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Remedial Investigation Report on Waste Area Grouping 5 at Oak Ridge National Laboratory, Oak Ridge, Tennessee

Volume 4 Appendix C: Risk Assessment

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PREFACE

This document contains the baseline human health risk assessment report for the Waste Area Grouping 5 (WAG 5) of the Oak Ridge National Laboratory, Oak Ridge, Tennessee. This work was performed for the Environmental Restoration Program under Work Breakdown Structure 1.4.12.6.1.05 within the Activity Data Sheet 3305 entitled ORNL WAG 5. Publication of this document meets a milestone for the Risk Assessment Program current year work plan. The purpose of this document is to present the potential risks for specific landuse scenarios that may result from the WAG 5 source areas and their risk contributions to the integrator areas. The risk assessment effort was an integral part in the development of the Remedial Investigation Report and was utilized to focus and prioritize the investigations on important study group areas within WAG 5.

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CONTENTS

1. INTRODUCTION	1-1
1.1 BACKGROUND	1-1
1.2 WASTE DISPOSAL AREAS	1-2
1.3 STUDY GROUP AREAS	1-5
1.4 RISK EXPOSURE SCENARIOS	1-5
2. IDENTIFICATION OF CHEMICALS OF POTENTIAL CONCERN	2-1
2.1 GENERAL DATA COLLECTION CONSIDERATIONS	2-1
2.2 GENERAL DATA EVALUATION CONSIDERATIONS	2-1
2.3 DATA EVALUATION/PREPARATION	2-1
2.3.1 Data Validation Considerations	2-2
2.3.2 Tentatively Identified Compounds	2-2
2.3.3 Summary Statistics for WAG 5 Data Sets	2-2
2.3.4 Further Data Considerations	2-3
2.3.5 Comparison with Background Data	2-3
2.3.6 Essential Nutrient Evaluation	2-4
2.3.7 Toxicity Screening of Data	2-4
2.3.8 Summary of Background Comparison, Essential Nutrients, and Toxicity Screening	2-5
2.3.9 Comparison of Nondetected Analytes with Preliminary Remediation Goals	2-5
2.4 SUMMARY OF CONTAMINANTS OF POTENTIAL CONCERN FOR WAG 5	2-5
3. EXPOSURE ASSESSMENT	3-1
3.1 CHARACTERIZATION OF EXPOSURE SETTING	3-1
3.1.1 Groundwater and Surface Water	3-2
3.2 IDENTIFICATION OF EXPOSURE SCENARIOS	3-3
3.2.1 Current Land Use	3-3
3.2.2 Future Land Use	3-3
3.3 IDENTIFICATION OF EXPOSURE PATHWAYS	3-8
3.3.1 Future On-WAG Industrial Scenario	3-8
3.3.2 Future On-WAG Residential Scenario	3-9
3.3.3 Off-WAG Residential Scenario	3-9
3.4 QUANTITATION OF EXPOSURE	3-10
3.4.1 CDI Calculations for the Industrial Land Use Scenario	3-10
3.4.2 CDI Calculations for the Residential Land Use Scenario	3-11
4. TOXICITY ASSESSMENT	4-1
4.1 TOXICITY INFORMATION FOR NONCARCINOGENIC EFFECTS	4-1
4.2 TOXICITY INFORMATION FOR CARCINOGENIC EFFECTS	4-2
4.3 CHEMICALS WITHOUT EPA TOXICITY VALUES	4-2
4.3.1 Evaluation of Soil Lead Toxicity	4-2
4.4 SUMMARY OF TOXICITY PROFILES FOR WAG 5 COPCS	4-3

CONTENTS (continued)

5. RISK CHARACTERIZATION	5-1
5.1 EVALUATION OF CARCINOGENS AND NONCARCINOGENS	5-1
5.2 RISK SUMMARY BY MEDIA	5-2
5.2.1 Soil Risk Summary	5-2
5.2.2 Sediment Risk Summary	5-7
5.2.3 Groundwater Risk Summary	5-13
5.2.4 Surface Water Risk Summary	5-13
5.2.5 Off-WAG Residential Scenario	5-14
5.3 RISK SUMMARY BY AREA	5-23
5.3.1 Fissile Storage Area	5-29
5.3.2 New Hydrofracture Facility Tanks Area	5-29
5.3.3 Old Hydrofracture Facility Pond Area	5-31
5.3.4 Old Hydrofracture Facility Tanks Area	5-34
5.3.5 Process Waste Sludge Basin Area	5-35
5.3.6 SW-3 Drainage Area	5-38
5.3.7 Solid Waste Storage Area 5 North	5-40
5.3.8 Solid Waste Storage Area 5 Southeast Area	5-42
5.3.9 Solid Waste Storage Area 5 Southwest	5-42
5.3.10 White Oak Creek	5-44
5.4 RISK CHARACTERIZATION SUMMARY	5-47
5.4.1 Identification of Pathway Risks/HIs of Interest	5-47
5.4.2 Identification of Individual Analyte Risks/HQs	5-49
6. EVALUATION OF UNCERTAINTIES	6-1
6.1 UNCERTAINTY IN THE SELECTION OF POTENTIAL CONTAMINANTS OF CONCERN	6-1
6.2 UNCERTAINTY IN THE EXPOSURE ASSESSMENT	6-2
6.2.1 Representative Concentrations	6-2
6.2.2 Representative Exposure Parameters	6-3
6.3 UNCERTAINTY IN DOSE-RESPONSE RELATIONSHIPS	6-4
6.3.1 Radiological Risk	6-4
6.3.2 Chemical Risk	6-4
6.4 UNCERTAINTIES IN RISK CHARACTERIZATION	6-5
6.4.1 Definition of Excess Risk	6-5
7. PRELIMINARY REMEDIAL ACTION OBJECTIVES	7-1
7.1 INTRODUCTION	7-1
7.2 METHODS FOR IDENTIFYING REMEDIAL GOAL OPTIONS	7-2
7.2.1 Chemicals of Concern	7-2
7.2.2 RGO Calculations	7-2
7.3 WAG 5 REMEDIAL GOAL OBJECTIVES	7-4
7.3.1 WAG 5 RGO Summary	7-4
7.3.2 Fissile Storage Area	7-5
7.3.3 New Hydrofracture Facility Tanks	7-5
7.3.4 Old Hydrofracture Facility Pond	7-5
7.3.5 Old Hydrofracture Facility Tanks	7-5

CONTENTS (continued)

7.3.6 Process Waste Sludge Basin	7-5
7.3.7 Surface Water Drainage Area 3	7-5
7.3.8 Solid Waste Storage Area 5 North	7-6
7.3.9 Solid Waste Storage Area 5 Southeast	7-6
7.3.10 Solid Waste Storage Area 5 Southwest	7-6
7.3.11 White Oak Creek.	7-6
7.3.12 TRU Drainage Area (D1)	7-6
7.3.13 Solid Waste Storage Area 5 South Drainage (D2).	7-6
7.3.14 SW-3 Drainage (D3).	7-6
8. REFERENCES	8-1
APPENDIX A Tables	A-1
APPENDIX B Exhibits	B-1
APPENDIX C Toxicity Profiles	C-1
APPENDIX D Tables for WAG-wide Analysis	D-1

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FIGURES

1a. Waste Area Grouping within the boundaries of the White Oak Creek and Melton Branch	1-3
1b. Study Group Areas of WAG 5	1-4
2a. Preliminary Conceptual Model for Residents on WAG 5	3-5
2b. Preliminary Conceptual Model for Excavation on WAG 5	3-6
3. Preliminary Conceptual Model for Industrial Worker on WAG 5.	3-7
4. Total Cumulative Risk From Exposure to the Different Contaminated Areas Within WAG 5.	5-5
5a. Sediment Risks by Location	5-9
5b. Sediment Pathways and Contaminants of Concern	5-10
6a. WAG 5 Surface Water Risk Summary at Melton Branch	5-16
6b. WAG 5 Surface Water Risk Summary at Melton Branch and White Oak Creek	5-17
6c. WAG 5 Surface Water Risk Summary at Melton Branch (RI Data).	5-18
6d. WAG 5 Surface Water Risk Summary at White Oak Creek.	5-19
6e. White Oak Dam Ingestion Risk and Relative Contaminant Contribution	5-21
6f. WAG 5 Surface Water Risk Summary—Percent Contribution to Annual Water Ingestion Dose at White Oak Lake Dam by WAG and Source Area.	5-22
6g. Clinch River Surface Water (WAG 5 Diluted Concentrations) Risk Summary	5-24
7a. Study Area Risk Prioritization (Carcinogenic Residential and Industrial Risks)	5-25
7b. Study Area Risk Prioritization (Residential Groundwater and Soil Carcinogenic Risks)	5-26
7c. Study Area Risk Prioritization (Noncarcinogenic Residential and Industrial Risks)	5-27
7d. Study Area Risk Prioritization (Residential Groundwater and Soil Noncarcinogenic Risks).	5-28
8a. FS Risk Pathways Summary	5-30
8b. NHFT Risk Pathways Summary	5-32
8c. OHFP Risk Pathways Summary	5-33
8d. OHFT Risk Pathways Summary	5-36
8e. PWSB Risk Pathways Summary	5-37
8f. SW3 Risk Pathways Summary	5-39
8g. SWSA 5 North Risk Pathways Summary	5-41
8h. SWSA 5 Southeast Risk Pathways Summary	5-43
8i. SWSA 5 Southwest Risk Pathways Summary	5-45
8j. White Oak Creek Risk Pathways Summary	5-46

TABLES

(Tables are presented in Appendices A and D.)

Appendix A

1a.	Summary table of contaminants analyzed for and detected in each medium within WAG 5	A-3
1b.	Potential exposure pathways for the different media in each designated area of WAG 5	A-9
2a.	Comparison of WAG 5 soil MD with TMBG values—Residential Scenario	A-10
2b.	Comparison of WAG 5 sediment MD with TMBG values—Residential Scenario ...	A-35
2c.	Comparison of WAG 5 groundwater MD with TMBG values—Residential Scenario	A-47
2d.	Comparison of WAG 5 surface water MD with TMBG values—Residential Scenario	A-67
3a.	Toxicity screening for detected inorganic and organic analytes in WAG 5 soil	A-99
3b.	Toxicity screening for detected radionuclides in WAG 5 soil	A-104
4a.	Toxicity screening for detected inorganic and organic analytes in WAG 5 sediment	A-111
4b.	Toxicity screening for detected radionuclides in WAG 5 sediment	A-115
5a.	Toxicity screening for detected inorganic and organic analytes in WAG 5 groundwater	A-120
5b.	Toxicity screening for detected radionuclides in WAG 5 groundwater	A-125
6a.	Toxicity screening for detected inorganic and organic analytes in WAG 5 surface water	A-129
6b.	Toxicity screening for detected radionuclides in WAG 5 surface water	A-132
7a.	Comparison of maximum detected concentrations for analytes dropped by toxicity screening in WAG 5 soil with residential PRGs	A-136
7b.	Comparison of maximum detected concentrations for analytes dropped by toxicity screening in WAG 5 sediment with residential PRGs	A-137
7c.	Comparison of maximum detected concentrations for analytes dropped by toxicity screening in WAG 5 groundwater with residential PRGs	A-138
7d.	Comparison of maximum detected concentrations for analytes dropped by toxicity screening in WAG 5 surface water with residential PRGs	A-143
8a.	Analytes in WAG 5 soil eliminated from COPCs list	A-147
8b.	Analytes in WAG 5 sediment eliminated from COPCs list	A-157
8c.	Analytes in WAG 5 groundwater eliminated from COPCs list	A-162
8d.	Analytes in WAG 5 surface water eliminated from COPCs list	A-168
9a.	Chronic daily intake and doses for soil COPCs of WAG 5 designated areas	A-175
9b.	Chronic daily intake and doses for sediment COPCs of WAG 5 designated areas ..	A-200
9c.	Chronic daily intakes for WAG 5 groundwater COPCs—Residential Scenario	A-211
9d.	Chronic daily intakes for WAG 5 surface water COPCs—Residential Scenario	A-219
10.	Parameters used to calculate contaminant concentration in produce from groundwater irrigation	A-225
11.	Analyte dependent parameters and concentrations of COPCs in produce irrigated by WAG 5 groundwater	A-226
12.	Concentrations of COPCs from root uptake of soil contaminants at WAG 5	A-231
13.	Parameters used for WAG 5 impoundments model	A-237
14.	Model parameters used to estimate the air concentrations from WAG 5 drainages ..	A-238
15.	Model parameters used to estimate indoor concentrations of tritium from the groundwater vapor of WAG 5	A-239
16.	Toxicity information for the WAG 5 noncarcinogenic COPCs	A-240

TABLES (continued)

17.	Toxicity information for the WAG 5 carcinogenic COPCs	A-243
18.	Toxicity information for the WAG 5 radionuclide COPCs	A-245

Appendix D

D.1a.	Comparison of WAG 5 soil MD with TMBG values—Residential Scenario	D-3
D.1b.	Comparison of WAG 5 sediment MD with TMBG values—Residential Scenario	D-6
D.1c.	Comparison of WAG 5 groundwater MD with TMBG values—Residential Scenario .	D-9
D.1d.	Comparison of WAG 5 surface water MD with TMBG values—Residential Scenario	D-12
D.2a.	Toxicity screening for detected inorganic and organic analytes in WAG 5 soil	D-26
D.2b.	Toxicity screening for detected radionuclides in WAG 5 soil	D-28
D.3a.	Toxicity screening for detected inorganic and organic analytes in WAG 5 sediment .	D-30
D.3b.	Toxicity screening for detected radionuclides in WAG 5 sediment	D-32
D.4a.	Toxicity screening for detected inorganic and organic analytes in WAG 5 groundwater	D-34
D.4b.	Toxicity screening for detected radionuclides in WAG 5 sediment	D-36
D.5a.	Toxicity screening for detected inorganic and organic analytes in WAG 5 surface water	D-37
D.5b.	Toxicity screening for detected radionuclides in WAG 5 surface water	D-40
D.6a.	Comparison of maximum detected concentrations for analytes dropped by toxicity screening in WAG 5 soil with residential PRGs	D-43
D.6b.	Comparison of maximum detected concentrations for analytes dropped by toxicity screening in WAG 5 sediment with residential PRGs	D-44
D.6c.	Comparison of maximum detected concentrations for analytes dropped by toxicity screening in WAG 5 groundwater with residential PRGs	D-45
D.6d.	Comparison of maximum detected concentrations for analytes dropped by toxicity screening in WAG 5 surface water with residential PRGs	D-46
D.7a.	Analytes in WAG 5 soil eliminated from COPC list	D-48
D.7b.	Analytes in WAG 5 sediment eliminated from COPC list	D-50
D.7c.	Analytes in WAG 5 groundwater eliminated from COPC list	D-52
D.7d.	Analytes in WAG 5 surface water eliminated from COPC list	D-54
D.8a.	Chronic Daily Intake and doses for soil COPC of WAG 5	D-59
D.8b.	Chronic Daily Intake and doses for sediment COPC of WAG 5	D-64
D.8c.	Chronic Daily Intake and doses for groundwater COPC of WAG 5	D-68
D.8d.	Chronic Daily Intake and doses for surface water COPC of WAG 5	D-70
D.9a.	COPCs evaluated quantitatively for WAG 5 soil	D-73
D.9b.	COPCs evaluated quantitatively for WAG 5 sediment	D-75
D.9c.	COPCs evaluated quantitatively for WAG 5 groundwater	D-77
D.9d.	COPCs evaluated quantitatively for WAG 5 surface water	D-79
D.10a.	COPCs evaluated qualitatively for WAG 5 soil	D-83
D.10b.	COPCs evaluated qualitatively for WAG 5 sediment	D-84
D.10c.	COPCs evaluated qualitatively for WAG 5 groundwater	D-85
D.10d.	COPCs evaluated qualitatively for WAG 5 surface water	D-86
D.11a.	Carcinogenic risk for WAG 5 soil COPCs	D-89
D.11b.	Carcinogenic risk for WAG 5 sediment COPCs	D-93
D.11c.	Carcinogenic risk for WAG 5 groundwater COPCs	D-96
D.11d.	Carcinogenic risk for WAG 5 surface water COPCs	D-98
D.12a.	Noncarcinogenic hazard quotients for WAG 5 soil COPCs	D-100
D.12b.	Noncarcinogenic hazard quotients for WAG 5 sediment COPCs	D-101

TABLES (continued)

D.12c.	Noncarcinogenic hazard quotients for WAG 5 groundwater COPCs	D-102
D.12d.	Noncarcinogenic hazard quotients for WAG 5 surface water COPCs	D-103
D.13a.	RGOs for the soil of WAG 5	D-104
D.13b.	RGOs for the sediment of WAG 5	D-106
D.13c.	RGOs for the groundwater of WAG 5	D-108
D.13d.	RGOs for the surface water of WAG 5	D-110

EXHIBITS

(Exhibits are presented in Appendix B.)

1a.	COPCs evaluated quantitatively for WAG 5 soil	B-3
1b.	COPCs evaluated quantitatively for WAG 5 sediment	B-9
1c.	COPCs evaluated quantitatively for WAG 5 groundwater	B-13
1d.	COPCs evaluated quantitatively for WAG surface water	B-18
2a.	COPCs evaluated qualitatively for WAG 5 soil	B-23
2b.	COPCs evaluated qualitatively for WAG 5 sediment	B-25
2c.	COPCs evaluated qualitatively for WAG 5 groundwater	B-27
2d.	COPCs evaluated qualitatively for WAG 5 surface water	B-31
3.	On-site industrial exposure scenario	B-35
4.	On-site residential exposure scenario (soil or sediment)	B-39
5.	On-site residential exposure scenario (groundwater)	B-43
6.	On-site residential exposure scenario (tritium from groundwater)	B-46
7.	On-site residential exposure scenario (homegrown produce)	B-47
8.	On-site excavation exposure scenario	B-48
9a.	Carcinogenic risk for WAG 5 soil COPCs	B-52
9b.	Carcinogenic risk for WAG 5 sediment COPCs	B-70
9c.	Carcinogenic risk for WAG 5 groundwater COPCs	B-78
9d.	Carcinogenic risk for WAG 5 surface water COPCs	B-83
10a.	Noncarcinogenic hazard quotients for WAG 5 soil COPCs	B-88
10b.	Noncarcinogenic hazard quotients for WAG 5 sediment COPCs	B-95
10c.	Noncarcinogenic hazard quotients for WAG 5 groundwater COPCs	B-99
10d.	Noncarcinogenic hazard quotients for WAG 5 surface water COPCs	B-102
11a.	COCs for WAG 5 soil and associated carcinogenic risks for contributing pathways	B-104
11b.	COCs for WAG 5 sediment and associated carcinogenic risks for contributing pathways	B-109
11c.	COCs for WAG 5 groundwater and associated carcinogenic risks for contributing pathways	B-113
12.	COCs for WAG 5 and associated noncarcinogenic hazard quotients for pathways of concern	B-116
13a.	Total cumulative risk and HI summary for WAG 5 soil COPCs	B-118
13b.	Total cumulative risk and HI summary for WAG 5 sediment COPCs	B-119
13c.	Total cumulative risk and HI summary for WAG 5 groundwater COPCs	B-120
14.	WAG 5 RGOs for soil, sediment, and groundwater	B-121
15.	Fissile Storage Area RGOs for soil, sediment, and groundwater of WAG 5	B-128
16.	New Hydrofracture Tank RGOs for soil of WAG 5 (residential scenario)	B-129
17.	Old Hydrofracture Pond RGOs for soil, sediment, and groundwater of WAG 5 ...	B-130
18.	Old Hydrofracture Tank RGOs for soil of WAG 5 (industrial and residential scenarios)	B-132
19.	Process Waste Sludge Basin RGOs for soil and sediment of WAG 5	B-133
20.	Surface Water Area RGOs for soil of WAG 5	B-135
21.	Solid Waste Storage Area 5 North RGOs for soil and groundwater of WAG 5	B-136
22.	Solid Waste Storage Area 5 South RGOs for soil and groundwater of WAG 5	B-138
23.	Solid Waste Storage Area 5 Southwest RGOs for soil and groundwater of WAG 5	B-140
24.	White Oak Creek RGOs for soil and groundwater of WAG 5	B-142

EXHIBITS (continued)

25.	Drainage D1 RGOs for sediment of WAG 5	B-144
26.	Drainage D2 RGOs for sediment of WAG 5	B-145
27.	Drainage D3 RGOs for sediment of WAG 5	B-146
28.	Estimate future carcinogenic risk from exposure to radioactive COCs in soils of the different areas of WAG 5 as a function of time using RESRAD 5.19— Residential Scenario	B-147

TOXICITY PROFILES

C. TOXICITY PROFILES FOR WAG 5 CONTAMINANTS OF CONCERN	C-3
C.1 INORGANICS	C-3
C.1.1 Antimony	C-3
C.1.2 Arsenic	C-4
C.1.3 Barium	C-5
C.1.4 Beryllium	C-6
C.1.5 Boron	C-7
C.1.6 Cadmium	C-8
C.1.7 Chromium, Chromium III, and Chromium VI	C-9
C.1.8 Cyanide	C-10
C.1.9 Lead	C-10
C.1.10 Manganese	C-11
C.1.11 Mercury	C-13
C.1.12 Nickel	C-14
C.1.13 Nitrate/Nitrite	C-15
C.1.14 Selenium	C-16
C.1.15 Silver	C-16
C.1.16 Vanadium	C-17
C.1.17 Zinc	C-18
C.2 ORGANICS	C-20
C.2.1 Acetone	C-20
C.2.2 Benzene	C-20
C.2.3 Bis(2-ethylhexyl)phthalate	C-23
C.2.4 Carbon Tetrachloride	C-24
C.2.5 Chloroform	C-25
C.2.6 1,1-Dichloroethene	C-26
C.2.7 1,2-Dichloroethene	C-27
C.2.8 Methylene Chloride	C-27
C.2.9 Polychlorinated Biphenyls (Aroclor-1254 and Aroclor-1260)	C-29
C.2.10 Tetrachloroethylene	C-30
C.2.11 Vinyl Chloride	C-31
C.3 RADIONUCLIDES	C-33
C.3.1 Americium-241	C-35
C.3.2 Cesium-134 and -137	C-35
C.3.3 Cobalt-60	C-36
C.3.4 Curium-244	C-36
C.3.5 Europium-152 and -154	C-37
C.3.6 Plutonium-238 and -239	C-37
C.3.7 Radium-226	C-38
C.3.8 Strontium-90	C-38
C.3.9 Technetium-99	C-39
C.3.10 Thallium-208	C-39
C.3.11 Thorium-228, -230, -232, and -234	C-39
C.3.12 Tritium	C-40
C.3.13 Uranium-234, -235, -238	C-41

ACRONYMS AND ABBREVIATIONS

ARARs	Applicable or Relevant and Appropriate Requirements
BHHRA	Baseline Human Health Risk Assessment
CDI	Chronic Daily Intake
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
COCs	Chemicals of Concern
COPCs	Chemicals of Potential Concern
D&D	Decontamination & Decommissioning
DL	Detection Limit
DOE	(United States) Department of Energy
DQOs	Data Quality Objectives
EPA	(United States) Environmental Protection Agency
ER	Environmental Restoration
FS	Feasibility Study
HEAST	Health Effects Assessment Summary Tables
HI	Hazard Index
HQ	Hazard Quotient
IEUBK	Integrated Exposure Uptake Biokinetic Model
IRIS	Integrated Risk Information System
LLLW	Liquid Low-Level Waste
MMES	Martin Marietta Energy Systems, Inc.
MEPAS	Multimedia Environmental Pollutant Assessment Systems
NHF	New Hydrofracture Facility
NHFT	New Hydrofracture Facility Tank
NOAEL	No-Observed-Adverse-Effects Level
NT	Not Tested
OHF	Old Hydrofracture Facility
OHFP	Old Hydrofracture Facility Pond
OHFT	Old Hydrofracture Facility Tank
ORNL	Oak Ridge National Laboratory
ORO	Oak Ridge Operations
ORR	Oak Ridge Reservation
OSWER	Office of Solid Waste and Emergency Response
OU	Operable Unit
PRGs	Preliminary Remediation Goals
PWSB	Process Waste Sludge Basin
QA/QC	Quality Assurance/Quality Control
RAGS	<i>Risk Assessment Guidance for Superfund</i>
RAOs	Remedial Action Objectives
RAPS	Remedial Action Priority Systems
RAS	Risk Analysis Section (ORNL)
RfC	Reference Concentration
RfD	Reference Dose
RfDAD	Dermally Absorbed Reference Dose
RGOs	Remedial Goal Options
RME	Reasonable Maximum Exposure

ACRONYMS AND ABBREVIATIONS (continued)

SARA	Superfund Amendments and Reauthorization Act
SAS	Statistical Analysis System
SF	Slope Factor
SWSA	Solid Waste Storage Areas
TAL	Target Analyte List
TCL	Target Compound List
TDEC	Tennessee Department of Environment and Conservation
TICs	Tentatively Identified Compounds
TRU	Transuranic
USRADS	Ultrasonic Ranging and Data System
VOCs	Volatile Organic Compounds
WAG	Waste Area Grouping

1. INTRODUCTION

1.1 BACKGROUND

Waste Area Grouping (WAG) 5 is part of Oak Ridge National Laboratory (ORNL) and is located on the United States Department of Energy's Oak Ridge Reservation (DOE-ORR). The site lies southeast of Haw Ridge in Melton Valley and comprises approximately 32 ha (80 ac) [12 ha (30 ac) of forested area and the balance in grassed fields]. The western and southern boundaries of WAG are contiguous with the WAG 2 area which includes White Oak Creek and Melton Branch and associated floodplains (Fig. 1a).

Waste Area Grouping 5 consists of several contaminant source areas for the disposal of low-level radioactive, transuranic (TRU), and fissile wastes (1959 to 1973) as well as inorganic and organic chemical wastes. Wastes were buried in trenches and auger holes. Radionuclides from buried wastes are being transported by shallow groundwater to Melton Branch and White Oak Creek. Different chemicals of potential concern (COPCs) were identified (e.g., cesium-137, strontium-90, radium-226, thorium-228, etc.); other constituents and chemicals, such as vinyl chloride, bis(2-ethylhexyl)phthalate, trichloroethene, were also identified as COPCs. Based on the results of this assessment contaminants of concern (COCs) were subsequently identified.

The objectives of the WAG 5 Baseline Human Health Risk Assessment (BHHRA) are to document the potential health hazards (i.e., risks) that may result from contaminants on or released from the site and provide information necessary for reaching informed remedial decisions. As part of the DOE-Oak Ridge Operations (ORO), ORNL and its associated waste/contamination sites fall under the auspices of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), also known as Superfund under the Superfund Amendments and Reauthorization Act (SARA). The results of the BHHRA will 1) document and evaluate risks to human health, 2) help determine the need for remedial action, 3) determine chemical concentrations protective of current and future human receptors, and 4) help select and compare various remedial alternatives (Energy Systems 1993a).

The human health risk assessment methodology used in this risk assessment is based on *Risk Assessment Guidance for Superfund* (RAGS) (EPA 1989). First, the data for the different media are evaluated to determine usability for risk assessment. Second, through the process of selecting COPCs, contaminants to be considered in the BHHRA are identified for each media, and the representative concentrations for these contaminants are determined. Third, an assessment of exposure potential is performed, and exposure pathways are identified. Subsequently, exposure is estimated quantitatively, and the toxicity of each of the COPCs is determined. The results of the exposure and toxicity assessments are combined and summarized in the risk characterization section.

In agreement with the regulatory agencies involved in environmental restoration (ER) activities for the Oak Ridge Reservation (ORR), the sites associated with ORNL have been partitioned into two categories: source control and integrator operable units (OUs). Source control OUs are defined as on-site (property owned/managed by DOE-ORO) waste areas that are currently releasing or have the potential to release contaminants into the environment. The integrator OUs (surface water and groundwater) may receive contaminants released from source control OUs and potentially transport them to off-site locations creating a potential for off-site receptor exposure. Separate evaluation of

source control and integrator OUs is necessary because of the complexity of the physical characteristics of the sites and many different source control OUs can contribute to integrator OU contamination. In addition, immediate attention can be given to source control OUs while continued monitoring activities, characterization, and investigation of the integrator OUs are conducted. After source control OUs have been evaluated and any necessary remediation has been accomplished, integrator OUs are evaluated and any necessary remediation is implemented.

To aid in identifying and defining important source control study areas within WAG 5, the WAG was broken into 10 Study Group Areas (Fig. 1b). Although these Study Group Areas are not separate OUs, the on-WAG risk assessment was partitioned into these areas so that preliminary remedial strategies can be developed for more localized remediation targets. Accordingly, each Study Group Area is evaluated independently. In addition to the 10 Study Group Areas, three surface water drainages associated with WAG 5 are evaluated in this WAG 5 BHHRA. For comparative purposes, a "WAG-wide" risk assessment was also performed, in which data for the entire WAG 5 site was compiled and evaluated.

The WAG 5 BHHRA evaluates risk for media-defined on-WAG and off-WAG exposures from contaminants in soil, sediment, surface water, groundwater, and air releases for current and future land use. Because WAG 5 is located within the confines of ORNL, public access currently is denied. Buildings do exist in the Solid Waste Storage Area (SWSA) 5 North, the Old Hydrofracture Facility (OHF), and the New Hydrofracture Facility (NHF) areas, but positive access control is enforced and continuous industrial exposure settings do not occur. Furthermore, most of these buildings are scheduled for decontamination and decommissioning (D&D) investigations and implementations. For these reasons, current land use is designated as "restricted industrial," and no current on-WAG exposure scenarios are evaluated by the WAG 5 BHHRA. At present, off-WAG migration of contaminants from WAG 5 source control Study Group Areas has not proceeded to a point where human receptors might be exposed. Consequently, no current off-WAG exposure scenarios are evaluated by this WAG 5 BHHRA. Current contamination concentrations are used, however, to evaluate risk to hypothetical future off-WAG residents. A hypothetical future on-WAG resident was also evaluated using current contaminant concentrations.

1.2 WASTE STORAGE / DISPOSAL AREAS

The following list discusses the principal waste disposal areas addressed in the Remedial Investigation (RI) Report and the WAG 5 BHHRA.

- **Solid Waste Storage Area 5 South**—designated to dispose of liquid low-level wastes (LLLW) from 1959 to 1973. Unknown quantities of TRU wastes were also buried in SWSA 5 South before the designation of the TRU waste storage area in 1970.
- **Old Hydrofracture Facility**—operated from 1964 to 1979 and was used to dispose of LLLW.
- **New Hydrofracture Facility**—used to dispose of concentrated LLLW/TRU waste sludge from the South Tank Farm Gunit tanks of WAG 1 on the main ORNL plant area.

Fig. 1a. Waste Area Grouping within the Boundaries of the White Oak Creek and Melton Branch

Fig. 1b. Study Group Areas of WAG 5

$\frac{1}{m_0}, \frac{1}{m_1}, \dots, \frac{1}{m_{n-1}}$

- **Process Waste Sludge Basin (PWSB)**—located at the northern perimeter of SWSA 5 South and was used for the storage and decantation of sludge produced by the ORNL Process Waste Treatment Plant from 1976 to 1981. The basin contains standing water with approximately 4 ft of sludge.
- **Transuranic direct burial trenches**—located in the SWSA 5 North area and were used from 1970 through 1979 for storing concrete casks filled and sealed at their point of origin.

1.3 STUDY GROUP AREAS

As previously noted, the WAG was divided into 10 Study Group Areas to aid in identifying and defining important source control study areas within WAG 5. Although these Study Group Areas are not separate OUs, the on-WAG soil and groundwater risk assessment was partitioned into these areas so that preliminary remedial strategies can be developed for more localized remediation targets. Accordingly, each Study Group Area is evaluated independently. These areas were defined as:

1. Fissile Storage (FS)
2. New Hydrofracture Facility Tanks (NHFT)
3. Old Hydrofracture Facility Pond (OHFP)
4. Old Hydrofracture Facility Tanks (OHFT)
5. Process Waste Sludge Basin (PWSB)
6. Surface Water Drainage Area 3 (SW-3)
7. Solid Waste Storage Area 5 North (SWSA5N)
8. Solid Waste Storage Area 5 Southeast (SWSA5SE)
9. Solid Waste Storage Area 5 Southwest (SWSA5SW)
10. White Oak Creek

In addition to these 10 Study Group Areas, sediment and surface water of ponds and drainages of WAG 5 were assessed, because these areas serve as integrator areas for contaminants which migrate from the source control areas. The areas designated for this assessment are drainages D1, D2, and D3 and impoundments OHFP and PWSB. The sediments were assumed to be dry, which would result in higher particularization and external exposure levels, thereby ensuring a conservative approach (see Chap. 6).

1.4 RISK EXPOSURE SCENARIOS

Exposure scenarios used to evaluate risk for future land use are industrial and on- and off-WAG residential. As a conservative assumption, current contaminant concentrations are used for the calculation of future on-WAG risk. However, for radiological analytes, the United States Department of Energy (DOE)-validated computer code, RESRAD, was employed to demonstrate risk reduction through the natural decay process.

The future industrial scenario is evaluated using industrial default occupational values provided in United States Environmental Protection Agency (EPA) guidance (EPA 1991b, 1991c). The exposure pathways evaluated for the future industrial exposure scenario are ingestion, inhalation,

dermal contact, and external exposure. In addition, the exposure media evaluated are soil and dried sediment. Dried sediments reflect the seasonal characteristics of drainages whose sediments result from washing out of soil and sand from land into water.

The future on-WAG residential scenario is evaluated by calculating a reasonable maximum exposure (RME) estimate of the risk to hypothetical future human receptors. This is judged to be a conservative scenario because WAG 5 is well within the ORNL boundaries; therefore, residential use is unlikely in the near or even foreseeable future. However, the intent of this evaluation is to present potential risks that are unlikely to underestimate risk to future human receptors from exposure to WAG 5 contaminated media. Analytes (i.e., COPCs) with risks below the EPA target risk range levels, for the conservative residential evaluation, should not require further action in terms of remediation. Exposure is calculated for a lifetime, which includes exposures as both child and adult. Exposure pathways evaluated for the hypothetical future on-WAG residential scenario are:

- ingestion of groundwater, soil, dried sediment, and home-grown produce irrigated with groundwater;
- inhalation of contaminants from surface water, groundwater, soil, and dry sediment (dust/particulates and volatile organics);
- dermal contact with groundwater, soil, and dry sediment; and
- external exposure to radiation from soil and dry sediment.

For the evaluation of the future off-WAG residential scenario, the migration of contaminants off-WAG is assumed to occur primarily via surface water and groundwater, both of which discharge into the White Oak Creek watershed system. This risk assessment evaluates two exposure points to comprehensively address the potential risks associated with the migration of contaminants from WAG 5. These exposure points are 1) hypothetical, future residents at Melton Branch and 2) hypothetical, future residents at White Oak Lake Dam. White Oak Creek watershed surface water and groundwater serve as the integrator study areas for WAG 5 contaminants. Therefore, the total risk to a hypothetical future resident at the White Oak Lake Dam from exposure to contaminants in both of these integrator study areas is important in determining the need for remediation of the WAG 5 source control study areas. The hypothetical future off-WAG residential scenario evaluates the exposure pathways for surface water, while the hypothetical future on-WAG residential scenario evaluates the exposure pathways for groundwater. The surface water pathways for the future off-WAG resident are 1) ingestion, 2) dermal contact, and 3) inhalation.

The following sections describe the methodology used in evaluating the WAG 5 analytical data, physical characteristics, potential pathways, and potential receptors for use in quantifying the potential risk to human health from exposure to WAG 5 COPCs. Organization of the WAG 5 BHHRA is as follows:

- **Chapter 1. Introduction.** A general overview of the report is provided.
- **Chapter 2. Identification of Chemicals of Potential Concern.** A discussion of data evaluation and analysis and the selection of COPCs is provided.
- **Chapter 3. Exposure Assessment.** Exposure scenarios and exposure pathways are defined. Equations for exposure calculations and values for exposure parameters are provided and discussed.
- **Chapter 4. Toxicity Assessment.** Toxicity information for carcinogenic and noncarcinogenic effects is provided.
- **Chapter 5. Risk Characterization.** Information from the exposure and toxicity assessments is used to calculate carcinogenic and noncarcinogenic risk for WAG 5 exposure pathways.
- **Chapter 6. Uncertainty Assessment.** All uncertainties involved in the calculation of health risk in the WAG 5 BHHRA are discussed qualitatively.
- **Chapter 7. Remedial Goal Options.** Media clean-up levels for each COPC in each land use scenario evaluated in the WAG 5 BHHRA are presented and discussed.
- **Chapter 8. References.** A complete list of references used in the preparation of the WAG 5 BHHRA is provided.
- **Appendix A. Tables.** The tables used for providing more detailed information on the topics discussed in this WAG 5 BHHRA are provided.
- **Appendix B. Exhibits.** The exhibits used for detailing information described in this WAG 5 BHHRA are presented.
- **Appendix C. Toxicity Profiles.** The toxicity profiles mentioned in Chap. 4 of this WAG 5 BHHRA are presented.
- **Appendix D. Tables.** The complete tables used for detailing information on the WAG-wide risk assessment performed for WAG 5.

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2. IDENTIFICATION OF CHEMICALS OF POTENTIAL CONCERN

The following discussion addresses the analytical data evaluation steps necessary to 1) identify a set of chemicals that are likely to be site-related and 2) report analyte concentrations of acceptable quality for use in a quantitative BHHRA.

2.1 GENERAL DATA COLLECTION CONSIDERATIONS

The data presented in this BHHRA are from recent sampling event periods (referred to as current data). Historical data were also reviewed and evaluated by Bechtel National Inc., but only fully validated, current data were used by the Martin Marietta Energy Systems, Inc. (MMES) Risk Analysis Section (RAS) in this WAG 5 BHHRA.

Concentrations of analytes detected in each of the WAG 5 media were compared with background data to ensure that only site-related contamination is investigated in the BHHRA. Those analytes that did not exceed background concentrations were eliminated from further consideration. The background data sets were supplied to the MMES RAS by Bechtel National, Inc. Please refer to Volume II, Appendix A, for the technical memorandum describing the exact sampling locations, number of samples collected, sampling and analysis guidance used, analysis and analytical techniques used, and the quality assurance/quality control (QA/QC) methods used for obtaining the representative background data sets.

2.2 GENERAL DATA EVALUATION CONSIDERATIONS

Waste Area Grouping 5 consists of 10 Study Group Areas that are slightly different due to either physical settings (e.g., hydrology, geology, etc.), geographical location, operational history, or implementability of potential future remedial alternatives. Because of these differences, media data were evaluated separately for each Study Group Area.

2.3 DATA EVALUATION/PREPARATION

The data included in this BHHRA are the result of the inorganic, organic, and radionuclide analyses of samples from various sampling locations within WAG 5. Fully validated data, grouped by media, were received in electronic format from Bechtel National, Inc. The ASCII text electronic files were read into a Statistical Analysis System (SAS; SAS Institute Inc.) data base on a DEC workstation, model 5000/240 (Digital Equipment Corporation) by MMES RAS personnel, who then performed an independent review and quality check of the data. Inaccurate or erroneous data were corrected after verification with Bechtel National, Inc., personnel. The data evaluation was performed in accordance with RAGS (EPA 1989). This process assisted in selecting the COPCs which are being evaluated quantitatively in this WAG 5 BHHRA.

2.3.1 Data Validation Considerations

Details of the validation process for the current data can be found in Volume II, Appendix A of this WAG 5 RI. As described previously, historical data were not available as validated data and were not considered in this BHHRA. The current data are 100% validated, and the evaluation/validation process performed by Bechtel National, Inc., included comparison of the samples with associated blanks using two criteria. These criteria are 1) if the concentration of the analyte in the sample was at least five times greater than the maximum concentration detected in the associated blank, then the analyte concentration was not changed from the reported value and 2) if the concentration of the analyte in the sample was greater than the concentration found in the blank, but less than five times the concentration in the blank, then the analyte concentration was changed to reflect the concentration reported in the blank, and a nondetect qualifier (U) was also added to the data set for these species. For common laboratory contaminants such as acetone, 2-butanone, methylene chloride, and phthalate esters, if the concentration of the analyte in the sample was at least 10 times greater than the associated maximum concentration detected in the blank, then the analyte concentration was not changed from the reported value [similar to criterion 1) described previously].

The standard methods of data evaluation described in RAGS (EPA 1989) were employed. Specifically, data qualifiers were evaluated where 1) J (although indicative of an estimated value) was treated as a detected analyte and was included in the BHHRA data set; 2) U was treated as a nondetected analyte, and the reported detection limit was used as the concentration value; and 3) UJ was treated as data flagged with a U qualifier. When an analyte was not detected (U or UJ) in any of the media samples, a separate data set for the medium (i.e., a nondetected analytes data set) was created. These data are evaluated and discussed in Sect. 2.3.9.

2.3.2 Tentatively Identified Compounds

Tentatively identified compounds (TICs) are detected analytes not included on the target analyte list (TAL) or on the target compound list (TCL) and for which both the identity and concentration are questionable.

According to RAGS (EPA 1989), when only a few TICs are present in comparison to TCL and TAL chemicals, and when historical and/or site-specific information about such analytes are not available, the TICs are generally not included in the risk assessment. However, because SWSAs within WAG 5 received large amounts of mixed wastes over a long period of time, the possibility of the presence of analytes not included on the TAL or TCL lists must be considered. Since exact source term records are not available, the potential presence of TICs is an uncertainty associated with the WAG 5 BHHRA.

2.3.3 Summary Statistics for WAG 5 Data Sets

In this subsection, detected concentrations were analyzed for each media in WAG 5. A minimum of one detected hit signified a detected analyte. Frequency distributions were fitted to different statistical distributions of detected concentrations by comparison of normal to lognormal distributions. The distribution resulting in a fit with the highest confidence value was chosen. The minimum, maximum, and mean concentrations were determined for each fitted distribution. The

upper 95th percentile confidence limit on the mean was calculated according to the appropriate distribution. For lognormal distributions, all calculated values were transformed back into normal space. Finally, the smaller of the maximum detected concentration or the upper 95th percentile confidence limit was chosen as the representative concentration.

Table 1a presents all the analytes that were statistically evaluated for each medium in WAG 5, and Table 1b shows the exposure pathways to be investigated for each study area. Groundwater was collected from 52 wells and evaluated for 97 analytes with a total number of 1519 detects. Surface water from 14 sampling stations was analyzed for 88 chemicals with a total number of 1069 detects. Soil and sediment were collected at each of the different Study Group Areas and analyzed for 87 and 86 chemicals, respectively. A total number of 1278 detects were found for soil, and 613 detects were recorded for sediment.

The summary statistics for the WAG 5 data sets were carried out for each media. Media-specific tables were generated, and each table is further subdivided into the Study Group Area of interest and includes 1) the analyte type (inorganic, organic, and radionuclide); 2) the number of detected concentrations per number of observations (i.e., frequency of detection); 3) the distribution type (i.e., normal, lognormal, or no distribution test); 4) the minimum detected concentration, maximum detected concentration, and mean concentration; 5) the upper 95th percentile confidence limit on the mean; 6) the maximum nondetected concentration (for those analytes with only nondetected values); and 7) units of measure (Table 2). For those analytes with all nondetected values, no distribution test was performed (NT). Therefore, no upper 95th percentile confidence limit can be reported; instead the maximum detection limit (DL) is listed as the representative exposure concentration for these analytes. In a separate analytical step, the maximum DL of nondetected analytes is compared to risk-based preliminary remediation goals (PRGs) (refer to Sect. 2.3.9 of this BHHRA). Because of the size of the data set, a hard copy of the summary statistics is not included with this report; however, it can be provided upon request.

2.3.4 Further Data Considerations

For the radionuclide analyses, some closely related isotopes were grouped, and a total concentration value was reported for each group. In these cases, the most conservative toxicity value for the isotopes (i.e., the toxicity value that would result in the highest risk) was employed. The isotope groups in question were curium-243 and curium-244, uranium-233 and uranium-234, uranium-235 and uranium-236, strontium-89 and strontium-90, and plutonium-239 and plutonium-240. This association of isotopes was necessary since several samples were analyzed and results were reported in isotope groups only. For the statistical comparisons of the different samples to be valid, consistency is vital.

2.3.5 Comparison with Background Data

Only site-related contaminants should be considered in a BHHRA (EPA 1989). Therefore, a background comparison is conducted to distinguish site-related contaminants from naturally occurring or other nonsite-related concentrations of analytes detected during the sampling and analysis process. Background screening is an essential screening step in the process leading to the final selection of COPCs. This step is performed to ensure that risk management decisions are based on the excess risk posed by site-related contaminants rather than natural risk levels from background

constituents. It should be noted, however, that the background levels are compared to, but not subtracted from, the site contaminant levels. The related uncertainty in this conservative method is further discussed in Chap. 6 of this WAG 5 BHHRA. The background data set used for the screening of analytes for the WAG 5 BHHRA is provided in Volume II, Appendix A of this RI.

Detected analytes were compared to background data to identify COPCs. According to EPA Region IV Supplemental Guidance (1991a), if the maximum detected concentration (i.e., frequency of detection is ≥ 1) of the contaminant at the site is greater than twice the background concentration, the detected analyte is assumed to be related to the site activities and is therefore a COPC. Otherwise, the analyte is not considered a COPC and is eliminated from further analysis. Tables 2a-2d present the background screening results for the different designated areas within the soil, sediment, groundwater, and surface water, respectively, of WAG 5. [The reader should note that "scientific notation" will be employed throughout this document to describe numbers larger than 10 or smaller than 1 (i.e., $5.0E+6$ or $5.0E-6$). In using scientific notation, the decimal number to the left of the letter "E" is multiplied by an appropriate power (number to the right of "E") of 10. If the number to the right of E is positive, then the decimal number to the left of E is multiplied by 10 as many times as given by the number to the right of E. If the number to the right of E is negative, then the decimal number to the left of E is divided by 10 as many times as given by the number to the right of E.]

2.3.6 Essential Nutrient Evaluation

Essential nutrients (including calcium, copper, iron, magnesium, phosphorus, potassium, and sodium) (Dunne 1990) are considered to have little or no adverse effects on human health. In addition, these nutrients are not expected to have been used in any specific WAG 5 operation. These analytes have been included in the summary statistics for the purpose of reporting all the available information but are not considered to be COPCs.

2.3.7 Toxicity Screening of Data

A concentration-toxicity screen was applied to the data sets for analytes with at least one detected value in accordance with RAGS (EPA 1989). The objective of this screening procedure was to identify those analytes most likely to contribute significantly to the risk estimates and hazard indices [hazard index (HI)]. Those analytes with a negligible contribution to the total adverse health effects posed by site contaminants were identified and eliminated from the COPCs list. For the ingestion, inhalation, and external exposure toxicity values [i.e., reference doses (RfDs) and slope factors (SFs)], a toxicity score was calculated for each analyte by multiplying the analyte's maximum detected concentration by the toxicity value (i.e., concentration $\times$ SF and/or concentration $\times$ 1/RfD). Individual analyte toxicity scores were summed to obtain a total chemical score. The ratio of the specific analyte toxicity score to this total chemical score approximates the relative risk [or hazard quotient (HQ)] for each analyte. Analytes with a relative risk or HQ of less than 1% (i.e., less than 1% for all available toxicity scores) were eliminated from the COPCs list. Section 2.3.7.1 describes the subsequent screening step for final removal from the COPCs list. It is important to note that this toxicity screen was performed for each data set, and radionuclides were evaluated separately from nonradionuclides (according to EPA guidance; EPA 1989a). The results of the toxicity screening can be found in Tables 3 through 6.

2.3.7.1 Analytes eliminated (via Toxicity Screening) versus Preliminary Remediation Goals

Analytes eliminated from the COPCs list based on the toxicity screening (Tables 7a-7d) were compared with the appropriate PRGs [i.e., PRGs at a cancer risk level of 1.0×10^{-6} and/or a noncarcinogenic toxicity level (HQ) of 1.0]. Preliminary remediation goals are initial guidelines (protective of human health) that are based on readily available information and comply with Applicable or Relevant and Appropriate Requirements (ARARs). They are used in selecting remedial alternatives (EPA 1991b). The maximum detected concentration for those analytes previously eliminated from the COPCs list in each medium were compared with residential scenario PRGs (EPA 1989) to yield a conservative comparison. The analytes eliminated during the toxicity screening that have a maximum detected concentration greater than the corresponding PRG (at a risk level of 1.0×10^{-6}) are listed in Tables 7a-7d. These analytes were returned to the COPCs list for the WAG 5 BHHRA to ensure that no analytes that could potentially pose a risk were overlooked.

2.3.8 Summary of Background Comparison, Essential Nutrients, and Toxicity Screening

Tables 8a-8d summarize those detected analytes not included on the COPCs list because of 1) a comparison with background soil data (Sect. 2.3.5), 2) their use as essential nutrients in the human body (Sect. 2.3.6), or 3) the toxicity screening assessment results (Sect. 2.3.7).

2.3.9 Comparison of Nondetected Analytes with Preliminary Remediation Goals

Nondetected analytes (i.e., analytes assigned "U" or "UJ" qualifiers during the data validation process) are not believed to be associated with activities specific to WAG 5. To ensure protection of human health, however, nondetected analytes were compared to PRGs if they were 1) detected at least once in a medium in at least one Study Group Area and 2) could be evaluated quantitatively (i.e., if SFs and/or RfDs are available). The maximum reported detection limit for each nondetected analyte was compared with the noncarcinogenic (HQ = 1.0) and carcinogenic (risk = $1.0E-06$, which represents an incidence of one case of an excess cancer risk in one million) PRGs. Residential scenario PRGs were employed to ensure a conservative approach.

It is important to note that analytes that were always nondetected (i.e., frequency of detection was zero) were not considered further and were not included in the COPCs list for this BHHRA.

2.4 SUMMARY OF CONTAMINANTS OF POTENTIAL CONCERN FOR WAG 5

Exhibits 1a-1d list by media the detected (i.e., at least one detected value) COPCs to be evaluated quantitatively in this BHHRA and their representative concentrations. The COPCs are specified for each media and Study Group Area. In accordance with RAGS (EPA 1989), the smaller of the upper 95th percentile confidence limit concentration or the maximum detected concentration is considered the representative concentration. As previously discussed, the size of the data sets used for the WAG 5 BHHRA preclude including the complete summary statistics tables in this report. This information can be provided upon request.

The number of COPCs that can be quantitatively evaluated is limited by the availability of chemical-specific, EPA-approved toxicity information (i.e., SFs and RfDs) (EPA 1994a, EPA 1993).

The most current EPA-approved toxicity information was obtained from the electronic data bases of the Integrated Risk Information System (IRIS) (EPA 1994a) and the *Health Effects Assessment Summary Tables* (HEAST) (EPA 1993). Exhibits 2a-2d list the COPCs for WAG 5 that could not be evaluated quantitatively in this BHHRA because no current EPA-approved SFs or RfDs exist for these analytes (EPA 1994a; EPA 1993). With the exception of lead, for which an uptake biokinetic model exists (Appendix C of this BHHRA), these analytes are not considered further in this BHHRA.

3. EXPOSURE ASSESSMENT

In the context of human health risk assessment, exposure is defined as the direct contact of a person with a chemical or physical agent. Exposure assessment is the determination or estimation of the amount, frequency, duration, and route of exposure to the COPCs present at or migrating from a site. The general outline of an exposure assessment includes the characterization of the exposure setting, identification of the exposure pathways, and quantification of the resulting exposure. This section describes the exposure assessment process in three steps:

- 1) Characterization of exposure setting with respect to the general physical characteristics of WAG 5
- 2) Identification of exposure pathways based on considerations of sources, releases, types, and locations of chemicals at WAG 5; the likely environmental fate and transport of these chemicals; and the location and activities of the potentially exposed populations
- 3) Quantification of exposure which includes calculations of chronic daily intake based on current concentrations, contact rate, exposure frequency, exposure duration, body weight, and exposure averaging time [the values of some of these variables depend on site conditions and the characteristics of the potentially exposed population (e.g., an estimate of the reasonable maximum exposure) expected to occur under current and future land use for the residential scenario or the most likely exposure that would occur on-WAG for the industrial scenario]

The results of the exposure assessment combined with chemical-specific toxicity information provided in the toxicity assessment will be used to characterize potential risks that may be posed by the WAG 5 site.

3.1 CHARACTERIZATION OF EXPOSURE SETTING

The characterization of exposure setting identifies the physical characteristics of the site (e.g., climate, vegetation, hydrology, topography, geology, etc.), the human population characteristics present at or near the site, and the current land use in the vicinity of the site. The physical and environmental characteristics of WAG 5 are detailed in Volume III, Appendix B, Chap. B1 of this RI.

In summary, WAG 5 is located southeast of Haw Ridge in Melton Valley on DOE-ORR property. Melton Valley is a prominent northeast-southwest trending valley typical of landforms in the Valley and Ridge Physiographic Province. The average annual rainfall is 1.36 m (54 in.), and the prevailing wind directions are either up-valley (northeasterly) or down-valley (southwesterly). WAG 5 comprises an area of approximately 32 ha (80 ac) [including about 12 ha (30 ac) of forest and the balance in grassed fields]. The western and southern boundaries are contiguous with the WAG 2 area which includes White Oak Creek and Melton Branch and their associated floodplains.

3.1.1 Groundwater and Surface Water

Fig. 1a depicts the physical boundaries of WAG 2 and WAG 5 and shows that both Melton Branch and White Oak Creek, which border WAG 5 on the south and west, respectively, are part of the WAG 2 integrator. Accordingly, the groundwater and surface water systems of WAG 5 and WAG 2 are related. Waste Area Grouping 5 consists primarily of uplands adjacent to WAG 2 and serves as a groundwater recharge area. Waste Area Grouping 5 groundwater is primarily intercepted by the WAG 2 drainages with a potential, although slight, for groundwater transport underneath these drainages. The surface waters of WAG 5 drain into the WAG 2 waterways either by means of seep flow or overland flow.

Three drainages (D-1, D-2, and D-3) transport surface water from WAG 5 (Fig. 1b). Each is associated with a forested drainage swale (or valley) that extends from the WAG interior to White Oak Creek (D-1 which flows in a southwesterly direction) or Melton Branch (D-2 which flows in a southeasterly direction). Drainage D-3 (which flows in a easterly direction) is a small tributary along the east-central WAG boundary that discharges into a larger tributary of Melton Branch. Immediately downstream of the site, Melton Branch flows into White Oak Creek, which discharges at the ORR boundary into the Clinch River (a tributary of the Tennessee River).

Several seeps have been identified within the functional boundaries of WAG 5. The seep effluents are groundwater expressed at the surface, but for the scope of the WAG 5 BHHRA, seeps are defined as surface water sources. In effect, the seep effluent is integrated into the WAG 2 watershed surface waters. Confirmed historical seep data and screening samples from seeps throughout ORNL and WAG 5 show extensive tritium and strontium contamination. The majority of the risk at White Oak Dam is attributable to tritium and strontium emitted from various source areas within the White Oak Creek watershed. Surface water is determined to be the major transport mechanism for contaminant fluxes to potential off-site receptors.

3.1.1.1 Integration point assessment

The integration point assessment effort for ORNL actively uses monitoring, surveillance, compliance, and RI data to evaluate the off-WAG risk from a variety of sources that contribute to the surface water integrator at White Oak Creek floodplain. These data are used to 1) establish a baseline for evaluating the risk at different points within the integrator, 2) identify and prioritize source areas within the context of the integrator, and 3) establish the degree of risk reduction a source control action potentially can achieve. The integration point assessment is a flux-based risk assessment. Flux is defined here as the total amount of contaminant transported through a certain region or point in a given period of time (e.g., a year). A number of actual and potential sources of contaminants exist in the White Oak Creek watershed. The flow rates of the sources vary with the different surface water systems transporting these contaminants to the integrator and eventually to the Clinch River. Therefore, fluxes are an important concept for source control. Source control actions taken at areas with high fluxes of integrator contaminants of concern or with the potential for major releases achieve the quickest reduction of off-site exposure towards the desired levels.

An important objective during an investigation is to assimilate all available information from existing RI programs so that source area fluxes and mass balances of contaminants within the integrator system can be estimated. The information is then used to assess fluxes within the

watershed and compare them to fluxes that enter public access areas so that various contaminant sources can be differentiated for their relative impacts. Mass balance information is important in describing the accumulation and discharge of contaminants within a system where input and output are known. The integration point assessment provides a means of expressing this information to the public and risk managers in terms of risk. It also provides an important risk link between the source control and integrator contributions from a source area so that the effects of source control actions can be evaluated in the integrator.

Fluxes of the risk-driving contaminants from each WAG 5 Study Group Area were evaluated in depth by Bechtel National, Inc., and provided to RAS personnel. The flux data were used to compare off-WAG contaminant migration from WAG 5 to other source control OUs contributing to risk at White Oak Dam. In addition, flux data allowed the source control Study Group Areas within WAG 5 to be ranked according to off-WAG risks.

3.2 IDENTIFICATION OF EXPOSURE SCENARIOS

Exposure scenarios are defined by the completed or potential exposure pathways that are likely to exist for a known or potential receptor population. The potential receptors are identified based on current and future land use considerations.

A decision on the specific land use and its exposure pathways will ultimately be reached in a consensus agreement between all involved stakeholders. This represents a major goal of the CERCLA process, and the purpose of this WAG 5 BHHRA is to inform all stakeholders of the risks involved for specific land uses and exposure pathways.

3.2.1 Current Land Use

Since WAG 5 is located within the confines of ORNL, public access is currently denied. No actively used office or laboratory buildings are located within the vicinity of WAG 5. Buildings do exist in the SWSA 5 North, OHF, and NHF areas, but positive access control is enforced, and continuous industrial exposure settings do not occur. Furthermore, most of these buildings are scheduled for D&D investigations and implementations. For these reasons, current land use is designated as "restricted industrial," and no current on-WAG exposure scenarios are evaluated. Currently, off-WAG migration of contaminants from WAG 5 source control Study Group Areas has not progressed to a point where human receptors might be exposed. In addition, current contaminant concentrations are used to evaluate risks to hypothetical future off-WAG residents. Consequently, no current off-WAG exposure scenarios are evaluated.

3.2.2 Future Land Use

The purpose of evaluating future land use scenarios as part of the risk assessment is to establish whether remedial action is necessary for alternate land uses by determining if the cumulative risk or HI from the source areas could exceed levels of concern. The WAG 5 future land use scenario is based on the assumption that either industrial workers or residents could be exposed. Current contaminant concentrations are used for the on-site assessment of future exposure. This represents the maximum exposure to WAG 5 contaminants and will serve to define the potential human health

risks that would exist if residential occupation were to begin within a short timeframe. This is considered to be the RME for this BHHRA.

A more realistic exposure setting would allow the contaminant concentrations to be modeled into the future, with the current conditions serving as the reference point. However, the nonradioactive chemicals on the COPCs list are, for the most part, inorganic metals or environmentally-persistent organics. Therefore, the future concentrations can be expected to be the same as the current concentrations, at least for the near-term future and barring major soil erosion or soil loss.

The risks from radioactive contaminants, however, are analyzed for current concentrations and also for future concentrations by using the DOE-validated computer code RESRAD. The time-dependant decay of radioactive contaminants is an important consideration since the total amounts, or inventories, of certain radioactive contaminants will be considerably reduced in the near-term future through natural decay. The underlying assumption for modeling of the future contaminant concentrations is that the release of contaminants from the source control Study Group Areas has achieved a steady-state. A discussion of these assumptions is presented in Chap. 6 of this BHHRA report.

In the off-WAG assessment for residential land use, the primary fate for contaminants released from WAG 5 is considered to be transport via the surface waters of the White Oak Creek watershed integrator.

The preliminary conceptual model for the residential, excavation, and industrial land use scenarios are presented in Figs. 2a, 2b, and 3, respectively.

3.2.2.1 Industrial land use scenario

The future industrial scenario is evaluated using industrial default occupational values provided as EPA guidance (EPA 1991b, 1991c). It should be noted that the assumptions and default parameters for the industrial land use scenario are reasonable maximum values and do not reflect the use of protective clothing or other safety precautions.

The conceptual site model for the industrial land use scenario is presented in Fig. 3.

3.2.2.2 On-WAG residential land use scenario

A hypothetical future on-WAG resident was considered because the intake is representative of an RME. In an industrial area where redevelopment for homes is not feasible now or in the foreseeable future, future land use planning scenarios would be more accurately reflected as industrial rather than residential. However, to provide a conservative assessment of risk, a residential land use scenario is assumed. Consequently, appropriate default parameters and equations for residential land use were evaluated.

Under such land use, residents are expected to be continuously exposed to contaminated media. Exposure is higher than that under the industrial scenarios because exposure is more frequent and lasts for a longer duration of time. Exposure is calculated for a lifetime, which includes exposures

Fig. 2a. Preliminary Conceptual Model for Residents on WAG 5

Fig. 2b. Preliminary Conceptual Model for Excavation on WAG 5

Fig. 3. Preliminary Conceptual Model for Industrial Worker on WAG 5

for the receptor as both child and adult. In addition, an excavation scenario for building a residential basement was also assessed based upon current concentrations in soil samples down to a depth of 10 ft. The conceptual site model for the residential and excavation scenarios is presented in Figs. 2a and 2 b, respectively.

3.2.2.3 Off-WAG residential land use scenario

An off-WAG residential scenario is also considered since contamination is known to migrate from the WAG via surface water and groundwater. Children are included as potential receptors in the future residential land use scenario of this risk assessment to ensure a conservative approach in protecting human health. It is important to note that the hypothetical future off-WAG residential scenario evaluates exposure pathways for surface water only, while the hypothetical future on-WAG residential scenario evaluates the groundwater pathways.

3.3 IDENTIFICATION OF EXPOSURE PATHWAYS

The quantitation of RME for industrial land use and residential land use is discussed in this section. Exposure is quantified by calculating the chemical intakes for the various exposure pathways identified on- and off-WAG. The chronic daily intake (CDI) is the daily amount of a contaminant taken into the body via ingestion, inhalation, dermal contact, or externally from radiation. The first consideration in deriving the CDI is the derivation of the exposure point concentration, which is the amount of each contaminant in a particular medium to which receptors are exposed (as discussed in Sect. 2.3.4 and calculated in Tables 2a-d). To calculate the CDI, the exposure point concentration is evaluated in the context of an RME for the scenario, exposure pathway, and contaminant-specific exposure variables.

Each exposure pathway describes a single mechanism by which an individual or a population may be exposed to chemicals originating from the site. Exposure pathways of concern are identified by evaluating all components (i.e., source and mechanism of chemical release, transport medium, exposure point, potential human receptors, and routes of exposure) necessary to complete the potential exposure pathway. For an exposure pathway to be considered complete, each component must be identified and must be linked to each of the other components. Routes of exposure (i.e., ingestion, inhalation, dermal absorption, and external exposure to radiation) and potential receptors are crucial in identifying the validity of an exposure pathway. The descriptions of exposure pathways are presented for each future land use and for on-WAG and off-WAG exposures.

3.3.1 Future On-WAG Industrial Scenario

3.3.1.1 Soil and dry sediment

Soil and dry sediments are considered the primary sources of exposure to potential industrial receptors. The exposure pathways evaluated for soils and sediments include 1) incidental ingestion, 2) dermal contact, 3) inhalation of wind-generated soil dust and inhalation of volatile organic compounds (VOCs), 4) external exposure to radionuclides in the soil, and 5) ingestion of home-grown produce cultivated in contaminated soil/dry sediment. Risk calculations for soils were carried out for the 10 soil Study Group Areas and for the entire WAG.

3.3.2 Future On-WAG Residential Scenario

3.3.2.1 Soil and dry sediments

Soil and dry sediments were considered the primary sources of exposure to potential on-WAG residential receptors. The exposure routes/pathways evaluated for soils and sediments included 1) incidental ingestion, 2) dermal contact 3) inhalation of wind-generated soil dust and inhalation of VOCs, 4) external exposure to radionuclides in the soil, and 5) ingestion of home-grown produce cultivated in contaminated soil and dry sediment. Risk calculations for soils were carried out for the 10 Study Group Areas (Sect. 3.1.3).

3.3.2.2 Groundwater

The exposure pathways evaluated for groundwater intake of a hypothetical resident included 1) ingestion, 2) dermal contact, 3) inhalation of VOCs and inhalation via indoor water use, and 4) ingestion of produce irrigated with groundwater. Groundwater wells were grouped according to the area in which they were located, based on the surface coordinates of the sampling wells. These areas are FS, OHFP, PWSB, SW3, SWSA5SE, SWSA5SW and White Oak Creek.

3.3.2.3 Surface water

The surface water contributions to the on-WAG risk was assessed by considering the different exposure pathways of the impoundments (i.e. OHFP and PWSB) and the drainages (i.e., D1, D2 and D3). The only credible and potentially significant pathway of exposure that will be evaluated for the surface water is via the inhalation of volatiles, both VOCs and tritium. Chronic ingestion of surface water from the impoundments or drainages is considered unreasonable since the WAG 5 surface waters are limited and cannot provide a sufficient year-round source of drinking water. For the same reason of inadequate supply criteria, the dermal contact pathway for household usage (i.e., bathing, showering, etc.) is also judged not credible. Finally, the impoundments are too shallow and morassy to be considered for swimming.

3.3.3 Off-WAG Residential Scenario

3.3.3.1 Surface water

For the evaluation of the future off-WAG residential scenario, the migration of contaminants off-WAG is assumed to occur primarily via surface water and groundwater, both of which discharge into the White Oak Creek watershed system. The WAG 5 BHHRA evaluates two off-WAG exposure points to comprehensively address the potential risks associated with the migration of contaminants from WAG 5. These exposure points are 1) hypothetical future residents at Melton Branch and 2) hypothetical future residents at White Oak Lake Dam. White Oak Creek watershed surface water and groundwater serve as the two integrator Study Group Areas for WAG 5 contaminants. Therefore, the total risk from exposure to contaminants in both of these integrator Study Group Areas to a hypothetical future resident at the White Oak Lake Dam is important in determining the need for remediation of the WAG 5 source control Study Group Areas.

As previously noted, the exposure pathways for surface water are evaluated for the off-WAG residential scenario, while groundwater pathways are evaluated under the on-WAG residential land use scenario. The surface water exposure pathways for the future off-WAG resident are 1) ingestion, 2) dermal contact, and 3) inhalation. Data from the Office of Environmental Compliance and Documentation were used to calculate risk to the future off-WAG resident. Other potential transport mechanisms, such as the incorporation of contaminants into the animal food chain (e.g., fish ingestion), the air pathway, and direct groundwater transport, are currently not primary sources of off-WAG fluxes.

3.4 QUANTITATION OF EXPOSURE

The quantitation of exposure for industrial land use and residential land use are discussed in this section. Exposure is quantified by determining the exposure concentrations and calculating the chemical intakes for the various exposure pathways identified on- and off-WAG. The CDI is the amount of a contaminant an individual takes into his or her body per day via ingestion, inhalation, dermal contact, or external exposure to radiation. The first consideration in deriving the CDI is the methodology employed in developing an exposure concentration, which is the amount of each contaminant in the various media to which receptors are exposed. To calculate the CDI, the exposure concentration is evaluated in the context of the scenario, exposure pathway, and contaminant-specific exposure variables, such as duration of exposure and intake rate. The representative concentrations of the COPC are the concentrations used to estimate the RME exposure concentrations for the different pathways. Once the CDIs for the different potential pathways are determined, risk can be calculated.

Exhibits 3-8 list the equations used to calculate the CDIs and the exposure variables associated with each exposure pathway considered for the different land use scenarios.

3.4.1 CDI Calculations for the Industrial Land Use Scenario

To reflect restricted land use conditions, the intake and exposure duration parameters were modified to reflect the "most likely exposure" that would occur on-WAG. The media concentrations of the COPCs identified in Sect. 2.3 were used in calculating the CDIs. The smallest of the maximum detected concentration versus the upper 95th confidence limit concentration was assumed to represent the analyte concentration. Conservative CDI calculations were based on the assumption that an adult spends 8 hours/day, 5 days/week, and 50 weeks/year for 25 years at the facility (Exhibits 3a-3d). Parameters are industrial default occupational values provided as EPA guidance (EPA 1991b, 1991c). It is important to note that the assumptions and default parameters for the industrial land use scenario are reasonable maximum values and do not reflect the use of protective clothing or other safety precautions. The WAG 5 BHHRA evaluates risk to the general plant employee only and does not evaluate remediation workers.

Tables 9a and 9b list CDIs for ingestion, inhalation, and dermal contact with the COPCs in WAG 5 soil and dry sediment. Doses are also listed for external exposure to radionuclides in soil and dry sediment. Tables are provided for each of the 10 Study Group Areas (i.e., FS, NHFT, OHFP, OHFT, PWSB, SW3, SWSA5N, SWSA5SE, SWSA5SW, and White Oak Creek). Each table is divided by analyte type (i.e., inorganics, organics, and radionuclides). Similarly, Tables D.8a and

D.8b list the CDI's for the soil and sediment in the WAG-wide analysis provided in addition to the individual Study Group Areas.

3.4.2 CDI Calculations for the Residential Land Use Scenario

For the hypothetical future residential land use scenario, the residential defaults as provided by EPA guidance are used to calculate the CDIs for a person exposed for 6 years as a child and 24 years as an adult. The exposure frequency to soil contaminants was assumed 350 days/year for an exposure duration of 30 years. Exhibits 4-7 list the exposure parameters associated with each exposure pathway considered for the future residential scenario. The excavation scenario (an extension of the residential scenario but analyzed separately) employs the equations presented in Exhibit 8.

3.4.2.1 CDI calculations for the primary routes of exposure

Tables 9a-9d list the CDIs for ingestion, inhalation, and dermal contact with the COPCs in WAG 5 soils, sediments, groundwater, and surface water. Doses from external exposure to radionuclides in soil and sediment were also calculated. Tables are provided for each of the 10 soil and dry sediment Study Group Areas as well as the six integrator Study Group Areas (i.e., groundwater, surface water drainages D1, D2, and D3, and impoundments OHFP and PWSB) and were segregated by analyte type in each media.

Exhibits 8a-8d list the exposure parameters associated with each exposure pathway for the excavation subscenario. Table 9a lists the CDIs for ingestion, inhalation, and dermal contact with COPCs in soils for this subscenario.

3.4.2.2 CDI calculations for other routes of exposure

Other routes of exposure include residential ingestion of produce grown in contaminated dry soil and irrigation by contaminated groundwater through direct or indirect means, residential inhalation of volatile contaminants from on-WAG surface water, and inhalation of indoor VOCs from groundwater while showering. Exhibits 6 and 7 present the CDI equations and corresponding parameters used for the ingestion of produce and the inhalation of volatiles from groundwater exposures, respectively, under the residential land use scenario. In this subsection, the concentrations of contaminants used in the CDI calculations were derived or modeled. Table 9a provides the CDIs for these pathways of exposure.

Derivation of concentrations of COPCs in produce. To calculate the CDI for ingestion of produce, an estimate of the contaminant concentrations in produce was determined for all 10 Study Group Areas. It was assumed that vegetables would be grown in soil (with the groundwater of WAG 5 as the irrigation source).

It was further assumed that plants could be contaminated by two basic means: 1) root uptake from contaminated soil and 2) contamination from irrigation water. The contaminant concentration due to irrigation is calculated assuming that the irrigation process resembles direct foliar (i.e., spray irrigation) and indirect soil (i.e., interacting with soil prior to entering produce) depositions. The effective contaminant uptake, C_p , by plants from irrigation is the sum of the direct and indirect depositions.

Following the methodology used in Remedial Action Priority Systems (RAPS) [i.e., Multimedia Environmental Pollutant Assessment Systems (MEPAS)] (Whelan et al. 1987), this concentration is

$$C_{pd} = \frac{(C_w I) \cdot T_f \cdot r}{Y} \frac{1 - e^{-\lambda_e t_e}}{\lambda_e}$$

where

- C_{pd} = the contaminant concentration in produce,
- C_w = the concentration in the water used for irrigation (mg/L or pCi/L),
- I = the water application rate (L/m²/day),
- T_f = the translocation factor from plant surfaces to edible parts of the plant (dimensionless),
- r = the fraction of foliar deposition retained on the edible part of the plant (dimensionless),
- Y = the plant yield (kg/m²),
- λ_e = the effective soil weathering and decay constant,
- t_e = the duration of the growing period for crops.

Note that the term $C_w I$ is the deposition rate of the contaminant (units of mg/m²/day or pCi/m²/day).

The contaminant uptake by plants from irrigation via indirect contact with soil that has been contaminated through groundwater is calculated with the model developed by Barbier et al. [BAR-61] for radionuclide accumulation in soil. The model relates the concentration in the vegetation to the contaminant concentration in the groundwater:

$$C_{pi} = \frac{B_r \cdot C_w \cdot I \cdot (1 - L_R)}{\rho_s \cdot \lambda_e}$$

where

- C_{pi} = the concentration of contaminants on the plant from irrigation by indirect uptake (mg/kg or pCi/kg),
- B_r = soil-to-plant transfer coefficient (dimensionless),
- ρ_s = areal density of soil (kg/cm³),
- L_R = the surface run-off loss and is given by
 - $L_R = s(1 - K/I)$ for $K < I$ and
 - $L_R = 0.0$ for $K \geq I$.

K is the soil permeability and s is the land slope. Note that losses of contaminants from the root zone by infiltration into deeper soil layers are neglected in estimating contaminant accumulation in soil. This leads to conservative over-estimates of long-term accumulations. The specific parameters and

produce concentrations resulting from irrigation used in the previous equations can be found in Tables 10 and 11, respectively.

The plant concentration due to root uptake, C_v , is estimated by

$$C_v = B_v C_s$$

where B_v is the soil-to-plant transfer coefficient which is dimensionless, and C_s is the concentration in the dry soil in mg/kg or pCi/kg (refer to Table 12).

Derivation of volatile chemical concentrations in air from surface water. The following text describes different assessments of exposure to air emissions of volatile chemicals from surface water which were considered at 1) two different locations in the White Oak Creek watershed (seep locations A and B), 2) emissions from the impoundments (i.e., OHFP and PWSB), and 3) drainages within WAG 5 (i.e., D1, D2 and D3).

The first assessment was carried out for tritium emissions specifically. The tritium concentrations were results from a field survey of surface waters that was conducted at the southernmost boundary of SWSA 5. The two particular stations that were considered as part of the WAG 5 BHHRA are 05.SP011 and 05.SP008 in seep locations A and B, respectively.

In the second assessment, air emissions from the impoundments were estimated using an escape mechanism calculation that can be represented by a single term

$$\frac{dC_v}{dt} = K(C_s - C_v) \quad (A)$$

where

- C_s = is the vertically uniform radionuclide gas concentration,
- C_v = is the saturation value of C_s (usually, $C_v = 0$ for radionuclides),
- K = $1420 \text{ Us (d}^{-1}\text{)}$ is the depth average loss coefficient,

where U is the velocity in meters per second and s is the slope of the sides of the impoundment, and

C_v = is the concentration of VOC in the impoundment at any time (pCi/L).

The water concentration in the impoundment at any time is calculated by a mass balance equation assuming a uniform concentration through the impoundment with a zero initial concentration at $t=0$. The solution of the mass balance equation is given by

$$C_v = \frac{q_o C_o}{q + (\lambda + K)V} (1 - e^{-(qV + \lambda + K)t}) \quad (B)$$

where

- q_o = Circulating water flow rate (cm^3/sec)
- q = Net water body through flow (cm^3/sec), either natural or in the form of an artificial makeup/blowdown scheme.
- C_o = Discharge concentration (pCi/l)
- V = Water body volume (cm^3)
- λ = Radioactivity constant ($1/\text{sec}$)

By differentiating Eq. B with respect to t and substituting the result in Eq. A, the volatile concentration can be written as follows:

$$C_a = \frac{q_o C_o}{KV} e^{-(q/V + \lambda)t} \quad (C)$$

Since the through flow is limited within the impoundments in WAG 5 (i.e., $q \rightarrow 0$), Eq. C reduces to the following form:

$$C_a = \frac{q_o C_o}{KV} e^{-(\lambda)t}$$

The model assumes a uniform concentration and neglects any concentration gradient within the impoundment. This simple model stresses the role of strong advective effects in limited water bodies.

The basic assumptions in the previous model are not satisfied if rapid decay were to take place (i.e., $\lambda V/q_o \rightarrow 1$) since a significant concentration gradient exists within the impoundment.

The risk of inhaling tritium from the two impoundments was calculated for the future hypothetical residential scenario. The CDIs are listed in Table 9d, and the water and air concentrations and the corresponding parameters used in the model are listed in Table 13.

The third assessment was performed to derive the air concentration for the VOCs and tritium emissions from drainages D1, D2, and D3. The modeling was based on the source concentrations of contaminants in the surface water of the drainages.

The air concentrations were computed using a dispersion equation from a model developed by EPA for a line source (EPA 1973). The equation is given by

$$C_a = \frac{E}{d_z \times U_w}$$

where

- C_a = air concentration of the volatile (pCi/m³),
 d_z = vertical dispersion (m),
 U_w = wind velocity (m/s),
 E = emission rate for the volatile (pCi/m/s).

The expression used to calculate the emission rate from the stream channel is given by

$$E = K_r \times C_w \times b$$

where

- K_r = volatilization transfer coefficient (m/s),
 C_w = concentration of volatile in water (pCi/m³),
 b = average width of the water in the stream channel (m).

The volatilization transfer coefficient was computed by applying the "two-film theory of volatilization" (Thomann and Mueller 1987) given as

$$\frac{1}{K_r} = \frac{1}{K_l} + \frac{1}{K_g \times H_g}$$

where

$$H_g = \frac{H}{R \times (T+273)}$$

$$K_l = \sqrt{(1.024)^{T-20} \times \frac{D_{20} \times U}{Y}}$$

and

$$K_g = 1.94 \times 10^{-3} \times U_w \times \left(\frac{28}{M} \right)^{1/4}$$

where

- K_1 = liquid film coefficient (m/s),
- K_2 = gas film coefficient (m/s),
- H_e = effective Henry's Law constant for tritium (dimensionless),
- U = stream velocity (m/s),
- Y = stream depth (m),
- D_{20} = Oxygen diffusivity at 20 °C (m^2/s),
- T = surface water temperature (°C),
- M = molecular weight of the volatile (g/mol),
- U_w = wind velocity (m/s),
- H = Henry's Law constant ($atm \cdot m^3/mol$),
- R = universal gas constant = $8.206 \times 10^{-5} (atm \cdot m^3 / ^\circ K \cdot mol)$.

Table 14 presents the values of the parameters employed in this model for a hypothetical future resident.

Derivation of indoor tritium concentration from groundwater vapor. Inhalation of an indoor water vapor can occur in the shower, bathroom, and general house compartments. An inhalation exposure factor that translates unit concentrations in media (i.e., pCi/L) into exposure per unit time (i.e., pCi/y) was calculated for each of the compartments. The following formula was employed:

$$IEF = \frac{W_u \times \phi \times IR \times ET \times CF \times EF}{VR}$$

where

- IEF = inhalation exposure factor (L/year),
- W_u = water use in each compartment (L/hour),
- IR = indoor inhalation rate (m^3/day),
- ET = exposure time (hour/day),
- EF = exposure frequency (day/year),
- CF = conversion factor (1 day/24 hours),
- VR = ventilation rate of each compartment ($m^3/hour$),
- ϕ = water transfer efficiency and is given by the following formula.

$$\phi = \frac{2 \times 10^6 \times \phi_{Rn}}{2.5(DR_w)^{-23} + C(DR_o)^{-23}}$$

where,

- ϕ_{Rn} = transfer coefficient for each compartment,

- Dr_w = tritium (as $^3\text{HO}^3\text{H}$, or HTO) diffusion in water (m^2/s),
 Dr_a = tritium (as $^3\text{HO}^3\text{H}$, or HTO) diffusion in air (m^2/s),
 C = gas constant $\times 293^\circ\text{K}$ / Henry's law constant ($\text{gmol m}^{-3} \text{HOH} / \text{gmol m}^{-3} \text{air}$).

The inhalation exposure (IE) of the indoor tritium was calculated with the units of pCi/y with the expression

$$IE = (IEF_{\text{shower}} + IEF_{\text{bathroom}} + IEF_{\text{house}}) \times C_w$$

where

C_w = the concentration of tritium in the water (pCi/L).

Table 15 presents the corresponding parameters that were used in this model assuming residential land use.

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4. TOXICITY ASSESSMENT

The purpose of the toxicity assessment is to evaluate the potential for site contaminants to cause adverse health effects in exposed individuals. It provides, where possible, an estimate of the relationship between the extent of exposure to a contaminant and the increased likelihood and/or severity of adverse effects (EPA 1989). The first step in the toxicity assessment is to gather available toxicity information on the contaminants being evaluated. The information suggests whether exposure to an agent can cause an increase in the incidence of a particular adverse effect. For contaminants having potentially adverse health effects in humans, toxicity values were determined for noncarcinogenic and carcinogenic effects. These values characterize the relationship between the contaminant dose, or level of exposure, and the incidence of adverse effects in exposed populations.

The primary source of information used in the toxicity assessment was the January 1993 edition of the IRIS data base (EPA 1994a). In cases where toxicity information was unavailable in IRIS, the March 1993 edition of HEAST was consulted. HEAST was also the primary source of information on the carcinogenic effects of radionuclides (EPA 1993). For the generation of point estimates based on soil concentrations, HEAST SFs were used for calculating radiological risk. For calculating dose from the Ultrasonic Ranging and Data System (USRADS) survey and for performance of the uncertainty analysis of off-site effects, dose conversion factors found in Federal Guidance Report No. 11 (EPA 1988a) were used with a risk conversion factor (ICRP 1991) to estimate risk.

4.1 TOXICITY INFORMATION FOR NONCARCINOGENIC EFFECTS

The RfD is the toxicity value used to evaluate noncarcinogenic effects resulting from chemical exposure and is an estimate of the daily exposure to the human population, including sensitive subgroups likely to be without appreciable risk of harmful effects. It can be used to estimate a level of exposure at or below which no adverse effects are expected to occur. If the exposure level exceeds this threshold, concern for potential noncarcinogenic/systematic effects might arise.

The EPA developed RfDs based on the period of contaminant exposure. Subchronic RfDs are useful for characterizing potential noncarcinogenic effects associated with short-term exposures, such as 2 weeks to 7 years. Chronic RfDs are developed to be protective for long-term exposures, between 7 years and a lifetime. Contaminant RfDs vary depending on the mode of intake (i.e., ingestion, inhalation, or dermal contact). The inhalation RfD was recently replaced with the inhalation reference concentration (RfC), expressed in units of milligrams per cubic meter (mg/m^3) (EPA 1991a). Conversions between the inhalation RfC and RfD are made assuming that humans weigh 15 and 70 kg for children and adults, respectively, and breathe at a rate of $20 \text{ m}^3/\text{d}$. In addition, an exposure duration of 6 years as a child and 24 years as an adult is also assumed. No RfDs are available for the dermal route of exposure. Noncarcinogenic risks associated with dermal exposure were evaluated by extrapolating an oral RfD with the gastrointestinal value to a dermally absorbed reference dose (RfDAD), also termed a dermal RfD.

Uncertainties in the derivation of the RfDs are expressed in terms of the confidence level of the research evaluated, the uncertainty factors, and the modifying factors. The confidence level is expressed as low, medium, or high and is an indication of the quality of the studies examined. Reference doses based on low confidence level studies are likely to change, subject to additional information. The uncertainty factor is applied in the derivation of the RfD to account for variation in human sensitivity, animal to human extrapolation, extrapolation from subchronic to chronic studies, and extrapolation from levels of lowest observable adverse effect levels of no adverse effect levels. The modifying factor is a number from 0 to 10 and is included to reflect a professional assessment of additional uncertainties in the available data. The default value is 1 (EPA 1989). Table 16 summarizes the toxicity information for the WAG 5 noncarcinogenic COPCs.

4.2 TOXICITY INFORMATION FOR CARCINOGENIC EFFECTS

For carcinogenic effects, EPA uses a two-part evaluation in which the substance is assigned a weight-of-evidence classification, and an SF is calculated. In the first step, data are evaluated to determine the likelihood that the agent is a human carcinogen. Based on this evaluation, EPA gives the agent a weight-of-evidence classification. The second step involves calculating a slope factor, which measures the relationship between dose and response. In general, the SF is a plausible upper-bound estimate of the probability of a response per unit intake of a chemical over a lifetime. The SF is used in this risk assessment to estimate an increased upper-bound lifetime probability of developing cancer as a result of exposure to a particular level of a potential carcinogen (EPA 1989). Tables 17 and 18 summarize the toxicity information for the WAG 5 carcinogenic COPCs.

4.3 CHEMICALS WITHOUT EPA TOXICITY VALUES

Slope factors and RfDs are not currently available for all known chemicals because their carcinogenicity and/or noncarcinogenic effects have not yet been determined. These chemicals may contribute to carcinogenic and noncarcinogenic effects from exposure to the WAG 5 media, but their effect cannot be quantified at the present time. In addition, for several chemicals, epidemiological studies have indicated that they are not carcinogenic; consequently, these species do not have SFs. A qualitative summary of toxicity information for COPCs for WAG 5 can be found in Appendix C.

4.3.1 Evaluation of Soil Lead Toxicity

Lead is a toxic metal that can affect several target organs in a noncarcinogenic manner (see Appendix C). However, currently EPA does not endorse an RfD for lead. Instead, a recent Office of Solid Waste and Emergency Response (OSWER) directive [EPA 1994b] describes the use of an Integrated Exposure Uptake Biokinetic Model (IEUBK) to estimate the risks from lead to children. The guidance also sets a soil lead screening level of 400 ppm. The lead that was detected in the WAG 5 sediment media was only slightly above background and considerably (< 200 ppm level) below the 400 ppm screening level. The lead concentrations in groundwater were also only slightly elevated above background, and OSWER guidance states that the groundwater pathway should not pose a significant risk.

4.4 SUMMARY OF TOXICITY PROFILES FOR WAG 5 COPCS

The toxicity profiles for the COCs identified for the risk assessment are located in Appendix C.

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5. RISK CHARACTERIZATION

The purpose of the risk characterization is to integrate and summarize the information presented in the exposure and toxicity assessments for each of the different land use scenarios. This represents the final step in the human health risk assessment process. Potential carcinogenic effects are characterized by estimating the probability that an individual will develop cancer over a lifetime from projected intakes (and exposures) and chemical-specific dose-response data (i.e., SFs). Potential noncarcinogenic (systemic) effects are characterized by comparing projected intakes of contaminants to toxicity values (i.e., RfDs). The numerical risk or HQ estimates that are presented in this section must be interpreted in the context of the uncertainties and assumptions associated with the risk assessment process and the data upon which the risk estimates are based (Chap. 6).

5.1 EVALUATION OF CARCINOGENS AND NONCARCINOGENS

Carcinogenic risk and noncarcinogenic hazard potential for carcinogens and noncarcinogens, respectively, are calculated for the WAG 5 COPCs. These risks and hazard potential are based upon EPA-approved or -suggested SFs and RfDs. The SF is based upon an estimate of the incremental lifetime cancer risk which equates to incidence per unit of exposure, and the RfD is a level of exposure (threshold) below which no noncarcinogenic adverse health effects are expected to occur.

Cancer risk is an estimate of the incremental probability of developing excess cancer over a lifetime (EPA 1989), above and beyond the normal (unavoidable) incidence observed in the general population. The risk estimates for carcinogens are calculated by multiplying the EPA-approved SFs for inorganics, organics, and radionuclides by an estimate of the actual exposure to these contaminants (i.e., CDI and/or dose) via the different pathways of ingestion, inhalation, dermal contact, or external exposure. The risk equation ($\text{intake} \times \text{SF} = \text{risk}$) is based on the assumption that there is a linear relationship between dose and response (cancer incidence) (EPA 1989). The assumption that dose-response is linear is reliable only for predicting risk at low exposure levels; therefore, the application of the above equation is limited to risks below $1\text{E-}02$. At high exposure levels ($\geq 1\text{E-}02$), which is frequently the case for WAG 5 due to the high level of activity associated with radionuclides in various media, the one-hit equation [$\text{risk} = 1 - \exp(-\text{CDI} \times \text{SF})$] was applied to estimate risk (EPA 1989). Because some risks were calculated using the one-hit equation and others with the linear equation, the sum of the risk numbers mentioned in the text for individual analytes or exposure routes may not equal the total scenario risk referenced. This may also occur as a result of rounding associated with the estimation of cancer risks that are typically reported to one significant figure. Please refer to Chap. 6 for a discussion of the uncertainties related to excess cancer risks.

The HQ estimates for noncarcinogens are calculated by determining the ratio of the CDI for ingestion, inhalation, and dermal contact of a contaminant to the contaminant-specific reference toxicity value (RfD, RfC). This HQ assumes that below a given level of chronic exposure (i.e., the RfD) populations are unlikely to experience adverse health effects.

To estimate the potential risk to human health from all contaminants in a particular pathway, the risks and HQs are summed for all contaminants in that pathway, i.e., a cumulative risk (Total Pathway Risk) or a cumulative hazard quotient (Total Pathway HQ) is determined from exposure

to all contaminants (EPA 1989). In addition, an overall cumulative risk due to the site contaminants can be determined by summing the risks from all analytes from all of the pathways associated with a specific land use. Summations are conducted separately for chemicals (either carcinogens, noncarcinogens, or radionuclides.)

The constituents detected in the WAG 5 media and listed as COPCs were evaluated within the context of EPA-approved guidelines (EPA 1989) which describe three regions of interest for carcinogenic risk [risk $< 1.0\text{E-}06$, no concern; risk between $1.0\text{E-}06$ and $1.0\text{E-}04$, range of concern (or target risk range); and risk $\geq 1.0\text{E-}04$, unacceptable] and two areas of interest in terms of noncarcinogenic/systemic toxicity (HI < 1.0 , no concern, and HI ≥ 1.0 , concern). These boundaries allow an optional screening analysis to be performed to prioritize the large number of detected chemicals. The COCs that contribute to unacceptable risk in the BHHRA in each Study Group Area within WAG 5 were identified based on the total pathway risk or HQ in an effort to limit the number of chemicals to be considered. That is, if the total pathway risk or HQ is unacceptable (total pathway risk $\geq 1\text{E-}04$ or total pathway HQ ≥ 1.0), then all COPCs with individual risks $\geq 1\text{E-}06$ or an HQ ≥ 0.1 are considered COCs.

The risk results for the WAG 5 BHHRA are summarized in two formats in the following text. First, risk information is discussed by media. This view of the risk data will highlight the media and those areas within a specific media that have unacceptable risks. Second, the risks are summarized for the entire WAG and by area. In this approach to the data, all risks associated with the exposure evaluation of a particular area of concern are summarized to identify for specific area scenarios, pathways, and COPCs that are of concern. The risk characterization is concluded with a summarization of COCs by media.

5.2 RISK SUMMARY BY MEDIA

The media-specific risk characterization of the WAG 5 BHHRA includes potential risks determined as a result of exposure to soil, groundwater, sediment, and surface water. The risk estimates associated with the exposure to each of these media are presented by toxic effect (carcinogenic or noncarcinogenic) and by land use (excavation, industrial, and residential).

Besides having broken the site into logical study group areas, an additional risk assessment was performed for the data of the entire site. This "WAG-wide" risk assessment is employed to compare the results of the individual study group areas with the WAG-wide risk results. Some of the inherent problems in performing a WAG-wide analysis for a site as large as WAG 5, will be discussed in the uncertainty section (Chap. 6).

5.2.1 Soil Risk Summary

Figures 2a and 2b (Chap. 3) illustrate the site conceptual model that represents the exposure pathways related to contamination at WAG 5. The figures include exposure scenarios, transport media, and routes of exposure. The contaminated soil at WAG 5 is a primary exposure media for the future excavation, industrial, and residential land use scenarios. Soil exposure routes evaluated for each land use include ingestion, dermal contact, inhalation of dust and VOCs, and external exposure to radionuclides. Direct exposure to radiation in the soil at WAG 5 is the most probable route of exposure, since gamma radiation can travel beyond the source; therefore, external exposure

to radioactive contaminants in the soil is likely to be a completed pathway in all of these future land uses.

The ingestion and dermal contact pathways were evaluated for all COPCs when possible (i.e., when oral SFs or RfDs were available). The inhalation (dust, VOCs) pathway could only be evaluated (risk or HQ) for those COPCs with an inhalation SF or RfD, i.e. RfC. The inhalation exposure pathway was evaluated for both inhalation of soil particulates (dust) and for inhalation of VOCs from soil. The external exposure to radionuclides in the soil pathway was evaluated for all radioactive COPCs.

5.2.1.1 Excavation scenario—carcinogenic results

Future land use conditions include evaluating an excavation scenario in terms of carcinogenicity from exposure to the COPCs in the soil. As initially described in the Exposure Assessment (Chap. 3), future on-WAG residents may decide to build a basement and remove the soil cover to a depth of 10 ft. For the excavation land use scenario the ingestion, dermal contact, inhalation, and external exposure pathways were evaluated in terms of carcinogenic risk and noncarcinogenic toxicity to human health. However, this scenario will significantly underestimate the risk due to exposures to the subsurface contaminants due to the lack of exposure data on the buried waste itself.

Exhibit 9a and Table D.11a list the risk estimates for the excavation scenario from exposure to COPCs via ingestion, dermal contact, inhalation, and external exposure pathways for the WAG 5 soil. The total cumulative pathway risks are $>1.0E-04$ for the WAG-wide analysis and in the FS, OHFP, and White Oak Creek areas only (refer to Exhibit 13a). Table D.11a shows that for the WAG-wide analysis cobalt-60, cesium-137, and tellurium-208 present the majority of risk through the external exposure route. Exhibit 11a shows that the major route of exposure is via the external exposure to cobalt-60, radium-226, and cesium-137 in the FS; cesium-137 in the OHFP; and cesium-137 and cobalt-60 in the White Oak Creek.

5.2.1.2 Industrial scenario—carcinogenic results

The carcinogenic risks to a future industrial worker were determined for exposure to the soils via 1) incidental ingestion of soil/dry sediment, 2) inhalation of dust and VOCs, 3) dermal contact with the soil/dry sediment, and 4) external exposure to radionuclides. Exhibit 9a and Table D.11a list the risk estimates for the exposure of an industrial worker to the WAG 5 carcinogenic COPCs in the soil via each of these primary exposure routes.

The WAG-wide analysis in Table D.11a shows that the major pathways of concern are the external exposure and inhalation pathways. External exposure is driven by cobalt-60, cesium-137, and tellurium-208; while the inhalation pathway is predominated by the risks from radium-226 (and its decay product radon). A summary of the total cumulative pathway risks for each WAG 5 Study Group Area (i.e., the sum of the risks from all analytes across all exposure pathways) is presented in Exhibit 13a. The major pathways of concern for the industrial scenario (i.e., pathways with total pathway risk $\geq 1.0E-04$) are the external exposure pathway in all areas; the inhalation pathway in the FS, OHFT, PWSB, and SWSA5SW areas; and the ingestion pathway in the SWSA5SE area. The COCs that are the main contributors (i.e., that have individual risks $\geq 1.0E-06$ for the pathways

of concern) to the total cumulative risk are listed in Exhibit 11a. Various contaminants drive the external exposure risk values in the different areas of concern. Inhalation of radon from its parent isotope, radium-226, is the driver for the risk values in this pathway. Total radioactive strontium and cesium-137 are the main COCs in the ingestion pathway of the SWSA5SE area. As shown in Exhibit 11a, all exposure routes for the NHFT area are $< 1E-04$ and therefore are below concern. Consequently, no carcinogenic industrial soil COCs were identified for this area.

5.2.1.3 On-WAG residential scenario—carcinogenic results

Future exposure to on-WAG soil contaminants is assessed both in terms of current and estimated future concentrations of the COCs for a hypothetical resident. Exposure routes include ingestion, inhalation, dermal contact, and external exposure for radionuclides in soils and ingestion of produce grown on WAG soils. The expected risk from exposure to the estimated future concentrations are evaluated using RESRAD, Version 5.19. The routes of exposure considered in this scenario are ingestion, ingestion of produce, inhalation, and external exposure to contaminants in soil only.

Current contaminant concentrations. Exhibit 9a and Table D.11a list the carcinogenic risk estimates for the residential scenario from exposure to the WAG 5 soil COCs via the primary exposure pathways listed previously and via the ingestion of homegrown produce pathway. Exhibit 13a presents the total cumulative pathway risks for all areas of concern. The major contributing pathway to the total cumulative risks is the external exposure pathway for the entire site and in all areas. Various contaminants are contributing to this pathway in the different areas of concern. Among these contaminants are cobalt-60, cesium-137, radium-226, and thorium-228. Inhalation of radium-226 is also contributing to the total cumulative pathway risk WAG-wide and in the FS, OHFT, PWSB, and SWSA5SW areas. Ingestion and ingestion of produce pathways contributes to the total cumulative pathway risks WAG-wide and in some areas within WAG 5. The specific contributions of all COCs in the various pathways of concern in the different areas are listed in Exhibit 11a and Table D.11a..

Future contaminant concentrations. The excess cancer risk of exposure to radioactive COCs in the WAG 5 soil is estimated from present concentrations using RESRAD package, Version 5.19. The calculations of radionuclide quantities for use in estimating the excess cancer risk are based on EPA's slope factor methodology (EPA 1992). The soil ingestion, ingestion of produce, inhalation, and external exposure pathways were quantified to estimate the residential future risk as a function of time. Since the assessment of future risk to a hypothetical resident from exposure to COCs in the different areas within WAG 5 involves a large number of contaminants that exceed an excess cancer risk of 10^{-6} , the analyses were limited to radionuclides with a current excess cancer risk greater than or equal to 10^{-4} . Exhibit 28 presents all future risk values from exposure to these contaminants over the next 1000 years. Figure 4 summarizes the expected future total cumulative risk from exposure to contaminated soil at the different areas within WAG 5 in a logarithmic scale. The legend of the figure presents the areas of interest in a descending order (i.e., the first mentioned area, SWSA5SE, corresponds to the line with the highest total cumulative risk value).

Ultimately, all contaminants and their progeny will decay depending on their different half lives. The NHFT and SWSA5N areas pose the least amount of excess cancer risk to future residents. The total cumulative risk from the different exposure pathways to COCs in these areas is expected

Fig. 4. Total cumulative risk from exposure to the different contaminated areas within WAG 5 soil as a function of time

to be less than 10^{-6} in less than 60 years. The main exposure pathway of concern in these two areas is the external exposure pathway. The major contributing COCs to this pathway are radium-226 and thorium-228. The next area of concern is the SW 3 area. External exposure is the only pathway of concern in this area, and the major COCs are cesium-137 and thorium-228. Figure 4 shows that almost 50 years should pass before the total cumulative excess cancer risk is less than 10^{-4} in this area. For the rest of the areas, at least 250 years will elapse before the excess cancer risk from exposure to contaminants in these areas is less than 10^{-4} .

Exhibit 28 shows that the external exposure to COCs in the OHFT and the PWSB areas is the main pathway of concern. Other pathways, such as ingestion of produce, are important but less effective (i.e., pose a risk in the 10^{-6} range). The major contributing COCs to the external exposure pathway are cesium-137, radium-226, radium-228, and thorium-228 in the OHFT and radium-226, radium-228, and thorium-228 in the PWSB. It is important to note that potassium-40 appears to be a major contributor to the total cumulative risk in PWSB because it exceeds background screening levels followed in this project (i.e., twice the background rule) although it is a common background contaminant and not thought to be site related.

The main pathways of concern for the FS, SWSA5SW, and OHFP areas are external exposure and ingestion of produce. The COC for the ingestion of produce pathway in the three different areas is strontium-90. In addition, lead-210 in the FS and the SWSA5SW areas is expected to contribute to the ingestion of produce pathway; this COC has a maximum risk in the 10^{-6} risk range after 10 years of production and then subsequently degenerates. The COCs for the external pathway are cobalt-60, cesium-137, and radium-226 in the FS area; cesium-137, radium-226, thorium-228, and radium-228 in the SWSA5SW area; and cesium-137, thorium-228, cobalt-60, and radium-228 in the OHFP. Potassium-40 is also found in the SWSA5SW area. However, it is not expected to be related to site activities and therefore should not be considered in risk management decisions.

