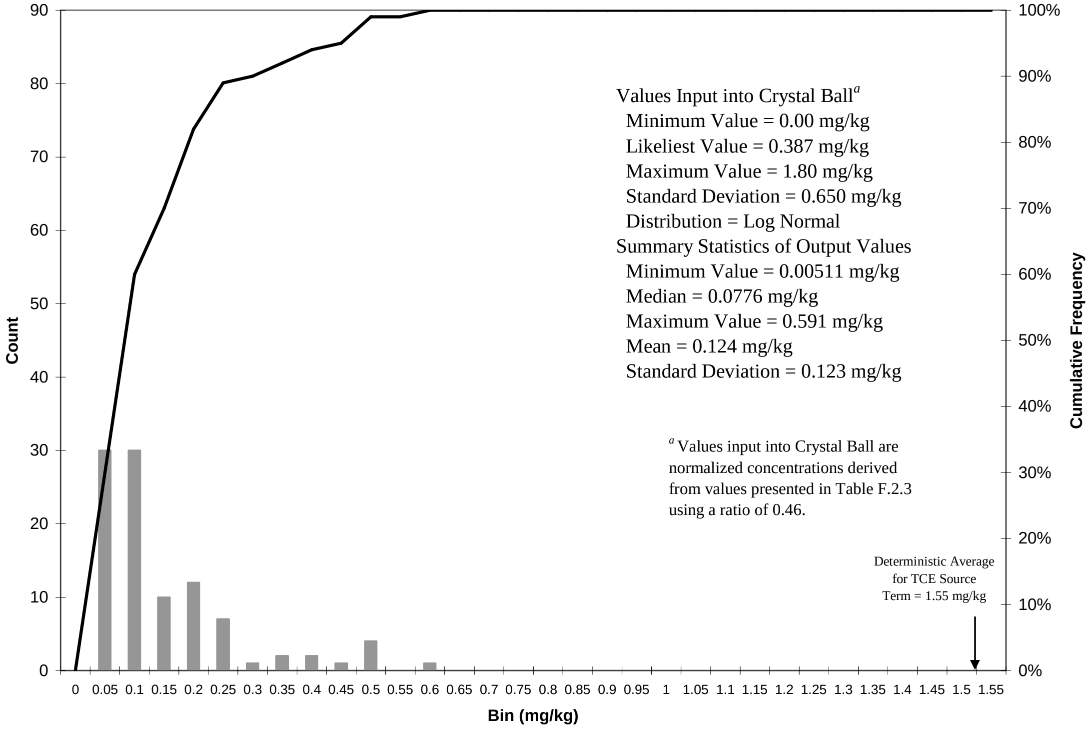


Values Input into Crystal Ball[a]
Minimum Value = 0.00 mg/kg
Likeliest Value = 5.94 mg/kg
Maximum Value = 68.0 mg/kg
Standard Deviation = 15.4 mg/kg
Distribution = Log Normal
Summary Statistics of Output Values
Minimum Value = 0.0234 mg/kg
Median = 1.67 mg/kg
Maximum Value = 48.2 mg/kg
Mean = 5.08 mg/kg
Standard Deviation = 8.66 mg/kg

[a] Values input into Crystal Ball are normalized concentrations derived from values presented in Table 2 using a ratio of 1.00.

Deterministic Average for TCE Source Term = 11.9 mg/kg

Fig. F.2.13. Histogram of Layer 3 TCE concentrations at C-720 Area used as SESOIL inputs.