Contaminants in the SWSA5SE and the White Oak Creek are expected to continue posing the highest total cumulative risk for a future hypothetical resident for the first 100 years. The total excess cancer risk is not expected to drop to an acceptable level (i.e., less than 10^{-4}) before at least 300 years have elapsed. The main pathways of concern for these areas are external exposure, ingestion of produce, and direct ingestion of soil. The major COCs for ingestion and ingestion of produce are cesium-137 and strontium-90. The major contributing radionuclides to the external pathway are cesium-137, cobalt-60, and thorium-228 in the WOC area and cesium-137 and thorium-228 in the SWSA5SE area. The sodium-22 contribution to total external pathway risk in the WOC area is expected to be associated with background.

The WAG-wide analysis showed very similar results and the main pathways of concern are the external exposure and inhalation, but the ingestion of produce also contributes significantly to the overall risk from the site. Ingestion of soil is more than one order of magnitude less important and this pathway does not exceed the 10^{-4} risk level.

5.2.1.4 Excavation scenario—noncarcinogenic results

For the excavation scenario, the HQ estimates from exposure to the WAG 5 soil noncarcinogenic COPCs via ingestion, dermal contact, and inhalation pathways are listed in Exhibit 10a and Table D.12a. The total pathway HIs are all less than unity for the entire WAG and

in all areas. In addition, the HQs from exposure to the individual analytes are all less than 0.1 in all WAG 5 Study Group Areas. Therefore, no noncarcinogenic COCs are identified for the excavation scenario for any area.

5.2.1.5 Industrial scenario—noncarcinogenic results

Exhibit 10a and Table D.12a list the HQ estimates for the exposure of an industrial worker to the WAG 5 noncarcinogenic COPCs in soil via the four primary exposure pathways listed previously. The cumulative pathway HIs (i.e., the sum of the HQs from all analytes across all pathways) are less than unity (1.0). In addition, the HQs from exposure to individual analytes are all less than unity (1.0) for all designated areas within WAG 5. Therefore, no noncarcinogenic COCs are identified for the industrial worker exposure scenario.

5.2.1.6 Residential scenario—noncarcinogenic results

Exhibit 13a and Table D.12a show that the total cumulative pathway HI is greater than or equal to 1.0 for WAG-wide and in the FS, OHFP, OHFT, SWSA5SE, SWSA5SW, and WOC areas. Exhibit 10a lists the HQ estimates for the exposure of a resident to the WAG 5 soil noncarcinogenic COPCs via the incidental ingestion, produce ingestion, dermal contact, and inhalation pathways. The main pathway of concern (i.e., total pathway HQ exceeds 1.0) for the areas of concern is via the ingestion of produce. Exhibit 12 presents the noncarcinogenic COCs (i.e., analytes with individual HQs exceeding 0.1) identified for this pathway in the different areas of concern. Among these are mercury, barium, manganese, and cadmium. For the WAG-wide analysis, only antimony, manganese and mercury exceeded an HQ of 0.1. The total contribution of the incidental ingestion, dermal contact, and inhalation of VOCs from soil to the total cumulative HI is negligible.

5.2.2 Sediment Risk Summary

The risk results from exposure to sediment are presented graphically in Figs. 5a and 5b. Figure 5a illustrates the relative risk/hazard ranking of each sediment study area (D1, D2, D3, OHFP, and PWSB) for each land use (industrial and residential). This figure provides a perspective on which sediment areas have the highest risk/hazard. Figure 5b illustrates for each area by land use the relative risk/hazard associated with the COCs within each exposure route of concern.

5.2.2.1 Industrial scenario—carcinogenic results

Exhibit 9b lists the risk estimates for the exposure of an industrial worker to the WAG 5 carcinogenic COPCs in the presumed dry sediments via ingestion, dermal contact, inhalation, and external exposure. The total cumulative pathway risks for the WAG 5 Study Group Areas (i.e., the sum of the risks from all analytes across all exposure pathways) are presented in Exhibit 13b. The industrial sediment risk figure (Fig. 5a) shows the ranking for the sediment areas from greatest to least risk to be OHFP, PWSB, D2, D3, and D1. In the WAG-wide analysis, all sediment data was consolidated and a single risk analysis was performed for the average sediment at the site. The external exposure route to dried sediments provides the highest risk, followed by the ingestion and inhalation pathways. All pathways show cumulative risks exceeding 10^{-4} , with the majority of risk being driven by cesium-137 and cobalt-60. Vinyl chloride is noteworthy since it contributes significantly (in addition to radium-226) to the inhalation risks for dried sediments.

The COCs for sediment are listed in Exhibit 11b with the corresponding exposure pathways of concern. All contaminants in the D1 area are below concern because the total pathway risks did not exceed $1.0\text{E-}04$ for any route of exposure. The total pathway risks from external exposure in all other areas are $\geq 1\text{E-}04$. The COCs driving the risk in the OHFP and PWSB areas are cesium-137 and cobalt-60, while D2 and D3 have several drivers, such as thallium-208, bismuth-212, bismuth-214, and actinium-228. Other COCs that are contributing to the total external exposure pathway risk are also listed in Exhibit 11b.

The total pathway risk from the inhalation pathway is $\geq 1\text{E-}04$ in the D2 area only. Vinyl chloride and radium-226 are identified as the primary COCs. The total pathway risks from the incidental ingestion pathway exceeded $1\text{E-}04$ in the OHFP and the PWSB areas only (i.e., $4.1\text{E-}02$ and $1.7\text{E-}03$, respectively). The drivers of this exposure pathway are cesium-137, curium-243/244, and total radioactive strontium. The total pathway risks from dermal contact with all COPCs in all areas within WAG 5 are less than $3\text{E-}06$.

5.2.2.2 Residential scenario—carcinogenic results

The residential sediment risk figure (Fig. 5a) ranks the areas in order of greatest to least risk as OHFP, PWSB, D2, D3, and D1. The total cumulative pathway risks for the WAG-wide analysis and all individual sediment areas are greater than $1.0\text{E-}04$. Exhibit 9b and Table D.11b list the carcinogenic risk estimates from exposure to COPCs in the sediments of WAG 5 via the primary exposure pathways. The main contributing pathway to the total cumulative risks in these areas is the external exposure pathway. Actinium-228, cesium-137, cobalt-60, bismuth-214, radium-226, and thorium-228 drive the risks in this pathway in all areas of concern. Inhalation of radium-226 and vinyl chloride provide a limited contribution to the total cumulative risk in the D2 area only. Ingestion of produce is a major pathway of concern in the OHFP and PWSB areas, but not for the WAG-wide results. Exhibit 11b lists all COCs that are contributing to the total cumulative exposure pathway risks in the different areas.

5.2.2.3 Industrial scenario—noncarcinogenic results

The industrial sediment noncarcinogenic figure (Fig. 5a) shows the ranking for the sediment areas from greatest to least hazard to be D2, PWSB, D1, OHFP, and D3. The HIs listed in Exhibit 10a and Table D.12b for the exposure of an WAG 5 industrial worker are less than unity (1.0) for all areas. Therefore, no sediment noncarcinogenic COCs are identified for the industrial exposure scenario.

5.2.2.4 Residential scenario—noncarcinogenic results

The residential sediment noncarcinogenic figure (Fig. 5a) shows the ranking for the sediment areas from greatest to least hazard to be D2, PWSB, D1, OHFP, and D3. Exhibit 13b shows that the total cumulative pathway HI is greater than or equal to 1.0 in the D2 area only. Exhibit 10b and Table D.12b list the HQ estimates for the exposure of a resident to the WAG 5 sediment noncarcinogenic COPCs via the incidental ingestion, dermal contact, and inhalation pathways. The major pathway of concern is the incidental ingestion of manganese and arsenic in this area (Fig. 5b). However, no single contaminant has a pathway HQ exceeding unity.

Fig. 5a. Sediment Risks by Location

Fig. 5b. Sediment Pathways and Contaminants of Concern

Drainage 3- Residential External Exposure Pathway

Drainage 3- Industrial External Exposure Pathway

OHFP- Residential Carcinogenic Ingestion Pathway

OHFP- Residential External Exposure Pathway

OHFP- Industrial External Exposure Pathway

Fig. 5b. (continued)

Fig. 5b. (continued)

5.2.3 Groundwater Risk Summary

5.2.3.1 Residential scenario—carcinogenic results

Exhibit 13c and Table D.11c show the total cumulative pathway risks in the different groundwater areas within WAG 5 and for the entire WAG 5 site. Exhibit 9c lists the risk estimates from exposure to COPCs in the groundwater of WAG 5. The total cumulative pathway risk exceeds $1.0E-04$ for the WAG-wide analysis and in all areas except the PWSB area. The major contributing pathways to the total cumulative risks in all areas of concern are the ingestion pathways (drinking water and irrigated produce). Other pathways contributing to the total risk are ingestion of produce and inhalation pathways WAG-wide and in the OHFP, SWSA5SE, SWSA5SW, and WOC areas. The contribution from ingestion of produce is usually one order of magnitude less than the ingestion of drinking water; except for the WAG-wide analysis where ingestion of produce risks even exceeds direct ingestion of groundwater. The total in-door inhalation of tritium (i.e., shower, bathroom, and house) is recognized as the major contributor to the total pathway risk for some areas of concern. In addition, inhalation of vinyl chloride provided a considerable contribution in the WOC area. Exhibit 11c lists all the COCs that contributed to the total pathway of concern in the different groundwater areas (i.e., total pathway risk $\geq 1E-04$).

5.2.3.2 Residential scenario—noncarcinogenic results

Exhibit 13c and Table D.12c show that the total cumulative HI exceeds 1.0 for the WAG-wide analysis and in the FS, SWSA5N, SWSA5SE, SWSA5SW, and WOC areas. Exhibit 10c lists the HQ estimates for the exposure of a resident to the WAG 5 groundwater noncarcinogenic COPCs via the incidental ingestion, produce ingestion, dermal contact, and inhalation pathways. The major contributing pathway for the entire site is the ingestion of produce, while in the individual areas of concern it is via the direct ingestion of groundwater. Other important pathways include ingestion of produce and dermal contact of particular contaminants. Exhibit 12 presents the noncarcinogenic COCs identified in all pathways of concern. Among these are manganese, vanadium, barium, and nickel as well as some organics like tetrachloroethene and 1,2-dichloroethene.

5.2.4 Surface Water Risk Summary

5.2.4.1 On-site residential scenario—carcinogenic results

The WAG-wide analysis of risks posed by on-site surface waters was evaluated differently than for the individual surface water bodies. Whereas the individual surface water bodies would not possess sufficient quantities of year-round water, the combination of impoundments, seeps, and drainages, although still unlikely, could result in sufficient quantities of a year-round water supply and was evaluated for the ingestion and dermal contact pathways. However, it is not possible to consolidate across the different types of surface waters (standing versus flowing), or across the different surface water events, since the temporal variability would make any consolidation attempt meaningless. Thus, the surface water results were organized into sources and events: impoundment, seep location, and drainages with high base, high base storm, low base, low base storm. Table D.11d details the carcinogenic risk results for the different surface water sources and events and shows that the cumulative total pathway results exceed 10^{-4} for all sources and events. It is, however, extremely unlikely that a hypothetical resident would build a collection system for the different sources rather

than using the existing abundant supply of water in the WOC or MB. Thus, these surface water risks represent possible, but not probable, results.

Exhibit 9d lists the risk estimates from inhalation of VOCs in the surface water of the drainages and the impoundments (i.e., D1, D2, D3, OHFP, and PWSB) within WAG 5. Other exposure pathways, i.e., ingestion and dermal contact, are not evaluated. The rationale of evaluating the inhalation pathway is presented in Sect. 3. Exhibit 11d shows that the total pathway risks of inhalation of tritium and other VOCs from the surface water of the impoundments and the drainage is less than $1.0E-04$. Therefore, inhalation of VOCs from surface water was excluded.

5.2.4.2 On-site residential scenario—noncarcinogenic results

Table D.12d shows the noncarcinogenic HQ values for the surface waters, if one assumes that sufficient quantities are present to be exposed to the contaminants via ingestion or dermal contact with the surface water.

Exhibit 10d lists the HQ estimates for the exposure of a resident to the WAG 5 surface water noncarcinogenic COPCs via the inhalation pathway only. The exhibit shows that none of the total cumulative HIs in the surface water areas exceed unity. Therefore, the contribution of the inhalation pathway to the total noncarcinogenic HQ is excluded.

5.2.5 Off-WAG Residential Scenario

Surface water risk calculations based on measured concentrations in streams at ORNL have been made for individual contaminants that have been classified as carcinogens. In addition, the HI for surface water use has also been calculated for noncarcinogens. Residential risk assessments based on surface water use have been calculated at four points: measured concentrations at the MB1 weir located on Melton Branch, White Oak Creek, White Oak Dam, and diluted concentrations in the Clinch River.

The Melton Branch assessment is presented to establish the baseline for the WAG 5 off-site resident. This baseline is based on the combination of current concentrations and a future residential land use condition. Contaminant concentrations in the future based on modeled groundwater contributions have not been conducted for the RI. Considerable uncertainty in the initial contaminant inventories deposited in the source areas and in current secondary sources will make reliable models of transport very uncertain. Residential risk results at the White Oak Creek weir are also presented. However, WAG 5 makes only minor contributions to the contaminants at this weir. Risk results based on WAG 5 contributions at White Oak Dam and in the Clinch River are also presented based on simple dilution of Melton Branch concentrations.

The contribution of WAG 5 source areas to the White Oak Dam risk and the Clinch River is presented to provide risk management information on the relative importance of current WAG 5 releases compared to other ORNL source areas. The risk information is generated based on data collected from the WAG 2 Site Investigation, the WAG 5 RI, and from monthly concentration and flow data collected at weirs within the White Oak Creek watershed by OECD from 1987-1993. Surface water risks for radionuclides are calculated using dose conversion factors.

5.2.5.1 Melton Branch surface water risk

Figures 6a and 6b show the contribution of the different pathways and the different contaminants to the hypothetical residential risk at Melton Branch. The results are presented for the RME scenario, which relies on the upper 95th confidence limit on the mean for the exposure concentration, and the central tendency scenario, which relies on the mean of the observed values for the exposure concentration.

The RME and central tendency scenarios show similar results. The drinking water ingestion pathway is the most important pathway for both carcinogenic and noncarcinogenic risk. Tritium and strontium-90 are the primary contributors to risk, exceeding the $1\text{E-}4$ risk level, and Aroclor, cobalt-60, cesium-137, and bromodichloromethane are in the $1\text{E-}6$ to $1\text{E-}4$ risk range of concern. The risk results for Aroclors, however, need to be qualified since most of the Aroclors were nondetected values or detected values above the detection limit. These surface water Aroclor data from the historical environmental monitoring program are believed to have a high uncertainty, and the risk evaluation presented here may be overly conservative. An additional risk from the indoor inhalation scenario is presented from tritium. Arsenic and manganese were detected at risk levels that exceeded unity for the HQ of the water ingestion scenario at Melton Branch for both the RME and central tendency scenarios. Contributions of WAG 5 areas to fluxes of COCs in Melton Branch is examined in more detail in Volume III, Appendix B, Sect. B2.3.9 of this RI Report. The majority of contamination in Melton Branch is attributable to sources in WAG 5.

In addition, carcinogenic risk results for the four surface water sampling results at Melton Branch conducted for the RI are shown in Fig. 6c. These results are "snapshots" of the Melton Branch concentrations and resulting risk during four different hydrologic conditions: high base, high base storm event, low base, and low base storm event. The results generally agree between the different sampling events and when they are compared to the risk results based on the compliance data that show strontium-90 and tritium as the primary risk contributors at Melton Branch. The only noticeable difference is the high base RI data which show a tritium risk slightly higher than that for strontium-90 and which did not detect any TRUs in the risk range of concern.

5.2.5.2 White Oak Creek surface water risk

Figure 6d presents the potential risk posed by the pathways for the residential use of surface water at the White Oak Creek weir. The carcinogenic ingestion pathway is the only pathway exceeding $1\text{E-}4$ risk. Strontium-90 and Aroclor were the contaminants responsible for the majority of the risk. Cesium-137, tritium, bromodichloromethane, and cobalt-60 were in the $1\text{E-}6$ to $1\text{E-}4$ risk range of concern. The contaminants for the carcinogenic ingestion pathway are illustrated at the bottom of Fig. 6b. None of the noncarcinogenic pathways had an HI exceeding unity. Although residential risk at this point exceeds acceptable levels, the White Oak Creek drainage of WAG 5 currently contributes a very small percentage of the observed contaminants at White Oak Creek. Contributions of WAG 5 areas to fluxes of COCs in White Oak Creek is examined in more detail in Volume III, Appendix B, Sect. B2.2.8. of this RI Report. The majority of contamination in White Oak Creek is attributed to sources in WAG 1 and WAG 4.

Fig. 6a. WAG 5 Surface Water Risk Summary at Melton Branch

Fig. 6b. WAG 5 Surface Water Risk Summary at Melton Branch and White Oak Creek

Fig. 6c. WAG 5 Surface Water Risk Summary at Melton Branch (RI Data)

Fig. 6d. WAG 5 Surface Water Risk Summary at White Oak Creek

5.2.5.3 White Oak Dam surface water risk

An important pathway for ORNL-ER risk management purposes has been the dose for the drinking water pathway calculated at White Oak Dam. The top half of Fig. 6e depicts the 12-month moving average of the risk from radionuclides at White Oak Dam over the last 7 years and the relative contribution of strontium-90, tritium, and cesium-137 to the drinking water risk. The figure suggests that the relative contribution of strontium-90 to risk has been increasing over time. Furthermore, this relative trend has increased at an even faster rate than can be explained by the radioactive decay rates. These decay rates are shown as straight lines in the bottom half of Fig. 6e. Holding constant all other factors and the relative contributions of strontium-90, tritium, and cesium-137 to risk, one would expect the relative contribution rates to closely follow the natural decay rate lines, i.e., the straight lines shown in the bottom half of Fig. 6e. Therefore, if radionuclide flux remained steady at the December 1987 levels, then relative contaminant risk would closely track the decay lines. A trend would then emerge that the contribution of strontium-90 relative to tritium has increased simply due to the tritium's shorter half life.

The evidence shows that the relative strontium-90 contribution to risk has increased at an even faster rate than can be explained solely by its longer decay process; this is presumed to be due to more recent sources within WAG 5, as described in Volume III, Appendix B, Sect. B3.4.2 of this RI Report. The tritium concentration has been observed to decrease even more than its decay rate would explain. The explanation is the decreased discharge of tritium, which is assumed to result from source depletion in addition to natural decay, as described in Volume III, Appendix B, Sect. B3.4.1 of this report. Therefore, in terms of trends in the near future for surface water risk resulting from WAG 5, it is postulated that this trend towards the increasing importance of strontium-90 to the surface water risk will continue at WAG 5 and be reflected in the risk results for White Oak Dam in the absence of any remedial actions at the source areas. However, current Early Actions and planned Interim Remedial Actions are specifically aimed at reducing the flow of strontium-90 to White Oak Dam and off-site. Strontium-90 removal systems at SWSA5SEC and SWSASE5D have been constructed, and systems for removing strontium-90 from the Corehole 8 plume in WAG 1 and from the tributary in WAG 4 are in the planning stages.

The drinking water risk at White Oak Dam is also used to prioritize contaminants and source areas. In concept, each source area drains to a single collection point, and the concentrations of COC at this point are multiplied by risk factors and flow volumes and compared to these same parameters at the White Oak Dam integration point. This process yields a relative contribution by a WAG or source area to the off-site risk attributed to discharges at White Oak Dam. These mass balance calculations in the watershed are approximate because of uncertainties associated with analytical results, flow measurements, temporal variability, and environmental variability; however, these data are useful in determining key areas of contaminant input into the White Oak Creek watershed. These key areas can then be ranked and prioritized on a common risk scale. The top half of Fig. 6f shows the ranking and the initial priority for remediation of the ORNL WAGs based on current off-site releases. WAG 5 is the highest contributor to the annual drinking water dose for a receptor at White Oak Dam.

The bottom half of Fig. 6f further breaks down the various WAGs at ORNL to the Study Areas considered in the RI and presents their contribution to risk along with the contributions of other defined source areas.

Fig. 6e. White Oak Dam Ingestion Risk and Relative Contaminant Contribution

Fig. 6f. WAG 5 Surface Water Risk Summary—Percent Contribution to Annual Water Ingestion Dose at White Oak Lake Dam by WAG and Source Area

5.2.5.4 Clinch River surface water risk

Discharges from the White Oak Creek watershed drain into the Clinch River, where they are diluted to much lower concentrations. The risk assessments conducted for the Clinch River to date have not analyzed a lot of surface water data for the primary COCs originating in the White Oak Creek watershed, so dilution factors based on the relative flow at Melton Branch and at Melton Hill Dam (which represents the Clinch River flow rates) used to generate Clinch River concentrations and risk results for current releases originating from WAG 5. The carcinogenic and noncarcinogenic risk results are presented in Fig. 6g. These risks are based on a simple dilution factor from Melton Branch to the Clinch River. The factor used is 1784 and is based on the median of the observed monthly ratios between 1987 and 1992. The carcinogenic ingestion pathway shows a risk of $1\text{E-}6$ and is due to strontium-90 and tritium.

5.3 RISK SUMMARY BY AREA

The objective of the additional risk assessment for the entire WAG 5 site was to compare the results of WAG-wide analysis to the results for the individual study groups. As was expected, the results for the WAG-wide analysis are close to the approximate average for all the study group areas in WAG 5. This is evident both in the numerical and graphical representations of the total risks for the study group areas. However, it is impossible for a hypothetical on-site resident to occupy all 80 ac of WAG 5 simultaneously, thus, the presented values of the WAG-wide analysis should be considered to be conservative estimates.

Figure 7a ranks the WAG 5 study areas relative to total risk for industrial and residential land use. The top three risk areas are the same for both land uses; these three areas are SWSA5SE, White Oak Creek, and OHFP. Figure 7b includes the ranking of areas relative to risk for the soil and groundwater exposure pathways separately. For the groundwater pathways, SWSA5SE, White Oak Creek, OHFP, SWSA5SW, FS, and SWSA5N have total pathway risks that exceed $1\text{E-}04$. However, the soil risks from all study areas exceed $1\text{E-}04$. The total HI for exposure to all noncarcinogenic COPCs via all soil and groundwater pathways is ranked by study area for residential and industrial land use in Fig. 7c. As with the carcinogenic results, the SWSA5SE also has the highest HI for residential and industrial. None of the areas have industrial HIs greater than 1; therefore, there are no noncarcinogenic COCs for the future industrial exposure to soil. For residential exposure, only the noncarcinogenic risk associated with the NHFT is below concern. As depicted in Fig. 7d, either the HI associated with groundwater, soil, or both is unacceptable for all other WAG 5 areas.

The results of the WAG 5 BHHRA are summarized in the following subsections by area. Within the subsection for each area the risk assessment results are discussed by land use (excavation, industrial, and residential) and media (soil, sediment, surface water, and groundwater). For each land use and media (i.e., excavation/soil or residential/groundwater) the summary of excess cancer risk estimates will be followed by a similar summarization of hazard estimates. Figures are employed to illustrate the pathways of concern for each area by land use. These figures are referenced in the text as appropriate.

Fig. 6g. Clinch River Surface Water (WAG 5 Diluted Concentrations) Risk Summary

Fig. 7a. Study Area Risk Prioritization (Carcinogenic Residential and Industrial Risks)

Fig. 7b. Study Area Risk Prioritization (Residential Groundwater and Soil Carcinogenic Risks)

Fig. 7c. Study Area Risk Prioritization (Noncarcinogenic Residential and Industrial Risks)

Fig. 7d. Study Area Risk Prioritization (Residential Groundwater and Soil Noncarcinogenic Risks)

5.3.1 Fissile Storage Area

The excavation scenario for the FS included exposure to soil via 1) incidental ingestion, 2) inhalation of dust and VOCs, 3) dermal contact, and 4) external exposure to radionuclides in soil. The total estimated excess cancer risk for excavation in this area is $1\text{E-}04$; therefore, this land use presents an unacceptable risk. External exposure is the only route contributing a risk $> 1\text{E-}04$. The majority of this risk is associated with exposure to cobalt-60 which has a risk of $9\text{E-}05$ (Exhibit 9a).

The total HI for exposure to FS soil COPCs during excavation is $4\text{E-}03$ (Exhibit 10a) which is below concern. Therefore, no noncarcinogenic COCs are identified for the excavation scenario for the FS.

The future industrial exposure scenario evaluated soil exposure via 1) incidental ingestion, 2) inhalation of dust and VOCs, 3) dermal contact, and 4) external exposure to radionuclides in soil. The total estimated cancer risk for the FS industrial scenario is $8\text{E-}03$ which is unacceptable. The majority of this risk is contributed by the external exposure (Fig. 8a) to cobalt-60 which has a risk of $7\text{E-}03$. In addition, the inhalation pathway has a total risk of $4\text{E-}04$ associated with radium-226.

The total HI for industrial exposure to FS soil COPCs is $1\text{E-}02$, which is below concern (Fig. 8a). Therefore, no noncarcinogenic COCs are identified for the FS future industrial scenario.

The future residential scenario for the FS was evaluated for exposure to soil via 1) incidental ingestion, 2) inhalation of dust and VOCs, 3) dermal contact, 4) external exposure, 5) ingestion of produce and groundwater via 1) ingestion, 2) inhalation of volatiles while showering, 3) dermal contact, and 4) ingestion of produce. For these exposure routes, the cumulative residential risk for the FS area is $4\text{E-}02$, which is unacceptable. The majority of this risk is associated with the external exposure to cobalt-60 ($4\text{E-}02$) in soil (Exhibit 9a). In addition, cesium-137 in soil contributes an external risk of $2\text{E-}03$. The total risk estimate associated with the exposure to groundwater for the FS area is $9\text{E-}04$, which is unacceptable (Exhibit 9c). The majority of this risk is the result of the ingestion of beryllium ($5\text{E-}04$) and tritium ($1\text{E-}04$).

The total HI for all residential pathways evaluated for the FS area is 38, which is unacceptable ($\text{HI} > 1$). The largest contribution to this hazard is the groundwater pathway which has an HI of 28 (Exhibit 10c). The primary exposure route contributing to this hazard is ingestion ($\text{HI}=26$). The COCs associated with this exposure route are manganese ($\text{HQ}=22$) and chromium ($\text{HQ}=2$). The cumulative HI resulting from exposure to all soil exposure routes is 10 (Exhibit 10a). The only exposure route contributing to this hazard is the ingestion of mercury in produce grown on FS soil.

5.3.2 New Hydrofracture Facility Tanks Area

The excavation scenario for the NHFT included exposure to soil via 1) incidental ingestion, 2) inhalation of dust and VOCs, 3) dermal contact, and 4) external exposure to radionuclides in soil. Exhibit 9a lists the summary risk estimate for excavation in this area as $9\text{E-}07$; therefore, no carcinogenic COCs are identified in the NHFT for this scenario.

Fig. 8a. FS Risk Pathways Summary

The HI for exposure to NHFT soil COPCs under the excavation scenario is $4\text{E-}07$ (Exhibit 10a), which is below concern. Therefore, no noncarcinogenic COCs are identified for the excavation scenario for the NHFT.

The future industrial exposure scenario evaluated NHFT soil exposure via 1) incidental ingestion, 2) inhalation of dust and VOCs, 3) dermal contact, and 4) external exposure to radionuclides in soil. The total estimated cancer risk listed in Exhibit 9a for the industrial scenario is $6\text{E-}05$. This excess cancer risk falls in the range of concern (between $1\text{E-}06$ and $1\text{E-}04$). External exposure to radium-228 and thorium-228 is responsible for most of this risk with risks of $2\text{E-}05$ and $4\text{E-}05$, respectively. However, because there are no pathways with a risk $> 1\text{E-}04$, there are no carcinogenic COCs associated with future industrial land use in the area of the NHFT (Fig. 8b).

The total HI for industrial exposure to NHFT soil COPCs is $1\text{E-}06$, which is below concern. Therefore, no noncarcinogenic COCs are identified for the NHFT future industrial scenario.

The future residential scenario for the NHFT was evaluated for exposure to soil via 1) incidental ingestion, 2) inhalation of dust and VOCs, 3) dermal contact, 4) external exposure, and 5) ingestion of produce. The cumulative residential risk for the NHFT area is $3\text{E-}04$, which is unacceptable (Exhibit 9a). Again, the majority of this risk is derived from external exposure (Fig. 8a) to radium-228 ($1\text{E-}04$) and thorium-228 ($2\text{E-}04$). The risk estimates determined for the ingestion, dermal contact, inhalation, and produce ingestion exposure routes were all $< 1\text{E-}06$ (below concern).

The total HI listed in Exhibit 10a for all residential pathways evaluated for the NHFT area is $2\text{E-}05$, which is below concern. Therefore, no noncarcinogenic COCs were observed for the NHFT future residential scenario.

5.3.3 Old Hydrofracture Facility Pond Area

The excavation scenario for the OHFP included exposure to soil via 1) incidental ingestion, 2) inhalation of dust and VOCs, 3) dermal contact, and 4) external exposure to radionuclides in soil. The total estimated excess cancer risk for excavation in this area is $1\text{E-}04$; therefore, this land use presents an unacceptable risk. External exposure is the only route contributing a risk $> 1\text{E-}04$, and cesium-137 ($1\text{E-}04$) is the only analyte contributing a risk $> 1\text{E-}04$ (Exhibit 9a).

The total HI for exposure to OHFP as a result of soil excavation is $2\text{E-}03$ (Exhibit 10a), which is below concern. Therefore, no noncarcinogenic COCs are identified for the excavation scenario for the OHFP.

The future industrial exposure scenario considered soil exposure via 1) incidental ingestion, 2) inhalation of dust and VOCs, 3) dermal contact, and 4) external exposure to radionuclides in soil. The summary risk estimate listed in Exhibit 9a for the OHFP industrial scenario is $1\text{E-}02$, which is unacceptable. The majority of the risk associated with this scenario is the result of external exposure to cesium-137, which has a risk of $1\text{E-}02$. No other exposure route contributes an excess cancer risk $> 1\text{E-}04$ (Fig. 8c).

Fig. 8b. NHFT Risk Pathways Summary

Fig. 8c. OHFP Risk Pathways Summary

The total HI for industrial exposure to OHFP soil COPCs is $5E-03$, which is below concern. Therefore, no noncarcinogenic COCs are identified for the OHFP future industrial scenario (Fig. 8c).

Sediment associated with the OHFP was also evaluated under the future industrial land use scenario. The same exposure routes listed for soil were included in the assessment of risk related to sediment COPCs. The summary risk estimate listed in Exhibit 9b for the OHFP sediment industrial scenario is $1E+00$. This extreme risk is associated the external exposure to cesium-137, which has a risk of $1E+00$. In addition, the ingestion of cesium-137 in sediment produces a risk estimate of $3E-02$.

The total HI for industrial exposure to OHFP sediment COPCs is $3E-02$, which is below concern ($HI < 1$). Therefore, no noncarcinogenic sediment COCs are identified for the OHFP future industrial scenario.

The future residential scenario for the OHFP was evaluated for exposure to soil via 1) incidental ingestion, 2) inhalation of dust and VOCs, 3) dermal contact, 4) external exposure, and 5) ingestion of produce; the future residential scenario was evaluated for exposure to groundwater via 1) ingestion, 2) inhalation of VOCs while showering, 3) dermal contact, and 4) ingestion of produce, and exposure to surface water was evaluated via inhalation. For these exposure routes the cumulative residential risk for the OHFP area is $8E-02$, which is unacceptable. The majority of this risk is associated with the external exposure to cesium-137 ($5E-02$) in soil (Exhibit 9a). The total risk estimate associated with the exposure to groundwater for the OHFP is $3E-02$, which is unacceptable (Exhibit 9c). The majority of this risk is the result of the ingestion (see Fig. 8c) of total radioactive strontium ($2E-02$). The inhalation risk posed by surface water is negligible ($7E-10$) (Exhibit 9d).

The total HI for residential soil and groundwater pathways evaluated for the OHFP is 2, which is unacceptable ($HI > 1$). The largest contribution to this hazard is the ingestion of produce grown in OHFP soil which has an HI of 1.5 (Exhibit 10a). The HI for groundwater ($9E-01$) is below concern (Fig. 8c). Sediment associated with the OHFP was also evaluated under the future residential scenario. The same exposure routes listed for soil were included in the assessment of sediment COPCs. The summary risk estimate listed in Exhibit 9b for the OHFP sediment residential scenario is $1E+00$. This extreme risk is associated with external exposure to cesium-137 which has a risk of $1E+00$. In addition, the ingestion of cesium-137 in sediment produces a risk estimate of $1E-01$.

The total HI for residential exposure to OHFP sediment COPCs is $1E-01$, which is below concern ($HI < 1$). Therefore, no noncarcinogenic sediment COCs are identified for the OHFP future residential scenario.

5.3.4 Old Hydrofracture Facility Tanks Area

The excavation scenario for the OHFT included exposure to soil via 1) incidental ingestion, 2) inhalation of dust and VOCs, 3) dermal contact, and 4) external exposure to radionuclides in soil. The summary risk estimate (Exhibit 9a) for excavation in this area is $4E-06$, and the HI (Exhibit 10a) is $2E-04$. Therefore, no carcinogenic or noncarcinogenic COCs are identified for the excavation scenario for the OHFT.

The future industrial exposure scenario evaluated OHFT soil exposure via 1) incidental ingestion, 2) inhalation of dust and VOCs, 3) dermal contact, and 4) external exposure to radionuclides in soil. The total estimated cancer risk listed in Exhibit 9a for the industrial scenario is $3\text{E-}04$, which is of concern. This risk is associated with the external ($1.5\text{E-}04$) and inhalation ($1.6\text{E-}04$) routes of exposure (Fig. 8d). The inhalation risk is due to radium-226, and the external risk is contributed by cesium-137, radium-226, radium-228, and thorium-228.

The total HI for industrial exposure to OHFT soil COPCs is $6\text{E-}04$, which is below concern. Therefore, no noncarcinogenic COCs are identified for the OHFT future industrial scenario.

The future residential scenario for the OHFT was evaluated for exposure to soil via 1) incidental ingestion, 2) inhalation of dust and VOCs, 3) dermal contact, 4) external exposure, and 5) ingestion of produce. The cumulative residential risk for the OHFT area is $1\text{E-}03$, which is unacceptable (Exhibit 9a). The relative contribution of risk by exposure route is presented in Fig. 8d. The majority of this risk is a result of the external exposure to cesium-137 ($3\text{E-}04$), radium-226 ($2\text{E-}04$), radium-228 ($1\text{E-}04$), and thorium-228 ($2\text{E-}04$) and the inhalation of radium-226 ($3\text{E-}04$).

The total HI listed in Exhibit 10a for residential pathways evaluated for the OHFT area is 1. This hazard is associated with the ingestion of silver (0.24) and cyanide (0.86) in produce. No other exposure route has an HI greater than $3\text{E-}03$ for this area (Fig. 8d).

5.3.5 Process Waste Sludge Basin Area

The excavation scenario for the PWSB included exposure to soil via 1) incidental ingestion, 2) inhalation of dust and VOCs, 3) dermal contact, and 4) external exposure to radionuclides in soil. The summary risk estimate (Exhibit 9a) for excavation in this area is $6\text{E-}06$, and the HI (Exhibit 10a) is $9\text{E-}04$. Therefore, no COCs are identified for the excavation scenario for the PWSB.

The future industrial exposure scenario considered soil exposure via 1) incidental ingestion, 2) inhalation of dust and VOCs, 3) dermal contact, and 4) external exposure to radionuclides in soil. The summary risk estimate listed in Exhibit 9a for the PWSB industrial scenario is $4\text{E-}04$, which is unacceptable. The relative contribution of risk by exposure route is presented in Fig. 8e. The majority of the risk associated with this scenario is the result of inhalation of radium-226 ($2\text{E-}04$) and external exposure to cesium-137 ($2\text{E-}05$), potassium-40 ($9\text{E-}05$), radium-226 ($5\text{E-}05$), radium-228 ($2\text{E-}05$), and thorium-228 ($5\text{E-}05$).

The total HI for industrial exposure to PWSB soil COPCs is $3\text{E-}03$, which is below concern. Therefore, no noncarcinogenic COCs are identified for the PWSB future industrial scenario (Fig. 8e).

Sediment associated with the PWSB was also evaluated under the future industrial land use scenario. The same exposure routes listed for soil were included in the assessment of risk related to sediment COPCs. The summary risk estimate listed in Exhibit 9b for the PWSB sediment industrial scenario is $4\text{E-}01$. The majority of this risk is associated with the external exposure to cobalt-60 ($2\text{E-}01$) and cesium-137 ($2\text{E-}01$).

Fig. 8d. OHFT Risk Pathways Summary

Fig. 8e. PWSB Risk Pathways Summary

The total HI for industrial exposure to PWSB sediment COPCs is $3E-01$, which is below concern ($HI < 1$). Therefore, no noncarcinogenic sediment COCs are identified for the PWSB future industrial scenario.

The future residential scenario for the PWSB was evaluated for exposure to soil via 1) incidental ingestion, 2) inhalation of dust and VOCs, 3) dermal contact, 4) external exposure, 5) ingestion of produce; groundwater via 1) ingestion, 2) inhalation of volatiles while showering, 3) dermal contact, and 4) ingestion of produce; and surface water via inhalation. The relative risk contribution from each of these routes is depicted in Fig. 8e. The cumulative residential risk for the PWSB area is $2E-03$, which is unacceptable. The majority of this risk is associated with the external exposure to cesium-137 ($9E-05$), potassium-40 ($4E-04$), radium-226 ($2E-04$), radium-228 ($1E-04$), and thorium-228 ($2E-04$) in soil (Exhibit 9a). The total risk estimate associated with the exposure to groundwater for the PWSB is $6E-05$, which is below concern (Exhibit 9c). The inhalation risk posed by surface water is negligible, $5E-11$ (Exhibit 9d).

The total HI for residential soil and groundwater pathways evaluated for the PWSB is 1. The largest contribution to this hazard is the ingestion of barium in produce grown in PWSB soil which has an HI of 0.8 (Exhibit 10a). The HI for groundwater (0.3) is due to the ingestion of bis(2-ethylhexyl) phthalate.

Sediment associated with the PWSB was also evaluated under the future residential scenario. The same exposure routes listed for soil were included in the assessment of sediment COPCs. The summary risk estimate listed in Exhibit 9b for the PWSB sediment residential scenario is $9E-01$. This extreme risk is associated with the external exposure to cobalt-60 ($7E-01$) and cesium-137 ($6E-01$). The total HI for residential exposure to PWSB sediment COPCs is 1 due to the ingestion and dermal contact with antimony and mercury.

5.3.6 SW-3 Drainage Area

The excavation scenario for SW-3 included exposure to soil via 1) incidental ingestion, 2) inhalation of dust and VOCs, 3) dermal contact, and 4) external exposure to radionuclides in soil. The summary risk estimate (Exhibit 9a) for excavation in this area is $2E-06$, and the HI (Exhibit 10a) is $2E-04$. Therefore, no carcinogenic or noncarcinogenic COCs are identified for the excavation scenario for SW-3.

The future industrial exposure scenario evaluated SW-3 soil exposure via 1) incidental ingestion, 2) inhalation of dust and VOCs, 3) dermal contact, and 4) external exposure to radionuclides in soil. The relative risk contribution from each of these routes is depicted in Fig. 8f. The total estimated cancer risk listed in Exhibit 9a for the industrial scenario is $1E-04$, which is of concern. This risk is associated with the external exposure to cesium-137 ($6E-05$), radium-228 ($2E-05$), and thorium-228 ($4E-05$).

The total HI for industrial exposure to SW-3 soil COPCs is $7E-04$, which is below concern. Consequently, no noncarcinogenic COCs are identified for the SW-3 future industrial scenario.

Fig. 8f. SW3 Risk Pathways Summary

The future residential scenario for SW-3 was evaluated for exposure to soil via 1) incidental ingestion, 2) inhalation of dust and VOCs, 3) dermal contact, 4) external exposure, and 5) ingestion of produce. The cumulative residential risk for the SW- area is $6E-04$, which is unacceptable (Exhibit 9a). The majority of this risk is result of the external exposure to cesium-137 ($3E-04$) and thorium-228 ($2E-04$). No other exposure route has a risk greater than $1E-04$ for this area (Fig. 8f).

The total HI listed in Exhibit 10a for residential pathways evaluated for the SW-3 area is 0.8. Therefore, no noncarcinogenic COCs are identified for the SW-3 future residential scenario.

5.3.7 Solid Waste Storage Area 5 North

The excavation scenario for the SWSA5N included exposure to soil via 1) incidental ingestion, 2) inhalation of dust and VOCs, 3) dermal contact, and 4) external exposure to radionuclides in soil. The total estimated excess cancer risk listed in Exhibit 9a for excavation in this area is $3E-06$; therefore, no carcinogenic COCs are identified for the excavation scenario for the SWSA5N.

The total HI for exposure to SWSA5N as a result of soil excavation is $8E-05$ (Exhibit 10a), which is below concern. Consequently, there are no noncarcinogenic COCs associated with the excavation scenario for the SWSA5N.

The future industrial exposure scenario considered soil exposure via 1) incidental ingestion, 2) inhalation of dust and VOCs, 3) dermal contact, and 4) external exposure to radionuclides in soil. Figure 8g illustrates the relative risk contribution of the exposure routes. The summary risk estimate (Exhibit 9a) for the SWSA5N industrial scenario is $2E-04$, which is unacceptable. The external exposure route contributes the majority of the risk associated with this scenario and is the only route with a risk in excess of $1E-06$. The total risk for external exposure is $2E-04$ due largely to thallium-208 ($1E-04$) in addition to risks from actinium-228 ($3E-05$), bismuth-214 ($2E-05$), radium-228 ($3E-05$), and thorium-228 ($5E-05$). The total HI for industrial exposure to SWSA5N soil COCs is $6E-06$, which is below concern. Therefore, no noncarcinogenic COCs are identified for the SWSA5N future industrial scenario.

The future residential scenario for the SWSA5N was evaluated for exposure to soil via 1) incidental ingestion, 2) inhalation of dust and VOCs, 3) dermal contact, 4) external exposure, 5) ingestion of produce and groundwater via 1) ingestion, 2) inhalation of VOCs while showering, 3) dermal contact, and 4) ingestion of irrigated produce (Fig. 8g). For these exposure routes the cumulative residential risk for the SWSA5N area is $2E-03$. Soil is the predominant pathway for residential risk ($1E-03$). As is the case with industrial exposure, the majority of the residential risk is associated with the external exposure route which contributes a risk of $1E-03$. The major COCs associated with external exposure are thallium-208 ($5E-04$), actinium-228 ($1E-04$), bismuth-214 ($1E-04$), radium-228 ($1E-04$), and thorium-228 ($2E-04$). No other soil pathway has a risk $>1E-04$. The total risk estimate associated with the exposure to groundwater for the SWSA5N is $7E-04$, which is unacceptable (Exhibit 9c). The majority of this risk is the result of the ingestion of beryllium ($2E-04$), curium 243/244 ($1E-04$), and potassium-40 ($1E-04$).

The total HI for residential soil and groundwater pathways evaluated for the SWSA5N is 27. This hazard is associated with exposure to manganese via groundwater ingestion (22), produce

Fig. 8g. SWSA 5 North Risk Pathways Summary

ingestion (1.4), and dermal contact (0.9) (Exhibit 10a). The HI for the soil pathway, 6E-04, is below concern.

5.3.8 Solid Waste Storage Area 5 Southeast Area

The excavation scenario for the SWSA5SE evaluated exposure to soil via 1) incidental ingestion, 2) inhalation of dust and VOCs, 3) dermal contact, and 4) external exposure to radionuclides in soil. The summary risk listed in Exhibit 9a for excavation in this area is 5E-05 due to external exposure to cesium-137. The total HI for exposure to SWSA5SE as a result of soil excavation is 2E-02 (Exhibit 10a). Consequently, there are no COCs associated with the excavation scenario.

The future industrial exposure scenario considered soil exposure via 1) incidental ingestion, 2) inhalation of dust and VOCs, 3) dermal contact, and 4) external exposure to radionuclides in soil. The total risk estimate (Exhibit 9a) for the SWSA5SE industrial scenario is 6E-02, which is unacceptable. The external route (6E-02) as a result of exposure to cesium-137 (6E-02) contributes most of the risk associated with this scenario (Fig. 8h). In addition, the ingestion route has a risk of 2E-04 that is caused by radioactive strontium.

The total HI for industrial exposure to SWSA5SE soil COCs is 7E-02, which is below concern. Therefore, no noncarcinogenic COCs are identified for the SWSA5SE future industrial scenario.

The future residential scenario for the SWSA5SE was evaluated for exposure to soil via 1) incidental ingestion, 2) inhalation of dust and VOCs, 3) dermal contact, 4) external exposure, 5) ingestion of produce and groundwater via 1) ingestion, 2) inhalation of volatiles while showering, 3) dermal contact, and 4) ingestion of irrigated produce (Fig. 8h). The cumulative residential risk for the SWSA5SE area is 8E-01. Excessive risks are contributed by both the groundwater and soil pathways. The total groundwater risk is 8E-01. The majority of this risk is due to the ingestion of americium-241 (5E-01), plutonium-238 (3E-01), and tritium (7E-02) in groundwater. In addition, the risk associated with the inhalation of tritium has a risk of 1E-02, and the ingestion of irrigated produce has a risk of 1E-01 due to americium-241 and plutonium-238. The risk from exposure to all soil exposure routes is 3E-01. The majority of the residential soil risk is associated with the external exposure to cesium-137 (3E-01).

The total HI for residential soil and groundwater pathways evaluated for the SWSA5SE is 245. This hazard is associated with exposure to manganese via groundwater ingestion (210), produce ingestion (14), and dermal contact (9) (Exhibit 10a). The HI for the soil pathway, 2, is due to the ingestion of manganese in produce (Fig 8h).

5.3.9 Solid Waste Storage Area 5 Southwest

The SWSA5SW soil excavation scenario evaluated exposure to soil via 1) incidental ingestion, 2) inhalation of dust and VOCs, 3) dermal contact, and 4) external exposure to radionuclides in soil. Exhibit 9a lists the summary risk estimate for excavation in this area is 2E-05 due to external exposure to cesium-137. The total HI for soil excavation is 1E-02 (Exhibit 10a). Consequently, there are no excavation COCs associated with SWSA5SW soil.

Fig. 8h. SWSA 5 Southeast Risk Pathways Summary

The future industrial exposure scenario considered soil exposure via 1) incidental ingestion, 2) inhalation of dust and VOCs, 3) dermal contact, and 4) external exposure to radionuclides in soil (Fig. 8i). The total risk estimate (Exhibit 9a) for the SWSA5SW industrial scenario is $1\text{E-}03$. The majority of this risk is due to external exposure ($1\text{E-}03$) to cesium-137 ($8\text{E-}04$), actinium-228 ($3\text{E-}05$), bismuth-214 ($2\text{E-}05$), radium-226 ($4\text{E-}05$), radium-228 ($3\text{E-}05$), thorium-228 ($4\text{E-}05$), and thallium-208 ($8\text{E-}05$). The inhalation route poses a $2\text{E-}04$ risk associated with radium-226.

The total HI for industrial exposure to SWSA5SW soil COPCs is $4\text{E-}02$, which is below concern. Therefore, no noncarcinogenic COCs are identified for the SWSA5SW future industrial scenario.

The future residential scenario for the SWSA5SW was evaluated for exposure to soil via 1) incidental ingestion, 2) inhalation of dust and VOCs, 3) dermal contact, 4) external exposure, 5) ingestion of produce and groundwater via 1) ingestion, 2) inhalation of volatiles while showering, 3) dermal contact, and 4) ingestion of irrigated produce. Figure 8i depicts the relative contribution of these routes to the total risk for the area. The cumulative residential risk for the SWSA5SW area is $5\text{E-}02$. Excessive risks are contributed by both the groundwater and soil pathways. The risk from exposure to all soil exposure routes is $4\text{E-}02$. The ingestion of produce has the largest contribution to the soil pathway risk due to radioactive strontium ($3\text{E-}02$). In addition, exposure to cesium-137 ($4\text{E-}03$) results in an unacceptable risk via the external route. The total groundwater risk is $2\text{E-}02$. The majority of this risk is due to the ingestion of tritium ($9\text{E-}03$) and vinyl chloride ($9\text{E-}04$). Tritium also contributes a significant risk via produce ingestion ($4\text{E-}03$) and inhalation ($2\text{E-}03$).

The total HI for residential soil and groundwater pathways evaluated for the SWSA5SW is 60. This hazard is associated with exposure to manganese via groundwater ingestion (49), produce ingestion (3), and dermal contact (2) (Exhibit 10c). The HI for the soil pathway is 3 due to the ingestion of barium (2) and manganese (1) in produce.

5.3.10 White Oak Creek

The excavation scenario for the White Oak Creek included exposure to soil via 1) incidental ingestion, 2) inhalation of dust and VOCs, 3) dermal contact, and 4) external exposure to radionuclides in soil. Exhibit 9a lists the summary risk estimate for excavation in this area as $7\text{E-}04$, which is due to the external exposure to cesium-137. External exposure to cesium-137 is the only exposure evaluated under this scenario which resulted in an excess cancer risk $> 1\text{E-}04$.

The HI for exposure to White Oak Creek soil COPCs under the excavation scenario is $8\text{E-}04$ (Exhibit 10a), which is below concern. Therefore, no noncarcinogenic COCs are identified for the excavation scenario for the White Oak Creek.

The future industrial exposure scenario evaluated White Oak Creek soil exposure via 1) incidental ingestion, 2) inhalation of dust and VOCs, 3) dermal contact, and 4) external exposure to radionuclides in soil (Fig. 8j). The total estimated cancer risk listed in Exhibit 9a for the industrial scenario is $5\text{E-}02$. The external exposure route is responsible for the majority of this risk due to cesium-137 ($5\text{E-}02$) and cobalt-60 ($1\text{E-}03$).

Fig. 8i. SWSA 5 Southwest Risk Pathways Summary

Fig. 8j. White Oak Creek Risk Pathways Summary

The total HI for industrial exposure to White Oak Creek soil COPCs is $3E-03$, which is below concern. Therefore, no noncarcinogenic COCs are identified for the White Oak Creek future industrial scenario.

The future residential scenario for the White Oak Creek was evaluated for exposure to soil via 1) incidental ingestion, 2) inhalation of dust and VOCs, 3) dermal contact, 4) external exposure, 5) ingestion of produce and groundwater via 1) ingestion, 2) inhalation of volatiles while showering, 3) dermal contact, and 4) ingestion of irrigated produce (Fig. 8j). The cumulative residential risk for the White Oak Creek area is $3E-01$, which is unacceptable (Exhibit 9a). Excessive risks are contributed by both the soil and groundwater pathways. The risk from exposure to all soil exposure routes is $2E-01$. The majority of this risk is derived from external exposure to cesium-137 ($2E-01$) and cobalt-60 ($7E-03$). In addition, there are unacceptable risks associated with the ingestion of cesium-137 in soil ($2E-04$) and the ingestion of strontium in produce ($2E-03$). The total groundwater risk is $1E-01$ and is due to the exposure to vinyl chloride via the ingestion ($9.5E-02$), produce ingestion ($1E-02$), dermal ($1E-03$), and inhalation ($6E-04$) routes of exposure.

The total HI for all residential pathways evaluated for the White Oak Creek area is 23. The groundwater pathway HI is 21 due to ingestion of 1,2-dichloroethene (10) and manganese (8). The only soil COC for this area is mercury via ingestion of produce (2).

5.4 RISK CHARACTERIZATION SUMMARY

The results of the carcinogenic risk (Exhibit 9a-9d) and noncarcinogenic HI (e.g., systemic toxicity) (Exhibit 10a-10d) assessments for the WAG 5 COCs are summarized in Exhibits 11-12. These exhibits present the WAG 5 COCs that have risks greater than or equal to $1.0E-06$ and/or an HQ greater than or equal to 0.1 provided that the total pathway risk is greater than or equal to $1.0E-04$ and/or total pathway HQ is greater than or equal to 1.0 for the industrial worker and residential land uses, respectively. The results summarized in Exhibit 13 are the cumulative risks and HIs for the industrial, excavation, and residential scenarios.

5.4.1 Identification of Pathway Risks/HIs of Interest

5.4.1.1 Industrial worker pathway risks/HQs

The pathway risks/HIs (i.e., the sum of the risks/HQs from all analytes in that pathway) of concern and the total cumulative risks/HIs (i.e., the sum of the risks/HQs from all analytes across all pathways) for the industrial worker scenario are reported in Exhibits 13a and 13b for soils and sediments, respectively. It is important to note that all total pathway HQs are excluded in these exhibits because none of them exceeded 1.0 (refer to Exhibits 10a and 10b) for this scenario. The total external exposure pathway risks in both soil and sediment are greater than $1.0E-04$ for all areas. The total pathway risks from inhalation are greater than or equal to $1E-04$ for soils of the FS, OHFT, PWSB, and SWSA5SW areas and sediments of the D2 area only. The total pathway risks from incidental ingestion exceed $1.0E-04$ in the SWSA5SE soils and the OHFP and PWSB sediments. The contribution of the dermal pathway is negligible in all soils and sediments.

5.4.1.2 Excavation pathway risks/HQs

The pathway risks/HIs of concern and the total cumulative risks/HIs for the excavation scenario are reported in Exhibit 13a for soils. The total external exposure pathway risks in soil are greater than $1.0E-04$ for the FS, OHFP, and WOC areas. The total pathway risks from the inhalation, dermal contact, and ingestion pathways are excluded because none of them exceeded $1E-06$ in all areas (refer to Exhibit 9a). The total pathway noncarcinogenic HQ contributions are negligible in all areas because none of them exceeded 1.0 (refer to Exhibit 10a) for this scenario. Please note that the risk estimates for the excavation scenario relied on the assumption that buried waste containers or tanks would not be hit or breached during the excavation.

5.4.1.3 Resident pathway risks/HIs

The pathway risks/HIs and the cumulative risks/HIs for the residential scenario are reported in Exhibits 13a, 13b, and 13c for soils, sediment, and groundwater. For surface water, inhalation of VOCs was the only credible pathway of concern. Exhibits 9d and 10d show that the inhalation pathway risks/HQs can be neglected in all surface water areas. The total pathway risks that exceed $1.0E-04$ for the different pathways of concern in the different media of concern are:

- external exposure to contaminated soil/sediment for all corresponding areas of concern;
- inhalation of VOCs in soils of FS, PWSB, and SWSA5SW areas; sediments of the D2 area; and groundwater of the OHFP, SWSA5SE, SWSA5SW and White Oak Creek areas;
- ingestion of produce in soils of the FS, OHFP, PWSB, SWSA5SE, SWSA5SW, and White Oak Creek areas and in the groundwater of the OHFP, SWSA5SE, SWSA5SW and White Oak Creek areas;
- incidental ingestion in soils of the SWSA5SE, SWSA5SW, and White Oak Creek areas; sediments of the OHFP area; and groundwater of the FS, OHFP, SWSA5N, SWSA5SE, SWSA5SW, and White Oak Creek areas; and
- dermal contact with groundwater in the White Oak Creek area only.

Exhibits 13a, 13b, and 13c also list all total pathway HQs that are greater than or equal to in the designated areas within each media in WAG 5. These pathways of concern include:

- incidental ingestion in sediments of the D2 area and groundwater of the FS, SWSA5N, SWSA5SE, SWSA5SW, and White Oak Creek areas;
- ingestion of produce pathway in the soils of the FS, OHFP, OHFT, SWSA5SE, SWSA5SW, and White Oak Creek areas and groundwater of the FS, SWSA5N, SWSA5SE, SWSA5SW and White Oak Creek areas; and
- dermal contact with groundwater of the FS, SWSA5N, SWSA5SE, and SWSA5SW areas.

5.4.2 Identification of Individual Analyte Risks/HQs

5.4.2.1 Industrial worker individual analyte risks/HQs

For the industrial worker land use scenario (Exhibit 11), no carcinogenic COCs are identified for the NHFT area. For all other areas, the following table summarizes analytes that are identified as carcinogenic COCs in soil and sediment in ascending order of their contribution to risk:

Carcinogenic COCs identified in the different areas— industrial scenario		
Area	Analytes identified as carcinogenic COCs	Pathway
Soil		
FS	Co-60, Cs-137, Ra-226, Pb-212, U-238 Ra-226	External Inhalation
OHFP	Cs-137, Th-228, Co-60, Ra-228	External
OHFT	Cs-137, Th-228, Ra-226, Ra-228	External
PWSB	K-40, Cs-137, Th-228, Ra-226, Ra-228	External
SW3	Cs-137, Th-228, Ra-228	External
SWSA5N	Tl-208, Ac-228, Th-228, Ra-228, Bi-214, Bi-212, Pb-214, Pb-212	External
SWSA5SE	Cs-137, Tl-208, Th-208, Pb-212, Pb-214, Ra-228, Ac-228 Cs-137, Cm-243/144	External Ingestion
SWSA5SW	Cs-137, Tl-208, Ra-226, Th-228, Ac-228, Ra-228, Bi-214, Pb-214, Pb-212 Ra-226	External Inhalation
WOC	Cs-137, Co-60, Tl-208, Th-228, Na-22, Ac-228, Ra-228, Pb-214, Co-57, Pb-212	External
Sediment		
D2	Ra-226, Tl-208, Ac-228, Bi-214, Co-60, Bi-212, Pb-212, Pb-214 Vinyl chloride, Ra-226	External Inhalation
D3	Tl-208, Bi-214, Ac-228, Pb-212, Pb-214	External
OHFP	Cs-137, Total radioactive strontium, Cm-243/244, Pu-238, Pu-239/240, Am-241, Co-60, Aroclor 1254, Th-228, Th-230 Cs-137, Co-60, Am-241, Cm-243/244	Ingestion External
PWSB	Total radioactive strontium, Cs-137, Am-241, Cm-243/244, Co-60, Pu-239/240, Pu-238, Th-228, U-232, Aroclor 1254, Aroclor 1248 Co-60, Cs-137, Eu-152, Eu-154, Th-228, Am-241, U-238	Ingestion External

It is important to note that potassium-40 and sodium-22 appeared in the PWSB and White Oak Creek areas, respectively, because the two analytes exceeded background screening levels followed

in this project. No noncarcinogenic COCs are identified in soil or sediment for any of the different areas under the industrial land use scenario [i.e., no HQs greater than one (1.0) were found for the COPCs] (refer to Exhibits 10a and 10b).

5.4.2.2 Excavation individual analyte risks/HQs

The following table summarizes analytes that are identified as carcinogenic COCs in soil and sediment for the excavation scenario in ascending order of their contribution to risk.

Carcinogenic COCs identified in the different areas— excavation scenario

Area	Analytes identified as carcinogenic COCs	Pathway
FS	Co-60, Ra-226, Cs-137	External
OHFP	Cs-137	External
WHITE OAK CREEK	Cs-137, Co-60, Tl-208	External

No noncarcinogenic COCs are identified in soil or sediment for any of the different areas in the excavation scenario [i.e., no HQs greater than one (1.0) were found for the COPCs] (refer to Exhibits 10a and 10b).

5.4.2.3 Residential individual analyte risks/HQs

For the residential land use scenario (Exhibit 11), carcinogenic COCs in soil, sediment, groundwater, and surface water are identified in the following table.

Carcinogenic COCs identified in the different areas—residential scenario

Area	Analytes identified as carcinogenic COCs	Pathway
Soil		
FS	Co-60, Cs-137, Ra-226, Pb-212 Total radioactive Strontium, Co-60, Cs-137 Ra-226	External Produce ingestion Inhalation
NHFT	Th-228, Ra-226	External
OHFP	Cs-137, Th-228, Co-60, Ra-228 Total radioactive strontium, Cs-137, Heptachlor Epoxide	External Produce ingestion
OHFT	Cs-137, Ra-226, Th-228, Ra-228 Ra-226	External Inhalation

Area	Analytes identified as carcinogenic COCs	Pathway
PWSB	K-40, Ra-226, Th-228, Ra-228, Cs-137 K-40, total radioactive strontium Ra-226	External Produce ingestion Inhalation
SW3	Cs-137, Th-228, Ra-228	External
SWSA5N	Tl-208, Th-228, Ra-228, Ac-228, Bi-214, Bi-212, Pb-214, Pb-212, Ra-223	External
SWSA5SE	Cs-137, Tl-208, Th-228, Ra-228, Ac-228, Pb-214, Pb-212 Total radioactive strontium, Cs-137, Cm-243/244 Total radioactive strontium, Cs-137, Cm-243/244, Am-241	External Produce ingestion Ingestion
SWSA5SW	Cs-137, Tl-208, K-40, Ra-226, Th-228, Aroclor 1260, Ra-228, B-214, Pb-214, Pb-212, U-238 Total radioactive strontium, K-40, Aroclor 1260, Cs-137-226 Ra-226 Total radioactive strontium, Aroclor 1260, Cs-137	External Produce ingestion Inhalation Ingestion
WHITE OAK CREEK	Cs-137, Co-60, Tl-208, Th-228, Na-22, Ra-228, Ac-228, Pb-214, Co-57, Pb-212, Cs-134 Total radioactive strontium, Cs-137 Total radioactive strontium, Cs-137	External Produce ingestion Ingestion
Sediment		
D1	B-214, Ac-228, Co-60, B-212, U-238, Pb-212, Pb-214, Ra-223, U-235, Radon 219	External
D2	Tl-208, Ra-226, Ac-228, Bi-214, Co-60, Bi-212, Pb-212, Pb-214, Ra-223, Radon 219, Ra-224, U-235, U-238, I-129 Vinyl Chloride, Ra-226	External Inhalation
D3	Tl-208, Bi-214, Ac-228, Pb-212, Pb-214	External
OHFP	Cs-137, Co-60, Th-228, Am-241, Cm-243/244 Cs-137, Total radioactive strontium, Cm-243/244, Pu-238, Am-241, Pu-239/240, Co-60, Aroclor 1254, Th-228, Aroclor 1260, Th-230, U-232	External Ingestion
PWSB	Co-60, Cs-137, Eu-152, Eu-154, Th-228, Am-241, U-238 Total radioactive strontium, Cs-137, Am-241, Cm-243/244, Co-60, Pu-239/240, Pu-238, Th-228, U-232, Aroclor 1254, Aroclor 1248, U-238, Eu-152, Eu-154	External Ingestion

Area	Analytes identified as carcinogenic COCs	Pathway
Groundwater		
FS	Beryllium, Tritium, Th-228, Ra-228, Th-232, Ra-226, Th-230, Am-241	Ingestion
OHFP	Total radioactive strontium, Tritium, Cs-137, Ra-228, Co-60, C-14, Cm-243/244, Carbon tetrachloride, Th-234, 1,2-Dichloroethane, Chloroform, U-233/234, Pu-238, Trichloroethene, Ra-226, Ra-226, Tc-99	Ingestion
	Total radioactive strontium, Tritium, Trichloroethene, Cs-137, Ra-228, C-14, Co-60, Carbon Tetrachloride	Produce ingestion
	Tritium, Carbon Tetrachloride	Inhalation
SWSA5N	Beryllium, K-40, Cm-243/244, Th-234, Ra-228, Th-234, Am-241, Ra-226, Pb-212, Bis(2-Ethylhexyl) Phthalate, Pu-238, Tritium, Th-228, Methylene Chloride, C-14, U-238	Ingestion
SWSA5SE	Am-241, Pu-238, Tritium, Pu-239/240, Ra-226, TRS, Vinyl Chloride, U-233/234, 1,1 -Dichloroethene, Cd-109, Th-228, Ra-228, Cm-243/244, C-14, 1,2-Dichloroethane, Trichloroethene, Tc-99, Bi-212, Th-231, Bis(2-Ethylhexyl) Phthalate, Benzene, U-238	Ingestion
	Am-241, Tritium, Pu-238, Pu-239/240, Ra-226, Total radioactive strontium, Vinyl Chloride, U-233/234, 1,1 -Dichloroethene, Cd-109, Th-228, Ra-228, C-14, Cm-243/244, Tc-99, Trichloroethene 1,2-Dichloroethane	Produce ingestion
	Tritium, 1,1-Dichloroethene, Vinyl Chloride	Inhalation
SWSA5SW	Tritium, Vinyl Chloride, Total radioactive strontium, K-40, Ra-228, Bis(2-Ethylhexyl) Phthalate, Carbon Tetrachloride, Th-228, Th-234, Co-60, Am-241, C-14, Pu-238, Pb-212, Ra-226, Ca-45, Cm-243/244, U-238, Th-232, U-233/234, Th-230	Ingestion
	Tritium, Vinyl Chloride, Total radioactive strontium, K-40, Ra-228, Bis(2-Ethylhexyl) Phthalate, C-14, Carbon Tetrachloride	Produce ingestion
	Tritium, Vinyl Chloride	Inhalation
WHITE OAK CREEK	Vinyl Chloride, Th-234, 1,1-Dichloroethene, Tritium, C-14, Benzene, Th-228	Ingestion
	Vinyl Chloride, Tritium, C-14, 1,1-Dichloroethene, Benzene, Vinyl Chloride	Produce ingestion
	Vinyl Chloride, Tritium, 1,1-Dichloroethene	Dermal
		Inhalation

It is important to note that certain analytes like potassium-40 and sodium-22 contributed to the total risk in some areas because they exceeded background screening levels followed in this project.

The following table summarizes all analytes identified as noncarcinogenic COCs for the residential scenario in the different areas of WAG 5.

Noncarcinogenic COCs identified in the different areas - residential scenario

Area	Analytes identified as carcinogenic COCs	Pathway
Soil		
FS	Mercury	Produce ingestion
OHFP	Cadmium	Produce ingestion
OHFT	Cyanide, Silver	Produce Ingestion
SWSA5SE	Manganese, Antimony	Produce ingestion
SWSA5SW	Barium, Manganese	Produce ingestion
WHITE OAK CREEK	Mercury	Produce ingestion
Sediment		
D2	Arsenic	Ingestion
Groundwater		
FS	Manganese, Barium, Vanadium, Nickel Manganese Manganese, Vanadium	Ingestion Produce ingestion Dermal
SWSA5N	Manganese, Barium, Nickel, Vanadium Manganese Manganese	Ingestion Produce ingestion Dermal
SWSA5SE	Manganese Manganese Manganese	Ingestion Produce ingestion Dermal
SWSA5SW	Manganese, Tetrachloroethene, Bis(2-Ethylhexyl) Phthalate, Carbon Tetrachloride Manganese Manganese, Tetrachloroethene, Bis(2-Ethylhexyl) Phthalate	Ingestion Produce ingestion Dermal
WHITE OAK CREEK	1,2-Dichloroethene (total), Manganese, Barium 1,2-Dichloroethene (total), Manganese	Ingestion Produce ingestion

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6. EVALUATION OF UNCERTAINTIES

The estimation of uncertainty, whether quantitative or qualitative, is fundamental to scientific activities that involve measured or assessed quantities. The estimates of risk generated in this assessment are conditional estimates of the risk based upon a number of assumptions concerning exposure and toxicity rather than probabilistic estimates. Generation of these point estimates of risk have the potential to yield underestimates or overestimates of the actual risk and can lead to improper remedial decisions. Therefore, it is necessary to specify the assumptions and uncertainties inherent in the risk assessment process to place the risk estimates in perspective and ensure that any risk management decisions are well informed.

Uncertainty about environmental risk assessments is known to be at least an order of magnitude or greater (EPA 1989). However, the evaluation of uncertainties for the WAG 5 BHHRA is a qualitative assessment since the resource requirements necessary to provide a valid quantitative statistical uncertainty analysis for the study areas in WAG 5 would generally outweigh the benefits. The focus of the discussion in this chapter will be on the important variables and assumptions that contribute most to the overall uncertainty.

6.1 UNCERTAINTY IN THE SELECTION OF POTENTIAL CONTAMINANTS OF CONCERN

The selection of COPCs conducted for this report has relied on field measurements of secondary media conducted for the RI. Therefore, the primary source of contaminants, buried waste, has not been addressed in the selection of contaminants. This is not expected to influence the selection of COPCs in the exposure media for current environmental conditions. However, under future land use conditions, other contaminants not currently accounted for, particularly those that are either currently contained or that have slow transport velocities, may appear in secondary media at concentrations that could contribute to the calculated risk.

In addition, for several site contaminants, toxicity information on either the noncarcinogenic or carcinogenic health effects to humans is currently unavailable in IRIS or HEAST. For some of these, the carcinogenic potential has not been evaluated. Others have been assigned a weight of evidence classification but have not been assigned an SF. In the future, a toxicity factor may be assigned to some of these contaminants as additional toxicity information is evaluated.

The uncertainty associated with the toxicity factors for noncarcinogens is measured by the uncertainty factor, the modifying factor, and the confidence level. For carcinogens, the weight of evidence classification indicates the likelihood that a contaminant is a human carcinogen. Toxicity factors that have high uncertainties may change as new information is evaluated. Therefore, a number of the contaminants of concern, particularly the ones with high uncertainties, may be subject to change. Finally, the toxicity of a contaminant could vary significantly with the chemical form present in the media of concern. Contaminants may currently be included as a potential contaminant of concern based on the assumption that the contaminant is in its most toxic form. If additional information is collected on its chemical species and it is found to be less toxic, the analyte may be dropped from the COPCs list.

6.2 UNCERTAINTY IN THE EXPOSURE ASSESSMENT

The WAG 5 RI is not intended to provide an exhaustive assessment of the physical characteristics of the site that can be used to predict future conditions. Instead, the collected information is intended to provide the basis for a conceptual model based on current conditions that will lay the groundwork for investigating remedial alternatives at identified study areas in WAG 5. The actual sources of contamination were not characterized for the RI. Instead, secondary sources were sampled to quantify the present-day transport processes that are active in WAG 5. Since limited information is available regarding the distribution, quantities, and containment of contaminants of concern in the majority of the buried waste at WAG 5, a quantitative model of future contaminant migration which provides exposure concentrations for use in future land use scenarios was not developed for the RI. Instead, essentially equilibrium conditions are assumed to derive exposure concentrations for groundwater and surface water in the future land use scenarios (future radionuclide soil concentrations were calculated based on decay processes). This situation leads to the primary uncertainty associated with the risk assessment results presented in this report, which is that the results are based on a combination of current exposure concentrations and future exposure conditions. Realistically, the various future land use scenarios presented in the risk assessment will not occur for some time in the future, and the media concentrations of contaminants of concern at that time will have changed.

However, the generated risk results are still useful in defining the current risk related problems that exist at WAG 5 and placing the large volume of information about contaminants in the study areas at WAG 5 on the same scale. This information can be combined with the regional groundwater model for Melton Valley which is being developed to evaluate potential groundwater pathways of both shallow and deep waste disposal. Modeling the groundwater component in shallow and intermediate intervals for the calculation of current groundwater fluxes of key constituents and the reduction afforded by implementing remedial actions can be used to support the evaluation of the risk reduction of any remedial actions at WAG 5 Study Group Areas which proceed to a feasibility study.

Another key uncertainty for the risk results is the likelihood of the addressed exposure pathways and land uses actually occurring. The estimates of risk presented in this report are conditional on these exposure scenarios occurring at some point in the foreseeable future. No attempt has been made to quantify this variable, and any land use decisions made with respect to WAG 5 will be documented in the Record of Decision for the site.

6.2.1 Representative Concentrations

The locations and number of media samples can affect the contaminants identified and the calculated exposure concentration. Higher densities of sample collection lead to more certain results for the exposure concentration. The number of samples collected for each of the Study Group Areas in WAG 5 vary between the identified areas; therefore, comparisons of the risk between areas will include some uncertainty with respect to uncertainty concerning the exposure concentration.

Moderate uncertainty can be introduced in the data aggregation process of estimating a representative exposure concentration in the analyzed media. The exposure concentration recommended by EPA for calculating the RME is the minimum of the maximum of the range and

the upper 95th confidence limit of the mean. The first step in determining the exposure concentration is to determine the frequency of detection for each analyte. The detection limit is used as a proxy value for all nondetected values. For analytes that have at least one detected concentration, a statistical test (the Shapiro-Wilk test) is performed to determine if a normal or lognormal distribution best fits the concentration distribution. If the distribution is lognormal, then nondetects are reassigned a value between zero and the detection limit based on the Lifereg SAS procedure which attempts to extrapolate the lower tail of the lognormal distribution. Based on the results of the Shapiro-Wilk test, the analyte's mean concentration and upper 95th confidence limit on the mean concentration are calculated appropriately (i.e., based on a normal or lognormal distribution). The maximum detected concentration is then compared against the upper 95th confidence limit; the smaller of these two measures is used as the analyte's exposure concentration. This method may moderately overestimate the exposure concentration. In addition, when the resulting individual contaminant risks are summed, the compounding conservatism will result in an overestimate of the upper 95th confidence limit of the summed risk.

Some uncertainty is unavoidably present in the contaminant concentrations detected and reported by the analytical laboratory. The quality of the analytical data used in the risk assessment depends on the adequacy of the set of procedures that specify how samples were selected and handled and how well these procedures were followed. Uncertainties associated with the data can include sampling errors, laboratory analysis errors, and data analysis errors. The QA/QC procedures (Kimbrough 1990) are used to minimize these uncertainties, and this issue is expected to have a low effect on either underestimating or overestimating the risk. However, current analytical methods are limited in their ability to achieve detection limits appropriate for use in risk assessment. Therefore, risks may be overestimated as a result of analyte concentrations being reported at the method detection limit.

6.2.2 Representative Exposure Parameters

For each exposure pathway, assumptions are made concerning the parameters, the routes of exposure, the amount of contaminated media an individual can be exposed to, and intake rates for different routes of exposure. In the absence of site-specific data, the assumptions used in this BHHRA are consistent with EPA-approved parameters and default values. When several of these upper-bound values are combined in estimating exposure for any one pathway, the resulting risks can be in excess of the 99th percentile and therefore outside the range that may be reasonably expected.

The guidance values for intake rates and exposure parameters are assumed to be representative of the potentially exposed populations. All contaminant exposures and intakes are assumed to be from the site-related exposure media (i.e., no other sources contribute to the receptor's health risk). Even if these assumptions are true, other areas of uncertainty may apply. Selected intake rates and population characteristics (i.e., weight, life-span, activities) are assumed to be representative of the exposed population. The consistent conservatism employed in the estimation of these parameters generally lead to overestimation of the potential risk.

6.3 UNCERTAINTY IN DOSE-RESPONSE RELATIONSHIPS

Uncertainty is present in the values used to represent the dose-response relationship. These uncertainties are contaminant specific and are embedded in the toxicity value. These factors are incorporated to represent sources of uncertainty that include the source of the data, duration of the study, extrapolations from short-term to long-term exposures, intrahuman or interspecies variability, and other special considerations.

6.3.1 Radiological Risk

The risk of increased incidence of cancer from exposure to low-level radiation is estimated by application of a risk factor to either the radiation dose or the radionuclide intake. Regardless of the type of risk factor used, the same basic uncertainties remain. These uncertainties are related to the model used for determining the health effects of radiation exposure. The model most frequently used for determining risk from radiation exposure is the linear nonthreshold model, which assumes some increased risk for any increment of radiation exposure with no threshold below which effects are not seen. The linear nonthreshold model is the most conservative model for evaluating radiation risk. This model uses historical data from high-dose radiation exposures (such as from the survivors of the atomic bombs) and extrapolates risk from these high exposures to the low-level environment or occupational dose range.

The current EPA-recommended radiation risk factors are based on the 1980 National Academy of Sciences Biological Effects of Ionizing Radiation Committee (BEIR) report, also referred to as BEIR III (NRC 1980). BEIR III recommendations were increased slightly by EPA to reflect recent information on the health effects of exposure to ionizing radiation. In early 1990, the National Academy of Sciences published the results of the most recent studies of the health effects of ionizing radiation, the BEIR V report (NRC 1990), which increases the estimates of cancer risk by a factor of 3 to 5 over the BEIR III report. These increases are based primarily on a re-evaluation of the doses received by atomic bomb victims.

6.3.2 Chemical Risk

The toxicological data (SFs and RfDs) for dose-response relationships of chemicals are frequently updated and revised, which can lead to overestimation or underestimation of risks. These values are often extrapolations from animals to humans, which also induces uncertainties in toxicity values because differences can exist in chemical absorption, metabolism, excretion, and toxic response between animals and humans. The EPA takes into account differences in body weight, surface area, and pharmacokinetic relationships between animals and humans to minimize the potential to underestimate the dose-response relationship; however, more conservatism is usually incorporated in these steps. In addition, in the analytical analyses for metals, risks may be overestimated because metals that are present are conservatively assumed to be in their most toxic forms. This can lead to an overestimation of total risk if quantitative analysis of such chemicals is not feasible.

For noncarcinogenic effects, the amount of human variability in physical characteristics is important in determining the risks that can be expected at low exposures and in determining the no observed adverse effects level (NOAEL) (EPA 1989). The NOAEL/uncertainty factor approach

incorporates a 10-fold factor to reflect the possible inter-individual variability in the human population and is generally considered to be a conservative estimate.

6.4 UNCERTAINTIES IN RISK CHARACTERIZATION

Uncertainties related to the summation of hazard indices and carcinogenic risk estimates across contaminants and pathways are a primary uncertainty in the risk characterization. In the absence of information on the toxicity of specific chemical mixtures, additive (cumulative) risks and HIs are assumed (EPA 1989). Limitations of the additive approach for noncarcinogens include: 1) the effects of a mixture of chemicals are generally unknown and possible interactions could be synergistic or antagonistic; 2) the RfD/RfCs have different accuracy and precision and are not based on the same severity or effect; and 3) HI summation is most properly applied to compounds that induce the same effects by the same mechanism. Therefore, the potential for occurrence of noncarcinogenic effects can be overestimated for chemicals that act by different mechanisms and on different target organs.

Limitations of the additive risk approach for multiple carcinogens include: 1) the SFs often represent the upper 95th percentile confidence limit estimate of potency; therefore, the summation can result in an excessively conservative estimate of lifetime risk and 2) the effects of a mixture of carcinogens is unknown and possible interactions could be synergistic or antagonistic. Despite these limitations, and the general unavailability of data on these interactions, summations were performed for the HI and carcinogenic risk at each of the WAG 5 Study Group Areas identified in the RI in accordance with EPA guidelines.

6.4.1 Definition of Excess Risk

Since exposure calculations are based on actual environmental sampling data from WAG 5, the reader should be aware that risk numbers should be interpreted as total risk rather than excess risk. Excess risk is defined herein as risk posed solely through exposures resulting from site-related activities. This is particularly of importance for naturally-occurring radionuclides but applies to naturally-occurring inorganic and organic chemicals as well. In other words, estimated health risks associated with naturally-occurring radionuclides will reflect combined exposure to background radiation levels as well as exposure to concentrations of these nuclides that result from management of radioactive waste. Consequently, the risks presented in the WAG 5 BHHRA are conservative risk estimates because they include both risks from background and excess risks from site-related activities. Guidance from EPA does not endorse subtraction of background levels prior to risk estimation. In contrast, potential health risks associated with radionuclides that do not normally occur in nature should be interpreted as excess risk.

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7. PRELIMINARY REMEDIAL ACTION OBJECTIVES

7.1 INTRODUCTION

To initiate development of remediation alternatives, remedial action objectives (RAOs) must first be established. Remedial action objectives are site-specific objectives that address the extent of site cleanup required by CERCLA remediation (EPA 1988b) based on preliminary assessment of potential chemicals and environmental media of concern and on potential exposure pathways. Identification of RAOs also helps determine preliminary remediation levels or remedial goal options (RGOs) (EPA 1991f) which are discussed further in the following text.

The WAG 5 RI focused on four environmental media (soil, sediment, groundwater, and surface water) and three land use scenarios (industrial, excavation, and residential). For each land use scenario, different environmental media are important and each medium is associated with certain dominant exposure pathways. For example, in the excavation scenario, external exposure to carcinogens in soil is the predominant exposure route. Based on these media and land use scenarios, multiple RAOs for WAG 5 source areas can be identified for use in the feasibility study. These RAOs differ based on the endpoint (a formal expression of the environmental or human health values to be protected) that a remedial action might address. The different endpoints might be:

- direct exposure to soil/dry sediments for a future hypothetical on-WAG resident,
- direct exposure to soil for a future industrial worker (this endpoint should also account for the fact that there is still a resident to protect, but that the resident is off-WAG),
- groundwater protection for a future hypothetical on-WAG resident, and
- surface water protection for a future off-WAG resident.

It is too early at this stage of the CERCLA process to determine which endpoint will be the goal of potential remediation at WAG 5. [This type of decision is made later in a consensus-building process by risk managers within DOE, EPA, the Tennessee Department of Environment and Conservation (TDEC), and the public.] Therefore, general RAOs are identified, and multiple endpoints are considered to supply sufficient information for comparison of risk reduction, technical feasibility, and cost associated with meeting the different remediation objectives.

The RAOs identified for WAG 5 are to:

- protect hypothetical future on-WAG residents from exposure to soil and dry sediments resulting in risks that fall in the target risk range of 10^{-6} to 10^{-4} for carcinogenic COCs or a target HI of 1 for systemic toxicant COCs,
- prevent groundwater contamination levels that could result in exposures to hypothetical future on-WAG residents leading to risks that fall in the target risk range of 10^{-6} to 10^{-4} for carcinogenic COCs or a target HI of 1 for systemic toxicant COCs,

- protect potential future industrial workers from exposure to soil and dry sediments resulting in risks that fall in the target risk range of 10^{-6} to 10^{-4} for carcinogenic COCs or a target HI of 1 for systemic toxicant COCs, and
- prevent transport of contaminants to surface water that could result in exposures to potential future off-WAG residents leading to risks that fall in the target risk range of 10^{-6} to 10^{-4} or a target HI of 1.

7.2 METHODS FOR IDENTIFYING REMEDIAL GOAL OPTIONS

Remedial goal objectives are a subset of the RAOs. Remedial goal objectives (sometimes referred to as modified PRGs) are chemical-specific, medium-specific numerical concentration limits that are identified for all contaminants and all pathways found to be of concern during the RI and baseline risk assessment process. Remedial goal objectives are not the first or the final set of clean-up levels in the CERCLA process but can be viewed as modified PRGs based on site characterization and baseline risk assessment findings. Remedial goal objectives are valuable for designing data quality objectives (DQOs) in the RI process, comparing to detected contaminant concentrations, and using as criteria in selecting and designing remediation alternatives in the feasibility study.

For WAG 5, RGOs have been identified for each RAO presented previously in this chapter. Section 7.2.2 discusses the methods used to develop RGOs for WAG 5, and Sect. 7.3 discusses and presents the WAG 5 RGOs in table format.

7.2.1 Chemicals of Concern

The contaminant screening process identified the COPCs associated with the three land use scenarios (excavation, industrial, and residential) for each media and each Study Group Area within WAG 5. These COPCs were the primary focus of the baseline risk assessment which in turn resulted in the identification of COCs for WAG 5. The COCs are those chemicals that have been found to pose health risks that may necessitate remediation efforts. These chemicals will be addressed in the feasibility study, which will examine risk reduction associated with remediation alternatives and whether potential alternatives will be sufficient to meet ARARs. In this document, an individual carcinogenic COC is defined as a chemical that contributes a risk exceeding 1×10^{-6} in a pathway with a total risk exceeding 1×10^{-4} . For a systemic toxicant COC, the individual HQ must exceed 0.1 in a pathway with an HI exceeding 1.

7.2.2 RGO Calculations

The RGOs were calculated for all WAG 5 COCs using one of two approaches. For all exposure pathways except produce ingestion, a risk-based concentration limit in the particular environmental medium was directly calculated based on target risk levels or target HQs. If the produce ingestion pathway is included, additional steps were required to estimate the RGO for the environmental medium (soil or groundwater) from the risk-based concentration limit in produce. Further details of the produce ingestion RGO calculations are presented in Sect. 7.2.2.2.

7.2.2.1 Risk-based remedial goal objectives

Risk-based RGOs were developed for all WAG 5 COCs identified in the BHHRA. Toxicity data used to develop RGOs are RfDs and SFs obtained from HEAST (1993) and IRIS (1994a). Based on these toxicity factors, target risk levels (for carcinogens) and target HQs and HIs (for noncarcinogens) were determined which represent human health risk goals reflecting regulatory acceptable risk levels as defined by EPA guidelines:

- Acceptable risk = $<1 \times 10^{-6}$
- Target risk range = 1×10^{-6} to 1×10^{-4}
- Unacceptable risk = $>1 \times 10^{-4}$

Target risk levels and HQs were then used along with toxicity data and exposure calculations to determine RGOs for each COC in each medium in all land use scenarios. The following example is a general representation of an RGO calculation for a carcinogenic chemical:

$$\text{STEP 1: } \text{Estimated Risk} = \frac{SF \times C \times IR \times EF \times ED}{BW \times AT}$$

$$\text{STEP 2: } RGO = \frac{TR \times BW \times AT}{SF \times IR \times EF \times ED}$$

where

- SF = cancer slope factor (mg/kg·day)⁻¹,
- C = chemical concentration in environmental medium (mg/kg),
- IR = ingestion rate (mg/day),
- EF = exposure frequency (days/year),
- ED = exposure duration (years),
- BW = body weight (kg),
- AT = averaging time (days),
- TR = target risk (unitless probability).

Calculations of RGOs for noncarcinogens are slightly different, but follow the same principle.

7.2.2.2 Produce ingestion remedial goal objectives

For the produce ingestion pathway, risk-based RGO calculations are somewhat different than for other pathways. First, the contaminant concentration in the produce must be estimated based on the concentration in the environmental medium (soil or groundwater) and media-specific uptake factors. Second, the produce concentration is used with ingestion rates to calculate human health risks. Third, the risk from produce ingestion is set to the target risk level (1×10^{-6} for carcinogens), and the produce concentration is back-calculated to reflect a level that is protective of human health.

Finally, this "target" produce concentration is used to calculate a concentration in the environmental medium that reflects a risk level within the target range. The following general equations illustrate the four steps used to calculate produce ingestion RGOs. (Similar steps are followed to calculate RGOs for noncarcinogens.)

$$\text{STEP 1: } \text{Estimated Produce Concentration } (C_v) = C \times UF$$

$$\text{STEP 2: } \text{Estimated Risk} = \frac{SF \times C_v \times IR \times EF \times ED}{BW \times AT}$$

$$\text{STEP 3: } RGO_{\text{produce}} = \frac{TR \times BW \times AT}{SF \times IR \times EF \times ED}$$

$$\text{STEP 4: } RGO_{\text{media}} = \frac{RGO_{\text{produce}}}{UF}$$

where

- C_v = chemical concentration in produce (mg/kg),
- C = chemical concentration in environmental medium (mg/kg),
- UF = media-specific calculations that include uptake factors (e.g., B_v and T_f); (See Sect. 3.3.2.2 for specific calculations),
- SF = cancer slope factor (mg/kg·day)⁻¹,
- IR = ingestion rate (mg/day),
- EF = exposure frequency (days/year),
- ED = exposure duration (years),
- BW = body weight (kg),
- AT = averaging time (days),
- TR = target risk (unitless probability).

7.3 WAG 5 REMEDIAL GOAL OBJECTIVES

7.3.1 WAG 5 RGO Summary

The following section presents a tabular summary of the WAG 5 chemical-specific RGOs for driving pathways by land use scenario and environmental medium. Exhibit 14 lists the WAG 5

concentration values for the COCs that would result in acceptable risk and HQ values, based on the individual study group areas. In addition, twice the mean of background values for the COCs are shown for comparison of RGOs to background levels. Remedial goal objectives for both carcinogens and noncarcinogens are listed. Tables D.13a through D.13d also list the RGOs for the contaminants for each of the media, based on the WAG-wide analysis. As can be seen, the results are very similar, if not identical in most of the RGO values.

Sections 7.3.2 through 7.3.14 present all the chemical-specific RGO values for each WAG 5 Study Group Area by land use scenario, medium, and exposure pathway (Exhibits 15 through 27).

7.3.2 Fissile Storage Area

Exhibit 15 presents the chemical-specific RGOs for the FS area for the excavation, industrial, and residential land use scenarios. RGOs are listed for soil in the excavation and industrial scenarios and for soil and groundwater in the residential scenario.

7.3.3 New Hydrofracture Facility Tanks

Exhibit 16 presents the chemical-specific RGOs for the NHFT for the residential land use scenario. Remedial goal objectives were calculated for only the soil medium in this scenario.

7.3.4 Old Hydrofracture Facility Pond

Exhibit 17 presents the chemical-specific RGOs for the OHFP for the excavation, industrial, and residential land use scenarios. Remedial goal objectives are listed for soil in the excavation scenario; for soil and sediment in the industrial scenario; and for soil, sediment, and groundwater in the residential scenario.

7.3.5 Old Hydrofracture Facility Tanks

Exhibit 18 presents the chemical-specific RGOs for the OHFT for the industrial and residential land use scenarios. Remedial goal objectives were calculated for only the soil medium in this scenario.

7.3.6 Process Waste Sludge Basin

Exhibit 19 presents the chemical-specific RGOs for the PWSB for the industrial and residential land use scenarios. Remedial goal objectives were calculated for the soil and sediment media in each scenario.

7.3.7 Surface Water Drainage Area 3

Exhibit 20 presents the chemical-specific RGOs for the SW-3 drainage for the industrial and residential land use scenarios. Remedial goal objectives were calculated for the soil medium in each scenario.

7.3.8 Solid Waste Storage Area 5 North

Exhibit 21 presents the chemical-specific RGOs for the SWSA5N for the industrial and residential land use scenarios. Remedial goal objectives were calculated for the soil medium in the industrial scenario and for the soil and groundwater media in the residential scenario.

7.3.9 Solid Waste Storage Area 5 Southeast

Exhibit 22 presents the chemical-specific RGOs for the SWSA5SE for the industrial and residential land use scenarios. Remedial goal objectives were calculated for the soil medium in the industrial scenario and for the soil and groundwater media in the residential scenario.

7.3.10 Solid Waste Storage Area 5 Southwest

Exhibit 23 presents the chemical-specific RGOs for the SWSA5SW for the industrial and residential land use scenarios. Remedial goal objectives were calculated for the soil medium in the industrial scenario and for the soil and groundwater media in the residential scenario.

7.3.11 White Oak Creek

Exhibit 24 presents the chemical-specific RGOs for White Oak Creek for the industrial and residential land use scenarios. Remedial goal objectives are listed for soil in the excavation and industrial scenarios and for soil and groundwater in the residential scenario.

7.3.12 TRU Drainage Area (D1)

Exhibit 25 presents the chemical-specific RGOs for D1 for the residential land use scenario. Remedial goal objectives were calculated for the sediment medium only in this scenario.

7.3.13 Solid Waste Storage Area 5 South Drainage (D2)

Exhibit 26 presents the chemical-specific RGOs for D2 for the industrial and residential land use scenarios. Remedial goal objectives were calculated for the sediment medium in these scenarios.

7.3.14 SW-3 Drainage (D3)

Exhibit 27 presents the chemical-specific RGOs for D3 for the industrial and residential land use scenarios. Remedial goal objectives were calculated for only the sediment medium in these scenarios.

8. REFERENCES

- ATSDR (Agency for Toxic Substances and Disease Registry). 1989a. *Toxicological Profile for Arsenic*. U.S. Department of Health and Human Services, Public Health Service. Atlanta, GA.
- ATSDR (Agency for Toxic Substances and Disease Registry). 1989b. *Toxicological Profile for Plutonium*. U.S. Department of Health and Human Services, Public Health Service. Atlanta, GA.
- ATSDR (Agency for Toxic Substances and Disease Registry). 1989c. *Toxicological Profile for Uranium*. DRAFT. U.S. Department of Health and Human Services, Public Health Service, Atlanta, GA.
- ATSDR (Agency for Toxic Substances and Disease Registry). 1990a. *Toxicological Profile for Plutonium*. U.S. Department of Health and Human Services, Public Health Service, Atlanta, GA.
- ATSDR (Agency for Toxic Substances and Disease Registry). 1990b. *Toxicological Profile for Thorium*. TP-90-25. United States Department of Health and Human Services, Public Health Service. Atlanta, GA.
- ATSDR (Agency for Toxic Substances and Disease Registry). 1993. *Toxicological Profile for Polychlorinated Biphenyls*. U.S. Department of Health and Human Services, Public Health Service. Atlanta, GA.
- Arena, J.M. 1974. *Poisoning: Toxicology, Symptoms, and Treatments*. Charles C. Thomas, Publisher. Springfield, IL.
- Barbier, G. 1961. *Absorption de Radioelements du Sol Par Divers Legumes Cultives dans les Conditions de la Pratique*. French Atomic Energy Commission Report CEA-1860.
- Biomedical and Environmental Analysis Section. 1994. *Toxicity Profiles for Use in Hazardous Waste Risk Assessment and Remediation*. Vol. I. ES/ER/TM-77. Martin Marietta Energy Systems. Health Sciences Research Division. Oak Ridge National Laboratory. Oak Ridge, TN.
- Budavari, S., M.J. O'Neil, A. Smith, and P.E. Heckelman, (eds). 1989. *The Merck Index: An Encyclopedia of Chemicals, Drugs, and Biologicals*, 11th ed. Merck and Company, Inc. Rahway, NJ.
- Burkart, W. 1989. "Radiotoxicity," pp. 805-827 in *Handbook on Toxicity of Inorganic Compounds*. H.G. Seiler, H. Sigel, and A. Sigel, (eds). Marcel Dekker. New York, NY.
- Casarett, A.P. 1968. *Radiation Biology*. Prentice-Hall, Inc. Engelwood Cliffs, NJ.
- Crystal Ball Software Version 3.0. 1993. Decisioneering, Inc. Denver, CO.

- Dunne, L.J. 1990. *Nutrition Almanac*. Third Edition. Nutrition Search, Inc. John D. Kirschmann, Director. McGraw Hill Publishing Company.
- Eicholz, G.G. 1983. "Source Terms for Nuclear Facilities and Medical and Industrial Sites," in *Radiological Assessment*. NUREG/CR-3332. ORNL-5968. J.E. Till and H.R. Meyer, (eds). U.S. Nuclear Regulatory Commission. Washington, DC.
- EPA (United States Environmental Protection Agency). 1973. *Workbook of Atmospheric Dispersion Estimates*. Publication No. AP-26. Office of Air Programs. U.S. Government Printing Office. Washington, DC.
- EPA (United States Environmental Protection Agency). 1977. *Proposed Guidance on Dose Limits for Persons Exposed to Transuranium Elements in the General Environment*. EPA 520/4-77-016. Office of Radiation Programs. Washington, DC.
- EPA (United States Environmental Protection Agency). 1988a. *Federal Guidance Report No. 11: Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion*. EPA/520/1-88/020. Office of Radiation Programs. Washington, DC.
- EPA (United States Environmental Protection Agency). 1988b. *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA*. EPA/540/G-88/004. OSWER Directive 9335.3-01. Office of Solid Waste and Emergency Response. Washington, DC.
- EPA (United States Environmental Protection Agency). 1989. *Risk Assessment Guidance for Superfund*. Volume 1, Human Health Evaluation Manual. EPA/540/1-89/002. Office of Emergency and Remedial Response. Washington, DC.
- EPA (United States Environmental Protection Agency). 1991a. *Region IV Risk Assessment Guidance*. Memorandum from Elmer W. Akin, Health Assessment Officer. Atlanta, GA.
- EPA (United States Environmental Protection Agency). 1991b. *Risk Assessment Guidance for Superfund*. Volume 1, Human Health Evaluation Manual (Part B, Development of Risk-based Preliminary Remediation Goals). Publication 9285.7-01B. Office of Emergency and Remedial Response. Washington, DC.
- EPA (United States Environmental Protection Agency). 1991c. *Risk Assessment for Superfund*. Volume 1, Human Health Evaluation Manual (Supplemental Guidance, Standard Default Exposure Factors). Interim Final. OSWER Directive 9285.6-03. Office of Emergency and Remedial Response. Washington, DC.
- EPA (United States Environmental Protection Agency). 1991d. *Risk Assessment for Superfund*. Volume 1, Human Health Evaluation Manual (Part C, Risk Evaluation of Remedial Alternatives). Interim. Publication 9285.7-01C. Office of Emergency and Remedial Response. Washington, DC.

- EPA (United States Environmental Protection Agency). 1991e. *Test Methods for Evaluating Solid Waste*. SW-846, 3rd Edition. Washington, DC.
- EPA (United States Environmental Protection Agency). 1991f. *Ecological Assessment of Superfund Sites: An Overview*. ECO Update, 1(2). Publication 9345.0-051. Office of Solid Waste and Emergency Response. Washington, DC.
- EPA (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, DC.
- EPA (United States Environmental Protection Agency). 1993. *Health Effects Assessment Summary Tables*. Office of Research and Development and Office of Emergency and Remedial Response. Washington, DC.
- EPA (United States Environmental Protection Agency). 1994a. *Integrated Risk Information System*. IRIS database. Office of Research and Development. Washington, DC.
- EPA (United States Environmental Protection Agency). 1994b. *Revised Interim Soil Lead Guidance for CERCLA Sites and RCRA Corrective Action Facilities*. OSWER directive 9355.4-12.
- Ershow, A.G. and K.P. Cantor. 1989. *Total Water and Tapwater Intake in the United States: Population-based Estimates of Quantities and Sources*. Life Sciences Research Office. Federation of American Societies for Experimental Biology. Bethesda, MD.
- Gillet, N., B. Muggenberg, J. Mewhinney, et al. 1988. "Primary Liver Tumors in Beagle Dogs Exposed by Inhalation to Aerosols of Plutonium-238 Dioxide." *American Journal of Pathology*. 133:265-276.
- Haley, T.J. 1979. *Handbook of the Physics and Chemistry of Rare Earths*, Volume 4, pp. 553-585. K.A. Gschneider, Jr. and L. Eyring, (eds). Elsevier/North-Holland, Amsterdam.
- Hamilton, L.D., et al. 1993. *Pilot Study Risk Assessment for Selected Problems at the Savannah River Site*. Informal Report. BNL-48776. Department of Applied Sciences. Brookhaven National Laboratory. Upton, NY.
- Hammonds, J.A. and Hoffman. 1992. *Toxicity Profiles for Radionuclides*. SENES Oak Ridge, Inc. Center for Risk Analysis. Oak Ridge, TN.
- Harley, J. 1980. "Plutonium in the Environment - A Review," in *J. Radiat. Res.* 21:83-104.
- International Commission on Radiological Protection (ICRP). 1986. *The Metabolism of Plutonium and Related Elements*. ICRP Publication 48. Pergamon Press. Oxford.
- International Commission on Radiological Protection (ICRP). 1989. *Age-dependent Doses to Members of the Public from Intake of Radionuclides: Part 1*. ICRP Publication No. 56. Pergamon Press, Inc. New York, NY.

- International Commission on Radiological Protection (ICRP). 1991. *Recommendations of the International Commission on Radiation Protection*. ICRP Publication No. 60. Pergamon Press, Inc. New York, NY.
- Killough, G.G. and K.F. Eckerman. 1983. "Internal Dosimetry," pp. 7-1 to 7-98 in *Radiological Assessment*. NUREG/CR-3332. ORNL-5966. J.E. Till and H.R. Meyer, (eds). U. S. Nuclear Regulatory Commission. Washington, DC.
- Klaassen, C.D., M.O. Amdur, and J. Doull, (eds). 1986. *Casarett and Doull's Toxicology: The Basic Science of Poisons, 3rd ed.* Macmillan Publishing Company. New York, NY.
- Kocher, D.C. 1981. *Radioactive Decay Data Tables*. DOE/TIC-11026. Technical Information Center. U.S. Department of Energy.
- Martin Marietta Energy Systems. (MMES). 1993. *Annotated Outlines for Documents Required by FFA and CERCLA for Oak Ridge Reservation Sites*. DOE/OR/01-1077. Oak Ridge, TN.
- Metivier, H.J. 1988. "Transuranium Elements," pp. 715-730 in *Handbook on Toxicity of Inorganic Compounds*. H.G. Sieler, H.G. Sigel, and A. Sigel, (eds). Marcel Dekker. New York, NY.
- National Council on Radiation Protection and Measurements (NCRP). 1979. *Tritium in the Environment*. NCRP Report No. 62. Washington, DC.
- National Council on Radiation Protection and Measurements (NCRP). 1977. *Environmental Radiation Measurements*. NCRP Report No. 50. Washington, DC.
- National Research Council (NRC). 1990. *Health Effects of Exposure to Low Levels of Ionizing Radiation. BEIR V*. Committee on the Biological Effects of Ionizing Radiation, Board on Radiation Effects Research, Commission on Life Sciences. National Academy of Sciences.
- National Research Council (NRC). 1980. Advisory Committee on the Biological Effects of Ionizing Radiation. *The Effects on Populations of Exposure to Low Levels of Ionizing Radiation: 1980*. Washington, D.C.: National Academy of Sciences.
- Nuclear Energy Agency/Organization for Economic Cooperation and Development (NEA/OECD). 1981. *The Environmental and Biological Behavior of Plutonium and Some Other Transuranium Elements*. Nuclear Energy Agency. OECD. Paris.
- Roseberry, A.M. and D.E. Burmaster. 1992. Lognormal Distributions for Water Intake by Children and Adults. *Risk Analysis*, 12:65-72.
- Sabbioni, E. and L. Manzo. 1980. *Advances in Neurotoxicology*, pp. 239-270. L. Manzo (ed). Pergamon Press, Inc. Oxford.
- SAIC (Science Applications International Corporation). 1993. *Human Health Baseline Risk Assessment for the Northwest Plume, Paducah Gaseous Diffusion Plant, Paducah, KY*. DOE/OR/07-1202&D1. KY/ER-39.

- Sanders, C.L. 1986. *Toxicological Aspects of Energy Production*. Macmillan Publishing Company. New York, NY.
- SAS Institute Inc. 1990. Statistical Analysis System (SAS) Language. Version 6. Cary, North Carolina.
- Sittig, M. 1981. *Handbook of Toxic and Hazardous Chemicals*. Noyes Publications. Park Ridge, NJ.
- Thomann, R.V. and J.A. Mueller. 1987. *Principles of Surface Water Quality Modeling*. Harper and Row Publishers. New York, NY.
- Till, J.E. and H.R. Meyer. 1983. *Radiological Assessment - A Textbook on Environmental Dose Analysis*. U.S. Nuclear Regulatory Commission. NUREG/CR-3332. ORNL-5968. Washington, DC.
- Turner, J.E. 1986. *Atoms, Radiation, and Radiation Protection*. Pergamon Press, Inc. New York, NY.
- Venugopal, B. and T.D. Luckey. 1978. *Metal Toxicity in Mammals*. Vol. 2. Plenum. New York, NY.
- Voelz, G.L., R.S. Grier, and L.H. Hempelmann. 1985. *Health Physics*, 48, 249.
- Whelan, G., D.L. Streng, J.G. Droppo, Jr., B.L. Steelman, and J.W. Buck. 1987. *The Remedial Action Priority System (RAPS): Mathematical Formulations*. DOE/RL/87-09, PNL-6200. Pacific National Laboratory. Prepared for Assistant Secretary, Environment, Safety, and Health, Office of Environmental Guidance and Compliance.
- World Health Organization (WHO). 1978. *Nitrates, Nitrites, and N-nitroso Compounds*. Environmental Health Criteria 5. United Nations Environment Program and the World Health Organization. Geneva, Switzerland.

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APPENDIX A

Tables

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Table 1a. Summary table of contaminants analyzed for and detected in each media within WAG 5

Analyte	Soil	Sediment	Groundwater	Surface water
Inorganics				
Aluminum	Yes	Yes	Yes	Yes
Antimony	Yes	Yes	Yes	Yes
Arsenic	Yes	Yes	Yes	Yes
Barium	Yes	Yes	Yes	Yes
Beryllium	Yes	Yes	Yes	Yes
Boron			Yes	Yes
Cadmium	Yes			
Calcium	Yes	Yes	Yes	Yes
Chromium	Yes	Yes	Yes	Yes
Cobalt	Yes	Yes	Yes	Yes
Copper	Yes	Yes	Yes	Yes
Iron	Yes	Yes	Yes	Yes
Lead	Yes	Yes	Yes	Yes
Magnesium	Yes	Yes	Yes	Yes
Manganese	Yes	Yes	Yes	Yes
Mercury	Yes	Yes	Yes	Yes
Molybdenum			Yes	
Nickel	Yes	Yes	Yes	Yes
Phosphorus			Yes	
Potassium	Yes	Yes	Yes	Yes
Selenium	Yes	Yes	Yes	Yes
Silicon			Yes	Yes
Silver	Yes	Yes	Yes	
Sodium	Yes	Yes	Yes	Yes
Thallium	Yes	Yes		
Vanadium	Yes	Yes	Yes	Yes
Zinc	Yes	Yes	Yes	Yes

Table 1a. (continued)

Analyte	Soil	Sediment	Groundwater	Surface water
Organics				
1,1,1-Trichloroethane			Yes	Yes
1,1-Dichloroethane		Yes	Yes	Yes
1,1-Dichloroethene		Yes	Yes	Yes
1,2-Benzenedicarboxylic Acid, Diethyl Ester	Yes			
1,2-Dichlorobenzene				Yes
1,2-Dichloroethane		Yes	Yes	Yes
1,2-Dichloroethene (Total)	Yes	Yes	Yes	Yes
1,2-Dichloropropane				Yes
2-Butanone	Yes	Yes		Yes
4,4'-DDD	Yes			
4-Methyl Phenol		Yes		Yes
4-Methyl-2-Pentanone		Yes		Yes
Acetone	Yes	Yes	Yes	
Alpha-BHC				Yes
Aroclor 1248		Yes		
Aroclor 1254	Yes	Yes		
Aroclor 1260	Yes	Yes		
Benzene		Yes	Yes	Yes
Benzene, 1,2,4-Trichloro-				Yes
Benzo(k)Fluoranthene	Yes			
Beta-BHC				Yes
Bis(2-Ethylhexyl) Phthalate	Yes	Yes	Yes	Yes
Bromomethane				Yes
Butyl Benzyl Phthalate	Yes			
Carbolic Acid		Yes		
Carbon Disulfide		Yes	Yes	Yes
Carbon Tetrachloride			Yes	

Table 1a. (continued)

Analyte	Soil	Sediment	Groundwater	Surface water
Chlordane, Gamma-	Yes			
Chloride			Yes	Yes
Chlorobenzene			Yes	
Chloroethane			Yes	
Chloroform	Yes	Yes	Yes	Yes
Chloromethane	Yes			
Cyanide	Yes		Yes	
Delta-BHC				Yes
Di-n-butyl Phthalate	Yes			
Dimethyl Phthalate			Yes	
Endrin	Yes			
Ethylbenzene	Yes			
Fluoranthene	Yes		Yes	
Fluoride			Yes	Yes
Heptachlor Epoxide	Yes			
Methylene Chloride	Yes		Yes	
Nitrate			Yes	Yes
Nitrate/Nitrite				Yes
Organic Chloride			Yes	
Phosphate			Yes	Yes
Phthalic Acid, Dioctyl Ester			Yes	
Pyrene	Yes		Yes	
Styrene	Yes			Yes
Sulfate			Yes	Yes
Sulfide		Yes	Yes	
TOX			Yes	
Tetrachloroethene	Yes		Yes	Yes
Toluene	Yes	Yes	Yes	Yes
Total Organic Carbon	Yes	Yes	Yes	Yes

Table 1a. (continued)

Analyte	Soil	Sediment	Groundwater	Surface water
Trichloroethene		Yes	Yes	Yes
Vinyl Chloride		Yes	Yes	Yes
Xylene (Total)		Yes	Yes	Yes
m-Dichlorobenzene				Yes
p-Dichlorobenzene				Yes
p-Nitrophenol	Yes			
Other				
Alkalinity as CaCO ₃				Yes
Total Dissolved Solids				Yes
Total Kjeldahl Nitrogen-TKN				Yes
Total Suspended Solids				Yes
Radionuclides				
Ac-228	Yes	Yes		
Alpha Particle	Yes	Yes	Yes	Yes
Am-241	Yes	Yes	Yes	Yes
Beta Particle	Yes	Yes	Yes	Yes
Bi-212	Yes	Yes	Yes	
Bi-214	Yes	Yes	Yes	
C-14	Yes	Yes	Yes	Yes
Ca-45	Yes	Yes	Yes	Yes
Cd-109			Yes	
Cm-242	No	Yes	Yes	
Cm-243	Yes		Yes	
Cm-243/244	Yes	Yes	Yes	Yes
Co-57	Yes			
Co-60	Yes	Yes	Yes	Yes
Cs-134	Yes			
Cs-137	Yes	Yes	Yes	Yes

Table 1a. (continued)

Analyte	Soil	Sediment	Groundwater	Surface water
Eu-152		Yes		
Eu-154		Yes		
Eu-155		Yes		
Fe-55			Yes	
Hg-203			Yes	
I-129	Yes	Yes		
K-40	Yes	Yes	Yes	Yes
Mn-54			Yes	
Na-22	Yes			
Pb-210		Yes		
Pb-212	Yes	Yes	Yes	Yes
Pb-214	Yes	Yes		
Pu-238	Yes	Yes	Yes	Yes
Pu-239/240	Yes	Yes	Yes	Yes
Ra-223	Yes	Yes		
Ra-224		Yes		
Ra-226	Yes	Yes	Yes	Yes
Ra-228	Yes	Yes	Yes	Yes
Radon 219		Yes		
Sn-119m				Yes
Sn-126	Yes	Yes		
Tc-99	Yes	Yes	Yes	Yes
Th-228	Yes	Yes	Yes	Yes
Th-230	Yes	Yes	Yes	Yes
Th-231		Yes	Yes	
Th-232	Yes	Yes	Yes	Yes
Th-234	Yes	Yes	Yes	Yes
Tl-208	Yes	Yes		
Total Radioactive Strontium	Yes	Yes	Yes	Yes

Table 1a. (continued)

Analyte	Soil	Sediment	Groundwater	Surface water
Tritium	Yes	Yes	Yes	Yes
U-232	Yes	Yes	Yes	Yes
U-233	Yes	Yes		
U-233/234	Yes	Yes	Yes	Yes
U-235		Yes	Yes	Yes
U-235/236		Yes	Yes	Yes
U-238	Yes	Yes	Yes	Yes

Note: This table is a high-level overview of the presence and analysis/detection of analytes in the four different media of WAG 5. Blank entries, as opposed to 'Yes' entries, indicate that the analyte was either not analyzed for or not detected in the specified environmental medium.

Table 1b. Potential exposure pathways for the different media in each designated area of WAG 5

Area	Soil						Sediment				Groundwater				Surface water		
	IG	IGP	D	IH	EX		IG	D	IH	EX	IG	IGP	D	IH	IG	D	IH
FS	Y	Y	Y	Y	Y		Y				Y	Y	Y	Y			
NIIFT	Y	Y	Y	Y	Y												
OIIFP	Y	Y	Y	Y	Y		Y		Y	Y	Y	Y	Y	Y			Y
OIIFT	Y	Y	Y	Y	Y												
PWSB	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y	Y	Y	Y			Y
SW3	Y	Y	Y	Y	Y												
SWSA5N	Y	Y	Y	Y	Y												
SWSA5SE	Y	Y	Y	Y	Y		Y	Y			Y	Y	Y	Y			
SWSA5SW	Y	Y	Y	Y	Y		Y	Y			Y	Y	Y	Y			
WOC	Y	Y	Y	Y	Y						Y	Y	Y	Y			
D1							Y	Y	Y	Y							Y
D2							Y	Y	Y	Y							Y
D3							Y	Y	Y	Y							Y
MB															Y	Y	Y
MBT																	Y

IG = Ingestion; IGP = Ingestion of Produce; D = Dermal; IH = Inhalation; EX = External; FS = Fissile Storage; NIIFT = New Hydrofracture Tank; OIIFP = Old Hydrofracture Pond; OIIFT = Old Hydrofracture Tank; PWSB = Process Waste Sludge Basin; SW3 = Surface Water Area 3; SWSA5 = Solid Waste Storage Area 5; N = North; SE = South East and SW = South West; WOC = White Oak Creek; D = Drainage; MB = Melton Branch; MBT = Melton Branch Tributary; Y = Yes.

Table 2a. Comparison of WAG 5 Soil MD with TMBG values-Residential Scenario

Analyte	Frequency of detection	Mean Concentration (MC)	Maximum Detection (MD)	Mean Background (MBG)	Twice Mean Background (TMBG)	Does MD exceed TMBG ?	Units
FS							
Inorganics							
Aluminum	1/1	9.00E+03	9.00E+03	2.50E+04	5.00E+04	NO	MG/KG
Antimony	0/1	2.60E+00		2.20E-01	4.40E-01		MG/KG
Arsenic	1/1	1.16E+01	1.16E+01	6.40E+00	1.30E+01	NO	MG/KG
Barium	1/1	7.09E+01	7.09E+01	1.20E+02	2.40E+02	NO	MG/KG
Beryllium	1/1	6.20E-01	6.20E-01	1.00E+00	2.10E+00	NO	MG/KG
Cadmium	0/1	6.50E-01		2.20E-01	4.40E-01		MG/KG
Calcium	1/1	4.11E+04	4.11E+04	1.30E+03	2.60E+03	YES	MG/KG
Chromium	1/1	1.89E+01	1.89E+01	2.60E+01	5.10E+01	NO	MG/KG
Cobalt	1/1	1.12E+01	1.12E+01	1.90E+01	3.70E+01	NO	MG/KG
Copper	1/1	1.16E+01	1.16E+01	1.90E+01	3.80E+01	NO	MG/KG
Iron	1/1	2.27E+04	2.27E+04	3.30E+04	6.70E+04	NO	MG/KG
Lead	1/1	2.70E+01	2.70E+01	2.20E+01	4.40E+01	NO	MG/KG
Magnesium	1/1	2.11E+03	2.11E+03	3.70E+03	7.30E+03	NO	MG/KG
Manganese	1/1	1.02E+03	1.02E+03	1.20E+03	2.40E+03	NO	MG/KG
Mercury	1/1	4.30E+00	4.30E+00	3.00E-01	5.90E-01	YES	MG/KG
Nickel	1/1	7.50E+00	7.50E+00	2.90E+01	5.80E+01	NO	MG/KG
Potassium	1/1	9.01E+02	9.01E+02	2.90E+03	5.70E+03	NO	MG/KG
Selenium	0/1	3.50E-01		6.60E-01	1.30E+00		MG/KG
Silver	0/1	6.50E-01		2.00E+00	4.00E+00		MG/KG
Sodium	1/1	4.83E+01	4.83E+01				MG/KG
Thallium	0/1	2.20E-01		4.40E-01	8.70E-01		MG/KG
Vanadium	1/1	2.07E+01	2.07E+01	3.80E+01	7.60E+01	NO	MG/KG
Zinc	1/1	4.14E+01	4.14E+01	6.00E+01	1.20E+02	NO	MG/KG
Organics							
1,1,1-Trichloroethane	0/1	1.20E-02		5.00E-03	1.00E-02		MG/KG
1,1-Dichloroethane	0/1	1.20E-02		5.00E-03	1.00E-02		MG/KG
1,2-Benzenedicarboxylic Acid, Diethyl Ester	0/1	3.90E-01					MG/KG
1,2-Dichloroethene (Total)	0/1	1.20E-02					MG/KG
2-Butanone	0/1	1.20E-02		8.40E-02	1.70E-01		MG/KG
4,4'-DDD	0/1	3.90E-03		8.20E-03	1.60E-02		MG/KG

Table 2a. (continued)

Analyte	Frequency of detection	Mean Concentration (MC)	Maximum Detection (MD)	Mean Background (MBG)	Twice Mean Background (TMBG)	Does MD exceed TMBG ?	Units
Acetone	0/1	1.20E-02		3.80E-02	7.60E-02		MG/KG
Aroclor 1254	0/1	3.90E-02		8.20E-02	1.60E-01		MG/KG
Aroclor 1260	1/1	1.80E-01	1.80E-01	8.20E-02	1.60E-01	YES	MG/KG
Benzo(k)Fluoranthene	0/1	3.90E-01		4.10E-02	8.10E-02		MG/KG
Bis(2-Ethylhexyl) Phthalate	0/1	3.90E-01					MG/KG
Butyl Benzyl Phthalate	0/1	3.90E-01					MG/KG
Carbon Tetrachloride	0/1	1.20E-02		5.00E-03	1.00E-02		MG/KG
Chlordane, Gamma-	0/1	2.00E-03					MG/KG
Chloroform	0/1	1.20E-02		5.30E-03	1.10E-02		MG/KG
Chloromethane	0/1	1.20E-02		1.00E-02	2.00E-02		MG/KG
Cyanide	0/1	2.70E-01		2.40E-01	4.90E-01		MG/KG
Di-n-butyl Phthalate	0/1	3.60E-01					MG/KG
Endrin	0/1	3.90E-03		8.20E-03	1.60E-02		MG/KG
Ethylbenzene	0/1	1.20E-02		5.00E-03	1.00E-02		MG/KG
Fluoranthene	0/1	3.90E-01		3.50E-01	7.00E-01		MG/KG
Heptachlor Epoxide	0/1	2.00E-03		4.10E-03	8.20E-03		MG/KG
Methylene Chloride	0/1	1.20E-02		5.00E-03	1.00E-02		MG/KG
Pyrene	1/1	4.10E-02	4.10E-02	9.50E-01	1.90E+00	NO	MG/KG
Styrene	0/1	1.20E-02		5.00E-03	1.00E-02		MG/KG
Tetrachloroethene	0/1	1.20E-02		5.00E-03	1.00E-02		MG/KG
Toluene	0/1	1.20E-02		5.00E-03	1.00E-02		MG/KG
Trichloroethene	0/1	1.20E-02		5.00E-03	1.00E-02		MG/KG
p-Nitrophenol	0/1	9.40E-01					MG/KG
Radionuclides							
Alpha Particle	1/1	2.40E+01	2.40E+01				PCI/G
Am-241	0/1	5.00E-01		4.00E-02	8.10E-02		PCI/G
Beta Particle	1/1	3.80E+02	3.80E+02				PCI/G
C-14	0/1	2.90E-01					PCI/G
Cm-242	0/1	1.70E-01					PCI/G
Cm-243/244	0/1	3.70E-01		1.40E+00	2.80E+00		PCI/G
Co-60	1/1	1.80E+02	1.80E+02	9.70E-03	1.90E-02	YES	PCI/G
Cs-137	1/1	3.60E+01	3.60E+01	7.20E-01	1.40E+00	YES	PCI/G

Table 2a. (continued)

Analyte	Frequency of detection	Mean Concentration (MC)	Maximum Detection (MD)	Mean Background (MBG)	Twice Mean Background (TMBG)	Does MD exceed TMBG ?	Units
K-40	1/1	3.20E+01	3.20E+01	1.60E+01	3.20E+01	NO	PCI/G
Pb-212	1/1	1.50E+00	1.50E+00				PCI/G
Pu-238	0/1	4.50E-01		8.30E-02	1.70E-01		PCI/G
Pu-239/240	0/1	4.50E-01		2.90E-02	5.90E-02		PCI/G
Ra-226	1/1	3.60E+00	3.60E+00	7.70E-01	1.50E+00	YES	PCI/G
Ra-228	0/1	5.00E-01					PCI/G
Th-230	0/1	1.30E+00		6.20E-01	1.20E+00		PCI/G
Th-232	1/1	1.90E+00	1.90E+00	7.10E-01	1.40E+00	YES	PCI/G
Total Radioactive Strontium	1/1	1.20E+02	1.20E+02	9.70E-01	1.90E+00	YES	PCI/G
Tritium	1/1	3.50E-01	3.50E-01	4.20E-02	8.40E-02	YES	PCI/G
U-233/234	1/1	7.30E+00	7.30E+00				PCI/G
U-238	1/1	7.00E+00	7.00E+00	1.20E+00	2.30E+00	YES	PCI/G
NHFT							
Inorganics							
Aluminum	2/2	1.66E+04	1.68E+04	2.50E+04	5.00E+04	NO	MG/KG
Arsenic	2/2	3.05E+00	3.10E+00	6.40E+00	1.30E+01	NO	MG/KG
Barium	2/2	1.91E+02	2.23E+02	1.20E+02	2.40E+02	NO	MG/KG
Beryllium	2/2	9.70E-01	9.80E-01	1.00E+00	2.10E+00	NO	MG/KG
Cadmium	0/2	4.90E-01		2.20E-01	4.40E-01		MG/KG
Calcium	2/2	4.51E+03	4.96E+03	1.30E+03	2.60E+03	YES	MG/KG
Chromium	2/2	2.90E+01	3.16E+01	2.60E+01	5.10E+01	NO	MG/KG
Cobalt	2/2	1.98E+01	2.00E+01	1.90E+01	3.70E+01	NO	MG/KG
Copper	2/2	2.17E+01	2.32E+01	1.90E+01	3.80E+01	NO	MG/KG
Iron	2/2	2.81E+04	2.85E+04	3.30E+04	6.70E+04	NO	MG/KG
Lead	2/2	8.10E+00	8.20E+00	2.20E+01	4.40E+01	NO	MG/KG
Magnesium	2/2	4.42E+03	4.96E+03	3.70E+03	7.30E+03	NO	MG/KG
Manganese	2/2	1.60E+03	1.81E+03	1.20E+03	2.40E+03	NO	MG/KG
Mercury	0/2	6.00E-02		3.00E-01	5.90E-01		MG/KG
Nickel	2/2	2.72E+01	3.03E+01	2.90E+01	5.80E+01	NO	MG/KG
Potassium	2/2	1.76E+03	2.04E+03	2.90E+03	5.70E+03	NO	MG/KG
Silver	2/2	1.25E+00	1.40E+00	2.00E+00	4.00E+00	NO	MG/KG
Sodium	2/2	5.11E+01	5.82E+01				MG/KG

Table 2a. (continued)

Analyte	Frequency of detection	Mean Concentration (MC)	Maximum Detection (MD)	Mean Background (MBG)	Twice Mean Background (TMBG)	Does MD exceed TMBG ?	Units
Thallium	0/2	8.25E-01		4.40E-01	8.70E-01		MG/KG
Vanadium	2/2	2.34E+01	2.34E+01	3.80E+01	7.60E+01	NO	MG/KG
Zinc	2/2	4.64E+01	4.99E+01	6.00E+01	1.20E+02	NO	MG/KG
Organics							
1,1,1-Trichloroethane	0/6	1.20E-02		5.00E-03	1.00E-02		MG/KG
1,1-Dichloroethane	0/6	1.20E-02		5.00E-03	1.00E-02		MG/KG
1,2-Benzenedicarboxylic Acid, Diethyl Ester	0/2	3.85E-01					MG/KG
1,2-Dichloroethene (Total)	0/6	1.20E-02					MG/KG
2-Butanone	0/6	1.20E-02		8.40E-02	1.70E-01		MG/KG
4,4'-DDD	0/2	3.85E-03		8.20E-03	1.60E-02		MG/KG
Acetone	0/6	1.13E-02		3.80E-02	7.60E-02		MG/KG
Aroclor 1254	0/2	3.20E-02		8.20E-02	1.60E-01		MG/KG
Aroclor 1260	0/2	3.60E-02		8.20E-02	1.60E-01		MG/KG
Benzo(k)Fluoranthene	0/2	3.85E-01		4.10E-02	8.10E-02		MG/KG
Bis(2-Ethylhexyl) Phthalate	0/2	3.85E-01					MG/KG
Butyl Benzyl Phthalate	0/2	3.85E-01					MG/KG
Carbon Tetrachloride	0/6	1.20E-02		5.00E-03	1.00E-02		MG/KG
Chlordane, Gamma-	0/2	2.00E-03					MG/KG
Chloroform	0/6	1.20E-02		5.30E-03	1.10E-02		MG/KG
Chloromethane	0/6	1.20E-02		1.00E-02	2.00E-02		MG/KG
Cyanide	0/2	5.75E-01		2.40E-01	4.90E-01		MG/KG
Di-n-butyl Phthalate	2/2	8.55E-02	1.30E-01				MG/KG
Endrin	0/2	3.85E-03		8.20E-03	1.60E-02		MG/KG
Ethylbenzene	0/6	1.20E-02		5.00E-03	1.00E-02		MG/KG
Fluoranthene	0/2	3.85E-01		3.50E-01	7.00E-01		MG/KG
Heptachlor Epoxide	0/2	2.00E-03		4.10E-03	8.20E-03		MG/KG
Methylene Chloride	0/6	8.50E-03		5.00E-03	1.00E-02		MG/KG
Pyrene	0/2	3.85E-01		9.50E-01	1.90E+00		MG/KG
Styrene	0/6	1.20E-02		5.00E-03	1.00E-02		MG/KG
Tetrachloroethene	0/6	1.20E-02		5.00E-03	1.00E-02		MG/KG
Toluene	1/6	1.02E-02	1.00E-03	5.00E-03	1.00E-02	NO	MG/KG
Total Organic Carbon	2/2	3.45E+02	4.03E+02				MG/KG

Table 2a. (continued)

Analyte	Frequency of detection	Mean Concentration (MC)	Maximum Detection (MD)	Mean Background (MBG)	Twice Mean Background (TMBG)	Does MD exceed TMBG ?	Units
Trichloroethene	0/6	1.20E-02		5.00E-03	1.00E-02		MG/KG
p-Nitrophenol	1/2	4.89E-01	5.80E-02				MG/KG
Radionuclides							
Alpha Particle	2/2	7.65E+00	8.59E+00				PCI/G
Am-241	1/2	5.80E-02	1.11E-01	4.00E-02	8.10E-02	YES	PCI/G
Beta Particle	2/2	2.72E+01	3.27E+01				PCI/G
C-14	1/2	1.96E+00	3.08E+00				PCI/G
Cm-242	0/2	9.35E-03					PCI/G
Cm-243/244	0/2	2.26E-02		1.40E+00	2.80E+00		PCI/G
Cs-137	1/2	7.91E-02	1.37E-01	7.20E-01	1.40E+00	NO	PCI/G
K-40	2/2	2.35E+01	2.62E+01	1.60E+01	3.20E+01	NO	PCI/G
Pu-238	2/2	1.80E-01	2.62E-01	8.30E-02	1.70E-01	YES	PCI/G
Pu-239/240	1/2	3.29E-02	5.10E-02	2.90E-02	5.90E-02	NO	PCI/G
Ra-226	2/2	7.78E-01	7.79E-01	7.70E-01	1.50E+00	NO	PCI/G
Ra-228	2/2	1.50E+00	1.61E+00				PCI/G
Tc-99	0/2	1.05E-01					PCI/G
Th-228	2/2	1.61E+00	1.67E+00	7.50E-01	1.50E+00	YES	PCI/G
Th-230	2/2	7.27E-01	1.28E+00	6.20E-01	1.20E+00	YES	PCI/G
Th-232	2/2	1.45E+00	1.55E+00	7.10E-01	1.40E+00	YES	PCI/G
Total Radioactive Strontium	1/2	5.11E-01	8.07E-01	9.70E-01	1.90E+00	NO	PCI/G
Tritium	2/2	7.14E-01	7.40E-01	4.20E-02	8.40E-02	YES	PCI/G
U-232	0/2	-1.05E-02					PCI/G
U-233/234	2/2	9.25E-01	9.69E-01				PCI/G
U-235/236	0/2	4.88E-02		3.10E-02	6.20E-02		PCI/G
U-238	2/2	9.11E-01	9.81E-01	1.20E+00	2.30E+00	NO	PCI/G
OHFP							
Inorganics							
Aluminum	5/5	2.30E+04	3.31E+04	2.50E+04	5.00E+04	NO	MG/KG
Antimony	0/1	6.80E+00		2.20E-01	4.40E-01		MG/KG
Arsenic	4/5	2.84E+00	5.10E+00	6.40E+00	1.30E+01	NO	MG/KG
Barium	5/5	1.07E+02	1.85E+02	1.20E+02	2.40E+02	NO	MG/KG
Beryllium	3/5	9.22E-01	1.10E+00	1.00E+00	2.10E+00	NO	MG/KG

Table 2a. (continued)

Analyte	Frequency of detection	Mean Concentration (MC)	Maximum Detection (MD)	Mean Background (MBG)	Twice Mean Background (TMBG)	Does MD exceed TMBG ?	Units
Cadmium	1/5	6.95E-01	2.00E+00	2.20E-01	4.40E-01	YES	MG/KG
Calcium	5/5	7.41E+04	2.46E+05	1.30E+03	2.60E+03	YES	MG/KG
Chromium	5/5	2.56E+01	3.48E+01	2.60E+01	5.10E+01	NO	MG/KG
Cobalt	4/5	1.40E+01	1.85E+01	1.90E+01	3.70E+01	NO	MG/KG
Copper	4/5	1.85E+01	2.42E+01	1.90E+01	3.80E+01	NO	MG/KG
Iron	5/5	2.71E+04	3.74E+04	3.30E+04	6.70E+04	NO	MG/KG
Lead	5/5	2.04E+01	2.32E+01	2.20E+01	4.40E+01	NO	MG/KG
Magnesium	5/5	1.14E+04	2.26E+04	3.70E+03	7.30E+03	YES	MG/KG
Manganese	5/5	6.68E+02	1.09E+03	1.20E+03	2.40E+03	NO	MG/KG
Mercury	4/5	1.37E-01	3.10E-01	3.00E-01	5.90E-01	NO	MG/KG
Nickel	3/5	2.43E+01	3.72E+01	2.90E+01	5.80E+01	NO	MG/KG
Potassium	5/5	2.04E+03	3.35E+03	2.90E+03	5.70E+03	NO	MG/KG
Selenium	0/3	6.70E-01		6.60E-01	1.30E+00		MG/KG
Silver	0/5	8.14E-01		2.00E+00	4.00E+00		MG/KG
Sodium	1/5	1.08E+02	9.08E+01				MG/KG
Thallium	0/5	5.58E-01		4.40E-01	8.70E-01		MG/KG
Vanadium	4/5	3.00E+01	3.55E+01	3.80E+01	7.60E+01	NO	MG/KG
Zinc	5/5	5.67E+01	7.58E+01	6.00E+01	1.20E+02	NO	MG/KG
Organics							
1,1,1-Trichloroethane	0/8	1.26E-02		5.00E-03	1.00E-02		MG/KG
1,1-Dichloroethane	0/8	1.26E-02		5.00E-03	1.00E-02		MG/KG
1,2-Benzenedicarboxylic Acid, Diethyl Ester	0/4	3.95E-01					MG/KG
1,2-Dichloroethene (Total)	0/8	1.26E-02					MG/KG
2-Butanone	0/8	1.26E-02		8.40E-02	1.70E-01		MG/KG
4,4'-DDD	0/4	3.93E-03		8.20E-03	1.60E-02		MG/KG
Acetone	3/8	2.33E-02	6.50E-01	3.80E-02	7.60E-02	YES	MG/KG
Aroclor 1254	1/4	3.73E-02	3.20E-02	8.20E-02	1.60E-01	NO	MG/KG
Aroclor 1260	1/4	3.17E-02	9.60E-03	8.20E-02	1.60E-01	NO	MG/KG
Benzo(k)Fluoranthene	0/4	3.95E-01		4.10E-02	8.10E-02		MG/KG
Bis(2-Ethylhexyl) Phthalate	0/4	3.95E-01					MG/KG
Butyl Benzyl Phthalate	0/4	3.95E-01					MG/KG
Carbon Tetrachloride	0/8	1.26E-02		5.00E-03	1.00E-02		MG/KG

Table 2a. (continued)

Analyte	Frequency of detection	Mean Concentration (MC)	Maximum Detection (MD)	Mean Background (MBG)	Twice Mean Background (TMBG)	Does MD exceed TMBG ?	Units
Chlordane, Gamma-	1/4	1.93E-03	1.30E-03				MG/KG
Chloroform	0/8	1.26E-02		5.30E-03	1.10E-02		MG/KG
Chloromethane	1/8	1.13E-02	2.00E-03	1.00E-02	2.00E-02	NO	MG/KG
Cyanide	0/3	5.80E-01		2.40E-01	4.90E-01		MG/KG
Di-n-butyl Phthalate	0/4	3.50E-01					MG/KG
Endrin	0/4	3.93E-03		8.20E-03	1.60E-02		MG/KG
Ethylbenzene	0/8	1.26E-02		5.00E-03	1.00E-02		MG/KG
Fluoranthene	0/4	3.95E-01		3.50E-01	7.00E-01		MG/KG
Heptachlor Epoxide	1/4	1.74E-03	5.40E-04	4.10E-03	8.20E-03	NO	MG/KG
Methylene Chloride	0/8	1.26E-02		5.00E-03	1.00E-02		MG/KG
Pyrene	0/4	3.95E-01		9.50E-01	1.90E+00		MG/KG
Styrene	0/8	1.26E-02		5.00E-03	1.00E-02		MG/KG
Tetrachloroethene	0/8	1.26E-02		5.00E-03	1.00E-02		MG/KG
Toluene	1/8	1.13E-02	1.00E-03	5.00E-03	1.00E-02	NO	MG/KG
Total Organic Carbon	2/2	3.79E+03	6.36E+03				MG/KG
Trichloroethene	0/8	1.26E-02		5.00E-03	1.00E-02		MG/KG
p-Nitrophenol	1/4	7.26E-01	8.20E-02				MG/KG
Radionuclides							
Alpha Particle	5/5	4.27E+01	1.75E+02				PCI/G
Am-241	4/5	1.04E-01	4.70E-01	4.00E-02	8.10E-02	YES	PCI/G
Beta Particle	5/5	7.54E+02	3.41E+03				PCI/G
C-14	0/4	7.68E-01					PCI/G
Cm-242	0/4	8.00E-03					PCI/G
Cm-243	0/1	0.00E+00		5.90E-02	1.20E-01		PCI/G
Cm-243/244	3/4	2.92E-01	5.30E-01	1.40E+00	2.80E+00	NO	PCI/G
Co-60	4/4	2.98E-01	6.15E-01	9.70E-03	1.90E-02	YES	PCI/G
Cs-137	5/5	1.36E+03	1.15E+03	7.20E-01	1.40E+00	YES	PCI/G
K-40	5/5	2.13E+01	2.28E+01	1.60E+01	3.20E+01	NO	PCI/G
Pu-238	3/5	8.94E-02	1.18E-01	8.30E-02	1.70E-01	NO	PCI/G
Pu-239/240	1/5	3.08E-02	5.90E-02	2.90E-02	5.90E-02	YES	PCI/G
Ra-226	4/5	1.05E+00	1.35E+00	7.70E-01	1.50E+00	NO	PCI/G
Ra-228	4/5	8.84E-01	1.38E+00				PCI/G

Table 2a. (continued)

Analyte	Frequency of detection	Mean Concentration (MC)	Maximum Detection (MD)	Mean Background (MBG)	Twice Mean Background (TMBG)	Does MD exceed TMBG ?	Units
Tc-99	0/4	2.43E-01					PCI/G
Th-228	5/5	1.40E+00	1.57E+00	7.50E-01	1.50E+00	YES	PCI/G
Th-230	5/5	1.12E+00	1.50E+00	6.20E-01	1.20E+00	YES	PCI/G
Th-232	5/5	1.23E+00	1.36E+00	7.10E-01	1.40E+00	NO	PCI/G
Total Radioactive Strontium	4/5	8.57E+01	1.42E+03	9.70E-01	1.90E+00	YES	PCI/G
Tritium	4/4	1.14E+00	1.67E+00	4.20E-02	8.40E-02	YES	PCI/G
U-232	0/4	9.50E-03					PCI/G
U-233/234	5/5	8.20E-01	9.07E-01				PCI/G
U-235/236	0/4	1.81E-02		3.10E-02	6.20E-02		PCI/G
U-238	5/5	9.33E-01	1.16E+00	1.20E+00	2.30E+00	NO	PCI/G
OHFT							
Inorganics							
Aluminum	5/5	2.66E+04	3.12E+04	2.50E+04	5.00E+04	NO	MG/KG
Arsenic	5/5	2.96E+00	3.70E+00	6.40E+00	1.30E+01	NO	MG/KG
Barium	5/5	1.09E+02	1.25E+02	1.20E+02	2.40E+02	NO	MG/KG
Beryllium	4/5	1.52E+00	1.90E+00	1.00E+00	2.10E+00	NO	MG/KG
Cadmium	0/5	2.82E-01		2.20E-01	4.40E-01		MG/KG
Calcium	5/5	4.66E+04	5.67E+04	1.30E+03	2.60E+03	YES	MG/KG
Chromium	5/5	3.00E+01	3.41E+01	2.60E+01	5.10E+01	NO	MG/KG
Cobalt	5/5	1.81E+01	2.05E+01	1.90E+01	3.70E+01	NO	MG/KG
Copper	4/5	1.81E+01	2.05E+01	1.90E+01	3.80E+01	NO	MG/KG
Iron	5/5	2.99E+04	3.47E+04	3.30E+04	6.70E+04	NO	MG/KG
Lead	5/5	2.13E+01	2.66E+01	2.20E+01	4.40E+01	NO	MG/KG
Magnesium	5/5	6.29E+03	9.61E+03	3.70E+03	7.30E+03	YES	MG/KG
Manganese	5/5	1.07E+03	1.40E+03	1.20E+03	2.40E+03	NO	MG/KG
Mercury	1/5	8.92E-02	1.30E-01	3.00E-01	5.90E-01	NO	MG/KG
Nickel	5/5	2.98E+01	3.50E+01	2.90E+01	5.80E+01	NO	MG/KG
Potassium	5/5	2.24E+03	3.07E+03	2.90E+03	5.70E+03	NO	MG/KG
Selenium	0/5	1.21E+00		6.60E-01	1.30E+00		MG/KG
Silver	2/5	1.51E+00	5.00E+00	2.00E+00	4.00E+00	YES	MG/KG
Sodium	3/5	8.01E+01	1.01E+02				MG/KG
Thallium	0/5	8.24E-01		4.40E-01	8.70E-01		MG/KG

Table 2a. (continued)

Analyte	Frequency of detection	Mean Concentration (MC)	Maximum Detection (MD)	Mean Background (MBG)	Twice Mean Background (TMBG)	Does MD exceed TMBG ?	Units
Vanadium	5/5	3.15E+01	3.76E+01	3.80E+01	7.60E+01	NO	MG/KG
Zinc	5/5	6.37E+01	7.16E+01	6.00E+01	1.20E+02	NO	MG/KG
Organics							
1,1,1-Trichloroethane	0/15	1.24E-02		5.00E-03	1.00E-02		MG/KG
1,1-Dichloroethane	0/15	1.24E-02		5.00E-03	1.00E-02		MG/KG
1,2-Benzenedicarboxylic Acid, Diethyl Ester	0/5	4.12E-01					MG/KG
1,2-Dichloroethene (Total)	0/15	1.24E-02					MG/KG
2-Butanone	0/15	1.24E-02		8.40E-02	1.70E-01		MG/KG
4,4'-DDD	0/5	4.10E-03		8.20E-03	1.60E-02		MG/KG
Acetone	6/15	1.27E-02	8.10E-02	3.80E-02	7.60E-02	YES	MG/KG
Aroclor 1254	0/5	4.10E-02		8.20E-02	1.60E-01		MG/KG
Aroclor 1260	0/5	4.10E-02		8.20E-02	1.60E-01		MG/KG
Benzo(k)Fluoranthene	0/5	4.10E-01		4.10E-02	8.10E-02		MG/KG
Bis(2-Ethylhexyl) Phthalate	1/5	3.48E-01	1.10E-01				MG/KG
Butyl Benzyl Phthalate	1/5	3.36E-01	5.20E-02				MG/KG
Carbon Tetrachloride	0/15	1.24E-02		5.00E-03	1.00E-02		MG/KG
Chlordane, Gamma-	0/5	2.14E-03					MG/KG
Chloroform	0/15	1.24E-02		5.30E-03	1.10E-02		MG/KG
Chloromethane	0/15	1.24E-02		1.00E-02	2.00E-02		MG/KG
Cyanide	1/5	6.42E-01	7.00E-01	2.40E-01	4.90E-01	YES	MG/KG
Di-n-butyl Phthalate	1/5	4.22E-01	4.40E-01				MG/KG
Endrin	0/5	4.10E-03		8.20E-03	1.60E-02		MG/KG
Ethylbenzene	0/15	1.24E-02		5.00E-03	1.00E-02		MG/KG
Fluoranthene	0/5	4.10E-01		3.50E-01	7.00E-01		MG/KG
Heptachlor Epoxide	0/5	2.14E-03		4.10E-03	8.20E-03		MG/KG
Methylene Chloride	0/15	1.17E-02		5.00E-03	1.00E-02		MG/KG
Pyrene	0/5	4.10E-01		9.50E-01	1.90E+00		MG/KG
Styrene	0/15	1.24E-02		5.00E-03	1.00E-02		MG/KG
Tetrachloroethene	0/15	1.24E-02		5.00E-03	1.00E-02		MG/KG
Toluene	3/15	1.02E-02	2.00E-03	5.00E-03	1.00E-02	NO	MG/KG
Total Organic Carbon	5/5	2.70E+03	4.56E+03				MG/KG
Trichloroethene	0/15	1.24E-02		5.00E-03	1.00E-02		MG/KG

Table 2a. (continued)

Analyte	Frequency of detection	Mean Concentration (MC)	Maximum Detection (MD)	Mean Background (MBG)	Twice Mean Background (TMBG)	Does MD exceed TMBG ?	Units
p-Nitrophenol	0/5	9.82E-01					MG/KG
Radionuclides							
Alpha Particle	5/5	8.99E+00	1.84E+01				PCI/G
Am-241	4/5	1.11E-01	4.20E-01	4.00E-02	8.10E-02	YES	PCI/G
Beta Particle	5/5	2.83E+01	3.57E+01				PCI/G
C-14	0/5	6.58E-01					PCI/G
Cm-242	0/4	-6.99E-03					PCI/G
Cm-243	0/1	8.00E-02		5.90E-02	1.20E-01		PCI/G
Cm-243/244	0/4	-5.83E-03		1.40E+00	2.80E+00		PCI/G
Cs-137	5/5	2.68E+00	7.07E+00	7.20E-01	1.40E+00	YES	PCI/G
K-40	5/5	2.17E+01	2.81E+01	1.60E+01	3.20E+01	NO	PCI/G
Pu-238	3/5	1.88E-01	1.60E+00	8.30E-02	1.70E-01	YES	PCI/G
Pu-239/240	0/5	1.99E-02		2.90E-02	5.90E-02		PCI/G
Ra-226	5/5	1.05E+00	1.76E+00	7.70E-01	1.50E+00	YES	PCI/G
Ra-228	5/5	1.47E+00	2.40E+00				PCI/G
Tc-99	0/5	1.26E-01					PCI/G
Th-228	5/5	1.39E+00	1.54E+00	7.50E-01	1.50E+00	YES	PCI/G
Th-230	5/5	1.02E+00	1.24E+00	6.20E-01	1.20E+00	NO	PCI/G
Th-232	5/5	1.19E+00	1.48E+00	7.10E-01	1.40E+00	YES	PCI/G
Total Radioactive Strontium	5/5	9.52E-01	1.80E+00	9.70E-01	1.90E+00	NO	PCI/G
Tritium	5/5	1.69E+00	3.07E+00	4.20E-02	8.40E-02	YES	PCI/G
U-232	0/4	8.75E-03					PCI/G
U-233/234	5/5	9.85E-01	1.21E+00				PCI/G
U-235/236	0/3	3.03E-02		3.10E-02	6.20E-02		PCI/G
U-238	5/5	8.62E-01	1.06E+00	1.20E+00	2.30E+00	NO	PCI/G
PWSB							
Inorganics							
Aluminum	5/5	2.43E+04	2.72E+04	2.50E+04	5.00E+04	NO	MG/KG
Antimony	0/1	2.90E+00		2.20E-01	4.40E-01		MG/KG
Arsenic	5/5	2.40E+00	2.80E+00	6.40E+00	1.30E+01	NO	MG/KG
Barium	5/5	1.56E+02	2.39E+02	1.20E+02	2.40E+02	YES	MG/KG
Beryllium	5/5	1.22E+00	1.50E+00	1.00E+00	2.10E+00	NO	MG/KG

Table 2a. (continued)

Analyte	Frequency of detection	Mean Concentration (MC)	Maximum Detection (MD)	Mean Background (MBG)	Twice Mean Background (TMBG)	Does MD exceed TMBG ?	Units
Cadmium	0/5	3.40E-01		2.20E-01	4.40E-01		MG/KG
Calcium	5/5	4.14E+03	1.17E+04	1.30E+03	2.60E+03	YES	MG/KG
Chromium	5/5	3.33E+01	3.70E+01	2.60E+01	5.10E+01	NO	MG/KG
Cobalt	5/5	1.86E+01	2.16E+01	1.90E+01	3.70E+01	NO	MG/KG
Copper	4/5	2.18E+01	2.53E+01	1.90E+01	3.80E+01	NO	MG/KG
Iron	5/5	3.03E+04	3.36E+04	3.30E+04	6.70E+04	NO	MG/KG
Lead	5/5	1.13E+01	1.53E+01	2.20E+01	4.40E+01	NO	MG/KG
Magnesium	5/5	6.42E+03	7.18E+03	3.70E+03	7.30E+03	NO	MG/KG
Manganese	5/5	8.18E+02	1.13E+03	1.20E+03	2.40E+03	NO	MG/KG
Mercury	0/5	6.60E-02		3.00E-01	5.90E-01		MG/KG
Nickel	5/5	3.53E+01	4.19E+01	2.90E+01	5.80E+01	NO	MG/KG
Potassium	5/5	2.70E+03	2.96E+03	2.90E+03	5.70E+03	NO	MG/KG
Selenium	1/4	8.48E-01	9.40E-01	6.60E-01	1.30E+00	NO	MG/KG
Silver	2/5	9.58E-01	1.40E+00	2.00E+00	4.00E+00	NO	MG/KG
Sodium	3/5	7.34E+01	8.31E+01				MG/KG
Thallium	1/5	4.10E-01	3.70E-01	4.40E-01	8.70E-01	NO	MG/KG
Vanadium	5/5	2.72E+01	3.11E+01	3.80E+01	7.60E+01	NO	MG/KG
Zinc	5/5	6.97E+01	7.61E+01	6.00E+01	1.20E+02	NO	MG/KG
Organics							
1,1,1-Trichloroethane	0/14	1.20E-02		5.00E-03	1.00E-02		MG/KG
1,1-Dichloroethane	0/14	1.20E-02		5.00E-03	1.00E-02		MG/KG
1,2-Benzenedicarboxylic Acid, Diethyl Ester	1/5	3.23E-01	6.40E-02				MG/KG
1,2-Dichloroethene (Total)	0/14	1.20E-02					MG/KG
2-Butanone	0/14	1.20E-02		8.40E-02	1.70E-01		MG/KG
4,4'-DDD	0/5	3.90E-03		8.20E-03	1.60E-02		MG/KG
Acetone	0/14	1.14E-02		3.80E-02	7.60E-02		MG/KG
Aroclor 1254	0/5	3.90E-02		8.20E-02	1.60E-01		MG/KG
Aroclor 1260	1/5	3.36E-02	1.00E-02	8.20E-02	1.60E-01	NO	MG/KG
Benzo(k)Fluoranthene	0/5	3.90E-01		4.10E-02	8.10E-02		MG/KG
Bis(2-Ethylhexyl) Phthalate	1/5	3.25E-01	5.70E-02				MG/KG
Butyl Benzyl Phthalate	1/5	2.54E-01	4.30E-02				MG/KG
Carbon Tetrachloride	0/14	1.20E-02		5.00E-03	1.00E-02		MG/KG

Table 2a. (continued)

Analyte	Frequency of detection	Mean Concentration (MC)	Maximum Detection (MD)	Mean Background (MBG)	Twice Mean Background (TMBG)	Does MD exceed TMBG ?	Units
Chlordane, Gamma-	0/5	2.02E-03					MG/KG
Chloroform	1/14	1.12E-02	1.00E-03	5.30E-03	1.10E-02	NO	MG/KG
Chloromethane	0/14	1.20E-02		1.00E-02	2.00E-02		MG/KG
Cyanide	0/5	5.86E-01		2.40E-01	4.90E-01		MG/KG
Di-n-butyl Phthalate	2/5	2.94E-01	1.50E-01				MG/KG
Endrin	0/5	3.90E-03		8.20E-03	1.60E-02		MG/KG
Ethylbenzene	0/14	1.20E-02		5.00E-03	1.00E-02		MG/KG
Fluoranthene	0/5	3.90E-01		3.50E-01	7.00E-01		MG/KG
Heptachlor Epoxide	0/5	2.02E-03		4.10E-03	8.20E-03		MG/KG
Methylene Chloride	0/14	1.20E-02		5.00E-03	1.00E-02		MG/KG
Pyrene	0/5	3.90E-01		9.50E-01	1.90E+00		MG/KG
Styrene	0/14	1.20E-02		5.00E-03	1.00E-02		MG/KG
Tetrachloroethene	0/14	1.20E-02		5.00E-03	1.00E-02		MG/KG
Toluene	3/14	1.06E-02	8.00E-03	5.00E-03	1.00E-02	NO	MG/KG
Total Organic Carbon	2/2	9.76E+02	1.15E+03				MG/KG
Trichloroethene	0/14	1.20E-02		5.00E-03	1.00E-02		MG/KG
p-Nitrophenol	0/5	9.46E-01					MG/KG
Radionuclides							
Alpha Particle	5/5	1.61E+01	2.04E+01				PCI/G
Am-241	2/2	3.45E-01	3.50E-01	4.00E-02	8.10E-02	YES	PCI/G
Beta Particle	5/5	4.48E+01	5.55E+01				PCI/G
C-14	0/5	-1.19E+00					PCI/G
Cm-243	1/2	8.50E-02	1.80E-01	5.90E-02	1.20E-01	YES	PCI/G
Cs-137	3/5	6.45E-01	2.00E+00	7.20E-01	1.40E+00	YES	PCI/G
K-40	5/5	2.83E+01	3.51E+01	1.60E+01	3.20E+01	YES	PCI/G
Pu-238	1/2	2.10E+00	4.15E+00	8.30E-02	1.70E-01	YES	PCI/G
Pu-239/240	0/2	5.00E-02		2.90E-02	5.90E-02		PCI/G
Ra-226	5/5	1.20E+00	2.07E+00	7.70E-01	1.50E+00	YES	PCI/G
Ra-228	5/5	1.42E+00	1.70E+00				PCI/G
To-99	0/2	2.40E-01					PCI/G
Th-228	4/4	1.60E+00	1.90E+00	7.50E-01	1.50E+00	YES	PCI/G
Th-230	4/4	7.29E-01	9.90E-01	6.20E-01	1.20E+00	NO	PCI/G

Table 2a. (continued)

Analyte	Frequency of detection	Mean Concentration (MC)	Maximum Detection (MD)	Mean Background (MBG)	Twice Mean Background (TMBG)	Does MD exceed TMBG ?	Units
Th-232	4/4	1.15E+00	2.04E+00	7.10E-01	1.40E+00	YES	PCI/G
Th-234	1/1	7.30E+00	7.30E+00	1.70E+00	3.40E+00	YES	PCI/G
Total Radioactive Strontium	3/5	1.37E+00	3.16E+00	9.70E-01	1.90E+00	YES	PCI/G
Tritium	1/5	4.14E+01	4.20E+00	4.20E-02	8.40E-02	YES	PCI/G
U-233/234	4/4	7.18E-01	8.10E-01				PCI/G
U-238	4/4	6.80E-01	9.00E-01	1.20E+00	2.30E+00	NO	PCI/G
SW3							
Inorganics							
Aluminum	1/1	1.66E+04	1.66E+04	2.50E+04	5.00E+04	NO	MG/KG
Arsenic	1/1	2.90E+00	2.90E+00	6.40E+00	1.30E+01	NO	MG/KG
Barium	1/1	1.32E+02	1.32E+02	1.20E+02	2.40E+02	NO	MG/KG
Beryllium	1/1	6.80E-01	6.80E-01	1.00E+00	2.10E+00	NO	MG/KG
Cadmium	0/1	2.40E-01		2.20E-01	4.40E-01		MG/KG
Calcium	1/1	1.70E+04	1.70E+04	1.30E+03	2.60E+03	YES	MG/KG
Chromium	1/1	4.34E+01	4.34E+01	2.60E+01	5.10E+01	NO	MG/KG
Cobalt	1/1	1.46E+01	1.46E+01	1.90E+01	3.70E+01	NO	MG/KG
Copper	1/1	1.62E+01	1.62E+01	1.90E+01	3.80E+01	NO	MG/KG
Iron	1/1	2.68E+04	2.68E+04	3.30E+04	6.70E+04	NO	MG/KG
Lead	1/1	3.74E+01	3.74E+01	2.20E+01	4.40E+01	NO	MG/KG
Magnesium	1/1	4.55E+03	4.55E+03	3.70E+03	7.30E+03	NO	MG/KG
Manganese	1/1	5.12E+02	5.12E+02	1.20E+03	2.40E+03	NO	MG/KG
Mercury	1/1	4.10E-01	4.10E-01	3.00E-01	5.90E-01	NO	MG/KG
Nickel	1/1	2.49E+01	2.49E+01	2.90E+01	5.80E+01	NO	MG/KG
Potassium	1/1	2.34E+03	2.34E+03	2.90E+03	5.70E+03	NO	MG/KG
Silver	1/1	1.00E+00	1.00E+00	2.00E+00	4.00E+00	NO	MG/KG
Sodium	0/1	6.15E+01					MG/KG
Thallium	0/1	3.10E-01		4.40E-01	8.70E-01		MG/KG
Vanadium	1/1	2.58E+01	2.58E+01	3.80E+01	7.60E+01	NO	MG/KG
Zinc	1/1	3.21E+02	3.21E+02	6.00E+01	1.20E+02	YES	MG/KG
Organics							
1,1,1-Trichloroethane	0/1	1.20E-02		5.00E-03	1.00E-02		MG/KG
1,1-Dichloroethane	0/1	1.20E-02		5.00E-03	1.00E-02		MG/KG

Table 2a. (continued)

Analyte	Frequency of detection	Mean Concentration (MC)	Maximum Detection (MD)	Mean Background (MBG)	Twice Mean Background (TMBG)	Does MD exceed TMBG ?	Units
1,2-Benzenedicarboxylic Acid, Diethyl Ester	0/1	4.10E-01					MG/KG
1,2-Dichloroethene (Total)	0/1	1.20E-02					MG/KG
2-Butanone	0/1	1.20E-02		8.40E-02	1.70E-01		MG/KG
4,4'-DDD	0/1	4.10E-03		8.20E-03	1.60E-02		MG/KG
Acetone	0/1	1.20E-02		3.80E-02	7.60E-02		MG/KG
Aroclor 1254	1/1	9.30E-02	9.30E-02	8.20E-02	1.60E-01	NO	MG/KG
Aroclor 1260	1/1	7.80E-02	7.80E-02	8.20E-02	1.60E-01	NO	MG/KG
Benzo(k)Fluoranthene	0/1	4.10E-01		4.10E-02	8.10E-02		MG/KG
Bis(2-Ethylhexyl) Phthalate	0/1	4.10E-01					MG/KG
Butyl Benzyl Phthalate	0/1	4.10E-01					MG/KG
Carbon Tetrachloride	0/1	1.20E-02		5.00E-03	1.00E-02		MG/KG
Chlordane, Gamma-	0/1	2.10E-03					MG/KG
Chloroform	0/1	1.20E-02		5.30E-03	1.10E-02		MG/KG
Chloromethane	0/1	1.20E-02		1.00E-02	2.00E-02		MG/KG
Di-n-butyl Phthalate	0/1	4.90E-01					MG/KG
Endrin	0/1	4.10E-03		8.20E-03	1.60E-02		MG/KG
Ethylbenzene	0/1	1.20E-02		5.00E-03	1.00E-02		MG/KG
Fluoranthene	0/1	4.10E-01		3.50E-01	7.00E-01		MG/KG
Heptachlor Epoxide	0/1	2.10E-03		4.10E-03	8.20E-03		MG/KG
Methylene Chloride	0/1	1.20E-02		5.00E-03	1.00E-02		MG/KG
Pyrene	0/1	4.10E-01		9.50E-01	1.90E+00		MG/KG
Styrene	0/1	1.20E-02		5.00E-03	1.00E-02		MG/KG
Tetrachloroethene	0/1	1.20E-02		5.00E-03	1.00E-02		MG/KG
Toluene	0/1	1.20E-02		5.00E-03	1.00E-02		MG/KG
Trichloroethene	0/1	1.20E-02		5.00E-03	1.00E-02		MG/KG
p-Nitrophenol	0/1	9.80E-01					MG/KG
Radionuclides							
Alpha Particle	1/1	1.04E+01	1.04E+01				PCI/G
Am-241	1/1	1.24E+00	1.24E+00	4.00E-02	8.10E-02	YES	PCI/G
Beta Particle	1/1	3.61E+01	3.61E+01				PCI/G
C-14	0/1	-7.90E-01					PCI/G
Cm-242	0/1	-5.90E-03					PCI/G

Table 2a. (continued)

Analyte	Frequency of detection	Mean Concentration (MC)	Maximum Detection (MD)	Mean Background (MBG)	Twice Mean Background (TMBG)	Does MD exceed TMBG ?	Units
Cm-243/244	0/1	8.70E-03		1.40E+00	2.80E+00		PCI/G
Cs-137	1/1	6.91E+00	6.91E+00	7.20E-01	1.40E+00	YES	PCI/G
K-40	1/1	1.84E+01	1.84E+01	1.60E+01	3.20E+01	NO	PCI/G
Pu-238	1/1	3.15E-01	3.15E-01	8.30E-02	1.70E-01	YES	PCI/G
Pu-239/240	1/1	1.77E+00	1.77E+00	2.90E-02	5.90E-02	YES	PCI/G
Ra-226	1/1	8.13E-01	8.13E-01	7.70E-01	1.50E+00	NO	PCI/G
Ra-228	1/1	1.20E+00	1.20E+00				PCI/G
Tc-99	0/1	1.94E-01					PCI/G
Th-228	1/1	1.63E+00	1.63E+00	7.50E-01	1.50E+00	YES	PCI/G
Th-230	1/1	1.65E+00	1.65E+00	6.20E-01	1.20E+00	YES	PCI/G
Th-232	1/1	1.27E+00	1.27E+00	7.10E-01	1.40E+00	NO	PCI/G
Total Radioactive Strontium	1/1	3.74E+00	3.74E+00	9.70E-01	1.90E+00	YES	PCI/G
Tritium	1/1	5.60E-01	5.60E-01	4.20E-02	8.40E-02	YES	PCI/G
U-232	1/1	1.48E-01	1.48E-01				PCI/G
U-233/234	1/1	5.65E+00	5.65E+00				PCI/G
U-235/236	0/1	3.69E-02		3.10E-02	6.20E-02		PCI/G
U-238	1/1	1.02E+00	1.02E+00	1.20E+00	2.30E+00	NO	PCI/G
SWSA 5N							
Inorganics							
Aluminum	6/6	2.37E+04	2.73E+04	2.50E+04	5.00E+04	NO	MG/KG
Arsenic	6/6	2.51E+00	5.00E+00	6.40E+00	1.30E+01	NO	MG/KG
Barium	6/6	1.16E+02	1.77E+02	1.20E+02	2.40E+02	NO	MG/KG
Beryllium	6/6	1.20E+00	1.60E+00	1.00E+00	2.10E+00	NO	MG/KG
Cadmium	0/6	3.57E-01		2.20E-01	4.40E-01		MG/KG
Calcium	6/6	6.04E+03	3.39E+04	1.30E+03	2.60E+03	YES	MG/KG
Chromium	6/6	3.40E+01	3.79E+01	2.60E+01	5.10E+01	NO	MG/KG
Cobalt	6/6	1.69E+01	2.13E+01	1.90E+01	3.70E+01	NO	MG/KG
Copper	6/6	2.11E+01	3.19E+01	1.90E+01	3.80E+01	NO	MG/KG
Iron	6/6	3.41E+04	3.82E+04	3.30E+04	6.70E+04	NO	MG/KG
Lead	6/6	1.30E+01	1.82E+01	2.20E+01	4.40E+01	NO	MG/KG
Magnesium	6/6	4.95E+03	7.71E+03	3.70E+03	7.30E+03	YES	MG/KG
Manganese	6/6	6.41E+02	9.90E+02	1.20E+03	2.40E+03	NO	MG/KG

Table 2a. (continued)

Analyte	Frequency of detection	Mean Concentration (MC)	Maximum Detection (MD)	Mean Background (MBG)	Twice Mean Background (TMBG)	Does MD exceed TMBG ?	Units
Mercury	2/6	6.13E-02	9.00E-02	3.00E-01	5.90E-01	NO	MG/KG
Nickel	6/6	2.86E+01	3.51E+01	2.90E+01	5.80E+01	NO	MG/KG
Potassium	6/6	2.27E+03	2.68E+03	2.90E+03	5.70E+03	NO	MG/KG
Selenium	1/4	1.52E+00	7.50E-01	6.60E-01	1.30E+00	NO	MG/KG
Silver	5/6	1.97E+00	2.50E+00	2.00E+00	4.00E+00	NO	MG/KG
Sodium	0/6	7.67E+01					MG/KG
Thallium	0/6	5.18E-01		4.40E-01	8.70E-01		MG/KG
Vanadium	6/6	3.05E+01	3.47E+01	3.80E+01	7.60E+01	NO	MG/KG
Zinc	6/6	5.79E+01	6.83E+01	6.00E+01	1.20E+02	NO	MG/KG
Organics							
1,1,1-Trichloroethane	0/12	1.22E-02		5.00E-03	1.00E-02		MG/KG
1,1-Dichloroethane	0/12	1.22E-02		5.00E-03	1.00E-02		MG/KG
1,2-Benzenedicarboxylic Acid, Diethyl Ester	1/6	3.80E-01	3.00E-01				MG/KG
1,2-Dichloroethene (Total)	0/12	1.22E-02					MG/KG
2-Butanone	1/12	1.14E-02	3.00E-03	8.40E-02	1.70E-01	NO	MG/KG
4,4'-DDD	0/6	3.95E-03		8.20E-03	1.60E-02		MG/KG
Acetone	0/12	2.06E-02		3.80E-02	7.60E-02		MG/KG
Aroclor 1254	0/6	3.95E-02		8.20E-02	1.60E-01		MG/KG
Aroclor 1260	1/6	3.72E-02	2.60E-02	8.20E-02	1.60E-01	NO	MG/KG
Benzo(k)Fluoranthene	0/6	3.97E-01		4.10E-02	8.10E-02		MG/KG
Bis(2-Ethylhexyl) Phthalate	1/6	3.39E-01	4.50E-02				MG/KG
Butyl Benzyl Phthalate	0/6	3.97E-01					MG/KG
Carbon Tetrachloride	0/12	1.22E-02		5.00E-03	1.00E-02		MG/KG
Chlordane, Gamma-	0/6	2.05E-03					MG/KG
Chloroform	0/12	1.22E-02		5.30E-03	1.10E-02		MG/KG
Chloromethane	0/12	1.22E-02		1.00E-02	2.00E-02		MG/KG
Cyanide	0/6	6.12E-01		2.40E-01	4.90E-01		MG/KG
Di-n-butyl Phthalate	2/6	6.30E-02	7.10E-02				MG/KG
Endrin	0/6	3.95E-03		8.20E-03	1.60E-02		MG/KG
Ethylbenzene	0/12	1.22E-02		5.00E-03	1.00E-02		MG/KG
Fluoranthene	0/6	3.97E-01		3.50E-01	7.00E-01		MG/KG
Heptachlor Epoxide	0/6	2.05E-03		4.10E-03	8.20E-03		MG/KG

Table 2a. (continued)

Analyte	Frequency of detection	Mean Concentration (MC)	Maximum Detection (MD)	Mean Background (MBG)	Twice Mean Background (TMBG)	Does MD exceed TMBG ?	Units
Methylene Chloride	2/12	1.08E-02	5.00E-03	5.00E-03	1.00E-02	NO	MG/KG
Pyrene	0/6	3.97E-01		9.50E-01	1.90E+00		MG/KG
Styrene	0/12	1.22E-02		5.00E-03	1.00E-02		MG/KG
Tetrachloroethene	0/12	1.22E-02		5.00E-03	1.00E-02		MG/KG
Toluene	0/12	1.22E-02		5.00E-03	1.00E-02		MG/KG
Trichloroethene	0/12	1.22E-02		5.00E-03	1.00E-02		MG/KG
p-Nitrophenol	0/6	9.62E-01					MG/KG
Radionuclides							
Ac-228	5/5	1.94E+00	2.40E+00				PCI/G
Alpha Particle	6/6	2.58E+01	2.90E+01				PCI/G
Beta Particle	6/6	3.78E+01	5.80E+01				PCI/G
Bi-212	2/2	2.25E+00	2.60E+00				PCI/G
Bi-214	1/1	9.40E-01	9.40E-01				PCI/G
C-14	1/6	3.01E+00	7.50E+00				PCI/G
Cs-137	2/6	3.50E+00	2.30E-01	7.20E-01	1.40E+00	NO	PCI/G
I-129	1/1	5.70E+00	5.70E+00				PCI/G
K-40	6/6	2.17E+01	2.40E+01	1.60E+01	3.20E+01	NO	PCI/G
Pb-212	6/6	1.37E+00	1.60E+00				PCI/G
Pb-214	6/6	9.28E-01	1.10E+00				PCI/G
Ra-223	1/1	5.60E-01	5.60E-01				PCI/G
Ra-226	6/6	7.17E-01	9.50E-01	7.70E-01	1.50E+00	NO	PCI/G
Ra-228	5/6	1.78E+00	2.40E+00				PCI/G
Sn-126	2/2	4.00E-01	4.60E-01				PCI/G
Th-228	5/5	1.49E+00	2.00E+00	7.50E-01	1.50E+00	YES	PCI/G
Th-232	5/5	1.94E+00	2.40E+00	7.10E-01	1.40E+00	YES	PCI/G
Tl-208	5/5	1.37E+00	1.80E+00				PCI/G
Total Radioactive Strontium	1/6	2.49E-01	6.90E-01	9.70E-01	1.90E+00	NO	PCI/G
Tritium	4/6	1.65E-01	2.20E-01	4.20E-02	8.40E-02	YES	PCI/G
SWSA SSE							
Inorganics							
Aluminum	5/5	2.09E+04	2.45E+04	2.50E+04	5.00E+04	NO	MG/KG
Antimony	1/1	6.20E+00	6.20E+00	2.20E-01	4.40E-01	YES	MG/KG

Table 2a. (continued)

Analyte	Frequency of detection	Mean Concentration (MC)	Maximum Detection (MD)	Mean Background (MBG)	Twice Mean Background (TMBG)	Does MD exceed TMBG ?	Units
Arsenic	5/5	3.86E+00	5.50E+00	6.40E+00	1.30E+01	NO	MG/KG
Barium	5/5	1.32E+02	1.59E+02	1.20E+02	2.40E+02	NO	MG/KG
Beryllium	5/5	1.01E+00	1.40E+00	1.00E+00	2.10E+00	NO	MG/KG
Cadmium	0/5	7.46E-01		2.20E-01	4.40E-01		MG/KG
Calcium	5/5	8.52E+03	1.33E+04	1.30E+03	2.60E+03	YES	MG/KG
Chromium	5/5	3.24E+01	3.84E+01	2.60E+01	5.10E+01	NO	MG/KG
Cobalt	5/5	1.93E+01	2.31E+01	1.90E+01	3.70E+01	NO	MG/KG
Copper	5/5	2.04E+01	3.14E+01	1.90E+01	3.80E+01	NO	MG/KG
Iron	5/5	3.19E+04	3.32E+04	3.30E+04	6.70E+04	NO	MG/KG
Lead	5/5	2.08E+01	3.85E+01	2.20E+01	4.40E+01	NO	MG/KG
Magnesium	5/5	5.58E+03	7.89E+03	3.70E+03	7.30E+03	YES	MG/KG
Manganese	5/5	1.79E+03	4.71E+03	1.20E+03	2.40E+03	YES	MG/KG
Mercury	1/5	6.63E-02	1.00E-01	3.00E-01	5.90E-01	NO	MG/KG
Nickel	5/5	3.05E+01	3.85E+01	2.90E+01	5.80E+01	NO	MG/KG
Potassium	5/5	2.24E+03	3.16E+03	2.90E+03	5.70E+03	NO	MG/KG
Selenium	3/5	9.05E-01	2.00E+00	6.60E-01	1.30E+00	YES	MG/KG
Silver	4/5	1.64E+00	2.20E+00	2.00E+00	4.00E+00	NO	MG/KG
Sodium	2/5	6.69E+01	1.41E+02				MG/KG
Thallium	1/5	5.16E-01	3.60E-01	4.40E-01	8.70E-01	NO	MG/KG
Vanadium	5/5	3.00E+01	3.45E+01	3.80E+01	7.60E+01	NO	MG/KG
Zinc	5/5	5.85E+01	7.81E+01	6.00E+01	1.20E+02	NO	MG/KG
Organics							
1,1,1-Trichloroethane	0/8	1.20E-02		5.00E-03	1.00E-02		MG/KG
1,1-Dichloroethane	0/8	1.20E-02		5.00E-03	1.00E-02		MG/KG
1,2-Benzenedicarboxylic Acid, Diethyl Ester	0/5	4.06E-01					MG/KG
1,2-Dichloroethene (Total)	0/8	1.20E-02					MG/KG
2-Butanone	1/8	1.28E-02	1.90E-02	8.40E-02	1.70E-01	NO	MG/KG
4,4'-DDD	0/5	4.08E-03		8.20E-03	1.60E-02		MG/KG
Acetone	1/8	2.14E-02	1.10E-01	3.80E-02	7.60E-02	YES	MG/KG
Aroclor 1254	0/5	4.08E-02		8.20E-02	1.60E-01		MG/KG
Aroclor 1260	1/5	4.22E-02	4.60E-02	8.20E-02	1.60E-01	NO	MG/KG
Benzo(k)Fluoranthene	1/5	3.32E-01	4.90E-02	4.10E-02	8.10E-02	NO	MG/KG

Table 2a. (continued)

Analyte	Frequency of detection	Mean Concentration (MC)	Maximum Detection (MD)	Mean Background (MBG)	Twice Mean Background (TMBG)	Does MD exceed TMBG ?	Units
Bis(2-Ethylhexyl) Phthalate	1/5	3.32E-01	5.20E-02				MG/KG
Butyl Benzyl Phthalate	0/5	4.06E-01					MG/KG
Carbon Tetrachloride	0/8	1.20E-02		5.00E-03	1.00E-02		MG/KG
Chlordane, Gamma-	0/5	2.10E-03					MG/KG
Chloroform	1/8	1.06E-02	1.00E-03	5.30E-03	1.10E-02	NO	MG/KG
Chloromethane	0/8	1.20E-02		1.00E-02	2.00E-02		MG/KG
Cyanide	1/5	4.86E-01	7.00E-02	2.40E-01	4.90E-01	NO	MG/KG
Di-n-butyl Phthalate	0/5	4.06E-01					MG/KG
Endrin	0/5	4.08E-03		8.20E-03	1.60E-02		MG/KG
Ethylbenzene	0/8	1.20E-02		5.00E-03	1.00E-02		MG/KG
Fluoranthene	1/5	3.31E-01	4.30E-02	3.50E-01	7.00E-01	NO	MG/KG
Heptachlor Epoxide	0/5	2.10E-03		4.10E-03	8.20E-03		MG/KG
Methylene Chloride	0/8	1.20E-02		5.00E-03	1.00E-02		MG/KG
Pyrene	1/5	3.32E-01	5.20E-02	9.50E-01	1.90E+00	NO	MG/KG
Styrene	0/8	1.20E-02		5.00E-03	1.00E-02		MG/KG
Tetrachloroethene	0/8	1.20E-02		5.00E-03	1.00E-02		MG/KG
Toluene	0/8	1.20E-02		5.00E-03	1.00E-02		MG/KG
Total Organic Carbon	1/1	1.36E+04	1.36E+04				MG/KG
Trichloroethene	0/8	1.20E-02		5.00E-03	1.00E-02		MG/KG
p-Nitrophenol	0/5	9.74E-01					MG/KG
Radionuclides							
Ac-228	1/1	1.00E+00	1.00E+00				PCI/G
Alpha Particle	4/5	1.08E+02	3.50E+02				PCI/G
Am-241	1/2	3.45E+00	6.78E+00	4.00E-02	8.10E-02	YES	PCI/G
Beta Particle	5/5	3.72E+04	1.59E+04				PCI/G
C-14	1/5	1.54E+01	2.77E+01				PCI/G
Ca-45	1/1	3.00E+01	3.00E+01				PCI/G
Cm-242	0/2	-4.39E-02					PCI/G
Cm-243/244	1/2	1.78E+01	3.56E+01	1.40E+00	2.80E+00	YES	PCI/G
Cs-137	5/5	2.51E+04	6.70E+03	7.20E-01	1.40E+00	YES	PCI/G
K-40	5/5	2.34E+01	3.20E+01	1.60E+01	3.20E+01	NO	PCI/G
Pb-212	1/1	1.90E+00	1.90E+00				PCI/G

Table 2a. (continued)

Analyte	Frequency of detection	Mean Concentration (MC)	Maximum Detection (MD)	Mean Background (MBG)	Twice Mean Background (TMBG)	Does MD exceed TMBG ?	Units
Pb-214	1/1	6.00E-01	6.00E-01				PCI/G
Pu-238	1/2	5.18E-01	8.85E-01	8.30E-02	1.70E-01	YES	PCI/G
Pu-239/240	1/2	4.45E-01	7.90E-01	2.90E-02	5.90E-02	YES	PCI/G
Ra-226	4/5	9.37E-01	1.10E+00	7.70E-01	1.50E+00	NO	PCI/G
Ra-228	3/5	1.28E+00	1.32E+00				PCI/G
Sn-126	1/1	1.80E-01	1.80E-01				PCI/G
Tc-99	0/2	2.88E-01					PCI/G
Th-228	2/3	1.50E+00	1.60E+00	7.50E-01	1.50E+00	YES	PCI/G
Th-230	1/3	2.27E+00	4.37E+00	6.20E-01	1.20E+00	YES	PCI/G
Th-232	5/5	1.06E+00	1.35E+00	7.10E-01	1.40E+00	NO	PCI/G
Th-234	0/1	6.70E-01		1.70E+00	3.40E+00		PCI/G
Tl-208	1/1	1.00E+00	1.00E+00				PCI/G
Total Radioactive Strontium	5/5	5.76E+04	1.03E+04	9.70E-01	1.90E+00	YES	PCI/G
Tritium	3/5	6.69E+02	1.86E+03	4.20E-02	8.40E-02	YES	PCI/G
U-232	1/1	5.32E-01	5.32E-01				PCI/G
U-233	1/1	1.05E+01	1.05E+01				PCI/G
U-233/234	1/2	1.57E+00	6.30E-01				PCI/G
U-235/236	0/1	0.00E+00		3.10E-02	6.20E-02		PCI/G
U-238	2/3	9.37E-01	9.57E-01	1.20E+00	2.30E+00	NO	PCI/G
SWSA SSW							
Inorganics							
Aluminum	5/5	2.09E+04	2.47E+04	2.50E+04	5.00E+04	NO	MG/KG
Arsenic	5/5	3.61E+00	7.10E+00	6.40E+00	1.30E+01	NO	MG/KG
Barium	5/5	2.22E+02	4.79E+02	1.20E+02	2.40E+02	YES	MG/KG
Beryllium	5/5	1.14E+00	1.20E+00	1.00E+00	2.10E+00	NO	MG/KG
Cadmium	0/5	3.80E-01		2.20E-01	4.40E-01		MG/KG
Calcium	5/5	4.06E+03	1.03E+04	1.30E+03	2.60E+03	YES	MG/KG
Chromium	5/5	2.83E+01	3.16E+01	2.60E+01	5.10E+01	NO	MG/KG
Cobalt	5/5	2.50E+01	5.27E+01	1.90E+01	3.70E+01	YES	MG/KG
Copper	5/5	2.05E+01	2.57E+01	1.90E+01	3.80E+01	NO	MG/KG
Iron	5/5	3.34E+04	4.39E+04	3.30E+04	6.70E+04	NO	MG/KG
Lead	5/5	1.69E+01	2.10E+01	2.20E+01	4.40E+01	NO	MG/KG

Table 2a. (continued)

Analyte	Frequency of detection	Mean Concentration (MC)	Maximum Detection (MD)	Mean Background (MBG)	Twice Mean Background (TMBG)	Does MD exceed TMBG ?	Units
Magnesium	5/5	4.75E+03	7.14E+03	3.70E+03	7.30E+03	NO	MG/KG
Manganese	5/5	1.69E+03	4.03E+03	1.20E+03	2.40E+03	YES	MG/KG
Mercury	1/5	7.86E-02	7.00E-02	3.00E-01	5.90E-01	NO	MG/KG
Nickel	5/5	2.86E+01	3.65E+01	2.90E+01	5.80E+01	NO	MG/KG
Potassium	5/5	2.10E+03	2.63E+03	2.90E+03	5.70E+03	NO	MG/KG
Selenium	0/4	6.95E-01		6.60E-01	1.30E+00		MG/KG
Silver	2/5	1.74E+00	2.20E+00	2.00E+00	4.00E+00	NO	MG/KG
Sodium	2/5	1.31E+02	6.22E+02				MG/KG
Thallium	0/5	5.14E-01		4.40E-01	8.70E-01		MG/KG
Vanadium	5/5	2.77E+01	3.00E+01	3.80E+01	7.60E+01	NO	MG/KG
Zinc	5/5	6.11E+01	8.76E+01	6.00E+01	1.20E+02	NO	MG/KG
Organics							
1,1,1-Trichloroethane	0/9	1.24E-02		5.00E-03	1.00E-02		MG/KG
1,1-Dichloroethane	0/9	1.24E-02		5.00E-03	1.00E-02		MG/KG
1,2-Benzenedicarboxylic Acid, Diethyl Ester	0/5	4.02E-01					MG/KG
1,2-Dichloroethene (Total)	1/9	1.13E-02	3.00E-03				MG/KG
2-Butanone	2/9	1.07E-02	2.10E-02	8.40E-02	1.70E-01	NO	MG/KG
4,4'-DDD	1/5	3.38E-03	8.20E-04	8.20E-03	1.60E-02	NO	MG/KG
Acetone	2/9	6.18E-03	1.80E-01	3.80E-02	7.60E-02	YES	MG/KG
Aroclor 1254	0/5	4.02E-02		8.20E-02	1.60E-01		MG/KG
Aroclor 1260	1/5	2.52E-01	1.20E+00	8.20E-02	1.60E-01	YES	MG/KG
Benzo(k)Fluoranthene	0/5	4.02E-01		4.10E-02	8.10E-02		MG/KG
Bis(2-Ethylhexyl) Phthalate	0/5	4.02E-01					MG/KG
Butyl Benzyl Phthalate	0/5	4.02E-01					MG/KG
Carbon Tetrachloride	0/9	1.24E-02		5.00E-03	1.00E-02		MG/KG
Chlordane, Gamma-	0/5	2.08E-03					MG/KG
Chloroform	1/9	1.11E-02	1.00E-03	5.30E-03	1.10E-02	NO	MG/KG
Chloromethane	0/9	1.24E-02		1.00E-02	2.00E-02		MG/KG
Cyanide	0/4	5.60E-01		2.40E-01	4.90E-01		MG/KG
Di-n-butyl Phthalate	0/5	4.02E-01					MG/KG
Endrin	1/5	3.32E-03	5.10E-04	8.20E-03	1.60E-02	NO	MG/KG
Ethylbenzene	1/9	1.18E-02	7.00E-03	5.00E-03	1.00E-02	NO	MG/KG

Table 2a. (continued)

Analyte	Frequency of detection	Mean Concentration (MC)	Maximum Detection (MD)	Mean Background (MBG)	Twice Mean Background (TMBG)	Does MD exceed TMBG ?	Units
Fluoranthene	0/5	4.02E-01		3.50E-01	7.00E-01		MG/KG
Heptachlor Epoxide	0/5	2.08E-03		4.10E-03	8.20E-03		MG/KG
Methylene Chloride	0/9	1.24E-02		5.00E-03	1.00E-02		MG/KG
Pyrene	0/5	4.02E-01		9.50E-01	1.90E+00		MG/KG
Styrene	0/9	1.24E-02		5.00E-03	1.00E-02		MG/KG
Tetrachloroethene	1/9	1.13E-02	3.00E-03	5.00E-03	1.00E-02	NO	MG/KG
Toluene	2/9	9.79E-03	2.00E-02	5.00E-03	1.00E-02	YES	MG/KG
Total Organic Carbon	1/1	8.26E+03	8.26E+03				MG/KG
Trichloroethene	0/9	1.24E-02		5.00E-03	1.00E-02		MG/KG
p-Nitrophenol	0/5	9.76E-01					MG/KG
Radionuclides							
Ac-228	3/3	1.69E+00	2.30E+00				PCI/G
Alpha Particle	6/6	6.37E+01	3.80E+02				PCI/G
Am-241	0/2	3.58E-01		4.00E-02	8.10E-02		PCI/G
Beta Particle	6/6	1.91E+03	1.00E+04				PCI/G
Bi-214	1/1	8.20E-01	8.20E-01				PCI/G
C-14	0/6	1.40E+00					PCI/G
Ca-45	2/2	2.72E+02	5.30E+02				PCI/G
Cm-242	0/2	-1.98E-01					PCI/G
Cm-243/244	0/2	-9.22E-02		1.40E+00	2.80E+00		PCI/G
Cs-137	5/6	5.18E+01	1.20E+02	7.20E-01	1.40E+00	YES	PCI/G
K-40	6/6	2.64E+01	3.30E+01	1.60E+01	3.20E+01	YES	PCI/G
Pb-212	4/4	1.48E+00	1.80E+00				PCI/G
Pb-214	2/2	1.30E+00	1.40E+00				PCI/G
Pu-238	0/2	-5.76E-02		8.30E-02	1.70E-01		PCI/G
Pu-239/240	0/2	1.27E-02		2.90E-02	5.90E-02		PCI/G
Ra-226	6/6	1.05E+00	2.40E+00	7.70E-01	1.50E+00	YES	PCI/G
Ra-228	6/6	1.64E+00	2.30E+00				PCI/G
Tc-99	2/6	3.95E-01	1.30E+00				PCI/G
Th-228	3/3	1.29E+00	1.50E+00	7.50E-01	1.50E+00	YES	PCI/G
Th-230	1/2	1.36E+00	1.21E+00	6.20E-01	1.20E+00	NO	PCI/G
Th-232	5/5	1.77E+00	2.30E+00	7.10E-01	1.40E+00	YES	PCI/G

Table 2a. (continued)

Analyte	Frequency of detection	Mean Concentration (MC)	Maximum Detection (MD)	Mean Background (MBG)	Twice Mean Background (TMBG)	Does MD exceed TMBG ?	Units
1,1,1-Trichloroethane	0/6	1.20E-02		5.00E-03	1.00E-02		MG/KG
1,1-Dichloroethane	0/6	1.20E-02		5.00E-03	1.00E-02		MG/KG
1,2-Benzenedicarboxylic Acid, Diethyl Ester	0/4	4.00E-01					MG/KG
1,2-Dichloroethene (Total)	0/6	1.20E-02					MG/KG
2-Butanone	0/6	1.20E-02		8.40E-02	1.70E-01		MG/KG
4,4'-DDD	0/4	4.00E-03		8.20E-03	1.60E-02		MG/KG
Acetone	0/6	1.28E-02		3.80E-02	7.60E-02		MG/KG
Aroclor 1254	0/4	4.00E-02		8.20E-02	1.60E-01		MG/KG
Aroclor 1260	2/4	3.96E-02	4.10E-02	8.20E-02	1.60E-01	NO	MG/KG
Benzo(k)Fluoranthene	0/4	4.00E-01		4.10E-02	8.10E-02		MG/KG
Bis(2-Ethylhexyl) Phthalate	1/4	3.23E-01	8.30E-02				MG/KG
Butyl Benzyl Phthalate	0/4	4.00E-01					MG/KG
Carbon Tetrachloride	0/6	1.20E-02		5.00E-03	1.00E-02		MG/KG
Chlordane, Gamma-	0/4	2.08E-03					MG/KG
Chloroform	0/6	1.20E-02		5.30E-03	1.10E-02		MG/KG
Chloromethane	0/6	1.20E-02		1.00E-02	2.00E-02		MG/KG
Cyanide	0/4	6.15E-01		2.40E-01	4.90E-01		MG/KG
Di-n-butyl Phthalate	1/4	3.08E-01	1.00E-01				MG/KG
Endrin	0/4	4.00E-03		8.20E-03	1.60E-02		MG/KG
Ethylbenzene	1/6	1.20E-02	1.20E-02	5.00E-03	1.00E-02	YES	MG/KG
Fluoranthene	0/4	4.00E-01		3.50E-01	7.00E-01		MG/KG
Heptachlor Epoxide	0/4	2.08E-03		4.10E-03	8.20E-03		MG/KG
Methylene Chloride	0/6	1.20E-02		5.00E-03	1.00E-02		MG/KG
Pyrene	0/4	4.00E-01		9.50E-01	1.90E+00		MG/KG
Styrene	2/6	2.71E-03	3.00E-03	5.00E-03	1.00E-02	NO	MG/KG
Tetrachloroethene	0/6	1.20E-02		5.00E-03	1.00E-02		MG/KG
Toluene	0/6	1.20E-02		5.00E-03	1.00E-02		MG/KG
Trichloroethene	0/6	1.20E-02		5.00E-03	1.00E-02		MG/KG
p-Nitrophenol	0/4	9.63E-01					MG/KG
Radionuclides							
Ac-228	2/2	1.65E+00	1.80E+00				PCI/G
Alpha Particle	4/4	1.49E+02	3.70E+02				PCI/G

Table 2a. (continued)

Analyte	Frequency of detection	Mean Concentration (MC)	Maximum Detection (MD)	Mean Background (MBG)	Twice Mean Background (TMBG)	Does MD exceed TMBG ?	Units
Am-241	1/1	8.00E-02	8.00E-02	4.00E-02	8.10E-02	NO	PCI/G
Beta Particle	4/4	3.57E+03	6.20E+03				PCI/G
C-14	0/4	-4.48E-01					PCI/G
Co-57	1/1	2.30E+00	2.30E+00	7.30E-03	1.50E-02	YES	PCI/G
Co-60	1/1	3.60E+01	3.60E+01	9.70E-03	1.90E-02	YES	PCI/G
Cs-134	1/1	4.00E-02	4.00E-02				PCI/G
Cs-137	3/4	4.17E+01	6.80E+03	7.20E-01	1.40E+00	YES	PCI/G
K-40	4/4	2.20E+01	2.90E+01	1.60E+01	3.20E+01	NO	PCI/G
Na-22	1/1	1.50E+00	1.50E+00				PCI/G
Pb-212	2/2	1.30E+00	1.40E+00				PCI/G
Pb-214	2/2	1.20E+00	1.40E+00				PCI/G
Ra-226	3/4	9.79E-01	1.02E+00	7.70E-01	1.50E+00	NO	PCI/G
Ra-228	3/4	1.70E+00	1.80E+00				PCI/G
Tc-99	1/1	9.20E-01	9.20E-01				PCI/G
Th-228	1/1	2.20E+00	2.20E+00	7.50E-01	1.50E+00	YES	PCI/G
Th-232	3/3	1.65E+00	1.80E+00	7.10E-01	1.40E+00	YES	PCI/G
Th-234	1/1	1.30E+00	1.30E+00	1.70E+00	3.40E+00	NO	PCI/G
Tl-208	1/1	2.00E+00	2.00E+00				PCI/G
Total Radioactive Strontium	2/4	1.04E+01	3.80E+02	9.70E-01	1.90E+00	YES	PCI/G
Tritium	4/4	2.05E+00	4.41E+00	4.20E-02	8.40E-02	YES	PCI/G

Table 2b. Comparison of WAG 5 sediment MD with TMBG values-Residential Scenario

Analyte	Frequency of detection	Mean Concentration (MC)	Maximum Detection (MD)	Mean Background (MBG)	Twice Mean Background (TMBG)	Does MD exceed TMBG ?	Units
D1							
Inorganics							
Aluminum	4/4	1.42E+04	1.67E+04	1.40E+04	2.80E+04	NO	MG/KG
Antimony	0/4	4.83E+00		4.00E+00	8.00E+00		MG/KG
Arsenic	4/4	3.18E+00	3.50E+00	6.10E+00	1.20E+01	NO	MG/KG
Barium	4/4	2.13E+02	2.81E+02	1.80E+02	3.60E+02	NO	MG/KG
Beryllium	4/4	9.82E-01	1.20E+00	1.10E+00	2.30E+00	NO	MG/KG
Cadmium	0/4	4.15E-01		1.60E+00	3.20E+00		MG/KG
Calcium	4/4	2.88E+03	3.20E+03	2.60E+03	5.20E+03	NO	MG/KG
Chromium	4/4	2.64E+01	3.37E+01				MG/KG
Cobalt	4/4	3.96E+01	5.74E+01	2.20E+01	4.40E+01	YES	MG/KG
Copper	2/4	1.59E+01	2.22E+01	2.00E+01	4.10E+01	NO	MG/KG
Iron	4/4	2.84E+04	3.63E+04	4.50E+04	9.10E+04	NO	MG/KG
Lead	4/4	2.01E+01	3.29E+01	2.00E+01	4.00E+01	NO	MG/KG
Magnesium	4/4	3.36E+03	4.11E+03	2.80E+03	5.70E+03	NO	MG/KG
Manganese	4/4	3.25E+03	4.88E+03	1.50E+03	3.00E+03	YES	MG/KG
Mercury	3/4	1.03E-01	1.40E-01				MG/KG
Nickel	4/4	4.92E+01	7.06E+01	2.60E+01	5.10E+01	YES	MG/KG
Potassium	4/4	1.93E+03	2.09E+03	2.30E+03	4.70E+03	NO	MG/KG
Selenium	0/4	6.60E-01		5.00E-01	1.00E+00		MG/KG
Silver	3/4	1.89E+00	2.30E+00	8.80E-01	1.80E+00	YES	MG/KG
Sodium	0/4	3.67E+02		8.10E+01	1.60E+02		MG/KG
Thallium	0/4	6.18E-01		3.00E-01	6.00E-01		MG/KG
Vanadium	4/4	2.29E+01	2.81E+01	2.70E+01	5.50E+01	NO	MG/KG
Zinc	4/4	5.89E+01	7.40E+01	6.70E+01	1.30E+02	NO	MG/KG
Organics							
1,1-Dichloroethane	0/4	1.55E-02		5.80E-03	1.20E-02		MG/KG
1,1-Dichloroethene	0/4	1.55E-02		5.80E-03	1.20E-02		MG/KG
1,2-Dichloroethane	0/4	1.55E-02		5.80E-03	1.20E-02		MG/KG
1,2-Dichloroethene (Total)	0/4	1.55E-02		5.80E-03	1.20E-02		MG/KG
2-Butanone	0/4	1.55E-02		1.20E-02	2.40E-02		MG/KG
4-Methyl Phenol	0/4	4.90E-01		4.10E-01	8.20E-01		MG/KG

Table 2b. (continued)

Analyte	Frequency of detection	Mean Concentration (MC)	Maximum Detection (MD)	Mean Background (MBG)	Twice Mean Background (TMBG)	Does MD exceed TMBG ?	Units
4-Methyl-2-Pentanone	1/4	1.25E-02	2.00E-03	1.20E-02	2.40E-02	NO	MG/KG
Acetone	0/4	1.55E-02		1.20E-02	2.40E-02		MG/KG
Aroclor 1248	0/4	5.00E-02		9.70E-02	1.90E-01		MG/KG
Aroclor 1254	0/4	5.00E-02		2.00E-01	3.90E-01		MG/KG
Aroclor 1260	4/4	3.43E-01	8.30E-01	2.00E-01	3.90E-01	YES	MG/KG
Benzene	0/4	1.55E-02		5.80E-03	1.20E-02		MG/KG
Bis(2-Ethylhexyl) Phthalate	0/4	4.90E-01		4.60E-01	9.20E-01		MG/KG
Carbolic Acid	0/4	4.90E-01		4.10E-01	8.20E-01		MG/KG
Carbon Disulfide	0/4	1.55E-02		5.80E-03	1.20E-02		MG/KG
Chloroform	0/4	1.55E-02		5.80E-03	1.20E-02		MG/KG
Sulfide	1/4	1.58E+01	1.60E+01	1.60E+01	3.20E+01	NO	MG/KG
Toluene	0/4	1.55E-02		5.80E-03	1.20E-02		MG/KG
Total Organic Carbon	1/1	1.19E+04	1.19E+04				MG/KG
Trichloroethene	0/4	1.55E-02		5.80E-03	1.20E-02		MG/KG
Vinyl Chloride	0/4	1.55E-02		1.20E-02	2.40E-02		MG/KG
Xylene (Total)	0/4	1.55E-02		5.80E-03	1.20E-02		MG/KG
Radionuclides							
Ac-228	1/1	1.40E+00	1.40E+00				PCI/G
Alpha Particle	4/4	3.20E+01	4.30E+01	2.20E+01	4.30E+01	NO	PCI/G
Am-241	2/2	5.70E-01	6.50E-01				PCI/G
Beta Particle	4/4	7.05E+01	9.08E+01	2.70E+01	5.30E+01	YES	PCI/G
Bi-212	1/1	1.50E+00	1.50E+00				PCI/G
Bi-214	1/1	8.60E-01	8.60E-01				PCI/G
C-14	0/4	-2.56E+00					PCI/G
Co-60	4/4	2.30E-01	3.70E-01				PCI/G
Cs-137	4/4	1.16E+00	2.10E+00	1.60E+01	3.30E+01	NO	PCI/G
Eu-155	1/1	1.50E-01	1.50E-01				PCI/G
K-40	4/4	2.09E+01	2.45E+01	2.00E+01	4.10E+01	NO	PCI/G
Pb-212	1/1	1.30E+00	1.30E+00				PCI/G
Pb-214	1/1	9.30E-01	9.30E-01				PCI/G
Pu-238	0/1	0.00E+00					PCI/G
Pu-239/240	0/1	4.70E-02					PCI/G

Table 2b. (continued)

Analyte	Frequency of detection	Mean Concentration (MC)	Maximum Detection (MD)	Mean Background (MBG)	Twice Mean Background (TMBG)	Does MD exceed TMBG ?	Units
Ra-223	1/1	3.70E-01	3.70E-01				PCI/G
Ra-224	1/1	1.60E+00	1.60E+00	1.20E+00	2.40E+00	NO	PCI/G
Ra-226	4/4	9.06E-01	1.20E+00	7.90E-01	1.60E+00	NO	PCI/G
Ra-228	4/4	1.33E+00	1.40E+00	1.30E+00	2.70E+00	NO	PCI/G
Radon 219	1/1	4.70E-01	4.70E-01				PCI/G
Sn-126	1/1	2.80E-01	2.80E-01				PCI/G
Tc-99	2/2	2.10E+00	2.90E+00				PCI/G
Th-228	4/4	1.12E+00	1.30E+00	1.30E+00	2.70E+00	NO	PCI/G
Th-230	4/4	2.00E+00	3.50E+00	1.00E+00	2.10E+00	YES	PCI/G
Th-231	1/1	5.30E-01	5.30E-01				PCI/G
Th-232	4/4	1.20E+00	1.40E+00	1.20E+00	2.40E+00	NO	PCI/G
Th-234	1/1	1.10E+01	1.10E+01	1.10E+00	2.30E+00	YES	PCI/G
Total Radioactive Strontium	4/4	9.36E-01	1.50E+00	6.70E-01	1.30E+00	YES	PCI/G
Tritium	4/4	1.06E+03	2.34E+03	5.00E+01	1.00E+02	YES	PCI/G
U-233/234	4/4	6.53E+00	9.40E+00	1.30E+00	2.50E+00	YES	PCI/G
U-235	4/4	2.37E-01	3.80E-01				PCI/G
U-238	4/4	9.58E+00	1.27E+01	1.00E+00	2.10E+00	YES	PCI/G
D2							
Inorganics							
Aluminum	4/4	1.08E+04	1.31E+04	1.40E+04	2.80E+04	NO	MG/KG
Antimony	0/4	1.29E+01		4.00E+00	8.00E+00		MG/KG
Arsenic	4/4	1.07E+01	1.40E+01	6.10E+00	1.20E+01	YES	MG/KG
Barium	4/4	8.29E+02	1.71E+03	1.80E+02	3.60E+02	YES	MG/KG
Beryllium	4/4	1.36E+00	1.70E+00	1.10E+00	2.30E+00	NO	MG/KG
Cadmium	0/4	1.23E+00		1.60E+00	3.20E+00		MG/KG
Calcium	4/4	3.14E+04	4.99E+04	2.60E+03	5.20E+03	YES	MG/KG
Chromium	4/4	1.79E+01	2.21E+01				MG/KG
Cobalt	4/4	2.35E+01	3.04E+01	2.20E+01	4.40E+01	NO	MG/KG
Copper	4/4	2.12E+01	3.28E+01	2.00E+01	4.10E+01	NO	MG/KG
Iron	4/4	8.05E+04	9.38E+04	4.50E+04	9.10E+04	YES	MG/KG
Lead	4/4	2.14E+01	2.69E+01	2.00E+01	4.00E+01	NO	MG/KG
Magnesium	4/4	3.02E+03	3.45E+03	2.80E+03	5.70E+03	NO	MG/KG

Table 2b. (continued)

Analyte	Frequency of detection	Mean Concentration (MC)	Maximum Detection (MD)	Mean Background (MBG)	Twice Mean Background (TMBG)	Does MD exceed TMBG ?	Units
Manganese	4/4	2.80E+04	4.26E+04	1.50E+03	3.00E+03	YES	MG/KG
Mercury	3/4	2.53E-01	3.80E-01				MG/KG
Nickel	4/4	2.00E+01	2.16E+01	2.60E+01	5.10E+01	NO	MG/KG
Potassium	4/4	1.41E+03	1.60E+03	2.30E+03	4.70E+03	NO	MG/KG
Selenium	1/4	2.21E+00	1.90E+00	5.00E-01	1.00E+00	YES	MG/KG
Silver	2/4	5.98E+00	7.30E+00	8.80E-01	1.80E+00	YES	MG/KG
Sodium	0/4	1.00E+03		8.10E+01	1.60E+02		MG/KG
Thallium	0/4	1.98E+00		3.00E-01	6.00E-01		MG/KG
Vanadium	4/4	2.22E+01	2.50E+01	2.70E+01	5.50E+01	NO	MG/KG
Zinc	3/4	5.86E+01	6.78E+01	6.70E+01	1.30E+02	NO	MG/KG
Organics							
1,1-Dichloroethane	3/4	6.61E-02	1.40E-01	5.80E-03	1.20E-02	YES	MG/KG
1,1-Dichloroethene	2/4	3.15E-02	2.80E-02	5.80E-03	1.20E-02	YES	MG/KG
1,2-Dichloroethane	1/4	4.23E-02	4.90E-02	5.80E-03	1.20E-02	YES	MG/KG
1,2-Dichloroethene (Total)	3/4	6.03E-01	2.10E+00	5.80E-03	1.20E-02	YES	MG/KG
2-Butanone	2/4	5.44E-02	1.70E-01	1.20E-02	2.40E-02	YES	MG/KG
4-Methyl Phenol	0/4	1.45E+00		4.10E-01	8.20E-01		MG/KG
4-Methyl-2-Pentanone	0/4	4.48E-02		1.20E-02	2.40E-02		MG/KG
Acetone	1/4	2.21E-01	6.40E-01	1.20E-02	2.40E-02	YES	MG/KG
Aroclor 1248	0/4	1.43E-01		9.70E-02	1.90E-01		MG/KG
Aroclor 1254	0/4	1.43E-01		2.00E-01	3.90E-01		MG/KG
Aroclor 1260	2/4	1.11E-01	8.50E-02	2.00E-01	3.90E-01	NO	MG/KG
Benzene	2/4	1.02E-02	1.10E-02	5.80E-03	1.20E-02	NO	MG/KG
Bis(2-Ethylhexyl) Phthalate	0/4	1.45E+00		4.60E-01	9.20E-01		MG/KG
Carbolic Acid	0/4	1.45E+00		4.10E-01	8.20E-01		MG/KG
Carbon Disulfide	0/4	4.48E-02		5.80E-03	1.20E-02		MG/KG
Chloroform	0/4	4.48E-02		5.80E-03	1.20E-02		MG/KG
Sulfide	4/4	1.70E+01	2.36E+01	1.60E+01	3.20E+01	NO	MG/KG
Toluene	2/4	6.44E-03	7.00E-03	5.80E-03	1.20E-02	NO	MG/KG
Total Organic Carbon	1/1	4.30E+04	4.30E+04				MG/KG
Trichloroethene	2/4	6.44E-03	7.00E-03	5.80E-03	1.20E-02	NO	MG/KG
Vinyl Chloride	2/4	4.38E-01	1.10E+00	1.20E-02	2.40E-02	YES	MG/KG