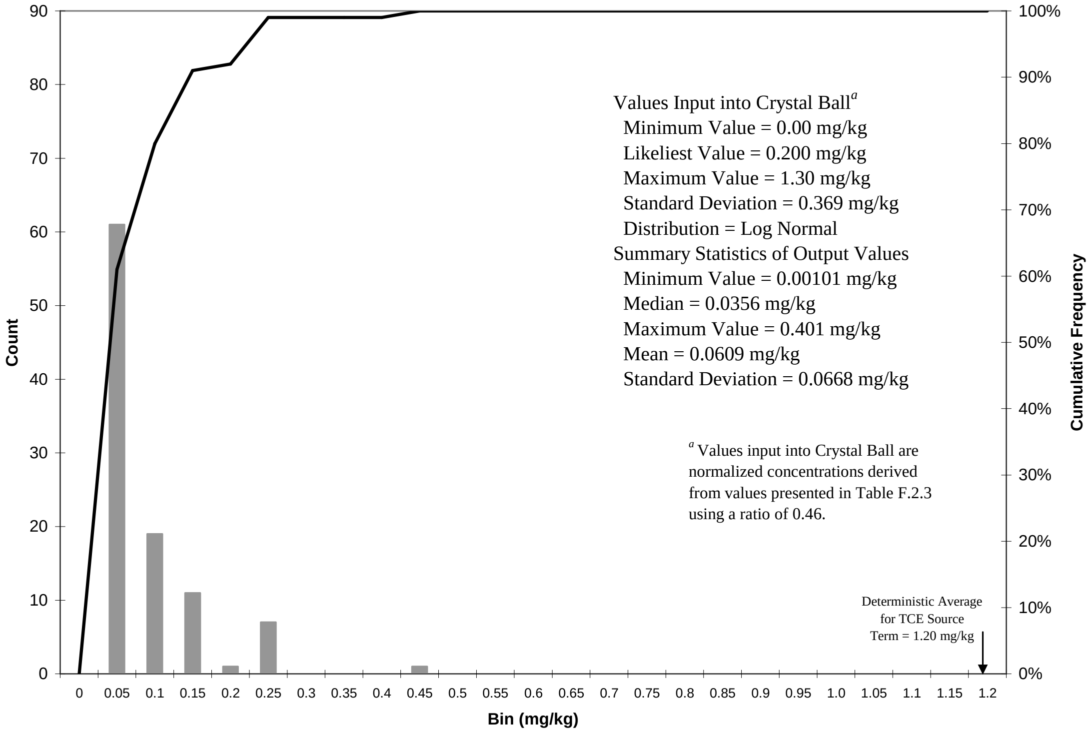


Values Input into Crystal Ball[a]
Minimum Value = 0.00 mg/kg
Likeliest Value = 0.387 mg/kg
Maximum Value = 1.80 mg/kg
Standard Deviation = 0.650 mg/kg
Distribution = Log Normal
Summary Statistics of Output Values
Minimum Value = 0.00511 mg/kg
Median = 0.0776 mg/kg
Maximum Value = 0.591 mg/kg
Mean = 0.124 mg/kg
Standard Deviation = 0.123 mg/kg

[a] Values input into Crystal Ball are normalized concentrations derived from values presented in Table F.2.3 using a ratio of 0.46.

Deterministic Average for TCE Source Term = 1.55 mg/kg

Fig. F.2.14. Histogram of Layer 4 TCE concentrations at C-720 Area used as SESOIL inputs.

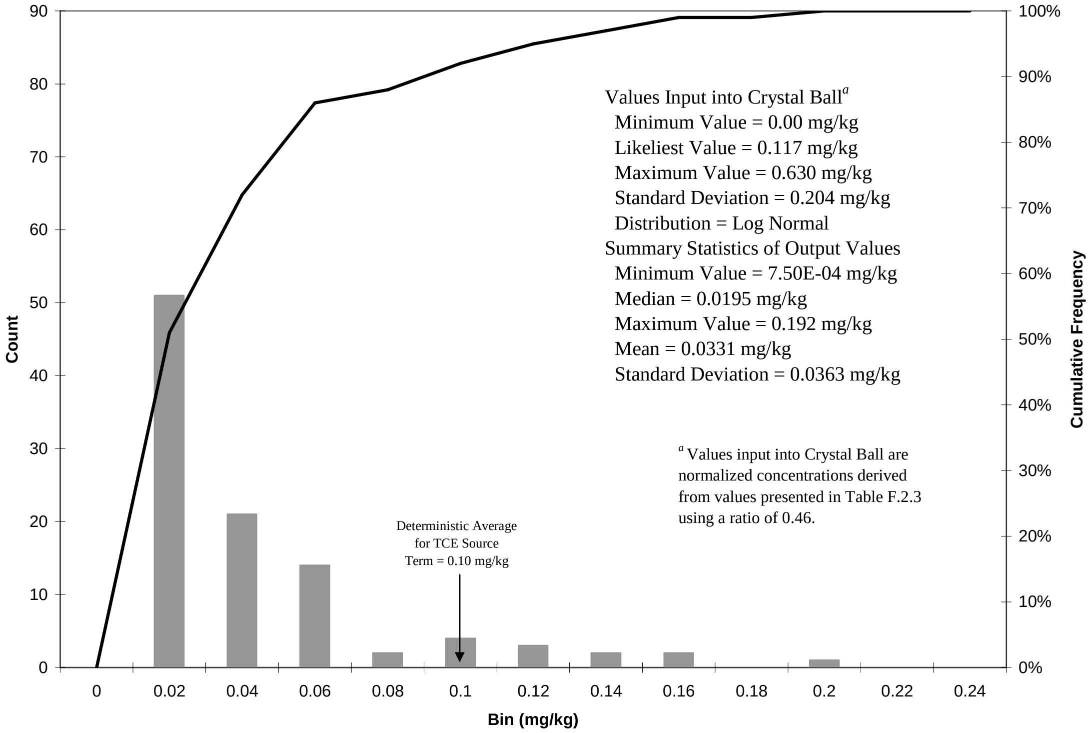


Values Input into Crystal Ball[a]
Minimum Value = 0.00 mg/kg
Likeliest Value = 0.200 mg/kg
Maximum Value = 1.30 mg/kg
Standard Deviation = 0.369 mg/kg
Distribution = Log Normal
Summary Statistics of Output Values
Minimum Value = 0.00101 mg/kg
Median = 0.0356 mg/kg
Maximum Value = 0.401 mg/kg
Mean = 0.0609 mg/kg
Standard Deviation = 0.0668 mg/kg

[a] Values input into Crystal Ball are normalized concentrations derived from values presented in Table F.2.3 using a ratio of 0.46.

Deterministic Average for TCE Source Term = 1.20 mg/kg

Fig. F.2.15. Histogram of Layer 5 TCE concentrations at C-720 Area used as SESOIL inputs.



Values Input into Crystal Ball[a]