Table 2b. (continued)

Analyte	Frequency of detection	Mean Concentration (MC)	Maximum Detection (MD)	Mean Background (MBG)	Twice Mean Background (TMBG)	Does MD exceed TMBG ?	Units
Xylene (Total)	0/4	4.48E-02		5.80E-03	1.20E-02		MG/KG
Radionuclides							
Ac-228	4/4	2.05E+00	2.30E+00				PCI/G
Alpha Particle	4/4	1.05E+02	1.70E+02	2.20E+01	4.30E+01	YES	PCI/G
Am-241	2/3	4.09E-01	6.20E-01				PCI/G
Beta Particle	4/4	2.26E+03	2.70E+03	2.70E+01	5.30E+01	YES	PCI/G
Bi-212	1/1	1.70E+00	1.70E+00				PCI/G
Bi-214	3/3	9.07E-01	1.20E+00				PCI/G
C-14	4/4	6.68E+01	9.70E+01				PCI/G
Ca-45	3/3	6.67E+01	9.20E+01				PCI/G
Cm-242	0/2	-1.95E-02					PCI/G
Cm-243/244	2/2	3.35E+00	5.52E+00				PCI/G
Co-60	4/4	5.80E-01	6.30E-01				PCI/G
Cs-137	4/4	7.48E+00	9.70E+00	1.60E+01	3.30E+01	NO	PCI/G
I-129	3/3	1.04E+01	1.40E+01				PCI/G
K-40	4/4	1.08E+01	1.20E+01	2.00E+01	4.10E+01	NO	PCI/G
Pb-212	4/4	1.55E+00	1.70E+00				PCI/G
Pb-214	4/4	1.02E+00	1.20E+00				PCI/G
Pu-238	3/3	1.76E+01	3.13E+01				PCI/G
Pu-239/240	1/3	1.62E-01	2.60E-01				PCI/G
Ra-223	2/2	8.25E-01	9.10E-01				PCI/G
Ra-224	3/3	3.80E+00	4.90E+00	1.20E+00	2.40E+00	YES	PCI/G
Ra-226	3/4	1.77E+00	3.00E+00	7.90E-01	1.60E+00	YES	PCI/G
Ra-228	4/4	2.05E+00	2.30E+00	1.30E+00	2.70E+00	NO	PCI/G
Radon 219	2/2	1.07E+00	1.20E+00				PCI/G
Tc-99	3/4	5.83E+00	1.20E+01				PCI/G
Th-228	4/4	2.03E+00	2.50E+00	1.30E+00	2.70E+00	NO	PCI/G
Th-230	3/3	9.58E-01	1.30E+00	1.00E+00	2.10E+00	NO	PCI/G
Th-232	4/4	1.45E+00	2.30E+00	1.20E+00	2.40E+00	NO	PCI/G
Tl-208	4/4	1.25E+00	1.40E+00				PCI/G
Total Radioactive Strontium	4/4	1.06E+03	1.40E+03	6.70E-01	1.30E+00	YES	PCI/G
Tritium	4/4	1.31E+03	1.67E+03	5.00E+01	1.00E+02	YES	PCI/G

Table 2b. (continued)

Analyte	Frequency of detection	Mean Concentration (MC)	Maximum Detection (MD)	Mean Background (MBG)	Twice Mean Background (TMBG)	Does MD exceed TMBG ?	Units
U-233/234	3/3	8.95E+00	1.60E+01	1.30E+00	2.50E+00	YES	PCI/G
U-235	1/3	2.46E-01	4.10E-01				PCI/G
U-238	3/3	2.30E+00	2.40E+00	1.00E+00	2.10E+00	YES	PCI/G
D3							
Inorganics							
Antimony	0/1	5.80E+00		4.00E+00	8.00E+00		MG/KG
Arsenic	1/1	1.70E+00	1.70E+00	6.10E+00	1.20E+01	NO	MG/KG
Barium	1/1	1.51E+02	1.51E+02	1.80E+02	3.60E+02	NO	MG/KG
Beryllium	1/1	1.00E+00	1.00E+00	1.10E+00	2.30E+00	NO	MG/KG
Cadmium	0/1	5.50E-01		1.60E+00	3.20E+00		MG/KG
Calcium	1/1	2.26E+03	2.26E+03	2.60E+03	5.20E+03	NO	MG/KG
Chromium	1/1	1.76E+01	1.76E+01				MG/KG
Cobalt	1/1	1.40E+01	1.40E+01	2.20E+01	4.40E+01	NO	MG/KG
Copper	1/1	8.20E+00	8.20E+00	2.00E+01	4.10E+01	NO	MG/KG
Iron	1/1	1.65E+04	1.65E+04	4.50E+04	9.10E+04	NO	MG/KG
Lead	1/1	1.53E+01	1.53E+01	2.00E+01	4.00E+01	NO	MG/KG
Magnesium	1/1	1.75E+03	1.75E+03	2.80E+03	5.70E+03	NO	MG/KG
Manganese	1/1	1.56E+03	1.56E+03	1.50E+03	3.00E+03	NO	MG/KG
Mercury	1/1	9.00E-02	9.00E-02				MG/KG
Nickel	1/1	1.72E+01	1.72E+01	2.60E+01	5.10E+01	NO	MG/KG
Potassium	1/1	1.21E+03	1.21E+03	2.30E+03	4.70E+03	NO	MG/KG
Selenium	1/1	1.70E+00	1.70E+00	5.00E-01	1.00E+00	YES	MG/KG
Silver	0/1	1.80E+00		8.80E-01	1.80E+00		MG/KG
Sodium	0/1	3.83E+02		8.10E+01	1.60E+02		MG/KG
Thallium	0/1	7.60E-01		3.00E-01	6.00E-01		MG/KG
Vanadium	1/1	1.67E+01	1.67E+01	2.70E+01	5.50E+01	NO	MG/KG
Zinc	1/1	3.54E+01	3.54E+01	6.70E+01	1.30E+02	NO	MG/KG
Organics							
1,1-Dichloroethane	0/1	1.80E-02		5.80E-03	1.20E-02		MG/KG
1,1-Dichloroethene	0/1	1.80E-02		5.80E-03	1.20E-02		MG/KG
1,2-Dichloroethane	0/1	1.80E-02		5.80E-03	1.20E-02		MG/KG
1,2-Dichloroethene (Total)	0/1	1.80E-02		5.80E-03	1.20E-02		MG/KG

Table 2b. (continued)

Analyte	Frequency of detection	Mean Concentration (MC)	Maximum Detection (MD)	Mean Background (MBG)	Twice Mean Background (TMBG)	Does MD exceed TMBG ?	Units
2-Butanone	1/1	3.40E-02	3.40E-02	1.20E-02	2.40E-02	YES	MG/KG
4-Methyl Phenol	0/1	5.70E-01		4.10E-01	8.20E-01		MG/KG
4-Methyl-2-Pentanone	0/1	1.80E-02		1.20E-02	2.40E-02		MG/KG
Acetone	0/1	1.60E-01		1.20E-02	2.40E-02		MG/KG
Aroclor 1248	0/1	5.80E-02		9.70E-02	1.90E-01		MG/KG
Aroclor 1254	0/1	5.80E-02		2.00E-01	3.90E-01		MG/KG
Aroclor 1260	0/1	5.80E-02		2.00E-01	3.90E-01		MG/KG
Benzene	0/1	1.80E-02		5.80E-03	1.20E-02		MG/KG
Bis(2-Ethylhexyl) Phthalate	0/1	5.70E-01		4.60E-01	9.20E-01		MG/KG
Carbolic Acid	0/1	5.70E-01		4.10E-01	8.20E-01		MG/KG
Carbon Disulfide	1/1	2.00E-03	2.00E-03	5.80E-03	1.20E-02	NO	MG/KG
Chloroform	1/1	2.00E-03	2.00E-03	5.80E-03	1.20E-02	NO	MG/KG
Sulfide	0/1	8.00E+00		1.60E+01	3.20E+01		MG/KG
Toluene	1/1	3.00E-03	3.00E-03	5.80E-03	1.20E-02	NO	MG/KG
Total Organic Carbon	1/1	1.46E+04	1.46E+04				MG/KG
Trichloroethene	0/1	1.80E-02		5.80E-03	1.20E-02		MG/KG
Vinyl Chloride	0/1	1.80E-02		1.20E-02	2.40E-02		MG/KG
Xylene (Total)	0/1	1.80E-02		5.80E-03	1.20E-02		MG/KG
Radionuclides							
Ac-228	1/1	1.50E+00	1.50E+00				PCI/G
Alpha Particle	1/1	2.70E+01	2.70E+01	2.20E+01	4.30E+01	NO	PCI/G
Beta Particle	1/1	2.20E+01	2.20E+01	2.70E+01	5.30E+01	NO	PCI/G
Bi-214	1/1	9.10E-01	9.10E-01				PCI/G
C-14	0/1	-3.50E+00					PCI/G
Cs-137	1/1	3.90E-01	3.90E-01	1.60E+01	3.30E+01	NO	PCI/G
I-129	1/1	1.30E+00	1.30E+00				PCI/G
K-40	1/1	1.30E+01	1.30E+01	2.00E+01	4.10E+01	NO	PCI/G
Pb-210	1/1	2.70E+00	2.70E+00				PCI/G
Pb-212	1/1	1.40E+00	1.40E+00				PCI/G
Pb-214	1/1	1.00E+00	1.00E+00				PCI/G
Ra-224	0/1	1.90E+00		1.20E+00	2.40E+00		PCI/G
Ra-226	1/1	8.80E-01	8.80E-01	7.90E-01	1.60E+00	NO	PCI/G

Table 2b. (continued)

Analyte	Frequency of detection	Mean Concentration (MC)	Maximum Detection (MD)	Mean Background (MBG)	Twice Mean Background (TMBG)	Does MD exceed TMBG ?	Units
Ra-228	1/1	1.50E+00	1.50E+00	1.30E+00	2.70E+00	NO	PCI/G
Sn-126	1/1	1.90E-01	1.90E-01				PCI/G
Th-228	1/1	1.20E+00	1.20E+00	1.30E+00	2.70E+00	NO	PCI/G
Th-232	1/1	1.50E+00	1.50E+00	1.20E+00	2.40E+00	NO	PCI/G
Th-234	1/1	1.80E+00	1.80E+00	1.10E+00	2.30E+00	NO	PCI/G
Tl-208	1/1	1.10E+00	1.10E+00				PCI/G
Total Radioactive Strontium	1/1	1.00E+00	1.00E+00	6.70E-01	1.30E+00	NO	PCI/G
Tritium	1/1	1.14E+01	1.14E+01	5.00E+01	1.00E+02	NO	PCI/G
OHFP							
Inorganics							
Aluminum	1/1	1.61E+04	1.61E+04	1.40E+04	2.80E+04	NO	MG/KG
Antimony	0/1	3.72E+01		4.00E+00	8.00E+00		MG/KG
Arsenic	1/1	9.10E+00	9.10E+00	6.10E+00	1.20E+01	NO	MG/KG
Barium	1/1	1.54E+02	1.54E+02	1.80E+02	3.60E+02	NO	MG/KG
Beryllium	0/1	8.50E-01		1.10E+00	2.30E+00		MG/KG
Cadmium	0/1	1.60E+00		1.60E+00	3.20E+00		MG/KG
Calcium	1/1	7.97E+04	7.97E+04	2.60E+03	5.20E+03	YES	MG/KG
Chromium	1/1	3.75E+01	3.75E+01				MG/KG
Cobalt	1/1	1.04E+01	1.04E+01	2.20E+01	4.40E+01	NO	MG/KG
Copper	1/1	1.91E+02	1.91E+02	2.00E+01	4.10E+01	YES	MG/KG
Iron	1/1	2.41E+04	2.41E+04	4.50E+04	9.10E+04	NO	MG/KG
Lead	1/1	1.64E+02	1.64E+02	2.00E+01	4.00E+01	YES	MG/KG
Magnesium	1/1	1.00E+04	1.00E+04	2.80E+03	5.70E+03	YES	MG/KG
Manganese	1/1	4.56E+02	4.56E+02	1.50E+03	3.00E+03	NO	MG/KG
Mercury	1/1	3.10E+00	3.10E+00				MG/KG
Nickel	0/1	3.09E+01		2.60E+01	5.10E+01		MG/KG
Potassium	1/1	2.09E+03	2.09E+03	2.30E+03	4.70E+03	NO	MG/KG
Selenium	0/1	1.50E+00		5.00E-01	1.00E+00		MG/KG
Silver	1/1	5.90E+00	5.90E+00	8.80E-01	1.80E+00	YES	MG/KG
Sodium	0/1	2.18E+02		8.10E+01	1.60E+02		MG/KG
Thallium	1/1	7.80E-01	7.80E-01	3.00E-01	6.00E-01	YES	MG/KG
Vanadium	0/1	4.54E+01		2.70E+01	5.50E+01		MG/KG

Table 2b. (continued)

Analyte	Frequency of detection	Mean Concentration (MC)	Maximum Detection (MD)	Mean Background (MBG)	Twice Mean Background (TMBG)	Does MD exceed TMBG ?	Units
Zinc	1/1	1.54E+02	1.54E+02	6.70E+01	1.30E+02	YES	MG/KG
Organics							
1,1-Dichloroethane	0/3	1.11E-01		5.80E-03	1.20E-02		MG/KG
1,1-Dichloroethene	0/3	1.11E-01		5.80E-03	1.20E-02		MG/KG
1,2-Dichloroethane	0/3	1.11E-01		5.80E-03	1.20E-02		MG/KG
1,2-Dichloroethene (Total)	0/3	1.11E-01		5.80E-03	1.20E-02		MG/KG
2-Butanone	0/3	1.11E-01		1.20E-02	2.40E-02		MG/KG
4-Methyl Phenol	0/1	2.10E+00		4.10E-01	8.20E-01		MG/KG
4-Methyl-2-Pentanone	0/3	1.11E-01		1.20E-02	2.40E-02		MG/KG
Acetone	2/3	2.93E-01	4.80E-01	1.20E-02	2.40E-02	YES	MG/KG
Aroclor 1248	0/1	2.10E-01		9.70E-02	1.90E-01		MG/KG
Aroclor 1254	1/1	2.30E+00	2.30E+00	2.00E-01	3.90E-01	YES	MG/KG
Aroclor 1260	1/1	6.30E-01	6.30E-01	2.00E-01	3.90E-01	YES	MG/KG
Benzene	0/3	1.11E-01		5.80E-03	1.20E-02		MG/KG
Bis(2-Ethylhexyl) Phthalate	0/1	9.10E-01		4.60E-01	9.20E-01		MG/KG
Carbolic Acid	0/1	2.10E+00		4.10E-01	8.20E-01		MG/KG
Carbon Disulfide	0/3	1.11E-01		5.80E-03	1.20E-02		MG/KG
Chloroform	0/3	1.11E-01		5.80E-03	1.20E-02		MG/KG
Toluene	0/3	1.11E-01		5.80E-03	1.20E-02		MG/KG
Trichloroethene	0/3	1.11E-01		5.80E-03	1.20E-02		MG/KG
Vinyl Chloride	0/3	1.11E-01		1.20E-02	2.40E-02		MG/KG
Xylene (Total)	0/3	1.11E-01		5.80E-03	1.20E-02		MG/KG
Radionuclides							
Alpha Particle	1/1	8.07E+04	8.07E+04	2.20E+01	4.30E+01	YES	PCI/G
Am-241	1/1	8.82E+02	8.82E+02				PCI/G
Beta Particle	1/1	7.94E+06	7.94E+06	2.70E+01	5.30E+01	YES	PCI/G
C-14	1/1	2.56E+02	2.56E+02				PCI/G
Cm-242	0/1	0.00E+00					PCI/G
Cm-243/244	1/1	2.44E+04	2.44E+04				PCI/G
Co-60	1/1	6.28E+03	6.28E+03				PCI/G
Cs-137	1/1	3.72E+06	3.72E+06	1.60E+01	3.30E+01	YES	PCI/G
Pu-238	1/1	1.22E+03	1.22E+03				PCI/G

Table 2b. (continued)

Analyte	Frequency of detection	Mean Concentration (MC)	Maximum Detection (MD)	Mean Background (MBG)	Twice Mean Background (TMBG)	Does MD exceed TMBG ?	Units
Pu-239/240	1/1	6.39E+02	6.39E+02				PCI/G
Ra-226	0/1	2.40E+03		7.90E-01	1.60E+00		PCI/G
Ra-228	0/1	2.90E+03		1.30E+00	2.70E+00		PCI/G
Th-228	1/1	1.74E+02	1.74E+02	1.30E+00	2.70E+00	YES	PCI/G
Th-230	1/1	3.09E+02	3.09E+02	1.00E+00	2.10E+00	YES	PCI/G
Th-232	1/1	5.28E+01	5.28E+01	1.20E+00	2.40E+00	YES	PCI/G
Total Radioactive Strontium	1/1	7.35E+05	7.35E+05	6.70E-01	1.30E+00	YES	PCI/G
Tritium	1/1	2.00E+00	2.00E+00	5.00E+01	1.00E+02	NO	PCI/G
U-232	1/1	3.76E+01	3.76E+01				PCI/G
U-233	1/1	1.58E+03	1.58E+03				PCI/G
U-235/236	0/1	1.00E+00		6.00E-01	1.20E+00		PCI/G
U-238	0/1	1.58E+01		1.00E+00	2.10E+00		PCI/G
PWSB							
Inorganics							
Aluminum	4/4	8.14E+02	1.24E+03	1.40E+04	2.80E+04	NO	MG/KG
Antimony	1/4	2.99E+01	2.76E+01	4.00E+00	8.00E+00	YES	MG/KG
Arsenic	4/4	3.83E+00	5.00E+00	6.10E+00	1.20E+01	NO	MG/KG
Barium	4/4	2.11E+02	2.43E+02	1.80E+02	3.60E+02	NO	MG/KG
Beryllium	0/4	2.23E+00		1.10E+00	2.30E+00		MG/KG
Cadmium	0/4	3.80E+00		1.60E+00	3.20E+00		MG/KG
Calcium	4/4	2.39E+05	2.74E+05	2.60E+03	5.20E+03	YES	MG/KG
Chromium	4/4	4.73E+01	6.39E+01				MG/KG
Cobalt	0/4	2.46E+01		2.20E+01	4.40E+01		MG/KG
Copper	4/4	9.36E+01	1.17E+02	2.00E+01	4.10E+01	YES	MG/KG
Iron	4/4	9.47E+04	1.03E+05	4.50E+04	9.10E+04	YES	MG/KG
Lead	4/4	1.03E+02	1.66E+02	2.00E+01	4.00E+01	YES	MG/KG
Magnesium	4/4	9.24E+04	1.03E+05	2.80E+03	5.70E+03	YES	MG/KG
Manganese	4/4	6.86E+02	7.17E+02	1.50E+03	3.00E+03	NO	MG/KG
Mercury	4/4	2.17E+01	2.94E+01				MG/KG
Nickel	0/4	4.74E+01		2.60E+01	5.10E+01		MG/KG
Potassium	0/4	9.10E+02		2.30E+03	4.70E+03		MG/KG
Selenium	0/4	1.04E+00		5.00E-01	1.00E+00		MG/KG

Table 2b. (continued)

Analyte	Frequency of detection	Mean Concentration (MC)	Maximum Detection (MD)	Mean Background (MBG)	Twice Mean Background (TMBG)	Does MD exceed TMBG ?	Units
Silver	0/4	5.38E+00		8.80E-01	1.80E+00		MG/KG
Sodium	4/4	1.91E+03	2.59E+03	8.10E+01	1.60E+02	YES	MG/KG
Thallium	1/4	2.23E+00	4.70E+00	3.00E-01	6.00E-01	YES	MG/KG
Vanadium	0/4	1.93E+01		2.70E+01	5.50E+01		MG/KG
Zinc	4/4	1.19E+03	1.59E+03	6.70E+01	1.30E+02	YES	MG/KG
Organics							
1,1-Dichloroethane	0/13	1.37E-01		5.80E-03	1.20E-02		MG/KG
1,1-Dichloroethene	0/12	1.45E-01		5.80E-03	1.20E-02		MG/KG
1,2-Dichloroethane	0/13	1.37E-01		5.80E-03	1.20E-02		MG/KG
1,2-Dichloroethene (Total)	0/13	1.37E-01		5.80E-03	1.20E-02		MG/KG
2-Butanone	10/13	3.67E-01	1.10E+00	1.20E-02	2.40E-02	YES	MG/KG
4-Methyl Phenol	4/4	1.60E+01	2.60E+01	4.10E-01	8.20E-01	YES	MG/KG
4-Methyl-2-Pentanone	0/13	1.37E-01		1.20E-02	2.40E-02		MG/KG
Acetone	9/13	1.67E+00	4.90E+00	1.20E-02	2.40E-02	YES	MG/KG
Aroclor 1248	2/4	4.96E-01	1.20E+00	9.70E-02	1.90E-01	YES	MG/KG
Aroclor 1254	4/4	1.06E+00	1.50E+00	2.00E-01	3.90E-01	YES	MG/KG
Aroclor 1260	0/4	2.15E-01		2.00E-01	3.90E-01		MG/KG
Benzene	0/13	1.37E-01		5.80E-03	1.20E-02		MG/KG
Bis(2-Ethylhexyl) Phthalate	2/4	9.27E-01	1.00E+00	4.60E-01	9.20E-01	YES	MG/KG
Carbolic Acid	4/4	1.71E+01	3.30E+01	4.10E-01	8.20E-01	YES	MG/KG
Carbon Disulfide	0/13	1.37E-01		5.80E-03	1.20E-02		MG/KG
Chloroform	0/13	1.37E-01		5.80E-03	1.20E-02		MG/KG
Toluene	2/13	9.46E-03	1.00E-02	5.80E-03	1.20E-02	NO	MG/KG
Total Organic Carbon	1/1	1.40E+01	1.40E+01				MG/KG
Trichloroethene	0/13	1.37E-01		5.80E-03	1.20E-02		MG/KG
Vinyl Chloride	0/13	1.37E-01		1.20E-02	2.40E-02		MG/KG
Xylene (Total)	3/13	2.32E-02	2.70E-02	5.80E-03	1.20E-02	YES	MG/KG
Radionuclides							
Alpha Particle	5/5	8.61E+03	1.40E+04	2.20E+01	4.30E+01	YES	PCI/G
Am-241	5/5	6.80E+02	1.17E+03				PCI/G
Beta Particle	5/5	2.98E+05	3.28E+05	2.70E+01	5.30E+01	YES	PCI/G
C-14	4/4	1.11E+02	1.55E+02				PCI/G

Table 2b. (continued)

Analyte	Frequency of detection	Mean Concentration (MC)	Maximum Detection (MD)	Mean Background (MBG)	Twice Mean Background (TMBG)	Does MD exceed TMBG ?	Units
Cm-242	2/5	3.22E-01	3.54E-01				PCI/G
Cm-243/244	5/5	7.04E+02	1.37E+03				PCI/G
Co-60	5/5	3.97E+03	6.83E+03				PCI/G
Cs-137	5/5	1.08E+04	1.78E+04	1.60E+01	3.30E+01	YES	PCI/G
Eu-152	1/2	7.74E+02	9.61E+02				PCI/G
Eu-154	1/3	3.50E+02	5.79E+02				PCI/G
Pu-238	5/5	9.70E+01	1.23E+02				PCI/G
Pu-239/240	5/5	9.30E+01	1.62E+02				PCI/G
Ra-226	0/5	9.60E+01		7.90E-01	1.60E+00		PCI/G
Ra-228	0/5	2.36E+02		1.30E+00	2.70E+00		PCI/G
Tc-99	4/4	2.09E+00	3.39E+00				PCI/G
Th-228	5/5	3.18E+02	3.88E+02	1.30E+00	2.70E+00	YES	PCI/G
Th-230	5/5	3.01E+01	4.30E+01	1.00E+00	2.10E+00	YES	PCI/G
Th-232	5/5	3.30E+00	4.94E+00	1.20E+00	2.40E+00	YES	PCI/G
Total Radioactive Strontium	5/5	9.72E+04	1.49E+05	6.70E-01	1.30E+00	YES	PCI/G
Tritium	4/4	1.99E+02	2.78E+02	5.00E+01	1.00E+02	YES	PCI/G
U-232	5/5	2.64E+02	3.21E+02				PCI/G
U-233	5/5	2.82E+03	4.76E+03				PCI/G
U-235/236	2/5	7.92E+00	8.13E+00	6.00E-01	1.20E+00	YES	PCI/G
U-238	5/5	7.44E+01	1.38E+02	1.00E+00	2.10E+00	YES	PCI/G

Table 2c. Comparison of WAG 5 groundwater MD with TMBG values-Residential Scenario

Analyte	Frequency of detection	Mean Concentration (MC)	Maximum Detection (MD)	Mean Background (MBG)	Twice Background mean (TMBG)	Does MD exceed TMBG ?	UNITS
FS							
Inorganics							
Aluminum	2/2	5.42E+01	8.97E+01	3.70E-01	7.40E-01	YES	MG/L
Antimony	0/2	1.36E-02		2.60E-02	5.20E-02		MG/L
Arsenic	2/2	3.30E-03	4.00E-03	2.60E-02	5.20E-02	NO	MG/L
Barium	2/2	6.34E-01	9.32E-01	2.50E-01	5.00E-01	YES	MG/L
Beryllium	2/2	4.15E-03	6.20E-03	1.60E-03	3.20E-03	YES	MG/L
Calcium	2/2	1.04E+02	1.33E+02	8.80E+01	1.80E+02	NO	MG/L
Chromium	2/2	1.50E-01	2.43E-01	7.50E-03	1.50E-02	YES	MG/L
Cobalt	2/2	5.31E-02	8.44E-02	3.70E-03	7.30E-03	YES	MG/L
Copper	2/2	3.62E-02	4.04E-02	8.10E-03	1.60E-02	YES	MG/L
Iron	2/2	7.27E+01	1.22E+02	5.70E-01	1.10E+00	YES	MG/L
Lead	2/2	2.80E-02	4.09E-02	2.90E-02	5.70E-02	NO	MG/L
Magnesium	2/2	3.93E+01	5.79E+01	1.40E+01	2.70E+01	YES	MG/L
Manganese	2/2	1.47E+00	2.32E+00	1.20E-01	2.40E-01	YES	MG/L
Mercury	0/2	1.50E-04		5.00E-05	1.00E-04		MG/L
Nickel	2/2	1.03E-01	1.66E-01	6.90E-03	1.40E-02	YES	MG/L
Potassium	2/2	1.63E+01	2.42E+01	2.20E+00	4.50E+00	YES	MG/L
Selenium	0/2	1.55E-02		2.30E-02	4.60E-02		MG/L
Silver	1/2	4.25E-03	4.80E-03	5.00E-03	1.00E-02	NO	MG/L
Sodium	2/2	3.45E+01	3.51E+01	1.60E+01	3.10E+01	YES	MG/L
Vanadium	2/2	8.63E-02	1.40E-01	2.70E-03	5.30E-03	YES	MG/L
Zinc	2/2	2.10E-01	2.97E-01	1.30E-02	2.60E-02	YES	MG/L
Organics							
1,1,1-Trichloroethane	0/3	1.00E-02		5.00E-03	1.00E-02		MG/L
1,1-Dichloroethane	0/3	1.00E-02		5.00E-03	1.00E-02		MG/L
1,1-Dichloroethene	0/3	1.00E-02		5.00E-03	1.00E-02		MG/L
1,2-Dichloroethane	0/3	1.00E-02		5.00E-03	1.00E-02		MG/L
1,2-Dichloroethene (Total)	0/3	1.00E-02		5.00E-03	1.00E-02		MG/L
Acetone	0/3	1.00E-02		6.10E-03	1.20E-02		MG/L
Benzene	0/3	1.00E-02		4.70E-03	9.30E-03		MG/L
Bis(2-Ethylhexyl) Phthalate	0/1	1.00E-02		7.10E-03	1.40E-02		MG/L

Table 2c. (continued)

Analyte	Frequency of detection	Mean Concentration (MC)	Maximum Detection (MD)	Mean Background (MBG)	Twice Background mean (TMBG)	Does MD exceed TMBG ?	UNITS
Carbon Disulfide	0/3	1.00E-02		2.00E-03	4.10E-03		MG/L
Carbon Tetrachloride	0/3	1.00E-02		5.00E-03	1.00E-02		MG/L
Chloride	1/1	5.51E+00	5.51E+00	3.10E+00	6.30E+00	NO	MG/L
Chlorobenzene	0/3	1.00E-02		5.00E-03	1.00E-02		MG/L
Chloroethane	0/3	1.00E-02		1.00E-02	2.00E-02		MG/L
Chloroform	0/3	1.00E-02		5.00E-03	1.00E-02		MG/L
Cyanide	0/2	1.00E-02		4.70E-09	9.30E-09		MG/L
Dimethyl Phthalate	0/2	1.00E-02		1.00E-02	2.00E-02		MG/L
Fluoranthene	0/2	1.00E-02		1.00E-02	2.00E-02		MG/L
Fluoride	1/1	6.90E-02	6.90E-02				
Methylene Chloride	0/3	1.00E-02		4.70E-03	9.30E-03		MG/L
Nitrate	0/1	2.50E-01		1.30E+00	2.70E+00		MG/L
Organic Chloride	0/1	1.00E-02					
Phosphate	1/1	2.20E+00	2.20E+00	8.80E-01	1.80E+00	YES	MG/L
Phthalic Acid, Dioctyl Ester	0/2	1.00E-02		1.00E-02	2.00E-02		MG/L
Pyrene	0/2	1.00E-02		1.00E-02	2.00E-02		MG/L
Sulfate	1/1	4.58E+01	4.58E+01	3.00E+01	6.10E+01	NO	MG/L
Sulfide	1/1	2.50E-01	2.50E-01				
TOX	0/1	1.00E-02		5.20E-03	1.00E-02		MG/L
Tetrachloroethene	0/3	1.00E-02		4.80E-03	9.60E-03		MG/L
Toluene	0/3	1.00E-02		4.90E-03	9.70E-03		MG/L
Total Dissolved Solids	1/1	3.42E+02	3.42E+02	3.10E+02	6.10E+02	NO	MG/L
Total Kjeldahl Nitrogen-TKN	1/1	1.12E+00	1.12E+00				
Total Organic Carbon	1/1	3.70E+00	3.70E+00	9.70E-01	1.90E+00	YES	MG/L
Total Suspended Solids	1/1	1.26E+03	1.26E+03	1.30E+01	2.50E+01	YES	MG/L
Trichloroethene	0/3	1.00E-02		5.00E-03	1.00E-02		MG/L
Vinyl Chloride	0/3	1.00E-02		1.00E-02	2.00E-02		MG/L
Xylene (Total)	0/3	1.00E-02		5.00E-03	1.00E-02		MG/L
Radionuclides							
Alpha Particle	1/2	1.03E+01	1.20E+01	2.60E+00	5.30E+00	YES	PC/L
Am-241	1/1	4.20E-01	4.20E-01				
Beta Particle	2/2	3.37E+01	5.80E+01	8.00E+00	1.60E+01	YES	PC/L

Table 2c. (continued)

Analyte	Frequency of detection	Mean Concentration (MC)	Maximum Detection (MD)	Mean Background (MBG)	Twice Background mean (TMBG)	Does MD exceed TMBG ?	UNITS
Bi-212	1/1	6.23E+01	6.23E+01				
C-14	0/2	-5.17E+01					
Ca-45	0/1	4.00E+01					
Cm-243	0/1	3.00E-02					
Cs-137	0/2	1.00E+01		6.20E+00	1.20E+01		PC/L
Fe-55	0/1	-5.00E+01					
Pu-238	0/2	4.70E-02					
Pu-239/240	0/2	-1.65E-02					
Ra-226	2/2	2.47E+00	3.03E+00				
Ra-228	1/2	5.50E+00	4.30E+00				
Tc-99	1/1	1.40E+01	1.40E+01				
Th-228	2/2	1.80E+01	3.20E+01				
Th-230	2/2	1.27E+01	2.40E+01				
Th-232	2/2	1.91E+01	3.50E+01				
Total Radioactive Strontium	1/2	8.85E-01	2.50E+00	5.20E+00	1.00E+01	NO	PC/L
Tritium	2/2	9.90E+04	1.10E+05	1.20E+03	2.40E+03	YES	PC/L
U-232	0/1	1.00E-02					
U-233/234	1/1	2.10E+00	2.10E+00				
U-235	0/1	2.30E-01					
U-238	0/1	0.00E+00					
OHFP							
Inorganics							
Aluminum	0/1	2.35E-02		3.70E-01	7.40E-01		MG/L
Antimony	0/1	1.79E-02		2.60E-02	5.20E-02		MG/L
Arsenic	0/1	2.50E-03		2.60E-02	5.20E-02		MG/L
Barium	1/1	1.46E-01	1.46E-01	2.50E-01	5.00E-01	NO	MG/L
Beryllium	0/1	5.00E-04		1.60E-03	3.20E-03		MG/L
Calcium	1/1	9.85E+01	9.85E+01	8.80E+01	1.80E+02	NO	MG/L
Chromium	0/1	5.80E-03		7.50E-03	1.50E-02		MG/L
Cobalt	0/1	3.80E-03		3.70E-03	7.30E-03		MG/L
Copper	0/1	4.20E-03		8.10E-03	1.60E-02		MG/L
Iron	0/1	2.23E-02		5.70E-01	1.10E+00		MG/L

Table 2c. (continued)

Analyte	Frequency of detection	Mean Concentration (MC)	Maximum Detection (MD)	Mean Background (MBG)	Twice Background mean (TMBG)	Does MD exceed TMBG ?	UNITS
Lead	1/1	2.00E-03	2.00E-03	2.90E-02	5.70E-02	NO	MG/L
Magnesium	1/1	7.82E+00	7.82E+00	1.40E+01	2.70E+01	NO	MG/L
Manganese	0/1	1.80E-03		1.20E-01	2.40E-01		MG/L
Mercury	0/1	1.00E-04		5.00E-05	1.00E-04		MG/L
Nickel	0/1	6.10E-03		6.90E-03	1.40E-02		MG/L
Potassium	1/1	1.29E+00	1.29E+00	2.20E+00	4.50E+00	NO	MG/L
Selenium	0/1	3.30E-03		2.30E-02	4.60E-02		MG/L
Silver	0/1	3.80E-03		5.00E-03	1.00E-02		MG/L
Sodium	1/1	1.39E+01	1.39E+01	1.60E+01	3.10E+01	NO	MG/L
Vanadium	0/1	3.30E-03		2.70E-03	5.30E-03		MG/L
Zinc	0/1	3.40E-03		1.30E-02	2.60E-02		MG/L
Organics							
1,1,1-Trichloroethane	1/1	6.00E-03	6.00E-03	5.00E-03	1.00E-02	NO	MG/L
1,1-Dichloroethane	1/1	8.00E-03	8.00E-03	5.00E-03	1.00E-02	NO	MG/L
1,1-Dichloroethene	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
1,2-Dichloroethane	1/1	3.00E-03	3.00E-03	5.00E-03	1.00E-02	NO	MG/L
1,2-Dichloroethene (Total)	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
Acetone	0/1	1.00E-02		6.10E-03	1.20E-02		MG/L
Alkalinity as CaCO ₃	1/1	2.90E+02	2.90E+02	2.50E+02	5.00E+02	NO	MG/L
Benzene	0/1	1.00E-02		4.70E-03	9.30E-03		MG/L
Bis(2-Ethylhexyl) Phthalate	0/1	1.00E-02		7.10E-03	1.40E-02		MG/L
Carbon Disulfide	0/1	1.00E-02		2.00E-03	4.10E-03		MG/L
Carbon Tetrachloride	1/1	9.00E-03	9.00E-03	5.00E-03	1.00E-02	NO	MG/L
Chloride	1/1	1.39E+01	1.39E+01	3.10E+00	6.30E+00	YES	MG/L
Chlorobenzene	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
Chloroethane	0/1	1.00E-02		1.00E-02	2.00E-02		MG/L
Chloroform	1/1	2.50E-02	2.50E-02	5.00E-03	1.00E-02	YES	MG/L
Cyanide	0/1	1.00E-02		4.70E-09	9.30E-09		MG/L
Dimethyl Phthalate	0/1	1.00E-02		1.00E-02	2.00E-02		MG/L
Fluoranthene	0/1	1.00E-02		1.00E-02	2.00E-02		MG/L
Fluoride	0/1	5.00E-02					
Methylene Chloride	0/1	1.00E-02		4.70E-03	9.30E-03		MG/L

Table 2c. (continued)

Analyte	Frequency of detection	Mean Concentration (MC)	Maximum Detection (MD)	Mean Background (MBG)	Twice Background mean (TMBG)	Does MD exceed TMBG ?	UNITS
Nitrate	1/1	1.10E+00	1.10E+00	1.30E+00	2.70E+00	NO	MG/L
Phosphate	1/1	1.20E-01	1.20E-01	8.80E-01	1.80E+00	NO	MG/L
Phthalic Acid, Dioctyl Ester	0/1	1.00E-02		1.00E-02	2.00E-02		MG/L
Pyrene	0/1	1.00E-02		1.00E-02	2.00E-02		MG/L
Sulfate	1/1	1.74E+01	1.74E+01	3.00E+01	6.10E+01	NO	MG/L
TOX	1/1	3.99E-02	3.99E-02	5.20E-03	1.00E-02	YES	MG/L
Tetrachloroethene	0/1	1.00E-02		4.80E-03	9.60E-03		MG/L
Toluene	0/1	1.00E-02		4.90E-03	9.70E-03		MG/L
Total Dissolved Solids	1/1	3.25E+02	3.25E+02	3.10E+02	6.10E+02	NO	MG/L
Total Kjeldahl Nitrogen-TKN	1/1	2.50E-01	2.50E-01				
Total Organic Carbon	1/1	1.24E+00	1.24E+00	9.70E-01	1.90E+00	NO	MG/L
Total Suspended Solids	0/1	1.00E+01		1.30E+01	2.50E+01		MG/L
Trichloroethene	1/1	7.00E-03	7.00E-03	5.00E-03	1.00E-02	NO	MG/L
Vinyl Chloride	0/1	1.00E-02		1.00E-02	2.00E-02		MG/L
Xylene (Total)	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
Radionuclides							
Alpha Particle	2/5	4.07E+01	1.93E+02	2.60E+00	5.30E+00	YES	PCI/L
Am-241	1/5	8.35E-02	1.96E-01				
Beta Particle	5/5	1.57E+04	6.81E+04	8.00E+00	1.60E+01	YES	PCI/L
C-14	4/5	6.26E+02	1.69E+03				
Ca-45	0/1	2.50E+01					
Cm-242	1/5	-1.84E-03	0.00E+00				
Cm-243/244	2/5	1.42E+00	7.08E+00				
Co-60	2/2	5.64E+01	8.85E+01	2.20E+01	4.30E+01	YES	PCI/L
Cs-137	1/5	5.62E+02	2.75E+03	6.20E+00	1.20E+01	YES	PCI/L
Pu-238	2/5	2.94E-01	5.44E-01				
Pu-239/240	0/5	5.53E-02					
Ra-226	1/4	2.15E-01	5.48E-01				
Ra-228	1/4	8.19E+01	3.02E+02				
Tc-99	4/5	2.26E+01	5.37E+01				
Th-228	0/4	4.72E-01					
Th-230	1/4	4.41E-01	1.73E-01				

Table 2c. (continued)

Analyte	Frequency of detection	Mean Concentration (MC)	Maximum Detection (MD)	Mean Background (MBG)	Twice Background mean (TMBG)	Does MD exceed TMBG ?	UNITS
Th-232	3/4	1.71E-01	2.70E-01				
Th-234	1/1	1.74E+02	1.74E+02				
Total Radioactive Strontium	5/5	9.20E+03	4.15E+04	5.20E+00	1.00E+01	YES	PCI/L
Tritium	5/5	1.40E+06	2.06E+06	1.20E+03	2.40E+03	YES	PCI/L
U-232	1/4	1.93E-01	7.68E-01				
U-233/234	1/5	3.13E+00	1.41E+01				
U-235	0/3	1.56E-02					
U-235/236	0/2	3.25E-02					
U-238	0/5	3.90E-01					
PWSB							
Inorganics							
Aluminum	3/3	9.26E-01	1.27E+00	3.70E-01	7.40E-01	YES	MG/L
Antimony	0/3	1.86E-02		2.60E-02	5.20E-02		MG/L
Arsenic	0/3	4.17E-03		2.60E-02	5.20E-02		MG/L
Barium	3/3	1.41E-01	1.61E-01	2.50E-01	5.00E-01	NO	MG/L
Beryllium	0/3	3.00E-04		1.60E-03	3.20E-03		MG/L
Boron	0/2	2.74E-02		1.20E-01	2.40E-01		MG/L
Calcium	3/3	8.58E+01	9.95E+01	8.80E+01	1.80E+02	NO	MG/L
Chromium	1/3	3.53E-03	4.00E-03	7.50E-03	1.50E-02	NO	MG/L
Cobalt	0/3	2.90E-03		3.70E-03	7.30E-03		MG/L
Copper	0/3	4.00E-03		8.10E-03	1.60E-02		MG/L
Iron	3/3	1.73E+00	2.66E+00	5.70E-01	1.10E+00	YES	MG/L
Lead	3/3	4.10E-03	5.10E-03	2.90E-02	5.70E-02	NO	MG/L
Magnesium	3/3	1.22E+01	1.51E+01	1.40E+01	2.70E+01	NO	MG/L
Manganese	3/3	5.92E-02	7.74E-02	1.20E-01	2.40E-01	NO	MG/L
Mercury	0/3	1.00E-04		5.00E-05	1.00E-04		MG/L
Molybdenum	0/2	6.00E-03		4.00E-02	8.00E-02		MG/L
Nickel	1/3	4.30E-03	4.50E-03	6.90E-03	1.40E-02	NO	MG/L
Phosphorus	0/2	4.49E-02		3.00E-01	6.00E-01		MG/L
Potassium	3/3	1.78E+00	2.38E+00	2.20E+00	4.50E+00	NO	MG/L
Selenium	0/3	7.97E-03		2.30E-02	4.60E-02		MG/L
Silicon	2/2	8.03E+00	8.36E+00	8.30E+00	1.70E+01	NO	MG/L

Table 2c. (continued)

Analyte	Frequency of detection	Mean Concentration (MC)	Maximum Detection (MD)	Mean Background (MBG)	Twice Background mean (TMBG)	Does MD exceed TMBG ?	UNITS
Silver	0/3	3.30E-03		5.00E-03	1.00E-02		MG/L
Sodium	3/3	6.66E+00	8.46E+00	1.60E+01	3.10E+01	NO	MG/L
Vanadium	1/3	2.53E-03	3.40E-03	2.70E-03	5.30E-03	NO	MG/L
Zinc	1/3	6.00E-03	8.40E-03	1.30E-02	2.60E-02	NO	MG/L
Organics							
1,1,1-Trichloroethane	0/4	7.50E-03		5.00E-03	1.00E-02		MG/L
1,1-Dichloroethane	0/4	7.50E-03		5.00E-03	1.00E-02		MG/L
1,1-Dichloroethene	0/4	7.50E-03		5.00E-03	1.00E-02		MG/L
1,2-Dichloroethane	0/4	7.50E-03		5.00E-03	1.00E-02		MG/L
1,2-Dichloroethene (Total)	0/4	7.50E-03		5.00E-03	1.00E-02		MG/L
Acetone	1/4	1.05E-02	1.20E-02	6.10E-03	1.20E-02	NO	MG/L
Benzene	0/4	7.50E-03		4.70E-03	9.30E-03		MG/L
Bis(2-Ethylhexyl) Phthalate	2/3	4.93E-02	8.20E-02	7.10E-03	1.40E-02	YES	MG/L
Carbon Disulfide	0/4	7.50E-03		2.00E-03	4.10E-03		MG/L
Carbon Tetrachloride	0/4	7.50E-03		5.00E-03	1.00E-02		MG/L
Chloride	1/1	2.24E+00	2.24E+00	3.10E+00	6.30E+00	NO	MG/L
Chlorobenzene	0/4	7.50E-03		5.00E-03	1.00E-02		MG/L
Chloroethane	0/4	1.00E-02		1.00E-02	2.00E-02		MG/L
Chloroform	0/4	7.50E-03		5.00E-03	1.00E-02		MG/L
Cyanide	0/3	1.00E-02		4.70E-09	9.30E-09		MG/L
Dimethyl Phthalate	0/3	1.00E-02		1.00E-02	2.00E-02		MG/L
Fluoranthene	0/3	1.00E-02		1.00E-02	2.00E-02		MG/L
Fluoride	0/1	1.00E+00					
Methylene Chloride	0/4	7.50E-03		4.70E-03	9.30E-03		MG/L
Nitrate	0/1	2.50E-01		1.30E+00	2.70E+00		MG/L
Organic Chloride	0/1	1.00E-02					
Phosphate	1/1	1.40E-01	1.40E-01	8.80E-01	1.80E+00	NO	MG/L
Phthalic Acid, Dioctyl Ester	0/3	1.00E-02		1.00E-02	2.00E-02		MG/L
Pyrene	0/3	1.00E-02		1.00E-02	2.00E-02		MG/L
Sulfate	1/1	2.52E+01	2.52E+01	3.00E+01	6.10E+01	NO	MG/L
Sulfide	0/2	4.10E-02					
Tetrachloroethene	0/4	7.50E-03		4.80E-03	9.60E-03		MG/L

Table 2c. (continued)

Analyte	Frequency of detection	Mean Concentration (MC)	Maximum Detection (MD)	Mean Background (MBG)	Twice Background mean (TMBG)	Does MD exceed TMBG ?	UNITS
Toluene	0/4	7.50E-03		4.90E-03	9.70E-03		MG/L
Total Dissolved Solids	1/1	3.53E+02	3.53E+02	3.10E+02	6.10E+02	NO	MG/L
Total Kjeldahl Nitrogen-TKN	3/3	6.73E-01	1.26E+00				
Total Organic Carbon	0/1	1.00E+00		9.70E-01	1.90E+00		MG/L
Total Suspended Solids	1/1	6.00E+01	6.00E+01	1.30E+01	2.50E+01	YES	MG/L
Trichloroethene	0/4	7.50E-03		5.00E-03	1.00E-02		MG/L
Vinyl Chloride	0/4	1.00E-02		1.00E-02	2.00E-02		MG/L
Xylene (Total)	0/4	7.50E-03		5.00E-03	1.00E-02		MG/L
Radionuclides							
Alpha Particle	0/5	1.12E+00		2.60E+00	5.30E+00		PCI/L
Am-241	1/5	8.30E-02	1.43E-01				
Beta Particle	3/5	7.36E+00	1.90E+01	8.00E+00	1.60E+01	YES	PCI/L
C-14	0/3	-1.50E+01					
Cm-242	0/2	0.00E+00					
Cm-243	0/1	2.00E-02					
Cm-243/244	0/4	-2.03E-02					
Co-60	1/2	-2.70E-01	5.40E-01	2.20E+01	4.30E+01	NO	PCI/L
Cs-137	0/6	8.53E+00		6.20E+00	1.20E+01		PCI/L
Mn-54	1/1	8.90E+00	8.90E+00				
Pu-238	0/4	4.94E-02					
Pu-239/240	0/4	3.31E-02					
Ra-226	1/2	1.61E-01	2.22E-01				
Ra-228	2/2	1.08E+00	1.13E+00				
Tc-99	0/3	2.23E-01					
Th-228	1/2	4.21E-01	4.03E-01				
Th-230	0/2	1.85E-01					
Th-232	1/2	1.11E-01	1.32E-01				
Total Radioactive Strontium	3/5	1.35E+00	4.80E+00	5.20E+00	1.00E+01	NO	PCI/L
Tritium	6/6	6.05E+03	1.70E+04	1.20E+03	2.40E+03	YES	PCI/L
U-232	0/3	1.27E-02					
U-233/234	4/5	4.69E-01	8.90E-01				
U-235	1/4	4.91E-02	1.50E-01				

Table 2c. (continued)

Analyte	Frequency of detection	Mean Concentration (MC)	Maximum Detection (MD)	Mean Background (MBG)	Twice Background mean (TMBG)	Does MD exceed TMBG ?	UNITS
U-235/236	0/1	-5.10E-03					
U-238	3/5	1.98E-01	5.50E-01				
SWSA 5N							
Inorganics							
Aluminum	7/11	6.65E+00	8.14E+01	3.70E-01	7.40E-01	YES	MG/L
Antimony	0/11	1.72E-02		2.60E-02	5.20E-02		MG/L
Arsenic	5/11	2.92E-03	5.00E-03	2.60E-02	5.20E-02	NO	MG/L
Barium	11/11	6.35E-01	9.22E-01	2.50E-01	5.00E-01	YES	MG/L
Beryllium	4/11	5.98E-04	5.40E-03	1.60E-03	3.20E-03	YES	MG/L
Boron	0/5	7.32E-02		1.20E-01	2.40E-01		MG/L
Calcium	11/11	1.15E+02	2.16E+02	8.80E+01	1.80E+02	YES	MG/L
Chromium	7/11	3.35E-02	1.59E-01	7.50E-03	1.50E-02	YES	MG/L
Cobalt	6/11	1.23E-02	8.22E-02	3.70E-03	7.30E-03	YES	MG/L
Copper	3/11	5.31E-03	1.14E-01	8.10E-03	1.60E-02	YES	MG/L
Iron	8/11	1.31E+01	1.24E+02	5.70E-01	1.10E+00	YES	MG/L
Lead	12/13	2.99E-02	1.18E-01	2.90E-02	5.70E-02	YES	MG/L
Magnesium	11/11	2.33E+01	4.07E+01	1.40E+01	2.70E+01	YES	MG/L
Manganese	10/11	7.65E-01	3.69E+00	1.20E-01	2.40E-01	YES	MG/L
Mercury	0/11	1.18E-04		5.00E-05	1.00E-04		MG/L
Molybdenum	0/5	6.00E-03		4.00E-02	8.00E-02		MG/L
Nickel	9/11	5.67E-02	4.16E-01	6.90E-03	1.40E-02	YES	MG/L
Phosphorus	1/5	4.52E-02	4.62E-02	3.00E-01	6.00E-01	NO	MG/L
Potassium	11/11	7.47E+00	2.06E+01	2.20E+00	4.50E+00	YES	MG/L
Selenium	0/8	9.63E-03		2.30E-02	4.60E-02		MG/L
Silicon	5/5	9.41E+00	1.18E+01	8.30E+00	1.70E+01	NO	MG/L
Silver	1/11	3.57E-03	6.60E-03	5.00E-03	1.00E-02	NO	MG/L
Sodium	11/11	3.12E+01	7.96E+01	1.60E+01	3.10E+01	YES	MG/L
Vanadium	7/11	1.67E-02	1.24E-01	2.70E-03	5.30E-03	YES	MG/L
Zinc	7/11	8.29E-02	1.18E+00	1.30E-02	2.60E-02	YES	MG/L
Organics							
1,1,1-Trichloroethane	0/10	7.50E-03		5.00E-03	1.00E-02		MG/L
1,1-Dichloroethane	0/10	7.50E-03		5.00E-03	1.00E-02		MG/L

Table 2c. (continued)

Analyte	Frequency of detection	Mean Concentration (MC)	Maximum Detection (MD)	Mean Background (MBG)	Twice Background mean (TMBG)	Does MD exceed TMBG ?	UNITS
1,1-Dichloroethene	0/10	7.50E-03		5.00E-03	1.00E-02		MG/L
1,2-Dichloroethane	0/10	7.50E-03		5.00E-03	1.00E-02		MG/L
1,2-Dichloroethene (Total)	0/10	7.50E-03		5.00E-03	1.00E-02		MG/L
Acetone	0/10	1.00E-02		6.10E-03	1.20E-02		MG/L
Alkalinity as CaCO ₃	1/1	3.70E+02	3.70E+02	2.50E+02	5.00E+02	NO	MG/L
Benzene	0/10	7.50E-03		4.70E-03	9.30E-03		MG/L
Bis(2-Ethylhexyl) Phthalate	2/10	1.14E-02	1.80E-02	7.10E-03	1.40E-02	YES	MG/L
Carbon Disulfide	0/10	7.50E-03		2.00E-03	4.10E-03		MG/L
Carbon Tetrachloride	0/10	7.50E-03		5.00E-03	1.00E-02		MG/L
Chloride	4/4	4.72E+00	9.91E+00	3.10E+00	6.30E+00	YES	MG/L
Chlorobenzene	0/10	7.50E-03		5.00E-03	1.00E-02		MG/L
Chloroethane	0/10	1.00E-02		1.00E-02	2.00E-02		MG/L
Chloroform	0/10	7.50E-03		5.00E-03	1.00E-02		MG/L
Cyanide	0/9	1.00E-02		4.70E-09	9.30E-09		MG/L
Dimethyl Phthalate	1/10	1.69E-01	1.60E+00	1.00E-02	2.00E-02	YES	MG/L
Fluoranthene	1/10	9.10E-03	1.00E-03	1.00E-02	2.00E-02	NO	MG/L
Fluoride	2/4	6.77E-01	6.10E-01				
Methylene Chloride	1/10	1.06E-02	4.80E-02	4.70E-03	9.30E-03	YES	MG/L
Nitrate	1/4	3.78E-01	7.60E-01	1.30E+00	2.70E+00	NO	MG/L
Organic Chloride	1/2	5.05E-01	1.00E+00				
Phosphate	3/4	3.46E-01	7.90E-01	8.80E-01	1.80E+00	NO	MG/L
Phthalic Acid, Dioctyl Ester	1/10	9.40E-03	4.00E-03	1.00E-02	2.00E-02	NO	MG/L
Pyrene	1/10	9.10E-03	1.00E-03	1.00E-02	2.00E-02	NO	MG/L
Sulfate	4/4	3.19E+01	6.85E+01	3.00E+01	6.10E+01	YES	MG/L
Sulfide	0/5	4.18E-02					
TOX	0/2	5.01E+00		5.20E-03	1.00E-02		MG/L
Tetrachloroethene	0/10	7.50E-03		4.80E-03	9.60E-03		MG/L
Toluene	0/10	7.50E-03		4.90E-03	9.70E-03		MG/L
Total Dissolved Solids	4/4	4.09E+02	5.47E+02	3.10E+02	6.10E+02	NO	MG/L
Total Kjeldahl Nitrogen-TKN	9/9	5.13E-01	1.10E+00				
Total Organic Carbon	2/4	2.09E+00	3.80E+00	9.70E-01	1.90E+00	YES	MG/L
Total Suspended Solids	4/4	9.53E+02	1.38E+03	1.30E+01	2.50E+01	YES	MG/L

Table 2c. (continued)

Analyte	Frequency of detection	Mean Concentration (MC)	Maximum Detection (MD)	Mean Background (MBG)	Twice Background mean (TMBG)	Does MD exceed TMBG ?	UNITS
Trichloroethene	0/10	7.50E-03		5.00E-03	1.00E-02		MG/L
Vinyl Chloride	0/10	1.00E-02		1.00E-02	2.00E-02		MG/L
Xylene (Total)	0/10	7.50E-03		5.00E-03	1.00E-02		MG/L
Radionuclides							
Alpha Particle	15/27	4.62E+01	7.10E+02	2.60E+00	5.30E+00	YES	PCI/L
Am-241	9/1	1.36E+00	3.73E+01				
Beta Particle	20/27	3.57E+01	2.45E+02	8.00E+00	1.60E+01	YES	PCI/L
Bi-214	1/1	1.68E+02	1.68E+02				
C-14	3/23	4.81E+01	8.80E+02				
Ca-45	0/1	1.70E+01					
Cm-242	0/13	2.24E-02					
Cm-243	2/16	1.61E-01	4.10E-01				
Cm-243/244	7/19	1.89E+01	1.80E+02				
Co-60	0/5	1.62E-01		2.20E+01	4.30E+01		PCI/L
Cs-137	3/29	7.56E+00	7.62E+00	6.20E+00	1.20E+01	NO	PCI/L
Fe-55	0/1	-3.50E+01					
Hg-203	1/1	1.45E+01	1.45E+01				
K-40	4/4	3.49E+02	6.72E+02				
Pb-212	7/7	2.37E+01	4.99E+01				
Pu-238	6/27	3.50E-01	2.24E+00				
Pu-239/240	0/27	3.98E-02					
Ra-226	12/21	1.93E+00	1.13E+01				
Ra-228	6/15	9.57E+00	4.86E+01				
Tc-99	8/20	1.24E+01	1.12E+02				
Th-228	10/21	1.89E+00	8.53E+00				
Th-230	12/21	1.22E+00	7.77E+00				
Th-232	12/22	1.82E+00	1.01E+01				
Th-234	3/3	2.59E+02	4.88E+02				
Total Radioactive Strontium	0/29	3.99E-01		5.20E+00	1.00E+01		PCI/L
Tritium	22/29	1.53E+03	7.86E+03	1.20E+03	2.40E+03	YES	PCI/L
U-232	0/18	9.06E-04					
U-233/234	15/24	1.86E+00	1.00E+01				

Table 2c. (continued)

Analyte	Frequency of detection	Mean Concentration (MC)	Maximum Detection (MD)	Mean Background (MBG)	Twice Background mean (TMBG)	Does MD exceed TMBG ?	UNITS
U-235	2/17	1.06E-01	3.60E-01				
U-235/236	1/7	2.73E-02	2.02E-01				
U-238	9/24	1.42E+00	9.88E+00				
SWSA SSE							
Inorganics							
Aluminum	12/15	6.49E+00	4.44E+01	3.70E-01	7.40E-01	YES	MG/L
Antimony	1/15	1.38E-02	1.40E-02	2.60E-02	5.20E-02	NO	MG/L
Arsenic	4/15	2.06E-03	1.37E-02	2.60E-02	5.20E-02	NO	MG/L
Barium	15/15	4.25E-01	8.47E-01	2.50E-01	5.00E-01	YES	MG/L
Beryllium	7/15	1.25E-03	1.90E-03	1.60E-03	3.20E-03	NO	MG/L
Boron	5/7	2.82E-01	1.49E+00	1.20E-01	2.40E-01	YES	MG/L
Calcium	15/15	1.02E+02	2.86E+02	8.80E+01	1.80E+02	YES	MG/L
Chromium	8/15	3.28E-02	1.35E-01	7.50E-03	1.50E-02	YES	MG/L
Cobalt	8/15	2.12E-02	1.93E-01	3.70E-03	7.30E-03	YES	MG/L
Copper	7/15	1.47E-02	6.30E-02	8.10E-03	1.60E-02	YES	MG/L
Iron	15/15	5.92E+02	2.86E+02	5.70E-01	1.10E+00	YES	MG/L
Lead	10/15	3.24E-02	7.52E-01	2.90E-02	5.70E-02	YES	MG/L
Magnesium	15/15	1.98E+01	3.86E+01	1.40E+01	2.70E+01	YES	MG/L
Manganese	15/15	6.43E+00	2.26E+01	1.20E-01	2.40E-01	YES	MG/L
Mercury	6/15	1.81E-04	4.50E-04	5.00E-05	1.00E-04	YES	MG/L
Molybdenum	0/7	1.20E-02		4.00E-02	8.00E-02		MG/L
Nickel	11/15	4.57E-02	1.55E-01	6.90E-03	1.40E-02	YES	MG/L
Phosphorus	1/7	6.60E-02	5.63E-02	3.00E-01	6.00E-01	NO	MG/L
Potassium	15/15	4.26E+00	1.24E+01	2.20E+00	4.50E+00	YES	MG/L
Selenium	0/15	7.71E-03		2.30E-02	4.60E-02		MG/L
Silicon	7/7	8.39E+00	1.01E+01	8.30E+00	1.70E+01	NO	MG/L
Silver	5/15	4.46E-03	1.46E-02	5.00E-03	1.00E-02	YES	MG/L
Sodium	15/15	1.71E+01	5.49E+01	1.60E+01	3.10E+01	YES	MG/L
Vanadium	8/15	1.91E-02	8.91E-02	2.70E-03	5.30E-03	YES	MG/L
Zinc	10/15	7.23E-02	4.16E-01	1.30E-02	2.60E-02	YES	MG/L
Organics							
1,1,1-Trichloroethane	2/16	3.36E-03	1.60E-02	5.00E-03	1.00E-02	YES	MG/L

Table 2c. (continued)

Analyte	Frequency of detection	Mean Concentration (MC)	Maximum Detection (MD)	Mean Background (MBG)	Twice Background mean (TMBG)	Does MD exceed TMBG ?	UNITS
1,1-Dichloroethane	4/16	4.94E-03	2.10E-02	5.00E-03	1.00E-02	YES	MG/L
1,1-Dichloroethene	2/16	4.77E-03	6.00E-03	5.00E-03	1.00E-02	NO	MG/L
1,2-Dichloroethane	4/16	3.19E-03	4.00E-03	5.00E-03	1.00E-02	NO	MG/L
1,2-Dichloroethene (Total)	10/16	3.40E-02	1.80E-01	5.00E-03	1.00E-02	YES	MG/L
Acetone	0/16	1.00E-02		6.10E-03	1.20E-02		MG/L
Alkalinity as CaCO3	1/1	4.07E+02	4.07E+02	2.50E+02	5.00E+02	NO	MG/L
Benzene	2/16	6.75E-03	2.00E-03	4.70E-03	9.30E-03	NO	MG/L
Bis(2-Ethylhexyl) Phthalate	1/10	9.50E-03	5.00E-03	7.10E-03	1.40E-02	NO	MG/L
Carbon Disulfide	1/16	7.25E-03	1.00E-03	2.00E-03	4.10E-03	NO	MG/L
Carbon Tetrachloride	0/16	7.81E-03		5.00E-03	1.00E-02		MG/L
Chloride	4/4	2.11E+01	3.44E+01	3.10E+00	6.30E+00	YES	MG/L
Chlorobenzene	1/16	7.46E-03	2.00E-03	5.00E-03	1.00E-02	NO	MG/L
Chloroethane	1/16	9.44E-03	1.00E-03	1.00E-02	2.00E-02	NO	MG/L
Chloroform	1/16	7.25E-03	1.00E-03	5.00E-03	1.00E-02	NO	MG/L
Cyanide	1/14	1.19E-02	4.85E-02	4.70E-09	9.30E-09	YES	MG/L
Dimethyl Phthalate	0/12	1.00E-02		1.00E-02	2.00E-02		MG/L
Fluoranthene	0/12	1.00E-02		1.00E-02	2.00E-02		MG/L
Fluoride	4/4	1.49E-01	2.50E-01				
Methylene Chloride	0/16	7.81E-03		4.70E-03	9.30E-03		MG/L
Nitrate	2/4	8.55E-01	1.66E+00	1.30E+00	2.70E+00	NO	MG/L
Phosphate	4/4	7.13E-01	1.17E+00	8.80E-01	1.80E+00	NO	MG/L
Phthalic Acid, Dioctyl Ester	0/12	1.00E-02		1.00E-02	2.00E-02		MG/L
Pyrene	0/12	1.00E-02		1.00E-02	2.00E-02		MG/L
Sulfate	4/4	1.66E+01	2.39E+01	3.00E+01	6.10E+01	NO	MG/L
Sulfide	0/9	3.02E-01					
TOX	4/4	6.01E-02	1.37E-01	5.20E-03	1.00E-02	YES	MG/L
Tetrachloroethene	8/16	6.97E-03	3.40E-02	4.80E-03	9.60E-03	YES	MG/L
Toluene	1/16	7.25E-03	1.00E-03	4.90E-03	9.70E-03	NO	MG/L
Total Dissolved Solids	4/4	3.42E+02	4.76E+02	3.10E+02	6.10E+02	NO	MG/L
Total Kjeldahl Nitrogen-TKN	9/11	3.05E-01	7.20E-01				
Total Organic Carbon	2/4	1.80E+00	2.78E+00	9.70E-01	1.90E+00	YES	MG/L
Total Suspended Solids	4/4	2.77E+02	5.34E+02	1.30E+01	2.50E+01	YES	MG/L

Table 2c. (continued)

Analyte	Frequency of detection	Mean Concentration (MC)	Maximum Detection (MD)	Mean Background (MBG)	Twice Background mean (TMBG)	Does MD exceed TMBG ?	UNITS
Trichloroethene	10/16	1.44E-02	2.10E-01	5.00E-03	1.00E-02	YES	MG/L
Vinyl Chloride	7/16	9.02E-03	2.78E-02	1.00E-02	2.00E-02	YES	MG/L
Xylene (Total)	0/16	7.81E-03		5.00E-03	1.00E-02		MG/L
Radionuclides							
Alpha Particle	11/20	3.77E+05	7.51E+06	2.60E+00	5.30E+00	YES	PCI/L
Am-241	11/21	5.46E+04	1.15E+06				
Beta Particle	19/21	3.39E+04	6.53E+05	8.00E+00	1.60E+01	YES	PCI/L
Bi-212	1/1	5.34E+02	5.34E+02				
C-14	10/22	2.48E+02	1.54E+03				
Ca-45	0/2	7.45E+01					
Cd-109	1/1	3.67E+02	3.67E+02				
Cm-242	0/11	3.27E-02					
Cm-243	0/2	8.50E-02					
Cm-243/244	12/18	5.61E+00	3.70E+01				
Co-60	0/7	1.08E+00		2.20E+01	4.30E+01		PCI/L
Cs-137	1/23	7.49E+00	8.74E+00	6.20E+00	1.20E+01	NO	PCI/L
Fe-55	1/2	1.20E+01	5.30E+01				
Hg-203	1/1	1.28E+01	1.28E+01				
Pu-238	10/23	3.51E+04	7.77E+05				
Pu-239/240	5/23	5.96E+02	1.36E+04				
Ra-226	5/15	4.70E+02	7.04E+03				
Ra-228	7/13	1.04E+01	7.74E+01				
Tc-99	6/13	7.85E+01	5.12E+02				
Th-228	6/14	1.84E+01	2.10E+02				
Th-230	5/14	1.02E+00	5.88E+00				
Th-231	1/1	3.53E+02	3.53E+02				
Th-232	4/14	3.91E-01	2.79E+00				
Total Radioactive Strontium	20/22	1.39E+03	1.46E+04	5.20E+00	1.00E+01	YES	PCI/L
Tritium	22/22	3.44E+07	2.99E+08	1.20E+03	2.40E+03	YES	PCI/L
U-232	1/11	2.79E-01	2.89E+00				
U-233/234	14/23	5.67E+02	3.80E+03				
U-235	0/17	2.49E+00					

Table 2c. (continued)

Analyte	Frequency of detection	Mean Concentration (MC)	Maximum Detection (MD)	Mean Background (MBG)	Twice Background mean (TMBG)	Does MD exceed TMBG ?	UNITS
U-235/236	1/6	6.33E-02	3.69E-01				
U-238	6/23	-1.39E+01	1.77E+00				
SWSA 5SW							
Inorganics							
Aluminum	9/10	1.65E+01	4.28E+01	3.70E-01	7.40E-01	YES	MG/L
Antimony	0/9	1.79E-02		2.60E-02	5.20E-02		MG/L
Arsenic	3/10	2.52E-03	1.05E-02	2.60E-02	5.20E-02	NO	MG/L
Barium	10/10	3.63E-01	5.99E-01	2.50E-01	5.00E-01	YES	MG/L
Beryllium	4/10	7.27E-04	2.50E-03	1.60E-03	3.20E-03	NO	MG/L
Boron	1/3	1.35E-01	2.17E-01	1.20E-01	2.40E-01	NO	MG/L
Calcium	10/10	1.63E+02	2.83E+02	8.80E+01	1.80E+02	YES	MG/L
Chromium	7/10	4.97E-02	1.17E-01	7.50E-03	1.50E-02	YES	MG/L
Cobalt	7/10	3.14E-02	7.31E-02	3.70E-03	7.30E-03	YES	MG/L
Copper	5/10	2.04E-02	7.54E-02	8.10E-03	1.60E-02	YES	MG/L
Iron	8/10	3.24E+01	2.19E+02	5.70E-01	1.10E+00	YES	MG/L
Lead	9/10	3.07E-02	1.77E-01	2.90E-02	5.70E-02	YES	MG/L
Magnesium	10/10	2.17E+01	3.14E+01	1.40E+01	2.70E+01	YES	MG/L
Manganese	10/10	3.81E+00	5.13E+00	1.20E-01	2.40E-01	YES	MG/L
Mercury	3/10	1.17E-04	3.20E-04	5.00E-05	1.00E-04	YES	MG/L
Molybdenum	1/4	7.83E-03	1.33E-02	4.00E-02	8.00E-02	NO	MG/L
Nickel	8/10	6.33E-02	2.35E-01	6.90E-03	1.40E-02	YES	MG/L
Phosphorus	0/3	4.49E-02		3.00E-01	6.00E-01		MG/L
Potassium	10/10	6.21E+00	1.39E+01	2.20E+00	4.50E+00	YES	MG/L
Selenium	0/7	6.11E-03		2.30E-02	4.60E-02		MG/L
Silicon	4/4	2.95E+01	6.17E+01	8.30E+00	1.70E+01	YES	MG/L
Silver	3/10	3.61E-03	1.54E-02	5.00E-03	1.00E-02	YES	MG/L
Sodium	10/10	2.19E+01	4.05E+01	1.60E+01	3.10E+01	YES	MG/L
Vanadium	6/10	2.24E-02	7.46E-02	2.70E-03	5.30E-03	YES	MG/L
Zinc	7/10	8.76E-02	1.98E-01	1.30E-02	2.60E-02	YES	MG/L
Organics							
1,1,1-Trichloroethane	3/10	2.28E-03	5.00E-03	5.00E-03	1.00E-02	NO	MG/L
1,1-Dichloroethane	5/10	4.66E-03	8.00E-03	5.00E-03	1.00E-02	NO	MG/L

Table 2c. (continued)

Analyte	Frequency of detection	Mean Concentration (MC)	Maximum Detection (MD)	Mean Background (MBG)	Twice Background mean (TMBG)	Does MD exceed TMBG ?	UNITS
1,1-Dichloroethene	0/10	1.00E-02		5.00E-03	1.00E-02		MG/L
1,2-Dichloroethane	0/10	1.00E-02		5.00E-03	1.00E-02		MG/L
1,2-Dichloroethene (Total)	6/10	1.85E-02	7.10E-02	5.00E-03	1.00E-02	YES	MG/L
Acetone	0/10	1.24E-02		6.10E-03	1.20E-02		MG/L
Benzene	1/10	1.01E-02	1.00E-03	4.70E-03	9.30E-03	NO	MG/L
Bis(2-Ethylhexyl) Phthalate	3/9	1.35E-02	3.10E+00	7.10E-03	1.40E-02	YES	MG/L
Carbon Disulfide	0/10	1.00E-02		2.00E-03	4.10E-03		MG/L
Carbon Tetrachloride	1/10	9.59E-03	6.00E-03	5.00E-03	1.00E-02	NO	MG/L
Chloride	4/4	1.15E+01	1.90E+01	3.10E+00	6.30E+00	YES	MG/L
Chlorobenzene	0/10	1.00E-02		5.00E-03	1.00E-02		MG/L
Chloroethane	1/10	1.10E-02	3.00E-03	1.00E-02	2.00E-02	NO	MG/L
Chloroform	1/10	1.01E-02	1.00E-03	5.00E-03	1.00E-02	NO	MG/L
Cyanide	1/9	8.48E-03	5.80E-03	4.70E-09	9.30E-09	YES	MG/L
Dimethyl Phthalate	0/9	1.00E-02		1.00E-02	2.00E-02		MG/L
Fluoranthene	0/9	1.00E-02		1.00E-02	2.00E-02		MG/L
Fluoride	1/4	3.78E-01	1.50E-01				
Methylene Chloride	0/10	1.22E-02		4.70E-03	9.30E-03		MG/L
Nitrate	2/4	8.06E-01	6.89E+00	1.30E+00	2.70E+00	YES	MG/L
Organic Chloride	0/1	1.00E-02					
Phosphate	4/4	7.58E-01	1.33E+00	8.80E-01	1.80E+00	NO	MG/L
Phthalic Acid, Dioctyl Ester	0/9	1.00E-02		1.00E-02	2.00E-02		MG/L
Pyrene	0/9	1.00E-02		1.00E-02	2.00E-02		MG/L
Sulfate	4/4	2.51E+01	2.93E+01	3.00E+01	6.10E+01	NO	MG/L
Sulfide	1/5	3.20E-01	2.50E-01				
TOX	3/3	1.18E+05	1.19E+02	5.20E-03	1.00E-02	YES	MG/L
Tetrachloroethene	2/10	1.97E-03	2.50E-01	4.80E-03	9.60E-03	YES	MG/L
Toluene	0/10	1.00E-02		4.90E-03	9.70E-03		MG/L
Total Dissolved Solids	4/4	3.93E+02	6.52E+02	3.10E+02	6.10E+02	YES	MG/L
Total Kjeldahl Nitrogen-TKN	6/7	3.18E-01	5.60E-01				
Total Organic Carbon	2/4	2.15E+00	3.62E+00	9.70E-01	1.90E+00	YES	MG/L
Total Suspended Solids	4/4	8.71E+02	1.46E+03	1.30E+01	2.50E+01	YES	MG/L
Trichloroethene	6/10	8.81E-03	3.40E-02	5.00E-03	1.00E-02	YES	MG/L

Table 2c. (continued)

Analyte	Frequency of detection	Mean Concentration (MC)	Maximum Detection (MD)	Mean Background (MBG)	Twice Background mean (TMBG)	Does MD exceed TMBG ?	UNITS
Vinyl Chloride	2/10	1.67E-02	3.60E-02	1.00E-02	2.00E-02	YES	MG/L
Xylene (Total)	0/10	1.00E-02		5.00E-03	1.00E-02		MG/L
Radionuclides							
Alpha Particle	9/12	6.78E+01	5.25E+01	2.60E+00	5.30E+00	YES	PCI/L
Am-241	5/11	8.81E-01	7.75E+00				
Beta Particle	11/13	4.66E+02	1.10E+03	8.00E+00	1.60E+01	YES	PCI/L
Bi-214	1/1	2.92E+01	2.92E+01				
C-14	11/14	3.23E+02	9.18E+02				
Ca-45	1/3	1.13E+02	2.80E+02				
Cm-242	1/6	1.09E-01	5.60E-01				
Cm-243	0/2	9.00E-02					
Cm-243/244	4/9	8.08E-01	3.44E+00				
Co-60	2/5	1.94E+01	5.18E+01	2.20E+01	4.30E+01	YES	PCI/L
Cs-137	1/14	9.67E+00	7.06E+00	6.20E+00	1.20E+01	NO	PCI/L
Fe-55	0/2	-1.46E+01					
K-40	2/2	5.66E+02	1.01E+03				
Pb-212	1/1	5.26E+01	5.26E+01				
Pu-238	5/12	7.09E-01	5.75E+00				
Pu-239/240	1/12	7.17E-02	1.13E-01				
Ra-226	7/9	1.56E+00	3.64E+00				
Ra-228	4/8	2.68E+01	9.62E+01				
Tc-99	3/8	7.87E+00	2.41E+01				
Th-228	6/9	5.67E+00	3.68E+01				
Th-230	4/9	3.21E+00	1.62E+01				
Th-232	6/9	3.96E+00	2.51E+01				
Th-234	1/1	1.73E+02	1.73E+02				
Total Radioactive Strontium	10/13	2.24E+02	5.74E+02	5.20E+00	1.00E+01	YES	PCI/L
Tritium	14/14	4.73E+06	2.72E+07	1.20E+03	2.40E+03	YES	PCI/L
U-232	0/7	3.00E-02					
U-233/234	10/12	3.37E+00	1.86E+01				
U-235	0/9	5.58E-02					
U-235/236	1/3	2.40E-01	6.90E-03				

Table 2c. (continued)

Analyte	Frequency of detection	Mean Concentration (MC)	Maximum Detection (MD)	Mean Background (MBG)	Twice Background mean (TMBG)	Does MD exceed TMBG ?	UNITS
U-238	4/12	2.29E+00	1.24E+01				
WOC							
Inorganics							
Aluminum	2/5	9.23E-02	2.72E-01	3.70E-01	7.40E-01	NO	MG/L
Antimony	0/5	1.86E-02		2.60E-02	5.20E-02		MG/L
Arsenic	1/5	2.66E-03	2.50E-03	2.60E-02	5.20E-02	NO	MG/L
Barium	5/5	3.74E-01	9.78E-01	2.50E-01	5.00E-01	YES	MG/L
Beryllium	0/5	3.00E-04		1.60E-03	3.20E-03		MG/L
Boron	1/5	1.35E-01	3.86E-01	1.20E-01	2.40E-01	YES	MG/L
Calcium	5/5	8.45E+01	1.71E+02	8.80E+01	1.80E+02	NO	MG/L
Chromium	0/5	3.30E-03		7.50E-03	1.50E-02		MG/L
Cobalt	0/5	2.90E-03		3.70E-03	7.30E-03		MG/L
Copper	0/5	4.12E-03		8.10E-03	1.60E-02		MG/L
Iron	5/5	7.70E-01	8.51E-01	5.70E-01	1.10E+00	NO	MG/L
Lead	5/5	3.38E-03	4.90E-03	2.90E-02	5.70E-02	NO	MG/L
Magnesium	5/5	1.94E+01	2.56E+01	1.40E+01	2.70E+01	NO	MG/L
Manganese	4/5	1.09E-01	7.98E-01	1.20E-01	2.40E-01	YES	MG/L
Mercury	1/5	1.02E-04	1.10E-04	5.00E-05	1.00E-04	YES	MG/L
Molybdenum	0/5	6.00E-03		4.00E-02	8.00E-02		MG/L
Nickel	0/5	4.20E-03		6.90E-03	1.40E-02		MG/L
Phosphorus	1/5	8.95E-02	2.68E-01	3.00E-01	6.00E-01	NO	MG/L
Potassium	5/5	1.88E+00	3.54E+00	2.20E+00	4.50E+00	NO	MG/L
Selenium	1/5	6.38E-03	5.10E-03	2.30E-02	4.60E-02	NO	MG/L
Silicon	5/5	9.87E+00	1.41E+01	8.30E+00	1.70E+01	NO	MG/L
Silver	0/5	3.30E-03		5.00E-03	1.00E-02		MG/L
Sodium	5/5	3.47E+01	1.32E+02	1.60E+01	3.10E+01	YES	MG/L
Vanadium	0/5	2.10E-03		2.70E-03	5.30E-03		MG/L
Zinc	0/5	4.80E-03		1.30E-02	2.60E-02		MG/L
Organics							
1,1,1-Trichloroethane	0/6	5.83E-03		5.00E-03	1.00E-02		MG/L
1,1-Dichloroethane	1/6	5.17E-03	1.00E-03	5.00E-03	1.00E-02	NO	MG/L
1,1-Dichloroethene	2/6	4.33E-03	5.00E-03	5.00E-03	1.00E-02	NO	MG/L

Table 2c. (continued)

Analyte	Frequency of detection	Mean Concentration (MC)	Maximum Detection (MD)	Mean Background (MBG)	Twice Background mean (TMBG)	Does MD exceed TMBG ?	UNITS
1,2-Dichloroethane	0/6	5.83E-03		5.00E-03	1.00E-02		MG/L
1,2-Dichloroethene (Total)	2/6	8.20E-01	3.30E+00	5.00E-03	1.00E-02	YES	MG/L
Acetone	0/6	1.03E-02		6.10E-03	1.20E-02		MG/L
Benzene	2/6	5.81E-03	2.50E-02	4.70E-03	9.30E-03	YES	MG/L
Bis(2-Ethylhexyl) Phthalate	0/5	1.00E-02		7.10E-03	1.40E-02		MG/L
Carbon Disulfide	0/6	5.83E-03		2.00E-03	4.10E-03		MG/L
Carbon Tetrachloride	0/6	5.83E-03		5.00E-03	1.00E-02		MG/L
Chlorobenzene	0/6	5.83E-03		5.00E-03	1.00E-02		MG/L
Chloroethane	0/6	1.00E-02		1.00E-02	2.00E-02		MG/L
Chloroform	0/6	5.83E-03		5.00E-03	1.00E-02		MG/L
Cyanide	0/5	1.00E-02		4.70E-09	9.30E-09		MG/L
Dimethyl Phthalate	0/5	1.00E-02		1.00E-02	2.00E-02		MG/L
Fluoranthene	0/5	1.00E-02		1.00E-02	2.00E-02		MG/L
Methylene Chloride	0/6	6.17E-03		4.70E-03	9.30E-03		MG/L
Phthalic Acid, Dioctyl Ester	0/5	1.00E-02		1.00E-02	2.00E-02		MG/L
Pyrene	0/5	1.00E-02		1.00E-02	2.00E-02		MG/L
Sulfide	0/5	4.20E-02					
Tetrachloroethene	0/6	5.83E-03		4.80E-03	9.60E-03		MG/L
Toluene	0/6	5.83E-03		4.90E-03	9.70E-03		MG/L
Total Kjeldahl Nitrogen-TKN	4/5	2.99E-01	6.80E-01				
Trichloroethene	2/6	5.51E-03	2.70E-02	5.00E-03	1.00E-02	YES	MG/L
Vinyl Chloride	2/6	1.12E+00	4.00E+00	1.00E-02	2.00E-02	YES	MG/L
Xylene (Total)	1/6	5.49E-03	2.00E-03	5.00E-03	1.00E-02	NO	MG/L
Radionuclides							
Alpha Particle	1/7	1.94E+00	1.11E+00	2.60E+00	5.30E+00	NO	PCI/L
Am-241	0/10	5.90E-02					
Beta Particle	5/10	1.52E+01	8.38E+01	8.00E+00	1.60E+01	YES	PCI/L
C-14	4/9	5.52E+02	2.49E+03				
Cm-242	0/5	4.10E-03					
Cm-243/244	0/10	1.03E-02					
Co-60	4/7	1.50E+01	3.65E+01	2.20E+01	4.30E+01	NO	PCI/L
Cs-137	0/10	7.79E+00		6.20E+00	1.20E+01		PCI/L

Table 2c. (continued)

Analyte	Frequency of detection	Mean Concentration (MC)	Maximum Detection (MD)	Mean Background (MBG)	Twice Background mean (TMBG)	Does MD exceed TMBG ?	UNITS
Pu-238	1/10	-8.98E-03	5.07E-02				
Pu-239/240	1/10	7.41E-02	2.47E-01				
Ra-226	1/5	1.46E-01	3.27E-01				
Ra-228	0/5	3.59E-01					
Tc-99	0/5	-4.31E-01					
Th-228	1/5	7.10E-01	2.59E+00				
Th-230	2/5	5.64E-01	6.32E-01				
Th-232	0/5	-4.61E-02					
Th-234	1/1	1.00E+03	1.00E+03				
Total Radioactive Strontium	1/10	6.99E-01	6.36E-01	5.20E+00	1.00E+01	NO	PC/L
Tritium	8/10	2.86E+04	6.48E+04	1.20E+03	2.40E+03	YES	PC/L
U-232	0/5	2.23E-02					
U-233/234	6/10	4.90E-01	1.24E+00				
U-235	3/6	1.48E-01	3.24E-01				
U-235/236	0/4	7.00E-03					
U-238	4/10	1.36E-01	4.10E-01				

Table 2d. Comparison of WAG 5 surface water MD with TMBG values-Residential Scenario

Analyte	Frequency of detection	Mean Concentration (MC)	Maximum Detection (MD)	Mean Background (MBG)	Twice Mean Background (TMBG)	Does MD exceed TMBG ?	Units
High Base							
D1							
Inorganics							
Aluminum	1/1	7.91E-01	7.91E-01	1.70E-01	3.40E-01	YES	MG/L
Antimony	0/1	1.79E-02		3.00E-02	6.00E-02		MG/L
Arsenic	0/1	2.70E-03		2.00E-03	4.00E-03		MG/L
Barium	1/1	5.08E-02	5.08E-02	4.20E-02	8.30E-02	NO	MG/L
Beryllium	0/1	5.00E-04		1.00E-03	2.00E-03		MG/L
Cadmium	0/1	1.70E-03		5.00E-03	1.00E-02		MG/L
Calcium	1/1	5.54E+01	5.54E+01	3.70E+01	7.40E+01	NO	MG/L
Chromium	0/1	5.80E-03		1.00E-02	2.00E-02		MG/L
Cobalt	0/1	3.80E-03		2.00E-02	4.00E-02		MG/L
Copper	1/1	4.60E-03	4.60E-03	1.20E-02	2.30E-02	NO	MG/L
Iron	1/1	1.01E+00	1.01E+00	4.00E-01	8.10E-01	YES	MG/L
Lead	1/1	5.40E-03	5.40E-03	7.00E-03	1.40E-02	NO	MG/L
Magnesium	1/1	1.03E+01	1.03E+01	5.10E+00	1.00E+01	YES	MG/L
Manganese	1/1	2.63E-01	2.63E-01	1.00E-01	2.10E-01	YES	MG/L
Mercury	0/1	1.00E-04		2.00E-03	4.00E-03		MG/L
Nickel	0/1	6.10E-03		2.00E-02	4.00E-02		MG/L
Potassium	1/1	1.64E+00	1.64E+00	1.00E+00	2.00E+00	NO	MG/L
Selenium	0/1	3.50E-03		2.00E-03	4.00E-03		MG/L
Sodium	1/1	5.17E+00	5.17E+00	3.50E+00	7.00E+00	NO	MG/L
Vanadium	0/1	3.30E-03		1.00E-02	2.00E-02		MG/L
Zinc	0/1	3.40E-03		1.10E-01	2.20E-01		MG/L
Organics							
1,1,1-Trichloroethane	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
1,1-Dichloroethane	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
1,1-Dichloroethene	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
1,2-Dichlorobenzene	0/1	1.00E-02		1.00E-02	2.00E-02		MG/L
1,2-Dichloroethane	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
1,2-Dichloroethene (Total)	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
1,2-Dichloropropane	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L

Table 2d. (continued)

Analyte	Frequency of detection	Mean Concentration (MC)	Maximum Detection (MD)	Mean Background (MBG)	Twice Mean Background (TMBG)	Does MD exceed TMBG ?	UNITS
2-Butanone	1/1	4.00E-03	4.00E-03	1.00E-02	2.00E-02	NO	MG/L
4-Methyl Phenol	0/1	1.00E-02		1.00E-02	2.00E-02		MG/L
4-Methyl-2-Pentanone	0/1	1.00E-02		1.00E-02	2.00E-02		MG/L
Alpha-BHC	0/1	5.00E-05		5.00E-05	1.00E-04		MG/L
Benzene	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
Benzene, 1,2,4-Trichloro-	0/1	1.00E-02		1.00E-02	2.00E-02		MG/L
Beta-BHC	0/1	5.00E-05		5.00E-05	1.00E-04		MG/L
Bis(2-Ethylhexyl) Phthalate	0/1	1.00E-02		1.00E-02	2.00E-02		MG/L
Bromomethane	0/1	1.00E-02		1.00E-02	2.00E-02		MG/L
Carbon Disulfide	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
Chloroform	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
Delta-BHC	0/1	5.00E-05		5.00E-05	1.00E-04		MG/L
Nitrate	0/2	2.50E-01					
Phosphate	0/2	1.00E-01					
Styrene	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
Tetrachloroethene	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
Toluene	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
Total Organic Carbon	1/1	2.09E+00	2.09E+00				
Trichloroethene	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
Vinyl Chloride	0/1	1.00E-02		1.00E-02	2.00E-02		MG/L
Xylene (Total)	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
m-Dichlorobenzene	0/1	1.00E-02		1.00E-02	2.00E-02		MG/L
p-Dichlorobenzene	0/1	1.00E-02		1.00E-02	2.00E-02		MG/L
Other							
TOX	1/1	1.22E-02	1.22E-02				
Total Kjeldahl Nitrogen-TKN	1/1	7.30E-01	7.30E-01				
Radionuclides							
Alpha Particle	1/1	4.70E+01	4.70E+01	4.50E+00	8.90E+00	YES	PCI/L
Am-241	0/1	8.60E-02					
Beta Particle	1/1	9.90E+01	9.90E+01	4.00E+00	8.00E+00	YES	PCI/L
C-14	0/1	-1.40E+01					
Co-60	0/1	2.00E+01					

Table 2d. (continued)

Analyte	Frequency of detection	Mean Concentration (MC)	Maximum Detection (MD)	Mean Background (MBG)	Twice Mean Background (TMBG)	Does MD exceed TMBG ?	UNITS
Cs-137	0/1	2.00E+01		2.00E+01	4.00E+01		PCI/L
Pu-238	1/1	2.90E-01	2.90E-01				
Pu-239/240	0/1	-1.60E-02					
Ra-226	0/1	1.00E-01		1.00E+00	2.00E+00		PCI/L
Ra-228	0/1	9.00E-02		3.00E+00	6.00E+00		PCI/L
Tc-99	0/1	2.90E+00					
Th-228	0/1	1.80E+00		1.00E+00	2.00E+00		PCI/L
Th-230	0/1	0.00E+00		2.10E+00	4.30E+00		PCI/L
Th-232	0/1	-7.20E-02		1.00E+00	2.00E+00		PCI/L
Total Radioactive Strontium	1/1	2.40E+01	2.40E+01				
Tritium	1/1	5.50E+04	5.50E+04	8.10E+02	1.60E+03	YES	PCI/L
U-233/234	1/1	2.70E+01	2.70E+01	1.00E+00	2.00E+00	YES	PCI/L
U-235	1/1	1.70E+00	1.70E+00				
U-238	1/1	4.50E+01	4.50E+01	1.00E+00	2.00E+00	YES	PCI/L
D2							
InOrganics							
Aluminum	1/1	9.72E-01	9.72E-01	1.70E-01	3.40E-01	YES	MG/L
Antimony	0/1	1.79E-02		3.00E-02	6.00E-02		MG/L
Arsenic	0/1	2.70E-03		2.00E-03	4.00E-03		MG/L
Barium	1/1	9.25E-02	9.25E-02	4.20E-02	8.30E-02	YES	MG/L
Beryllium	0/1	5.00E-04		1.00E-03	2.00E-03		MG/L
Cadmium	0/1	1.70E-03		5.00E-03	1.00E-02		MG/L
Calcium	1/1	9.16E+01	9.16E+01	3.70E+01	7.40E+01	YES	MG/L
Chromium	0/1	5.80E-03		1.00E-02	2.00E-02		MG/L
Cobalt	0/1	3.80E-03		2.00E-02	4.00E-02		MG/L
Copper	0/1	4.20E-03		1.20E-02	2.30E-02		MG/L
Iron	1/1	3.19E+00	3.19E+00	4.00E-01	8.10E-01	YES	MG/L
Lead	1/1	6.80E-03	6.80E-03	7.00E-03	1.40E-02	NO	MG/L
Magnesium	1/1	1.34E+01	1.34E+01	5.10E+00	1.00E+01	YES	MG/L
Manganese	1/1	2.56E+00	2.56E+00	1.00E-01	2.10E-01	YES	MG/L
Mercury	0/1	1.00E-04		2.00E-03	4.00E-03		MG/L
Nickel	0/1	6.10E-03		2.00E-02	4.00E-02		MG/L

Table 2d. (continued)

Analyte	Frequency of detection	Mean Concentration (MC)	Maximum Detection (MD)	Mean Background (MBG)	Twice Mean Background (TMBG)	Does MD exceed TMBG ?	UNITS
Potassium	1/1	1.60E+00	1.60E+00	1.00E+00	2.00E+00	NO	MG/L
Selenium	0/1	3.50E-03		2.00E-03	4.00E-03		MG/L
Sodium	1/1	1.36E+01	1.36E+01	3.50E+00	7.00E+00	YES	MG/L
Vanadium	0/1	3.30E-03		1.00E-02	2.00E-02		MG/L
Zinc	0/1	3.40E-03		1.10E-01	2.20E-01		MG/L
Organics							
1,2-Dichlorobenzene	0/1	1.00E-02		1.00E-02	2.00E-02		MG/L
4-Methyl Phenol	0/1	1.00E-02		1.00E-02	2.00E-02		MG/L
Alpha-BHC	0/1	5.00E-05		5.00E-05	1.00E-04		MG/L
Benzene, 1,2,4-Trichloro-	0/1	1.00E-02		1.00E-02	2.00E-02		MG/L
Beta-BHC	0/1	5.00E-05		5.00E-05	1.00E-04		MG/L
Bis(2-Ethylhexyl) Phthalate	0/1	1.00E-02		1.00E-02	2.00E-02		MG/L
Delta-BHC	0/1	5.00E-05		5.00E-05	1.00E-04		MG/L
Nitrate	0/2	2.50E-01					
Phosphate	0/2	1.00E-01					
Total Organic Carbon	1/1	2.26E+00	2.26E+00				
m-Dichlorobenzene	0/1	1.00E-02		1.00E-02	2.00E-02		MG/L
p-Dichlorobenzene	0/1	1.00E-02		1.00E-02	2.00E-02		MG/L
Other							
TOX	1/1	3.92E-02	3.92E-02				
Total Kjeldahl Nitrogen-TKN	1/1	5.60E-01	5.60E-01				
Radionuclides							
Alpha Particle	1/1	1.60E+01	1.60E+01	4.50E+00	8.90E+00	YES	PCI/L
Beta Particle	1/1	4.40E+03	4.40E+03	4.00E+00	8.00E+00	YES	PCI/L
C-14	1/1	3.20E+02	3.20E+02				
Co-60	0/1	2.00E+01					
Cs-137	0/1	2.00E+01		2.00E+01	4.00E+01		PCI/L
Ra-226	0/1	4.00E-02		1.00E+00	2.00E+00		PCI/L
Th-228	0/1	3.80E-01		1.00E+00	2.00E+00		PCI/L
Th-230	0/1	0.00E+00		2.10E+00	4.30E+00		PCI/L
Th-232	0/1	-2.70E-02		1.00E+00	2.00E+00		PCI/L
Total Radioactive Strontium	1/1	2.50E+03	2.50E+03				

Table 2d. (continued)

Analyte	Frequency of detection	Mean Concentration (MC)	Maximum Detection (MD)	Mean Background (MBG)	Twice Mean Background (TMBG)	Does MD exceed TMBG ?	UNITS
Tritium	1/1	7.60E+06	7.60E+06	8.10E+02	1.60E+03	YES	PCI/L
U-233/234	1/1	3.70E+00	3.70E+00	1.00E+00	2.00E+00	YES	PCI/L
U-235	0/1	-1.00E-02					
U-238	1/1	9.60E-01	9.60E-01	1.00E+00	2.00E+00	NO	PCI/L
D3							
InOrganics							
Aluminum	1/1	4.42E-01	4.42E-01	1.70E-01	3.40E-01	YES	MG/L
Antimony	0/1	1.79E-02		3.00E-02	6.00E-02		MG/L
Arsenic	0/1	2.70E-03		2.00E-03	4.00E-03		MG/L
Barium	1/1	5.08E-02	5.08E-02	4.20E-02	8.30E-02	NO	MG/L
Beryllium	0/1	5.00E-04		1.00E-03	2.00E-03		MG/L
Cadmium	0/1	1.70E-03		5.00E-03	1.00E-02		MG/L
Calcium	1/1	3.12E+01	3.12E+01	3.70E+01	7.40E+01	NO	MG/L
Chromium	0/1	5.80E-03		1.00E-02	2.00E-02		MG/L
Cobalt	0/1	3.80E-03		2.00E-02	4.00E-02		MG/L
Copper	0/1	4.20E-03		1.20E-02	2.30E-02		MG/L
Iron	1/1	5.13E-01	5.13E-01	4.00E-01	8.10E-01	NO	MG/L
Lead	1/1	4.80E-03	4.80E-03	7.00E-03	1.40E-02	NO	MG/L
Magnesium	1/1	6.05E+00	6.05E+00	5.10E+00	1.00E+01	NO	MG/L
Manganese	1/1	2.44E-01	2.44E-01	1.00E-01	2.10E-01	YES	MG/L
Mercury	0/1	1.00E-04		2.00E-03	4.00E-03		MG/L
Nickel	0/1	6.10E-03		2.00E-02	4.00E-02		MG/L
Potassium	1/1	1.74E+00	1.74E+00	1.00E+00	2.00E+00	NO	MG/L
Selenium	0/1	3.50E-03		2.00E-03	4.00E-03		MG/L
Sodium	1/1	3.57E+00	3.57E+00	3.50E+00	7.00E+00	NO	MG/L
Vanadium	0/1	3.30E-03		1.00E-02	2.00E-02		MG/L
Zinc	0/1	3.40E-03		1.10E-01	2.20E-01		MG/L
Organics							
1,1,1-Trichloroethane	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
1,1-Dichloroethane	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
1,1-Dichloroethene	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
1,2-Dichlorobenzene	0/1	1.00E-02		1.00E-02	2.00E-02		MG/L

Table 2d. (continued)

Analyte	Frequency of detection	Mean Concentration (MC)	Maximum Detection (MD)	Mean Background (MBG)	Twice Mean Background (TMBG)	Does MD exceed TMBG ?	UNITS
1,2-Dichloroethane	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
1,2-Dichloroethene (Total)	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
1,2-Dichloropropane	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
2-Butanone	0/1	1.00E-02		1.00E-02	2.00E-02		MG/L
4-Methyl Phenol	0/1	1.00E-02		1.00E-02	2.00E-02		MG/L
4-Methyl-2-Pentanone	0/1	1.00E-02		1.00E-02	2.00E-02		MG/L
Alpha-BHC	0/1	5.00E-05		5.00E-05	1.00E-04		MG/L
Benzene	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
Benzene, 1,2,4-Trichloro-	0/1	1.00E-02		1.00E-02	2.00E-02		MG/L
Beta-BHC	0/1	5.00E-05		5.00E-05	1.00E-04		MG/L
Bis(2-Ethylhexyl) Phthalate	0/1	1.00E-02		1.00E-02	2.00E-02		MG/L
Bromomethane	0/1	1.00E-02		1.00E-02	2.00E-02		MG/L
Carbon Disulfide	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
Chloride	1/1	2.41E+00	2.41E+00				
Chloroform	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
Delta-BHC	0/1	5.00E-05		5.00E-05	1.00E-04		MG/L
Fluoride	0/1	5.00E-02					
Nitrate	0/2	2.50E-01					
Phosphate	0/2	1.00E-01					
Styrene	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
Sulfate	1/1	2.19E+01	2.19E+01				
Tetrachloroethene	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
Toluene	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
Total Organic Carbon	1/1	1.69E+00	1.69E+00				
Trichloroethene	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
Vinyl Chloride	0/1	1.00E-02		1.00E-02	2.00E-02		MG/L
Xylene (Total)	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
m-Dichlorobenzene	0/1	1.00E-02		1.00E-02	2.00E-02		MG/L
p-Dichlorobenzene	0/1	1.00E-02		1.00E-02	2.00E-02		MG/L
Other							
TOX	0/1	1.00E-02					
Total Kjeldahl Nitrogen-TKN	1/1	4.00E-01	4.00E-01				

Table 2d. (continued)