Minimum Value = 0.00 mg/kg
Likeliest Value = 0.117 mg/kg
Maximum Value = 0.630 mg/kg
Standard Deviation = 0.204 mg/kg
Distribution = Log Normal
Summary Statistics of Output Values
Minimum Value = 7.50E-04 mg/kg
Median = 0.0195 mg/kg
Maximum Value = 0.192 mg/kg
Mean = 0.0331 mg/kg
Standard Deviation = 0.0363 mg/kg

[a] Values input into Crystal Ball are normalized concentrations derived from values presented in Table F.2.3 using a ratio of 0.46.

Deterministic Average for TCE Source Term = 0.10 mg/kg

Fig. F.2.16. Histogram of Layer 6 TCE concentrations at C-720 Area used as SESOIL inputs.

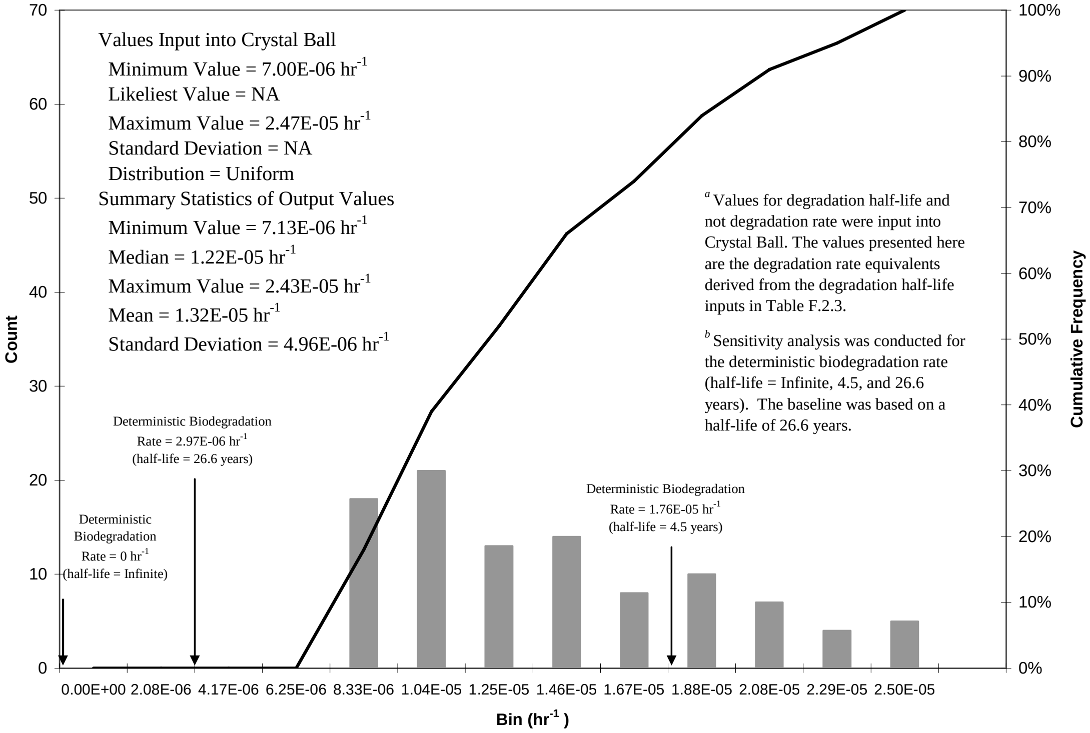
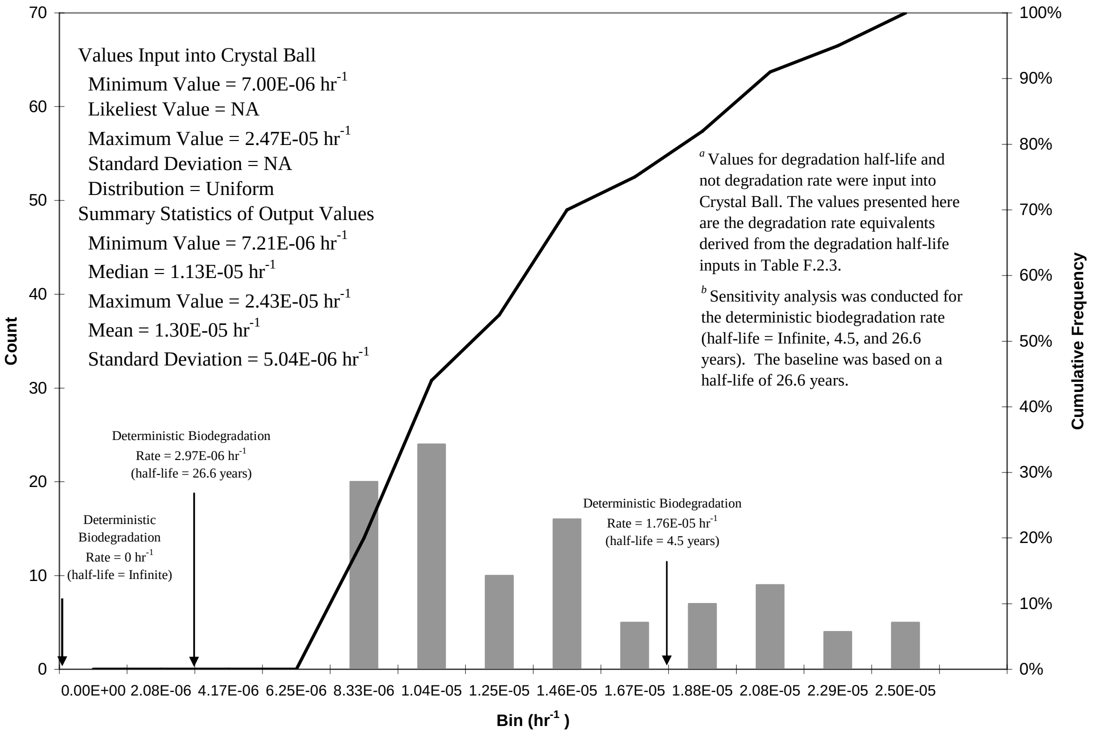