Analyte	Frequency of detection	Mean Concentration (MC)	Maximum Detection (MD)	Mean Background (MBG)	Twice Mean Background (TMBG)	Does MD exceed TMBG ?	UNITS
Radionuclides							
Alpha Particle	1/1	5.20E-01	5.20E-01	4.50E+00	8.90E+00	NO	PCI/L
Beta Particle	0/1	8.40E+00		4.00E+00	8.00E+00		PCI/L
C-14	0/1	-4.90E+01					
Co-60	0/1	2.00E+01					
Cs-137	0/1	2.00E+01		2.00E+01	4.00E+01		PCI/L
Ra-226	0/1	1.10E-01		1.00E+00	2.00E+00		PCI/L
Ra-228	0/1	2.60E+00		3.00E+00	6.00E+00		PCI/L
Sn-119m	1/1	1.90E+01	1.90E+01				
Th-228	0/1	2.70E-01		1.00E+00	2.00E+00		PCI/L
Th-230	0/1	-2.90E-02		2.10E+00	4.30E+00		PCI/L
Th-232	0/1	-1.40E-02		1.00E+00	2.00E+00		PCI/L
Total Radioactive Strontium	0/1	2.50E+00					
Tritium	1/1	2.40E+03	2.40E+03	8.10E+02	1.60E+03	YES	PCI/L
U-233/234	0/1	1.10E-01		1.00E+00	2.00E+00		PCI/L
U-235	0/1	0.00E+00					
U-238	0/1	-1.70E-02		1.00E+00	2.00E+00		PCI/L
High Base Storm							
D1							
InOrganics							
Aluminum	1/1	7.36E-01	7.36E-01	1.70E-01	3.40E-01	YES	MG/L
Antimony	0/1	1.22E-02		3.00E-02	6.00E-02		MG/L
Arsenic	0/1	2.20E-03		2.00E-03	4.00E-03		MG/L
Barium	1/1	4.42E-02	4.42E-02	4.20E-02	8.30E-02	NO	MG/L
Beryllium	0/1	3.00E-04		1.00E-03	2.00E-03		MG/L
Cadmium	0/1	1.70E-03		5.00E-03	1.00E-02		MG/L
Calcium	1/1	3.81E+01	3.81E+01	3.70E+01	7.40E+01	NO	MG/L
Chromium	1/1	2.90E-03	2.90E-03	1.00E-02	2.00E-02	NO	MG/L
Cobalt	0/1	2.90E-03		2.00E-02	4.00E-02		MG/L
Copper	0/1	4.90E-03		1.20E-02	2.30E-02		MG/L
Iron	1/1	8.68E-01	8.68E-01	4.00E-01	8.10E-01	YES	MG/L
Lead	1/1	2.80E-03	2.80E-03	7.00E-03	1.40E-02	NO	MG/L

Table 2d. (continued)

Analyte	Frequency of detection	Mean Concentration (MC)	Maximum Detection (MD)	Mean Background (MBG)	Twice Mean Background (TMBG)	Does MD exceed TMBG ?	UNITS
Magnesium	1/1	7.66E+00	7.66E+00	5.10E+00	1.00E+01	NO	MG/L
Manganese	1/1	5.03E-02	5.03E-02	1.00E-01	2.10E-01	NO	MG/L
Mercury	0/1	2.00E-04		2.00E-03	4.00E-03		MG/L
Nickel	1/1	6.00E-03	6.00E-03	2.00E-02	4.00E-02	NO	MG/L
Potassium	1/1	1.65E+00	1.65E+00	1.00E+00	2.00E+00	NO	MG/L
Selenium	0/1	2.70E-03		2.00E-03	4.00E-03		MG/L
Sodium	0/1	6.56E+00		3.50E+00	7.00E+00		MG/L
Vanadium	0/1	2.40E-03		1.00E-02	2.00E-02		MG/L
Zinc	1/1	1.16E-02	1.16E-02	1.10E-01	2.20E-01	NO	MG/L
Organics							
1,1,1-Trichloroethane	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
1,1-Dichloroethane	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
1,1-Dichloroethene	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
1,2-Dichlorobenzene	0/1	1.00E-02		1.00E-02	2.00E-02		MG/L
1,2-Dichloroethane	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
1,2-Dichloroethene (Total)	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
1,2-Dichloropropane	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
2-Butanone	1/1	7.00E-03	7.00E-03	1.00E-02	2.00E-02	NO	MG/L
4-Methyl Phenol	0/1	1.00E-02		1.00E-02	2.00E-02		MG/L
4-Methyl-2-Pentanone	0/1	1.00E-02		1.00E-02	2.00E-02		MG/L
Alpha-BHC	0/1	5.00E-05		5.00E-05	1.00E-04		MG/L
Benzene	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
Benzene, 1,2,4-Trichloro-	0/1	1.00E-02		1.00E-02	2.00E-02		MG/L
Beta-BHC	0/1	5.00E-05		5.00E-05	1.00E-04		MG/L
Bis(2-Ethylhexyl) Phthalate	1/1	4.00E-03	4.00E-03	1.00E-02	2.00E-02	NO	MG/L
Bromomethane	0/1	1.00E-02		1.00E-02	2.00E-02		MG/L
Carbon Disulfide	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
Chloroform	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
Delta-BHC	0/1	5.00E-05		5.00E-05	1.00E-04		MG/L
Styrene	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
Tetrachloroethene	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
Toluene	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L

Table 2d. (continued)

Analyte	Frequency of detection	Mean Concentration (MC)	Maximum Detection (MD)	Mean Background (MBG)	Twice Mean Background (TMBG)	Does MD exceed TMBG ?	UNITS
Total Organic Carbon	1/1	2.29E+00	2.29E+00				
Trichloroethene	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
Vinyl Chloride	0/1	1.00E-02		1.00E-02	2.00E-02		MG/L
Xylene (Total)	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
m-Dichlorobenzene	0/1	1.00E-02		1.00E-02	2.00E-02		MG/L
p-Dichlorobenzene	0/1	1.00E-02		1.00E-02	2.00E-02		MG/L
Other							
Total Kjeldahl Nitrogen-TKN	1/1	4.10E-01	4.10E-01				
Radionuclides							
Alpha Particle	1/1	6.03E+01	6.03E+01	4.50E+00	8.90E+00	YES	PCIL
Am-241	1/1	1.11E-01	1.11E-01				
Beta Particle	1/1	1.01E+02	1.01E+02	4.00E+00	8.00E+00	YES	PCIL
C-14	0/1	-1.28E+01					
Cm-243/244	0/1	0.00E+00					
Cs-137	0/1	1.10E+01		2.00E+01	4.00E+01		PCIL
Pu-238	0/1	4.10E-03					
Pu-239/240	1/1	7.54E-02	7.54E-02				
Ra-226	0/1	1.36E-02		1.00E+00	2.00E+00		PCIL
Ra-228	0/1	6.00E+00		3.00E+00	6.00E+00		PCIL
Tc-99	0/1	1.59E+00					
Th-228	1/1	5.73E-01	5.73E-01	1.00E+00	2.00E+00	NO	PCIL
Th-230	1/1	5.32E+00	5.32E+00	2.10E+00	4.30E+00	YES	PCIL
Th-232	1/1	5.87E-01	5.87E-01	1.00E+00	2.00E+00	NO	PCIL
Total Radioactive Strontium	1/1	1.63E+01	1.63E+01				
Tritium	1/1	2.50E+04	2.50E+04	8.10E+02	1.60E+03	YES	PCIL
U-232	0/1	-2.40E-02					
U-233/234	1/1	5.14E+01	5.14E+01	1.00E+00	2.00E+00	YES	PCIL
U-235/236	1/1	2.75E+00	2.75E+00	1.00E+00	2.00E+00	YES	PCIL
U-238	1/1	8.11E+01	8.11E+01	1.00E+00	2.00E+00	YES	PCIL
D2							
InOrganics							
Aluminum	0/1	2.19E-02		1.70E-01	3.40E-01		MG/L

Table 2d. (continued)

Analyte	Frequency of detection	Mean Concentration (MC)	Maximum Detection (MD)	Mean Background (MBG)	Twice Mean Background (TMBG)	Does MD exceed TMBG ?	UNITS
Antimony	0/1	1.22E-02		3.00E-02	6.00E-02		MG/L
Arsenic	0/1	2.20E-03		2.00E-03	4.00E-03		MG/L
Barium	1/1	4.68E-02	4.68E-02	4.20E-02	8.30E-02	NO	MG/L
Beryllium	0/1	3.40E-04		1.00E-03	2.00E-03		MG/L
Cadmium	0/1	1.70E-03		5.00E-03	1.00E-02		MG/L
Calcium	1/1	7.35E+01	7.35E+01	3.70E+01	7.40E+01	NO	MG/L
Chromium	0/1	2.50E-03		1.00E-02	2.00E-02		MG/L
Cobalt	0/1	2.90E-03		2.00E-02	4.00E-02		MG/L
Copper	0/1	3.60E-03		1.20E-02	2.30E-02		MG/L
Iron	1/1	2.69E-01	2.69E-01	4.00E-01	8.10E-01	NO	MG/L
Lead	0/1	1.90E-03		7.00E-03	1.40E-02		MG/L
Magnesium	1/1	1.07E+01	1.07E+01	5.10E+00	1.00E+01	YES	MG/L
Manganese	1/1	1.20E-01	1.20E-01	1.00E-01	2.10E-01	NO	MG/L
Mercury	0/1	2.00E-04		2.00E-03	4.00E-03		MG/L
Nickel	1/1	5.70E-03	5.70E-03	2.00E-02	4.00E-02	NO	MG/L
Potassium	1/1	1.46E+00	1.46E+00	1.00E+00	2.00E+00	NO	MG/L
Selenium	0/1	2.70E-03		2.00E-03	4.00E-03		MG/L
Sodium	1/1	1.13E+01	1.13E+01	3.50E+00	7.00E+00	YES	MG/L
Vanadium	0/1	2.40E-03		1.00E-02	2.00E-02		MG/L
Zinc	1/1	1.06E-02	1.06E-02	1.10E-01	2.20E-01	NO	MG/L
Organics							
1,1,1-Trichloroethane	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
1,1-Dichloroethane	1/1	2.00E-03	2.00E-03	5.00E-03	1.00E-02	NO	MG/L
1,1-Dichloroethene	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
1,2-Dichlorobenzene	0/1	1.00E-02		1.00E-02	2.00E-02		MG/L
1,2-Dichloroethane	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
1,2-Dichloroethene (Total)	1/1	3.00E-03	3.00E-03	5.00E-03	1.00E-02	NO	MG/L
1,2-Dichloropropane	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
2-Butanone	0/1	1.00E-02		1.00E-02	2.00E-02		MG/L
4-Methyl Phenol	0/1	1.00E-02		1.00E-02	2.00E-02		MG/L
4-Methyl-2-Pentanone	0/1	1.00E-02		1.00E-02	2.00E-02		MG/L
Alpha-BHC	0/1	5.00E-05		5.00E-05	1.00E-04		MG/L

Table 2d. (continued)

Analyte	Frequency of detection	Mean Concentration (MC)	Maximum Detection (MD)	Mean Background (MBG)	Twice Mean Background (TMBG)	Does MD exceed TMBG ?	UNITS
Benzene	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
Benzene, 1,2,4-Trichloro-	0/1	1.00E-02		1.00E-02	2.00E-02		MG/L
Beta-BHC	0/1	5.00E-05		5.00E-05	1.00E-04		MG/L
Bis(2-Ethylhexyl) Phthalate	1/1	6.00E-03	6.00E-03	1.00E-02	2.00E-02	NO	MG/L
Bromomethane	0/1	1.00E-02		1.00E-02	2.00E-02		MG/L
Carbon Disulfide	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
Chloroform	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
Delta-BHC	0/1	5.00E-05		5.00E-05	1.00E-04		MG/L
Styrene	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
Tetrachloroethene	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
Toluene	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
Total Organic Carbon	1/1	1.68E+00	1.68E+00				
Trichloroethene	1/1	1.00E-03	1.00E-03	5.00E-03	1.00E-02	NO	MG/L
Vinyl Chloride	0/1	1.00E-02		1.00E-02	2.00E-02		MG/L
Xylene (Total)	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
m-Dichlorobenzene	0/1	1.00E-02		1.00E-02	2.00E-02		MG/L
p-Dichlorobenzene	0/1	1.00E-02		1.00E-02	2.00E-02		MG/L
Other							
Total Kjeldahl Nitrogen-TKN	0/1	1.00E-01					
Radionuclides							
Alpha Particle	1/1	1.32E+01	1.32E+01	4.50E+00	8.90E+00	YES	PCIL
Am-241	1/1	1.44E-01	1.44E-01				
Beta Particle	1/1	2.82E+03	2.82E+03	4.00E+00	8.00E+00	YES	PCIL
C-14	1/1	1.18E+02	1.18E+02				
Cm-243/244	0/1	2.44E-02					
Cs-137	0/1	1.20E+01		2.00E+01	4.00E+01		PCIL
Pu-238	1/1	1.40E+01	1.40E+01				
Pu-239/240	1/1	1.32E-01	1.32E-01				
Ra-226	0/1	1.06E-01		1.00E+00	2.00E+00		PCIL
Ra-228	0/1	8.20E+00		3.00E+00	6.00E+00		PCIL
Tc-99	1/1	3.79E+01	3.79E+01				
Th-228	1/1	1.30E+00	1.30E+00	1.00E+00	2.00E+00	NO	PCIL

Table 2d. (continued)

Analyte	Frequency of detection	Mean Concentration (MC)	Maximum Detection (MD)	Mean Background (MBG)	Twice Mean Background (TMBG)	Does MD exceed TMBG ?	UNITS
1,1,1-Trichloroethane	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
1,1-Dichloroethane	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
1,1-Dichloroethene	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
1,2-Dichlorobenzene	0/1	1.00E-02		1.00E-02	2.00E-02		MG/L
1,2-Dichloroethane	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
1,2-Dichloroethene (Total)	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
1,2-Dichloropropane	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
2-Butanone	0/1	1.00E-02		1.00E-02	2.00E-02		MG/L
4-Methyl Phenol	0/1	1.00E-02		1.00E-02	2.00E-02		MG/L
4-Methyl-2-Pentanone	0/1	1.00E-02		1.00E-02	2.00E-02		MG/L
Alpha-BHC	0/1	5.00E-05		5.00E-05	1.00E-04		MG/L
Benzene	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
Benzene, 1,2,4-Trichloro-	0/1	1.00E-02		1.00E-02	2.00E-02		MG/L
Beta-BHC	0/1	5.00E-05		5.00E-05	1.00E-04		MG/L
Bis(2-Ethylhexyl) Phthalate	0/1	1.00E-02		1.00E-02	2.00E-02		MG/L
Bromomethane	0/1	1.00E-02		1.00E-02	2.00E-02		MG/L
Carbon Disulfide	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
Chloroform	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
Delta-BHC	0/1	5.00E-05		5.00E-05	1.00E-04		MG/L
Styrene	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
Tetrachloroethene	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
Toluene	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
Total Organic Carbon	1/1	5.13E+00	5.13E+00				
Trichloroethene	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
Vinyl Chloride	0/1	1.00E-02		1.00E-02	2.00E-02		MG/L
Xylene (Total)	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
m-Dichlorobenzene	0/1	1.00E-02		1.00E-02	2.00E-02		MG/L
p-Dichlorobenzene	0/1	1.00E-02		1.00E-02	2.00E-02		MG/L
Other							
Total Kjeldahl Nitrogen-TKN	1/1	3.30E-01	3.30E-01				
Radionuclides							
Alpha Particle	0/1	-2.32E-01		4.50E+00	8.90E+00		PCI/L

Table 2d. (continued)

Analyte	Frequency of detection	Mean Concentration (MC)	Maximum Detection (MD)	Mean Background (MBG)	Twice Mean Background (TMBG)	Does MD exceed TMBG ?	UNITS
Am-241	0/1	4.16E-02					
Beta Particle	1/1	3.08E+00	3.08E+00	4.00E+00	8.00E+00	NO	PCI/L
C-14	0/1	8.80E+00					
Cm-243/244	0/1	4.95E-02					
Cs-137	0/1	1.30E+01		2.00E+01	4.00E+01		PCI/L
Pu-238	0/1	8.00E-03					
Pu-239/240	0/1	4.80E-02					
Ra-226	0/1	-5.90E-02		1.00E+00	2.00E+00		PCI/L
Ra-228	0/1	7.30E+00		3.00E+00	6.00E+00		PCI/L
Tc-99	0/1	5.21E+00					
Th-228	1/1	5.15E-01	5.15E-01	1.00E+00	2.00E+00	NO	PCI/L
Th-230	1/1	7.11E-01	7.11E-01	2.10E+00	4.30E+00	NO	PCI/L
Th-232	1/1	1.06E-01	1.06E-01	1.00E+00	2.00E+00	NO	PCI/L
Total Radioactive Strontium	1/1	5.70E+01	5.70E+01				
Tritium	1/1	3.85E+02	3.85E+02	8.10E+02	1.60E+03	NO	PCI/L
U-232	0/1	2.50E-02					
U-233/234	0/1	4.38E-02		1.00E+00	2.00E+00		PCI/L
U-235/236	0/1	1.51E-02		1.00E+00	2.00E+00		PCI/L
U-238	0/1	4.90E-03		1.00E+00	2.00E+00		PCI/L
Impoundment							
OHFP							
InOrganics							
Aluminum	1/1	6.09E+00	6.09E+00	1.70E-01	3.40E-01	YES	MG/L
Antimony	0/1	9.20E-03		3.00E-02	6.00E-02		MG/L
Arsenic	0/1	2.10E-03		2.00E-03	4.00E-03		MG/L
Barium	1/1	5.49E-02	5.49E-02	4.20E-02	8.30E-02	NO	MG/L
Beryllium	0/1	2.00E-04		1.00E-03	2.00E-03		MG/L
Cadmium	0/1	1.00E-03		5.00E-03	1.00E-02		MG/L
Calcium	1/1	2.72E+01	2.72E+01	3.70E+01	7.40E+01	NO	MG/L
Chromium	0/1	4.10E-03		1.00E-02	2.00E-02		MG/L
Cobalt	0/1	3.00E-03		2.00E-02	4.00E-02		MG/L
Copper	1/1	1.26E-02	1.26E-02	1.20E-02	2.30E-02	NO	MG/L

Table 2d. (continued)

Analyte	Frequency of detection	Mean Concentration (MC)	Maximum Detection (MD)	Mean Background (MBG)	Twice Mean Background (TMBG)	Does MD exceed TMBG ?	UNITS
Iron	1/1	4.41E-01	4.41E-01	4.00E-01	8.10E-01	NO	MG/L
Lead	0/1	2.50E-03		7.00E-03	1.40E-02		MG/L
Magnesium	1/1	4.87E+00	4.87E+00	5.10E+00	1.00E+01	NO	MG/L
Manganese	1/1	1.92E-01	1.92E-01	1.00E-01	2.10E-01	NO	MG/L
Mercury	0/1	2.00E-04		2.00E-03	4.00E-03		MG/L
Nickel	1/1	4.40E-03	4.40E-03	2.00E-02	4.00E-02	NO	MG/L
Potassium	1/1	3.48E+00	3.48E+00	1.00E+00	2.00E+00	YES	MG/L
Selenium	1/1	3.10E-03	3.10E-03	2.00E-03	4.00E-03	NO	MG/L
Sodium	1/1	4.45E+00	4.45E+00	3.50E+00	7.00E+00	NO	MG/L
Vanadium	1/1	5.20E-03	5.20E-03	1.00E-02	2.00E-02	NO	MG/L
Zinc	1/1	4.01E-02	4.01E-02	1.10E-01	2.20E-01	NO	MG/L
Organics							
1,1,1-Trichloroethane	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
1,1-Dichloroethane	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
1,1-Dichloroethene	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
1,2-Dichlorobenzene	0/1	1.00E-02		1.00E-02	2.00E-02		MG/L
1,2-Dichloroethane	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
1,2-Dichloroethene (Total)	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
1,2-Dichloropropane	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
2-Butanone	0/1	1.00E-02		1.00E-02	2.00E-02		MG/L
4-Methyl Phenol	0/1	1.00E-02		1.00E-02	2.00E-02		MG/L
4-Methyl-2-Pentanone	0/1	1.00E-02		1.00E-02	2.00E-02		MG/L
Alpha-BHC	0/1	5.00E-05		5.00E-05	1.00E-04		MG/L
Benzene	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
Benzene, 1,2,4-Trichloro-	0/1	1.00E-02		1.00E-02	2.00E-02		MG/L
Beta-BHC	0/1	5.00E-05		5.00E-05	1.00E-04		MG/L
Bis(2-Ethylhexyl) Phthalate	1/1	1.00E-03	1.00E-03	1.00E-02	2.00E-02	NO	MG/L
Bromomethane	0/1	1.00E-02		1.00E-02	2.00E-02		MG/L
Carbon Disulfide	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
Chloride	1/1	8.10E-01	8.10E-01				
Chloroform	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
Delta-BHC	0/1	5.00E-05		5.00E-05	1.00E-04		MG/L

Table 2d. (continued)

Analyte	Frequency of detection	Mean Concentration (MC)	Maximum Detection (MD)	Mean Background (MBG)	Twice Mean Background (TMBG)	Does MD exceed TMBG ?	UNITS
Fluoride	1/1	1.40E-01	1.40E-01				
Styrene	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
Sulfate	1/1	1.48E+01	1.48E+01				
Tetrachloroethene	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
Toluene	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
Total Organic Carbon	1/1	7.76E+00	7.76E+00				
Trichloroethene	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
Vinyl Chloride	0/1	1.00E-02		1.00E-02	2.00E-02		MG/L
Xylene (Total)	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
m-Dichlorobenzene	0/1	1.00E-02		1.00E-02	2.00E-02		MG/L
p-Dichlorobenzene	0/1	1.00E-02		1.00E-02	2.00E-02		MG/L
Other							
Alkalinity as CaCO ₃	1/1	6.00E+00	6.00E+00				
TOX	0/1	5.00E-03					
Total Dissolved Solids	1/1	1.11E+02	1.11E+02				
Total Kjeldahl Nitrogen-TKN	1/1	7.60E-01	7.60E-01				
Total Suspended Solids	0/1						
Radionuclides							
Alpha Particle	1/1	6.38E+03	6.38E+03	4.50E+00	8.90E+00	YES	PCI/L
Am-241	1/1	3.92E-01	3.92E-01				
Beta Particle	1/1	2.03E+05	2.03E+05	4.00E+00	8.00E+00	YES	PCI/L
C-14	0/1	1.10E+01					
Cm-243/244	1/1	1.62E+01	1.62E+01				
Co-60	1/1	1.52E+02	1.52E+02				
Cs-137	1/1	2.50E+04	2.50E+04	2.00E+01	4.00E+01	YES	PCI/L
Pu-238	1/1	3.16E-01	3.16E-01				
Pu-239/240	1/1	5.06E-01	5.06E-01				
Ra-226	0/1	2.53E-02		1.00E+00	2.00E+00		PCI/L
Ra-228	0/1	2.40E+01		3.00E+00	6.00E+00		PCI/L
Tc-99	1/1	4.32E+01	4.32E+01				
Th-228	1/1	8.77E-01	8.77E-01	1.00E+00	2.00E+00	NO	PCI/L
Th-230	1/1	4.87E-01	4.87E-01	2.10E+00	4.30E+00	NO	PCI/L

Table 2d. (continued)

Analyte	Frequency of detection	Mean Concentration (MC)	Maximum Detection (MD)	Mean Background (MBG)	Twice Mean Background (TMBG)	Does MD exceed TMBG ?	UNITS
Th-232	0/1	-2.26E-02		1.00E+00	2.00E+00		PC/L
Total Radioactive Strontium	1/1	9.00E+04	9.00E+04				
Tritium	1/1	2.01E+04	2.01E+04	8.10E+02	1.60E+03	YES	PC/L
U-232	1/1	3.33E+00	3.33E+00				
U-233/234	1/1	1.02E+02	1.02E+02	1.00E+00	2.00E+00	YES	PC/L
U-235/236	0/1	1.19E-01		1.00E+00	2.00E+00		PC/L
U-238	1/1	9.10E-01	9.10E-01	1.00E+00	2.00E+00	NO	PC/L
PWSB							
Organics							
1,1,1-Trichloroethane	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
1,1-Dichloroethane	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
1,1-Dichloroethene	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
1,2-Dichlorobenzene	0/1	1.00E-02		1.00E-02	2.00E-02		MG/L
1,2-Dichloroethane	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
1,2-Dichloroethene (Total)	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
1,2-Dichloropropane	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
2-Butanone	0/1	1.00E-02		1.00E-02	2.00E-02		MG/L
4-Methyl Phenol	0/1	1.00E-02		1.00E-02	2.00E-02		MG/L
4-Methyl-2-Pentanone	0/1	1.00E-02		1.00E-02	2.00E-02		MG/L
Alpha-BHC	0/1	5.00E-05		5.00E-05	1.00E-04		MG/L
Benzene	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
Benzene, 1,2,4-Trichloro-	0/1	1.00E-02		1.00E-02	2.00E-02		MG/L
Beta-BHC	0/1	5.00E-05		5.00E-05	1.00E-04		MG/L
Bis(2-Ethylhexyl) Phthalate	0/1	1.00E-02		1.00E-02	2.00E-02		MG/L
Bromomethane	1/1	2.00E-03	2.00E-03	1.00E-02	2.00E-02	NO	MG/L
Carbon Disulfide	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
Chloroform	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
Delta-BHC	0/1	5.00E-05		5.00E-05	1.00E-04		MG/L
Styrene	1/1	1.00E-03	1.00E-03	5.00E-03	1.00E-02	NO	MG/L
Tetrachloroethene	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
Toluene	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
Total Organic Carbon	1/1	3.36E+01	3.36E+01				

Table 2d. (continued)

Analyte	Frequency of detection	Mean Concentration (MC)	Maximum Detection (MD)	Mean Background (MBG)	Twice Mean Background (TMBG)	Does MD exceed TMBG ?	UNITS
Trichloroethene	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
Vinyl Chloride	0/1	1.00E-02		1.00E-02	2.00E-02		MG/L
Xylene (Total)	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
m-Dichlorobenzene	0/1	1.00E-02		1.00E-02	2.00E-02		MG/L
p-Dichlorobenzene	0/1	1.00E-02		1.00E-02	2.00E-02		MG/L
Other							
Alkalinity as CaCO3	1/1	3.00E+01	3.00E+01				
Total Dissolved Solids	1/1	2.98E+02	2.98E+02				
Total Kjeldahl Nitrogen-TKN	1/1	4.48E+00	4.48E+00				
Total Suspended Solids	1/1	1.40E+01	1.40E+01				
Radionuclides							
Alpha Particle	1/1	3.84E+02	3.84E+02	4.50E+00	8.90E+00	YES	PCI/L
Am-241	1/1	5.02E-01	5.02E-01				
Beta Particle	1/1	1.30E+04	1.30E+04	4.00E+00	8.00E+00	YES	PCI/L
C-14	1/1	4.20E+01	4.20E+01				
Cm-243/244	1/1	5.10E+00	5.10E+00				
Co-60	1/1	1.27E+02	1.27E+02				
Cs-137	1/1	4.94E+01	4.94E+01	2.00E+01	4.00E+01	YES	PCI/L
Pu-238	1/1	2.14E-01	2.14E-01				
Pu-239/240	0/1	1.29E-01					
Ra-226	0/1	2.17E-01		1.00E+00	2.00E+00		PCI/L
Ra-228	0/1	1.10E+01		3.00E+00	6.00E+00		PCI/L
Tc-99	0/1	6.64E+00					
Th-228	0/1	1.59E+00		1.00E+00	2.00E+00		PCI/L
Th-230	0/1	9.10E-02		2.10E+00	4.30E+00		PCI/L
Th-232	0/1	3.88E-02		1.00E+00	2.00E+00		PCI/L
Total Radioactive Strontium	1/1	5.98E+03	5.98E+03				
Tritium	1/1	9.49E+03	9.49E+03	8.10E+02	1.60E+03	YES	PCI/L
U-232	1/1	2.18E+01	2.18E+01				
U-233/234	1/1	2.62E+02	2.62E+02	1.00E+00	2.00E+00	YES	PCI/L
U-235/236	0/1	2.38E-02		1.00E+00	2.00E+00		PCI/L
U-238	1/1	4.82E+00	4.82E+00	1.00E+00	2.00E+00	YES	PCI/L

Table 2d. (continued)

Analyte	Frequency of detection	Mean Concentration (MC)	Maximum Detection (MD)	Mean Background (MBG)	Twice Mean Background (TMBG)	Does MD exceed TMBG ?	UNITS
Low Base							
D1							
InOrganics							
Aluminum	1/2	7.94E-02	1.37E-01	1.70E-01	3.40E-01	NO	MG/L
Antimony	0/2	1.29E-02		3.00E-02	6.00E-02		MG/L
Arsenic	0/2	1.30E-03		2.00E-03	4.00E-03		MG/L
Barium	2/2	6.80E-02	6.84E-02	4.20E-02	8.30E-02	NO	MG/L
Beryllium	0/2	2.00E-04		1.00E-03	2.00E-03		MG/L
Cadmium	0/2	1.30E-03		5.00E-03	1.00E-02		MG/L
Calcium	2/2	7.17E+01	7.32E+01	3.70E+01	7.40E+01	NO	MG/L
Chromium	0/2	2.10E-03		1.00E-02	2.00E-02		MG/L
Cobalt	0/2	2.60E-03		2.00E-02	4.00E-02		MG/L
Copper	0/2	2.50E-03		1.20E-02	2.30E-02		MG/L
Iron	1/2	7.59E-02	1.34E-01	4.00E-01	8.10E-01	NO	MG/L
Lead	0/2	2.50E-03		7.00E-03	1.40E-02		MG/L
Magnesium	2/2	1.15E+01	1.17E+01	5.10E+00	1.00E+01	YES	MG/L
Manganese	2/2	1.95E-02	1.98E-02	1.00E-01	2.10E-01	NO	MG/L
Mercury	0/2	2.00E-04		2.00E-03	4.00E-03		MG/L
Nickel	0/2	3.40E-03		2.00E-02	4.00E-02		MG/L
Potassium	2/2	2.35E+00	2.39E+00	1.00E+00	2.00E+00	YES	MG/L
Selenium	0/2	3.10E-03		2.00E-03	4.00E-03		MG/L
Sodium	2/2	6.19E+00	6.33E+00	3.50E+00	7.00E+00	NO	MG/L
Vanadium	0/2	5.50E-03		1.00E-02	2.00E-02		MG/L
Zinc	1/2	4.65E-03	4.90E-03	1.10E-01	2.20E-01	NO	MG/L
Organics							
1,1,1-Trichloroethane	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
1,1-Dichloroethane	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
1,1-Dichloroethene	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
1,2-Dichloroethane	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
1,2-Dichloroethene (Total)	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
1,2-Dichloropropane	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
2-Butanone	0/1	1.00E-02		1.00E-02	2.00E-02		MG/L

Table 2d. (continued)

Analyte	Frequency of detection	Mean Concentration (MC)	Maximum Detection (MD)	Mean Background (MBG)	Twice Mean Background (TMBG)	Does MD exceed TMBG ?	UNITS
4-Methyl-2-Pentanone	0/1	1.00E-02		1.00E-02	2.00E-02		MG/L
Benzene	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
Bromomethane	0/1	1.00E-02		1.00E-02	2.00E-02		MG/L
Carbon Disulfide	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
Chloroform	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
Styrene	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
Tetrachloroethene	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
Toluene	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
Trichloroethene	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
Vinyl Chloride	0/1	1.00E-02		1.00E-02	2.00E-02		MG/L
Xylene (Total)	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
Radionuclides							
Alpha Particle	1/1	1.58E+01	1.58E+01	4.50E+00	8.90E+00	YES	PCI/L
Am-241	0/1	1.10E-01					
Beta Particle	1/1	8.16E+01	8.16E+01	4.00E+00	8.00E+00	YES	PCI/L
C-14	0/1	-6.60E+01					
Cs-137	0/1	0.00E+00		2.00E+01	4.00E+01		PCI/L
Pb-212	1/1	2.12E+01	2.12E+01				
Pu-238	0/1	3.00E-01					
Pu-239/240	0/1	1.40E-01					
Ra-226	0/1	0.00E+00		1.00E+00	2.00E+00		PCI/L
Tc-99	0/1	0.00E+00					
Th-228	1/1	2.60E-01	2.60E-01	1.00E+00	2.00E+00	NO	PCI/L
Th-230	0/1	7.00E-02		2.10E+00	4.30E+00		PCI/L
Th-232	0/1	-1.00E-02		1.00E+00	2.00E+00		PCI/L
Total Radioactive Strontium	1/1	2.99E+01	2.99E+01				
Tritium	1/1	1.17E+05	1.17E+05	8.10E+02	1.60E+03	YES	PCI/L
U-232	0/1	0.00E+00					
U-233/234	1/1	1.04E+01	1.04E+01	1.00E+00	2.00E+00	YES	PCI/L
U-235	1/1	8.00E-01	8.00E-01				
U-238	1/1	1.85E+01	1.85E+01	1.00E+00	2.00E+00	YES	PCI/L

Table 2d. (continued)

Analyte	Frequency of detection	Mean Concentration (MC)	Maximum Detection (MD)	Mean Background (MBG)	Twice Mean Background (TMBG)	Does MD exceed TMBG ?	UNITS
InOrganics							
Aluminum	0/1	5.92E-02		1.70E-01	3.40E-01		MG/L
Antimony	0/1	1.29E-02		3.00E-02	6.00E-02		MG/L
Arsenic	1/1	1.30E-03	1.30E-03	2.00E-03	4.00E-03	NO	MG/L
Barium	1/1	1.22E-01	1.22E-01	4.20E-02	8.30E-02	YES	MG/L
Beryllium	0/1	2.00E-04		1.00E-03	2.00E-03		MG/L
Cadmium	0/1	1.30E-03		5.00E-03	1.00E-02		MG/L
Calcium	1/1	1.14E+02	1.14E+02	3.70E+01	7.40E+01	YES	MG/L
Chromium	0/1	2.10E-03		1.00E-02	2.00E-02		MG/L
Cobalt	0/1	2.60E-03		2.00E-02	4.00E-02		MG/L
Copper	0/1	2.50E-03		1.20E-02	2.30E-02		MG/L
Iron	1/1	4.74E+00	4.74E+00	4.00E-01	8.10E-01	YES	MG/L
Lead	0/1	2.50E-03		7.00E-03	1.40E-02		MG/L
Magnesium	1/1	1.52E+01	1.52E+01	5.10E+00	1.00E+01	YES	MG/L
Manganese	1/1	2.93E+00	2.93E+00	1.00E-01	2.10E-01	YES	MG/L
Mercury	0/1	2.00E-04		2.00E-03	4.00E-03		MG/L
Nickel	1/1	6.90E-03	6.90E-03	2.00E-02	4.00E-02	NO	MG/L
Potassium	1/1	1.93E+00	1.93E+00	1.00E+00	2.00E+00	NO	MG/L
Selenium	0/1	3.10E-03		2.00E-03	4.00E-03		MG/L
Sodium	1/1	1.72E+01	1.72E+01	3.50E+00	7.00E+00	YES	MG/L
Vanadium	0/1	5.50E-03		1.00E-02	2.00E-02		MG/L
Zinc	0/1	4.40E-03		1.10E-01	2.20E-01		MG/L
Organics							
1,1,1-Trichloroethane	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
1,1-Dichloroethane	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
1,1-Dichloroethene	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
1,2-Dichloroethane	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
1,2-Dichloroethene (Total)	1/1	2.00E-03	2.00E-03	5.00E-03	1.00E-02	NO	MG/L
1,2-Dichloropropane	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
2-Butanone	0/1	1.00E-02		1.00E-02	2.00E-02		MG/L
4-Methyl-2-Pentanone	0/1	1.00E-02		1.00E-02	2.00E-02		MG/L
Benzene	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L

Table 2d. (continued)

Analyte	Frequency of detection	Mean Concentration (MC)	Maximum Detection (MD)	Mean Background (MBG)	Twice Mean Background (TMBG)	Does MD exceed TMBG ?	UNITS
Bromomethane	0/1	1.00E-02		1.00E-02	2.00E-02		MG/L
Carbon Disulfide	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
Chloroform	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
Styrene	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
Tetrachloroethene	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
Toluene	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
Trichloroethene	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
Vinyl Chloride	0/1	1.00E-02		1.00E-02	2.00E-02		MG/L
Xylene (Total)	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
Radionuclides							
Alpha Particle	1/1	1.09E+01	1.09E+01	4.50E+00	8.90E+00	YES	PCI/L
Am-241	1/1	9.30E+00	9.30E+00				
Beta Particle	1/1	4.03E+03	4.03E+03	4.00E+00	8.00E+00	YES	PCI/L
C-14	1/1	1.80E+02	1.80E+02				
Cs-137	0/1	0.00E+00		2.00E+01	4.00E+01		PCI/L
Pu-238	1/1	1.77E+01	1.77E+01				
Pu-239/240	0/1	0.00E+00					
Ra-226	1/1	2.80E-01	2.80E-01	1.00E+00	2.00E+00	NO	PCI/L
Ra-228	1/1	1.61E+03	1.61E+03	3.00E+00	6.00E+00	YES	PCI/L
Tc-99	1/1	1.88E+01	1.88E+01				
Th-228	0/1	-7.00E-02		1.00E+00	2.00E+00		PCI/L
Th-230	0/1	0.00E+00		2.10E+00	4.30E+00		PCI/L
Th-232	0/1	9.00E-02		1.00E+00	2.00E+00		PCI/L
Total Radioactive Strontium	1/1	1.78E+03	1.78E+03				
Tritium	1/1	9.60E+05	9.60E+05	8.10E+02	1.60E+03	YES	PCI/L
U-232	0/1	1.10E-01					
U-233/234	1/1	3.20E+00	3.20E+00	1.00E+00	2.00E+00	YES	PCI/L
U-235	0/1	1.00E-02					
U-238	0/1	2.80E-01		1.00E+00	2.00E+00		PCI/L
D3							
InOrganics							
Aluminum	1/1	3.19E-01	3.19E-01	1.70E-01	3.40E-01	NO	MG/L

Table 2d. (continued)

Analyte	Frequency of detection	Mean Concentration (MC)	Maximum Detection (MD)	Mean Background (MBG)	Twice Mean Background (TMBG)	Does MD exceed TMBG ?	UNITS
Antimony	0/1	1.29E-02		3.00E-02	6.00E-02		MG/L
Arsenic	0/1	3.90E-03		2.00E-03	4.00E-03		MG/L
Barium	1/1	6.04E-02	6.04E-02	4.20E-02	8.30E-02	NO	MG/L
Beryllium	0/1	2.00E-04		1.00E-03	2.00E-03		MG/L
Cadmium	0/1	1.30E-03		5.00E-03	1.00E-02		MG/L
Calcium	1/1	3.02E+01	3.02E+01	3.70E+01	7.40E+01	NO	MG/L
Chromium	0/1	2.10E-03		1.00E-02	2.00E-02		MG/L
Cobalt	0/1	2.60E-03		2.00E-02	4.00E-02		MG/L
Copper	0/1	4.10E-03		1.20E-02	2.30E-02		MG/L
Iron	1/1	3.06E-01	3.06E-01	4.00E-01	8.10E-01	NO	MG/L
Lead	0/1	2.50E-03		7.00E-03	1.40E-02		MG/L
Magnesium	1/1	5.46E+00	5.46E+00	5.10E+00	1.00E+01	NO	MG/L
Manganese	1/1	7.73E-02	7.73E-02	1.00E-01	2.10E-01	NO	MG/L
Mercury	0/1	2.00E-04		2.00E-03	4.00E-03		MG/L
Nickel	0/1	3.40E-03		2.00E-02	4.00E-02		MG/L
Potassium	1/1	2.30E+00	2.30E+00	1.00E+00	2.00E+00	YES	MG/L
Selenium	0/1	3.10E-03		2.00E-03	4.00E-03		MG/L
Sodium	1/1	3.91E+00	3.91E+00	3.50E+00	7.00E+00	NO	MG/L
Vanadium	0/1	5.50E-03		1.00E-02	2.00E-02		MG/L
Zinc	0/1	4.80E-03		1.10E-01	2.20E-01		MG/L
Organics							
1,1,1-Trichloroethane	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
1,1-Dichloroethane	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
1,1-Dichloroethene	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
1,2-Dichloroethane	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
1,2-Dichloroethene (Total)	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
1,2-Dichloropropane	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
2-Butanone	0/1	1.00E-02		1.00E-02	2.00E-02		MG/L
4-Methyl-2-Pentanone	0/1	1.00E-02		1.00E-02	2.00E-02		MG/L
Benzene	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
Bromomethane	0/1	1.00E-02		1.00E-02	2.00E-02		MG/L
Carbon Disulfide	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L

Table 2d. (continued)

Analyte	Frequency of detection	Mean Concentration (MC)	Maximum Detection (MD)	Mean Background (MBG)	Twice Mean Background (TMBG)	Does MD exceed TMBG ?	UNITS
Chloroform	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
Styrene	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
Tetrachloroethene	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
Toluene	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
Trichloroethene	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
Vinyl Chloride	0/1	1.00E-02		1.00E-02	2.00E-02		MG/L
Xylene (Total)	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
Radionuclides							
Alpha Particle	0/1	1.00E+00		4.50E+00	8.90E+00		PCI/L
Am-241	0/1	6.00E-02					
Beta Particle	1/1	6.70E+00	6.70E+00	4.00E+00	8.00E+00	NO	PCI/L
C-14	0/1	-5.90E+01					
Cs-137	0/1	0.00E+00		2.00E+01	4.00E+01		PCI/L
Pu-238	0/1	3.00E-02					
Pu-239/240	0/1	0.00E+00					
Ra-226	1/1	2.50E-01	2.50E-01	1.00E+00	2.00E+00	NO	PCI/L
Tc-99	0/1	1.59E+00					
Th-228	0/1	-2.00E-02		1.00E+00	2.00E+00		PCI/L
Th-230	0/1	4.00E-02		2.10E+00	4.30E+00		PCI/L
Th-232	0/1	0.00E+00		1.00E+00	2.00E+00		PCI/L
Total Radioactive Strontium	0/1	0.00E+00					
Tritium	1/1	2.68E+03	2.68E+03	8.10E+02	1.60E+03	YES	PCI/L
U-232	0/1	0.00E+00					
U-233/234	0/1	0.00E+00		1.00E+00	2.00E+00		PCI/L
U-235	0/1	0.00E+00					
U-238	0/1	-1.00E-02		1.00E+00	2.00E+00		PCI/L
Low Base Storm							
D1							
InOrganics							
Aluminum	1/4	2.59E-01	7.05E-01	1.70E-01	3.40E-01	YES	MG/L
Antimony	0/4	1.29E-02		3.00E-02	6.00E-02		MG/L
Arsenic	0/4	2.40E-03		2.00E-03	4.00E-03		MG/L

Table 2d. (continued)

Analyte	Frequency of detection	Mean Concentration (MC)	Maximum Detection (MD)	Mean Background (MBG)	Twice Mean Background (TMBG)	Does MD exceed TMBG ?	UNITS
Barium	4/4	5.62E-02	5.82E-02	4.20E-02	8.30E-02	NO	MG/L
Beryllium	0/4	2.33E-04		1.00E-03	2.00E-03		MG/L
Cadmium	0/4	1.30E-03		5.00E-03	1.00E-02		MG/L
Calcium	4/4	5.02E+01	5.26E+01	3.70E+01	7.40E+01	NO	MG/L
Chromium	0/4	2.10E-03		1.00E-02	2.00E-02		MG/L
Cobalt	0/4	2.60E-03		2.00E-02	4.00E-02		MG/L
Copper	0/4	1.73E-02		1.20E-02	2.30E-02		MG/L
Iron	0/4	2.81E-02		4.00E-01	8.10E-01		MG/L
Lead	0/4	2.50E-03		7.00E-03	1.40E-02		MG/L
Magnesium	4/4	8.54E+00	9.17E+00	5.10E+00	1.00E+01	NO	MG/L
Manganese	4/4	6.39E-02	1.21E-01	1.00E-01	2.10E-01	NO	MG/L
Mercury	0/4	2.00E-04		2.00E-03	4.00E-03		MG/L
Nickel	0/4	3.40E-03		2.00E-02	4.00E-02		MG/L
Potassium	4/4	4.71E+00	5.28E+00	1.00E+00	2.00E+00	YES	MG/L
Selenium	1/4	2.78E-03	3.00E-03	2.00E-03	4.00E-03	NO	MG/L
Sodium	4/4	4.50E+00	4.79E+00	3.50E+00	7.00E+00	NO	MG/L
Vanadium	0/4	5.50E-03		1.00E-02	2.00E-02		MG/L
Zinc	0/4	1.60E-02		1.10E-01	2.20E-01		MG/L
Organics							
1,1,1-Trichloroethane	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
1,1-Dichloroethane	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
1,1-Dichloroethene	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
1,2-Dichlorobenzene	0/1	1.00E-02		1.00E-02	2.00E-02		MG/L
1,2-Dichloroethane	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
1,2-Dichloroethene (Total)	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
1,2-Dichloropropane	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
2-Butanone	0/1	1.00E-02		1.00E-02	2.00E-02		MG/L
4-Methyl Phenol	0/1	1.00E-02		1.00E-02	2.00E-02		MG/L
4-Methyl-2-Pentanone	0/1	1.00E-02		1.00E-02	2.00E-02		MG/L
Alpha-BHC	0/1	5.00E-05		5.00E-05	1.00E-04		MG/L
Benzene	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
Benzene, 1,2,4-Trichloro-	0/1	1.00E-02		1.00E-02	2.00E-02		MG/L

Table 2d. (continued)

Analyte	Frequency of detection	Mean Concentration (MC)	Maximum Detection (MD)	Mean Background (MBG)	Twice Mean Background (TMBG)	Does MD exceed TMBG ?	UNITS
Beta-BHC	0/1	5.00E-05		5.00E-05	1.00E-04		MG/L
Bis(2-Ethylhexyl) Phthalate	1/1	1.00E-03	1.00E-03	1.00E-02	2.00E-02	NO	MG/L
Bromomethane	0/1	1.00E-02		1.00E-02	2.00E-02		MG/L
Carbon Disulfide	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
Chloroform	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
Delta-BHC	0/1	5.00E-05		5.00E-05	1.00E-04		MG/L
Nitrate/Nitrite	0/1	2.50E-01					
Phosphate	1/1	1.10E-01	1.10E-01				
Styrene	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
Tetrachloroethene	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
Toluene	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
Total Organic Carbon	1/1	1.06E+01	1.06E+01				
Trichloroethene	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
Vinyl Chloride	0/1	1.00E-02		1.00E-02	2.00E-02		MG/L
Xylene (Total)	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
m-Dichlorobenzene	0/1	1.00E-02		1.00E-02	2.00E-02		MG/L
p-Dichlorobenzene	0/1	1.00E-02		1.00E-02	2.00E-02		MG/L
Other							
TOX	1/1	9.70E-03	9.70E-03				
Total Kjeldahl Nitrogen-TKN	1/1	5.40E-01	5.40E-01				
Radionuclides							
Alpha Particle	1/1	1.79E+01	1.79E+01	4.50E+00	8.90E+00	YES	PCI/L
Am-241	0/1	6.92E-02					
Beta Particle	1/1	6.35E+01	6.35E+01	4.00E+00	8.00E+00	YES	PCI/L
C-14	0/1	1.30E+01					
Cm-243/244	0/1	5.49E-02					
Cs-137	0/1	1.60E+01		2.00E+01	4.00E+01		PCI/L
Pu-238	0/1	4.00E-02					
Pu-239/240	0/1	5.33E-02					
Ra-226	0/1	3.86E-02		1.00E+00	2.00E+00		PCI/L
Ra-228	0/1	7.30E+00		3.00E+00	6.00E+00		PCI/L
Tc-99	0/1	-1.42E+00					

[illegible]

Organics

Table 2d. (continued)

Analyte	Frequency of detection	Mean Concentration (MC)	Maximum Detection (MD)	Mean Background (MBG)	Twice Mean Background (TMBG)	Does MD exceed TMBG ?	UNITS
1,1,1-Trichloroethane	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
1,1-Dichloroethane	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
1,1-Dichloroethene	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
1,2-Dichlorobenzene	0/1	1.00E-02		1.00E-02	2.00E-02		MG/L
1,2-Dichloroethane	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
1,2-Dichloroethene (Total)	1/1	2.00E-03	2.00E-03	5.00E-03	1.00E-02	NO	MG/L
1,2-Dichloropropane	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
2-Butanone	0/1	1.00E-02		1.00E-02	2.00E-02		MG/L
4-Methyl Phenol	0/1	1.00E-02		1.00E-02	2.00E-02		MG/L
4-Methyl-2-Pentanone	0/1	1.00E-02		1.00E-02	2.00E-02		MG/L
Alpha-BHC	0/1	5.00E-05		5.00E-05	1.00E-04		MG/L
Benzene	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
Benzene, 1,2,4-Trichloro-	0/1	1.00E-02		1.00E-02	2.00E-02		MG/L
Beta-BHC	0/1	5.00E-05		5.00E-05	1.00E-04		MG/L
Bis(2-Ethylhexyl) Phthalate	0/1	1.00E-02		1.00E-02	2.00E-02		MG/L
Bromomethane	0/1	1.00E-02		1.00E-02	2.00E-02		MG/L
Carbon Disulfide	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
Chloroform	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
Delta-BHC	0/1	5.00E-05		5.00E-05	1.00E-04		MG/L
Nitrate/Nitrite	0/1	2.50E-01					
Phosphate	0/1	1.00E-01					
Styrene	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
Tetrachloroethene	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
Toluene	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
Total Organic Carbon	1/1	5.40E+00	5.40E+00				
Trichloroethene	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
Vinyl Chloride	0/1	1.00E-02		1.00E-02	2.00E-02		MG/L
Xylene (Total)	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
m-Dichlorobenzene	0/1	1.00E-02		1.00E-02	2.00E-02		MG/L
p-Dichlorobenzene	0/1	1.00E-02		1.00E-02	2.00E-02		MG/L
Other							
TOX	1/1	1.98E-02	1.98E-02				

Table 2d. (continued)

Analyte	Frequency of detection	Mean Concentration (MC)	Maximum Detection (MD)	Mean Background (MBG)	Twice Mean Background (TMBG)	Does MD exceed TMBG ?	UNITS
Total Kjeldahl Nitrogen-TKN	1/1	3.60E-01	3.60E-01				
Radionuclides							
Am-241	1/1	9.02E-01	9.02E-01				
Beta Particle	1/1	4.68E+03	4.68E+03	4.00E+00	8.00E+00	YES	PCI/L
C-14	1/1	1.78E+02	1.78E+02				
Cm-243/244	0/1	-9.70E-03					
Cs-137	0/1	1.50E+01		2.00E+01	4.00E+01		PCI/L
Pu-238	1/1	1.91E+01	1.91E+01				
Pu-239/240	1/1	1.99E-01	1.99E-01				
Ra-226	0/1	2.71E-02		1.00E+00	2.00E+00		PCI/L
Ra-228	0/1	1.20E+01		3.00E+00	6.00E+00		PCI/L
Tc-99	1/1	3.01E+01	3.01E+01				
Th-228	1/1	5.57E-01	5.57E-01	1.00E+00	2.00E+00	NO	PCI/L
Th-230	0/1	1.09E-01		2.10E+00	4.30E+00		PCI/L
Th-232	0/1	1.60E-02		1.00E+00	2.00E+00		PCI/L
Total Radioactive Strontium	1/1	2.09E+03	2.09E+03				
Tritium	1/1	1.08E+07	1.08E+07	8.10E+02	1.60E+03	YES	PCI/L
U-232	0/1	2.75E-01					
U-233/234	1/1	6.20E+00	6.20E+00	1.00E+00	2.00E+00	YES	PCI/L
U-235	0/1	7.50E-02					
U-238	1/1	3.94E-01	3.94E-01	1.00E+00	2.00E+00	NO	PCI/L
D3							
InOrganics							
Aluminum	1/3	2.56E-01	4.75E-01	1.70E-01	3.40E-01	YES	MG/L
Antimony	0/3	1.29E-02		3.00E-02	6.00E-02		MG/L
Arsenic	0/3	2.40E-03		2.00E-03	4.00E-03		MG/L
Barium	3/3	4.40E-02	4.70E-02	4.20E-02	8.30E-02	NO	MG/L
Beryllium	0/3	2.13E-04		1.00E-03	2.00E-03		MG/L
Cadmium	0/3	1.30E-03		5.00E-03	1.00E-02		MG/L
Calcium	3/3	2.62E+01	3.10E+01	3.70E+01	7.40E+01	NO	MG/L
Chromium	0/3	2.10E-03		1.00E-02	2.00E-02		MG/L
Cobalt	0/3	2.60E-03		2.00E-02	4.00E-02		MG/L

Table 2d. (continued)

Analyte	Frequency of detection	Mean Concentration (MC)	Maximum Detection (MD)	Mean Background (MBG)	Twice Mean Background (TMBG)	Does MD exceed TMBG ?	UNITS
Copper	0/3	1.57E-02		1.20E-02	2.30E-02		MG/L
Iron	0/3	3.56E-02		4.00E-01	8.10E-01		MG/L
Lead	3/3	2.70E-03	2.90E-03	7.00E-03	1.40E-02	NO	MG/L
Magnesium	3/3	4.91E+00	5.97E+00	5.10E+00	1.00E+01	NO	MG/L
Manganese	3/3	1.94E-01	3.55E-01	1.00E-01	2.10E-01	YES	MG/L
Mercury	0/3	2.00E-04		2.00E-03	4.00E-03		MG/L
Nickel	0/3	3.40E-03		2.00E-02	4.00E-02		MG/L
Potassium	3/3	4.76E+00	5.34E+00	1.00E+00	2.00E+00	YES	MG/L
Selenium	0/3	2.70E-03		2.00E-03	4.00E-03		MG/L
Sodium	3/3	3.52E+00	3.91E+00	3.50E+00	7.00E+00	NO	MG/L
Vanadium	0/3	5.50E-03		1.00E-02	2.00E-02		MG/L
Zinc	0/3	2.17E-02		1.10E-01	2.20E-01		MG/L
Organics							
1,1,1-Trichloroethane	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
1,1-Dichloroethane	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
1,1-Dichloroethene	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
1,2-Dichlorobenzene	0/1	1.00E-02		1.00E-02	2.00E-02		MG/L
1,2-Dichloroethane	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
1,2-Dichloroethene (Total)	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
1,2-Dichloropropane	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
2-Butanone	0/1	1.00E-02		1.00E-02	2.00E-02		MG/L
4-Methyl Phenol	0/1	1.00E-02		1.00E-02	2.00E-02		MG/L
4-Methyl-2-Pentanone	0/1	1.00E-02		1.00E-02	2.00E-02		MG/L
Alpha-BHC	0/1	5.00E-05		5.00E-05	1.00E-04		MG/L
Benzene	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
Benzene, 1,2,4-Trichloro-	0/1	1.00E-02		1.00E-02	2.00E-02		MG/L
Beta-BHC	0/1	5.00E-05		5.00E-05	1.00E-04		MG/L
Bis(2-Ethylhexyl) Phthalate	1/1	3.00E-03	3.00E-03	1.00E-02	2.00E-02	NO	MG/L
Bromomethane	0/1	1.00E-02		1.00E-02	2.00E-02		MG/L
Carbon Disulfide	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
Chloroform	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
Delta-BHC	0/1	5.00E-05		5.00E-05	1.00E-04		MG/L

Table 2d. (continued)

Analyte	Frequency of detection	Mean Concentration (MC)	Maximum Detection (MD)	Mean Background (MBG)	Twice Mean Background (TMBG)	Does MD exceed TMBG ?	UNITS
Nitrate/Nitrite	0/1	2.50E-01					
Phosphate	1/1	1.40E-01	1.40E-01				
Styrene	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
Tetrachloroethene	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
Toluene	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
Total Organic Carbon	1/1	1.19E+01	1.19E+01				
Trichloroethene	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
Vinyl Chloride	0/1	1.00E-02		1.00E-02	2.00E-02		MG/L
Xylene (Total)	0/1	1.00E-02		5.00E-03	1.00E-02		MG/L
m-Dichlorobenzene	0/1	1.00E-02		1.00E-02	2.00E-02		MG/L
p-Dichlorobenzene	0/1	1.00E-02		1.00E-02	2.00E-02		MG/L
Other							
TOX	1/1	6.90E-03	6.90E-03				
Total Kjeldahl Nitrogen-TKN	1/1	4.30E-01	4.30E-01				
Radionuclides							
Alpha Particle	0/1	1.10E+00		4.50E+00	8.90E+00		PCI/L
Am-241	1/1	7.36E-02	7.36E-02				
Beta Particle	1/1	4.39E+00	4.39E+00	4.00E+00	8.00E+00	NO	PCI/L
C-14	0/1	5.00E+00					
Cm-243/244	0/1	0.00E+00					
Cs-137	0/1	1.30E+01		2.00E+01	4.00E+01		PCI/L
Pu-238	0/1	0.00E+00					
Pu-239/240	0/1	2.49E-02					
Ra-226	0/1	4.54E-02		1.00E+00	2.00E+00		PCI/L
Ra-228	0/1	5.37E-01		3.00E+00	6.00E+00		PCI/L
Tc-99	0/1	5.73E-01					
Th-228	1/1	4.77E-01	4.77E-01	1.00E+00	2.00E+00	NO	PCI/L
Th-230	1/1	1.99E-01	1.99E-01	2.10E+00	4.30E+00	NO	PCI/L
Th-232	0/1	5.22E-02		1.00E+00	2.00E+00		PCI/L
Total Radioactive Strontium	0/1	3.30E-01					
Tritium	1/1	1.16E+03	1.16E+03	8.10E+02	1.60E+03	NO	PCI/L
U-232	0/1	6.90E-02					

Table 2d. (continued)

Analyte	Frequency of detection	Mean Concentration (MC)	Maximum Detection (MD)	Mean Background (MBG)	Twice Mean Background (TMBG)	Does MD exceed TMBG ?	UNITS
U-233/234	0/1	3.07E-01		1.00E+00	2.00E+00		PCI/L
U-235	0/1	5.30E-02					
U-238	0/1	3.40E-02		1.00E+00	2.00E+00		PCI/L

Table 3a. Toxicity screening for detected inorganic and organic analytes in WAG 5 soil
(Carcinogenic and noncarcinogenic effect; ingestion and inhalation)

Analyte	Maximum det. conc. mg/kg	Ingestion					Inhalation					Final decision		
		SF kg-d/mg	RfD mg/kg-d	Noncarc. toxicity score	Carc. toxicity score	% of total noncarc. score	% of total carc. score	SF kg-d/mg	RfD mg/kg-d	Noncarc. toxicity score	Carc. toxicity score		% of total noncarc. score	% of total carc. score
FS														
Inorganics														
Mercury	4.30E+00		3.00E-04	1.40E+04		99.99				8.60E-05	5.00E+04	100		
Organics														
Aroclor 1260	1.80E-01	7.70E+00		1.40E+00		100								
Pyrene	4.10E-02		3.00E-02	1.40E+00		0.01								DROP
NIIFT														
Organics														
Di-n-butyl Phthalate	1.30E-01		1.00E-01	1.30E+00		99.62								
Toluene	1.00E-03		2.00E-01	5.00E-03		0.38			1.10E-01	8.80E-03		100		
OHFP														
Inorganics														
Cadmium	2.00E+00		1.00E-03	2.00E+03		97.65		6.10E+00		1.20E+01		99.96		
Organics														
Acetone	6.50E-01		1.00E-01	6.50E+00		0.32								DROP
Aroclor 1254	3.20E-02	7.70E+00		2.50E-01		75.75								
Aroclor 1260	9.60E-03	7.70E+00		7.40E-02		22.73								
Chloromethane	2.00E-03	1.30E-02		2.60E-05		0.01		6.30E-03		1.30E-05		0		DROP
Heptachlor Epoxide	5.40E-04	9.10E+00	1.30E-05	4.90E-03		1.51		9.10E+00		4.90E-03		0.04		
Toluene	1.00E-03		2.00E-01	5.00E-03		0			1.10E-01	8.80E-03		100		

Table 3a. (continued)

Analyte	Maximum det. conc. mg/kg	Ingestion					Inhalation					Final decision	
		SF kg-d/mg	RfD mg/kg-d	Noncarc. toxicity score	Carc. toxicity score	% of total noncarc. score	% of total carc. score	SF kg-d/mg	RfD mg/kg-d	Noncarc. toxicity score	Carc. toxicity score		% of total noncarc. score
OHFT													
Inorganics													
Silver	5.00E+00		5.00E-03	1.00E+03		95.6							
Organics													
Acetone	8.10E-02		1.00E-01	8.10E-01		0.08							
Bis(2-Ethylhexyl) Phthalate	1.10E-01	1.40E-02	2.00E-02	5.50E+00	1.50E-03	0.53	100						DROP
Butyl Benzyl Phthalate	5.20E-02		2.00E-01	2.60E-01		0.02							DROP
Cyanide	7.00E-01		2.00E-02	3.50E+01		3.35							DROP
Di-n-butyl Phthalate	4.40E-01		1.00E-01	4.40E+00		0.42							DROP
Toluene	2.00E-03		2.00E-01	1.00E-02		0			1.10E-01	1.80E-02		100	
PWSB													
Inorganics													
Barium	2.40E+02		7.00E-02	3.40E+03		99.86							
Organics													
1,2-Benzenedicarboxylic Acid, Diethyl Ester	6.40E-02		8.00E-01	8.00E-02		0							DROP
Aroclor 1260	1.00E-02	7.70E+00			7.70E-02		98.97						
Bis(2-Ethylhexyl) Phthalate	5.70E-02	1.40E-02	2.00E-02	2.90E+00	8.00E-04	0.08	1.03						
Butyl Benzyl Phthalate	4.30E-02		2.00E-01	2.20E-01		0.01							DROP
Chloroform	1.00E-03	6.10E-03	1.00E-02	1.00E-01	6.10E-06	0	0.01	8.10E-02		8.10E-05		100	

A-100

Table 3a. (continued)

Analyte	Maximum det. conc. mg/kg	Ingestion					Inhalation					Final decision		
		SF kg-d/mg	RfD mg/kg-d	Noncarc toxicity score	Carc. toxicity score	% of total noncarc. score	% of total carc. score	SF kg-d/mg	RfD mg/kg-d	Noncarc. toxicity score	Carc. toxicity score		% of total noncarc. score	% of total carc. score
Di-n-butyl Phthalate	1.50E-01		1.00E-01	1.50E+00		0.04								DROP
Toluene	8.00E-03		2.00E-01	4.00E-02		0			1.10E-01	7.00E-02		0		DROP
Inorganics														
Zinc	3.20E+02		3.00E-01	1.10E+03		100								
Organics														
Aroclor 1254	9.30E-02	7.70E+00			7.20E-01		54.39							
Aroclor 1260	7.80E-02	7.70E+00			6.00E-01		45.61							
Organics														
1,2-Benzenedicarboxylic Acid, Diethyl Ester	3.00E-01		8.00E-01	3.80E-01		10.95								
2-Butanone	3.00E-03		6.00E-01	5.00E-03		0.15			2.90E-01	1.10E-02		64.29		
Aroclor 1260	2.60E-02	7.70E+00			2.00E-01		99.67							
Bis(2-Ethylhexyl) Phthalate	4.50E-02	1.40E-02	2.00E-02	2.30E+00	6.30E-04	65.73	0.31							
Di-n-butyl Phthalate	7.10E-02		1.00E-01	7.10E-01		20.74								
Methylene Chloride	5.00E-03	7.50E-03	6.00E-02	8.30E-02	3.80E-05	2.43	0.02		8.60E-01	5.80E-03		35.71		
Inorganics														
Antimony	6.20E+00		4.00E-04	1.60E+04		31.28								

Table 3a. (continued)

Table 3a. (continued)													
Analyte	Maximum det. conc. mg/kg	Ingestion					Inhalation					Final decision	
		SF kg-d/mg	RfD mg/kg-d	Noncarc. toxicity score	Carc. toxicity score	% of total noncarc. score	% of total carc. score	SF kg-d/mg	RfD mg/kg-d	Noncarc. toxicity score	Carc. toxicity score		% of total noncarc. score
Manganese	4.70E+03		1.40E-01	3.40E+04		67.89			1.40E-05	3.30E+08		100	
Selenium	2.00E+00		5.00E-03	4.00E+02		0.81							
Organics													
2-Butanone	1.90E-02		6.00E-01	3.20E-02		0			2.90E-01	6.70E-02		0	
Acetone	1.10E-01		1.00E-01	1.10E+00		0							
Aroclor 1260	4.60E-02	7.70E+00			3.50E-01		98.8						
Benzo(k)Fluoranthene	4.90E-02	7.30E-02			3.60E-03		1						
Bis(2-Ethylhexyl) Phthalate	5.20E-02	1.40E-02	2.00E-02	2.60E+00	7.30E-04	0.01	0.2						
Chloroform	1.00E-03	6.10E-03	1.00E-02	1.00E-01	6.10E-06	0	0	8.10E-02			8.10E-05	100	
Cyanide	7.00E-02		2.00E-02	3.50E+00		0.01							
Fluoranthene	4.30E-02		4.00E-02	1.10E+00		0							
Pyrene	5.20E-02		3.00E-02	1.70E+00		0							
Inorganics								SWSA5SW					
Barium	4.80E+02		7.00E-02	6.80E+03		19.2			1.40E-04	3.40E+06		1.17	
Manganese	4.00E+03		1.40E-01	2.90E+04		80.78			1.40E-05	2.80E+08		98.83	
Organics													
1,2-Dichloroethene (Total)	3.00E-03		9.00E-03	3.30E-01		0							
2-Butanone	2.10E-02		6.00E-01	3.50E-02		0			2.90E-01	7.40E-02		0	

SWSA5SW

A-102

Table 3a. (continued)

Analyte	Maximum det. conc. mg/kg	Ingestion					Inhalation					Final decision		
		SF kg-d/mg	RfD mg/kg-d	Noncarc. toxicity score	Carc. toxicity score	% of total noncarc. score	% of total carc. score	SF kg-d/mg	RfD mg/kg-d	Noncarc. toxicity score	Carc. toxicity score		% of total noncarc. score	% of total carc. score
4,4'-DDB	8.20E-04	2.40E-01			2.00E-04		0							DROP
Acetone	1.80E-01		1.00E-01	1.80E+00		0.01								DROP
Aroclor 1260	1.20E+00	7.70E+00			9.20E+00		100							
Chloroform	1.00E-03	6.10E-03	1.00E-02	1.00E-01	6.10E-06	0	0	8.10E-02			8.10E-05		100	
Endrin	5.10E-04		3.00E-04	1.70E+00		0								DROP
Ethylbenzene	7.00E-03		1.00E-01	7.00E-02		0			2.90E-01	2.50E-02		0		DROP
Tetrachloroethene	3.00E-03		1.00E-02	3.00E-01		0								DROP
Toluene	2.00E-02		2.00E-01	1.00E-01		0			1.10E-01	1.80E-01		0		DROP
Inorganics														A-105
Mercury	9.60E-01		3.00E-04	3.20E+03		99.84							100	
Organics														
Aroclor 1260	4.10E-02	7.70E+00			3.20E-01		99.63							
Bis(2-Ethylhexyl) Phthalate	8.30E-02	1.40E-02	2.00E-02	4.20E+00	1.20E-03	0.13	0.37							DROP
Di-n-butyl Phthalate	1.00E-01		1.00E-01	1.00E+00		0.03								
Ethylbenzene	1.20E-02		1.00E-01	1.20E-01		0			2.90E-01	4.20E-02		0		DROP
Styrene	3.00E-03		2.00E-01	1.50E-02		0			2.90E-01	1.10E-02		0		DROP

Table 3b. Toxicity screening for detected radionuclides in WAG 5 soil
(Ingestion, inhalation, and external exposure)

Radionuclide Ingestion, Inhalation, and External Exposure											
Analyte	Maximum det. conc. (pCi/g)	Ingestion			Inhalation			External exposure			Final decision
		SF (1/pCi)	Toxicity score	% of total toxicity score	SF (1/pCi)	Toxicity score	% of total toxicity score	SF (1/pCi)	Toxicity score	% of total toxicity score	
FS											
Radionuclides											
Co-60	1.80E+02	1.50E-11	2.70E-09	30.67	1.50E-10	2.70E-08	4.134835	8.60E-06	1.50E-03	94.25964	
Cs-137	3.60E+01	2.80E-11	1.00E-09	11.45	1.90E-11	6.80E-10	0.104749	2.00E-06	7.20E-05	4.38417	
Pb-212	1.50E+00	5.50E-12	8.30E-12	0.09	4.30E-11	6.50E-11	0.009878	2.80E-07	4.20E-07	0.025574	DROP
Ra-226	3.60E+00	1.20E-10	4.30E-10	4.91	3.00E-09	1.10E-08	1.653934	6.00E-06	2.20E-05	1.315251	
Th-232	1.90E+00	1.20E-11	2.30E-11	0.26	2.80E-08	5.30E-08	8.147157	2.60E-11	4.90E-11	3.01E-06	
Total Radioactive Strontium											
	1.20E+02	3.60E-11	4.30E-09	49.07	6.20E-11	7.40E-09	1.139377	0.00E+00	0.00E+00	0	
Tritium	3.50E-01	5.40E-14	1.90E-14	0	7.80E-14	2.70E-14	4.18E-06	0.00E+00	0.00E+00	0	DROP
U-233/234	7.30E+00	1.60E-11	1.20E-10	1.33	2.60E-08	1.90E-07	29.06636	3.00E-11	2.20E-10	1.33E-05	
U-238	7.00E+00	2.80E-11	2.00E-10	2.23	5.20E-08	3.60E-07	55.74371	3.60E-08	2.50E-07	0.015345	
NIIFT											
Radionuclides											
Am-241	1.10E-01	2.40E-10	2.70E-11	6.82	3.20E-08	3.60E-09	1.415958	4.90E-09	5.40E-10	0.003879	
C-14	3.10E+00	9.00E-13	2.80E-12	0.71	6.40E-15	2.00E-14	7.86E-06	0.00E+00	0.00E+00	0	DROP
Pu-238	2.60E-01	2.20E-10	5.80E-11	14.75	3.90E-08	1.00E-08	4.07327	2.80E-11	7.30E-12	5.23E-05	
Ra-228	1.60E+00	1.00E-10	1.60E-10	41.21	6.90E-10	1.10E-09	0.442846	2.90E-06	4.70E-06	33.29841	
Th-228	1.70E+00	5.50E-11	9.20E-11	23.51	7.80E-08	1.30E-07	51.92642	5.60E-06	9.40E-06	66.69667	
Th-230	1.30E+00	1.30E-11	1.70E-11	4.26	2.90E-08	3.70E-08	14.79739	5.40E-11	6.90E-11	0.000493	
Th-232	1.60E+00	1.20E-11	1.90E-11	4.76	2.80E-08	4.30E-08	17.30083	2.60E-11	4.00E-11	0.000287	
Tritium	7.40E-01	5.40E-14	4.00E-14	0.01	7.80E-14	5.80E-14	2.30E-05	0.00E+00	0.00E+00	0	DROP

Table 3b. (continued)

Analyte	Maximum det. conc. (pCi/g)	Ingestion			Inhalation			External exposure			Final decision
		SF (I/pCi)	Toxicity score	% of total toxicity score	SF (I/pCi)	Toxicity score	% of total toxicity score	SF (I/pCi)	Toxicity score	% of total toxicity score	
U-233/234	9.70E-01	1.60E-11	1.60E-11	3.97	2.60E-08	2.50E-08	10.04325	3.00E-11	2.90E-11	0.000207	
OHFP											
Radionuclides											
Am-241	4.70E-01	2.40E-10	1.10E-10	0.13	3.20E-08	1.50E-08	4.734569	4.90E-09	2.30E-09	9.98E-05	
Co-60	6.20E-01	1.50E-11	9.20E-12	0.01	1.50E-10	9.20E-11	0.02904	8.60E-06	5.30E-06	0.229151	DROP
Cs-137	1.10E+03	2.80E-11	3.20E-08	38.36	1.90E-11	2.20E-08	6.84844	2.00E-06	2.30E-03	99.21643	
Pu-239/240	5.90E-02	2.30E-10	1.40E-11	0.02	3.80E-08	2.20E-09	0.705778	1.70E-11	1.00E-12	4.35E-08	DROP
Ra-228	1.40E+00	1.00E-10	1.40E-10	0.17	6.90E-10	9.50E-10	0.299751	2.90E-06	4.00E-06	0.17339	DROP
Th-228	1.60E+00	5.50E-11	8.60E-11	0.1	7.80E-08	1.20E-07	38.55022	5.60E-06	8.80E-06	0.380922	
Th-230	1.50E+00	1.30E-11	2.00E-11	0.02	2.90E-08	4.40E-08	13.69373	5.40E-11	8.10E-11	3.51E-06	
Total Radioactive Strontium	1.40E+03	3.60E-11	5.10E-08	61.17	6.20E-11	8.80E-08	27.71485	0.00E+00	0.00E+00	0	
Tritium	1.70E+00	5.40E-14	9.00E-14	0	7.80E-14	1.30E-13	4.10E-05	0.00E+00	0.00E+00	0	DROP
U-233/234	9.10E-01	1.60E-11	1.50E-11	0.02	2.60E-08	2.40E-08	7.423577	3.00E-11	2.70E-11	1.18E-06	
OHFT											
Radionuclides											
Am-241	4.20E-01	2.40E-10	1.00E-10	8.24	3.20E-08	1.30E-08	4.870791	4.90E-09	2.10E-09	0.005108	
Cs-137	7.10E+00	2.80E-11	2.00E-10	16.17	1.90E-11	1.30E-10	0.048683	2.00E-06	1.40E-05	35.09889	
Pu-238	1.60E+00	2.20E-10	3.50E-10	28.76	3.90E-08	6.20E-08	22.61438	2.80E-11	4.50E-11	0.000111	
Ra-226	1.80E+00	1.20E-10	2.10E-10	17.26	3.00E-09	5.30E-09	1.913525	6.00E-06	1.10E-05	26.21246	
Ra-228	2.40E+00	1.00E-10	2.40E-10	19.61	6.90E-10	1.70E-09	0.600151	2.90E-06	7.00E-06	17.2764	
Th-228	1.50E+00	5.50E-11	8.50E-11	6.92	7.80E-08	1.20E-07	43.53269	5.60E-06	8.60E-06	21.40685	
Th-232	1.50E+00	1.20E-11	1.80E-11	1.45	2.80E-08	4.10E-08	15.01827	2.60E-11	3.80E-11	9.55E-05	

Table 3h. (continued)

Analyte	Maximum det. conc. (pCi/g)	Ingestion			Inhalation			External exposure			Final decision
		SF (1/pCi)	Toxicity score	% of total toxicity score	SF (1/pCi)	Toxicity score	% of total toxicity score	SF (1/pCi)	Toxicity score	% of total toxicity score	
Tritium	3.10E+00	5.40E-14	1.70E-13	0.01	7.80E-14	2.40E-13	8.68E-05	0.00E+00	0.00E+00	0	DROP
U-233/234	1.20E+00	1.60E-11	1.90E-11	1.58	2.60E-08	3.10E-08	11.40142	3.00E-11	3.60E-11	9.01E-05	
PWSB											
Radionuclides											
Am-241	3.50E-01	2.40E-10	8.40E-11	3.86	3.20E-08	1.10E-08	2.716946	4.90E-09	1.70E-09	0.003363	
Cm-243	1.80E-01	1.90E-10	3.40E-11	1.57	2.60E-08	4.70E-09	1.135295	1.60E-07	2.90E-08	0.05647	
Cs-137	2.00E+00	2.80E-11	5.60E-11	2.57	1.90E-11	3.80E-11	0.009218	2.00E-06	4.00E-06	7.843097	
K-40	3.50E+01	1.10E-11	3.90E-10	17.74	7.60E-12	2.70E-10	0.064712	5.40E-07	1.90E-05	37.16452	
Pu-238	4.20E+00	2.20E-10	9.10E-10	41.94	3.90E-08	1.60E-07	39.26229	2.80E-11	1.20E-10	0.000228	
Ra-226	2.10E+00	1.20E-10	2.50E-10	11.41	3.00E-09	6.20E-09	1.506449	6.00E-06	1.20E-05	24.35282	
Ra-228	1.70E+00	1.00E-10	1.70E-10	7.81	6.90E-10	1.20E-09	0.284552	2.90E-06	4.90E-06	9.666618	
Th-228	1.90E+00	5.50E-11	1.00E-10	4.8	7.80E-08	1.50E-07	35.95101	5.60E-06	1.10E-05	20.86264	
Th-232	2.00E+00	1.20E-11	2.40E-11	1.12	2.80E-08	5.70E-08	13.85642	2.60E-11	5.30E-11	0.000104	
Th-234	7.30E+00	4.00E-12	2.90E-11	1.34	3.20E-11	2.30E-10	0.056668	3.50E-09	2.60E-08	0.050098	
Total Radioactive Strontium	3.20E+00	3.60E-11	1.10E-10	5.23	6.20E-11	2.00E-10	0.047527	0.00E+00	0.00E+00	0	
Tritium	4.20E+00	5.40E-14	2.30E-13	0.01	7.80E-14	3.30E-13	7.95E-05	0.00E+00	0.00E+00	0	DROP
U-233/234	8.10E-01	1.60E-11	1.30E-11	0.6	2.60E-08	2.10E-08	5.108828	3.00E-11	2.40E-11	4.76E-05	
SW3											
Radionuclides											
Am-241	1.20E+00	2.40E-10	3.00E-10	20.82	3.20E-08	4.00E-08	8.794595	4.90E-09	6.10E-09	0.022985	
Cs-137	6.90E+00	2.80E-11	1.90E-10	13.54	1.90E-11	1.30E-10	0.029099	2.00E-06	1.40E-05	52.2804	
Pu-238	3.20E-01	2.20E-10	6.90E-11	4.85	3.90E-08	1.20E-08	2.722823	2.80E-11	8.80E-12	3.34E-05	

Table 3b. (continued)

Analyte	Maximum det. conc. (pCi/g)	Ingestion			Inhalation			External exposure		
		SF (1/pCi)	Toxicity score	% of total toxicity score	SF (1/pCi)	Toxicity score	% of total toxicity score	SF (1/pCi)	Toxicity score	% of total toxicity score
Pu-239/240	1.80E+00	2.30E-10	4.10E-10	28.49	3.80E-08	6.70E-08	14.90737	1.70E-11	3.00E-11	0.000114
Ra-228	1.20E+00	1.00E-10	1.20E-10	8.4	6.90E-10	8.30E-10	0.183516	2.90E-06	3.50E-06	13.16467
Th-228	1.60E+00	5.50E-11	9.00E-11	6.27	7.80E-08	1.30E-07	28.17905	5.60E-06	9.10E-06	34.53079
Th-230	1.70E+00	1.30E-11	2.10E-11	1.5	2.90E-08	4.80E-08	10.60538	5.40E-11	8.90E-11	0.000337
Total Radioactive Strontium	3.70E+00	3.60E-11	1.30E-10	9.42	6.20E-11	2.30E-10	0.051393	0.00E+00	0.00E+00	0
Tritium	5.60E-01	5.40E-14	3.00E-14	0	7.80E-14	4.40E-14	9.68E-06	0.00E+00	0.00E+00	0
U-232	1.50E-01	3.70E-11	5.50E-12	0.38	6.00E-08	8.90E-09	1.968145	4.60E-11	6.80E-12	2.58E-05
U-233/234	5.70E+00	1.60E-11	9.00E-11	6.33	2.60E-08	1.50E-07	32.55862	3.00E-11	1.70E-10	0.000641
SWSA 5N										
Radionuclides										
Ac-228	2.40E+00	5.00E-13	1.20E-12	0.08	2.60E-11	6.20E-11	0.027433	2.90E-06	7.00E-06	12.35019
Bi-212	2.60E+00	3.10E-13	8.10E-13	0.05	6.60E-12	1.70E-11	0.007544	5.90E-07	1.50E-06	2.72201
Bi-214	9.40E-01	1.30E-13	1.20E-13	0.01	2.10E-12	2.00E-12	0.000868	5.30E-06	5.00E-06	8.840322
C-14	7.50E+00	9.00E-13	6.80E-12	0.44	6.40E-15	4.80E-14	2.11E-05	0.00E+00	0.00E+00	0
I-129	5.70E+00	1.90E-10	1.10E-09	71.34	1.20E-10	6.80E-10	0.300706	4.10E-09	2.30E-08	0.041469
Pb-212	1.60E+00	5.50E-12	8.80E-12	0.58	4.30E-11	6.90E-11	0.030246	2.80E-07	4.50E-07	0.794955
Pb-214	1.10E+00	1.70E-13	1.90E-13	0.01	2.90E-12	3.20E-12	0.001402	6.40E-07	7.00E-07	1.249215
Ra-223	5.60E-01	6.40E-11	3.60E-11	2.36	3.10E-09	1.70E-09	0.763194	2.30E-07	1.30E-07	0.228549
Ra-228	2.40E+00	1.00E-10	2.40E-10	15.81	6.90E-10	1.70E-09	0.728024	2.90E-06	7.00E-06	12.35019
Sn-126	4.60E-01	5.60E-12	2.60E-12	0.17	7.70E-11	3.50E-11	0.015572	3.30E-08	1.50E-08	0.026936
Th-228	2.00E+00	5.50E-11	1.10E-10	7.25	7.80E-08	1.60E-07	68.58197	5.60E-06	1.10E-05	19.87387
Th-232	2.40E+00	1.20E-11	2.90E-11	1.9	2.80E-08	6.70E-08	29.543	2.60E-11	6.20E-11	0.000111

DROP

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Table 3b. (continued)

Analyte	Maximum det. conc. (pCi/g)	Ingestion			Inhalation			External exposure			Final decision
		SF (1/pCi)	Toxicity score	% of total toxicity score	SF (1/pCi)	Toxicity score	% of total toxicity score	SF (1/pCi)	Toxicity score	% of total toxicity score	
Tl-208	1.80E+00	1.80E-14	3.20E-14	0	5.00E-15	9.00E-15	3.96E-06	1.30E-05	2.30E-05	41.52219	
Tritium	2.20E-01	5.40E-14	1.20E-14	0	7.80E-14	1.70E-14	7.54E-06	0.00E+00	0.00E+00	0	DROP
SWSA SSE											
Radionuclides											
Ac-228	1.00E+00	5.00E-13	5.00E-13	0	2.60E-11	2.60E-11	0.00122	2.90E-06	2.90E-06	0.021594	DROP
Am-241	6.80E+00	2.40E-10	1.60E-09	0.29	3.20E-08	2.20E-07	10.17752	4.90E-09	3.30E-08	0.000247	
C-14	2.80E+01	9.00E-13	2.50E-11	0	6.40E-15	1.80E-13	8.32E-06	0.00E+00	0.00E+00	0	DROP
Ca-45	3.00E+01	9.90E-13	3.00E-11	0.01	5.10E-12	1.50E-10	0.007177	5.80E-18	1.70E-16	1.30E-12	DROP
Cm-243/244	3.60E+01	1.60E-10	5.70E-09	1.01	2.20E-08	7.80E-07	36.73964	3.00E-11	1.10E-09	7.95E-06	DROP
Cs-137	6.70E+03	2.80E-11	1.90E-07	33.11	1.90E-11	1.30E-07	5.971599	2.00E-06	1.30E-02	99.77926	
Pb-212	1.90E+00	5.50E-12	1.00E-11	0	4.30E-11	8.20E-11	0.003833	2.80E-07	5.30E-07	0.003961	DROP
Pb-214	6.00E-01	1.70E-13	1.00E-13	0	2.90E-12	1.70E-12	8.16E-05	6.40E-07	3.80E-07	0.002859	DROP
Pu-238	8.90E-01	2.20E-10	1.90E-10	0.03	3.90E-08	3.50E-08	1.619087	2.80E-11	2.50E-11	1.85E-07	
Pu-239/240	7.90E-01	2.30E-10	1.80E-10	0.03	3.80E-08	3.00E-08	1.408228	1.70E-11	1.30E-11	1.00E-07	
Ra-228	1.30E+00	1.00E-10	1.30E-10	0.02	6.90E-10	9.10E-10	0.042725	2.90E-06	3.80E-06	0.028504	DROP
Sn-126	1.80E-01	5.60E-12	1.00E-12	0	7.70E-11	1.40E-11	0.00065	3.30E-08	5.90E-09	4.42E-05	DROP
Th-228	1.60E+00	5.50E-11	8.80E-11	0.02	7.80E-08	1.20E-07	5.854325	5.60E-06	9.00E-06	0.066718	
Th-230	4.40E+00	1.30E-11	5.70E-11	0.01	2.90E-08	1.30E-07	5.94486	5.40E-11	2.40E-10	1.76E-06	
Tl-208	1.00E+00	1.80E-14	1.80E-14	0	5.00E-15	5.00E-15	2.33E-07	1.30E-05	1.30E-05	0.096801	DROP
Total Radioactive Strontium	1.00E+04	3.60E-11	3.70E-07	65.45	6.20E-11	6.40E-07	29.9565	0.00E+00	0.00E+00	0	
Tritium	1.90E+03	5.40E-14	1.00E-10	0.02	7.80E-14	1.50E-10	0.006806	0.00E+00	0.00E+00	0	DROP
U-232	5.30E-01	3.70E-11	2.00E-11	0	6.00E-08	3.20E-08	1.497356	4.60E-11	2.40E-11	1.82E-07	

Table 3b. (continued)

Analyte	Ingestion				Inhalation				External exposure		
	Maximum det. conc. (pCi/g)	SF (l/pCi)	Toxicity score	% of total toxicity score	SF (l' pCi)	Toxicity score	% of total toxicity score	SF (l/pCi)	Toxicity score	% of total toxicity score	Final decision
U-233	1.10E+01	1.60E-11	1.70E-10	0.03	2.70E-08	2.80E-08	11.73788	4.20E-11	4.40E-10	3.28E-06	DR OP
U-233/234	6.30E-01	1.60E-11	1.00E-11	0	2.60E-08	1.60E-08	0.76838	3.00E-11	1.90E-11	1.41E-07	
SWSA55W											
Radionuclides											
Ac-228	2.30E+00	5.00E-13	1.20E-12	0	2.60E-11	6.00E-11	0.003776	2.90E-06	6.70E-06	2.096915	DROP
Bi-214	8.20E-01	1.30E-13	1.10E-13	0	2.10E-12	1.70E-12	0.000166	5.30E-06	4.30E-06	1.366296	
Ca-45	5.30E+02	9.90E-13	5.20E-10	0.27	5.10E-12	2.70E-09	0.261065	5.80E-18	3.10E-15	9.66E-10	
Cs-137	1.20E+02	2.80E-11	3.40E-09	1.75	1.90E-11	2.30E-09	0.22021	2.00E-06	2.40E-04	75.45121	
K-40	3.30E+01	1.10E-11	3.60E-10	0.19	7.60E-12	2.50E-10	0.024223	5.40E-07	1.80E-05	5.602252	DROP
Pb-212	1.80E+00	5.50E-12	9.90E-12	0.01	4.30E-11	7.70E-11	0.007476	2.80E-07	5.00E-07	0.158448	
Pb-214	1.40E+00	1.70E-13	2.40E-13	0	2.90E-12	4.10E-12	0.000392	6.40E-07	9.00E-07	0.281685	DROP
Ra-226	2.40E+00	1.20E-10	2.90E-10	0.15	3.00E-09	7.20E-09	0.6954	6.00E-06	1.40E-05	4.527072	
Ra-228	2.30E+00	1.00E-10	2.30E-10	0.12	6.90E-10	1.60E-09	0.153278	2.90E-06	6.70E-06	2.096915	DROP
Tc-99	1.30E+00	1.30E-12	1.70E-12	0	8.30E-12	1.10E-11	0.001042	6.00E-13	7.80E-13	2.45E-07	
Th-228	1.50E+00	5.50E-11	8.30E-11	0.04	7.80E-08	1.20E-07	11.30025	5.60E-06	8.40E-06	2.640792	-
Th-232	2.30E+00	1.20E-11	2.80E-11	0.01	2.80E-08	6.40E-08	6.219965	2.60E-11	6.00E-11	1.88E-05	
Tl-208	1.40E+00	1.80E-14	2.50E-14	0	5.00E-15	7.00E-15	6.76E-07	1.30E-05	1.80E-05	5.721717	DROP
Total Radioactive Strontium	5.20E+03	3.60E-11	1.90E-07	97.3	6.20E-11	3.20E-07	31.13846	0.00E+00	0.00E+00	0	
Tritium	1.30E+01	5.40E-14	7.20E-13	0	7.80E-14	1.00E-12	0.000101	0.00E+00	0.00E+00	0	DROP
U-233/234	9.90E+00	1.60E-11	1.60E-10	0.08	2.60E-08	2.60E-07	24.86054	3.00E-11	3.00E-10	9.34E-05	
U-238	5.00E+00	2.80E-11	1.40E-10	0.07	5.20E-08	2.60E-07	25.11166	3.60E-08	1.80E-07	0.056588	
WOC											

Table 3b. (continued)

Analyte	Maximum det. conc. (pCi/g)	Ingestion			Inhalation			External exposure			Final decision
		SF (1/pCi)	Toxicity score	% of total toxicity score	SF (1/pCi)	Toxicity score	% of total toxicity score	SF (1/pCi)	Toxicity score	% of total toxicity score	
Radionuclides											
Ac-228	1.80E+00	5.00E-13	9.00E-13	0	2.60E-11	4.70E-11	0.012266	2.90E-06	5.20E-06	0.037363	DROP
Co-57	2.30E+00	5.80E-13	1.30E-12	0	8.20E-12	1.90E-11	0.004943	1.90E-07	4.40E-07	0.003128	DROP
Co-60	3.60E+01	1.50E-11	5.40E-10	0.26	1.50E-10	5.40E-09	1.415286	8.60E-06	3.10E-04	2.216004	
Cs-134	4.00E-02	4.10E-11	1.60E-12	0	2.80E-11	1.10E-12	0.000294	5.20E-06	2.10E-07	0.001489	DROP
Cs-137	6.80E+03	2.80E-11	1.90E-07	92.89	1.90E-11	1.30E-07	33.86204	2.00E-06	1.40E-02	97.34385	
Na-22	1.50E+00	6.80E-12	1.00E-11	0	4.80E-12	7.20E-12	0.001887	7.20E-06	1.10E-05	0.077302	DROP
Pb-212	1.40E+00	5.50E-12	7.70E-12	0	4.30E-11	6.00E-11	0.015778	2.80E-07	3.90E-07	0.002806	DROP
Pb-214	1.40E+00	1.70E-13	2.40E-13	0	2.90E-12	4.10E-12	0.001064	6.40E-07	9.00E-07	0.006413	DROP
Ra-228	1.80E+00	1.00E-10	1.80E-10	0.09	6.90E-10	1.20E-09	0.325516	2.90E-06	5.20E-06	0.037363	DROP
Tc-99	9.20E-01	1.30E-12	1.20E-12	0	8.30E-12	7.60E-12	0.002001	6.00E-13	5.50E-13	3.95E-09	DROP
Th-228	2.20E+00	5.50E-11	1.20E-10	0.06	7.80E-08	1.70E-07	44.97465	5.60E-06	1.20E-05	0.088182	
Th-232	1.80E+00	1.20E-11	2.20E-11	0.01	2.80E-08	5.00E-08	13.20934	2.60E-11	4.70E-11	3.35E-07	
Tl-208	2.00E+00	1.80E-14	3.60E-14	0	5.00E-15	1.00E-14	2.62E-06	1.30E-05	2.60E-05	0.186099	DROP
Total Radioactive Strontium											
	3.80E+02	3.60E-11	1.40E-08	6.67	6.20E-11	2.40E-08	6.174842	0.00E+00	0.00E+00	0	
Tritium	4.40E+00	5.40E-14	2.40E-13	0	7.80E-14	3.40E-13	9.02E-05	0.00E+00	0.00E+00	0	DROP

Table 4a. Toxicity screening for detected inorganic and organic analytes in WAG 5 sediment
(Carcinogenic and noncarcinogenic effects; ingestion and inhalation)

Analyte	Ingestion						Inhalation						Final decision	
	Maximum det. conc. mg/kg	SF kg-d/mg	RfD mg/kg-d	Noncarc. toxicity score	Carc. toxicity score	% of total noncarc. score	% of total carc. score	SF kg-d/mg	RfD mg/kg-d	Noncarc. toxicity score	Carc. toxicity score	% of total noncarc. score		% of total carc. score
D1														
Inorganics														
Chromium	3.40E+01		5.00E-03					4.10E+01						
Manganese	4.90E+03		1.40E-01	3.50E+04		88.66			1.40E-05	3.40E+08		100		
Mercury	1.40E-01		3.00E-04	4.70E+02		1.19			8.60E-05	1.60E+03		0		
Nickel	7.10E+01		2.00E-02	3.50E+03		8.98								
Silver	2.30E+00		5.00E-03	4.60E+02		1.17								
Organics														
4-Methyl-2-Pentanone	2.00E-03		8.00E-02	2.50E-02		0			2.30E-02	8.80E-02		0		
Aroclor 1260	8.30E-01	7.70E+00			6.40E+00		100						DROP	
D2														
Inorganics														
Arsenic	1.40E+01		3.00E-04	4.70E+04		12.32		5.00E+01		7.00E+02		99.95		
Barium	1.70E+03		7.00E-02	2.40E+04		6.45			1.40E-04	1.20E+07		0.4		
Chromium	2.20E+01		5.00E-03					4.10E+01						
Manganese	4.30E+04		1.40E-01	3.00E+05		80.34			1.40E-05	3.00E+09		99.6		
Mercury	3.80E-01		3.00E-04	1.30E+03		0.33			8.60E-05	4.40E+03		0	DROP	
Selenium	1.90E+00		5.00E-03	3.80E+02		0.1							DROP	
Silver	7.30E+00		5.00E-03	1.50E+03		0.39							DROP	
Organics														

Table 4a. (continued)

Analyte	Maximum det. conc. mg/kg	Ingestion					Inhalation							
		SF kg-d/mg	RfD mg/kg-d	Noncarc. toxicity score	Carc. toxicity score	% of total noncarc. score	% of total carc. score	SF kg-d/mg	RfD mg/kg-d	Noncarc. toxicity score	Carc. toxicity score	% of total noncarc. score	% of total carc. score	Final
1,1-Dichloroethane	1.40E-01		1.00E-01	1.40E+00		0			1.40E-01	9.80E-01		0		DROP
1,1-Dichloroethene	2.80E-02	6.00E-01	9.00E-03	3.10E+00	1.70E-02	0	0.61	1.20E+00			3.40E-02		0	DROP
1,2-Dichloroethane	4.90E-02	9.10E-02			4.50E-03		0.16	9.10E-02			4.50E-03		0	DROP
1,2-Dichloroethene (Total)	2.10E+00		9.00E-03	2.30E+02		0.06								DROP
2-Butanone	1.70E-01		6.00E-01	2.80E-01		0			2.90E-01	6.00E-01		0		DROP
Acetone	6.40E-01		1.00E-01	6.40E+00		0								DROP
Aroclor 1260	8.50E-02	7.70E+00			6.50E-01		23.66							
Benzene	1.10E-02	2.90E-02			3.20E-04		0.01	2.90E-02					0	DROP
Toluene	7.00E-03		2.00E-01	3.50E-02		0			1.10E-01	6.10E-02		0		DROP
Trichloroethene	7.00E-03	1.10E-02			7.70E-05		0	6.00E-03			4.20E-05		0	DROP
Vinyl Chloride	1.10E+00	1.90E+00			2.10E+00		75.56	3.00E-01			3.30E-01		0.05	DROP
Inorganics							D3							
Chromium	1.80E+01		5.00E-03					4.10E+01						
Mercury	9.00E-02		3.00E-04	3.00E+02		46.85			8.60E-05	1.10E+03		99.92		
Selenium	1.70E+00		5.00E-03	3.40E+02		53.1								
Organics														
2-Butanone	3.40E-02		6.00E-01	5.70E-02		0.01			2.90E-01	1.20E-01		0.01		DROP
Carbon Disulfide	2.00E-03		1.00E-01	2.00E-02		0			2.90E-03	7.00E-01		0.07		DROP
Chloroform	2.00E-03	6.10E-03	1.00E-02	2.00E-01	1.20E-05	0.03	100	8.10E-02			1.60E-04		100	

D3

Table 4a. (continued)

Analyte	Maximum det. conc. mg/kg	Ingestion					Inhalation					Final		
		SF kg-d/mg	RfD mg/kg-d	Noncarc. toxicity score	Carc. toxicity score	% of total noncarc. score	% of total carc. score	SF kg-d/mg	RfD mg/kg-d	Noncarc. toxicity score	Carc. toxicity score		% of total noncarc. score	% of total carc. score
Toluene	3.00E-03		2.00E-01	1.50E-02		0			1.10E-01	2.60E-02		0		DROP
Inorganics						OHFP								
Chromium	3.80E+01		5.00E-03					4.10E+01						
Mercury	3.10E+00		3.00E-04	1.00E+04		85.89			8.60E-05	3.60E+04		100		
Silver	5.90E+00		5.00E-03	1.20E+03		9.81								
Zinc	1.50E+02		3.00E-01	5.10E+02		4.27								
Organics														
Acetone	4.80E-01		1.00E-01	4.80E+00		0.04								
Aroclor 1254	2.30E+00	7.70E+00			1.80E+01		78.5							DROP
Aroclor 1260	6.30E-01	7.70E+00			4.90E+00		21.5							
Inorganics						PWSB								
Antimony	2.80E+01		4.00E-04	6.90E+04		38.84								
Chromium	6.40E+01		5.00E-03					4.10E+01						
Mercury	2.90E+01		3.00E-04	9.80E+04		55.16			8.60E-05	3.40E+05		100		
Zinc	1.60E+03		3.00E-01	5.30E+03		2.98								
Organics														
2-Butanone	1.10E+00		6.00E-01	1.80E+00		0			2.90E-01	3.90E+00		0		DROP
4-Methyl Phenol	2.60E+01		5.00E-03	5.20E+03		2.93								

PW5B

OHFP

Table 4a. (continued)

Analyte	Maximum det. conc. mg/kg	Ingestion					Inhalation							
		SF kg-d/mg	RfD mg/kg-d	Noncarc. toxicity score	Carc. toxicity score	% of total noncarc. score	% of total carc. score	SF kg-d/mg	RfD mg/kg-d	Noncarc. toxicity score	Carc. toxicity score	% of total noncarc. score	% of total carc. score	Final
Acetone	4.90E+00		1.00E-01	4.90E+01		0.03								DROP
Aroclor 1248	1.20E+00	7.70E+00			9.20E+00		44.41							
Aroclor 1254	1.50E+00	7.70E+00			1.20E+01		55.52							
Bis(2-Ethylhexyl) Phthalate	1.00E+00	1.40E-02	2.00E-02	5.00E+01	1.40E-02	0.03	0.07							DROP
Carbolic Acid	3.30E+01		6.00E-01	5.50E+01		0.03								DROP
Toluene	1.00E-02		2.00E-01	5.00E-02		0			1.10E-01	8.80E-02		0		DROP
Xylene (Total)	2.70E-02		2.00E+00	1.40E-02		0								DROP

Table 4b. Toxicity screening for detected radionuclides in WAG 5 sediment
(Ingestion, inhalation, and external exposure)

Analyte	Maximum det. conc (pCi/g)	Ingestion			Inhalation			External exposure			Final decision
		SF (I/pCi)	Toxicity score	% of total toxicity score	SF (I/pCi)	Toxicity score	% of total toxicity score	SF (I/pCi)	Toxicity score	% of total toxicity score	
DI											
Radionuclides											
Ac-228	1.40E+00	5.00E-13	7.00E-13	0.07	2.60E-11	3.60E-11	0.003505	2.90E-06	4.10E-06	28.83611	
Am-241	6.50E-01	2.40E-10	1.60E-10	15.82	3.20E-08	2.10E-08	2.002652	4.90E-09	3.20E-09	0.022621	
Bi-212	1.50E+00	3.10E-13	4.70E-13	0.05	6.60E-12	9.90E-12	0.000953	5.90E-07	8.90E-07	6.285705	
Bi-214	8.60E-01	1.30E-13	1.10E-13	0.01	2.10E-12	1.80E-12	0.000174	5.30E-06	4.60E-06	32.37316	
Co-60	3.70E-01	1.50E-11	5.60E-12	0.56	1.50E-10	5.60E-11	0.005344	8.60E-06	3.20E-06	22.60013	
Eu-155	1.50E-01	4.50E-13	6.80E-14	0.01	1.80E-11	2.70E-12	0.00026	5.90E-08	8.90E-09	0.062857	DROP
Pb-212	1.30E+00	5.50E-12	7.20E-12	0.72	4.30E-11	5.60E-11	0.005382	2.80E-07	3.60E-07	2.585307	
Pb-214	9.30E-01	5.50E-12	5.10E-12	0.52	4.30E-11	4.00E-11	0.00385	2.80E-07	2.60E-07	1.849489	
Ra-223	3.70E-01	6.40E-11	2.40E-11	2.4	3.10E-09	1.10E-09	0.110435	2.30E-07	8.50E-08	0.604422	
Radon 219	4.70E-01				4.60E-14	2.20E-14	2.08E-06	1.60E-07	7.50E-08	0.534107	DROP
Sn-126	2.80E-01	5.60E-12	1.60E-12	0.16	7.70E-11	2.20E-11	0.002076	3.30E-08	9.20E-09	0.065627	DROP
Tc-99	2.90E+00	1.30E-12	3.80E-12	0.38	8.30E-12	2.40E-11	0.002317	6.00E-13	1.70E-12	1.24E-05	DROP
Th-230	3.50E+00	1.30E-11	4.60E-11	4.61	2.90E-08	1.00E-07	9.772558	5.40E-11	1.90E-10	0.001342	
Th-231	5.30E-01	4.00E-13	2.10E-13	0.02	4.90E-13	2.60E-13	2.50E-05	2.30E-09	1.20E-09	0.008658	DROP
Th-234	1.10E+01	4.00E-12	4.40E-11	4.46	3.20E-11	3.50E-10	0.033891	3.50E-09	3.90E-08	0.273446	
Total Radioactive Strontium	1.50E+00	3.60E-11	5.40E-11	5.47	6.20E-11	9.30E-11	0.008934	0.00E+00	0.00E+00	0	
Tritium	2.30E+03	5.40E-14	1.30E-10	12.81	7.80E-14	1.80E-10	0.017573	0.00E+00	0.00E+00	0	
U-233/234	9.40E+00	1.60E-11	1.50E-10	15.25	2.60E-08	2.40E-07	23.53116	3.00E-11	2.80E-10	0.002003	
U-235	3.80E-01	1.60E-11	6.10E-12	0.62	2.50E-08	9.50E-09	0.914673	2.40E-07	9.10E-08	0.647747	DROP

Table 4h. (continued)

Analyte	Maximum det. conc. (pCi/g)	Ingestion			Inhalation			External exposure		
		SF (1/pCi)	Toxicity score	% of total toxicity score	SF (1/pCi)	Toxicity score	% of total toxicity score	SF (1/pCi)	Toxicity score	% of total toxicity score
U-238	1.30E+01	2.80E-11	3.60E-10	36.05	5.20E-08	6.60E-07	63.58421	3.60E-08	4.60E-07	3.247259
D2										
Radionuclides										
Ac-228	2.30E+00	5.00E-13	1.20E-12	0	2.60E-11	6.00E-11	0.002946	2.90E-06	6.70E-06	11.656
Am-241	6.20E-01	2.40E-10	1.50E-10	0.24	3.20E-08	2.00E-08	0.9773	4.90E-09	3.00E-09	0.005309
Bi-212	1.70E+00	3.10E-13	5.30E-13	0	6.60E-12	1.10E-11	0.000553	5.90E-07	1.00E-06	1.752768
Bi-214	1.20E+00	1.30E-13	1.60E-13	0	2.10E-12	2.50E-12	0.000124	5.30E-06	6.40E-06	11.11426
C-14	9.70E+01	9.00E-13	8.70E-11	0.14	6.40E-15	6.20E-13	3.06E-05	0.00E+00	0.00E+00	0
Ca-45	9.20E+01	9.90E-13	9.10E-11	0.15	5.10E-12	4.70E-10	0.023112	5.80E-18	5.30E-16	9.32E-10
Cm-243/244	5.50E+00	1.60E-10	8.80E-10	1.42	2.20E-08	1.20E-07	5.98202	3.00E-11	1.70E-10	0.000289
Co-60	6.30E-01	1.50E-11	9.50E-12	0.02	1.50E-10	9.50E-11	0.004655	8.60E-06	5.40E-06	9.468093
I-129	1.40E+01	1.90E-10	2.70E-09	4.27	1.20E-10	1.70E-09	0.082755	4.10E-09	5.70E-08	0.100308
Pb-212	1.70E+00	5.50E-12	9.40E-12	0.02	4.30E-11	7.30E-11	0.003601	2.80E-07	4.80E-07	0.831822
Pb-214	1.20E+00	5.50E-12	6.60E-12	0.01	4.30E-11	5.20E-11	0.002542	2.80E-07	3.40E-07	0.587169
Pu-238	3.10E+01	2.20E-10	6.90E-09	11.06	3.90E-08	1.20E-06	60.13054	2.80E-11	8.80E-10	0.001532
Pu-239/240	2.60E-01	2.30E-10	6.00E-11	0.1	3.80E-08	9.90E-09	0.48668	1.70E-11	4.40E-12	7.72E-06
Ra-223	9.10E-01	6.40E-11	5.80E-11	0.09	3.10E-09	2.80E-09	0.13896	2.30E-07	2.10E-07	0.365757
Ra-224	4.90E+00	3.80E-11	1.90E-10	0.3	1.20E-09	5.90E-09	0.289643	2.30E-08	1.10E-07	0.196946
Ra-226	3.00E+00	1.20E-10	3.60E-10	0.58	3.00E-09	9.00E-09	0.443332	6.00E-06	1.80E-05	31.45546
Radon 219	1.20E+00				4.60E-14	5.50E-14	2.72E-06	1.60E-07	1.90E-07	0.335525
Tc-99	1.20E+01	1.30E-12	1.60E-11	0.03	8.30E-12	1.00E-10	0.004906	6.00E-13	7.20E-12	1.26E-05
Tl-208	1.40E+00	1.80E-14	2.50E-14	0	5.00E-15	7.00E-15	3.45E-07	1.30E-05	1.80E-05	31.80496

Table 4b. (continued)

Analyte	Maximum det. conc. (pCi/g)	Ingestion			Inhalation			External exposure		
		SF (1/pCi)	Toxicity score	% of total toxicity score	SF (1/pCi)	Toxicity score	% of total toxicity score	SF (1/pCi)	Toxicity score	% of total toxicity score
Total Radioactive Strontium	1.40E+03	3.60E-11	5.00E-08	80.92	6.20E-11	8.70E-08	4.275687	0.00E+00	0.00E+00	0
Tritium	1.70E+03	5.40E-14	9.00E-11	0.14	7.80E-14	1.30E-10	0.006409	0.00E+00	0.00E+00	0
U-233/234	1.60E+01	1.60E-11	2.60E-10	0.41	2.60E-08	4.20E-07	20.49177	3.00E-11	4.80E-10	0.000839
U-235	4.10E-01	1.60E-11	6.60E-12	0.01	2.50E-08	1.00E-08	0.504905	2.40E-07	9.80E-08	0.171957
U-238	2.40E+00	2.80E-11	6.70E-11	0.11	5.20E-08	1.20E-07	6.147531	3.60E-08	8.60E-08	0.150986
D3										
Radionuclides										
Ac-228	1.50E+00	5.00E-13	7.50E-13	0.04	2.60E-11	3.90E-11	0.350885	2.90E-06	4.40E-06	18.00718
Bi-214	9.10E-01	1.30E-13	1.20E-13	0.01	2.10E-12	1.90E-12	0.017193	5.30E-06	4.80E-06	19.9652
I-129	1.30E+00	1.90E-10	2.50E-10	12.08	1.20E-10	1.60E-10	1.403541	4.10E-09	5.30E-09	0.022064
Pb-210	2.70E+00	6.60E-10	1.80E-09	87.18	4.00E-09	1.10E-08	97.16821	1.60E-10	4.30E-10	0.001788
Pb-212	1.40E+00	5.50E-12	7.70E-12	0.38	4.30E-11	6.00E-11	0.541623	2.80E-07	3.90E-07	1.622716
Pb-214	1.00E+00	5.50E-12	5.50E-12	0.27	4.30E-11	4.30E-11	0.386873	2.80E-07	2.80E-07	1.159083
Sn-126	1.90E-01	5.60E-12	1.10E-12	0.05	7.70E-11	1.50E-11	0.131627	3.30E-08	6.30E-09	0.025955
Tl-208	1.10E+00	1.80E-14	2.00E-14	0	5.00E-15	5.50E-15	4.95E-05	1.30E-05	1.40E-05	59.19601
OHFP										
Radionuclides										
Am-241	8.80E+02	2.40E-10	2.10E-07	0.16	3.20E-08	2.80E-05	3.616863	4.90E-09	4.30E-06	5.77E-05
C-14	2.60E+02	9.00E-13	2.30E-10	0	6.40E-15	1.60E-12	2.10E-07	0.00E+00	0.00E+00	0
Cm-243/244	2.40E+04	1.60E-10	3.90E-06	2.89	2.20E-08	5.40E-04	68.7901	3.00E-11	7.30E-07	9.77E-06
Co-60	6.30E+03	1.50E-11	9.40E-08	0.07	1.50E-10	9.40E-07	0.120639	8.60E-06	5.40E-02	0.720133
Cs-137	3.70E+06	2.80E-11	1.00E-04	77.01	1.90E-11	7.10E-05	9.057535	2.00E-06	7.40E+00	99.2668
DROP										

Table 4b. (continued)

Analyte	Maximum det. conc. (pCi/g)	Ingestion			Inhalation			External exposure		
		SF (1/pCi)	Toxicity score	% of total toxicity score	SF (1/pCi)	Toxicity score	% of total toxicity score	SF (1/pCi)	Toxicity score	% of total toxicity score
Pu-238	1.20E+03	2.20E-10	2.70E-07	0.2	3.90E-08	4.80E-05	6.097305	2.80E-11	3.40E-08	4.56E-07
Pu-239/240	6.40E+02	2.30E-10	1.50E-07	0.11	3.80E-08	2.40E-05	3.111701	1.70E-11	1.10E-08	1.45E-07
Th-228	1.70E+02	5.50E-11	9.60E-09	0.01	7.80E-08	1.40E-05	1.739231	5.60E-06	9.70E-04	0.013001
Th-230	3.10E+02	1.30E-11	4.00E-09	0	2.90E-08	9.00E-06	1.148339	5.40E-11	1.70E-08	2.23E-07
Th-232	5.30E+01	1.20E-11	6.30E-10	0	2.80E-08	1.50E-06	0.189455	2.60E-11	1.40E-09	1.83E-08
Total Radioactive Strontium	7.40E+05	3.60E-11	2.60E-05	19.56	6.20E-11	4.60E-05	5.839726	0.00E+00	0.00E+00	0
U-232	3.80E+01	3.70E-11	1.40E-09	0	6.00E-08	2.30E-06	0.289103	4.60E-11	1.70E-09	2.31E-08
U-233	1.60E+03	1.60E-11	2.50E-08	0.02	2.70E-08	4.30E-05	5.183445	4.20E-11	6.60E-08	8.85E-07
PWSB										
Radionuclides										
Am-241	1.20E+03	2.40E-10	2.80E-07	4.27	3.20E-08	3.70E-05	25.36418	4.90E-09	5.70E-06	0.005603
C-14	1.60E+02	9.00E-13	1.40E-10	0	6.40E-15	9.90E-13	6.72E-07	0.00E+00	0.00E+00	0
Cm-242	3.50E-01	1.30E-11	4.60E-12	0	3.90E-09	1.40E-09	0.000935	3.40E-11	1.20E-11	1.18E-08
Cm-243/244	1.40E+03	1.60E-10	2.20E-07	3.34	2.20E-08	3.00E-05	20.41871	3.00E-11	4.10E-08	4.02E-05
Co-60	6.80E+03	1.50E-11	1.00E-07	1.56	1.50E-10	1.00E-06	0.693552	8.60E-06	5.90E-02	57.3686
Cs-137	1.80E+04	2.80E-11	5.00E-07	7.59	1.90E-11	3.40E-07	0.229118	2.00E-06	3.60E-02	34.79551
Eu-152	9.60E+02	2.10E-12	2.00E-09	0.03	1.10E-10	1.10E-07	0.071615	3.60E-06	3.50E-03	3.381419
Eu-154	5.80E+02	3.00E-12	1.70E-09	0.03	1.40E-10	8.10E-08	0.054915	4.10E-06	2.40E-03	2.320254
Pu-238	1.20E+02	2.20E-10	2.70E-08	0.41	3.90E-08	4.80E-06	3.249786	2.80E-11	3.40E-09	3.37E-06
Pu-239/240	1.60E+02	2.30E-10	3.70E-08	0.57	3.80E-08	6.20E-06	4.170457	1.70E-11	2.80E-09	2.69E-06
Tc-99	3.40E+00	1.30E-12	4.40E-12	0	8.30E-12	2.80E-11	1.91E-05	6.00E-13	2.00E-12	1.99E-09
Th-228	3.90E+02	5.50E-11	2.10E-08	0.32	7.80E-08	3.00E-05	20.50271	5.60E-06	2.20E-03	2.123699

Table 4b. (continued)

Analyte	Maximum det. conc. (pCi/g)	Ingestion			Inhalation			External exposure			Final decision
		SF (1/pCi)	Toxicity score	% of total toxicity score	SF (1/pCi)	Toxicity score	% of total toxicity score	SF (1/pCi)	Toxicity score	% of total toxicity score	
Th-230	4.30E+01	1.30E-11	5.60E-10	0.01	2.90E-08	1.20E-06	0.844795	5.40E-11	2.30E-09	2.27E-06	DROP
Th-232	4.90E+00	1.20E-11	5.90E-11	0	2.80E-08	1.40E-07	0.093707	2.60E-11	1.30E-10	1.26E-07	DROP
Total Radioactive Strontium	1.50E+05	3.60E-11	5.40E-06	81.63	6.20E-11	9.20E-06	6.258395	0.00E+00	0.00E+00	0	
Tritium	2.80E+02	5.40E-14	1.50E-11	0	7.80E-14	2.20E-11	1.47E-05	0.00E+00	0.00E+00	0	DROP
U-232	3.20E+02	3.70E-11	1.20E-08	0.18	6.00E-08	1.90E-05	13.04792	4.60E-11	1.50E-08	1.44E-05	
U-235/236	8.10E+00	1.50E-11	1.20E-10	0	2.50E-08	2.00E-07	0.137694	2.40E-11	2.00E-10	1.91E-07	DROP
U-238	1.40E+02	2.80E-11	3.90E-09	0.06	5.20E-08	7.20E-06	4.861468	3.60E-08	5.00E-06	0.004856	

Table Sa. Toxicity screening for detected inorganic and organic analytes in WAG 5 groundwater
(Carcinogenic and noncarcinogenic effect; Inhalation and ingestion)

		Inhalation					Ingestion							
Analyte	Maximum det. conc. mg/kg	SF kg-d/mg	RfD mg/kg-d	Noncarc. toxicity score	Carc. toxicity score	% of total noncarc. score	% of total carc. score	SF kg-d/mg	RfD mg/kg-d	Noncarc. toxicity score	Carc. toxicity score	% of total noncarc. score	% of total carc. score	DROP
FS														
Inorganics														
Barium	9.30E-01		7.00E-02	1.30E+01		2.39			1.40E-04	6.50E+03		3.86		
Beryllium	6.20E-03	4.30E+00	5.00E-03	1.20E+00	2.70E-02	0.22	100	8.40E+00			5.20E-02		0.52	
Chromium	2.40E-01		5.00E-03	4.90E+01		8.73		4.10E+01			1.00E+01		99.48	
Manganese	2.30E+00		5.00E-03	4.60E+02		83.39			1.40E-05	1.60E+05		96.14		
Nickel	1.70E-01		2.00E-02	8.30E+00		1.49								
Vanadium	1.40E-01		7.00E-03	2.00E+01		3.59								
Zinc	3.00E-01		3.00E-01	9.90E-01		0.18								DROP
OHFP														
Organics														
1,1-Dichloroethane	8.00E-03		1.00E-01	8.00E-02		0.5			1.40E-01	5.60E-02		100		
1,2-Dichloroethane	3.00E-03	9.10E-02			2.70E-04		16.32	9.10E-02			2.70E-04		9.69	
Carbon Tetrachloride	9.00E-03	1.30E-01	7.00E-04	1.30E+01	1.20E-03	79.74	69.96	5.30E-02			4.80E-04		16.93	
Chloroform	2.50E-02	6.10E-03	1.00E-02	2.50E+00	1.50E-04	15.5	9.12	8.10E-02			2.00E-03		71.88	
Nitrate	1.10E+00		1.60E+00	6.90E-01		4.26								
Trichloroethene	7.00E-03	1.10E-02			7.70E-05		4.6	6.00E-03			4.20E-05		1.49	
PWSB														
Chromium	4.00E+00		5.00E-03	8.00E-01		15.94		4.10E+01			1.60E-01		100	
Organics														
Acetone	1.20E-02		1.00E-01	1.20E-01		2.84								

A-120
DROP

Table 5a. (continued)

		Inhalation						Ingestion							
		Maximum det. conc. mg/kg	SF kg-d/mg	RfD mg/kg-d	Noncarc. toxicity score	Carc. toxicity score	% of total noncarc. score	% of total carc. score	SF kg-d/mg	RfD mg/kg-d	Noncarc. toxicity score	Carc. toxicity score	% of total noncarc. score	% of total carc. score	DROP
Analyte															
Bis(2-Ethylhexyl) Phthalate															
		8.20E-02	1.40E-02	2.00E-02	4.10E+00	1.10E-03	97.16	100							
SWSA 5N															
Inorganics															
Barium		9.20E-01		7.00E-02	1.30E+01		1.59			1.40E-04	6.50E+03		2.44		
Beryllium		5.40E-03	4.30E+00	5.00E-03	1.10E+00	2.30E-02	0.13	97.43	8.40E+00		4.50E-02		0.69		
Chromium		1.60E-01		5.00E-03	3.20E+01		3.84		4.10E+01		6.50E+00		99.31		
Manganese		3.70E+00		5.00E-03	7.40E+02		89.01			1.40E-05	2.60E+05		97.56		
Nickel		4.20E-01		2.00E-02	2.10E+01		2.51								
Vanadium		1.20E-01		7.00E-03	1.80E+01		2.14								
Zinc		1.20E+00		3.00E-01	3.90E+00		0.47								DROP
Organics															
Bis(2-Ethylhexyl) Phthalate		1.80E-02	1.40E-02	2.00E-02	9.00E-01	2.50E-04	0.11	1.06							
Dimethyl Phthalate		1.60E+00		1.00E+01	1.60E-01		0.02								DROP
Fluoranthene		1.00E-03		4.00E-02	2.50E-02		0								DROP
Methylene Chloride		4.80E-02	7.50E-03	6.00E-02	8.00E-01	3.60E-04	0.1	1.51		8.60E-01	5.60E-02		0		DROP
Nitrate		7.60E-01		1.60E+00	4.80E-01		0.06								DROP
Phthalic Acid, Dioctyl Ester		4.00E-03		2.00E-02	2.00E-01		0.02								DROP
Pyrene		1.00E-03		3.00E-02	3.30E-02		0								DROP
SWSA 5SE															
Inorganics															
Barium		8.50E-01		7.00E-02	1.20E+01		0.26			1.40E-04	5.90E+03		0.37		DROP

Table 5a. (continued)

Analyte	Maximum det. conc. mg/kg	Inhalation						Ingestion					
		SF kg-d/mg	RfD mg/kg-d	Noncarc. toxicity score	Carc. toxicity score	% of total noncarc. score	% of total carc. score	SF kg-d/mg	RfD mg/kg-d	Noncarc. toxicity score	Carc. toxicity score	% of total noncarc. score	% of total carc. score
Boron	1.50E+00		9.00E-02	1.70E+01		0.36		4.10E+01	5.70E-03	2.60E+02		0.02	
Chromium	1.40E-01		5.00E-03	2.70E+01		0.58					5.50E+00		99.69
Manganese	2.30E+01		5.00E-03	4.50E+03		97.62			1.40E-05	1.60E+06		99.61	
Mercury	4.50E-04		3.00E-04	1.50E+00		0.03			8.60E-05	5.30E+00		0	
Nickel	1.60E-01		2.00E-02	7.80E+00		0.17							
Silver	1.50E-02		5.00E-03	2.90E+00		0.06							
Vanadium	8.90E-02		7.00E-03	1.30E+01		0.27							
Zinc	4.20E-01		3.00E-01	1.40E+00		0.03							
Organics													
1,1-Dichloroethane	2.10E-02		1.00E-01	2.10E-01		0			1.40E-01	1.50E-01		0	
1,1-Dichloroethene	6.00E-03	6.00E-01	9.00E-03	6.70E-01	3.60E-03	0.01	6.08	1.20E+00			7.20E-03		0.13
1,2-Dichloroethane	4.00E-03	9.10E-02			3.60E-04		0.61	9.10E-02			3.60E-04		0.01
1,2-Dichloroethene (Total)	1.80E-01		9.00E-03	2.00E+01		0.43							
Benzene	2.00E-03	2.90E-02			5.80E-05		0.1	2.90E-02			5.80E-05		0
Bis(2-Ethylhexyl) Phthalate	5.00E-03	1.40E-02	2.00E-02	2.50E-01	7.00E-05	0.01	0.12						
Carbon Disulfide	1.00E-03		1.00E-01	1.00E-02		0			2.90E-03	3.50E-01		0	
Chlorobenzene	2.00E-03		2.00E-02	1.00E-01		0			5.70E-03	3.50E-01		0	
Chloroethane	1.00E-03								2.90E+00	3.50E-04		0	
Chloroform	1.00E-03	6.10E-03	1.00E-02	1.00E-01	6.10E-06	0	0.01	8.10E-02			8.10E-05		0
Cyanide	4.90E-02		2.00E-02	2.40E+00		0.05							
Nitrate	1.70E+00		1.60E+00	1.00E+00		0.02							

Table 5a. (continued)

Analyte	Maximum det. conc. mg/kg	Inhalation					Ingestion					DROP		
		SF kg-d/mg	RfD mg/kg-d	Noncarc. toxicity score	Carc. toxicity score	% of total noncarc. score	% of total carc. score	SF kg-d/mg	RfD mg/kg-d	Noncarc. toxicity score	Carc. toxicity score		% of total noncarc. score	% of total carc. score
Tetrachloroethene	3.40E-02		1.00E-02	3.40E+00		0.07								DROP
Toluene	1.00E-03		2.00E-01	5.00E-03		0			1.10E-01	8.80E-03		0		DROP
Trichloroethene	2.10E-01	1.10E-02			2.30E-03		3.9	6.00E-03			1.30E-03		0.02	
Vinyl Chloride	2.80E-02	1.90E+00			5.30E-02		89.18	3.00E-01			8.30E-03		0.15	
Inorganics							SWSA5SW							
Barium	6.00E-01		7.00E-02	8.60E+00		0.67			1.40E-04	4.20E+03		1.15		
Chromium	1.20E-01		5.00E-03	2.30E+01		1.82		4.10E+01			4.80E+00		99.76	
Manganese	5.10E+00		5.00E-03	1.00E+03		79.76			1.40E-05	3.60E+05		98.84		DROP
Mercury	3.20E-04		3.00E-04	1.10E+00		0.08			8.60E-05	3.70E+00		0		DROP
Nickel	2.40E-01		2.00E-02	1.20E+01		0.91								DROP
Silver	1.50E-02		5.00E-03	3.10E+00		0.24								DROP
Vanadium	7.50E-02		7.00E-03	1.10E+01		0.83								DROP
Zinc	2.00E-01		3.00E-01	6.60E-01		0.05								DROP
Organics														
1,1-Dichloroethane	8.00E-03		1.00E-01	8.00E-02		0.01			1.40E-01	5.60E-02		0		DROP
1,2-Dichloroethene (Total)	7.10E-02		9.00E-03	7.90E+00		0.61								DROP
Benzene	1.00E-03	2.90E-02			2.90E-05		0.03	2.90E-02			2.90E-05		0	DROP
Bis(2-Ethylhexyl) Phthalate	3.10E+00	1.40E-02	2.00E-02	1.60E+02	4.30E-02	12.05	38.41							
Carbon Tetrachloride	6.00E-03	1.30E-01	7.00E-04	8.60E+00	7.80E-04	0.67	0.69	5.30E-02			3.20E-04		0.01	DROP
Chloroethane	3.00E-03								2.90E+00	1.10E-03		0		DROP

Table 5a. (continued)

Table Sa. (continued)														
Analyte	Maximum det. conc. mg/kg	Inhalation					Ingestion							
		SF kg-d/mg	RfD mg/kg-d	Noncarc. toxicity score	Carc. toxicity score	% of total noncarc. score	% of total carc. score	SF kg-d/mg	RfD mg/kg-d	Noncarc. toxicity score	Carc. toxicity score	% of total noncarc. score	% of total carc. score	DROP
Chloroform	1.00E-03	6.10E-03	1.00E-02	1.00E-01	6.10E-06	0.01	0.01	8.10E-02			8.10E-05	0		DROP
Cyanide	5.80E-03		2.00E-02	2.90E-01		0.02								DROP
Nitrate	6.90E+00		1.60E+00	4.30E+00		0.33								DROP
Tetrachloroethene	2.50E-01		1.00E-02	2.50E+01		1.94								DROP
Trichloroethene	3.40E-02	1.10E-02			3.70E-04		0.33	6.00E-03			2.00E-04	0		DROP
Vinyl Chloride	3.60E-02	1.90E+00			6.80E-02		60.54	3.00E-01			1.10E-02	0.22		
							WOC							
Inorganics														
Barium	9.80E-01		7.00E-02	1.40E+01		2.56			1.40E-04	6.80E+03		10.91		
Boron	3.90E-01		9.00E-02	4.30E+00		0.79			5.70E-03	6.80E+01		0.11		DROP
Manganese	8.00E-01		5.00E-03	1.60E+02		29.26			1.40E-05	5.60E+04		88.98		
Mercury	1.10E-04		3.00E-04	3.70E-01		0.07			8.60E-05	1.30E+00		0		DROP
Organics														
1,1-Dichloroethane	1.00E-03		1.00E-01	1.00E-02		0			1.40E-01	7.00E-03		0		DROP
1,1-Dichloroethene	5.00E-03	6.00E-01	9.00E-03	5.60E-01	3.00E-03	0.1	0.04	1.20E+00			6.00E-03	0.5		DROP
1,2-Dichloroethene (Total)	3.30E+00		9.00E-03	3.70E+02		67.22								DROP
Benzene	2.50E-02	2.90E-02			7.30E-04		0.01	2.90E-02			7.30E-04	0.06		DROP
Trichloroethene	2.70E-02	1.10E-02			3.00E-04		0	6.00E-03			1.60E-04	0.01		DROP
Vinyl Chloride	4.00E+00	1.90E+00			7.60E+00		99.95	3.00E-01			1.20E+00	99.43		
Xylene (Total)	2.00E-03		2.00E+00	1.00E-03		0								DROP

Table 5b. Toxicity screening for detected radionuclides in WAG 5 groundwater
(Ingestion)

Analyte	Maximum det. conc. (pCi/g)	SF (1/pCi)	Toxicity score	% of total toxicity score	Final decision
FS					
Radionuclides					
Am-241	4.20E-01	2.40E-10	1.00E-10	1.07	
Bi-212	6.20E+01	3.10E-13	1.90E-11	0.21	DROP
Ra-226	3.00E+00	1.20E-10	3.60E-10	3.87	
Ra-228	4.30E+00	1.00E-10	4.30E-10	4.58	
Tc-99	1.40E+01	1.30E-12	1.80E-11	0.19	DROP
Th-228	3.20E+01	5.50E-11	1.80E-09	18.73	
Th-230	2.40E+01	1.30E-11	3.10E-10	3.32	
Th-232	3.50E+01	1.20E-11	4.20E-10	4.47	
Tritium	1.10E+05	5.40E-14	5.90E-09	63.21	
U-233/234	2.10E+00	1.60E-11	3.40E-11	0.36	DROP
OHFP					
Radionuclides					
Am-241	2.00E-01	2.40E-10	4.70E-11	0	DROP
C-14	1.70E+03	9.00E-13	1.50E-09	0.09	DROP
Cm-242	0.00E+00	1.30E-11	0.00E+00	0	DROP
Cm-243/244	7.10E+00	1.60E-10	1.10E-09	0.07	DROP
Co-60	8.90E+01	1.50E-11	1.30E-09	0.08	DROP
Cs-137	2.80E+03	2.80E-11	7.70E-08	4.48	
Pu-238	5.40E-01	2.20E-10	1.20E-10	0.01	DROP
Ra-226	5.50E-01	1.20E-10	6.60E-11	0	DROP
Ra-228	3.00E+02	1.00E-10	3.00E-08	1.76	
Tc-99	5.40E+01	1.30E-12	7.00E-11	0	DROP
Th-230	1.70E-01	1.30E-11	2.20E-12	0	DROP
Th-232	2.70E-01	1.20E-11	3.20E-12	0	DROP
Th-234	1.70E+02	4.00E-12	7.00E-10	0.04	DROP
Total Radioactive Strontium	4.20E+04	3.60E-11	1.50E-06	86.98	
Tritium	2.10E+06	5.40E-14	1.10E-07	6.48	
U-232	7.70E-01	3.70E-11	2.80E-11	0	DROP
U-233/234	1.40E+01	1.60E-11	2.30E-10	0.01	DROP

PWSB

Radionuclides

Table 5b. (continued)

Analyte	Maximum det. conc. (pCi/g)	SF (1/pCi)	Toxicity score	% of total toxicity score	Final decision
Am-241	1.40E-01	2.40E-10	3.40E-11	2.96	
Mn-54	8.90E+00	1.10E-12	9.80E-12	0.85	DROP
Ra-226	2.20E-01	1.20E-10	2.70E-11	2.3	
Ra-228	1.10E+00	1.00E-10	1.10E-10	9.76	
Th-228	4.00E-01	5.50E-11	2.20E-11	1.91	
Th-232	1.30E-01	1.20E-11	1.60E-12	0.14	DROP
Tritium	1.70E+04	5.40E-14	9.20E-10	79.31	
U-233/234	8.90E-01	1.60E-11	1.40E-11	1.23	
U-235	1.50E-01	1.60E-11	2.40E-12	0.21	DROP
U-238	5.50E-01	2.80E-11	1.50E-11	1.33	
SWSA 5N					
Radionuclides					
Am-241	3.70E+01	2.40E-10	9.00E-09	15.79	
Bi-214	1.70E+02	1.30E-13	2.20E-11	0.04	DROP
C-14	8.80E+02	9.00E-13	7.90E-10	1.4	
Cm-243	4.10E-01	1.90E-10	7.80E-11	0.14	DROP
Cm-243/244	1.80E+02	1.60E-10	2.90E-08	50.81	
Hg-203	1.40E+01	6.60E-13	9.60E-12	0.02	DROP
K-40	6.70E+02	1.10E-11	7.40E-09	13.03	
Pb-212	5.00E+01	5.50E-12	2.70E-10	0.48	DROP
Pu-238	2.20E+00	2.20E-10	4.90E-10	0.87	DROP
Ra-226	1.10E+01	1.20E-10	1.40E-09	2.39	
Ra-228	4.90E+01	1.00E-10	4.90E-09	8.57	
Tc-99	1.10E+02	1.30E-12	1.50E-10	0.26	DROP
Th-228	8.50E+00	5.50E-11	4.70E-10	0.83	DROP
Th-230	7.80E+00	1.30E-11	1.00E-10	0.18	DROP
Th-232	1.00E+01	1.20E-11	1.20E-10	0.21	DROP
Th-234	4.90E+02	4.00E-12	2.00E-09	3.45	
Tritium	7.90E+03	5.40E-14	4.20E-10	0.75	DROP
U-233/234	1.00E+01	1.60E-11	1.60E-10	0.28	DROP
U-235	3.60E-01	1.60E-11	5.80E-12	0.01	DROP
U-235/236	2.00E-01	1.50E-11	3.00E-12	0.01	DROP
U-238	9.90E+00	2.80E-11	2.80E-10	0.49	DROP

Table 5b. (continued)

Analyte	Maximum det. conc. (pCi/g)	SF (1/pCi)	Toxicity score	% of total toxicity score	Final decision
SWSA 5SE					
Radionuclides					
Am-241	1.10E+06	2.40E-10	2.80E-04	58.94	
Bi-212	5.30E+02	3.10E-13	1.70E-10	0	DROP
C-14	1.50E+03	9.00E-13	1.40E-09	0	DROP
Cd-109	3.70E+02	7.90E-12	2.90E-09	0	DROP
Cm-243/244	3.70E+01	1.60E-10	5.90E-09	0	DROP
Fe-55	5.30E+01	2.70E-13	1.40E-11	0	DROP
Hg-203	1.30E+01	6.60E-13	8.40E-12	0	DROP
Pu-238	7.80E+05	2.20E-10	1.70E-04	36.62	
Pu-239/240	1.40E+04	2.30E-10	3.10E-06	0.67	DROP
Ra-226	7.00E+03	1.20E-10	8.40E-07	0.18	DROP
Ra-228	7.70E+01	1.00E-10	7.70E-09	0	DROP
Tc-99	5.10E+02	1.30E-12	6.70E-10	0	DROP
Th-228	2.10E+02	5.50E-11	1.20E-08	0	DROP
Th-230	5.90E+00	1.30E-11	7.60E-11	0	DROP
Th-231	3.50E+02	4.00E-13	1.40E-10	0	DROP
Th-232	2.80E+00	1.20E-11	3.30E-11	0	DROP
Total Radioactive Strontium	1.50E+04	3.60E-11	5.30E-07	0.11	DROP
Tritium	3.00E+08	5.40E-14	1.60E-05	3.46	
U-232	2.90E+00	3.70E-11	1.10E-10	0	DROP
U-233/234	3.80E+03	1.60E-11	6.10E-08	0.01	DROP
U-235/236	3.70E-01	1.50E-11	5.50E-12	0	DROP
U-238	1.80E+00	2.80E-11	5.00E-11	0	DR OP
SWSA5SW					
Radionuclides					
Am-241	7.80E+00	2.40E-10	1.90E-09	0.12	DROP
Bi-214	2.90E+01	1.30E-13	3.80E-12	0	DROP
C-14	9.20E+02	9.00E-13	8.30E-10	0.05	DROP
Ca-45	2.80E+02	9.90E-13	2.80E-10	0.02	DROP
Cm-242	5.60E-01	1.30E-11	7.30E-12	0	DROP
Cm-243/244	3.40E+00	1.60E-10	5.50E-10	0.04	DROP
Co-60	5.20E+01	1.50E-11	7.80E-10	0.05	DROP

Table 5b. (continued)

Analyte	Maximum det. conc. (pCi/g)	SF (1/pCi)	Toxicity score	% of total toxicity score	Final decision
K-40	1.00E+03	1.10E-11	1.10E-08	0.73	DROP
Pb-212	5.30E+01	5.50E-12	2.90E-10	0.02	DROP
Pu-238	5.80E+00	2.20E-10	1.30E-09	0.08	DROP
Pu-239/240	1.10E-01	2.30E-10	2.60E-11	0	DROP
Ra-226	3.60E+00	1.20E-10	4.40E-10	0.03	DROP
Ra-228	9.60E+01	1.00E-10	9.60E-09	0.63	DROP
Tc-99	2.40E+01	1.30E-12	3.10E-11	0	DROP
Th-228	3.70E+01	5.50E-11	2.00E-09	0.13	DROP
Th-230	1.60E+01	1.30E-11	2.10E-10	0.01	DROP
Th-232	2.50E+01	1.20E-11	3.00E-10	0.02	DROP
Th-234	1.70E+02	4.00E-12	6.90E-10	0.05	DROP
Total Radioactive Strontium	5.70E+02	3.60E-11	2.10E-08	1.36	
Tritium	2.70E+07	5.40E-14	1.50E-06	96.61	
U-233/234	1.90E+01	1.60E-11	3.00E-10	0.02	DROP
U-235/236	6.90E-03	1.50E-11	1.00E-13	0	DROP
U-238	1.20E+01	2.80E-11	3.50E-10	0.02	DROP
WOC					
Radionuclides					
C-14	2.50E+03	9.00E-13	2.20E-09	22.3	
Pu-238	5.10E-02	2.20E-10	1.10E-11	0.11	DROP
Pu-239/240	2.50E-01	2.30E-10	5.70E-11	0.57	DROP
Ra-226	3.30E-01	1.20E-10	3.90E-11	0.39	DROP
Th-228	2.60E+00	5.50E-11	1.40E-10	1.42	
Th-230	6.30E-01	1.30E-11	8.20E-12	0.08	DROP
Th-234	1.00E+03	4.00E-12	4.00E-09	39.88	
Tritium	6.50E+04	5.40E-14	3.50E-09	34.88	
U-233/234	1.20E+00	1.60E-11	2.00E-11	0.2	DROP
U-235	3.20E-01	1.60E-11	5.20E-12	0.05	DROP
U-238	4.10E-01	2.80E-11	1.10E-11	0.11	DROP

Table 6a. Toxicity screening for detected inorganic and organic analytes in WAGS surface water
(Carcinogenic and noncarcinogenic effects; Ingestion and Inhalation)

Analyte	Maximum det. conc. mg/kg	Ingestion					Inhalation					Final decision	
		SF kg-d/mg	RfD mg/kg-d	Noncarc. toxicity score	Carc. toxicity score	% of total noncarc. score	% of total carc. score	SF kg-d/mg	RfD mg/kg-d	Noncarc. toxicity score	Carc. toxicity score		% of total noncarc. score
High Base													
Inorganics													
Manganese	2.60E-01		5.00E-03	5.30E+01		99.99			1.40E-05	1.80E+04		100	
Organics													
2-Butanone	4.00E-03		6.00E-01	6.70E-03		0.01			2.90E-01	1.40E-02		0	DROP
D2													
Inorganics													
Barium	9.30E-02		7.00E-02	1.30E+00		0.26			1.40E-04	6.50E+02		0.36	DROP
Manganese	2.60E+00		5.00E-03	5.10E+02		99.74			1.40E-05	1.80E+05		99.64	
D3													
Inorganics													
Manganese	2.40E-01		5.00E-03	4.90E+01		100			1.40E-05	1.70E+04		100	
High Base Storm													
D1													
Organics													
2-Butanone	7.00E-03		6.00E-01	1.20E-02		5.51			2.90E-01	2.50E-02		100	
Bis(2-Ethylhexyl) Phthalate	4.00E-03	1.40E-02	2.00E-02	2.00E-01	5.60E-05	94.49	100						
D2													
Organics													
1,1-Dichloroethane	2.00E-03		1.00E-01	2.00E-02		3.06			1.40E-01	1.40E-02		100	

Table 6a. (continued)

Table 6a. (continued)														
Analyte	Maximum det. conc. mg/kg	Ingestion					Inhalation					Final decision		
		SF kg-d/mg	RfD mg/kg-d	Noncarc. toxicity score	Carc. toxicity score	% of total noncarc. score	% of total carc. score	SF kg-d/mg	RfD mg/kg-d	Noncarc. toxicity score	Carc. toxicity score		% of total noncarc. score	% of total carc. score
1,2-Dichloroethene (Total)	3.00E-03		9.00E-03	3.30E-01		51.02								
Bis(2-Ethylhexyl) Phthalate	6.00E-03	1.40E-02	2.00E-02	3.00E-01	8.40E-05	45.92	88.42							
Trichloroethene	1.00E-03	1.10E-02			1.10E-05		11.58	6.00E-03			6.00E-06		100	
Organics														
Bis(2-Ethylhexyl) Phthalate	1.00E-03	1.40E-02	2.00E-02	5.00E-02	1.40E-05	100	100							
Organics														
Bromomethane	2.00E-03		1.40E-03	1.40E+00		99.65			1.40E-03	1.40E+00		99.75		A-150
Styrene	1.00E-03		2.00E-01	5.00E-03		0.35			2.90E-01	3.50E-03		0.25		DROP
Inorganics														
Barium	1.20E-01		7.00E-02	1.70E+00		0.3								
Manganese	2.90E+00		5.00E-03	5.90E+02		99.67			1.40E-04	8.50E+02		0.41		DROP
Organics									1.40E-05	2.10E+05		99.59		
1,2-Dichloroethene (Total)	2.00E-03		9.00E-03	2.20E-01		0.04								DROP
Organics														

A-150

681

681

681

Table 6a. (continued)

Analyte	Maximum det. conc. mg/kg	Ingestion					Inhalation					Final decision	
		SF kg-d/mg	RfD mg/kg-d	Noncarc. toxicity score	Carc. toxicity score	% of total noncarc. score	% of total carc. score	SF kg-d/mg	RfD mg/kg-d	Noncarc. toxicity score	Carc. toxicity score		% of total noncarc. score
Bis(2-Ethylhexyl) Phthalate	1.00E-03	1.40E-02	2.00E-02	5.00E-02	1.40E-05	100	100						
D2													
Inorganics													
Barium	1.10E-01		7.00E-02	1.60E+00		0.26			1.40E-04	7.60E+02		0.36	DROP
Manganese	3.00E+00		5.00E-03	6.00E+02		99.71			1.40E-05	2.10E+05		99.64	
Organics													
1,2-Dichloroethene (Total)	2.00E-03		9.00E-03	2.20E-01		0.04							DROP
D3													
Inorganics													
Manganese	3.60E-01		5.00E-03	7.10E+01		99.79			1.40E-05	2.50E+04		100	
Organics													
Bis(2-Ethylhexyl) Phthalate	3.00E-03	1.40E-02	2.00E-02	1.50E-01	4.20E-05	0.21	100						

Table 6b. Toxicity screening for detected radionuclides in WAG 5 surface water
(Ingestion)

Analyte	Maximum det. conc. (pCi/g)	SF (1/pCi)	Toxicity score	% of total toxicity score	Decision
High Base					
D1					
Radionuclides					
Pu-238	2.90E-01	2.20E-10	6.40E-11	1.14	
Total Radioactive Strontium	2.40E+01	3.60E-11	8.60E-10	15.38	
Tritium	5.50E+04	5.40E-14	3.00E-09	52.88	
U-233/234	2.70E+01	1.60E-11	4.30E-10	7.69	
U-235	1.70E+00	1.60E-11	2.70E-11	0.48	DROP
U-238	4.50E+01	2.80E-11	1.30E-09	22.43	
D2					
Radionuclides					
C-14	3.20E+02	9.00E-13	2.90E-10	0.06	DROP
Total Radioactive Strontium	2.50E+03	3.60E-11	9.00E-08	17.97	
Tritium	7.60E+06	5.40E-14	4.10E-07	81.96	
U-233/234	3.70E+00	1.60E-11	5.90E-11	0.01	DROP
D3					
Radionuclides					
Tritium	2.40E+03	5.40E-14	1.30E-10	100	
High Base Storm					
D1					
Radionuclides					
Am-241	1.10E-01	2.40E-10	2.70E-11	0.51	DROP
Pu-239/240	7.50E-02	2.30E-10	1.70E-11	0.33	DROP
Th-230	5.30E+00	1.30E-11	6.90E-11	1.33	
Total Radioactive Strontium	1.60E+01	3.60E-11	5.90E-10	11.32	
Tritium	2.50E+04	5.40E-14	1.40E-09	26.04	
U-233/234	5.10E+01	1.60E-11	8.20E-10	15.86	
U-235/236	2.80E+00	1.50E-11	4.10E-11	0.8	DROP
U-238	8.10E+01	2.80E-11	2.30E-09	43.8	
D2					
Radionuclides					
Am-241	1.40E-01	2.40E-10	3.50E-11	0.01	DROP
C-14	1.20E+02	9.00E-13	1.10E-10	0.04	DROP

Table 6b. (continued)

Analyte	Maximum det. conc. (pCi/g)	SF (1/pCi)	Toxicity score	% of total toxicity score	Decision
Pu-238	1.40E+01	2.20E-10	3.10E-09	1.11	
Pu-239/240	1.30E-01	2.30E-10	3.00E-11	0.01	DROP
Tc-99	3.80E+01	1.30E-12	4.90E-11	0.02	DROP
Th-230	1.00E+01	1.30E-11	1.40E-10	0.05	DROP
Total Radioactive Strontium	1.40E+03	3.60E-11	5.10E-08	18.24	
Tritium	4.20E+06	5.40E-14	2.20E-07	80.53	
D3					
Radionuclides					
Total Radioactive Strontium	5.70E+01	3.60E-11	2.10E-09	100	
Impoundment					
OHFP					
Radionuclides					
Am-241	3.90E-01	2.40E-10	9.40E-11	0	DROP
Cm-243/244	1.60E+01	1.60E-10	2.60E-09	0.07	DROP
Co-60	1.50E+02	1.50E-11	2.30E-09	0.06	DROP
Cs-137	2.50E+04	2.80E-11	7.00E-07	17.73	
Pu-238	3.20E-01	2.20E-10	7.00E-11	0	DROP
Pu-239/240	5.10E-01	2.30E-10	1.20E-10	0	DROP
Tc-99	4.30E+01	1.30E-12	5.60E-11	0	DROP
Total Radioactive Strontium	9.00E+04	3.60E-11	3.20E-06	82.07	
Tritium	2.00E+04	5.40E-14	1.10E-09	0.03	DROP
U-232	3.30E+00	3.70E-11	1.20E-10	0	DROP
U-233/234	1.00E+02	1.60E-11	1.60E-09	0.04	DROP
PWSB					
Radionuclides					
Am-241	5.00E-01	2.40E-10	1.20E-10	0.05	DROP
C-14	4.20E+01	9.00E-13	3.80E-11	0.02	DROP
Cm-243/244	5.10E+00	1.60E-10	8.20E-10	0.36	DROP
Co-60	1.30E+02	1.50E-11	1.90E-09	0.85	DROP
Cs-137	4.90E+01	2.80E-11	1.40E-09	0.61	DROP
Pu-238	2.10E-01	2.20E-10	4.70E-11	0.02	DROP
Total Radioactive Strontium	6.00E+03	3.60E-11	2.20E-07	95.58	
Tritium	9.50E+03	5.40E-14	5.10E-10	0.23	DROP

Table 6b. (continued)

Analyte	Maximum det. conc. (pCi/g)	SF (1/pCi)	Toxicity score	% of total toxicity score	Decision
U-232	2.20E+01	3.70E-11	8.10E-10	0.36	DROP
U-233/234	2.60E+02	1.60E-11	4.20E-09	1.86	
U-238	4.80E+00	2.80E-11	1.30E-10	0.06	DROP
Low Base					
D1					
Radionuclides					
Pb-212	2.10E+01	5.50E-12	1.20E-10	1.42	
Total Radioactive Strontium	3.00E+01	3.60E-11	1.10E-09	13.11	
Tritium	1.20E+05	5.40E-14	6.30E-09	76.97	
U-233/234	1.00E+01	1.60E-11	1.70E-10	2.03	
U-235	8.00E-01	1.60E-11	1.30E-11	0.16	DROP
U-238	1.90E+01	2.80E-11	5.20E-10	6.31	
D2					
Radionuclides					
Am-241	9.30E+00	2.40E-10	2.20E-09	0.79	DROP
C-14	1.80E+02	9.00E-13	1.60E-10	0.06	DROP
Pu-238	1.80E+01	2.20E-10	3.90E-09	1.37	
Ra-228	1.60E+03	1.00E-10	1.60E-07	56.91	
Tc-99	1.90E+01	1.30E-12	2.40E-11	0.01	DROP
Total Radioactive Strontium	1.80E+03	3.60E-11	6.40E-08	22.58	
Tritium	9.60E+05	5.40E-14	5.20E-08	18.27	
U-233/234	3.20E+00	1.60E-11	5.10E-11	0.02	DROP
D3					
Radionuclides					
Tritium	2.70E+03	5.40E-14	1.40E-10	100	
Low Base Storm					
D1					
Radionuclides					
Tritium	2.80E+04	5.40E-14	1.50E-09	69.77	
U-233/234	1.10E+01	1.60E-11	1.70E-10	7.74	
U-235	6.80E-01	1.60E-11	1.10E-11	0.5	DROP
U-238	1.70E+01	2.80E-11	4.80E-10	21.99	
D2					

Table 6b. (continued)

Analyte	Maximum det. conc. (pCi/g)	SF (1/pCi)	Toxicity score	% of total toxicity score	Decision
Radionuclides					
Am-241	9.00E-01	2.40E-10	2.20E-10	0.03	DROP
C-14	1.80E+02	9.00E-13	1.60E-10	0.02	DROP
Pu-238	1.90E+01	2.20E-10	4.20E-09	0.63	DROP
Pu-239/240	2.00E-01	2.30E-10	4.60E-11	0.01	DROP
Tc-99	3.00E+01	1.30E-12	3.90E-11	0.01	DROP
Total Radioactive Strontium	2.10E+03	3.60E-11	7.50E-08	11.34	
Tritium	1.10E+07	5.40E-14	5.80E-07	87.94	
U-233/234	6.20E+00	1.60E-11	9.90E-11	0.01	DROP
D3					
Radionuclides					
Am-241	7.40E-02	2.40E-10	1.80E-11	100	

Table 7a. Comparison of maximum detected concentrations for analytes dropped by toxicity screening in WAG 5 soil with residential PRGs

Analyte	Frequency of detection	Maximum Det. conc. (MD)	PRG for HQ=1.0	PRG for risk=10 ⁻⁴	PRG for risk=10 ⁻⁶	Is MD > PRG for HQ = 1.0	Is MD > PRG for risk=10 ⁻⁴	Units
FS								
Radionuclides								
Pb-212	1/1	1.50E+00		1.50E+01	1.50E-01		YES	PCI/G
OHFP								
Radionuclides								
Co-60	4/4	6.20E-01		4.80E-01	4.80E-03		YES	PCI/G
Ra-228	4/5	1.40E+00		1.40E+00	1.40E-02		YES	PCI/G
SWSA 5N								
Radionuclides								
Pb-212	6/6	1.60E+00		1.50E+01	1.50E-01		YES	PCI/G
SWSA 5SE								
Radionuclides								
Ac-228	1/1	1.00E+00		1.40E+00	1.40E-02		YES	PCI/G
Pb-212	1/1	1.90E+00		1.50E+01	1.50E-01		YES	PCI/G
Pb-214	1/1	6.00E-01		6.50E+00	6.50E-02		YES	PCI/G
Ra-228	3/5	1.30E+00		1.40E+00	1.40E-02		YES	PCI/G
Tl-208	1/1	1.00E+00		3.20E-01	3.20E-03		YES	PCI/G
SWSA5SW								
Radionuclides								
Pb-212	4/4	1.80E+00		1.50E+01	1.50E-01		YES	PCI/G
Pb-214	2/2	1.40E+00		6.50E+00	6.50E-02		YES	PCI/G
WOC								
Radionuclides								
Ac-228	2/2	1.80E+00		1.40E+00	1.40E-02		YES	PCI/G
Co-57	1/1	2.30E+00		2.20E+01	2.20E-01		YES	PCI/G
Cs-134	1/1	4.00E-02		8.00E-01	8.00E-03		YES	PCI/G
Na-22	1/1	1.50E+00		5.80E-01	5.80E-03		YES	PCI/G
Pb-212	2/2	1.40E+00		1.50E+01	1.50E-01		YES	PCI/G
Pb-214	2/2	1.40E+00		6.50E+00	6.50E-02		YES	PCI/G
Ra-228	3/4	1.80E+00		1.40E+00	1.40E-02		YES	PCI/G
Tl-208	1/1	2.00E+00		3.20E-01	3.20E-03		YES	PCI/G

Table 7b. Comparison of maximum detected concentrations for analytes dropped by toxicity screening in WAG 5 sediment with residential PRGs

Analyte	Frequency of detection	Maximum Det. conc. (MD)	PRG for HQ=1.0	PRG for risk=10 ⁻⁴	PRG for risk=10 ⁻⁴	Is MD > PRG for HQ = 1.0	Is MD > PRG for risk=10 ⁻⁴	Units
D1								
Radionuclides								
Radon 219	1/1	4.70E-01		2.70E+01	2.70E-01		YES	PCI/G
U-235	4/4	3.80E-01		1.70E+01	1.70E-01		YES	PCI/G
D2								
Radionuclides								
Pb-212	4/4	1.70E+00		1.50E+01	1.50E-01		YES	PCI/G
Pb-214	4/4	1.20E+00		1.50E+01	1.50E-01		YES	PCI/G
Ra-223	2/2	9.10E-01		1.80E+01	1.80E-01		YES	PCI/G
Ra-224	3/3	4.90E+00		1.70E+02	1.70E+00		YES	PCI/G
Ra-224(2)	3/3	4.90E+00		1.80E+00	1.80E-02		YES	PCI/G
Radon 219	2/2	1.20E+00		2.70E+01	2.70E-01		YES	PCI/G
U-235	1/3	4.10E-01		1.70E+01	1.70E-01		YES	PCI/G
OHFP								
Radionuclides								
Co-60	1/1	6.30E+03		4.80E-01	4.80E-03		YES	PCI/G
U-232	1/1	3.80E+01		2.00E+03	2.00E+01		YES	PCI/G

Table 7c. (continued)

Analyte	Frequency of detection	Maximum Det. conc. (MD)	PRG for HQ=1.0	PRG for risk=10 ⁻⁴	PRG for risk=10 ⁻⁶	Is MD > PRG for HQ = 1.0	Is MD > PRG for risk=10 ⁻⁴	Units
Dimethyl Phthalate	1/10	1.60E+00	3.60E+02					MG/L
Fluoranthene	1/10	1.00E-03	4.50E-01					MG/L
Nitrate	1/4	7.60E-01	5.80E+01					MG/L
Phthalic Acid, Dioctyl Ester	1/10	4.00E-03	7.30E-01					MG/L
Pyrene	1/10	1.00E-03	3.60E-01					MG/L
Radionuclides								
Bi-214	1/1	1.70E+02		3.70E+04	3.70E+02			PCI/L
Cm-243	2/16	4.10E-01		2.50E+01	2.50E-01		YES	PCI/L
Hg-203	1/1	1.40E+01		7.20E+03	7.20E+01			PCI/L
Pb-212	7/7	5.00E+01		8.70E+02	8.70E+00		YES	PCI/L
Pu-238	6/27	2.20E+00		2.20E+01	2.20E-01		YES	PCI/L
Tc-99	8/20	1.10E+02		3.70E+03	3.70E+01		YES	PCI/L
Th-228	10/21	8.50E+00		8.70E+01	8.70E-01		YES	PCI/L
Th-230	12/21	7.80E+00		3.70E+02	3.70E+00		YES	PCI/L
Th-232	12/22	1.00E+01		4.00E+02	4.00E+00		YES	PCI/L
Tritium	22/29	7.90E+03		8.80E+04	8.80E+02		YES	PCI/L
U-233/234	15/24	1.00E+01		3.00E+02	3.00E+00		YES	PCI/L
U-235	2/17	3.60E-01		3.00E+02	3.00E+00			PCI/L
U-235/236	1/7	2.00E-01		3.20E+02	3.20E+00			PCI/L
U-238	9/24	9.90E+00		1.70E+02	1.70E+00		YES	PCI/L
SWSA 5SE								
Inorganics								
Barium	15/15	8.50E-01	2.50E+00					MG/L
Boron	5/7	1.50E+00	3.30E+00					MG/L
Mercury	6/15	4.50E-04	5.40E-04					MG/L
Nickel	11/15	1.60E-01	7.20E-01					MG/L
Silver	5/15	1.50E-02	1.80E-01					MG/L
Vanadium	8/15	8.90E-02	2.10E-01					MG/L
Zinc	10/15	4.20E-01	1.10E+01					MG/L
Organics								
1,1-Dichloroethane	4/16	2.10E-02	1.00E+00					MG/L
1,2-Dichloroethane	4/16	4.00E-03		2.00E-02	2.00E-04		YES	MG/L

Table 7c. (continued)

Analyte	Frequency of detection	Maximum Det. conc. (MD)	PRG for HQ=1.0	PRG for risk=10 ⁻⁴	PRG for risk=10 ⁻⁴	Is MD > PRG for HQ = 1.0	Is MD > PRG for risk=10 ⁻⁴	Units
1,2-Dichloroethene (Total)	10/16	1.80E-01	3.30E-01					MG/L
Benzene	2/16	2.00E-03		6.10E-02	6.10E-04		YES	MG/L
Bis(2-Ethylhexyl) Phthalate	1/10	5.00E-03	5.90E-01	4.90E-01	4.90E-03		YES	MG/L
Carbon Disulfide	1/16	1.00E-03	2.80E-02					MG/L
Chlorobenzene	1/16	2.00E-03	5.10E-02					MG/L
Chloroethane	1/16	1.00E-03	2.80E+01					MG/L
Chloroform	1/16	1.00E-03	3.40E-01	2.70E-02	2.70E-04		YES	MG/L
Cyanide	1/14	4.90E-02	7.00E-01					MG/L
Nitrate	2/4	1.70E+00	5.80E+01					MG/L
Tetrachloroethene	8/16	3.40E-02	2.10E-01					MG/L
Toluene	1/16	1.00E-03	9.50E-01					MG/L
Radionuclides								
Bi-212	1/1	5.30E+02		1.50E+04	1.50E+02		YES	PC/L
C-14	10/22	1.50E+03		5.30E+03	5.30E+01		YES	PC/L
Cd-109	1/1	3.70E+02		6.00E+02	6.00E+00		YES	PC/L
Cm-243/244	12/18	3.70E+01		3.00E+01	3.00E-01		YES	PC/L
Fe-55	1/2	5.30E+01		1.80E+04	1.80E+02			PC/L
Hg-203	1/1	1.30E+01		7.20E+03	7.20E+01			PC/L
Pu-239/240	5/23	1.40E+04		2.10E+01	2.10E-01		YES	PC/L
Ra-226	5/15	7.00E+03		4.00E+01	4.00E-01		YES	PC/L
Ra-228	7/13	7.70E+01		4.80E+01	4.80E-01		YES	PC/L
Tc-99	6/13	5.10E+02		3.70E+03	3.70E+01		YES	PC/L
Th-228	6/14	2.10E+02		8.70E+01	8.70E-01		YES	PC/L
Th-230	5/14	5.90E+00		3.70E+02	3.70E+00		YES	PC/L
Th-231	1/1	3.50E+02		1.20E+04	1.20E+02		YES	PC/L
Th-232	4/14	2.80E+00		4.00E+02	4.00E+00			PC/L
Total Radioactive Strontium	20/22	1.50E+04		1.30E+02	1.30E+00		YES	PC/L
U-232	1/11	2.90E+00		1.30E+02	1.30E+00		YES	PC/L
U-233/234	14/23	3.80E+03		3.00E+02	3.00E+00		YES	PC/L
U-235/236	1/6	3.70E-01		3.20E+02	3.20E+00			PC/L
U-238	6/23	1.80E+00		1.70E+02	1.70E+00		YES	PC/L

SWSA5SW

Table 7c. (continued)

Analyte	Frequency of detection	Maximum Det. conc. (MD)	PRG for HQ=1.0	PRG for risk=10 ⁻⁴	PRG for risk=10 ⁻⁶	Is MD > PRG for HQ = 1.0	Is MD > PRG for risk=10 ⁻⁴	Units
InOrganics								
Mercury	3/10	3.20E-04	5.40E-04					MG/L
Nickel	8/10	2.40E-01	7.20E-01					MG/L
Silver	3/10	1.50E-02	1.80E-01					MG/L
Vanadium	6/10	7.50E-02	2.10E-01					MG/L
Zinc	7/10	2.00E-01	1.10E+01					MG/L
Organics								
1,1-Dichloroethane	5/10	8.00E-03	1.00E+00					MG/L
1,2-Dichloroethene (Total)	6/10	7.10E-02	3.30E-01					MG/L
Benzene	1/10	1.00E-03		6.10E-02	6.10E-04		YES	MG/L
Carbon Tetrachloride	1/10	6.00E-03	2.40E-02	2.50E-02	2.50E-04		YES	MG/L
Chloroethane	1/10	3.00E-03	2.80E+01					MG/L
Chloroform	1/10	1.00E-03	3.40E-01	2.70E-02	2.70E-04		YES	MG/L
Cyanide	1/9	5.80E-03	7.00E-01					MG/L
Nitrate	2/4	6.90E+00	5.80E+01					MG/L
Trichloroethene	6/10	3.40E-02						MG/L
Radionuclides								
Am-241	5/11	7.80E+00		2.00E+01	2.00E-01		YES	PC/L
Bi-214	1/1	2.90E+01		3.70E+04	3.70E+02			PC/L
C-14	11/14	9.20E+02		5.30E+03	5.30E+01		YES	PC/L
Ca-45	1/3	2.80E+02		4.80E+03	4.80E+01		YES	PC/L
Cm-242	1/6	5.60E-01		3.70E+02	3.70E+00			PC/L
Cm-243/244	4/9	3.40E+00		3.00E+01	3.00E-01		YES	PC/L
Co-60	2/5	5.20E+01		3.20E+02	3.20E+00		YES	PC/L
K-40	2/2	1.00E+03		4.30E+02	4.30E+00		YES	PC/L
Pb-212	1/1	5.30E+01		8.70E+02	8.70E+00		YES	PC/L
Pu-238	5/12	5.80E+00		2.20E+01	2.20E-01		YES	PC/L
Pu-239/240	1/12	1.10E-01		2.10E+01	2.10E-01			PC/L
Ra-226	7/9	3.60E+00		4.00E+01	4.00E-01		YES	PC/L
Ra-228	4/8	9.60E+01		4.80E+01	4.80E-01		YES	PC/L
Tc-99	3/8	2.40E+01		3.70E+03	3.70E+01			PC/L
Th-228	6/9	3.70E+01		8.70E+01	8.70E-01		YES	PC/L

Table 7c. (continued)

Analyte	Frequency of detection	Maximum Det. conc. (MD)	PRG for HQ=1.0	PRG for risk=10 ⁻⁴	PRG for risk=10 ⁻⁴	Is MD > PRG for HQ = 1.0	Is MD > PRG for risk=10 ⁻⁴	Units
Th-230	4/9	1.60E+01		3.70E+02	3.70E+00		YES	PCI/L
Th-232	6/9	2.50E+01		4.00E+02	4.00E+00		YES	PCI/L
Th-234	1/1	1.70E+02		1.20E+03	1.20E+01		YES	PCI/L
U-233/234	10/12	1.90E+01		3.00E+02	3.00E+00		YES	PCI/L
U-235/236	1/3	6.90E-03		3.20E+02	3.20E+00			PCI/L
U-238	4/12	1.20E+01		1.70E+02	1.70E+00		YES	PCI/L
WOC								
InOrganics								
Boron	1/5	3.90E-01	3.30E+00					MG/L
Mercury	1/5	1.10E-04	5.40E-04					MG/L
Organics								
1,1-Dichloroethane	1/6	1.00E-03	1.00E+00					MG/L
1,1-Dichloroethene	2/6	5.00E-03	3.20E-01	1.70E-03	1.70E-05		YES	MG/L
Benzene	2/6	2.50E-02		6.10E-02	6.10E-04		YES	MG/L
Trichloroethene	2/6	2.70E-02						MG/L
Xylene (Total)	1/6	2.00E-03	7.30E+01					MG/L
Radionuclides								
Pu-238	1/10	5.10E-02		2.20E+01	2.20E-01			PCI/L
Pu-239/240	1/10	2.50E-01		2.10E+01	2.10E-01		YES	PCI/L
Ra-226	1/5	3.30E-01		4.00E+01	4.00E-01			PCI/L
Th-230	2/5	6.30E-01		3.70E+02	3.70E+00			PCI/L
U-233/234	6/10	1.20E+00		3.00E+02	3.00E+00			PCI/L
U-235	3/6	3.20E-01		3.00E+02	3.00E+00			PCI/L
U-238	4/10	4.10E-01		1.70E+02	1.70E+00			PCI/L

Table 7d. Comparison of maximum detected concentrations for analytes dropped by toxicity screening in WAG 5 surface water with residential PRGs

Analyte	Frequency of detection	Maximum Det. conc. (MD)	PRG for HQ=1.0	PRG for risk=10 ⁻⁴	PRG for risk=10 ⁻⁶	Is MD > PRG for HQ = 1.0	Is MD > PRG for risk=10 ⁻⁴	Units
High Base								
D1								
Organics								
2-Butanone	1/1	4.00E-03	2.50E+00					MG/L
Radionuclides								
U-235	1/1	1.70E+00		3.00E+02	3.00E+00			PCI/L
D2								
Inorganics								
Barium	1/1	9.30E-02	2.50E+00					MG/L
Radionuclides								
C-14	1/1	3.20E+02		5.30E+03	5.30E+01		YES	PCI/L
U-233/234	1/1	3.70E+00		3.00E+02	3.00E+00		YES	PCI/L
MB								
Radionuclides								
Ca-45	1/1	1.70E+02		4.80E+03	4.80E+01		YES	PCI/L
MBT								
Radionuclides								
Tc-99	1/1	3.80E+00		3.70E+03	3.70E+01			PCI/L
High Base Storm								
D1								
Radionuclides								
Am-241	1/1	1.10E-01		2.00E+01	2.00E-01			PCI/L
Pu-239/240	1/1	7.50E-02		2.10E+01	2.10E-01			PCI/L
U-235/236	1/1	2.80E+00		3.20E+02	3.20E+00			PCI/L
D2								
Radionuclides								
Am-241	1/1	1.40E-01		2.00E+01	2.00E-01			PCI/L
C-14	1/1	1.20E+02		5.30E+03	5.30E+01		YES	PCI/L
Pu-239/240	1/1	1.30E-01		2.10E+01	2.10E-01			PCI/L
Tc-99	1/1	3.80E+01		3.70E+03	3.70E+01		YES	PCI/L
Th-230	1/1	1.00E+01		3.70E+02	3.70E+00		YES	PCI/L

Table 7d. (continued)

Analyte	Frequency of detection	Maximum Det. conc. (MD)	PRG for HQ=1.0	PRG for risk=10 ⁻⁴	PRG for risk=10 ⁻⁶	Is MD > PRG for HQ = 1.0	Is MD > PRG for risk=10 ⁻⁴	Units
MB								
Radionuclides								
Am-241	2/2	1.60E-01		2.00E+01	2.00E-01			PCI/L
Cm-243/244	1/2	2.90E-01		3.00E+01	3.00E-01			PCI/L
Pu-238	1/2	3.30E-01		2.20E+01	2.20E-01		YES	PCI/L
Th-230	2/2	9.60E+00		3.70E+02	3.70E+00		YES	PCI/L
Th-232	2/2	2.10E+00		4.00E+02	4.00E+00			PCI/L
MBT								
Radionuclides								
Am-241	1/1	5.20E-02		2.00E+01	2.00E-01			PCI/L
Pu-239/240	1/1	7.30E-02		2.10E+01	2.10E-01			PCI/L
Th-232	1/1	3.10E+00		4.00E+02	4.00E+00			PCI/L
Impoundment								
OIHP								
Radionuclides								
Am-241	1/1	3.90E-01		2.00E+01	2.00E-01		YES	PCI/L
Cm-243/244	1/1	1.60E+01		3.00E+01	3.00E-01		YES	PCI/L
Co-60	1/1	1.50E+02		3.20E+02	3.20E+00		YES	PCI/L
Pu-238	1/1	3.20E-01		2.20E+01	2.20E-01		YES	PCI/L
Pu-239/240	1/1	5.10E-01		2.10E+01	2.10E-01		YES	PCI/L
Tc-99	1/1	4.30E+01		3.70E+03	3.70E+01		YES	PCI/L
Tritium	1/1	2.00E+04		8.80E+04	8.80E+02		YES	PCI/L
U-232	1/1	3.30E+00		1.30E+02	1.30E+00		YES	PCI/L
U-233/234	1/1	1.00E+02		3.00E+02	3.00E+00		YES	PCI/L
PWSB								
Organics								
Styrene	1/1	1.00E-03	1.50E+00					MG/L
Radionuclides								
Am-241	1/1	5.00E-01		2.00E+01	2.00E-01		YES	PCI/L
C-14	1/1	4.20E+01		5.30E+03	5.30E+01			PCI/L
Cm-243/244	1/1	5.10E+00		3.00E+01	3.00E-01		YES	PCI/L
Co-60	1/1	1.30E+02		3.20E+02	3.20E+00		YES	PCI/L

Table 7d. (continued)

Analyte	Frequency of detection	Maximum Det. conc. (MD)	PRG for HQ=1.0	PRG for risk=10 ⁻⁴	PRG for risk=10 ⁻⁴	Is MD > PRG for HQ = 1.0	Is MD > PRG for risk=10 ⁻⁴	Units
Am-241	1/1	9.00E-01		2.00E+01	2.00E-01		YES	PCI/L
C-14	1/1	1.80E+02		5.30E+03	5.30E+01		YES	PCI/L
Pu-238	1/1	1.90E+01		2.20E+01	2.20E-01		YES	PCI/L
Pu-239/240	1/1	2.00E-01		2.10E+01	2.10E-01			PCI/L
Tc-99	1/1	3.00E+01		3.70E+03	3.70E+01			PCI/L
U-233/234	1/1	6.20E+00		3.00E+02	3.00E+00		YES	PCI/L
MB								
Radionuclides								
Am-241	1/2	7.60E-02		2.00E+01	2.00E-01			PCI/L

Table 8a. Analytes in WAG 5 soil eliminated from COPCs list

Analyte	Frequency of detection	Reason for elimination from COPCs list
FS		
Inorganics		
Aluminum	1/1	B
Arsenic	1/1	B
Barium	1/1	B
Beryllium	1/1	B
Calcium	1/1	E
Chromium	1/1	B
Cobalt	1/1	B
Copper	1/1	E
Iron	1/1	E
Lead	1/1	B
Magnesium	1/1	E
Manganese	1/1	B
Nickel	1/1	B
Potassium	1/1	E
Sodium	1/1	E
Vanadium	1/1	B
Zinc	1/1	B
Organics		
Pyrene	1/1	T
Radionuclides		
K-40	1/1	B
Tritium	1/1	T
NHFT		
Inorganics		
Aluminum	2/2	B
Arsenic	2/2	B
Barium	2/2	B
Beryllium	2/2	B
Calcium	2/2	E
Chromium	2/2	B

Table 8a. (continued)

Analyte	Frequency of detection	Reason for elimination from COPCs list
Cobalt	2/2	B
Copper	2/2	E
Iron	2/2	E
Lead	2/2	B
Magnesium	2/2	E
Manganese	2/2	B
Nickel	2/2	B
Potassium	2/2	E
Silver	2/2	B
Sodium	2/2	E
Vanadium	2/2	B
Zinc	2/2	B
Radionuclides		
C-14	1/2	T
Cs-137	1/2	B
K-40	2/2	B
Pu-239/240	1/2	B
Ra-226	2/2	B
Total Radioactive Strontium	1/2	B
Tritium	2/2	T
U-238	2/2	B
OHFP		
Inorganics		
Aluminum	5/5	B
Arsenic	4/5	B
Barium	5/5	B
Beryllium	3/5	B
Calcium	5/5	E
Chromium	5/5	B
Cobalt	4/5	B
Copper	4/5	E
Iron	5/5	E
Lead	5/5	B

Table 8a. (continued)

Analyte	Frequency of detection	Reason for elimination from COPCs list
Magnesium	5/5	E
Manganese	5/5	B
Mercury	4/5	B
Nickel	3/5	B
Potassium	5/5	E
Sodium	1/5	E
Vanadium	4/5	B
Zinc	5/5	B
Organics		
Acetone	3/8	T
Chloromethane	1/8	T
Radionuclides		
Cm-243/244	3/4	B
K-40	5/5	B
Pu-238	3/5	B
Pu-239/240	1/5	T
Ra-226	4/5	B
Th-232	5/5	B
Tritium	4/4	T
U-238	5/5	B
OHFT		
Inorganics		
Aluminum	5/5	B
Arsenic	5/5	B
Barium	5/5	B
Beryllium	4/5	B
Calcium	5/5	E
Chromium	5/5	B
Cobalt	5/5	B
Copper	4/5	E
Iron	5/5	E
Lead	5/5	B
Magnesium	5/5	E

Table 8a. (continued)

Analyte	Frequency of detection	Reason for elimination from COPCs list
Manganese	5/5	B
Mercury	1/5	B
Nickel	5/5	B
Potassium	5/5	E
Sodium	3/5	E
Vanadium	5/5	B
Zinc	5/5	B
Organics		
Acetone	6/15	T
Butyl Benzyl Phthalate	1/5	T
Di-n-butyl Phthalate	1/5	T
Radionuclides		
K-40	5/5	B
Th-230	5/5	B
Total Radioactive Strontium	5/5	B
Tritium	5/5	T
U-238	5/5	B
PWSB		
Inorganics		
Aluminum	5/5	B
Arsenic	5/5	B
Beryllium	5/5	B
Calcium	5/5	E
Chromium	5/5	B
Cobalt	5/5	B
Copper	4/5	E
Iron	5/5	E
Lead	5/5	B
Magnesium	5/5	E
Manganese	5/5	B
Nickel	5/5	B
Potassium	5/5	E
Selenium	1/4	B

Table 8a. (continued)

Analyte	Frequency of detection	Reason for elimination from COPCs list
Silver	2/5	B
Sodium	3/5	E
Thallium	1/5	B
Vanadium	5/5	B
Zinc	5/5	B
Organics		
1,2-Benzenedicarboxylic Acid, Diethyl Ester	1/5	T
Butyl Benzyl Phthalate	1/5	T
Di-n-butyl Phthalate	2/5	T
Toluene	3/14	T
Radionuclides		
Th-230	4/4	B
Tritium	1/5	T
U-238	4/4	B
SW3		
Inorganics		
Aluminum	1/1	B
Arsenic	1/1	B
Barium	1/1	B
Beryllium	1/1	B
Calcium	1/1	E
Chromium	1/1	B
Cobalt	1/1	B
Copper	1/1	E
Iron	1/1	E
Lead	1/1	B
Magnesium	1/1	E
Manganese	1/1	B
Mercury	1/1	B
Nickel	1/1	B
Potassium	1/1	E
Silver	1/1	B
Sodium	0/1	E

Table 8a. (continued)

Analyte	Frequency of detection	Reason for elimination from COPCs list
Vanadium	1/1	B
Radionuclides		
K-40	1/1	B
Ra-226	1/1	B
Th-232	1/1	B
Tritium	1/1	T
U-238	1/1	B
SWSA 5N		
Inorganics		
Aluminum	6/6	B
Arsenic	6/6	B
Barium	6/6	B
Beryllium	6/6	B
Calcium	6/6	E
Chromium	6/6	B
Cobalt	6/6	B
Copper	6/6	E
Iron	6/6	E
Lead	6/6	B
Magnesium	6/6	E
Manganese	6/6	B
Mercury	2/6	B
Nickel	6/6	B
Potassium	6/6	E
Selenium	1/4	B
Silver	5/6	B
Sodium	0/6	E
Vanadium	6/6	B
Zinc	6/6	B
Radionuclides		
C-14	1/6	T
Cs-137	2/6	B
K-40	6/6	B

Table 8a. (continued)

Analyte	Frequency of detection	Reason for elimination from COPCs list
Ra-226	6/6	B
Sn-126	2/2	T
Total Radioactive Strontium	1/6	B
Tritium	4/6	T
SWSA SSE		
Inorganics		
Aluminum	5/5	B
Arsenic	5/5	B
Barium	5/5	B
Beryllium	5/5	B
Calcium	5/5	E
Chromium	5/5	B
Cobalt	5/5	B
Copper	5/5	E
Iron	5/5	E
Lead	5/5	B
Magnesium	5/5	E
Mercury	1/5	B
Nickel	5/5	B
Potassium	5/5	E
Selenium	3/5	T
Silver	4/5	B
Sodium	2/5	E
Thallium	1/5	B
Vanadium	5/5	B
Zinc	5/5	B
Organics		
2-Butanone	1/8	T
Acetone	1/8	T
Benzo(k)Fluoranthene	1/5	T
Bis(2-Ethylhexyl) Phthalate	1/5	T
Cyanide	1/5	T
Fluoranthene	1/5	T

Table 8a. (continued)

Analyte	Frequency of detection	Reason for elimination from COPCs list
Pyrene	1/5	T
Radionuclides		
C-14	1/5	T
Ca-45	1/1	T
K-40	5/5	B
Ra-226	4/5	B
Sn-126	1/1	T
Th-232	5/5	B
Tritium	3/5	T
U-233/234	1/2	T
U-238	2/3	B
SWSASSW		
Inorganics		
Aluminum	5/5	B
Arsenic	5/5	B
Beryllium	5/5	B
Calcium	5/5	E
Chromium	5/5	B
Copper	5/5	E
Iron	5/5	E
Lead	5/5	B
Magnesium	5/5	E
Mercury	1/5	B
Nickel	5/5	B
Potassium	5/5	E
Silver	2/5	B
Sodium	2/5	E
Vanadium	5/5	B
Zinc	5/5	B
Organics		
1,2-Dichloroethene (Total)	1/9	T
2-Butanone	2/9	T
4,4'-DDD	1/5	T

Table 8a. (continued)

Analyte	Frequency of detection	Reason for elimination from COPCs list
Acetone	2/9	T
Endrin	1/5	T
Ethylbenzene	1/9	T
Tetrachloroethene	1/9	T
Toluene	2/9	T
Radionuclides		
Ca-45	2/2	T
Tc-99	2/6	T
Th-230	1/2	B
Tritium	6/6	T
WOC		
Inorganics		
Aluminum	4/4	B
Arsenic	4/4	B
Barium	4/4	B
Beryllium	4/4	B
Calcium	4/4	E
Chromium	4/4	B
Cobalt	4/4	B
Copper	4/4	E
Iron	4/4	E
Lead	4/4	B
Magnesium	4/4	E
Manganese	4/4	B
Nickel	4/4	B
Potassium	4/4	E
Silver	3/4	B
Sodium	0/4	E
Vanadium	4/4	B
Zinc	4/4	B
Organics		
Bis(2-Ethylhexyl) Phthalate	1/4	T
Di-n-butyl Phthalate	1/4	T

Table 8a. (continued)

Analyte	Frequency of detection	Reason for elimination from COPCs list
Ethylbenzene	1/6	T
Styrene	2/6	T
Radionuclides		
Am-241	1/1	B
K-40	4/4	B
Ra-226	3/4	B
Tc-99	1/1	T
Th-234	1/1	B
Tritium	4/4	T

B = Based on Background comparison; T = Based on toxicity screening; E = Essential nutrients

Table 8b. Analytes in WAG 5 sediment eliminated from COPCs list

Analyte	Frequency of detection	Reason for elimination from COPCs list
D1		
Inorganics		
Aluminum	4/4	B
Arsenic	4/4	B
Barium	4/4	B
Beryllium	4/4	B
Calcium	4/4	E
Copper	2/4	E
Iron	4/4	E
Lead	4/4	B
Magnesium	4/4	E
Potassium	4/4	E
Sodium	0/4	E
Vanadium	4/4	B
Zinc	4/4	B
Organics		
4-Methyl-2-Pentanone	1/4	T
Radionuclides		
Alpha Particle	4/4	B
Cs-137	4/4	B
Eu-155	1/1	T
K-40	4/4	B
Ra-224	1/1	B
Ra-226	4/4	B
Ra-228	4/4	B
Sn-126	1/1	T
Tc-99	2/2	T
Th-228	4/4	B
Th-231	1/1	T
Th-232	4/4	B

D2

Inorganics

Table 8b. (continued)

Analyte	Frequency of detection	Reason for elimination from COPCs list
Aluminum	4/4	B
Beryllium	4/4	B
Calcium	4/4	E
Cobalt	4/4	B
Copper	4/4	E
Iron	4/4	E
Lead	4/4	B
Magnesium	4/4	E
Mercury	3/4	T
Nickel	4/4	B
Potassium	4/4	E
Selenium	1/4	T
Silver	2/4	T
Sodium	0/4	E
Vanadium	4/4	B
Zinc	3/4	B
Organics		
1,1-Dichloroethane	3/4	T
1,1-Dichloroethene	2/4	T
1,2-Dichloroethane	1/4	T
1,2-Dichloroethene (Total)	3/4	T
2-Butanone	2/4	T
Acetone	1/4	T
Benzene	2/4	T
Toluene	2/4	T
Trichloroethene	2/4	T
Radionuclides		
Am-241	2/3	T
C-14	4/4	T
Ca-45	3/3	T
Cs-137	4/4	B
K-40	4/4	B
Pu-239/240	1/3	T

Table 8b. (continued)

Analyte	Frequency of detection	Reason for elimination from COPCs list
Ra-228	4/4	B
Tc-99	3/4	T
Th-228	4/4	B
Th-230	3/3	B
Th-232	4/4	B
Tritium	4/4	T
D3		
Inorganics		
Arsenic	1/1	B
Barium	1/1	B
Beryllium	1/1	B
Calcium	1/1	E
Cobalt	1/1	B
Copper	1/1	E
Iron	1/1	E
Lead	1/1	B
Magnesium	1/1	E
Manganese	1/1	B
Nickel	1/1	B
Potassium	1/1	E
Sodium	0/1	E
Vanadium	1/1	B
Zinc	1/1	B
Organics		
2-Butanone	1/1	T
Carbon Disulfide	1/1	T
Toluene	1/1	T
Radionuclides		
Alpha Particle	1/1	B
Beta Particle	1/1	B
Cs-137	1/1	B
K-40	1/1	B
Ra-226	1/1	B

Table 8b. (continued)

Analyte	Frequency of detection	Reason for elimination from COPCs list
Ra-228	1/1	B
Sn-126	1/1	T
Th-228	1/1	B
Th-232	1/1	B
Th-234	1/1	B
Total Radioactive Strontium	1/1	B
Tritium	1/1	B
OHFP		
Inorganics		
Aluminum	1/1	B
Arsenic	1/1	B
Barium	1/1	B
Calcium	1/1	E
Cobalt	1/1	B
Copper	1/1	E
Iron	1/1	E
Magnesium	1/1	E
Manganese	1/1	B
Potassium	1/1	E
Sodium	0/1	E
Organics		
Acetone	2/3	T
Radionuclides		
C-14	1/1	T
Th-232	1/1	T
Tritium	1/1	B
PWSB		
Inorganics		
Aluminum	4/4	B
Arsenic	4/4	B
Barium	4/4	B
Calcium	4/4	E
Copper	4/4	E

Table 8b. (continued)

Analyte	Frequency of detection	Reason for elimination from COPCs list
Iron	4/4	E
Magnesium	4/4	E
Manganese	4/4	B
Potassium	0/4	E
Sodium	4/4	E
Organics		
2-Butanone	10/13	T
Acetone	9/13	T
Bis(2-Ethylhexyl) Phthalate	2/4	T
Carbolic Acid	4/4	T
Toluene	2/13	T
Xylene (Total)	3/13	T
Radionuclides		
C-14	4/4	T
Cm-242	2/5	T
Tc-99	4/4	T
Th-230	5/5	T
Th-232	5/5	T
Tritium	4/4	T
U-235/236	2/5	T

B = Based on Background comparison; T = Based on toxicity screening; E = Essential nutrient

Table 8c. Analytes in WAG 5 groundwater eliminated from COPCs list

Analyte	Frequency of detection	Reason for elimination from COPCs list
FS		
Inorganics		
Arsenic	2/2	B
Calcium	2/2	E
Copper	2/2	E
Iron	2/2	E
Lead	2/2	B
Magnesium	2/2	E
Potassium	2/2	E
Silver	1/2	B
Sodium	2/2	E
Zinc	2/2	T
Radionuclides		
Bi-212	1/1	T
Tc-99	1/1	T
Total Radioactive Strontium	1/2	B
U-233/234	1/1	T
OHFP		
Inorganics		
Barium	1/1	B
Calcium	1/1	E
Copper	0/1	E
Iron	0/1	E
Lead	1/1	B
Magnesium	1/1	E
Potassium	1/1	E
Sodium	1/1	E
Radionuclides		
Am-241	1/5	T
Cm-242	1/5	T
Th-230	1/4	T
Th-232	3/4	T
U-232	1/4	T

Table 8c. (continued)

Analyte	Frequency of detection	Reason for elimination from COPCs list
PWSB		
Inorganics		
Barium	3/3	B
Calcium	3/3	E
Chromium	1/3	B
Copper	0/3	E
Iron	3/3	E
Lead	3/3	B
Magnesium	3/3	E
Manganese	3/3	B
Nickel	1/3	B
Phosphorus	0/2	E
Potassium	3/3	E
Silicon	2/2	B
Sodium	3/3	E
Vanadium	1/3	B
Zinc	1/3	B
Radionuclides		
Co-60	1/2	B
Mn-54	1/1	T
Th-232	1/2	T
Total Radioactive Strontium	3/5	B
U-235	1/4	T
SWSA 5N		
Inorganics		
Arsenic	5/11	B
Calcium	11/11	E
Copper	3/11	E
Iron	8/11	E
Magnesium	11/11	E
Phosphorus	1/5	E
Potassium	11/11	E
Silicon	5/5	B

Table 8c. (continued)

Analyte	Frequency of detection	Reason for elimination from COPCs list
Silver	1/11	B
Sodium	11/11	E
Zinc	7/11	T
Organics		
Dimethyl Phthalate	1/10	T
Fluoranthene	1/10	T
Nitrate	1/4	T
Phthalic Acid, Dioctyl Ester	1/10	T
Pyrene	1/10	T
Radionuclides		
Bi-214	1/1	T
Cs-137	3/29	B
Hg-203	1/1	T
U-235	2/17	T
U-235/236	1/7	T
SWSA SSE		
Inorganics		
Antimony	1/15	B
Arsenic	4/15	B
Barium	15/15	T
Beryllium	7/15	B
Boron	5/7	T
Calcium	15/15	E
Copper	7/15	E
Iron	15/15	E
Magnesium	15/15	E
Mercury	6/15	T
Nickel	11/15	T
Phosphorus	1/7	E
Potassium	15/15	E
Silicon	7/7	B
Silver	5/15	T
Sodium	15/15	E

Table 8c. (continued)

Analyte	Frequency of detection	Reason for elimination from COPCs list
Vanadium	8/15	T
Zinc	10/15	T
Organics		
1,1-Dichloroethane	4/16	T
1,2-Dichloroethene (Total)	10/16	T
Carbon Disulfide	1/16	T
Chlorobenzene	1/16	T
Chloroethane	1/16	T
Cyanide	1/14	T
Nitrate	2/4	T
Tetrachloroethene	8/16	T
Toluene	1/16	T
Radionuclides		
Cs-137	1/23	B
Fe-55	1/2	T
Hg-203	1/1	T
Th-232	4/14	T
U-235/236	1/6	T
SWSASSW		
Inorganics		
Arsenic	3/10	B
Beryllium	4/10	B
Boron	1/3	B
Calcium	10/10	E
Copper	5/10	E
Iron	8/10	E
Magnesium	10/10	E
Mercury	3/10	T
Molybdenum	1/4	B
Nickel	8/10	T
Phosphorus	0/3	E
Potassium	10/10	E
Silver	3/10	T

Table 8c. (continued)

Analyte	Frequency of detection	Reason for elimination from COPCs list
Sodium	10/10	E
Vanadium	6/10	T
Zinc	7/10	T
Organics		
1,1-Dichloroethane	5/10	T
1,2-Dichloroethene (Total)	6/10	T
Chloroethane	1/10	T
Cyanide	1/9	T
Nitrate	2/4	T
Trichloroethene	6/10	T
Radionuclides		
Bi-214	1/1	T
Cm-242	1/6	T
Cs-137	1/14	B
Pu-239/240	1/12	T
Tc-99	3/8	T
U-235/236	1/3	T
	WOC	
Inorganics		
Aluminum	2/5	B
Arsenic	1/5	B
Boron	1/5	T
Calcium	5/5	E
Copper	0/5	E
Iron	5/5	E
Lead	5/5	B
Magnesium	5/5	E
Mercury	1/5	T
Phosphorus	1/5	E
Potassium	5/5	E
Selenium	1/5	B
Silicon	5/5	B
Sodium	5/5	E

Table 8c. (continued)

Analyte	Frequency of detection	Reason for elimination from COPCs list
Organics		
1,1-Dichloroethane	1/6	T
Trichloroethene	2/6	T
Xylene (Total)	1/6	T
Radionuclides		
Alpha Particle	1/7	B
Co-60	4/7	B
Pu-238	1/10	T
Ra-226	1/5	T
Th-230	2/5	T
Total Radioactive Strontium	1/10	B
U-233/234	6/10	T
U-235	3/6	T
U-238	4/10	T

B = Based on Background comparison; T = Based on toxicity screening; E = Essential nutrient

Table 8d. Analytes in WAG 5 surface water eliminated from COPCs list

Analyte	Frequency of detection	Reason for elimination from COPCs list
High Base		
D1		
Inorganics		
Barium	1/1	B
Calcium	1/1	E
Copper	1/1	E
Iron	1/1	E
Lead	1/1	B
Magnesium	1/1	E
Potassium	1/1	E
Sodium	1/1	E
Organics		
2-Butanone	1/1	T
Radionuclides		
U-235	1/1	T
D2		
Inorganics		
Barium	1/1	T
Calcium	1/1	E
Copper	0/1	E
Iron	1/1	E
Lead	1/1	B
Magnesium	1/1	E
Potassium	1/1	E
Sodium	1/1	E
Radionuclides		
U-238	1/1	B
D3		
Inorganics		
Barium	1/1	B
Calcium	1/1	E
Copper	0/1	E

Table 8d. (continued)

Analyte	Frequency of detection	Reason for elimination from COPCs list
Iron	1/1	E
Lead	1/1	B
Magnesium	1/1	E
Potassium	1/1	E
Sodium	1/1	E
Radionuclides		
Alpha Particle	1/1	B
High Base Storm		
D1		
Inorganics		
Barium	1/1	B
Calcium	1/1	E
Chromium	1/1	B
Copper	0/1	E
Iron	1/1	E
Lead	1/1	B
Magnesium	1/1	E
Manganese	1/1	B
Nickel	1/1	B
Potassium	1/1	E
Sodium	0/1	E
Zinc	1/1	B
Radionuclides		
Am-241	1/1	T
Pu-239/240	1/1	T
Th-228	1/1	B
Th-232	1/1	B
U-235/236	1/1	T
D2		
Inorganics		
Barium	1/1	B
Calcium	1/1	E
Copper	0/1	E

Table 8d. (continued)

Analyte	Frequency of detection	Reason for elimination from COPCs list
Iron	1/1	E
Magnesium	1/1	E
Manganese	1/1	B
Nickel	1/1	B
Potassium	1/1	E
Sodium	1/1	E
Zinc	1/1	B
Radionuclides		
Am-241	1/1	T
Pu-239/240	1/1	T
Th-228	1/1	B
Th-232	1/1	B
U-233/234	1/1	B
U-238	1/1	B
D3		
Inorganics		
Barium	1/1	B
Calcium	1/1	E
Copper	0/1	E
Iron	0/1	E
Lead	1/1	B
Magnesium	1/1	E
Manganese	1/1	B
Potassium	1/1	E
Sodium	0/1	E
Zinc	1/1	B
Radionuclides		
Beta Particle	1/1	B
Th-228	1/1	B
Th-230	1/1	B
Th-232	1/1	B
Tritium	1/1	B

Table 8d. (continued)

Analyte	Frequency of detection	Reason for elimination from COPCs list
Impoundment		
OHFP		
Inorganics		
Barium	1/1	B
Calcium	1/1	E
Copper	1/1	E
Iron	1/1	E
Magnesium	1/1	E
Manganese	1/1	B
Nickel	1/1	B
Potassium	1/1	E
Selenium	1/1	B
Sodium	1/1	E
Vanadium	1/1	B
Zinc	1/1	B
Radionuclides		
Th-228	1/1	B
Th-230	1/1	B
U-238	1/1	B
PWSB		
Organics		
Styrene	1/1	T
Radionuclides		
C-14	1/1	T
Pu-238	1/1	T
Low Base		
D1		
Inorganics		
Aluminum	1/2	B
Barium	2/2	B
Calcium	2/2	E
Copper	0/2	E
Iron	1/2	E

Table 8d. (continued)

Analyte	Frequency of detection	Reason for elimination from COPCs list
Magnesium	2/2	E
Manganese	2/2	B
Potassium	2/2	E
Sodium	2/2	E
Zinc	1/2	B
Radionuclides		
Th-228	1/1	B
U-235	1/1	T
D2		
Inorganics		
Arsenic	1/1	B
Barium	1/1	T
Calcium	1/1	E
Copper	0/1	E
Iron	1/1	E
Magnesium	1/1	E
Nickel	1/1	B
Potassium	1/1	E
Sodium	1/1	E
Organics		
1,2-Dichloroethene (Total)	1/1	T
Radionuclides		
Ra-226	1/1	B
Tc-99	1/1	T
D3		
Inorganics		
Aluminum	1/1	B
Barium	1/1	B
Calcium	1/1	E
Copper	0/1	E
Iron	1/1	E
Magnesium	1/1	E
Manganese	1/1	B

Table 8d. (continued)

Analyte	Frequency of detection	Reason for elimination from COPCs list
Potassium	1/1	E
Sodium	1/1	E
Radionuclides		
Beta Particle	1/1	B
Ra-226	1/1	B
Low Base Storm		
D1		
Inorganics		
Barium	4/4	B
Calcium	4/4	E
Copper	0/4	E
Iron	0/4	E
Magnesium	4/4	E
Manganese	4/4	B
Potassium	4/4	E
Selenium	1/4	B
Sodium	4/4	E
Radionuclides		
Th-228	1/1	B
Th-230	1/1	B
U-235	1/1	T
D2		
Inorganics		
Barium	3/3	T
Calcium	3/3	E
Chromium	3/3	B
Copper	2/3	E
Iron	2/3	E
Magnesium	3/3	E
Nickel	1/3	B
Potassium	1/3	E
Selenium	1/3	B
Sodium	3/3	E

Table 8d. (continued)

Analyte	Frequency of detection	Reason for elimination from COPCs list
Organics		
1,2-Dichloroethene (Total)	1/1	T
Radionuclides		
Pu-239/240	1/1	T
Tc-99	1/1	T
Th-228	1/1	B
U-238	1/1	B
D3		
Inorganics		
Barium	3/3	B
Calcium	3/3	E
Copper	0/3	E
Iron	0/3	E
Lead	3/3	B
Magnesium	3/3	E
Potassium	3/3	E
Sodium	3/3	E
Radionuclides		
Beta Particle	1/1	B
Th-228	1/1	B
Th-230	1/1	B
Tritium	1/1	B

B = Based on Background comparison; T = Based on toxicity screening; E = Essential nutrients

Table 9a. Chronic daily intake and doses for soil COPCs of WAG 5 designated areas (Excavation, industrial, and residential scenarios)

[illegible]

Table 9a. (continued)

Analyte	Carcinogenic effects (CDI)						Noncarcinogenic effects (CDI)			
	Concentrations (mg/kg;pCi/g)	Ingestion (mg/kg-d;pCi)	Produce ingestion (mg/kg-d;pCi)	Dermal (mg/kg-d)	Inhalation (mg/kg-d;pCi)	External (pCi-y/g)	Ingestion (mg/kg-d;pCi)	Produce ingestion (mg/kg-d;pCi)	Dermal (mg/kg-d)	Inhalation (mg/kg-d;pCi)
Am-241	1.10E-01	4.60E-01			4.30E-05	6.80E-03				
Pu-238	2.60E-01	1.10E+00			1.00E-04	1.60E-02				
Ra-228	1.60E+00	6.70E+00			6.30E-04	9.80E-02				
Th-228	1.70E+00	7.00E+00			6.50E-04	1.00E-01				
Th-230	1.30E+00	5.30E+00			5.00E-04	7.80E-02				
Th-232	1.60E+00	6.50E+00			6.00E-04	9.40E-02				
U-233/234	9.70E-01	4.00E+00			3.80E-04	5.90E-02				
Inorganics					OHFP					
Cadmium	1.50E+00	3.40E-09		2.10E-10	3.20E-13		2.40E-07		1.50E-08	2.20E-11
Organics										
Aroclor 1254	3.20E-02	7.50E-11		4.70E-11	7.00E-15		5.20E-09		3.30E-09	4.90E-13
Aroclor 1260	9.60E-03	2.20E-11		1.40E-11	2.10E-15		1.60E-09		9.90E-10	1.50E-13
Heptachlor Epoxide	5.40E-04	1.30E-12		8.00E-13	1.20E-16		8.80E-11		5.60E-11	8.20E-15
Toluene	1.00E-03	2.30E-12		1.50E-12	3.70E-11		1.60E-10		1.00E-10	2.60E-09
Radionuclides										
Am-241	3.50E-01	1.50E+00			1.40E-04	2.20E-02				
Co-60	6.20E-01	2.60E+00			2.40E-04	3.70E-02				
Cs-137	1.10E+03	4.80E+03			4.50E-01	7.00E+01				
Ra-228	1.40E+00	5.70E+00			5.40E-04	8.40E-02				
Th-228	1.50E+00	6.40E+00			5.90E-04	9.30E-02				
Th-230	1.40E+00	5.80E+00			5.40E-04	8.40E-02				

Table 9a. (continued)

Analyte	Concentrations (mg/kg-pCi/g)	Carcinogenic effects (CDI)					Noncarcinogenic effects (CDI)			
		Ingestion (mg/kg-d;pCi)	Produce ingestion (mg/kg-d;pCi)	Dermal (mg/kg-d)	Inhalation (mg/kg-d;pCi)	External (pCi-y/g)	Ingestion (mg/kg-d;pCi)	Produce ingestion (mg/kg-d;pCi)	Dermal (mg/kg-d)	Inhalation (mg/kg-d;pCi)
Aroclor 1260	1.00E-02	2.30E-11		1.50E-11	2.20E-15		1.60E-09		1.00E-09	1.50E-13
Bis(2-Ethylhexyl) Phthalate	5.70E-02	1.30E-10		8.40E-11	1.20E-14		9.30E-09		5.90E-09	8.70E-13
Chloroform	2.00E-03	4.70E-12		2.90E-12	1.00E-10		3.30E-10		2.10E-10	7.30E-09
Radionuclides										
Am-241	3.50E-01	1.50E+00			1.40E-04	2.10E-02				
Cm-243	1.80E-01	7.50E-01			7.00E-05	1.10E-02				
Cs-137	2.00E+00	8.30E+00			7.80E-04	1.20E-01				
K-40	3.50E+01	1.40E+02			1.30E-02	2.10E+00				
Pu-238	4.20E+00	1.70E+01			1.60E-03	2.50E-01				
Ra-226	1.70E+00	7.10E+00			6.60E-04	1.00E-01				
Ra-228	1.60E+00	6.90E+00			6.40E-04	1.00E-01				
Th-228	1.90E+00	7.90E+00			7.40E-04	1.20E-01				
Th-232	1.70E+00	7.20E+00			6.70E-04	1.10E-01				
Th-234	7.30E+00	3.00E+01			2.80E-03	4.40E-01				
Total Radioactive Strontium	3.20E+00	1.30E+01			1.20E-03	1.90E-01				
U-233/234	8.10E-01	3.40E+00			3.20E-04	4.90E-02				
SW3										
Inorganics										
Zinc	3.20E+02	7.50E-07		4.70E-08	7.00E-11		5.20E-05		3.30E-06	4.90E-09
Organics										
Aroclor 1254	9.30E-02	2.20E-10		1.40E-10	2.00E-14		1.50E-08		9.60E-09	1.40E-12
Aroclor 1260	7.80E-02	1.80E-10		1.10E-10	1.70E-14		1.30E-08		8.00E-09	1.20E-12

Table 9a. (continued)