Fig. F.2.17. Histogram of Degradation Rate SESOIL inputs for SWMU 1.



Values Input into Crystal Ball
Minimum Value = 7.00E-06 hr^{-1}
Likeliest Value = NA
Maximum Value = 2.47E-05 hr^{-1}
Standard Deviation = NA
Distribution = Uniform
Summary Statistics of Output Values
Minimum Value = 7.21E-06 hr^{-1}
Median = 1.13E-05 hr^{-1}
Maximum Value = 2.43E-05 hr^{-1}
Mean = 1.30E-05 hr^{-1}
Standard Deviation = 5.04E-06 hr^{-1}

[a] Values for degradation half-life and not degradation rate were input into Crystal Ball. The values presented here are the degradation rate equivalents derived from the degradation half-life inputs in Table F.2.3.

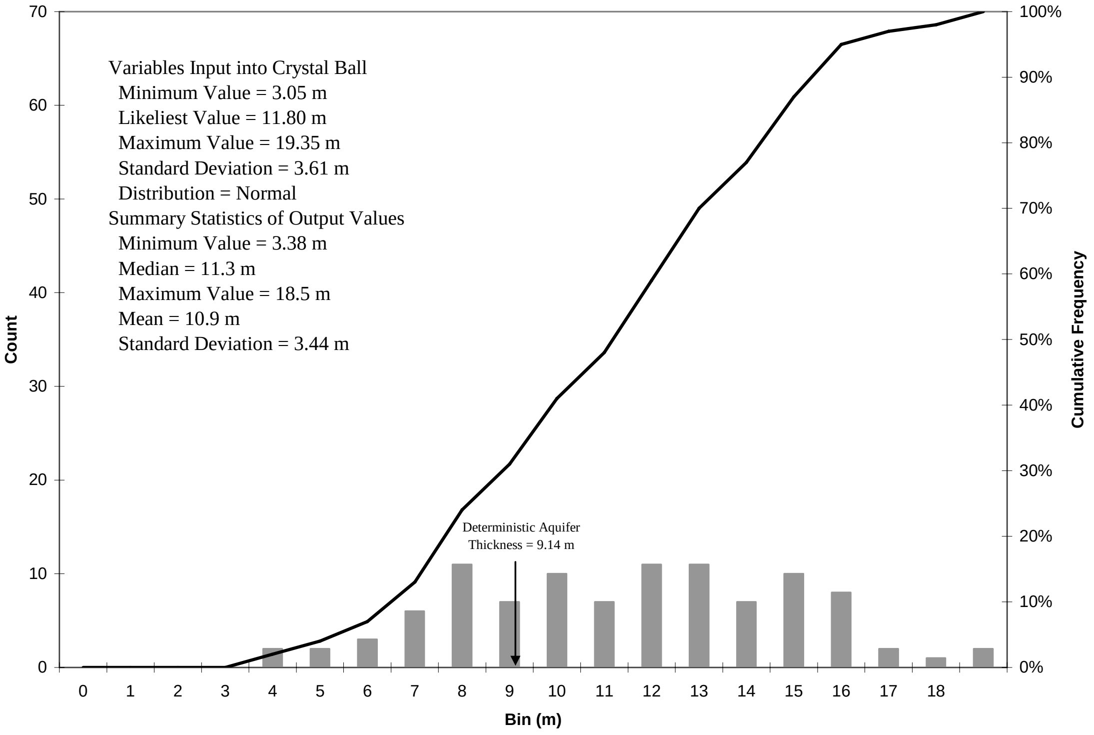
[b] Sensitivity analysis was conducted for the deterministic biodegradation rate (half-life = Infinite, 4.5, and 26.6 years). The baseline was based on a half-life of 26.6 years.

Deterministic Biodegradation Rate = 0 hr^{-1} (half-life = Infinite)

Deterministic Biodegradation Rate = 2.97E-06 hr^{-1} (half-life = 26.6 years)

Deterministic Biodegradation Rate = 1.76E-05 hr^{-1} (half-life = 4.5 years)

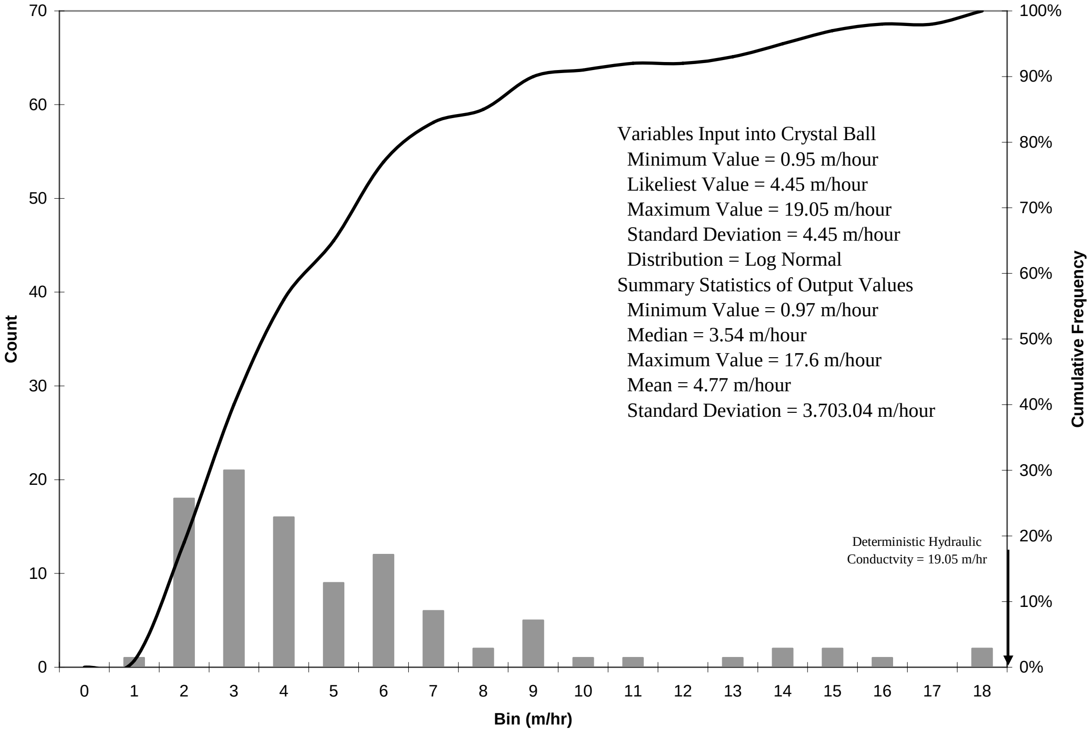
Fig. F.2.18. Histogram of Degradation Rate SESOIL inputs for C-720 Area.