Analyte	Concentrations (mg/kg;pCi/g)	Carcinogenic effects (CDI)					Noncarcinogenic effects (CDI)			
		Ingestion (mg/kg-d;pCi)	Produce ingestion (mg/kg-d;pCi)	Dermal (mg/kg-d)	Inhalation (mg/kg-d;pCi)	External (pCi-y/g)	Ingestion (mg/kg-d;pCi)	Produce ingestion (mg/kg-d;pCi)	Dermal (mg/kg-d)	Inhalation (mg/kg-d;pCi)
Radionuclides										
Am-241	1.20E+00	5.20E+00			4.80E-04	7.50E-02				
Cs-137	6.90E+00	2.90E+01			2.70E-03	4.20E-01				
Pu-238	3.20E-01	1.30E+00			1.20E-04	1.90E-02				
Pu-239/240	1.80E+00	7.40E+00			6.90E-04	1.10E-01				
Ra-228	1.20E+00	5.00E+00			4.70E-04	7.30E-02				
Th-228	1.60E+00	6.80E+00			6.30E-04	9.90E-02				
Th-230	1.70E+00	6.90E+00			6.40E-04	1.00E-01				
Total Radioactive Strontium	3.70E+00	1.60E+01			1.50E-03	2.30E-01				
U-232	1.50E-01	6.20E-01			5.80E-05	9.00E-03				
U-233/234	5.70E+00	2.40E+01			2.20E-03	3.40E-01				
SWSA 5N										
Inorganics										
Selenium	2.30E+00	5.30E-09		3.30E-10	4.90E-13		3.70E-07		2.30E-08	3.40E-11
Organics										
2-Butanone	3.00E-03	7.00E-12		4.40E-12	1.10E-10		4.90E-10		3.10E-10	7.90E-09
Aroclor 1260	2.60E-02	6.10E-11		3.80E-11	5.70E-15		4.20E-09		2.70E-09	4.00E-13
Methylene Chloride	5.00E-03	1.20E-11		7.40E-12	5.00E-10		8.20E-10		5.20E-10	3.50E-08
Radionuclides										
Ac-228	2.10E+00	8.80E+00			8.20E-04	1.30E-01				
Bi-212	2.60E+00	1.10E+01			1.00E-03	1.60E-01				
Bi-214	9.40E-01	3.90E+00			3.70E-04	5.70E-02				

Table 9a. (continued)

Analyte	Concentrations (mg/kg-pCi/g)	Carcinogenic effects (CDI)					Noncarcinogenic effects (CDI)			
		Ingestion (mg/kg-d;pCi)	Produce ingestion (mg/kg-d;pCi)	Dermal (mg/kg-d)	Inhalation (mg/kg-d;pCi)	External (pCi-y/g)	Ingestion (mg/kg-d;pCi)	Produce ingestion (mg/kg-d;pCi)	Dermal (mg/kg-d)	Inhalation (mg/kg-d;pCi)
I-129	5.70E+00	2.40E+01			2.20E-03	3.50E-01				
Pb-212	1.50E+00	6.30E+00			5.80E-04	9.10E-02				
Pb-214	1.00E+00	4.20E+00			3.90E-04	6.20E-02				
Ra-223	5.60E-01	2.30E+00			2.20E-04	3.40E-02				
Ra-228	2.10E+00	8.80E+00			8.20E-04	1.30E-01				
Th-228	1.70E+00	7.10E+00			6.60E-04	1.00E-01				
Th-232	2.10E+00	8.80E+00			8.20E-04	1.30E-01				
Tl-208	1.60E+00	6.50E+00			6.00E-04	9.40E-02				
SWSA SSE										
Inorganics										
Antimony	6.20E+00	1.40E-08		9.10E-10	1.30E-12		1.00E-06		6.40E-08	9.40E-11
Manganese	3.30E+03	7.60E-06		4.80E-07	7.10E-10		5.30E-04		3.40E-05	5.00E-08
Organics										
Aroclor 1260	4.40E-02	1.00E-10		6.50E-11	9.50E-15		7.20E-09		4.50E-09	6.70E-13
Chloroform	1.00E-03	2.30E-12		1.50E-12	5.20E-11		1.60E-10		1.00E-10	3.70E-09
Radionuclides										
Ac-228	1.00E+00	4.20E+00			3.90E-04	6.10E-02				
Am-241	6.80E+00	2.80E+01			2.60E-03	4.10E-01				
Cm-243/244	3.60E+01	1.50E+02			1.40E-02	2.20E+00				
Cs-137	3.50E+02	1.50E+03			1.40E-01	2.10E+01				
Pb-212	1.90E+00	7.90E+00			7.40E-04	1.20E-01				
Pb-214	6.00E-01	2.50E+00			2.30E-04	3.70E-02				

A-180

Table 9a. (continued)

Analyte	Carcinogenic effects (CDI)						Noncarcinogenic effects (CDI)			
	Concentrations (mg/kg;pCi/g)	Ingestion (mg/kg-d;pCi)	Produce ingestion (mg/kg-d;pCi)	Dermal (mg/kg-d)	Inhalation (mg/kg-d;pCi)	External (pCi-y/g)	Ingestion (mg/kg-d;pCi)	Produce ingestion (mg/kg-d;pCi)	Dermal (mg/kg-d)	Inhalation (mg/kg-d;pCi)
Pu-238	8.90E-01	3.70E+00			3.40E-04	5.40E-02				
Pu-239/240	7.90E-01	3.30E+00			3.10E-04	4.80E-02				
Ra-228	1.30E+00	5.50E+00			5.10E-04	8.00E-02				
Th-228	1.60E+00	6.70E+00			6.20E-04	9.70E-02				
Th-230	4.40E+00	1.80E+01			1.70E-03	2.70E-01				
Tl-208	1.00E+00	4.20E+00			3.90E-04	6.10E-02				
Total Radioactive Strontium	1.00E+04	4.30E+04			4.00E+00	6.30E+02				
U-232	5.30E-01	2.20E+00			2.10E-04	3.20E-02				
SWSA 55W										
A-181										
Inorganics										
Barium	3.20E+02	7.40E-07		4.70E-08	6.90E-11		5.20E-05		3.30E-06	4.80E-09
Manganese	2.30E+03	5.40E-06		3.40E-07	5.10E-10		3.80E-04		2.40E-05	3.60E-08
Organics										
Aroclor 1260	1.40E+00	3.20E-09		2.00E-09	3.00E-13		2.30E-07		1.40E-07	2.10E-11
Chloroform	1.00E-03	2.30E-12		1.50E-12	5.20E-11		1.60E-10		1.00E-10	3.70E-09
Radionuclides										
Ac-228	2.30E+00	9.50E+00			8.90E-04	1.40E-01				
Bi-214	8.20E-01	3.40E+00			3.20E-04	5.00E-02				
Cs-137	7.50E+01	3.10E+02			2.90E-02	4.50E+00				
I-129	3.30E+00	1.40E+01			1.30E-03	2.00E-01				
K-40	3.10E+01	1.30E+02			1.20E-02	1.90E+00				
Pb-210	6.10E+00	2.50E+01			2.40E-03	3.70E-01				

Table 9a. (continued)

Analyte	Concentrations (mg/kg;pCi/g)	Carcinogenic effects (CDI)					Noncarcinogenic effects (CDI)			
		Ingestion (mg/kg-d;pCi)	Produce ingestion (mg/kg-d;pCi)	Dermal (mg/kg-d)	Inhalation (mg/kg-d;pCi)	External (pCi-y/g)	Ingestion (mg/kg-d;pCi)	Produce ingestion (mg/kg-d;pCi)	Dermal (mg/kg-d)	Inhalation (mg/kg-d;pCi)
Pb-212	1.60E+00	6.80E+00			6.40E-04	1.00E-01				
Pb-214	1.40E+00	5.80E+00			5.40E-04	8.50E-02				
Ra-226	1.30E+00	5.50E+00			5.10E-04	8.10E-02				
Ra-228	2.10E+00	8.90E+00			8.30E-04	1.30E-01				
Th-228	1.40E+00	5.90E+00			5.60E-04	8.70E-02				
Th-232	2.20E+00	9.10E+00			8.50E-04	1.30E-01				
Tl-208	1.40E+00	5.80E+00			5.40E-04	8.50E-02				
Total Radioactive Strontium	5.20E+03	2.20E+04			2.00E+00	3.20E+02				
U-233/234	9.90E+00	4.10E+01			3.90E-03	6.00E-01				
U-238	5.00E+00	2.10E+01			1.90E-03	3.00E-01				
WOC										
Inorganics										
Mercury	8.10E-01	1.90E-09			1.20E-10	1.80E-13	1.30E-07		8.40E-09	1.20E-11
Organics										
Aroclor 1260	4.10E-02	9.60E-11			6.00E-11	8.90E-15	6.70E-09		4.20E-09	6.20E-13
Radionuclides										
Ac-228	1.80E+00	7.50E+00			7.00E-04	1.10E-01				
Co-57	2.30E+00	9.60E+00			8.90E-04	1.40E-01				
Co-60	3.60E+01	1.50E+02			1.40E-02	2.20E+00				
Cs-134	4.00E-02	1.70E-01			1.60E-05	2.40E-03				
Cs-137	5.50E+03	2.30E+04			2.10E+00	3.30E+02				
Na-22	1.50E+00	6.20E+00			5.80E-04	9.10E-02				

Table 9a. (continued)

Analyte	Concentrations (mg/kg;pCi/g)	Carcinogenic effects (CDI)					Noncarcinogenic effects (CDI)			
		Ingestion (mg/kg-d;pCi)	Produce ingestion (mg/kg-d;pCi)	Dermal (mg/kg-d)	Inhalation (mg/kg-d;pCi)	External (pCi-y/g)	Ingestion (mg/kg-d;pCi)	Produce ingestion (mg/kg-d;pCi)	Dermal (mg/kg-d)	Inhalation (mg/kg-d;pCi)
Pb-212	1.40E+00	5.80E+00			5.40E-04	8.50E-02				
Pb-214	1.40E+00	5.80E+00			5.40E-04	8.50E-02				
Ra-228	1.80E+00	7.50E+00			7.00E-04	1.10E-01				
Th-228	2.20E+00	9.20E+00			8.60E-04	1.30E-01				
Th-232	1.80E+00	7.50E+00			7.00E-04	1.10E-01				
Tl-208	2.00E+00	8.30E+00			7.80E-04	1.20E-01				
Total Radioactive Strontium	3.80E+02	1.60E+03			1.50E-01	2.30E+01				
Industrial scenario										
FS										
Inorganics										
Mercury	4.30E+00	7.50E-07		4.70E-08	7.00E-11		2.10E-06		1.30E-07	2.00E-10
Organics										
Aroclor 1260	1.80E-01	3.10E-08		2.00E-08	2.90E-12		8.80E-08		5.60E-08	8.20E-12
Radionuclides										
Co-60	1.80E+02	5.60E+04			5.30E+00	8.20E+02				
Cs-137	3.60E+01	1.10E+04			1.10E+00	1.60E+02				
Pb-212	1.30E+00	4.70E+02			4.40E-02	6.80E+00				
Ra-226	3.60E+00	1.10E+03			1.10E-01	1.60E+01				
Th-232	1.90E+00	5.90E+02			5.50E-02	8.70E+00				
Total Radioactive Strontium	1.20E+02	3.80E+04			3.50E+00	5.50E+02				
U-233/234	7.30E+00	2.30E+03			2.10E-01	3.30E+01				
U-238	7.00E+00	2.20E+03			2.00E-01	3.20E+01				

Table 9a. (continued)

Analyte	Carcinogenic effects (CDI)						Noncarcinogenic effects (CDI)			
	Concentrations (mg/kg;pCi/g)	Ingestion (mg/kg-d;pCi)	Produce ingestion (mg/kg-d;pCi)	Dermal (mg/kg-d)	Inhalation (mg/kg-d;pCi)	External (pCi-y/g)	Ingestion (mg/kg-d;pCi)	Produce ingestion (mg/kg-d;pCi)	Dermal (mg/kg-d)	Inhalation (mg/kg-d;pCi)
NIIFT										
Organics										
Di-n-butyl Phthalate	1.30E-01	2.30E-08		1.40E-08	2.10E-12		6.40E-08		4.00E-08	5.90E-12
Toluene	1.00E-03	1.70E-10		1.10E-10	2.80E-09		4.90E-10		3.10E-10	7.80E-09
Radionuclides										
Am-241	1.10E-01	3.50E+01			3.20E-03	5.10E-01				
Pu-238	2.60E-01	8.20E+01			7.60E-03	1.20E+00				
Ra-228	1.60E+00	5.00E+02			4.70E-02	7.40E+00				
Th-228	1.70E+00	5.20E+02			4.90E-02	7.60E+00				
Th-230	1.30E+00	4.00E+02			3.70E-02	5.80E+00				
Th-232	1.60E+00	4.80E+02			4.50E-02	7.10E+00				
U-233/234	9.70E-01	3.00E+02			2.80E-02	4.40E+00				
OHFP										
Inorganics										
Cadmium	1.50E+00	2.50E-07		1.60E-08	2.40E-11		7.10E-07		4.50E-08	6.60E-11
Organics										
Aroclor 1254	3.20E-02	5.60E-09		3.50E-09	5.20E-13		1.60E-08		9.90E-09	1.50E-12
Aroclor 1260	9.60E-03	1.70E-09		1.10E-09	1.60E-13		4.70E-09		3.00E-09	4.40E-13
Heptachlor Epoxide	5.40E-04	9.40E-11		6.00E-11	8.80E-15		2.60E-10		1.70E-10	2.50E-14
Toluene	1.00E-03	1.70E-10		1.10E-10	2.80E-09		4.90E-10		3.10E-10	7.80E-09
Radionuclides										
Am-241	3.50E-01	1.10E+02			1.00E-02	1.60E+00				

Table 9a. (continued)

Analyte	Concentrations (mg/kg;pCi/g)	Carcinogenic effects (CDI)					Noncarcinogenic effects (CDI)			
		Ingestion (mg/kg-d;pCi)	Produce ingestion (mg/kg-d;pCi)	Dermal (mg/kg-d)	Inhalation (mg/kg-d;pCi)	External (pCi-y/g)	Ingestion (mg/kg-d;pCi)	Produce ingestion (mg/kg-d;pCi)	Dermal (mg/kg-d)	Inhalation (mg/kg-d;pCi)
Co-60	6.20E-01	1.90E+02			1.80E-02	2.80E+00				
Cs-137	1.10E+03	3.60E+05			3.30E+01	5.20E+03				
Ra-228	1.40E+00	4.30E+02			4.00E-02	6.30E+00				
Th-228	1.50E+00	4.80E+02			4.50E-02	7.00E+00				
Th-230	1.40E+00	4.30E+02			4.00E-02	6.30E+00				
Total Radioactive Strontium	6.50E+02	2.00E+05			1.90E+01	3.00E+03				
U-233/234	8.90E-01	2.80E+02			2.60E-02	4.10E+00				
OHFT										
Inorganics										
Silver	4.30E+00	7.40E-07		4.70E-08	7.00E-11		2.10E-06	1.30E-07	1.90E-10	A-185
Organics										
Bis(2-Ethylhexyl) Phthalate	1.10E-01	1.90E-08		1.20E-08	1.80E-12		5.40E-08	3.40E-08	5.00E-12	
Cyanide	6.70E-01	1.20E-07		7.40E-08	1.10E-11		3.30E-07	2.10E-07	3.10E-11	
Toluene	2.00E-03	3.50E-10		2.20E-10	5.60E-09		9.80E-10	6.20E-10	1.60E-08	
Radionuclides										
Am-241	2.50E-01	8.00E+01			7.40E-03	1.20E+00				
Cs-137	5.80E+00	1.80E+03			1.70E-01	2.60E+01				
Pu-238	8.70E-01	2.70E+02			2.60E-02	4.00E+00				
Ra-226	1.30E+00	4.20E+02			3.90E-02	6.10E+00				
Ra-228	1.90E+00	5.80E+02			5.40E-02	8.50E+00				
Th-228	1.50E+00	4.70E+02			4.40E-02	6.90E+00				
Th-232	1.30E+00	4.20E+02			3.90E-02	6.10E+00				

Table 9a. (continued)

Analyte	Concentrations (mg/kg;pCi/g)	Carcinogenic effects (CDI)					Noncarcinogenic effects (CDI)			
		Ingestion (mg/kg-d;pCi)	Produce ingestion (mg/kg-d;pCi)	Dermal (mg/kg-d)	Inhalation (mg/kg-d;pCi)	External (pCi-y/g)	Ingestion (mg/kg-d;pCi)	Produce ingestion (mg/kg-d;pCi)	Dermal (mg/kg-d)	Inhalation (mg/kg-d;pCi)
U-233/234	1.20E+00	3.80E+02			3.50E-02	5.50E+00				
PWSB										
Inorganics										
Barium	1.90E+02	3.40E-05		2.10E-06	3.10E-09		9.40E-05		6.00E-06	8.80E-09
Organics										
Aroclor 1260	1.00E-02	1.70E-09		1.10E-09	1.60E-13		4.90E-09		3.10E-09	4.60E-13
Bis(2-Ethylhexyl) Phthalate	5.70E-02	1.00E-08		6.30E-09	9.30E-13		2.80E-08		1.80E-08	2.60E-12
Chloroform	1.00E-03	1.70E-10		1.10E-10	3.90E-09		4.90E-10		3.10E-10	1.10E-08
Radionuclides										
Am-241	3.50E-01	1.10E+02			1.00E-02	1.60E+00				
Cm-243	1.80E-01	5.60E+01			5.30E-03	8.20E-01				
Cs-137	2.00E+00	6.30E+02			5.80E-02	9.10E+00				
K-40	3.50E+01	1.10E+04			1.00E+00	1.60E+02				
Pu-238	4.20E+00	1.30E+03			1.20E-01	1.90E+01				
Ra-226	1.70E+00	5.30E+02			5.00E-02	7.80E+00				
Ra-228	1.60E+00	5.10E+02			4.80E-02	7.50E+00				
Th-228	1.90E+00	5.90E+02			5.50E-02	8.70E+00				
Th-232	1.70E+00	5.40E+02			5.10E-02	7.90E+00				
Th-234	7.30E+00	2.30E+03			2.10E-01	3.30E+01				
Total Radioactive Strontium	3.20E+00	9.90E+02			9.20E-02	1.40E+01				
U-233/234	8.10E-01	2.50E+02			2.40E-02	3.70E+00				

SW3

Table 9a. (continued)

Analyte	Concentrations (mg/kg;pCi/g)	Carcinogenic effects (CDI)					Noncarcinogenic effects (CDI)			
		Ingestion (mg/kg-d;pCi)	Produce ingestion (mg/kg-d;pCi)	Dermal (mg kg-d)	Inhalation (mg/kg-d;pCi)	External (pCi-y/g)	Ingestion (mg/kg-d;pCi)	Produce ingestion (mg/kg-d;pCi)	Dermal (mg/kg-d)	Inhalation (mg/kg-d;pCi)
Inorganics										
Zinc	3.20E+02	5.60E-05		3.50E-06	5.20E-09		1.60E-04		9.90E-06	1.50E-08
Organics										
Aroclor 1254	9.30E-02	1.60E-08		1.00E-08	1.50E-12		4.50E-08		2.90E-08	4.20E-12
Aroclor 1260	7.80E-02	1.40E-08		8.60E-09	1.30E-12		3.80E-08		2.40E-08	3.60E-12
Radionuclides										
Am-241	1.20E+00	3.90E+02			3.60E-02	5.70E+00				
Cs-137	6.90E+00	2.20E+03			2.00E-01	3.20E+01				
Pu-238	3.20E-01	9.80E+01			9.20E-03	1.40E+00				
Pu-239/240	1.80E+00	5.50E+02			5.20E-02	8.10E+00				
Ra-228	1.20E+00	3.80E+02			3.50E-02	5.50E+00				
Th-228	1.60E+00	5.10E+02			4.80E-02	7.40E+00				
Th-230	1.70E+00	5.20E+02			4.80E-02	7.50E+00				
Total Radioactive Strontium	3.70E+00	1.20E+03			1.10E-01	1.70E+01				
U-232	1.50E-01	4.60E+01			4.30E-03	6.80E-01				
U-233/234	5.70E+00	1.80E+03			1.60E-01	2.60E+01				
SWSASN										
Organics										
1,2-Benzenedicarboxylic Acid, Diethyl Ester	3.00E-01	5.20E-08		3.30E-08	4.90E-12		1.50E-07		9.30E-08	1.40E-11
2-Butanone	3.00E-03	5.20E-10		3.30E-10	8.40E-09		1.50E-09		9.30E-10	2.40E-08
Aroclor 1260	2.60E-02	4.50E-09		2.90E-09	4.20E-13		1.30E-08		8.00E-09	1.20E-12

Table 9a. (continued)

Analyte	Concentrations (mg/kg;pCi/g)	Carcinogenic effects (CDI)					Noncarcinogenic effects (CDI)			
		Ingestion (mg/kg-d;pCi)	Produce ingestion (mg/kg-d;pCi)	Dermal (mg/kg-d)	Inhalation (mg/kg-d;pCi)	External (pCi-y/g)	Ingestion (mg/kg-d;pCi)	Produce ingestion (mg/kg-d;pCi)	Dermal (mg/kg-d)	Inhalation (mg/kg-d;pCi)
Bis(2-Ethylhexyl) Phthalate	4.50E-02	7.90E-09		5.00E-09	7.30E-13		2.20E-08		1.40E-08	2.10E-12
Di-n-butyl Phthalate	7.10E-02	1.20E-08		7.80E-09	1.20E-12		3.50E-08		2.20E-08	3.20E-12
Methylene Chloride	5.00E-03	8.70E-10		5.50E-10	3.80E-08		2.40E-09		1.50E-09	1.10E-07
Radionuclides										
Ac-228	2.10E+00	6.70E+02			6.20E-02	9.70E+00				
Bi-212	2.60E+00	8.10E+02			7.60E-02	1.20E+01				
Bi-214	9.40E-01	2.90E+02			2.70E-02	4.30E+00				
I-129	5.70E+00	1.80E+03			1.70E-01	2.60E+01				
Pb-212	1.50E+00	4.60E+02			4.30E-02	6.70E+00				
Pb-214	1.00E+00	3.30E+02			3.00E-02	4.80E+00				
Ra-223	5.60E-01	1.80E+02			1.60E-02	2.60E+00				
Ra-228	2.20E+00	6.70E+02			6.30E-02	9.80E+00				
Th-228	1.80E+00	5.60E+02			5.20E-02	8.10E+00				
Th-232	2.10E+00	6.70E+02			6.20E-02	9.70E+00				
Tl-208	1.60E+00	5.00E+02			4.70E-02	7.30E+00				
SWSA SSE										
Inorganics										
Antimony	6.20E+00	1.10E-06		6.80E-08	1.00E-10		3.00E-06		1.90E-07	2.80E-10
Manganese	3.30E+03	5.70E-04		3.60E-05	5.30E-08		1.60E-03		1.00E-04	1.50E-07
Organics										
Aroclor 1260	4.40E-02	7.70E-09		4.80E-09	7.20E-13		2.10E-08		1.40E-08	2.00E-12
Chloroform	1.00E-03	1.70E-10		1.10E-10	3.90E-09		4.90E-10		3.10E-10	1.10E-08

Table 9a. (continued)

Analyte	Concentrations (mg/kg;pCi/g)	Carcinogenic effects (CDI)					Noncarcinogenic effects (CDI)			
		Ingestion (mg/kg-d;pCi)	Produce ingestion (mg/kg-d;pCi)	Dermal (mg/kg-d)	Inhalation (mg/kg-d;pCi)	External (pCi-y/g)	Ingestion (mg/kg-d;pCi)	Produce ingestion (mg/kg-d;pCi)	Dermal (mg/kg-d)	Inhalation (mg/kg-d;pCi)
Radionuclides										
Ac-228	1.00E+00	3.10E+02			2.90E-02	4.60E+00				
Am-241	6.80E+00	2.10E+03			2.00E-01	3.10E+01				
Cm-243/244	3.60E+01	1.10E+04			1.00E+00	1.60E+02				
Cs-137	6.70E+03	2.10E+06			2.00E+02	3.10E+04				
Pb-212	1.90E+00	5.90E+02			5.50E-02	8.70E+00				
Pb-214	6.00E-01	1.90E+02			1.80E-02	2.70E+00				
Pu-238	8.90E-01	2.80E+02			2.60E-02	4.00E+00				
Pu-239/240	7.90E-01	2.50E+02			2.30E-02	3.60E+00				
Ra-228	1.30E+00	4.10E+02			3.90E-02	6.00E+00				
Th-228	1.60E+00	5.00E+02			4.70E-02	7.30E+00				
Th-230	4.40E+00	1.40E+03			1.30E-01	2.00E+01				
Tl-208	1.00E+00	3.10E+02			2.90E-02	4.60E+00				
Total Radioactive Strontium	1.00E+04	3.20E+06			3.00E+02	4.70E+04				
U-232	5.30E-01	1.70E+02			1.60E-02	2.40E+00				
SWSA SSW										
Inorganics										
Barium	3.60E+02	6.30E-03		4.00E-06	5.90E-09		1.80E-04		1.10E-05	1.60E-08
Manganese	2.70E+03	4.80E-04		3.00E-05	4.50E-08		1.30E-03		8.40E-05	1.20E-07
Organics										
Aroclor 1260	1.20E+00	2.10E-07		1.30E-07	2.00E-11		5.90E-07		3.70E-07	5.50E-11
Chloroform	1.00E-03	1.70E-10		1.10E-10	3.90E-09		4.90E-10		3.10E-10	1.10E-08

Table 9a. (continued)

Analyte	Carcinogenic effects (CDI)						Noncarcinogenic effects (CDI)			
	Concentrations (mg/kg;pCi/g)	Ingestion (mg/kg-d;pCi)	Produce ingestion (mg/kg-d;pCi)	Dermal (mg/kg-d)	Inhalation (mg/kg-d;pCi)	External (pCi-y/g)	Ingestion (mg/kg-d;pCi)	Produce ingestion (mg/kg-d;pCi)	Dermal (mg/kg-d)	Inhalation (mg/kg-d;pCi)
Radionuclides										
Ac-228	2.30E+00	7.10E+02			6.70E-02	1.00E+01				
Bi-214	8.20E-01	2.60E+02			2.40E-02	3.70E+00				
Cs-137	8.40E+01	2.60E+04			2.50E+00	3.80E+02				
K-40	3.20E+01	1.00E+04			9.50E-01	1.50E+02				
Pb-212	1.70E+00	5.30E+02			5.00E-02	7.80E+00				
Pb-214	1.40E+00	4.40E+02			4.10E-02	6.40E+00				
Ra-226	1.50E+00	4.60E+02			4.30E-02	6.70E+00				
Ra-228	2.00E+00	6.20E+02			5.80E-02	9.10E+00				
Th-228	1.50E+00	4.70E+02			4.40E-02	6.80E+00				
Th-232	2.20E+00	6.80E+02			6.40E-02	1.00E+01				
Tl-208	1.40E+00	4.40E+02			4.10E-02	6.40E+00				
Total Radioactive Strontium	5.20E+03	1.60E+06			1.50E+02	2.40E+04				
U-233/234	9.90E+00	3.10E+03			2.90E-01	4.50E+01				
U-238	5.00E+00	1.60E+03			1.50E-01	2.30E+01				
WOC										
Inorganics										
Mercury	8.10E-01	1.40E-07		9.00E-09	1.30E-11		4.00E-07		2.50E-08	3.70E-11
Organics										
Aroclor 1260	4.10E-02	7.20E-09		4.50E-09	6.70E-13		2.00E-08		1.30E-08	1.90E-12
Radionuclides										
Ac-228	1.80E+00	5.60E+02			5.30E-02	8.20E+00				

A-190

Table 9a. (continued)

Analyte	Carcinogenic effects (CDI)						Noncarcinogenic effects (CDI)			
	Concentrations (mg/kg;pCi/g)	Ingestion (mg/kg-d;pCi)	Produce ingestion (mg/kg-d;pCi)	Dermal (mg/kg-d)	Inhalation (mg/kg-d;pCi)	External (pCi-y/g)	Ingestion (mg/kg-d;pCi)	Produce ingestion (mg/kg-d;pCi)	Dermal (mg/kg-d)	Inhalation (mg/kg-d;pCi)
Co-57	2.30E+00	7.20E+02			6.70E-02	1.10E+01				
Co-60	3.60E+01	1.10E+04			1.10E+00	1.60E+02				
Cs-134	4.00E-02	1.30E+01			1.20E-03	1.80E-01				
Cs-137	5.50E+03	1.70E+06			1.60E+02	2.50E+04				
Na-22	1.50E+00	4.70E+02			4.40E-02	6.80E+00				
Pb-212	1.40E+00	4.40E+02			4.10E-02	6.40E+00				
Pb-214	1.40E+00	4.40E+02			4.10E-02	6.40E+00				
Ra-228	1.80E+00	5.60E+02			5.30E-02	8.20E+00				
Th-228	2.20E+00	6.90E+02			6.40E-02	1.00E+01				
Th-232	1.80E+00	5.60E+02			5.20E-02	8.20E+00				
Tl-208	2.00E+00	6.30E+02			5.80E-02	9.10E+00				
Total Radioactive Strontium	3.80E+02	1.20E+05			1.10E+01	1.70E+03				
Residential scenario										
FS										
Inorganics										
Mercury	4.30E+00	6.70E-06	1.30E-03	1.50E-07	2.00E-10		1.60E-05	3.10E-03	3.50E-07	4.80E-10
Organics										
Aroclor 1260	1.80E-01	2.80E-07	1.00E-07	6.30E-08	8.60E-12		6.60E-07	2.40E-07	1.50E-07	2.00E-11
Radionuclides										
Co-60	1.80E+02	2.30E+05	1.40E+06		8.80E+00	4.10E+03				
Cs-137	3.60E+01	4.50E+04	6.00E+04		1.80E+00	8.30E+02				
Pb-212	1.50E+00	1.90E+03	8.60E+04		7.40E-02	3.50E+01				

Table 9a. (continued)

Analyte	Carcinogenic effects (CDI)						Noncarcinogenic effects (CDI)			
	Concentrations (mg/kg;pCi/g)	Ingestion (mg/kg-d;pCi)	Produce ingestion (mg/kg-d;pCi)	Dermal (mg/kg-d)	Inhalation (mg/kg-d;pCi)	External (pCi-y/g)	Ingestion (mg/kg-d;pCi)	Produce ingestion (mg/kg-d;pCi)	Dermal (mg/kg-d)	Inhalation (mg/kg-d;pCi)
Ra-226	3.60E+00	4.50E+03	4.20E+03		1.80E-01	8.30E+01				
Th-232	1.90E+00	2.40E+03	6.70E+03		9.30E-02	4.40E+01				
Total Radioactive Strontium	1.20E+02	1.50E+05	2.00E+07		5.90E+00	2.80E+03				
U-233/234	7.30E+00	9.20E+03	1.50E+04		3.60E-01	1.70E+02				
U-238	7.00E+00	8.80E+03	1.50E+04		3.40E-01	1.60E+02				
Organics										
Di-n-butyl Phthalate	1.30E-01	2.00E-07	5.90E-07	4.50E-08	6.20E-12		4.70E-07	1.40E-06	1.10E-07	1.40E-11
Toluene	1.00E-03	1.60E-09	2.10E-07	3.50E-10	8.10E-09		3.70E-09	4.90E-07	8.10E-10	1.90E-08
Radionuclides										
Am-241	1.10E-01	1.40E+02	2.30E+01		5.40E-03	2.60E+00				
Pu-238	2.60E-01	3.30E+02	5.50E+01		1.30E-02	6.00E+00				
Ra-228	1.60E+00	2.00E+03	1.90E+03		7.90E-02	3.70E+01				
Th-228	1.70E+00	2.10E+03	5.90E+03		8.20E-02	3.80E+01				
Th-230	1.30E+00	1.60E+03	4.50E+03		6.30E-02	2.90E+01				
Th-232	1.60E+00	2.00E+03	5.50E+03		7.60E-02	3.60E+01				
U-233/234	9.70E-01	1.20E+03	2.00E+03		4.70E-02	2.20E+01				
Inorganics										
Cadmium	1.50E+00	2.30E-06	6.50E-04	5.10E-08	6.90E-11		5.30E-06	1.50E-03	1.20E-07	1.60E-10
Organics										
Aroclor 1254	3.20E-02	5.00E-08	8.10E-08	1.10E-08	1.50E-12		1.20E-07	1.90E-07	2.60E-08	3.50E-12

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Table 9a. (continued)

Analyte	Concentrations (mg/kg;pCi/g)	Carcinogenic effects (CDI)					Noncarcinogenic effects (CDI)			
		Ingestion (mg/kg-d;pCi)	Produce ingestion (mg/kg-d;pCi)	Dermal (mg/kg-d)	Inhalation (mg/kg-d;pCi)	External (pCi-y/g)	Ingestion (mg/kg-d;pCi)	Produce ingestion (mg/kg-d;pCi)	Dermal (mg/kg-d)	Inhalation (mg/kg-d;pCi)
Aroclor 1260	9.60E-03	1.50E-08	5.60E-09	3.30E-09	4.60E-13		3.50E-08	1.30E-08	7.80E-09	1.10E-12
Heptachlor Epoxide	5.40E-04	8.50E-10	1.20E-07	1.90E-10	2.60E-14		2.00E-09	2.70E-07	4.40E-10	6.00E-14
Toluene	1.00E-03	1.60E-09	2.10E-07	3.50E-10	8.10E-09		3.70E-09	4.90E-07	8.10E-10	1.90E-08
Radionuclides										
Am-241	3.50E-01	4.50E+02	7.40E+01		1.70E-02	8.10E+00				
Co-60	6.20E-01	7.70E+02	4.90E+03		3.00E-02	1.40E+01				
Cs-137	1.10E+03	1.40E+06	1.90E+06		5.60E+01	2.60E+04				
Ra-228	1.40E+00	1.70E+03	1.60E+03		6.80E-02	3.20E+01				
Th-228	1.50E+00	1.90E+03	5.40E+03		7.50E-02	3.50E+01				
Th-230	1.40E+00	1.70E+03	4.90E+03		6.80E-02	3.20E+01				
Total Radioactive Strontium	6.50E+02	8.20E+05	1.10E+08		3.20E+01	1.50E+04				
U-233/234	8.90E-01	1.10E+03	1.90E+03		4.40E-02	2.10E+01				
Inorganics										
Silver	4.30E+00	6.70E-06	5.20E-04	1.50E-07	2.00E-10		1.60E-05	1.20E-03	3.30E-07	4.70E-10
Organics										
Bis(2-Ethylhexyl) Phthalate	1.10E-01	1.70E-07	2.40E-09	3.80E-08	5.20E-12		4.00E-07	5.60E-09	8.90E-08	1.20E-11
Cyanide	6.70E-01	1.10E-06	7.40E-03	2.30E-07	3.20E-11		2.50E-06	1.70E-02	5.50E-07	7.50E-11
Toluene	2.00E-03	3.10E-09	4.20E-07	7.00E-10	1.60E-08		7.30E-09	9.70E-07	1.60E-09	3.80E-08
Radionuclides										
Am-241	2.50E-01	3.20E+02	5.40E+01		1.20E-02	5.90E+00				
Cs-137	5.80E+00	7.30E+03	9.70E+03		2.80E-01	1.30E+02				

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Table 9a. (continued)

Analyte	Concentrations (mg/kg;pCi/g)	Carcinogenic effects (CDI)					Noncarcinogenic effects (CDI)			
		Ingestion (mg/kg-d;pCi)	Produce ingestion (mg/kg-d;pCi)	Dermal (mg/kg-d)	Inhalation (mg/kg-d;pCi)	External (pCi-y/g)	Ingestion (mg/kg-d;pCi)	Produce ingestion (mg/kg-d;pCi)	Dermal (mg/kg-d)	Inhalation (mg/kg-d;pCi)
Pu-238	8.70E-01	1.10E+03	1.80E+02		4.30E-02	2.00E+01				
Ra-226	1.30E+00	1.70E+03	1.60E+03		6.60E-02	3.10E+01				
Ra-228	1.90E+00	2.30E+03	2.20E+03		9.10E-02	4.30E+01				
Th-228	1.50E+00	1.90E+03	5.30E+03		7.40E-02	3.50E+01				
Th-232	1.30E+00	1.70E+03	4.70E+03		6.50E-02	3.10E+01				
U-233/234	1.20E+00	1.50E+03	2.50E+03		5.90E-02	2.80E+01				
Inorganics					PWSB					
Barium	1.90E+02	3.00E-04	2.40E-02	6.70E-06	9.20E-09		7.00E-04	5.50E-02	1.60E-05	2.10E-08
Organics										
Aroclor 1260	1.00E-02	1.60E-08	5.80E-09	3.50E-09	4.80E-13		3.70E-08	1.40E-08	8.10E-09	1.10E-12
Bis(2-Ethylhexyl) Phthalate	5.70E-02	8.90E-08	1.20E-09	2.00E-08	2.70E-12		2.10E-07	2.90E-09	4.60E-08	6.30E-12
Chloroform	1.00E-03	1.60E-09	5.70E-07	3.50E-10	1.10E-08		3.70E-09	1.30E-06	8.10E-10	2.70E-08
Radionuclides										
Am-241	3.50E-01	4.40E+02	7.40E+01		1.70E-02	8.10E+00				
Cm-243	1.80E-01	2.30E+02	3.80E+02		8.80E-03	4.10E+00				
Cs-137	2.00E+00	2.50E+03	3.40E+03		9.80E-02	4.60E+01				
K-40	3.50E+01	4.40E+04	1.10E+07		1.70E+00	8.00E+02				
Pu-238	4.20E+00	5.20E+03	8.70E+02		2.00E-01	9.60E+01				
Ra-226	1.70E+00	2.20E+03	2.00E+03		8.40E-02	3.90E+01				
Ra-228	1.60E+00	2.10E+03	1.90E+03		8.10E-02	3.80E+01				
Th-228	1.90E+00	2.40E+03	6.70E+03		9.30E-02	4.40E+01				

Table 9a. (continued)

Analyte	Concentrations (mg/kg-pCi/g)	Carcinogenic effects (CDI)					Noncarcinogenic effects (CDI)			
		Ingestion (mg/kg-d;pCi)	Produce ingestion (mg/kg-d;pCi)	Dermal (mg/kg-d)	Inhalation (mg/kg-d;pCi)	External (pCi-y/g)	Ingestion (mg/kg-d;pCi)	Produce ingestion (mg/kg-d;pCi)	Dermal (mg/kg-d)	Inhalation (mg/kg-d;pCi)
Th-232	1.70E+00	2.20E+03	6.10E+03		8.50E-02	4.00E+01				
Th-234	7.30E+00	9.20E+03	2.60E+04		3.60E-01	1.70E+02				
Total Radioactive Strontium	3.20E+00	4.00E+03	5.30E+03		1.50E-01	7.30E+01				
U-233/234	8.10E-01	1.00E+03	1.70E+03		4.00E-02	1.90E+01				
Inorganics										
Zinc	3.20E+02	5.00E-04	1.00E-01	1.10E-03	1.50E-08		1.20E-03	2.40E-01	2.60E-03	3.60E-08
Organics										
Aroclor 1254	9.30E-02	1.50E-07	2.40E-07	3.20E-08	4.40E-12		3.40E-07	5.50E-07	7.60E-08	1.00E-11
Aroclor 1260	7.80E-02	1.20E-07	4.50E-08	2.70E-08	3.70E-12		2.80E-07	1.10E-07	6.30E-08	8.60E-12
Radionuclides										
Am-241	1.20E+00	1.60E+03	2.60E+02		6.10E-02	2.90E+01				
Cs-137	6.90E+00	8.70E+03	1.20E+04		3.40E-01	1.60E+02				
Pu-238	3.20E-01	4.00E+02	6.60E+01		1.50E-02	7.20E+00				
Pu-239/240	1.80E+00	2.20E+03	3.70E+02		8.70E-02	4.10E+01				
Ra-228	1.20E+00	1.50E+03	1.40E+03		5.90E-02	2.80E+01				
Th-228	1.60E+00	2.10E+03	5.80E+03		8.00E-02	3.80E+01				
Th-230	1.70E+00	2.10E+03	5.80E+03		8.10E-02	3.80E+01				
Total Radioactive Strontium	3.70E+00	4.70E+03	6.30E+03		1.80E-01	8.60E+01				
U-232	1.50E-01	1.90E+02	3.10E+02		7.30E-03	3.40E+00				
U-233/234	5.70E+00	7.10E+03	1.20E+04		2.80E-01	1.30E+02				

Table 9a. (continued)

Analyte	Concentrations (mg/kg;pCi/g)	Carcinogenic effects (CDI)					Noncarcinogenic effects (CDI)			
		Ingestion (mg/kg-d;pCi)	Produce ingestion (mg/kg-d;pCi)	Dermal (mg/kg-d)	Inhalation (mg/kg-d;pCi)	External (pCi-y/g)	Ingestion (mg/kg-d;pCi)	Produce ingestion (mg/kg-d;pCi)	Dermal (mg/kg-d)	Inhalation (mg/kg-d;pCi)
Organics										
1,2-Benzenedicarboxylic Acid, Diethyl Ester	3.00E-01	4.70E-07	9.00E-05	1.00E-07	1.40E-11		1.10E-06	2.10E-04	2.40E-07	3.30E-11
2-Butanone	3.00E-03	4.70E-09	1.60E-05	1.00E-09	2.50E-08		1.10E-08	3.80E-05	2.40E-09	5.70E-08
Aroclor 1260	2.60E-02	4.10E-08	1.50E-08	9.10E-09	1.20E-12		9.50E-08	3.50E-08	2.10E-08	2.90E-12
Bis(2-Ethylhexyl) Phthalate	4.50E-02	7.00E-08	9.90E-10	1.60E-08	2.10E-12		1.60E-07	2.30E-09	3.70E-08	5.00E-12
Di-n-butyl Phthalate	7.10E-02	1.10E-07	3.20E-07	2.50E-08	3.40E-12		2.60E-07	7.60E-07	5.80E-08	7.90E-12
Methylene Chloride	5.00E-03	7.80E-09	7.00E-06	1.70E-09	1.10E-07		1.80E-08	1.60E-05	4.10E-09	2.60E-07
Radionuclides										
Ac-228	2.10E+00	2.70E+03	4.50E+03		1.00E-01	4.90E+01				
Bi-212	2.60E+00	3.30E+03	2.20E+05		1.30E-01	6.00E+01				
Bi-214	9.40E-01	1.20E+03	7.90E+04		4.60E-02	2.20E+01				
I-129	5.70E+00	7.20E+03	9.60E+04		2.80E-01	1.30E+02				
Pb-212	1.50E+00	1.80E+03	8.30E+04		7.20E-02	3.40E+01				
Pb-214	1.00E+00	1.30E+03	6.00E+04		5.10E-02	2.40E+01				
Ra-223	5.60E-01	7.10E+02	6.60E+02		2.70E-02	1.30E+01				
Ra-228	2.20E+00	2.70E+03	2.50E+03		1.10E-01	5.00E+01				
Th-228	1.80E+00	2.20E+03	6.30E+03		8.70E-02	4.10E+01				
Th-232	2.10E+00	2.70E+03	7.50E+03		1.00E-01	4.90E+01				
Tl-208	1.60E+00	2.00E+03	2.70E+05		7.80E-02	3.70E+01				

A-196

SWSA SSE

Inorganics

Table 9a. (continued)

Analyte	Concentrations (mg/kg;pCi/g)	Carcinogenic effects (CDI)					Noncarcinogenic effects (CDI)			
		Ingestion (mg/kg-d;pCi)	Produce ingestion (mg/kg-d;pCi)	Dermal (mg/kg-d)	Inhalation (mg/kg-d;pCi)	External (pCi-y/g)	Ingestion (mg/kg-d;pCi)	Produce ingestion (mg/kg-d;pCi)	Dermal (mg/kg-d)	Inhalation (mg/kg-d;pCi)
Antimony	6.20E+00	9.70E-06	5.60E-05	2.20E-07	2.90E-10		2.30E-05	1.30E-04	5.00E-07	6.90E-10
Manganese	3.30E+03	5.10E-03	8.00E-02	1.10E-04	1.60E-07		1.20E-02	1.90E-01	2.70E-04	3.60E-07
Organics										
Aroclor 1260	4.40E-02	6.90E-08	2.60E-08	1.50E-08	2.10E-12		1.60E-07	6.00E-08	3.60E-08	4.90E-12
Chloroform	1.00E-03	1.60E-09	5.70E-07	3.50E-10	1.10E-08		3.70E-09	1.30E-06	8.10E-10	2.70E-08
Radionuclides										
Ac-228	1.00E+00	1.30E+03	2.10E+03		4.90E-02	2.30E+01				
Am-241	6.80E+00	8.50E+03	1.40E+03		3.30E-01	1.60E+02				
Cm-243/244	3.60E+01	4.50E+04	7.50E+04		1.70E+00	8.20E+02				
Cs-137	6.70E+03	8.40E+06	1.10E+07		3.30E+02	1.50E+05				
Pb-212	1.90E+00	2.40E+03	1.10E+05		9.30E-02	4.40E+01				
Pb-214	6.00E-01	7.60E+02	3.40E+04		2.90E-02	1.40E+01				
Pu-238	8.90E-01	1.10E+03	1.90E+02		4.30E-02	2.00E+01				
Pu-239/240	7.90E-01	1.00E+03	1.70E+02		3.90E-02	1.80E+01				
Ra-228	1.30E+00	1.70E+03	1.60E+03		0.065	3.00E+01				
Th-228	1.60E+00	2.00E+03	5.60E+03		7.80E-02	3.70E+01				
Th-230	4.40E+00	5.50E+03	1.50E+04		2.10E-01	1.00E+02				
Tl-208	1.00E+00	1.30E+03	1.70E+05		4.90E-02	2.30E+01				
Total Radioactive Strontium	1.00E+04	1.30E+07	1.70E+09		5.00E+02	2.40E+05				
U-232	5.30E-01	6.70E+02	1.10E+03		2.60E-02	1.20E+01				
U-233	1.10E+01	1.30E+04	2.20E+04		5.10E-01	2.40E+02				
Inorganics										

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Table 9a. (continued)

Analyte	Concentrations (mg/kg;pCi/g)	Carcinogenic effects (CDI)					Noncarcinogenic effects (CDI)			
		Ingestion (mg/kg-d;pCi)	Produce ingestion (mg/kg-d;pCi)	Dermal (mg/kg-d)	Inhalation (mg/kg-d;pCi)	External (pCi-y/g)	Ingestion (mg/kg-d;pCi)	Produce ingestion (mg/kg-d;pCi)	Dermal (mg/kg-d)	Inhalation (mg/kg-d;pCi)
Mercury	8.10E-01	1.30E-06	2.50E-04	2.80E-08	3.90E-11		3.00E-06	5.90E-04	6.60E-08	9.00E-11
Organics										
Aroclor 1260	4.10E-02	6.40E-08	2.40E-08	1.40E-08	1.90E-12		1.50E-07	5.60E-08	3.30E-08	4.50E-12
Radionuclides										
Ac-228	1.80E+00	2.30E+03	3.80E+03		8.80E-02	4.10E+01				
Co-57	2.30E+00	2.90E+03	1.80E+04		1.10E-01	5.30E+01				
Co-60	3.60E+01	4.50E+04	2.80E+05		1.80E+00	8.30E+02				
Cs-134	4.00E-02	5.00E+01	6.70E+01		2.00E-03	9.20E-01				
Cs-137	5.50E+03	6.90E+06	9.20E+06		2.70E+02	1.30E+05				
Na-22	1.50E+00	1.90E+03	6.30E+04		7.40E-02	3.50E+01				
Pb-212	1.40E+00	1.80E+03	8.00E+04		6.90E-02	3.20E+01				
Pb-214	1.40E+00	1.80E+03	8.00E+04		6.90E-02	3.20E+01				
Ra-228	1.80E+00	2.30E+03	2.10E+03		8.80E-02	4.10E+01				
Th-228	2.20E+00	2.80E+03	7.80E+03		1.10E-01	5.10E+01				
Th-232	1.80E+00	2.30E+03	6.30E+03		8.80E-02	4.10E+01				
Tl-208	2.00E+00	2.50E+03	3.40E+05		9.80E-02	4.60E+01				
Total Radioactive Strontium	3.80E+02	4.80E+05	6.40E+07		1.90E+01	8.70E+03				

A-199

Table 9b. Chronic daily intake and doses for sediment COPCs of WAG 5 designated areas
(Industrial and residential scenarios)

Analyte	Concentrations (mg/kg;pCi/g)	Carcinogenic effects (CDI)				Noncarcinogenic effects (CDI)			
		Ingestion (mg/kg-d;pCi)	Dermal (mg/kg-d)	Inhalation (mg/kg-d;pCi)	External (pCi-y/g)	Ingestion (mg/kg-d;pCi)	Dermal (mg/kg-d)	Inhalation (mg/kg-d;pCi)	
Industrial scenario									
D1									
Inorganics									
Chromium VI	3.32E+01	5.80E-06	3.70E-07	5.40E-10		1.60E-05	1.00E-06	1.50E-09	
Manganese	4.88E+03	8.50E-04	5.40E-05	8.00E-08		2.40E-03	1.50E-04	2.20E-07	
Mercury	1.37E-01	2.40E-08	1.50E-09	2.20E-12		6.70E-08	4.20E-09	6.30E-12	
Nickel	6.58E+01	1.20E-05	7.30E-07	1.10E-09		3.20E-05	2.00E-06	3.00E-09	
Silver	2.30E+00	4.00E-07	2.50E-08	3.80E-11		1.10E-06	7.10E-08	1.10E-10	
Organics									
Aroclor 1260	8.30E-01	1.50E-07	9.20E-08	1.40E-11		4.10E-07	2.60E-07	3.80E-11	
Radionuclides									
Ac-228	1.40E+00	4.40E+02		4.10E-02	6.40E+00				
Am-241	6.50E-01	2.00E+02		1.90E-02	3.00E+00				
Bi-212	1.50E+00	4.70E+02		4.40E-02	6.80E+00				
Bi-214	8.60E-01	2.70E+02		2.50E-02	3.90E+00				
Co-60	3.15E-01	9.80E+01		9.20E-03	1.40E+00				
Pb-212	1.30E+00	4.10E+02		3.80E-02	5.90E+00				
Pb-214	9.30E-01	2.90E+02		2.70E-02	4.20E+00				
Ra-223	3.70E-01	1.20E+02		1.10E-02	1.70E+00				
Radon 219	4.70E-01	1.50E+02		1.40E-02	2.10E+00				
Th-230	3.17E+00	9.90E+02		9.20E-02	1.40E+01				

Table 9b. (continued)

Analyte	Concentrations (mg/kg;pCi/g)	Carcinogenic effects (CDI)				Noncarcinogenic effects (CDI)			
		Ingestion (mg/kg-d;pCi)	Dermal (mg/kg-d)	Inhalation (mg/kg-d;pCi)	External (pCi-y/g)	Ingestion (mg/kg;pCi/g)	Dermal (mg/kg-d)	Inhalation (mg/kg-d;pCi)	
Total Radioactive Strontium									
Tritium	1.30E+00	4.10E+02		3.80E-02	5.90E+00				
	2.34E+03	7.30E+05		6.80E+01	1.10E+04				
U-233/234	8.77E+00	2.70E+03		2.60E-01	4.00E+01				
U-235	3.60E-01	1.10E+02		1.00E-02	1.60E+00				
U-238	1.27E+01	4.00E+03		3.70E-01	5.80E+01				
D2									
Inorganics									
Arsenic	1.40E+01	2.40E-06	1.50E-07	2.30E-10		6.80E-06	4.30E-07	6.40E-10	
Barium	1.60E+03	2.80E-04	1.80E-05	2.60E-08		7.90E-04	5.00E-05	7.30E-08	
Chromium VI	2.21E+01	3.90E-06	2.40E-07	3.60E-10		1.10E-05	6.80E-07	1.00E-09	
Manganese	4.26E+04	7.40E-03	4.70E-04	6.90E-07		2.10E-02	1.30E-03	1.90E-06	
Organics									
Aroclor 1260	8.50E-02	1.50E-08	9.40E-09	1.40E-12		4.20E-08	2.60E-08	3.90E-12	
Vinyl Chloride	1.03E+00	1.80E-07	1.10E-07	8.40E-03		5.10E-07	3.20E-07	2.30E-02	
Radionuclides									
Ac-228	2.30E+00	7.20E+02		6.70E-02	1.10E+01				
Bi-212	1.70E+00	5.30E+02		5.00E-02	7.80E+00				
Bi-214	1.19E+00	3.70E+02		3.50E-02	5.40E+00				
Cm-243/244	5.52E+00	1.70E+03		1.60E-01	2.50E+01				
Co-60	6.30E-01	2.00E+02		1.80E-02	2.90E+00				
I-129	1.39E+01	4.30E+03		4.10E-01	6.30E+01				
Pb-212	1.70E+00	5.30E+02		5.00E-02	7.80E+00				

Table 9b. (continued)

Analyte	Concentrations (mg/kg;pCi/g)	Carcinogenic effects (CDI)				Noncarcinogenic effects (CDI)		
		Ingestion (mg/kg-d;pCi)	Dermal (mg/kg-d)	Inhalation (mg/kg-d;pCi)	External (pCi-y/g)	Ingestion (mg/kg;pCi/g)	Dermal (mg/kg-d)	Inhalation (mg/kg-d;pCi)
Pb-214	1.20E+00	3.80E+02		3.50E-02	5.50E+00			
Pu-238	3.13E+01	9.80E+03		9.10E-01	1.40E+02			
Ra-223	9.10E-01	2.80E+02		2.70E-02	4.20E+00			
Ra-224	4.90E+00	1.50E+03		1.40E-01	2.20E+01			
Ra-226	2.92E+00	9.10E+02		8.50E-02	1.30E+01			
Radon 219	1.20E+00	3.80E+02		3.50E-02	5.50E+00			
Tl-208	1.40E+00	4.40E+02		4.10E-02	6.40E+00			
Total Radioactive Strontium	1.29E+03	4.00E+05		3.80E+01	5.90E+03			
U-233/234	1.60E+01	5.00E+03		4.70E-01	7.30E+01			
U-235	4.10E-01	1.30E+02		1.20E-02	1.90E+00			
U-238	2.40E+00	7.50E+02		7.00E-02	1.10E+01			
D3								
Inorganics								
Chromium VI	1.76E+01	3.10E-06	1.90E-07	2.90E-10		8.60E-06	5.40E-07	8.00E-10
Mercury	9.00E-02	1.60E-08	9.90E-10	1.50E-12		4.40E-08	2.80E-09	4.10E-12
Selenium	1.70E+00	3.00E-07	1.90E-08	2.80E-11		8.30E-07	5.30E-08	7.80E-11
Organics								
Chloroform	2.00E-03	3.50E-10	2.20E-10	7.80E-09		9.80E-10	6.20E-10	2.20E-08
Radionuclides								
Ac-228	1.50E+00	4.70E+02		4.40E-02	6.80E+00			
Bi-214	9.10E-01	2.80E+02		2.70E-02	4.20E+00			
I-129	1.30E+00	4.10E+02		3.80E-02	5.90E+00			

Table 9b. (continued)

Analyte	Concentrations (mg/kg-pCi/g)	Carcinogenic effects (CDI)				Noncarcinogenic effects (CDI)		
		Ingestion (mg/kg-d;pCi)	Dermal (mg/kg-d)	Inhalation (mg/kg-d;pCi)	External (pCi-y/g)	Ingestion (mg/kg-pCi/g)	Dermal (mg/kg-d)	Inhalation (mg/kg-d;pCi)
Pb-210	2.70E+00	8.40E+02		7.90E-02	1.20E+01			
Pb-212	1.40E+00	4.40E+02		4.10E-02	6.40E+00			
Pb-214	1.00E+00	3.10E+02		2.90E-02	4.60E+00			
Tl-208	1.10E+00	3.40E+02		3.20E-02	5.00E+00			
OHFP								
Inorganics								
Chromium VI	3.75E+01	6.60E-06	4.10E-07	6.10E-10		1.80E-05	1.20E-06	1.70E-09
Mercury	3.10E+00	5.40E-07	3.40E-08	5.10E-11		1.50E-06	9.60E-08	1.40E-10
Silver	5.90E+00	1.00E-06	6.50E-08	9.60E-11		2.90E-06	1.80E-07	2.70E-10
Zinc	1.54E+02	2.70E-05	1.70E-06	2.50E-09		7.50E-05	4.80E-06	7.00E-09
Organics								
Aroclor 1254	2.30E+00	4.00E-07	2.50E-07	3.80E-11		1.10E-06	7.10E-07	1.10E-10
Aroclor 1260	6.30E-01	1.10E-07	7.00E-08	1.00E-11		3.10E-07	1.90E-07	2.90E-11
Radionuclides								
Am-241	8.82E+02	2.80E+05		2.60E+01	4.00E+03			
Cm-243/244	2.44E+04	7.60E+06		7.10E+02	1.10E+05			
Co-60	6.28E+03	2.00E+06		1.80E+02	2.90E+04			
Cs-137	3.72E+06	1.20E+09		1.10E+05	1.70E+07			
Pu-238	1.22E+03	3.80E+05		3.60E+01	5.60E+03			
Pu-239/240	6.39E+02	2.00E+05		1.90E+01	2.90E+03			
Th-228	1.74E+02	5.40E+04		5.10E+00	7.90E+02			
Th-230	3.09E+02	9.70E+04		9.00E+00	1.40E+03			

Table 9b. (continued)

Analyte	Concentrations (mg/kg;pCi/g)	Carcinogenic effects (CDI)				Noncarcinogenic effects (CDI)			
		Ingestion (mg/kg-d;pCi)	Dermal (mg/kg-d)	Inhalation (mg/kg-d;pCi)	External (pCi-y/g)	Ingestion (mg/kg;pCi/g)	Dermal (mg/kg-d)	Inhalation (mg/kg-d;pCi)	
Total Radioactive Strontium									
U-232	7.35E+05	2.30E+08		2.10E+04	3.40E+06				
	3.76E+01	1.20E+04		1.10E+00	1.70E+02				
PWSB									
Inorganics									
Antimony	2.76E+01	4.80E-06	3.00E-07	4.50E-10		1.40E-05	8.50E-07	1.30E-09	
Chromium VI	6.39E+01	1.10E-05	7.10E-07	1.00E-09		3.10E-05	2.00E-06	2.90E-09	
Mercury	2.75E+01	4.80E-06	3.00E-07	4.50E-10		1.30E-05	8.50E-07	1.30E-09	
Zinc	1.59E+03	2.80E-04	1.80E-05	2.60E-08		7.80E-04	4.90E-05	7.30E-08	
Organics									
4-Methyl Phenol	2.60E+01	4.50E-06	2.90E-06	4.20E-10		1.30E-05	8.00E-06	1.20E-09	
Aroclor 1248	1.20E+00	2.10E-07	1.30E-07	2.00E-11		5.90E-07	3.70E-07	5.50E-11	
Aroclor 1254	1.33E+00	2.30E-07	1.50E-07	2.20E-11		6.50E-07	4.10E-07	6.10E-11	
Radionuclides									
Am-241	1.17E+03	3.70E+05		3.40E+01	5.30E+03				
Cm-243/244	1.10E+03	3.50E+05		3.20E+01	5.00E+03				
Co-60	5.88E+03	1.80E+06		1.70E+02	2.70E+04				
Cs-137	1.78E+04	5.60E+06		5.20E+02	8.10E+04				
Eu-152	9.61E+02	3.00E+05		2.80E+01	4.40E+03				
Eu-154	5.79E+02	1.80E+05		1.70E+01	2.60E+03				
Pu-238	1.23E+02	3.80E+04		3.60E+00	5.60E+02				
Pu-239/240	1.43E+02	4.50E+04		4.20E+00	6.50E+02				
Th-228	3.82E+02	1.20E+05		1.10E+01	1.70E+03				

Table 9b. (continued)

Analyte	Concentrations (mg/kg;pCi/g)	Carcinogenic effects (CDI)				Noncarcinogenic effects (CDI)		
		Ingestion (mg/kg-d;pCi)	Dermal (mg/kg-d)	Inhalation (mg/kg-d;pCi)	External (pCi-y/g)	Ingestion (mg/kg;pCi/g)	Dermal (mg/kg-d)	Inhalation (mg/kg-d;pCi)
Total Radioactive Strontium								
U-232	1.20E+05	3.70E+07		3.50E+03	5.50E+05			
	3.21E+02	1.00E+05		9.40E+00	1.50E+03			
U-238	1.09E+02	3.40E+04		3.20E+00	5.00E+02			
Residential scenario								
D1								
Inorganics								
Chromium VI	3.32E+01	5.20E-05	1.20E-06	1.60E-09		1.20E-04	2.70E-06	3.70E-09
Manganese	4.88E+03	7.60E-03	1.70E-04	2.30E-07		1.80E-02	4.00E-04	5.40E-07
Mercury	1.37E-01	2.10E-07	4.80E-09	6.50E-12		5.00E-07	1.10E-08	1.50E-11
Nickel	6.58E+01	1.00E-04	2.30E-06	3.10E-09		2.40E-04	5.40E-06	7.30E-09
Silver	2.30E+00	3.60E-06	8.00E-08	1.10E-10		8.40E-06	1.90E-07	2.50E-10
Organics								
Aroclor 1260	8.30E-01	1.30E-06	2.90E-07	3.90E-11		3.00E-06	6.80E-07	9.20E-11
Radionuclides								
Ac-228	1.40E+00	1.80E+03		6.90E-02	3.20E+01			
Am-241	6.50E-01	8.20E+02		3.20E-02	1.50E+01			
Bi-212	1.50E+00	1.90E+03		7.40E-02	3.50E+01			
Bi-214	8.60E-01	1.10E+03		4.20E-02	2.00E+01			
Co-60	3.15E-01	4.00E+02		1.50E-02	7.20E+00			
Pb-212	1.30E+00	1.60E+03		6.40E-02	3.00E+01			
Pb-214	9.30E-01	1.20E+03		4.60E-02	2.10E+01			
Ra-223	3.70E-01	4.70E+02		1.80E-02	8.50E+00			

Table 9b. (continued)

Analyte	Concentrations (mg/kg;pCi/g)	Carcinogenic effects (CDI)				Noncarcinogenic effects (CDI)		
		Ingestion (mg/kg-d;pCi)	Dermal (mg/kg-d)	Inhalation (mg/kg-d;pCi)	External (pCi-y/g)	Ingestion (mg/kg;pCi/g)	Dermal (mg/kg-d)	Inhalation (mg/kg-d;pCi)
Radon 219	4.70E-01	5.90E+02		2.30E-02	1.10E+01			
Th-230	3.17E+00	4.00E+03		1.60E-01	7.30E+01			
Th-234	1.10E+01	1.40E+04		5.40E-01	2.50E+02			
Total Radioactive Strontium	1.30E+00	1.60E+03		6.40E-02	3.00E+01			
Tritium	2.34E+03	2.90E+06		1.10E+02	5.40E+04			
U-233/234	8.77E+00	1.10E+04		4.30E-01	2.00E+02			
U-235	3.60E-01	4.50E+02		1.80E-02	8.30E+00			
U-238	1.27E+01	1.60E+04		6.20E-01	2.90E+02			
D2								
Inorganics								
Arsenic	1.40E+01	2.20E-05	4.90E-07	6.60E-10		5.10E-05	1.10E-06	1.50E-09
Barium	1.60E+03	2.50E-03	5.60E-05	7.60E-08		5.90E-03	1.30E-04	1.80E-07
Chromium VI	2.21E+01	3.50E-05	7.70E-07	1.00E-09		8.10E-05	1.80E-06	2.40E-09
Manganese	4.26E+04	6.70E-02	1.50E-03	2.00E-06		1.60E-01	3.50E-03	4.70E-06
Organics								
Aroclor 1260	8.50E-02	1.30E-07	3.00E-08	4.00E-12		3.10E-07	6.90E-08	9.40E-12
Vinyl Chloride	1.03E+00	1.60E-06	3.60E-07	2.40E-02		3.80E-06	8.40E-07	5.70E-02
Radionuclides								
Ac-228	2.30E+00	2.90E+03		1.10E-01	5.30E+01			
Bi-212	1.70E+00	2.10E+03		8.30E-02	3.90E+01			
Bi-214	1.19E+00	1.50E+03		5.80E-02	2.70E+01			
Cm-243/244	5.52E+00	7.00E+03		2.70E-01	1.30E+02			

Table 9b. (continued)

Analyte	Concentrations (mg/kg;pCi/g)	Carcinogenic effects (CDI)				Noncarcinogenic effects (CDI)		
		Ingestion (mg/kg-d;pCi)	Dermal (mg/kg-d)	Inhalation (mg/kg-d;pCi)	External (pCi-y/g)	Ingestion (mg/kg;pCi/g)	Dermal (mg/kg-d)	Inhalation (mg/kg-d;pCi)
Co-60	6.30E+01	7.90E+02		3.10E-02	1.40E+01			
I-129	1.39E+01	1.80E+04		6.80E-01	3.20E+02			
Pb-212	1.70E+00	2.10E+03		8.30E-02	3.90E+01			
Pb-214	1.20E+00	1.50E+03		5.90E-02	2.80E+01			
Pu-238	3.13E+01	3.90E+04		1.50E+00	7.20E+02			
Ra-223	9.10E-01	1.10E+03		4.50E-02	2.10E+01			
Ra-224	4.90E+00	6.20E+03		2.40E-01	1.10E+02			
Ra-226	2.92E+00	3.70E+03		1.40E-01	6.70E+01			
Radon 219	1.20E+00	1.50E+03		5.90E-02	2.80E+01			
Tl-208	1.40E+00	1.80E+03		6.90E-02	3.20E+01			
Total Radioactive Strontium	1.29E+03	1.60E+06		6.30E+01	3.00E+04			
U-233/234	1.60E+01	2.00E+04		7.80E-01	3.70E+02			
U-235	4.10E-01	5.20E+02		2.00E-02	9.40E+00			
U-238	2.40E+00	3.00E+03		1.20E-01	5.50E+01			
			D3					
Inorganics								
Chromium VI	1.76E+01	2.80E-03	6.10E-07	8.40E-10		6.40E-05	1.40E-06	2.00E-09
Mercury	9.00E-02	1.40E-07	3.10E-09	4.30E-12		3.30E-07	7.30E-09	1.00E-11
Selenium	1.70E+00	2.70E-06	5.90E-08	8.10E-11		6.20E-06	1.40E-07	1.90E-10
Organics								
Chloroform	2.00E-03	3.10E-09	7.00E-10	2.30E-08		7.30E-09	1.60E-09	5.30E-08
Radionuclides								

Table 9b. (continued)

Analyte	Concentrations (mg/kg;pCi/g)	Carcinogenic effects (CDI)				Noncarcinogenic effects (CDI)		
		Ingestion (mg/kg-d;pCi)	Dermal (mg/kg-d)	Inhalation (mg/kg-d;pCi)	External (pCi-y/g)	Ingestion (mg/kg;pCi/g)	Dermal (mg/kg-d)	Inhalation (mg/kg-d;pCi)
Ac-228	1.50E+00	1.90E+03		7.40E-02	3.50E+01			
Bi-214	9.10E-01	1.10E+03		4.50E-02	2.10E+01			
I-129	1.30E+00	1.60E+03		6.40E-02	3.00E+01			
Pb-210	2.70E+00	3.40E+03		1.30E-01	6.20E+01			
Pb-212	1.40E+00	1.80E+03		6.90E-02	3.20E+01			
Pb-214	1.00E+00	1.30E+03		4.90E-02	2.30E+01			
Tl-208	1.10E+00	1.40E+03		5.40E-02	2.50E+01			
OHFP								
Inorganics								
Chromium VI	3.75E+01	5.90E-05	1.30E-06	1.80E-09		1.40E-04	3.10E-06	4.20E-09
Mercury	3.10E+00	4.90E-06	1.10E-07	1.50E-10		1.10E-05	2.50E-07	3.40E-10
Silver	5.90E+00	9.20E-06	2.10E-07	2.80E-10		2.20E-05	4.80E-07	6.50E-10
Zinc	1.54E+02	2.40E-04	5.40E-06	7.30E-09		5.60E-04	1.30E-05	1.70E-08
Organics								
Aroclor 1254	2.30E+00	3.60E-06	8.00E-07	1.10E-10		8.40E-06	1.90E-06	2.50E-10
Aroclor 1260	6.30E-01	9.90E-07	2.20E-07	3.00E-11		2.30E-06	5.10E-07	7.00E-11
Radionuclides								
Am-241	8.82E+02	1.10E+06		4.30E+01	2.00E+04			
Cm-243/244	2.44E+04	3.10E+07		1.20E+03	5.60E+05			
Co-60	6.28E+03	7.90E+06		3.10E+02	1.40E+05			
Cs-137	3.72E+06	4.70E+09		1.80E+05	8.60E+07			
Pu-238	1.22E+03	1.50E+06		6.00E+01	2.80E+04			

Table 9b. (continued)

Analyte	Concentrations (mg/kg;pCi/g)	Carcinogenic effects (CDI)				Noncarcinogenic effects (CDI)		
		Ingestion (mg/kg-d;pCi)	Dermal (mg/kg-d)	Inhalation (mg/kg-d;pCi)	External (pCi-y/g)	Ingestion (mg/kg;pCi/g)	Dermal (mg/kg-d)	Inhalation (mg/kg-d;pCi)
Pu-239/240	6.39E+02	8.10E+05		3.10E+01	1.50E+04			
Th-228	1.74E+02	2.20E+05		8.50E+00	4.00E+03			
Th-230	3.09E+02	3.90E+05		1.50E+01	7.10E+03			
Total Radioactive Strontium	7.35E+05	9.30E+08		3.60E+04	1.70E+07			
U-232	3.76E+01	4.70E+04		1.80E+00	8.70E+02			
U-233	1.58E+03	2.00E+06		7.70E+01	3.60E+04			
Inorganics			PWSB					
Antimony	2.76E+01	4.30E-05	9.60E-07	1.30E-09		1.00E-04	2.20E-06	3.10E-09
Chromium VI	6.39E+01	1.00E-04	2.20E-06	3.00E-09		2.30E-04	5.20E-06	7.10E-09
Mercury	2.75E+01	4.30E-05	9.60E-07	1.30E-09		1.00E-04	2.20E-06	3.10E-09
Zinc	1.59E+03	2.50E-03	5.50E-05	7.60E-08		5.80E-03	1.30E-04	1.80E-07
Organics								
4-Methyl Phenol	2.60E+01	4.10E-05	9.10E-06	1.20E-09		9.50E-05	2.10E-05	2.90E-09
Aroclor 1248	1.20E+00	1.90E-06	4.20E-07	5.70E-11		4.40E-06	9.80E-07	1.30E-10
Aroclor 1254	1.33E+00	2.10E-06	4.60E-07	6.30E-11		4.80E-06	1.10E-06	1.50E-10
Radionuclides								
Am-241	1.17E+03	1.50E+06		5.70E+01	2.70E+04			
Cm-243/244	1.10E+03	1.40E+06		5.40E+01	2.50E+04			
Co-60	5.88E+03	7.40E+06		2.90E+02	1.40E+05			
Cs-137	1.78E+04	2.20E+07		8.70E+02	4.10E+05			
Eu-152	9.61E+02	1.20E+06		4.70E+01	2.20E+04			

Table 9b. (continued)

Analyte	Concentrations (mg/kg;pCi/g)	Carcinogenic effects (CDI)				Noncarcinogenic effects (CDI)		
		Ingestion (mg/kg-d;pCi)	Dermal (mg/kg-d)	Inhalation (mg/kg-d;pCi)	External (pCi-y/g)	Ingestion (mg/kg;pCi/g)	Dermal (mg/kg-d)	Inhalation (mg/kg-d;pCi)
Eu-154	5.79E+02	7.30E+05		2.80E+01	1.30E+04			
Pu-238	1.23E+02	1.50E+05		6.00E+00	2.80E+03			
Pu-239/240	1.43E+02	1.80E+05		7.00E+00	3.30E+03			
Th-228	3.82E+02	4.80E+05		1.90E+01	8.80E+03			
Total Radioactive Strontium	1.20E+05	1.50E+08		5.90E+03	2.80E+06			
U-232	3.21E+02	4.00E+05		1.60E+01	7.40E+03			
U-238	1.09E+02	1.40E+05		5.30E+00	2.50E+03			

Table 9c. Chronic daily intake for WAG 5 groundwater COPCs - Residential Scenario

Analytes	Carcinogenic Effects (CDI)					Noncarcinogenic Effects (CDI)			
	Concentration (mg/l;pCi/l)	Ingestion (mg/l-d;pCi)	Produce ingestion (mg/l-d;pCi)	Dermal (mg/l-d)	Inhalation (mg/l-d;pCi)	Ingestion (mg/l-d;pCi)	Produce ingestion (mg/l-d;pCi)	Dermal (mg/l-d)	Inhalation (mg/l-d;pCi)
Residential scenario									
FS									
Inorganics									
Barium	9.32E-01	1.90E-02	1.40E-03	3.10E-05		4.40E-02	3.20E-03	7.10E-05	
Beryllium	6.20E-03	1.30E-04	7.90E-06	2.00E-07		2.90E-04	1.90E-05	4.70E-07	
Chromium	2.43E-03	4.90E-03	3.30E-04	8.00E-06		1.20E-02	7.80E-04	1.90E-05	
Manganese	2.32E+00	4.70E-02	3.00E-03	7.60E-05		1.10E-01	7.10E-03	1.80E-04	
Nickel	1.66E-01	3.40E-03	2.30E-04	5.40E-06		7.90E-03	5.40E-04	1.30E-05	
Vanadium	1.40E-01	2.80E-03	1.80E-04	4.60E-06		6.60E-03	4.20E-04	1.10E-05	
Radionuclides									
Am-241	4.20E-01	8.80E+03	5.60E+02						
Ra-226	3.03E+00	6.40E+04	4.10E+03						
Ra-228	4.30E+00	9.00E+04	5.90E+03						
Th-228	3.20E+01	6.70E+05	4.20E+04						
Th-230	2.40E+01	5.00E+05	3.20E+04						
Th-232	3.50E+01	7.40E+05	4.60E+04						
Tritium	1.10E+05	2.30E+09	8.70E+08		2.70E+08				
OHFP									
Organics									
1,1-Dichloroethane	8.00E-03	1.60E-04	2.00E-05	2.30E-06	6.10E-06	3.80E-04	4.60E-05	5.40E-06	1.40E-05
1,2-Dichloroethane	3.00E-03	6.10E-05	9.30E-06	5.20E-07	2.30E-06	1.40E-04	2.20E-05	1.20E-06	5.30E-06
Carbon Tetrachloride	9.00E-03	1.80E-04	1.50E-05	6.50E-06	6.90E-06	4.30E-04	3.50E-05	1.50E-05	1.60E-05

Table 9c. (continued)

Analytes	Concentration (mg/l;pCi/l)	Carcinogenic Effects (CDI)				Noncarcinogenic Effects (CDI)			
		Ingestion (mg/l-d;pCi)	Produce ingestion (mg/l-d;pCi)	Dermal (mg/l-d)	Inhalation (mg/l-d;pCi)	Ingestion (mg/l-d;pCi)	Produce ingestion (mg/l-d;pCi)	Dermal (mg/l-d)	Inhalation (mg/l-d;pCi)
Chloroform	2.50E-02	5.10E-04	5.60E-05	7.30E-06	1.90E-05	1.20E-03	1.30E-04	1.70E-05	4.50E-05
Nitrate	1.10E+00	2.20E-02	1.40E-03			5.20E-02	3.30E-03		
Trichloroethene	7.00E-03	1.40E-04	7.10E-03	3.70E-06	5.30E-06	3.30E-04	1.60E-02	8.60E-06	1.20E-05
Radionuclides									
C-14	1.23E+03	2.60E+07	1.10E+07						
Cm-243/244	4.44E+00	9.30E+04	5.80E+03						
Co-60	8.85E+01	1.90E+06	1.30E+05						
Cs-137	1.73E+03	3.60E+07	2.30E+06						
Pu-238	5.44E-01	1.10E+04	7.10E+02						
Ra-226	4.89E-01	1.00E+04	6.70E+02						
Ra-228	2.55E+02	5.30E+06	3.40E+05						
Tc-99	4.20E+01	8.80E+05	3.50E+05						
Th-234	1.74E+02	3.70E+06	1.50E+05						
Total Radioactive Strontium	2.65E+04	5.60E+08	4.70E+07						
Tritium	1.96E+06	4.10E+10	1.60E+10		4.80E+09				
U-233/234	8.98E+00	1.90E+05	1.20E+04						
Inorganics									
PWSEB									
Chromium	4.00E-03	8.10E-05	5.60E-06	1.30E-07		1.90E-04	1.30E-05	3.10E-07	
Organics									
Acetone	1.17E-02	2.40E-04	2.30E-04	2.20E-07		5.50E-04	5.40E-04	5.10E-07	
Bis(2-Ethylhexyl) Phthalate	8.20E-02	1.70E-03	1.10E-04	6.30E-05		3.90E-03	2.50E-04	1.50E-04	

Table 9c. (continued)

Analytes	Concentration (mg/l;pCi/l)	Carcinogenic Effects (CDI)				Noncarcinogenic Effects (CDI)			
		Ingestion (mg/l-d;pCi)	Produce ingestion (mg/l-d;pCi)	Dermal (mg/l-d)	Inhalation (mg/l-d;pCi)	Ingestion (mg/l-d;pCi)	Produce ingestion (mg/l-d;pCi)	Dermal (mg/l-d)	Inhalation (mg/l-d;pCi)
Radionuclides									
Am-241	1.30E-01	2.70E+03	1.70E+02						
Ra-226	2.22E-01	4.70E+03	3.00E+02						
Ra-228	1.13E+00	2.40E+04	1.50E+03						
Th-228	4.03E-01	8.50E+03	5.20E+02						
Tritium	1.23E+04	2.60E+08	9.60E+07		3.00E+07				
U-233/234	7.22E-01	1.50E+04	9.50E+02						
U-238	3.92E-01	8.20E+03	5.20E+02						
SWSA 5N									
Inorganics									
Barium	9.22E-01	1.90E-02	1.40E-03	3.00E-05		4.40E-02	3.20E-03	7.00E-05	
Beryllium	2.29E-03	4.70E-05	2.90E-06	7.50E-08		1.10E-04	6.90E-06	1.80E-07	
Chromium	1.08E-01	2.20E-03	1.50E-04	3.50E-06		5.10E-03	3.60E-04	8.30E-06	
Manganese	2.29E+00	4.70E-02	3.00E-03	7.50E-05		1.10E-01	7.10E-03	1.70E-04	
Nickel	1.50E-01	3.10E-03	2.00E-04	4.90E-06		7.10E-03	4.80E-04	1.10E-05	
Vanadium	5.27E-02	1.10E-03	6.80E-05	1.70E-06		2.50E-03	1.60E-04	4.00E-06	
Organics									
Bis(2-Ethylhexyl) Phthalate	1.31E-02	2.70E-04	1.70E-05	1.00E-05		6.20E-04	3.90E-05	2.30E-05	
Methylene Chloride	1.60E-02	3.30E-04	5.70E-05	2.40E-06	1.20E-05	7.60E-04	1.30E-04	5.50E-06	2.80E-05
Radionuclides									
Am-241	3.15E+09	6.60E+04	4.20E+03						
C-14	1.23E+02	2.60E+06	1.10E+06						

Table 9c. (continued)

Analytes	Concentration (mg/l;pCi/l)	Carcinogenic Effects (CDI)				Noncarcinogenic Effects (CDI)			
		Ingestion (mg/l-d;pCi)	Produce ingestion (mg/l-d;pCi)	Dermal (mg/l-d)	Inhalation (mg/l-d;pCi)	Ingestion (mg/l-d;pCi)	Produce ingestion (mg/l-d;pCi)	Dermal (mg/l-d)	Inhalation (mg/l-d;pCi)
Cm-243	2.33E-01	4.90E+03	3.00E+02						
Cm-243/244	3.93E+01	8.30E+05	5.10E+04						
K-40	6.22E+02	1.30E+07	1.10E+06						
Pb-212	3.41E+01	7.20E+05	4.50E+04						
Pu-238	5.55E-01	1.20E+04	7.30E+02						
Ra-226	3.14E+00	6.60E+04	4.30E+03						
Ra-228	1.71E+01	3.60E+05	2.30E+04						
Tc-99	2.27E+01	4.80E+05	1.90E+05						
Th-228	2.80E+00	5.90E+04	3.60E+03						
Th-230	1.94E+00	4.10E+04	2.50E+03						
Th-232	2.90E+00	6.10E+04	3.80E+03						
Th-234	4.88E+02	1.00E+07	4.30E+05						
Tritium	2.20E+03	4.60E+07	1.80E+07		5.40E+06				
U-233/234	2.82E+00	5.90E+04	3.70E+03						
U-238	2.34E+00	4.90E+04	3.00E+03						
SWSA SSE									
Inorganics									
Chromium	1.01E-01	2.10E-03	1.40E-04	3.30E-06		4.80E-03	3.20E-04	7.70E-06	
Manganese	2.26E+01	4.60E-01	3.00E-02	7.40E-04		1.10E+00	7.10E-02	1.70E-03	
Organics									
1,1-Dichloroethene	5.53E-03	1.10E-04	1.40E-05	1.60E-06	4.20E-06	2.60E-04	3.20E-05	3.80E-06	9.80E-06
1,2-Dichloroethane	4.00E-03	8.10E-05	1.20E-05	6.90E-07	3.10E-06	1.90E-04	2.90E-05	1.60E-06	7.10E-06

Table 9c. (continued)

Analytes	Carcinogenic Effects (CDI)					Noncarcinogenic Effects (CDI)			
	Concentration (mg/l-pCi/l)	Ingestion (mg/l-d,pCi)	Produce ingestion (mg/l-d,pCi)	Dermal (mg/l-d)	Inhalation (mg/l-d,pCi)	Ingestion (mg/l-d,pCi)	Produce ingestion (mg/l-d,pCi)	Dermal (mg/l-d)	Inhalation (mg/l-d,pCi)
Benzene	2.00E-03	4.10E-05	4.10E-06	1.40E-06	1.50E-06	9.50E-05	9.60E-06	3.20E-06	3.60E-06
Bis(2-Ethylhexyl) Phthalate	5.00E-03	1.00E-04	2.00E-05	3.80E-06		2.40E-04	4.70E-05	8.90E-06	
Chloroform	1.00E-03	2.00E-05	2.20E-06	2.90E-07	7.60E-07	4.70E-05	5.20E-06	6.80E-07	1.80E-06
Trichloroethene	2.97E-02	6.00E-04	1.10E-04	1.60E-05	2.30E-05	1.40E-03	2.50E-04	3.60E-05	5.30E-05
Vinyl Chloride	1.37E-02	2.80E-04	4.70E-05	3.30E-06	1.00E-05	6.50E-04	1.10E-04	7.70E-06	2.40E-05
Radionuclides									
Am-241	1.49E+05	3.10E+09	2.00E+08						
Bi-212	5.34E+02	1.10E+07	2.40E+03						
C-14	4.34E+02	9.10E+06	3.90E+06						
Cd-109	3.67E+02	7.70E+06	6.30E+05						
Cm-243/244	1.04E+01	2.20E+05	1.30E+04						
Pu-238	9.30E+04	2.00E+09	1.20E+08						
Pu-239/240	1.61E+03	3.40E+07	2.10E+06						
Ra-226	1.30E+03	2.70E+07	1.80E+06						
Ra-228	2.07E+01	4.30E+05	2.90E+04						
Tc-99	1.61E+02	3.40E+06	1.30E+06						
Th-228	4.49E+01	9.40E+05	5.80E+04						
Th-230	1.85E+00	3.90E+04	2.40E+03						
Th-231	3.53E+02	7.40E+06	3.40E+04						
Total Radioactive Strontium	2.78E+03	5.80E+07	4.90E+06						
Tritium	6.52E+07	4.40E+12	5.20E+11		1.60E+11				
U-232	7.53E-01	1.60E+04	9.90E+02						

Table 9c. (continued)

Analytes	Concentration (mg/l;pCi/l)	Carcinogenic Effects (CDI)				Noncarcinogenic Effects (CDI)			
		Ingestion (mg/l-d;pCi)	Produce ingestion (mg/l-d;pCi)	Dermal (mg/l-d)	Inhalation (mg/l-d;pCi)	Ingestion (mg/l-d;pCi)	Produce ingestion (mg/l-d;pCi)	Dermal (mg/l-d)	Inhalation (mg/l-d;pCi)
U-233/234	1.29E+03	2.70E+07	1.70E+06						
U-238	1.77E+00	3.70E+04	2.40E+03						
SWSA5SW									
Inorganics									
Barium	4.64E-01	9.40E-03	6.80E-04	1.50E-05		2.20E-02	1.60E-03	3.50E-05	
Chromium	7.40E-02	1.50E-03	1.00E-04	2.40E-06		3.50E-03	2.40E-04	5.70E-06	
Manganese	5.13E+00	1.00E-01	6.70E-03	1.70E-04		2.40E-01	1.60E-02	3.90E-04	
Organics									
Benzene	1.00E-03	2.00E-05	2.10E-06	6.90E-07	7.60E-07	4.70E-05	4.80E-06	1.60E-06	1.80E-06
Bis(2-Ethylhexyl) Phthalate	2.21E-01	4.50E-03	2.80E-04	1.70E-04		1.00E-02	6.60E-04	3.90E-04	
Carbon Tetrachloride	6.00E-03	1.20E-04	1.00E-05	4.30E-06	4.60E-06	2.80E-04	2.30E-05	1.00E-05	1.10E-05
Chloroform	1.00E-03	2.00E-05	2.20E-06	2.90E-07	7.60E-07	4.70E-05	5.20E-06	6.80E-07	1.80E-06
Tetrachloroethene	1.13E-01	2.30E-03	1.90E-04	1.40E-03		5.40E-03	4.30E-04	3.20E-03	
Vinyl Chloride	2.32E-02	4.70E-04	7.70E-05	5.50E-06	1.80E-05	1.10E-03	1.80E-04	1.30E-05	4.10E-05
Radionuclides									
Am-241	2.13E+00	4.50E+04	2.80E+03						
C-14	4.67E+02	9.80E+06	4.20E+06						
Ca-45	2.80E+02	5.90E+06	5.20E+05						
Cm-243/244	1.53E+00	3.20E+04	2.00E+03						
Co-60	4.12E+01	8.60E+05	5.80E+04						
K-40	1.01E+03	2.10E+07	1.70E+06						
Pb-212	5.26E+01	1.10E+06	7.00E+04						

Table 9c. (continued)

Analytes	Concentration (mg/lipCi/l)	Carcinogenic Effects (CDI)				Noncarcinogenic Effects (CDI)			
		Ingestion (mg/l-d;pCi)	Produce ingestion (mg/l-d;pCi)	Dermal (mg/l-d)	Inhalation (mg/l-d;pCi)	Ingestion (mg/l-d;pCi)	Produce ingestion (mg/l-d;pCi)	Dermal (mg/l-d)	Inhalation (mg/l-d;pCi)
Pu-238	1.55E+00	3.30E+04	2.00E+03						
Ra-226	2.42E+00	5.10E+04	3.30E+03						
Ra-228	5.39E+01	1.10E+06	7.40E+04						
Th-228	1.30E+01	2.70E+05	1.70E+04						
Th-230	6.53E+00	1.40E+05	8.60E+03						
Th-232	9.00E+00	1.90E+05	1.20E+04						
Th-234	1.73E+02	3.60E+06	1.50E+05						
Total Radioactive Strontium	3.42E+02	7.20E+06	5.90E+05						
Tritium	8.08E+06	1.70E+11	6.50E+10		2.00E+10				
U-233/234	6.24E+00	1.30E+05	8.20E+03						
U-238	4.33E+00	9.10E+04	5.70E+03						
WOC									
Inorganics									
Barium	8.72E-01	1.80E-02	1.30E-03	2.90E-05		4.10E-02	3.00E-03	6.70E-05	
Manganese	7.98E-01	1.60E-02	1.10E-03	2.60E-05		3.80E-02	2.50E-03	6.10E-05	
Organics									
1,1-Dichloroethene	5.00E-03	1.00E-04	1.20E-05	1.50E-06	3.80E-06	2.40E-04	2.90E-05	3.40E-06	8.90E-06
1,2-Dichloroethene (Total)	1.95E+00	4.00E-02	5.90E-03			9.30E-02	1.40E-02		
Benzene	1.90E-02	3.90E-04	3.90E-05	1.30E-05	1.40E-05	9.00E-04	9.10E-05	3.00E-05	3.40E-05
Vinyl Chloride	2.58E+00	5.30E-02	8.70E-03	6.20E-04	2.00E-03	1.20E-01	2.00E-02	1.40E-03	4.60E-03
Radionuclides									
C-14	1.13E+03	2.40E+07	9.10E+06						

Table 9c. (continued)

Analytes	Concentration (mg/l;pCi/l)	Carcinogenic Effects (CDI)				Noncarcinogenic Effects (CDI)		
		Ingestion (mg/l-d;pCi)	Produce ingestion (mg/l-d;pCi)	Dermal (mg/l-d)	Inhalation (mg/l-d;pCi)	Ingestion (mg/l-d;pCi)	Produce ingestion (mg/l-d;pCi)	Dermal (mg/l-d)
Pu-239/240	1.69E-01	3.60E+03	2.20E+02					
Th-228	1.72E+00	3.60E+04	2.20E+03					
Th-234	1.00E+03	2.10E+07	8.70E+05					
Tritium	4.43E+04	9.30E+08	3.50E+08		1.10E+08			

Table 9d. Chronic daily intake for WAG 5 surface water COPCs - Residential Scenario

Analyte	Concentration (mg/l;pCi/l)	Carcinogenic Effects (CDI)			Noncarcinogenic Effects (CDI)		
		Ingestion (mg/l-d;pCi)	Dermal (mg/l-d)	Inhalation (mg/l-d;pCi)	Ingestion (mg/l-d;pCi)	Dermal (mg/l-d;pCi)	Inhalation (mg/l-d;pCi)
High Base							
D1							
Inorganics							
Manganese	2.63E-01	-	-	-	-	-	-
Radionuclides							
Pu-238	2.90E-01	-	-	-	-	-	-
Total-Radioactive-Strontium	2.40E+01	-	-	-	-	-	-
Tritium	2.42E+02	-	-	3.80E+05	-	-	-
U-233/234	2.70E+01	-	-	-	-	-	-
U-238	4.50E+01	-	-	-	-	-	-
D2							
Inorganics							
Manganese	2.56E+00	-	-	-	-	-	-
Radionuclides							
C-14	3.20E+02	-	-	-	-	-	-
Total-Radioactive-Strontium	2.50E+03	-	-	-	-	-	-
Tritium	3.12E+04	-	-	4.90E+07	-	-	-
U-233/234	3.70E+00	-	-	-	-	-	-
D3							
Inorganics							
Manganese	2.44E-01	-	-	-	-	-	-
Radionuclides							

Table 9d. (continued)

Analyte--	Concentration (mg/l;pCi/l)	Carcinogenic Effects (CDI)			Noncarcinogenic Effects (CDI)		
		Ingestion (mg/l-d;pCi)	Dermal (mg/l-d)	Inhalation (mg/l-d;pCi)	Ingestion (mg/l-d;pCi)	Dermal (mg/l-d;pCi)	Inhalation (mg/l-d;pCi)
Tritium	9.60E+00	-	-	1.27E+04	-	-	-
High-Base-Storm							
D1							
Organics							
2-Butanone	7.00E-03	-	-	5.30E-06	-	-	1.20E-05
Bis(2-Ethylhexyl)-Phthalate	4.00E-03	-	-	-	-	-	-
Radionuclides							
Th-230	5.32E+00	-	-	-	-	-	-
Total-Radioactive-Strontium	1.63E+01	-	-	-	-	-	-
Tritium	1.10E+02	-	-	1.70E+05	-	-	-
U-233/234	5.14E+01	-	-	-	-	-	-
U-238	8.11E+01	-	-	-	-	-	-
D2							
Organics							
1,1-Dichloroethane	2.00E-03	-	-	1.50E-06	-	-	3.60E-06
1,2-Dichloroethene-(Total)	3.00E-03	-	-	-	-	-	-
Bis(2-Ethylhexyl)-Phthalate	6.00E-03	-	-	-	-	-	-
Trichloroethene	1.00E-03	-	-	7.60E-07	-	-	1.80E-06
Radionuclides							
C-14	1.18E+02	-	-	-	-	-	-
Pu-238	1.40E+01	-	-	-	-	-	-
Tc-99	3.79E+01	-	-	-	-	-	-

Table 9d. (continued)

Analyte--	Concentration (mg/l;pCi/l)	Carcinogenic Effects (CDI)			Noncarcinogenic Effects (CDI)		
		Ingestion (mg/l-d;pCi)	Dermal (mg/l-d)	Inhalation (mg/l-d;pCi)	Ingestion (mg/l-d;pCi)	Dermal (mg/l-d;pCi)	Inhalation (mg/l-d;pCi)
Th-230	1.04E+01	-	-	-	-	-	-
Total-Radioactive-Strontium	1.41E+03	-	-	-	-	-	-
Tritium	1.70E+04	-	-	2.70E+07	-	-	-
Radionuclides			D3				
Total-Radioactive-Strontium	5.70E+01	-	-	-	-	-	-
Organics			Impoundment				
Bis(2-Ethylhexyl)-Phthalate	1.00E-03	-	-	-	-	-	-
Radionuclides			OIHP				
Am-241	3.92E-01	-	-	-	-	-	-
Cm-243/244	1.62E+01	-	-	-	-	-	-
Co-60	1.52E+02	-	-	-	-	-	-
Cs-137	2.50E+04	-	-	-	-	-	-
Pu-238	3.16E-01	-	-	-	-	-	-
Pu-239/240	5.06E-01	-	-	-	-	-	-
Tc-99	4.32E+01	-	-	-	-	-	-
Total-Radioactive-Strontium	9.00E+04	-	-	-	-	-	-
Tritium	5.43E+00	-	-	8.50E+03	-	-	-
U-232	3.33E+00	-	-	-	-	-	-
U-233/234	1.02E+02	-	-	-	-	-	-

Table 9d. (continued)

Analyte--	Carcinogenic Effects (CDI)				Noncarcinogenic Effects (CDI)		
	Concentration (mg/l;pCi/l)	Ingestion (mg/l-d;pCi)	Dermal (mg/l-d)	Inhalation (mg/l-d;pCi)	Ingestion (mg/l-d;pCi)	Dermal (mg/l-d;pCi)	Inhalation (mg/l-d;pCi)
Inorganics							
Manganese	2.93E+00	-	-	-	-	-	-
Radionuclides							
Am-241	9.30E+00	-	-	-	-	-	-
C-14	1.80E+02	-	-	-	-	-	-
Pu-238	1.77E+01	-	-	-	-	-	-
Ra-228	1.61E+03	-	-	-	-	-	-
Total-Radioactive-Strontium	1.78E+03	-	-	-	-	-	-
Tritium	3.94E+03	-	-	6.20E+06	-	-	-
U-233/234	3.20E+00	-	-	-	-	-	-
D3							
Radionuclides							
Tritium	1.07E+01	-	-	1.46E+04	-	-	-
Total-Radioactive-Strontium	6.13E+02	-	-	-	-	-	-
Low-Base-Storm							
D1							
Organics							
Bis(2-Ethylhexyl)-Phthalate	1.00E-03	-	-	-	-	-	-
Radionuclides							
Tritium	1.25E+02	-	-	2.00E+05	-	-	-
U-233/234	1.06E+01	-	-	-	-	-	-
U-238	1.72E+01	-	-	-	-	-	-

Table 9d. (continued)

Analyte--	Concentration (mg/l;pCi/l)	Carcinogenic Effects (CDI)			Noncarcinogenic Effects (CDI)		
		Ingestion (mg/l-d;pCi)	Dermal (mg/l-d)	Inhalation (mg/l-d;pCi)	Ingestion (mg/l-d;pCi)	Dermal (mg/l-d;pCi)	Inhalation (mg/l-d;pCi)
D2							
Inorganics							
Manganese	2.96E+00	-	-	-	-	-	-
Radionuclides							
Am-241	9.02E-01	-	-	-	-	-	-
C-14	1.78E+02	-	-	-	-	-	-
Pu-238	1.91E+01	-	-	-	-	-	-
Total-Radioactive-Strontium	2.09E+03	-	-	-	-	-	-
Tritium	4.43E+04	-	-	7.00E+07	-	-	-
U-233/234	6.20E+00	-	-	-	-	-	-
D3							
Inorganics							
Manganese	3.55E-01	-	-	-	-	-	-
Organics							
Bis(2-Ethylhexyl)-Phthalate	3.00E-03	-	-	-	-	-	-
Radionuclides							
Am-241	7.36E-02	-	-	-	-	-	-

Table 10. Parameters used to calculate contaminant concentration in produce from groundwater irrigation (direct and indirect deposition)

Parameter	Value	Reference
Irrigation rate (I) (L/m ² .y)	326	(3.62 L/m ² -d)(365d/yr)(3/12) Roane County Extension agent
Translocation factor (T _p)	1.0	NCRP 1985
Length of growing season (years)	0.167	Based on 2 months/year Whelan 1987
Plant yield (Y) (kg/m ²)	2	NCRP 1985
Fraction of deposition (r)	0.2	NCRP 1985
Effective loss rate (λ_e) (1/year)	Calculated value	NCRP 1989 $\lambda_e = \lambda_R + \lambda_w$
Radioactive decay constant (λ_R) (1/year)	calculated radionuclide specific	NCRP 1989 (0.693/T _{1/2})
Weathering decay constant(λ_w) (1/year)	18.1	Whelan 1987
Areal density for effective root zone(ρ_e) (kg/m ²)	225	Soil density x root depth (i.e.,1500 kg/m ³ x 0.15m) Till & Meyer
Permeability of soil (K) (L/m ² -y)	2.19 x 10 ³	Israelsen 1950
Slope of the ground at WAG 5	7.5%	Baughn 1987 Conservative value that accounts for less surface run-off

Table 11. Analyte dependent parameters and concentrations of COPCs in produce irrigated by WAG 5 groundwater

Analyte	Groundwater conc. (mg/l;pCi/l)	Radioactive half-life (y)	Radioactive decay constant (1/y)	Soil -to-plant B _v value	Direct irrigation (mg/kg;pCi/g)	Indirect irrigation (mg/kg;pCi/g)	Total produce concentration (mg/kg;pCi/g)
FS							
Inorganics							
Barium	9.30E-01			1.50E-01	1.59E+00	1.12E-02	1.60E+00
Beryllium	6.20E-03			4.70E-04	1.06E-02	2.33E-07	1.06E-02
Manganese	2.30E+00			3.00E-02	3.94E+00	5.52E-03	3.95E+00
Nickel	1.70E-01			6.00E-02	2.91E-01	8.17E-04	2.92E-01
Vanadium	1.40E-01			5.50E-03	2.40E-01	6.16E-05	2.40E-01
Radionuclides							
Am-241	4.20E-01	4.32E+02	1.60E-03	1.00E-03	7.20E-04	3.36E-08	7.20E-04
Ra-226	3.00E+00	1.60E+03	4.33E-04	4.00E-02	5.14E-03	9.61E-06	5.15E-03
Ra-228	4.30E+00	5.75E+00	1.21E-01	4.00E-02	7.33E-03	1.37E-05	7.34E-03
Th-228	3.20E+01	1.90E+00	3.65E-01	1.00E-03	5.39E-02	2.51E-06	5.39E-02
Th-230	2.40E+01	7.54E+04	9.19E-06	1.00E-03	4.11E-02	1.92E-06	4.11E-02
Th-232	3.50E+01	1.40E+10	4.95E-11	1.00E-03	6.00E-02	2.80E-06	6.00E-02
Tritium	1.10E+05	1.23E+01	5.63E-02	4.80E+00	1.88E+02	4.21E+01	2.30E+02
OHFP							
Organics							
1,1-Dichloroethane	8.00E-03			8.94E-01	1.37E-02	5.73E-04	1.43E-02
1,2-Dichloroethane	3.00E-03			1.35E+00	5.14E-03	3.24E-04	5.47E-03
Carbon Tetrachloride	9.00E-03			2.89E-01	1.54E-02	2.08E-04	1.56E-02
Chloroform	2.50E-02			7.04E-01	4.28E-02	1.41E-03	4.42E-02
Nitrate	1.10E+00			0.00E+00	1.88E+00	0.00E+00	1.88E+00
Radionuclides							
C-14	1.20E+03	5.73E+03	1.21E-04	5.50E+00	2.06E+00	5.28E-01	2.58E+00
Cm-243/244	4.40E+00	2.85E+01	2.43E-02	1.00E-03	7.53E-03	3.52E-07	7.53E-03
Co-60	8.90E+01	5.27E+00	1.31E-01	8.00E-02	1.52E-01	5.66E-04	1.52E-01
Cs-137	1.70E+03	3.02E+01	2.29E-02	4.00E-02	2.91E+00	5.44E-03	2.92E+00
Pu-238	5.40E-01	8.77E+01	7.90E-03	1.00E-03	9.25E-04	4.32E-08	9.25E-04
Ra-226	4.90E-01	1.60E+03	4.33E-04	4.00E-02	8.40E-04	1.57E-06	8.41E-04
Ra-228	2.50E+02	5.75E+00	1.21E-01	4.00E-02	4.26E-01	7.95E-04	4.27E-01
Tc-99	4.20E+01	2.13E+05	3.25E-06	5.00E+00	7.20E-02	1.68E-02	8.88E-02
Th-234	1.70E+02	6.60E-02	1.05E+01	1.00E-03	1.92E-01	8.61E-06	1.92E-01