Variables Input into Crystal Ball
Minimum Value = 3.05 m
Likeliest Value = 11.80 m
Maximum Value = 19.35 m
Standard Deviation = 3.61 m
Distribution = Normal
Summary Statistics of Output Values
Minimum Value = 3.38 m
Median = 11.3 m
Maximum Value = 18.5 m
Mean = 10.9 m
Standard Deviation = 3.44 m

Deterministic Aquifer Thickness = 9.14 m

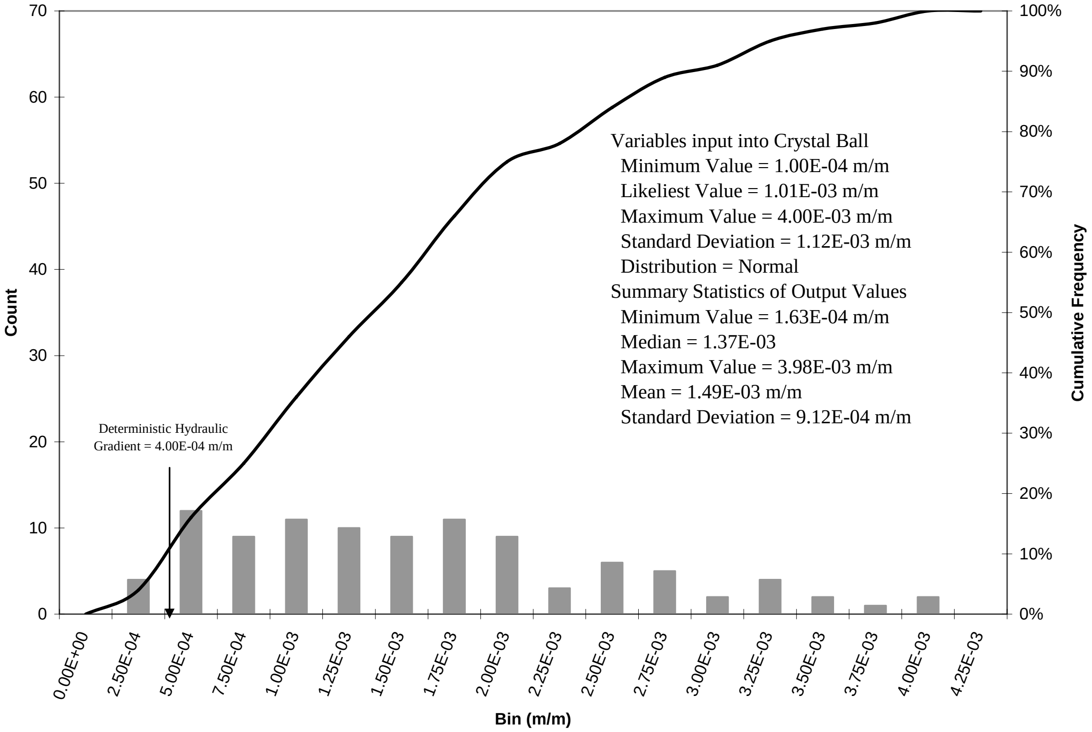
Fig. F.2.19. Histogram of Aquifer Thickness AT123D inputs for SWMU 1 and the C-720 Area.



Variables Input into Crystal Ball
Minimum Value = 0.95 m/hour
Likeliest Value = 4.45 m/hour
Maximum Value = 19.05 m/hour
Standard Deviation = 4.45 m/hour
Distribution = Log Normal
Summary Statistics of Output Values
Minimum Value = 0.97 m/hour
Median = 3.54 m/hour
Maximum Value = 17.6 m/hour
Mean = 4.77 m/hour
Standard Deviation = 3.703.04 m/hour

Deterministic Hydraulic Conductvity = 19.05 m/hr

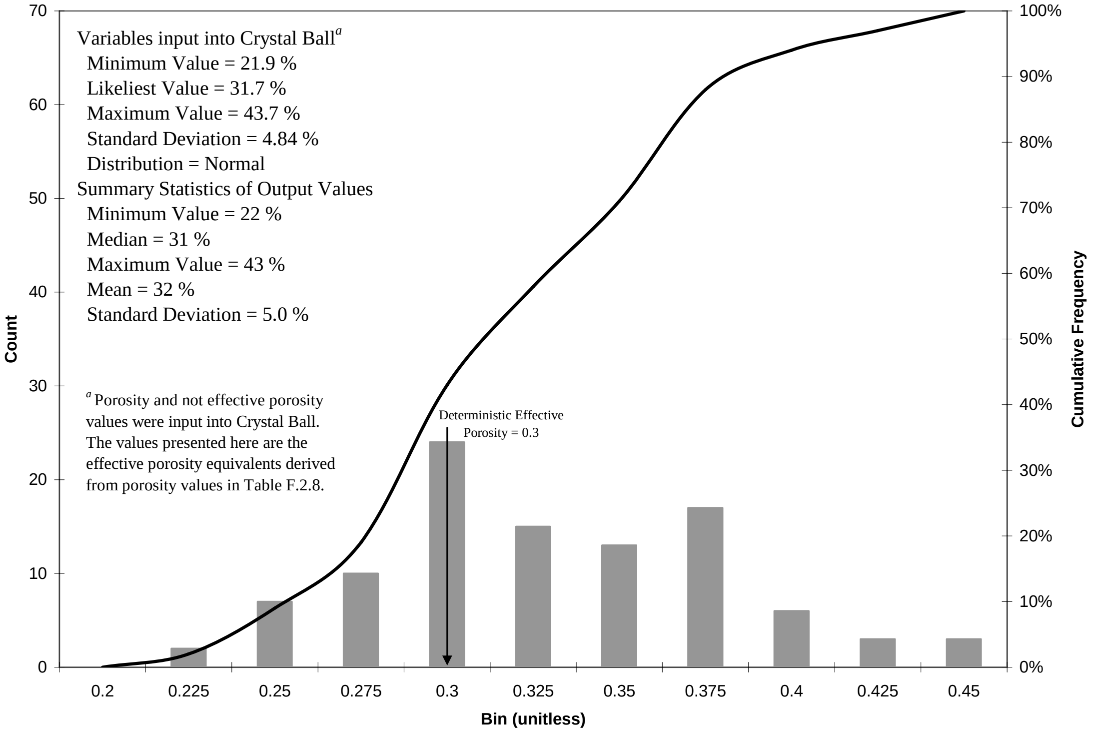
Fig. F.2.20. Histogram of Hydraulic Conductivity AT123D inputs for SWMU 1 and the C-720 Area.



Variables input into Crystal Ball
Minimum Value = 1.00E-04 m/m
Likeliest Value = 1.01E-03 m/m
Maximum Value = 4.00E-03 m/m
Standard Deviation = 1.12E-03 m/m
Distribution = Normal
Summary Statistics of Output Values
Minimum Value = 1.63E-04 m/m
Median = 1.37E-03
Maximum Value = 3.98E-03 m/m
Mean = 1.49E-03 m/m
Standard Deviation = 9.12E-04 m/m

Deterministic Hydraulic Gradient = 4.00E-04 m/m

Fig. F.2.21. Histogram of Hydraulic Gradient AT123D inputs for SWMU 1 and the C-720 Area.

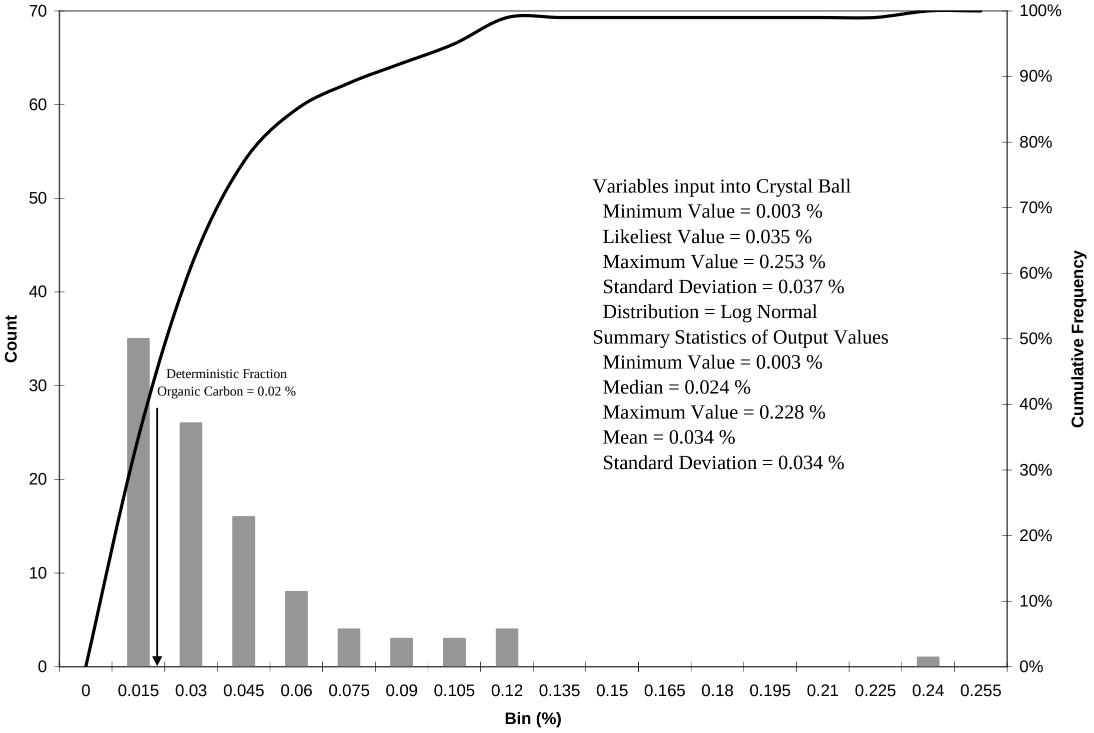


Variables input into Crystal Ball[a]
Minimum Value = 21.9 %
Likeliest Value = 31.7 %
Maximum Value = 43.7 %
Standard Deviation = 4.84 %
Distribution = Normal
Summary Statistics of Output Values
Minimum Value = 22 %
Median = 31 %
Maximum Value = 43 %
Mean = 32 %
Standard Deviation = 5.0 %

[a] Porosity and not effective porosity values were input into Crystal Ball. The values presented here are the effective porosity equivalents derived from porosity values in Table F.2.8.

Deterministic Effective Porosity = 0.3

Fig. F.2.22. Histogram of Effective Porosity AT123D inputs for SWMU 1 and the C-720 Area.



Variables input into Crystal Ball
Minimum Value = 0.003 %
Likeliest Value = 0.035 %
Maximum Value = 0.253 %
Standard Deviation = 0.037 %
Distribution = Log Normal
Summary Statistics of Output Values
Minimum Value = 0.003 %
Median = 0.024 %
Maximum Value = 0.228 %
Mean = 0.034 %
Standard Deviation = 0.034 %

Deterministic Fraction Organic Carbon = 0.02 %

Fig. F.2.23. Histogram of Organic Carbon Content AT123D inputs for SWMU 1 and the C-720 Area.

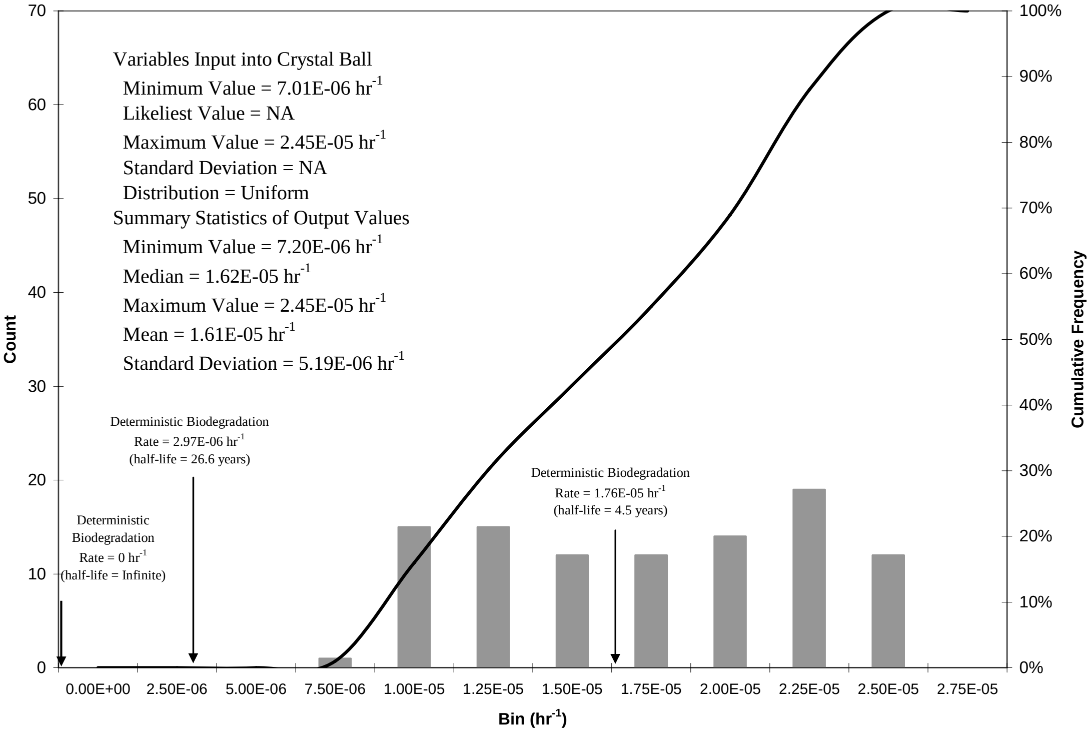


Fig. F.2.24. Histogram of Degradation Rate inputs for SWMU 1, and the C-720 Area.