Table 11. (continued)

Analyte	Groundwater conc. (mg/l;pCi/l)	Radioactive half-life (y)	Radioactive decay constant (1/y)	Soil to-plant B _v value	Direct irrigation (mg/kg;pCi/g)	Indirect irrigation (mg/kg;pCi/g)	Total produce concentration (mg/kg;pCi/g)
Total Radioactive Strontium	2.70E+04	2.90E+01	2.39E-02	3.00E-01	4.62E+01	6.48E-01	4.69E+01
Tritium	2.00E+06	1.23E+01	5.63E-02	4.80E+00	3.42E+03	7.66E+02	4.18E+03
U-233/234	9.00E+00	2.45E+05	2.83E-06	2.50E-03	1.54E-02	1.80E-06	1.54E-02
PWSB							
Organics							
Acetone	1.20E-02			0.00E+00	2.06E-02	3.24E-04	2.09E-02
Bis(2-Ethylhexyl) Phthalate	8.20E-02			2.69E-05	1.41E-01	1.77E-07	1.41E-01
Radionuclides							
Am-241	1.30E-01	4.32E+02	1.60E-03	1.00E-03	2.23E-04	1.04E-08	2.23E-04
Ra-226	2.20E-01	1.60E+03	4.33E-04	4.00E-02	3.77E-04	7.04E-07	3.78E-04
Ra-228	1.10E+00	5.75E+00	1.21E-01	4.00E-02	1.87E-03	3.50E-06	1.88E-03
Th-228	4.00E-01	1.90E+00	3.65E-01	1.00E-03	6.74E-04	3.14E-08	6.74E-04
Tritium	1.20E+04	1.23E+01	5.63E-02	4.80E+00	2.05E+01	4.60E+00	2.51E+01
U-233/234	7.20E-01	2.45E+05	2.83E-06	2.50E-03	1.23E-03	1.44E-07	1.23E-03
U-238	3.90E-01	4.46E+09	1.55E-10	2.50E-03	6.68E-04	7.80E-08	6.68E-04
SWSASN							
Inorganics							
Barium	9.20E-01			1.50E-01	1.58E+00	1.10E-02	1.59E+00
Beryllium	2.30E-03			4.70E-04	3.94E-03	8.65E-08	3.94E-03
Manganese	2.30E+00			3.00E-02	3.94E+00	5.52E-03	3.95E+00
Nickel	1.50E-01			6.00E-02	2.57E-01	7.20E-04	2.58E-01
Vanadium	5.30E-02			5.50E-03	9.08E-02	2.33E-05	9.08E-02
Organics							
Bis(2-Ethylhexyl) Phthalate	1.30E-02			2.69E-05	2.23E-02	2.80E-08	2.23E-02
Methylene Chloride	1.60E-02			1.71E+00	2.74E-02	2.19E-03	2.96E-02
Radionuclides							
Am-241	3.20E+00	4.32E+02	1.60E-03	1.00E-03	5.48E-03	2.56E-07	5.48E-03
C-14	1.20E+02	5.73E+03	1.21E-04	5.50E+00	2.06E-01	5.28E-02	2.58E-01
Cm-243	2.30E-01	2.85E+01	2.43E-02	1.00E-03	3.94E-04	1.84E-08	3.94E-04
Cm-243/244	3.90E+01	2.85E+01	2.43E-02	1.00E-03	6.67E-02	3.12E-06	6.68E-02
K-40	6.20E+02	1.26E+09	5.50E-10	3.00E-01	1.06E+00	1.49E-02	1.08E+00
Pb-212	3.40E+01	1.06E+01	6.51E-02	1.00E-02	5.81E-02	2.71E-05	5.81E-02

Table 11. (continued)

Analyte	Groundwater conc. (mg/l;pCi/l)	Radioactive half-life (y)	Radioactive decay constant (1/y)	Soil-to- plant B _v value	Direct irrigation (mg/kg;pCi/g)	Indirect irrigation (mg/kg;pCi/g)	Total produce concentration (mg/kg;pCi/g)
Pu-238	5.50E-01	4.46E+09	1.55E-10	1.00E-03	9.42E-04	4.40E-08	9.42E-04
Ra-226	3.10E+00	1.60E+03	4.33E-04	4.00E-02	5.31E-03	9.93E-06	5.32E-03
Ra-228	1.70E+01	5.75E+00	1.21E-01	4.00E-02	2.90E-02	5.41E-05	2.90E-02
Tc-99	2.30E+01	2.13E+05	3.25E-06	5.00E+00	3.94E-02	9.21E-03	4.86E-02
Th-228	2.80E+00	1.90E+00	3.65E-01	1.00E-03	4.72E-03	2.20E-07	4.72E-03
Th-230	1.90E+00	7.54E+04	9.19E-06	1.00E-03	3.26E-03	1.52E-07	3.26E-03
Th-232	2.90E+00	1.40E+10	4.95E-11	1.00E-03	4.97E-03	2.32E-07	4.97E-03
Th-234	4.90E+02	6.60E-02	1.05E+01	1.00E-03	5.54E-01	2.48E-05	5.54E-01
Tritium	2.20E+03	1.23E+01	5.63E-02	4.80E+00	3.76E+00	8.43E-01	4.60E+00
U-233/234	2.80E+00	2.45E+05	2.83E-06	2.50E-03	4.80E-03	5.60E-07	4.80E-03
U-238	2.30E+00	4.46E+09	1.55E-10	2.50E-03	3.94E-03	4.60E-07	3.94E-03
SWSASSE							
Inorganics							
Manganese	2.30E+01			3.00E-02	3.94E+01	5.52E-02	3.95E+01
Organics							
1,1-Dichloroethene	5.50E-03			8.94E-01	9.42E-03	3.94E-04	9.82E-03
1,2-Dichloroethane	4.00E-03			1.35E+00	6.85E-03	4.32E-04	7.29E-03
Benzene	2.00E-03			5.76E-01	3.43E-03	9.22E-05	3.52E-03
Chloroform	1.00E-03			7.04E-01	1.71E-03	5.64E-05	1.77E-03
Vinyl Chloride	1.40E-02			1.54E+00	2.40E-02	1.73E-03	2.57E-02
Radionuclides							
Am-241	1.50E+05	4.32E+02	1.60E-03	1.00E-03	2.57E+02	1.20E-02	2.57E+02
Bi-212	5.30E+02	1.14E-04	6.07E+03	1.00E-01	2.84E-03	1.26E-05	2.85E-03
C-14	4.30E+02	5.73E+03	1.21E-04	5.50E+00	7.37E-01	1.89E-01	9.26E-01
Cd-109	3.70E+02	1.27E+00	5.47E-01	3.00E-01	6.18E-01	8.63E-03	6.27E-01
Cm-243/244	1.00E+01	2.85E+01	2.43E-02	1.00E-03	1.71E-02	7.99E-07	1.71E-02
Pu-238	9.30E+04	4.46E+09	1.55E-10	1.00E-03	1.59E+02	7.45E-03	1.59E+02
Pu-239/240	1.60E+03	2.40E+04	2.89E-05	1.00E-03	2.74E+00	1.28E-04	2.74E+00
Ra-226	1.30E+03	1.60E+03	4.33E-04	4.00E-02	2.23E+00	4.16E-03	2.23E+00
Ra-228	2.10E+01	5.75E+00	1.21E-01	4.00E-02	3.58E-02	6.68E-05	3.58E-02
Tc-99	1.60E+02	2.13E+05	3.25E-06	5.00E+00	2.74E-01	6.40E-02	3.38E-01
Th-228	4.50E+01	1.90E+00	3.65E-01	1.00E-03	7.58E-02	3.53E-06	7.58E-02

Table 11. (continued)

Analyte	Groundwater conc. (mg/l;pCi/l)	Radioactive half-life (y)	Radioactive decay constant (1/y)	Soil-to- plant B _v value	Direct irrigation (mg/kg;pCi/g)	Indirect irrigation (mg/kg;pCi/g)	Total produce concentration (mg/kg;pCi/g)
Th-230	1.80E+00	7.54E+04	9.19E-06	1.00E-03	3.08E-03	1.44E-07	3.08E-03
Th-231	3.50E+02	2.88E-03	2.41E+02	1.00E-03	4.41E-02	1.96E-06	4.41E-02
Total Radioactive Strontium	2.80E+03	2.90E+01	2.39E-02	3.00E-01	4.79E+00	6.72E-02	4.86E+00
Tritium	6.50E+07	1.23E+01	5.63E-02	4.80E+00	1.11E+05	2.49E+04	1.36E+05
U-232	7.50E-01	2.50E-03	1.33E-03	2.50E-03	1.29E-03	1.50E-07	1.29E-03
U-233/234	1.30E+03	2.45E+05	2.83E-06	2.50E-03	2.23E+00	2.60E-04	2.23E+00
U-238	1.80E+00	4.46E+09	1.55E-10	2.50E-03	3.08E-03	3.60E-07	3.09E-03
SWSA5SW							
Inorganics							
Barium	4.60E-01			1.50E-01	7.88E-01	5.52E-03	7.94E-01
Manganese	5.10E+00			3.00E-02	8.74E+00	1.22E-02	8.75E+00
Organics							
Benzene	1.00E-03			5.76E-01	1.71E-03	4.61E-05	1.76E-03
Bis(2-Ethylhexyl) Phthalate	2.20E-01			2.69E-05	3.77E-01	4.74E-07	3.77E-01
Carbon Tetrachloride	6.00E-03			2.89E-01	1.03E-02	1.39E-04	1.04E-02
Chloroform	1.00E-03			7.04E-01	1.71E-03	5.64E-05	1.77E-03
Tetrachloroethene	1.10E-01			3.04E-01	1.88E-01	2.68E-03	1.91E-01
Vinyl Chloride	2.30E-02			1.54E+00	3.94E-02	2.84E-03	4.22E-02
Radionuclides							
Am-241	2.10E+00	4.32E+02	1.60E-03	1.00E-03	3.60E-03	1.68E-07	3.60E-03
C-14	4.70E+02	5.73E+03	1.21E-04	5.50E+00	8.05E-01	2.07E-01	1.01E+00
Ca-45	2.80E+02	4.46E-01	1.55E+00	5.00E-01	4.47E-01	1.03E-02	4.57E-01
Cm-243/244	1.50E+00	2.85E+01	2.43E-02	1.00E-03	2.57E-03	1.20E-07	2.57E-03
Co-60	4.10E+01	5.27E+00	1.31E-01	8.00E-02	6.98E-02	2.61E-04	7.01E-02
K-40	1.00E+03	1.26E+09	5.50E-10	3.00E-01	1.71E+00	2.40E-02	1.74E+00
Pb-212	5.30E+01	1.06E+01	6.51E-02	1.00E-02	9.05E-02	4.23E-05	9.06E-02
Pu-238	1.50E+00	8.77E+01	7.90E-03	1.00E-03	2.57E-03	1.20E-07	2.57E-03
Ra-226	2.40E+00	1.60E+03	4.33E-04	4.00E-02	4.11E-03	7.68E-06	4.12E-03
Ra-228	5.40E+01	5.75E+00	1.21E-01	4.00E-02	9.20E-02	1.72E-04	9.22E-02
Th-228	1.30E+01	1.90E+00	3.65E-01	1.00E-03	2.19E-02	1.02E-06	2.19E-02
Th-230	6.50E+00	7.54E+04	9.19E-06	1.00E-03	1.11E-02	5.20E-07	1.11E-02
Th-232	9.00E+00	1.40E+10	4.95E-11	1.00E-03	1.54E-02	7.20E-07	1.54E-02

Table 11. (continued)

Analyte	Groundwater conc. (mg/l;pCi/l)	Radioactive half-life (y)	Radioactive decay constant (1/y)	Soil to- plant B _v value	Direct irrigation (mg/kg;pCi/g)	Indirect irrigation (mg/kg;pCi/g)	Total produce concentration (mg/kg;pCi/g)
Th-234	1.70E+02	6.60E+02	1.05E+01	1.00E-03	1.92E-01	8.61E-06	1.92E-01
Total Radioactive Strontium	3.40E+02	2.90E+01	2.39E-02	3.00E-01	5.82E-01	8.15E-03	5.90E-01
Tritium	8.10E+06	1.23E+01	5.63E-02	4.80E+00	1.38E+04	3.10E+03	1.69E+04
U-233/234	6.20E+00	2.45E+05	2.83E-06	2.50E-03	1.06E-02	1.24E-06	1.06E-02
U-238	4.30E+00	4.46E+09	1.55E-10	2.50E-03	7.37E-03	8.61E-07	7.37E-03
WOC							
Inorganics							
Barium	8.70E-01			1.50E-01	1.49E+00	1.04E-02	1.50E+00
Manganese	8.00E-01			3.00E-02	1.37E+00	1.92E-03	1.37E+00
Organics							
1,1-Dichloroethene	5.00E-03			8.94E-01	8.57E-03	3.58E-04	8.93E-03
1,2-Dichloroethene (Total)	1.90E+00			1.35E+00	3.26E+00	2.05E-01	3.46E+00
Benzene	1.90E-02			5.76E-01	3.26E-02	8.76E-04	3.34E-02
Vinyl Chloride	2.60E+00			1.54E+00	4.46E+00	3.21E-01	4.78E+00
Radionuclides							
C-14	1.10E+03	5.73E+03	1.21E-04	5.00E+00	1.88E+00	4.40E-01	2.33E+00
Pu-239/240	1.70E-01	2.40E+04	2.89E-05	1.00E-03	2.91E-04	1.36E-08	2.91E-04
Th-228	1.70E+00	1.90E+00	3.65E-01	1.00E-03	2.86E-03	1.33E-07	2.86E-03
Th-234	1.00E+03	6.60E+02	1.05E+01	1.00E-03	1.13E+00	5.07E-05	1.13E+00
Tritium	4.40E+04	1.23E+01	5.63E-02	4.80E+00	7.52E+01	1.69E+01	9.20E 01

Table 12. Concentrations of COPCs from root uptake of soil contaminants at WAG 5

Analyte	Representative concentration in soil	Soil-to-plant transfer coefficient (B_v)	Plant concentration from root uptake	Units
FS				
Inorganics				
Mercury	4.30E+00	3.80E-01	1.60E+00	MG/KG
Organics				
Aroclor 1260	1.80E-01	7.10E-04	1.30E-04	MG/KG
Radionuclides				
Co-60	1.80E+02	9.40E-03	1.70E+00	PCI/G
Cs-137	3.60E+01	2.00E-03	7.20E-02	PCI/G
Pb-212	1.50E+00	6.80E-02	1.00E-01	PCI/G
Ra-226	3.60E+00	1.40E-03	5.00E-03	PCI/G
Th-232	1.90E+00	4.20E-03	8.00E-03	PCI/G
Total Radioactive Strontium	1.20E+02	2.00E-01	2.40E+01	PCI/G
U-233/234	7.30E+00	2.50E-03	1.80E-02	PCI/G
U-238	7.00E+00	2.50E-03	1.80E-02	PCI/G
NIIFT				
Organics				
Di-n-butyl Phthalate	1.30E-01	5.60E-03	7.30E-04	MG/KG
Toluene	1.00E-03	2.60E-01	2.60E-04	MG/KG
Radionuclides				
Am-241	1.10E-01	2.50E-04	2.80E-05	PCI/G
Pu-238	2.60E-01	2.50E-04	6.60E-05	PCI/G
Ra-228	1.60E+00	1.40E-03	2.30E-03	PCI/G
Th-228	1.70E+00	4.20E-03	7.00E-03	PCI/G
Th-230	1.30E+00	4.20E-03	5.40E-03	PCI/G
Th-232	1.60E+00	4.20E-03	6.50E-03	PCI/G
U-233/234	9.70E-01	2.50E-03	2.40E-03	PCI/G
OHFP				
Inorganics				
Cadmium	1.50E+00	5.50E-01	8.00E-01	MG/KG
Organics				
Aroclor 1254	3.20E-02	3.10E-03	1.00E-04	MG/KG
Aroclor 1260	9.60E-03	7.10E-04	6.90E-06	MG/KG

Table 12. (continued)

Analyte	Representative concentration in soil	Soil-to-plant transfer coefficient (B_p)	Plant concentration from root uptake	Units
Heptachlor Epoxide	5.40E-04	2.60E-01	1.40E-04	MG/KG
Toluene	1.00E-03	2.60E-01	2.60E-04	MG/KG
Radionuclides				
Am-241	3.50E-01	2.50E-04	8.80E-05	PCI/G
Co-60	6.20E-01	9.40E-03	5.80E-03	PCI/G
Cs-137	1.10E+03	2.00E-03	2.30E+00	PCI/G
Ra-228	1.40E+00	1.40E-03	1.90E-03	PCI/G
Th-228	1.50E+00	4.20E-03	6.40E-03	PCI/G
Th-230	1.40E+00	4.20E-03	5.80E-03	PCI/G
Total Radioactive Strontium	6.50E+02	2.00E-01	1.30E+02	PCI/G
U-233/234	8.90E-01	2.50E-03	2.20E-03	PCI/G
OHFT				
Inorganics				
Silver	4.30E+00	1.50E-01	6.40E-01	MG/KG
Organics				
Bis(2-Ethylhexyl) Phthalate	1.10E-01	2.70E-05	3.00E-06	MG/KG
Cyanide	6.70E-01	1.40E+01	9.10E+00	MG/KG
Toluene	2.00E-03	2.60E-01	5.10E-04	MG/KG
Radionuclides				
Am-241	2.50E-01	2.50E-04	6.40E-05	PCI/G
Cs-137	5.80E+00	2.00E-03	1.20E-02	PCI/G
Pu-238	8.70E-01	2.50E-04	2.20E-04	PCI/G
Ra-226	1.30E+00	1.40E-03	1.90E-03	PCI/G
Ra-228	1.90E+00	1.40E-03	2.60E-03	PCI/G
Th-228	1.50E+00	4.20E-03	6.30E-03	PCI/G
Th-232	1.30E+00	4.20E-03	5.60E-03	PCI/G
U-233/234	1.20E+00	2.50E-03	3.00E-03	PCI/G
PWSB				
Inorganics				
Barium	1.90E+02	1.50E-01	2.90E+01	MG/KG
Organics				
Aroclor 1260	1.00E-02	7.10E-04	7.10E-06	MG/KG
Bis(2-Ethylhexyl) Phthalate	5.70E-02	2.70E-05	1.50E-06	MG/KG

Table 12. (continued)

Analyte	Representative concentration in soil	Soil-to-plant transfer coefficient (B_p)	Plant concentration from root uptake	Units
Chloroform	1.00E-03	7.00E-01	7.00E-04	MG/KG
Radionuclides				
Am-241	3.50E-01	2.50E-04	8.80E-05	PCI/G
Cm-243	1.80E-01	2.50E-03	4.50E-04	PCI/G
Cs-137	2.00E+00	2.00E-03	4.00E-03	PCI/G
K-40	3.50E+01	3.70E-01	1.30E+01	PCI/G
Pu-238	4.20E+00	2.50E-04	1.00E-03	PCI/G
Ra-226	1.70E+00	1.40E-03	2.40E-03	PCI/G
Ra-228	1.60E+00	1.40E-03	2.30E-03	PCI/G
Th-228	1.90E+00	4.20E-03	8.00E-03	PCI/G
Th-232	1.70E+00	4.20E-03	7.30E-03	PCI/G
Th-234	7.30E+00	4.20E-03	3.10E-02	PCI/G
Total Radioactive Strontium	3.20E+00	2.00E-01	6.30E-01	PCI/G
U-233/234	8.10E-01	2.50E-03	2.00E-03	PCI/G
SW3				
Inorganics				
Zinc	3.20E+02	4.00E-01	1.30E+02	MG/KG
Organics				
Aroclor 1254	9.30E-02	3.10E-03	2.90E-04	MG/KG
Aroclor 1260	7.80E-02	7.10E-04	5.60E-05	MG/KG
Radionuclides				
Am-241	1.20E+00	2.50E-04	3.10E-04	PCI/G
Cs-137	6.90E+00	2.00E-03	1.40E-02	PCI/G
Pu-238	3.20E-01	2.50E-04	7.90E-05	PCI/G
Pu-239/240	1.80E+00	2.50E-04	4.40E-04	PCI/G
Ra-228	1.20E+00	1.40E-03	1.70E-03	PCI/G
Th-228	1.60E+00	4.20E-03	6.80E-03	PCI/G
Th-230	1.70E+00	4.20E-03	6.90E-03	PCI/G
Total Radioactive Strontium	3.70E+00	2.00E-01	7.50E-01	PCI/G
U-232	1.50E-01	2.50E-03	3.70E-04	PCI/G
U-233/234	5.70E+00	2.50E-03	1.40E-02	PCI/G
SWSA5N				
Organics				

Table 12. (continued)

Analyte	Representative concentration in soil	Soil-to-plant transfer coefficient (B_p)	Plant concentration from root uptake	Units
1,2-Benzenedicarboxylic Acid, Diethyl Ester	3.00E-01	3.70E-01	1.10E-01	MG/KG
2-Butanone	3.00E-03	6.70E+00	2.00E-02	MG/KG
Aroclor 1260	2.60E-02	7.10E-04	1.90E-05	MG/KG
Bis(2-Ethylhexyl) Phthalate	4.50E-02	2.70E-05	1.20E-06	MG/KG
Di-n-butyl Phthalate	7.10E-02	5.60E-03	4.00E-04	MG/KG
Methylene Chloride	5.00E-03	1.70E+00	8.60E-03	MG/KG
Radionuclides				
Ac-228	2.10E+00	2.50E-03	5.30E-03	PCI/G
Bi-212	2.60E+00	1.00E-01	2.60E-01	PCI/G
Bi-214	9.40E-01	1.00E-01	9.40E-02	PCI/G
I-129	5.70E+00	2.00E-02	1.10E-01	PCI/G
Pb-212	1.50E+00	6.80E-02	9.90E-02	PCI/G
Pb-214	1.00E+00	6.80E-02	7.10E-02	PCI/G
Ra-223	5.60E-01	1.40E-03	7.80E-04	PCI/G
Ra-228	2.20E+00	1.40E-03	3.00E-03	PCI/G
Th-228	1.80E+00	4.20E-03	7.50E-03	PCI/G
Th-232	2.10E+00	4.20E-03	8.90E-03	PCI/G
Tl-208	1.60E+00	2.00E-01	3.20E-01	PCI/G
SWSA5SE				
Inorganics				
Antimony	6.20E+00	1.10E-02	6.80E-02	MG/KG
Manganese	3.30E+03	3.00E-02	9.80E+01	MG/KG
Organics				
Aroclor 1260	4.40E-02	7.10E-04	3.10E-05	MG/KG
Chloroform	1.00E-03	7.00E-01	7.00E-04	MG/KG
Radionuclides				
Ac-228	1.00E+00	2.50E-03	2.50E-03	PCI/G
Am-241	6.80E+00	2.50E-04	1.70E-03	PCI/G
Cm-243/244	3.60E+01	2.50E-03	8.90E-02	PCI/G
Cs-137	6.70E+03	2.00E-03	1.30E+01	PCI/G
Pb-212	1.90E+00	6.80E-02	1.30E-01	PCI/G
Pb-214	6.00E-01	6.80E-02	4.10E-02	PCI/G
Pu-238	8.90E-01	2.50E-04	2.20E-04	PCI/G

Table 12. (continued)

Analyte	Representative concentration in soil	Soil-to-plant transfer coefficient (B_v)	Plant concentration from root uptake	Units
Pu-239/240	7.90E-01	2.50E-04	2.00E-04	PCI/G
Ra-228	1.30E+00	1.40E-03	1.80E-03	PCI/G
Th-228	1.60E+00	4.20E-03	6.70E-03	PCI/G
Th-230	4.40E+00	4.20E-03	1.80E-02	PCI/G
Tl-208	1.00E+00	2.00E-01	2.00E-01	PCI/G
Total Radioactive Strontium	1.00E+04	2.00E-01	2.10E+03	PCI/G
U-232	5.30E-01	2.50E-03	1.30E-03	PCI/G
SWSA5SW				
Inorganics				
Barium	3.60E+02	1.50E-01	5.40E+01	MG/KG
Manganese	2.70E+03	3.00E-02	8.20E+01	MG/KG
Organics				
Aroclor 1260	1.20E+00	7.10E-04	8.50E-04	MG/KG
Chloroform	1.00E-03	7.00E-01	7.00E-04	MG/KG
Radionuclides				
Ac-228	2.30E+00	2.50E-03	5.70E-03	PCI/G
Bi-214	8.20E-01	1.00E-01	8.20E-02	PCI/G
Cs-137	8.40E+01	2.00E-03	1.70E-01	PCI/G
K-40	3.20E+01	3.70E-01	1.20E+01	PCI/G
Pb-212	1.70E+00	6.80E-02	1.20E-01	PCI/G
Pb-214	1.40E+00	6.80E-02	9.50E-02	PCI/G
Ra-226	1.50E+00	1.40E-03	2.00E-03	PCI/G
Ra-228	2.00E+00	1.40E-03	2.80E-03	PCI/G
Th-228	1.50E+00	4.20E-03	6.30E-03	PCI/G
Th-232	2.20E+00	4.20E-03	9.20E-03	PCI/G
Tl-208	1.40E+00	2.00E-01	2.80E-01	PCI/G
Total Radioactive Strontium	5.20E+03	2.00E-01	1.00E+03	PCI/G
U-233/234	9.90E+00	2.50E-03	2.50E-02	PCI/G
U-238	5.00E+00	2.50E-03	1.30E-02	PCI/G
WOC				
Inorganics				
Mercury	8.10E-01	3.80E-01	3.10E-01	MG/KG
Organics				

Table 12. (continued)

Analyte	Representative concentration in soil	Soil-to-plant transfer coefficient (B_p)	Plant concentration from root uptake	Units
Aroclor 1260	4.10E-02	7.10E-04	2.90E-05	MG/KG
Radionuclides				
Ac-228	1.80E+00	2.50E-03	4.50E-03	PCI/G
Co-57	2.30E+00	9.40E-03	2.20E-02	PCI/G
Co-60	3.60E+01	9.40E-03	3.40E-01	PCI/G
Cs-134	4.00E-02	2.00E-03	8.00E-05	PCI/G
Cs-137	5.50E+03	2.00E-03	1.10E+01	PCI/G
Na-22	1.50E+00	5.00E-02	7.50E-02	PCI/G
Pb-212	1.40E+00	6.80E-02	9.50E-02	PCI/G
Pb-214	1.40E+00	6.80E-02	9.50E-02	PCI/G
Ra-228	1.80E+00	1.40E-03	2.50E-03	PCI/G
Th-228	2.20E+00	4.20E-03	9.20E-03	PCI/G
Th-232	1.80E+00	4.20E-03	7.50E-03	PCI/G
Tl-208	2.00E+00	2.00E-01	4.00E-01	PCI/G
Total Radioactive Strontium	3.80E+02	2.00E-01	7.60E+01	PCI/G

Table 13. Parameters used for WAG 5 impoundments model (OHFP and PWSB)

Parameter	OHFP	PWSB	Reference
Flow rate (q) (cm ² /s)	3.3×10^{-4}	3.3×10^{-4}	DOE/OR/01-1128&D0
Water velocity (U) (m/s)	7.06×10^{-7}	7.06×10^{-7}	DOE/OR/01-1128&D0
Slope (s)	0.67	0.9	ORNL/sub/87-99053/8/v2
Time(t) (s)	2.07×10^7	2.2×10^7	Bechtel Job No. 19118, May, 1994
Water body volume(V) (cm ³)	1.3×10^8	5.2×10^8	ORNL/RAP/LTR-87/17

Table 14. Model parameters used to estimate the air concentrations from WAG 5 drainages

Parameter	Drainage D1	Drainage D2	Drainage D3
Wind velocity (U) (m/s)	2.0	2.0	2.0
Oxygen diffusivity (D_{20}) (m^2/s)	1.81×10^{-4}	1.81×10^{-4}	1.81×10^{-4}
Vertical dispersion (d) (m)	5.0	5.0	5.0
Henry's constant (H) ($atm \cdot m^3/mol$)	1.31×10^{-6}	1.31×10^{-6}	1.31×10^{-6}
Universal gas constant (R) ($atm \cdot m^3/^{\circ}K \cdot mol$)	8.206×10^{-5}	8.206×10^{-5}	8.206×10^{-5}
Stream velocity (U) (m/d)	3600	2900	4200
Surface water temperature (T) ($^{\circ}C$)	13.1	14.5	14.5
Stream width (b) (m)	1.0	1.0	1.0
Stream depth (Y) (m)	0.038	0.037	0.024

Table 15. Model parameters used to estimate indoor concentrations of tritium from the groundwater vapor of WAG 5

Parameter	Shower	Bathroom	House
Water use (W_d) (L/h)	480.0	42.0	42.0
Tritium Diffusion in water (DR_w) (m^2/s)	1.9×10^{-9}	1.9×10^{-9}	1.9×10^{-9}
Transfer Coefficient (ϕ_{Rw})	0.7	0.7	0.54
Tritium diffusion in air (DR_a) (m^2/s)	2.5×10^{-5}	2.5×10^{-5}	2.5×10^{-5}
Ventilation rate (VR) (m^3/h)	12.0	54.0	750.0
Exposure time (ET) (h/d)	0.25	0.33	14
Indoor-inhalation rate (IR) (m^3/d)	15	15	15
Gas specific constant (C) ($gmol.m\ HOH/ gmol.m\ air$)	4.5×10^4	4.5×10^4	4.5×10^4

Table 16. Toxicity information for the WAG 5 noncarcinogenic COPCs

Chemical	Chronic oral RfD ^{1,2} (mg/kg-d)	Confidence Level	%GI absorp.	Primary Source for GI ³	Chronic dermal RfD ⁴ (mg/kg-d)	Chronic inhalation RfD ^{5,6} (mg/kg-d)	RfD Basis	Critical effect ⁷	Uncertainty factor; Modifying factor
Inorganics									
ANTIMONY	4.0E-04	Low	.15	Friberg et al. 1986	6.0E-05		Oral, Oral-water	Longevity, blood glucose, and cholesterol (rat)	UF=1000 MF=1
ARSENIC	3.0E-04	Medium	.9	ATSDR	2.7E-04		Oral, Oral-water	Hyperpigmentation and keratosis	UF=3 MF=1
BARIUM	7.0E-02	(O) Medium	.1	Owen 1990	7.0E-03	1.4E-04	Oral, Oral-water Inhalation	(O): Increased blood pressure (I): Baritosis	(O) UF=3 (O) MF=1 (I) UF=1000
BERYLLIUM	5.0E-03	Low	.05	NA	2.5E-04		Oral	Slightly decreased body weight (rat)	UF=100 MF=1
BORON	9.0E-02	(O) Medium	1		9.0E-02	5.7E-03	Oral, Inhalation	(O): Testicular atrophy and spermatogenic arrest (dog) (I): Respiratory tract irritation and bronchitis	(O) UF=100 (O) MF=1 (I) UF=100
CADMIUM (DIET)	1.0E-03	High	.06	Owen 1990	6.0E-05		Oral	Renal toxicity, osteomalacia, osteoporosis, and significant proteinuria	UF=10 MF=1
CADMIUM (WATER)	5.0E-04	High	.06	Owen 1990	3.0E-05		Oral, Oral-water	Renal toxicity, osteomalacia, osteoporosis, and significant proteinuria	UF=10 MF=1
CHROMIUM(VI)	5.0E-03	Low	.106	ATSDR	5.3E-04		Oral	Severe liver damage and CNS involvement (?)	UF=500 MF=1
CYANIDE (CN-)	2.0E-02	Medium	.4	ATSDR	8.0E-03		Oral	Weight loss, thyroid effects, and myelin degeneration (rat)	UF=100 MF=5

Table 16. (continued)

Chemical	Chronic oral RfD ^a (mg/kg-d)	Confidence Level	%GI ^b absorp.	Primary Source for GI ^c	Chronic dermal RfD ^d (mg/kg-d)	Chronic inhalation RfD ^{e,f} (mg/kg-d)	RfD Basis	Critical effect ^g	Uncertainty factor; Modifying factor
ACETONE	1.0E-01	Low	1		1.0E-01		Oral	Kidney nephrotoxicity and increased liver and kidney weights (rat)	UF=1000 MF=1
BIS(2-ETHYLHEXYL) PHTHALATE	2.0E-02	Medium	1	US EPA 1980	2.0E-02		Oral	Increased relative liver weight (guinea pig)	UF=1000 MF=1
CARBON TETRACHLORIDE	7.0E-04	Medium	.85	ATSDR	7.0E-04		Oral	Liver lesions (rat)	UF=1000 MF=1
CHLOROFORM	1.0E-02	Medium	.98	ATSDR	9.8E-03		Oral	Liver fatty cyst formation (dog)	UF=1000 MF=1
DICHLOROBENZENE, 1,4-		(?) Medium	1	ATSDR		2.3E-01	Inhalation	(?): Increased liver weight (rat)	(?) UF=100 (?) MF=1
DICHLOROETHYLENE, 1,1-	9.0E-03	Medium	.998	ATSDR	9.0E-03		Oral, Oral-water	Hepatic lesions (rat)	UF=1000 MF=1
DICHLOROETHYLENE, 1,2-T-	2.0E-02	Low	1		2.0E-02		Oral, Oral-water	Increased serum alkaline phosphatase (mouse)	UF=1000 MF=1
METHYLENE CHLORIDE	6.0E-02	Medium	1		6.0E-02	8.6E-01	Oral, Oral-water Inhalation	(O): Liver toxicity (rat) (?): Liver toxicity (rat)	(O) UF=100 (O) MF=1 (?) UF=100
TETRACHLOROETHYLENE	1.0E-02	Medium	1	ATSDR	1.0E-02		Oral	Hepatotoxicity (mouse) Weight gain (rat)	UF=1000 MF=1

ATSDR = Agency for toxic substances and disease registry, Public Health Service (1987-1990); NA = No data available or data inclusive; GI = Gastrointestinal (%GI = percent gastrointestinal absorption); RfD = Reference dose; CNS = Central Nervous System; O = Oral and I = Inhalation, Otherwise the pathway is assumed to be oral..

If the critical effects information was derived from laboratory animal tests, the animal type appears at the end of the critical effects information enclosed within parentheses.

Otherwise, nothing follows the critical effects information, and the test subject is human; If (?) follows the critical effects information, the information was gathered from a Material Safety Data Sheet (MSDS), and no test subject was given.

^aBased on Integrated Risk Information System (IRIS) (EPA 1994).

^bBased on Health Effects Assessment Summary Tables (HEAST) (EPA 1993b)

^cThe dermal RfD = (RfD x %GI absorption); Dermal RfD = RfD (i.e., %GI = 100) when the % GI absorption value is unknown (NA), or when the % GI > 80.0

^dRfC were converted to units of mg/kg-d (i.e., RfD units) by using the inhalation rate and body weight of an adult (i.e., RfC x 20 m³/d x (1/70kg) = RfD) (EPA 1989a).

^eBEIAS (Biomedical and Environmental Information Analysis Section) Toxicity Profiles (BEIAS 1993).

Table 17. Toxicity information for the WAG 5 carcinogenic COPCs

Chemical	Oral RfD ^a (mg/kg-d)	% GI absorp.	Primary Source for GI ^b	Dermal SF ^a (mg/kg-d)	Inhalation SF ^a (mg/kg-d)	EPA Weight-of-Evidence classification	Type of cancer
Inorganic							
ARSENIC		0.9	ATSDR		5.0E+01	A (O,D)	(I): Respiratory system tumors
BERYLLIUM	4.3E+00	0.05	NA	8.6E+01	8.4E+00	B2 (I)	(I): Breast, bone, uterus, and lung tumors
CADMIUM (DIET)		0.06	Owen 1990		6.1E+00	B1 (I)	Respiratory tract and lung tumors
CADMIUM (WATER)		0.06	Owen 1990		6.1E+00	B1 (I)	Respiratory tract and lung tumors
CHROMIUM(VI)		0.106	ATSDR		4.1E+01	A (I)	(I): Lung tumors
Organic							
AROCOR-1254 ^c	7.7E+00	0.95	QIII Draft	8.1E+00		B2	Trabecular carcinoma, adenocarcinoma, and neoplastic nodule (rat)
AROCOR-1260 ^c	7.7E+00	0.9	QIII Draft	8.6E+00		B2	Trabecular carcinoma, adenocarcinoma, and neoplastic nodule (rat)
BENZENE	2.9E-02	1	ATSDR	2.9E-02	2.9E-02	A (O,I)	(O): Pulmonary tissue edema (?) (I): Leukemia
BIS(2-ETHYLHEXYL)PHTHALATE	1.4E-02	1		1.4E-02		B2	Liver neoplastic nodule and hepatocellular carcinoma (rat)
CARBON TETRACHLORIDE	1.3E-01	0.85	ATSDR	1.3E-01	5.3E-02	B2	(O): Liver tumors (I): Pulmonary edema (?)
CHLOROFORM	6.1E-03	0.98	ATSDR	6.2E-03	8.1E-02	B2 (O)	(O): Colon, rectum, bladder, and liver carcinoma (mouse)
DICHLOROBENZENE, 1,4-	2.4E-02	1	ATSDR	2.4E-02		B2	Liver tumors (mouse)
DICHLOROETHANE, 1,2-	9.1E-02	1		9.1E-02	9.1E-02	B2 (O,I)	(O): Circulatory system sarcoma (rat) (I): Liver injury (?)

Table 17. (continued)

Chemical	Oral SF (mg/kg-d)	%GI absorp.	Primary Source for GI ^a	Dermal SF ^b (mg/kg-d)	Inhalation SF ^c (mg/kg-d)	EPA Weight-of-Evidence classification	Type of cancer
DICHLOROETHYLENE, 1,1-	6.0E-01	0.998	ATSDR	6.0E-01	1.2E+00	C	(O): CNS depression (rat) (O): Kidney adenocarcinoma (mouse)
HEXACHLOROCYCLOHEXANE, ALPHA-	6.3E+00	1		6.3E+00	6.3E+00	B2	(O): Liver tumors (mouse) (O): CNS excitement (?)
HEXACHLOROCYCLOHEXANE, BETA-	1.8E+00	1		1.8E+00	1.8E+00	C	(O): Liver tumors (mouse)
METHYLENE CHLORIDE	7.5E-03	1		7.5E-03		B2	Liver hepatocellular carcinoma and neoplastic nodule (rat)
VINYL CHLORIDE	1.9E+00	1		1.9E+00	3.0E-01	A	(O): Liver and lung tumors (rat) (O): Liver, lung, brain, hematopoietic system, and digestive tract tumors

NA = No data available or data inconclusive; O = Oral and I = Inhalation, otherwise, nothing precedes the effects information, and the pathway is assumed to be Oral
If the effects information was derived from laboratory animal tests, the animal type appears at the end of the effects information enclosed within parentheses. Otherwise, nothing follows the effects information, and the test subject is human; If (?) follows the critical effects information, the information was gathered from a Material Safety Data Sheet (MSDS), and no test subject was given.

^aBased on integrated Risk Information System (IRIS) (EPA 1994) or Health Effects Assessment Summary Tables (HEAST) (EPA 1993b)
^bThe dermal SF = (SF / %GI absorption).

^cEPA Weight of Evidence Classification System for Carcinogenicity-used to characterize the extent to which available data indicate that an agent is a human carcinogen: A = human carcinogen; B1 or B2 = probable human carcinogen (B1 indicates that limited data on humans are available and B2 indicates sufficient evidence in animals and inadequate or no evidence in humans); C = possible human carcinogen; D = not classifiable as to human carcinogenicity; E = evidence of noncarcinogenicity for humans.

^dFor these archolers, the oral (7.7E+00) for polychlorinated biphenyls was used.

Table 18. Toxicity information for the WAG 5 radionuclide COPCs

Chemical	External exposure SF (g/pCi-y)	Oral SF (l/pCi)	Inhalation SF (l/pCi)	ICRP Class	EPA Class	Type of cancer
Ac-228	2.9E-6	5E-13	2.6E-11	Y	A	various
Am-241	4.9E-9	2.4E-10	3.2E-8	W	A	various
Bi-212	5.9E-7	3.1E-13	6.6E-12	W	A	various
Bi-214	5.3E-6	1.3E-13	2.1E-12	W	A	various
C-14	0	9E-13	6.4E-15	G	A	various
Ca-45	5.8E-18	9.9E-13	5.1E-12	W	A	various
Cd-109	7.3E-10	7.9E-12	6.5E-11	Y	A	various
Cm-243	1.6E-7	1.9E-10	2.6E-8	W	A	various
Cm-244	3E-11	1.6E-10	2.2E-8	W	A	various
Co-57	1.9E-7	5.8E-13	8.2E-12	Y	A	various
Co-60	8.6E-6	1.5E-11	1.5E-10	Y	A	various
Cs-134	5.2E-6	4.1E-11	2.8E-11	D	A	various
Cs-137	0	2.8E-11	1.9E-11	D	A	various
Eu-152	3.6E-6	2.1E-12	1.1E-10	W	A	various
Eu-154	4.1E-6	3E-12	1.4E-10	W	A	various
I-129	4.1E-9	1.9E-10	1.2E-10	D	A	various
K-40	5.4E-7	1.1E-11	7.6E-12	D	A	various
Mn-54	2.9E-6	1.1E-12	5.3E-12	W	A	various
Na-22	7.2E-6	6.8E-12	4.8E-12	D	A	various
Pb-210	1.3E-10	5.1E-10	1.3E-9	D	A	various
Pb-212	2.8E-7	5.5E-12	4.3E-11	D	A	various
Pb-214	6.4E-7	1.7E-13	2.9E-12	D	A	various
Pu-238	2.8E-11	2.2E-10	3.9E-8	Y	A	various
Pu-239	1.7E-11	2.3E-10	3.8E-8	Y	A	various
Pu-240	2.7E-11	2.3E-10	3.8E-8	Y	A	various
Ra-223	2.3E-7	6.4E-11	3.1E-9	W	A	various
Ra-226	1.2E-8	1.2E-10	3.0E-9	W	A	various
Ra-228	0	1.0E-10	6.6E-10	W	A	various
Rn-219	1.6E-7		4.6E-14	G	A	various
Sr-89	0	3.60E-11	6.20E-11	D	A	various
Sr-90	0	3.60E-11	5.60E-11	D	A	various

Table 18. (continued)

Chemical	External exposure SF ^a (g/pCi-y)	Oral SF ^a (l/pCi)	Inhalation SF ^a (l/pCi)	ICRP Class ^{b,c}	EPA Class ^c	Type of cancer
Tc-99	6.0E-13	1.3E-12	8.3E-12	W	A	various
Th-228	5.5E-10	1.1E-11	7.7E-8	Y	A	various
Th-230	5.4E-11	1.3E-11	2.9E-8	Y	A	various
Th-231	2.3E-9	4.0E-13	4.9E-13	Y	A	various
Th-232	2.6E-11	1.2E-11	2.8E-8	Y	A	various
Th-234	3.5E-9	4E-12	3.2E-11	Y	A	various
Ti-208	0.000013	1.8E-14	5E-15	D	A	various
U-232	4.6E-11	3.7E-11	6E-8	Y	A	various
U-233	4.2E-11	1.6E-11	2.7E-8	Y	A	various
U-234	3E-11	1.6E-11	2.6E-8	Y	A	various
U-235	2.4E-7	1.6E-11	2.5E-8	Y	A	various
U-236	2.4E-11	1.5E-11	2.5E-8	Y	A	various
U-238	2.1E-11	1.6E-11	2.4E-8	Y	A	various

^aBased on Health Effects Assessment Summary Tables (HEAST) (EPA 1993b); Radionuclide slope factors include contributions from daughter products.

^bLung clearance classification recommended by the International Commission on Radiological Protection (ICRP): Y = Year, W = Week, D = Day, G = Gas

^cEPA Weight of Evidence Classification System for Carcinogenicity-used to characterize the extent to which available data indicate that an agent is a human carcinogen: A = human carcinogen; B1 or B2 = probable human carcinogen (B1 indicates that limited data on humans are available and B2 indicates sufficient evidence in animals and inadequate or no evidence in humans); C = possible human carcinogen; D = not classifiable as to human carcinogenicity; E = evidence of noncarcinogenicity for humans.

B. EXHIBITS

5

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APPENDIX B

Exhibits

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Exhibit 1a. COPCs evaluated quantitatively^a for WAG 5 soil

Analyte	Frequency of Detection	Representative Concentration ^b	Units
FS			
Inorganics			
Mercury	1/1	4.30E+00	MG/KG
Organics			
Aroclor 1260	1/1	1.80E-01	MG/KG
Radionuclides			
Co-60	1/1	1.80E+02	PCI/G
Cs-137	1/1	3.60E+01	PCI/G
Pb-212	1/1	1.50E+00	PCI/G
Ra-226	1/1	3.60E+00	PCI/G
Th-232	1/1	1.90E+00	PCI/G
Total Radioactive Strontium	1/1	1.20E+02	PCI/G
U-233/234	1/1	7.30E+00	PCI/G
U-238	1/1	7.00E+00	PCI/G
NHFT			
Organics			
Di-n-butyl Phthalate	2/2	1.30E-01	MG/KG
Toluene	1/6	1.00E-03	MG/KG
Radionuclides			
Am-241	1/2	1.10E-01	PCI/G
Pu-238	2/2	2.60E-01	PCI/G
Ra-228	2/2	1.60E+00	PCI/G
Th-228	2/2	1.70E+00	PCI/G
Th-230	2/2	1.30E+00	PCI/G
Th-232	2/2	1.60E+00	PCI/G
U-233/234	2/2	9.70E-01	PCI/G
OHFP			
Inorganics			
Cadmium	1/5	1.50E+00	MG/KG
Organics			
Aroclor 1254	1/4	3.20E-02	MG/KG
Aroclor 1260	1/4	9.60E-03	MG/KG
Heptachlor Epoxide	1/4	5.40E-04	MG/KG

Exhibit 1a. (continued)

Analyte	Frequency of detection	Representative Concentration ^b	Units
Toluene	1/8	1.00E-03	MG/KG
Radionuclides			
Am-241	4/5	3.50E-01	PCI/G
Co-60	4/4	6.20E-01	PCI/G
Cs-137	5/5	1.10E+03	PCI/G
Ra-228	4/5	1.40E+00	PCI/G
Th-228	5/5	1.50E+00	PCI/G
Th-230	5/5	1.40E+00	PCI/G
Total Radioactive Strontium	4/5	6.50E+02	PCI/G
U-233/234	5/5	8.90E-01	PCI/G
OHFT			
Inorganics			
Silver	2/5	4.30E+00	MG/KG
Organics			
Bis(2-Ethylhexyl) Phthalate	1/5	1.10E-01	MG/KG
Cyanide	1/5	6.70E-01	MG/KG
Toluene	3/15	2.00E-03	MG/KG
Radionuclides			
Am-241	4/5	2.50E-01	PCI/G
Cs-137	5/5	5.80E+00	PCI/G
Pu-238	3/5	8.70E-01	PCI/G
Ra-226	5/5	1.30E+00	PCI/G
Ra-228	5/5	1.90E+00	PCI/G
Th-228	5/5	1.50E+00	PCI/G
Th-232	5/5	1.30E+00	PCI/G
U-233/234	5/5	1.20E+00	PCI/G
PWSB			
Inorganics			
Barium	5/5	1.90E+02	MG/KG
Organics			
Aroclor 1260	1/5	1.00E-02	MG/KG
Bis(2-Ethylhexyl) Phthalate	1/5	5.70E-02	MG/KG
Chloroform	1/14	1.00E-03	MG/KG

Exhibit 1a. (continued)

Analyte	Frequency of detection	Representative Concentration ^b	Units
Radionuclides			
Am-241	2/2	3.50E-01	PCI/G
Cm-243	1/2	1.80E-01	PCI/G
Cs-137	3/5	2.00E+00	PCI/G
K-40	5/5	3.50E+01	PCI/G
Pu-238	1/2	4.20E+00	PCI/G
Ra-226	5/5	1.70E+00	PCI/G
Ra-228	5/5	1.60E+00	PCI/G
Th-228	4/4	1.90E+00	PCI/G
Th-232	4/4	1.70E+00	PCI/G
Th-234	1/1	7.30E+00	PCI/G
Total Radioactive Strontium	3/5	3.20E+00	PCI/G
U-233/234	4/4	8.10E-01	PCI/G
SW3			
Inorganics			
Zinc	1/1	3.20E+02	MG/KG
Organics			
Aroclor 1254	1/1	9.30E-02	MG/KG
Aroclor 1260	1/1	7.80E-02	MG/KG
Radionuclides			
Am-241	1/1	1.20E+00	PCI/G
Cs-137	1/1	6.90E+00	PCI/G
Pu-238	1/1	3.20E-01	PCI/G
Pu-239/240	1/1	1.80E+00	PCI/G
Ra-228	1/1	1.20E+00	PCI/G
Th-228	1/1	1.60E+00	PCI/G
Th-230	1/1	1.70E+00	PCI/G
Total Radioactive Strontium	1/1	3.70E+00	PCI/G
U-232	1/1	1.50E-01	PCI/G
U-233/234	1/1	5.70E+00	PCI/G

SWSA 5N

Organics

Exhibit 1a. (continued)

Analyte	Frequency of detection	Representative Concentration ^b	Units
1,2-Benzenedicarboxylic Acid, Diethyl Ester	1/6	3.00E-01	MG/KG
2-Butanone	1/12	3.00E-03	MG/KG
Aroclor 1260	1/6	2.60E-02	MG/KG
Bis(2-Ethylhexyl) Phthalate	1/6	4.50E-02	MG/KG
Di-n-butyl Phthalate	2/6	7.10E-02	MG/KG
Methylene Chloride	2/12	5.00E-03	MG/KG
Radionuclides			
Ac-228	5/5	2.10E+00	PCI/G
Bi-212	2/2	2.60E+00	PCI/G
Bi-214	1/1	9.40E-01	PCI/G
I-129	1/1	5.70E+00	PCI/G
Pb-212	6/6	1.50E+00	PCI/G
Pb-214	6/6	1.00E+00	PCI/G
Ra-223	1/1	5.60E-01	PCI/G
Ra-228	5/6	2.20E+00	PCI/G
Th-228	5/5	1.80E+00	PCI/G
Th-232	5/5	2.10E+00	PCI/G
Tl-208	5/5	1.60E+00	PCI/G
SWSA SSE			
Inorganics			
Antimony	1/1	6.20E+00	MG/KG
Manganese	5/5	3.30E+03	MG/KG
Organics			
Aroclor 1260	1/5	4.40E-02	MG/KG
Chloroform	1/8	1.00E-03	MG/KG
Radionuclides			
Ac-228	1/1	1.00E+00	PCI/G
Am-241	1/2	6.80E+00	PCI/G
Cm-243/244	1/2	3.60E+01	PCI/G
Cs-137	5/5	6.70E+03	PCI/G
Pb-212	1/1	1.90E+00	PCI/G
Pb-214	1/1	6.00E-01	PCI/G

Exhibit 1a. (continued)

Analyte	Frequency of detection	Representative Concentration ^b	Units
Pu-238	1/2	8.90E-01	PCI/G
Pu-239/240	1/2	7.90E-01	PCI/G
Ra-228	3/5	1.30E+00	PCI/G
Th-228	2/3	1.60E+00	PCI/G
Th-230	1/3	4.40E+00	PCI/G
Tl-208	1/1	1.00E+00	PCI/G
Total Radioactive Strontium	5/5	1.00E+04	PCI/G
U-232	1/1	5.30E-01	PCI/G
U-233	1/1	11	PCI/G
SWSA5SW			
Inorganics			
Barium	5/5	3.60E+02	MG/KG
Manganese	5/5	2.70E+03	MG/KG
Organics			
Aroclor 1260	1/5	1.20E+00	MG/KG
Chloroform	1/9	1.00E-03	MG/KG
Radionuclides			
Ac-228	3/3	2.30E+00	PCI/G
Bi-214	1/1	8.20E-01	PCI/G
Cs-137	5/6	8.40E+01	PCI/G
K-40	6/6	3.20E+01	PCI/G
Pb-212	4/4	1.70E+00	PCI/G
Pb-214	2/2	1.40E+00	PCI/G
Ra-226	6/6	1.50E+00	PCI/G
Ra-228	6/6	2.00E+00	PCI/G
Th-228	3/3	1.50E+00	PCI/G
Th-232	5/5	2.20E+00	PCI/G
Tl-208	2/2	1.40E+00	PCI/G
Total Radioactive Strontium	6/6	5.20E+03	PCI/G
U-233/234	2/2	9.90E+00	PCI/G
U-238	2/2	5.00E+00	PCI/G

WOC

Inorganics

Exhibit 1a. (continued)

Analyte	Frequency of detection	Representative Concentration ^b	Units
Mercury	1/4	8.10E-01	MG/KG
Organics			
Aroclor 1260	2/4	4.10E-02	MG/KG
Radionuclides			
Ac-228	2/2	1.80E+00	PCI/G
Co-57	1/1	2.30E+00	PCI/G
Co-60	1/1	3.60E+01	PCI/G
Cs-134	1/1	4.00E-02	PCI/G
Cs-137	3/4	5.50E+03	PCI/G
Na-22	1/1	1.50E+00	PCI/G
Pb-212	2/2	1.40E+00	PCI/G
Pb-214	2/2	1.40E+00	PCI/G
Ra-228	3/4	1.80E+00	PCI/G
Th-228	1/1	2.20E+00	PCI/G
Th-232	3/3	1.80E+00	PCI/G
Tl-208	1/1	2.00E+00	PCI/G
Total Radioactive Strontium	2/4	3.80E+02	PCI/G

^a Analytes evaluated quantitatively have at least one detected value with an EPA-approved slope factors and/or reference doses.

^b The representative concentration is the smallest of two values : the maximum detected concentration versus the upper 95% confidence limit on the mean concentration (EPA 1989a)

Exhibit 1b. COPCs evaluated quantitatively^a for WAG 5 sediment

Analyte	Frequency of Detection	Representative Concentration ^b	Units
D1			
Inorganics			
Chromium VI	4/4	3.30E+01	MG/KG
Manganese	4/4	4.90E+03	MG/KG
Mercury	3/4	1.40E-01	MG/KG
Nickel	4/4	6.60E+01	MG/KG
Silver	3/4	2.30E+00	MG/KG
Organics			
Aroclor 1260	4/4	8.30E-01	MG/KG
Radionuclides			
Ac-228	1/1	1.40E+00	PCI/G
Am-241	2/2	6.50E-01	PCI/G
Bi-212	1/1	1.50E+00	PCI/G
Bi-214	1/1	8.60E-01	PCI/G
Co-60	4/4	3.10E-01	PCI/G
Pb-212	1/1	1.30E+00	PCI/G
Pb-214	1/1	9.30E-01	PCI/G
Ra-223	1/1	3.70E-01	PCI/G
Radon 219	1/1	4.70E-01	PCI/G
Th-230	4/4	3.20E+00	PCI/G
Th-234	1/1	1.10E+01	PCI/G
Total Radioactive Strontium	4/4	1.30E+00	PCI/G
Tritium	4/4	2.30E+03	PCI/G
U-233/234	4/4	8.80E+00	PCI/G
U-235	4/4	3.60E-01	PCI/G
U-238	4/4	1.30E+01	PCI/G
D2			
Inorganics			
Arsenic	4/4	1.40E+01	MG/KG
Barium	4/4	1.60E+03	MG/KG
Chromium VI	4/4	2.20E+01	MG/KG
Manganese	4/4	4.30E+04	MG/KG
Organics			

Exhibit 1b. (continued)

Analyte	Frequency of Detection	Representative Concentration ^b	Units
Aroclor 1260	2/4	8.50E-02	MG/KG
Vinyl Chloride	2/4	1.00E+00	MG/KG
Radionuclides			
Ac-228	4/4	2.30E+00	PCI/G
Bi-212	1/1	1.70E+00	PCI/G
Bi-214	3/3	1.20E+00	PCI/G
Cm-243/244	2/2	5.50E+00	PCI/G
Co-60	4/4	6.30E-01	PCI/G
I-129	3/3	1.40E+01	PCI/G
Pb-212	4/4	1.70E+00	PCI/G
Pb-214	4/4	1.20E+00	PCI/G
Pu-238	3/3	3.10E+01	PCI/G
Ra-223	2/2	9.10E-01	PCI/G
Ra-224	3/3	4.90E+00	PCI/G
Ra-226	3/4	2.90E+00	PCI/G
Radon 219	2/2	1.20E+00	PCI/G
Tl-208	4/4	1.40E+00	PCI/G
Total Radioactive Strontium	4/4	1.30E+03	PCI/G
U-233/234	3/3	1.60E+01	PCI/G
U-235	1/3	4.10E-01	PCI/G
U-238	3/3	2.40E+00	PCI/G
D3			
Inorganics			
Chromium VI	1/1	1.80E+01	MG/KG
Mercury	1/1	9.00E-02	MG/KG
Selenium	1/1	1.70E+00	MG/KG
Organics			
Chloroform	1/1	2.00E-03	MG/KG
Radionuclides			
Ac-228	1/1	1.50E+00	PCI/G
Bi-214	1/1	9.10E-01	PCI/G
I-129	1/1	1.30E+00	PCI/G
Pb-210	1/1	2.70E+00	PCI/G

Exhibit 1b. (continued)

Analyte	Frequency of Detection	Representative Concentration ^b	Units
Pb-212	1/1	1.40E+00	PCI/G
Pb-214	1/1	1.00E+00	PCI/G
Tl-208	1/1	1.10E+00	PCI/G
OHFP			
Inorganics			
Chromium VI	1/1	3.80E+01	MG/KG
Mercury	1/1	3.10E+00	MG/KG
Silver	1/1	5.90E+00	MG/KG
Zinc	1/1	1.50E+02	MG/KG
Organics			
Aroclor 1254	1/1	2.30E+00	MG/KG
Aroclor 1260	1/1	6.30E-01	MG/KG
Radionuclides			
Am-241	1/1	8.80E+02	PCI/G
Cm-243/244	1/1	2.40E+04	PCI/G
Co-60	1/1	6.30E+03	PCI/G
Cs-137	1/1	3.70E+06	PCI/G
Pu-238	1/1	1.20E+03	PCI/G
Pu-239/240	1/1	6.40E+02	PCI/G
Th-228	1/1	1.70E+02	PCI/G
Th-230	1/1	3.10E+02	PCI/G
Total Radioactive Strontium	1/1	7.40E+05	PCI/G
U-232	1/1	3.80E+01	PCI/G
U-233	1/1	1600	PCI/G
PWSB			
Inorganics			
Antimony	1/4	2.80E+01	MG/KG
Chromium VI	4/4	6.40E+01	MG/KG
Mercury	4/4	2.80E+01	MG/KG
Zinc	4/4	1.60E+03	MG/KG
Organics			
4-Methyl Phenol	4/4	2.60E+01	MG/KG
Aroclor 1248	2/4	1.20E+00	MG/KG

Exhibit 1b. (continued)

Analyte	Frequency of Detection	Representative Concentration ^b	Units
Aroclor 1254	4/4	1.30E+00	MG/KG
Radionuclides			
Am-241	5/5	1.20E+03	PCI/G
Cm-243/244	5/5	1.10E+03	PCI/G
Co-60	5/5	5.90E+03	PCI/G
Cs-137	5/5	1.80E+04	PCI/G
Eu-152	1/2	9.60E+02	PCI/G
Eu-154	1/3	5.80E+02	PCI/G
Pu-238	5/5	1.20E+02	PCI/G
Pu-239/240	5/5	1.40E+02	PCI/G
Th-228	5/5	3.80E+02	PCI/G
Total Radioactive Strontium	5/5	1.20E+05	PCI/G
U-232	5/5	3.20E+02	PCI/G
U-238	5/5	1.10E+02	PCI/G

^a Analytes evaluated quantitatively have at least one detected value with an EPA-approved slope factors and/or reference doses.

^b The representative concentration is the smallest of two values : the maximum detected concentration versus the upper 95% confidence limit on the mean concentration (EPA 1989a)

Exhibit 1c. COPCs evaluated quantitatively* for WAG 5 groundwater

Analyte	Frequency of Detection	Representative Concentration ^b	Units
FS			
Inorganics			
Barium	2/2	9.30E-01	MG/L
Beryllium	2/2	6.20E-03	MG/L
Chromium VI	2/2	2.40E-01	MG/L
Manganese	2/2	2.30E+00	MG/L
Nickel	2/2	1.70E-01	MG/L
Vanadium	2/2	1.40E-01	MG/L
Radionuclides			
Am-241	1/1	4.20E-01	PCI/L
Ra-226	2/2	3.00E+00	PCI/L
Ra-228	1/2	4.30E+00	PCI/L
Th-228	2/2	3.20E+01	PCI/L
Th-230	2/2	2.40E+01	PCI/L
Th-232	2/2	3.50E+01	PCI/L
Tritium	2/2	1.10E+05	PCI/L
OHFP			
Organics			
1,1-Dichloroethane	1/1	8.00E-03	MG/L
1,2-Dichloroethane	1/1	3.00E-03	MG/L
Carbon Tetrachloride	1/1	9.00E-03	MG/L
Chloroform	1/1	2.50E-02	MG/L
Nitrate	1/1	1.10E+00	MG/L
Trichloroethene	1/1	7.00E-03	MG/L
Radionuclides			
C-14	4/5	1.20E+03	PCI/L
Cm-243/244	2/5	4.40E+00	PCI/L
Co-60	2/2	8.90E+01	PCI/L
Cs-137	1/5	1.70E+03	PCI/L
Pu-238	2/5	5.40E-01	PCI/L
Ra-226	1/4	4.90E-01	PCI/L
Ra-228	1/4	2.50E+02	PCI/L
Tc-99	4/5	4.20E+01	PCI/L

Exhibit 1c. (continued)

Analyte	Frequency of Detection	Representative Concentration ^b	Units
Th-234	1/1	1.70E+02	PCI/L
Total Radioactive Strontium	5/5	2.70E+04	PCI/L
Tritium	5/5	2.00E+06	PCI/L
U-233/234	1/5	9.00E+00	PCI/L
PWSB			
Inorganics			
Chromium VI	1/3	0.004	MG/L
Organics			
Acetone	1/4	1.20E-02	MG/L
Bis(2-Ethylhexyl) Phthalate	2/3	8.20E-02	MG/L
Radionuclides			
Am-241	1/5	1.30E-01	PCI/L
Ra-226	1/2	2.20E-01	PCI/L
Ra-228	2/2	1.10E+00	PCI/L
Th-228	1/2	4.00E-01	PCI/L
Tritium	6/6	1.20E+04	PCI/L
U-233/234	4/5	7.20E-01	PCI/L
U-238	3/5	3.90E-01	PCI/L
SWSA 5N			
Inorganics			
Barium	11/11	9.20E-01	MG/L
Beryllium	4/11	2.30E-03	MG/L
Chromium VI	7/11	1.10E-01	MG/L
Manganese	10/11	2.30E+00	MG/L
Nickel	9/11	1.50E-01	MG/L
Vanadium	7/11	5.30E-02	MG/L
Organics			
Bis(2-Ethylhexyl) Phthalate	2/10	1.30E-02	MG/L
Methylene Chloride	1/10	1.60E-02	MG/L
Radionuclides			
Am-241	9/1	3.20E+00	PCI/L
C-14	3/23	1.20E+02	PCI/L
Cm-243	2/16	2.30E-01	PCI/L

Exhibit 1c. (continued)

Analyte	Frequency of Detection	Representative Concentration ^b	Units
Cm-243/244	7/19	3.90E+01	PCI/L
K-40	4/4	6.20E+02	PCI/L
Pb-212	7/7	3.40E+01	PCI/L
Pu-238	6/27	5.50E-01	PCI/L
Ra-226	12/21	3.10E+00	PCI/L
Ra-228	6/15	1.70E+01	PCI/L
Tc-99	8/20	2.30E+01	PCI/L
Th-228	10/21	2.80E+00	PCI/L
Th-230	12/21	1.90E+00	PCI/L
Th-232	12/22	2.90E+00	PCI/L
Th-234	3/3	4.90E+02	PCI/L
Tritium	22/29	2.20E+03	PCI/L
U-233/234	15/24	2.80E+00	PCI/L
U-238	9/24	2.30E+00	PCI/L
SWSA SSE			
Inorganics			
Chromium VI	8/15	1.00E-01	MG/L
Manganese	15/15	2.30E+01	MG/L
Organics			
1,1-Dichloroethene	2/16	5.50E-03	MG/L
1,2-Dichloroethane	4/16	4.00E-03	MG/L
Benzene	2/16	2.00E-03	MG/L
Bis(2-Ethylhexyl) Phthalate	1/10	5.00E-03	MG/L
Chloroform	1/16	1.00E-03	MG/L
Trichloroethene	10/16	3.00E-02	MG/L
Vinyl Chloride	7/16	1.40E-02	MG/L
Radionuclides			
Am-241	11/21	1.50E+05	PCI/L
Bi-212	1/1	5.30E+02	PCI/L
C-14	10/22	4.30E+02	PCI/L
Cd-109	1/1	3.70E+02	PCI/L
Cm-243/244	12/18	1.00E+01	PCI/L
Pu-238	10/23	9.30E+04	PCI/L

Exhibit 1c. (continued)

Analyte	Frequency of Detection	Representative Concentration ^b	Units
Pu-239/240	5/23	1.60E+03	PCI/L
Ra-226	5/15	1.30E+03	PCI/L
Ra-228	7/13	2.10E+01	PCI/L
Tc-99	6/13	1.60E+02	PCI/L
Th-228	6/14	4.50E+01	PCI/L
Th-230	5/14	1.80E+00	PCI/L
Th-231	1/1	3.50E+02	PCI/L
Total Radioactive Strontium	20/22	2.80E+03	PCI/L
Tritium	22/22	6.50E+07	PCI/L
U-232	1/11	7.50E-01	PCI/L
U-233/234	14/23	1.30E+03	PCI/L
U-238	6/23	1.80E+00	PCI/L
SWSASSW			
Inorganics			
Barium	10/10	4.60E-01	MG/L
Chromium VI	7/10	7.40E-02	MG/L
Manganese	10/10	5.10E+00	MG/L
Organics			
Benzene	1/10	1.00E-03	MG/L
Bis(2-Ethylhexyl) Phthalate	3/9	2.20E-01	MG/L
Carbon Tetrachloride	1/10	6.00E-03	MG/L
Chloroform	1/10	1.00E-03	MG/L
Tetrachloroethene	2/10	1.10E-01	MG/L
Vinyl Chloride	2/10	2.30E-02	MG/L
Radionuclides			
Am-241	5/11	2.10E+00	PCI/L
C-14	11/14	4.70E+02	PCI/L
Ca-45	1/3	2.80E+02	PCI/L
Cm-243/244	4/9	1.50E+00	PCI/L
Co-60	2/5	4.10E+01	PCI/L
K-40	2/2	1.00E+03	PCI/L
Pb-212	1/1	5.30E+01	PCI/L
Pu-238	5/12	1.50E+00	PCI/L

Exhibit 1c. (continued)

Analyte	Frequency of Detection	Representative Concentration ^a	Units
Ra-226	7/9	2.40E+00	PCI/L
Ra-228	4/8	5.40E+01	PCI/L
Th-228	6/9	1.30E+01	PCI/L
Th-230	4/9	6.50E+00	PCI/L
Th-232	6/9	9.00E+00	PCI/L
Th-234	1/1	1.70E+02	PCI/L
Total Radioactive Strontium	10/13	3.40E+02	PCI/L
Tritium	14/14	8.10E+06	PCI/L
U-233/234	10/12	6.20E+00	PCI/L
U-238	4/12	4.30E+00	PCI/L
WOC			
Inorganics			
Barium	5/5	8.70E-01	MG/L
Manganese	4/5	8.00E-01	MG/L
Organics			
1,1-Dichloroethene	2/6	5.00E-03	MG/L
1,2-Dichloroethene (Total)	2/6	1.90E+00	MG/L
Benzene	2/6	1.90E-02	MG/L
Vinyl Chloride	2/6	2.60E+00	MG/L
Radionuclides			
C-14	4/9	1.10E+03	PCI/L
Pu-239/240	1/10	1.70E-01	PCI/L
Th-228	1/5	1.70E+00	PCI/L
Th-234	1/1	1.00E+03	PCI/L
Tritium	8/10	4.40E+04	PCI/L

^a Analytes evaluated quantitatively have at least one detected value with an EPA-approved slope factors and/or reference doses.

^bThe representative concentration is the smallest of two values : the maximum detected concentration versus the upper 95% confidence limit on the mean concentration (EPA 1989a)

Exhibit 1d. COPCs evaluated quantitatively^a for WAG 5 surface water

Analyte	Frequency of Detection	Representative Concentration ^b	Units
High Base			
D1			
Inorganics			
Manganese	1/1	2.60E-01	MG/L
Radionuclides			
Pu-238	1/1	2.90E-01	PCI/L
Total Radioactive Strontium	1/1	2.40E+01	PCI/L
Tritium	1/1	5.50E+04	PCI/L
U-233/234	1/1	2.70E+01	PCI/L
U-238	1/1	4.50E+01	PCI/L
D2			
Inorganics			
Manganese	1/1	2.60E+00	MG/L
Radionuclides			
C-14	1/1	3.20E+02	PCI/L
Total Radioactive Strontium	1/1	2.50E+03	PCI/L
Tritium	1/1	7.60E+06	PCI/L
U-233/234	1/1	3.70E+00	PCI/L
D3			
Inorganics			
Manganese	1/1	2.40E-01	MG/L
Radionuclides			
Tritium	1/1	2.40E+03	PCI/L
Organics			
4-Methyl Phenol	1/1	8.00E-03	MG/L
4-Methyl-2-Pentanone	1/1	1.00E-03	MG/L
Radionuclides			
Ca-45	1/1	9.90E+02	PCI/L
Total Radioactive Strontium	1/1	1.40E+03	PCI/L

High Base Storm**Organics**

Exhibit 1d. (continued)

Analyte	Frequency of detection	Representative Concentration ^a	Units
2-Butanone	1/1	7.00E-03	MG/L
Bis(2-Ethylhexyl) Phthalate	1/1	4.00E-03	MG/L
Radionuclides			
Th-230	1/1	5.30E+00	PCI/L
Total Radioactive Strontium	1/1	1.60E+01	PCI/L
Tritium	1/1	2.50E+04	PCI/L
U-233/234	1/1	5.10E+01	PCI/L
U-238	1/1	8.10E+01	PCI/L
D2			
Organics			
1,1-Dichloroethane	1/1	2.00E-03	MG/L
1,2-Dichloroethene (Total)	1/1	3.00E-03	MG/L
Bis(2-Ethylhexyl) Phthalate	1/1	6.00E-03	MG/L
Trichloroethene	1/1	1.00E-03	MG/L
Radionuclides			
C-14	1/1	1.20E+02	PCI/L
Pu-238	1/1	1.40E+01	PCI/L
Tc-99	1/1	3.80E+01	PCI/L
Th-230	1/1	1.00E+01	PCI/L
Total Radioactive Strontium	1/1	1.40E+03	PCI/L
Tritium	1/1	4.20E+06	PCI/L
D3			
Radionuclides			
Total Radioactive Strontium	1/1	5.70E+01	PCI/L
Impoundment			
OHFP			
Organics			
Bis(2-Ethylhexyl) Phthalate	1/1	1.00E-03	MG/L
Radionuclides			
Am-241	1/1	3.90E-01	PCI/L
Cm-243/244	1/1	1.60E+01	PCI/L

Exhibit 1d. (continued)

Analyte	Frequency of detection	Representative Concentration ^a	Units
Co-60	1/1	1.50E+02	PCI/L
Cs-137	1/1	2.50E+04	PCI/L
Pu-238	1/1	3.20E-01	PCI/L
Pu-239/240	1/1	5.10E-01	PCI/L
Tc-99	1/1	4.30E+01	PCI/L
Total Radioactive Strontium	1/1	9.00E+04	PCI/L
Tritium	1/1	2.00E+04	PCI/L
U-232	1/1	3.30E+00	PCI/L
U-233/234	1/1	1.00E+02	PCI/L
PWSB			
Organics			
Bromomethane	1/1	2.00E-03	MG/L
Radionuclides			
Am-241	1/1	5.00E-01	PCI/L
Cm-243/244	1/1	5.10E+00	PCI/L
Co-60	1/1	1.30E+02	PCI/L
Cs-137	1/1	4.90E+01	PCI/L
Total Radioactive Strontium	1/1	6.00E+03	PCI/L
Tritium	1/1	9.50E+03	PCI/L
U-232	1/1	2.20E+01	PCI/L
U-233/234	1/1	2.60E+02	PCI/L
U-238	1/1	4.80E+00	PCI/L
Low Base			
D1			
Radionuclides			
Pb-212	1/1	2.10E+01	PCI/L
Total Radioactive Strontium	1/1	3.00E+01	PCI/L
Tritium	1/1	1.20E+05	PCI/L
U-233/234	1/1	1.00E+01	PCI/L
U-238	1/1	1.90E+01	PCI/L
D2			
Inorganics			

Exhibit 1d. (continued)

Analyte	Frequency of detection	Representative Concentration ^b	Units
Manganese	1/1	2.90E+00	MG/L
Radionuclides			
Am-241	1/1	9.30E+00	PCI/L
C-14	1/1	1.80E+02	PCI/L
Pu-238	1/1	1.80E+01	PCI/L
Ra-228	1/1	1.60E+03	PCI/L
Total Radioactive Strontium	1/1	1.80E+03	PCI/L
Tritium	1/1	9.60E+05	PCI/L
U-233/234	1/1	3.20E+00	PCI/L
D3			
Radionuclides			
Tritium	1/1	2.70E+03	PCI/L
Low Base Storm			
D1			
Organics			
Bis(2-Ethylhexyl) Phthalate	1/1	1.00E-03	MG/L
Radionuclides			
Tritium	1/1	2.80E+04	PCI/L
U-233/234	1/1	1.10E+01	PCI/L
U-238	1/1	1.70E+01	PCI/L
D2			
Inorganics			
Manganese	3/3	3.00E+00	MG/L
Radionuclides			
Am-241	1/1	9.00E-01	PCI/L
C-14	1/1	1.80E+02	PCI/L
Pu-238	1/1	1.90E+01	PCI/L
Total Radioactive Strontium	1/1	2.10E+03	PCI/L
Tritium	1/1	1.10E+07	PCI/L
U-233/234	1/1	6.20E+00	PCI/L
D3			
Inorganics			

Exhibit 1d. (continued)

Analyte	Frequency of detection	Representative Concentration ^b	Units
Manganese	3/3	3.60E-01	MG/L
Organics			
Bis(2-Ethylhexyl) Phthalate	1/1	3.00E-03	MG/L
Radionuclides			
Am-241	1/1	7.40E-02	PCI/L

^a Analytes evaluated quantitatively have at least one detected value with an EPA-approved slope factors and/or reference doses.

^b The representative concentration is the smallest of two values : the maximum detected concentration versus the upper 95% confidence limit on the mean concentration (EPA 1989a)

Exhibit 2a. COPCs evaluated qualitatively^a for WAG 5 soil

Analyte	Frequency of Detection	Representative Concentration ^b	Units
FS			
Radionuclides			
Alpha Particle	1/1	2.40E+01	PCI/G
Beta Particle	1/1	3.80E+02	PCI/G
NHFT			
Organics			
Total Organic Carbon	2/2	4.00E+02	MG/KG
p-Nitrophenol	1/2	5.80E-02	MG/KG
Radionuclides			
Alpha Particle	2/2	8.60E+00	PCI/G
Beta Particle	2/2	3.30E+01	PCI/G
OHFP			
Organics			
Chlordane, Gamma-	1/4	1.30E-03	MG/KG
Total Organic Carbon	2/2	6.40E+03	MG/KG
p-Nitrophenol	1/4	8.20E-02	MG/KG
Radionuclides			
Alpha Particle	5/5	1.30E+02	PCI/G
Beta Particle	5/5	3.40E+03	PCI/G
OHFT			
Organics			
Total Organic Carbon	5/5	4.50E+03	MG/KG
Radionuclides			
Alpha Particle	5/5	1.30E+01	PCI/G
Beta Particle	5/5	3.20E+01	PCI/G
PWSB			
Organics			
Total Organic Carbon	2/2	1.20E+03	MG/KG
Radionuclides			
Alpha Particle	5/5	2.00E+01	PCI/G
Beta Particle	5/5	5.60E+01	PCI/G
SW3			

Exhibit 2a. (continued)

Analyte	Frequency of Detection	Representative Concentration ^b	Units
Radionuclides			
Alpha Particle	1/1	1.00E+01	PCI/G
Beta Particle	1/1	3.60E+01	PCI/G
SWSA 5N			
Radionuclides			
Alpha Particle	6/6	2.80E+01	PCI/G
Beta Particle	6/6	4.50E+01	PCI/G
SWSA 5SE			
Organics			
Total Organic Carbon	1/1	1.40E+04	MG/KG
Radionuclides			
Alpha Particle	4/5	3.50E+02	PCI/G
Beta Particle	5/5	1.60E+04	PCI/G
SWSA5SW			
Inorganics			
Cobalt	5/5	3.60E+01	MG/KG
Organics			
Total Organic Carbon	1/1	8.30E+03	MG/KG
Radionuclides			
Alpha Particle	6/6	2.00E+02	PCI/G
Beta Particle	6/6	1.00E+04	PCI/G
WOC			
Radionuclides			
Alpha Particle	4/4	3.70E+02	PCI/G
Beta Particle	4/4	6.20E+03	PCI/G

* Analytes evaluated qualitatively have at least one detected value, however, no EPA-approved slope factors and/or reference doses are currently available.

^bThe representative concentration is the smallest of two values : the maximum detected concentration versus the upper 95% confidence limit on the mean concentration (EPA 1989a).

Exhibit 2b. COPCs evaluated qualitatively^a for WAG 5 sediment

Analyte	Frequency of Detection	Representative Concentration ^b	Units
D1			
Inorganics			
Cobalt	4/4	5.10E+01	MG/KG
Organics			
Sulfide	1/4	1.60E+01	MG/KG
Total Organic Carbon	1/1	1.20E+04	MG/KG
Radionuclides			
Beta Particle	4/4	9.10E+01	PCI/G
D2			
Organics			
Sulfide	4/4	2.20E+01	MG/KG
Total Organic Carbon	1/1	4.30E+04	MG/KG
Radionuclides			
Alpha Particle	4/4	1.70E+02	PCI/G
Beta Particle	4/4	2.60E+03	PCI/G
D3			
Organics			
Total Organic Carbon	1/1	1.50E+04	MG/KG
OHFP			
Inorganics			
Lead	1/1	1.60E+02	MG/KG
Thallium	1/1	7.80E-01	MG/KG
Radionuclides			
Alpha Particle	1/1	8.10E+04	PCI/G
Beta Particle	1/1	7.90E+06	PCI/G
PWSB			
Inorganics			
Lead	4/4	1.50E+02	MG/KG
Thallium	1/4	3.90E+00	MG/KG
Organics			
Total Organic Carbon	1/1	1.40E+01	MG/KG
Radionuclides			

Exhibit 2b. (continued)

Analyte	Frequency of Detection	Representative Concentration ^b	Units
Alpha Particle	5/5	1.30E+04	PCI/G
Beta Particle	5/5	3.30E+05	PCI/G

^a Analytes evaluated qualitatively have at least one detected value, however, no EPA-approved slope factors and/or reference doses are currently available.

^b The representative concentration is the smallest of two values : the maximum detected concentration versus the upper 95% confidence limit on the mean concentration (EPA 1989a).

Exhibit 2c. COPCs evaluated qualitatively* for WAG 5 groundwater

Analyte	Frequency of Detection	Representative Concentration ^b	Units
FS			
Inorganics			
Aluminum	2/2	9.00E+01	MG/L
Cobalt	2/2	8.40E-02	MG/L
Organics			
Chloride	1/1	5.50E+00	MG/L
Fluoride	1/1	6.90E-02	MG/L
Phosphate	1/1	2.20E+00	MG/L
Sulfate	1/1	4.60E+01	MG/L
Sulfide	1/1	2.50E-01	MG/L
Total Dissolved Solids	1/1	3.40E+02	MG/L
Total Kjeldahl Nitrogen-TKN	1/1	1.10E+00	MG/L
Total Organic Carbon	1/1	3.70E+00	MG/L
Total Suspended Solids	1/1	1.30E+03	MG/L
Radionuclides			
Alpha Particle	1/2	1.20E+01	PCI/L
Beta Particle	2/2	5.80E+01	PCI/L
OHFP			
Organics			
1,1,1-Trichloroethane	1/1	6.00E-03	MG/L
Alkalinity as CaCO ₃	1/1	2.90E+02	MG/L
Chloride	1/1	1.40E+01	MG/L
Phosphate	1/1	1.20E-01	MG/L
Sulfate	1/1	1.70E+01	MG/L
TOX	1/1	4.00E-02	MG/L
Total Dissolved Solids	1/1	3.30E+02	MG/L
Total Kjeldahl Nitrogen-TKN	1/1	2.50E-01	MG/L
Total Organic Carbon	1/1	1.20E+00	MG/L
Radionuclides			
Alpha Particle	2/5	1.20E+02	PCI/L
Beta Particle	5/5	4.40E+04	PCI/L

Exhibit 2c. (continued)

Analyte	Frequency of detection	Representative Concentration ^b	Units
PWSB			
Inorganics			
Aluminum	3/3	1.30E+00	MG/L
Organics			
Chloride	1/1	2.20E+00	MG/L
Phosphate	1/1	1.40E-01	MG/L
Sulfate	1/1	2.50E+01	MG/L
Total Dissolved Solids	1/1	3.50E+02	MG/L
Total Kjeldahl Nitrogen-TKN	3/3	1.30E+00	MG/L
Total Suspended Solids	1/1	6.00E+01	MG/L
Radionuclides			
Beta Particle	3/5	1.40E+01	PCI/L
SWSA 5N			
Inorganics			
Aluminum	7/11	7.30E+01	MG/L
Cobalt	6/11	3.60E-02	MG/L
Lead	12/13	6.50E-02	MG/L
Organics			
Alkalinity as CaCO ₃	1/1	3.70E+02	MG/L
Chloride	4/4	8.80E+00	MG/L
Fluoride	2/4	6.10E-01	MG/L
Organic Chloride	1/2	1.00E+00	MG/L
Phosphate	3/4	7.90E-01	MG/L
Sulfate	4/4	6.30E+01	MG/L
Total Dissolved Solids	4/4	5.50E+02	MG/L
Total Kjeldahl Nitrogen-TKN	9/9	6.90E-01	MG/L
Total Organic Carbon	2/4	3.70E+00	MG/L
Total Suspended Solids	4/4	1.40E+03	MG/L
Radionuclides			
Alpha Particle	15/27	9.10E+01	PCI/L
Beta Particle	20/27	5.40E+01	PCI/L
SWSA 5SE			
Inorganics			

Exhibit 2c. (continued)

Analyte	Frequency of detection	Representative Concentration ^b	Units
Aluminum	12/15	2.70E+01	MG/L
Cobalt	8/15	6.00E-02	MG/L
Lead	10/15	1.30E-01	MG/L
Organics			
1,1,1-Trichloroethane	2/16	8.90E-03	MG/L
Alkalinity as CaCO ₃	1/1	4.10E+02	MG/L
Chloride	4/4	3.40E+01	MG/L
Fluoride	4/4	2.20E-01	MG/L
Phosphate	4/4	1.20E+00	MG/L
Sulfate	4/4	2.40E+01	MG/L
TOX	4/4	1.40E-01	MG/L
Total Dissolved Solids	4/4	4.20E+02	MG/L
Total Kjeldahl Nitrogen-TKN	9/11	4.80E-01	MG/L
Total Organic Carbon	2/4	2.80E+00	MG/L
Total Suspended Solids	4/4	5.10E+02	MG/L
Radionuclides			
Alpha Particle	11/20	1.00E+06	PCI/L
Beta Particle	19/21	8.70E+04	PCI/L
SWSASSW			
Inorganics			
Aluminum	9/10	2.60E+01	MG/L
Cobalt	7/10	4.90E-02	MG/L
Lead	9/10	8.20E-02	MG/L
Silicon	4/4	6.20E+01	MG/L
Organics			
1,1,1-Trichloroethane	3/10	4.20E-03	MG/L
Chloride	4/4	1.90E+01	MG/L
Fluoride	1/4	1.50E-01	MG/L
Phosphate	4/4	1.30E+00	MG/L
Sulfate	4/4	2.90E+01	MG/L
Sulfide	1/5	2.50E-01	MG/L
TOX	3/3	1.20E+02	MG/L
Total Dissolved Solids	4/4	6.50E+02	MG/L

Exhibit 2c. (continued)

Analyte	Frequency of detection	Representative Concentration ^a	Units
Total Kjeldahl Nitrogen-TKN	6/7	5.20E-01	MG/L
Total Organic Carbon	2/4	3.60E+00	MG/L
Total Suspended Solids	4/4	1.50E+03	MG/L
Radionuclides			
Alpha Particle	9/12	5.30E+01	PCI/L
Beta Particle	11/13	6.90E+02	PCI/L
WOC			
Organics			
Total Kjeldahl Nitrogen-TKN	4/5	5.80E-01	MG/L
Radionuclides			
Beta Particle	5/10	3.00E+01	PCI/L

^a Analytes evaluated qualitatively have at least one detected value, however, no EPA-approved slope factors and/or reference doses are currently available.

^b The representative concentration is the smallest of two values : the maximum detected concentration versus the upper 95% confidence limit on the mean concentration (EPA 1989a).

Exhibit 2d. COPCs evaluated qualitatively^a for WAG 5 sediment

Analyte	Frequency of detection	Representative Concentration ^b	Units
High Base			
D1			
Inorganics			
Aluminum	1/1	7.90E-01	MG/L
Organics			
Total Organic Carbon	1/1	2.10E+00	MG/L
Other			
TOX	1/1	1.20E-02	MG/L
Total Kjeldahl Nitrogen-TKN	1/1	7.30E-01	MG/L
Radionuclides			
Alpha Particle	1/1	4.70E+01	PCI/L
Beta Particle	1/1	9.90E+01	PCI/L
D2			
Inorganics			
Aluminum	1/1	9.70E-01	MG/L
Organics			
Total Organic Carbon	1/1	2.30E+00	MG/L
Other			
TOX	1/1	3.90E-02	MG/L
Total Kjeldahl Nitrogen-TKN	1/1	5.60E-01	MG/L
Radionuclides			
Alpha Particle	1/1	1.60E+01	PCI/L
Beta Particle	1/1	4.40E+03	PCI/L
D3			
Inorganics			
Aluminum	1/1	4.40E-01	MG/L
Organics			
Chloride	1/1	2.40E+00	MG/L
Sulfate	1/1	2.20E+01	MG/L
Total Organic Carbon	1/1	1.70E+00	MG/L
Other			
Total Kjeldahl Nitrogen-TKN	1/1	4.00E-01	MG/L

Exhibit 2d. (continued)

Analyte	Frequency of Detection	Representative Concentration ^b	Units
Radionuclides			
Sn-119m	1/1	1.90E+01	PCI/L
High Base Storm			
D1			
Inorganics			
Aluminum	1/1	7.40E-01	MG/L
Organics			
Total Organic Carbon	1/1	2.30E+00	MG/L
Other			
Total Kjeldahl Nitrogen-TKN	1/1	4.10E-01	MG NH3-N/L
Radionuclides			
Alpha Particle	1/1	6.00E+01	PCI/L
Beta Particle	1/1	1.00E+02	PCI/L
D2			
Organics			
Total Organic Carbon	1/1	1.70E+00	MG/L
Radionuclides			
Alpha Particle	1/1	1.30E+01	PCI/L
Beta Particle	1/1	2.80E+03	PCI/L
D3			
Inorganics			
Aluminum	1/1	8.50E-01	MG/L
Organics			
Total Organic Carbon	1/1	5.10E+00	MG/L
Other			
Total Kjeldahl Nitrogen-TKN	1/1	3.30E-01	MG NH3-N/L
Impoundment			
OHFP			
Inorganics			
Aluminum	1/1	6.10E+00	MG/L
Organics			
Chloride	1/1	8.10E-01	MG/L
Fluoride	1/1	1.40E-01	MG/L

Exhibit 2d. (continued)

Analyte	Frequency of Detection	Representative Concentration ^b	Units
Sulfate	1/1	1.50E+01	MG/L
Total Organic Carbon	1/1	7.80E+00	MG/L
Other			
Alkalinity as CaCO ₃	1/1	6.00E+00	MG/L
Total Dissolved Solids	1/1	1.10E+02	MG/L
Total Kjeldahl Nitrogen-TKN	1/1	7.60E-01	MG/L
Radionuclides			
Alpha Particle	1/1	6.40E+03	PCI/L
Beta Particle	1/1	2.00E+05	PCI/L
PWSB			
Organics			
Total Organic Carbon	1/1	3.40E+01	MG/L
Other			
Alkalinity as CaCO ₃	1/1	3.00E+01	MG/L
Total Dissolved Solids	1/1	3.00E+02	MG/L
Total Kjeldahl Nitrogen-TKN	1/1	4.50E+00	MG/L
Total Suspended Solids	1/1	1.40E+01	MG/L
Radionuclides			
Alpha Particle	1/1	3.80E+02	PCI/L
Beta Particle	1/1	1.30E+04	PCI/L
Low Base			
D1			
Radionuclides			
Alpha Particle	1/1	1.60E+01	PCI/L
Beta Particle	1/1	8.20E+01	PCI/L
D2			
Radionuclides			
Alpha Particle	1/1	1.10E+01	PCI/L
Beta Particle	1/1	4.00E+03	PCI/L
Low Base Storm			
D1			
Inorganics			
Aluminum	1/4	7.10E-01	MG/L

Exhibit 2d. (continued)

Analyte	Frequency of Detection	Representative Concentration ^b	Units
Organics			
Phosphate	1/1	1.10E-01	MG/L
Total Organic Carbon	1/1	1.10E+01	MG/L
Other			
TOX	1/1	9.70E-03	MG/L
Total Kjeldahl Nitrogen-TKN	1/1	5.40E-01	MG/L
Radionuclides			
Alpha Particle	1/1	1.80E+01	PCI/L
Beta Particle	1/1	6.40E+01	PCI/L
D2			
Organics			
Total Organic Carbon	1/1	5.40E+00	MG/L
Other			
TOX	1/1	2.00E-02	MG/L
Total Kjeldahl Nitrogen-TKN	1/1	3.60E-01	MG/L
Radionuclides			
Beta Particle	1/1	4.70E+03	PCI/L
D3			
Inorganics			
Aluminum	1/3	4.80E-01	MG/L
Organics			
Phosphate	1/1	1.40E-01	MG/L
Total Organic Carbon	1/1	1.20E+01	MG/L
Other			
TOX	1/1	6.90E-03	MG/L
Total Kjeldahl Nitrogen-TKN	1/1	4.30E-01	MG/L

^a Analytes evaluated qualitatively have at least one detected value, however, no EPA-approved slope factors and/or reference doses are currently available.

^b The representative concentration is the smallest of two values : the maximum detected concentration versus the upper 95% confidence limit on the mean concentration (EPA 1989a).

Exhibit 3a. On-site industrial exposure scenario

Variable	Value used	Explanation/source
<u>Industrial ingestion of soil or sediment pathway</u>		
Chronic daily intake (mg/kg-d) = $[(CS \times FI \times EF \times ED \times IR)/(AT \times BW)]$		
Intake (pCi) = $[CS \times CF \times FI \times EF \times ED \times IR]$		
CS = Concentration in soil or sediment	Chemical-specific (mg/kg; pCi/g)	Concentration is derived from sample data
IR = Ingestion rate	0.00005 kg/day	OSWER Directive (EPA 1991b)
CF = Conversion factor	10^3 g/kg	Necessary to convert to appropriate units
FI = Fraction ingested	1 (unitless)	Maximum value used; equivalent to 100%
EF = Exposure frequency	250 days/year	OSWER Directive (EPA 1991b)
ED = Exposure duration	25 years	OSWER Directive (EPA 1991b)
BW = Body Weight	70 kg	Adult (Section 6, RAGS, EPA 1989a)
AT = Averaging time	365 days/year $\times$ 25 years	Averaging time for noncarcinogens (EPA 1989a; EPA 1991b)
	365 days/year $\times$ 70 years	Averaging time for carcinogens (EPA 1989a; EPA 1991b)

Exhibit 3b. On-site industrial exposure scenario

Variable	Value used	Explanation/source
<u>Industrial dermal contact with soil or sediment pathway</u>		
Chronic daily intake (mg/kg-d) = $[(CS \times CF \times AF \times ABS \times EF \times ED \times SA)/(AT \times BW)]$		
CS =	Concentration in soil or sediment	Chemical-specific (mg/kg) Concentration is derived from sample data
CF =	Conversion factors	$(10^{-6} \text{ kg/mg}) \times (10^4 \text{ cm}^2/\text{m}^2)$ Necessary to convert to appropriate units
SA =	Available surface area	0.316 m ² /day 50th Percentile surface area for head, hands, forearms, for a male adult (Dermal Exposure Assessment, EPA 1992a)
AF =	Adherence factor	1.0 mg/cm ² Adherence factor for soil (EPA Region IV New Interim Guidance, 2/11/92)
ABS =	Absorption factor	0.001 (unitless) 0.01 (unitless) Equivalent to 0.1% for inorganics and 1.0% for organics (EPA Region IV New Interim Guidance, 2/11/92)
EF =	Exposure frequency	250 days/year OSWER Directive (EPA 1991b)
ED =	Exposure duration	25 years OSWER Directive (EPA 1991b)
BW =	Body Weight	70 kg Adult (Section 6, RAGS, EPA 1989a)
AT =	Averaging time	365 days/year $\times$ 25 years Averaging time for noncarcinogens (EPA 1989a; EPA 1991b) 365 days/year $\times$ 70 years Averaging time for carcinogens (EPA 1989a; EPA 1991b)

Exhibit 3c. On-site industrial exposure scenario

Variable	Value used	Explanation/source
<i><u>Industrial inhalation of soil or sediment pathway</u></i>		
Chronic daily intake (mg/kg-d) = $[(CS \times EF \times ED \times IR \times (VF^{-1} + PEF^{-1})) / (AT \times BW)]$		
Intake (pCi) = $[CS \times ED \times CF \times EF \times IR \times (VF^{-1} + PEF^{-1})]$		
CS =	Concentration in soil or sediment	Chemical-specific (mg/kg; pCi/g) Concentration is derived from sample data
IR =	Inhalation rate	20 m ³ /day OSWER Directive (EPA 1991b)
VF =	Volatilization Factor	Chemical-specific (m ³ /kg) EPA letter from E.W. Akin to C.W. McGinn, 2/2/93
PEF =	Particulate emission factor	4.63×10^9 (m ³ /kg) EPA letter from E.W. Akin to C.W. McGinn, 2/2/93
CF =	Conversion factor	10 ³ g/kg Necessary to convert to appropriate units
EF =	Exposure frequency	250 days/year OSWER Directive (EPA 1991b)
ED =	Exposure duration	25 years OSWER Directive (EPA 1991b)
BW =	Body Weight	70 kg Adult (Section 6, RAGS, EPA 1989a)
AT =	Averaging time	365 days/year $\times$ 25 years Averaging time for noncarcinogens (EPA 1989a; EPA 1991b)
		365 days/year $\times$ 70 years Averaging time for carcinogens (EPA 1989a; EPA 1991b)

Exhibit 3d. On-site industrial exposure scenario

Variable	Value used	Explanation/source
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Industrial external exposure pathway

$$\text{Dose (pCi-year/g)} = [\text{CS} \times (1 - \text{Se}) \times \text{Te} \times \text{ED} \times \text{EF} \times \text{CF}]$$

CS	=	Concentration in soil or sediment	Chemical-specific (pCi/g)	Concentration is derived from sample data
ED	=	Exposure duration	25 years	OSWER Directive (EPA 1991b)
EF	=	Exposure frequency	250 days/year	OSWER Directive (EPA 1991b)
CF	=	Conversion factor	1 year/365 days	Necessary to convert to appropriate units
Se	=	Gamma shielding factor (unitless)	0.2	RAGS Part B, EPA 1991a; sect. 4.1.2 (default value)
Te	=	Gamma exposure time factor (unitless)	0.3	EPA memo from E.W. Akin to C.W. McGinn, 2/2/93 (based on 8 hours/24 hours)

Exhibit 4a. On-site residential exposure scenario

Variable	Value used	Explanation/source
<u>Residential ingestion of soil or sediment pathway</u>		
Chronic daily intake (mg/kg-d) = $[(CS \times FI \times EF)/AT] \times [(ED_c \times IR_c/BW_c) + (ED_a \times IR_a/BW_a)]$		
Intake (pCi) = $[CS \times CF \times EF \times FI \times [(ED_c \times IR_c) + (ED_a \times IR_a)]]$		
CS = Concentration in soil or sediment	Chemical-specific (mg/kg; pCi/g)	Concentration is derived from sample data
IR _c = Ingestion rate	0.0002 kg/day	Child rate (Section 6, RAGS, EPA 1989a)
IR _a	0.0001 kg/day	Adult rate (Section 6, RAGS, EPA 1989a)
CF = Conversion factor	10 ³ g/kg	Necessary to convert to appropriate units
FI = Fraction ingested	1 (unitless)	Maximum value used; equivalent to 100%
EF = Exposure frequency	350 days/year	OSWER Directive (EPA 1991b)
ED _c = Exposure duration	6 years	Two parts (child and adults) exposure for 30-years of exposure duration (OSWER Directive, EPA 1991b)
ED _a	24 years	
BW _c = Body Weight	15 kg	Child (OSWER Directive, EPA 1991b)
BW _a	70 kg	Adult (Section 6, RAGS, EPA 1989a)
AT = Averaging time	365 days/year × 30 years	Averaging time for noncarcinogens (EPA 1989a; EPA 1991b)
	365 days/year × 70 years	Averaging time for carcinogens (EPA 1989a; EPA 1991b)

Exhibit 4b. On-site residential exposure scenario

Variable	Value used	Explanation/source
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Residential dermal contact with soil or sediment scenario

$$\text{Chronic daily intake (mg/kg-d)} = [(CS \times CF \times AF \times ABS \times EF)/AT] \times [(SA_c \times ED_c/BW_c) + (SA_a \times ED_a/BW_a)]$$

CS	=	Concentration in soil or sediment	Chemical-specific (mg/kg)	Concentration is obtained from sample data
CF	=	Conversion factors	$(10^{-6} \text{ kg/mg}) \times (10^4 \text{ cm}^2/\text{m}^2)$	Necessary to convert to appropriate units
SA _c	=	Available surface area	0.182 m ² /day	Average surface area for head, hands, forearms, and lower legs; for a child
SA _a	=		0.53 m ² /day	and for an adult, respectively (Dermal Exposure Assessment, EPA 1992a)
AF	=	Adherence factor	1.0 mg/cm ²	Adherence factor for soil (EPA Region IV New Interim Guidance, 2/11/92)
ABS	=	Absorption factor	0.001 (unitless) 0.01 (unitless)	Equivalent to 0.1% for inorganics and 1.0% for organics (EPA Region IV New Interim Guidance, 2/11/92)
EF	=	Exposure frequency	350 days/year	OSWER Directive (EPA 1991b)
ED _c	=	Exposure duration	6 years	Two-part (child and adult) residential exposure for a 30-year duration
ED _a	=		24 years	OSWER Directive (EPA 1991b)
BW _c	=	Body weight	15 kg	Child (OSWER Directive, EPA 1991b)
BW _a	=		70 kg	Adult (Section 6, RAGS, EPA 1989a)
AT	=	Averaging time	365 days/year × 30 years	Averaging time for noncarcinogens (EPA 1989a; EPA 1991b)
			365 days/year × 70 years	Averaging time for carcinogens (EPA 1989a; EPA 1991b)

Exhibit 4c. On-site residential exposure scenario

Variable	Value used	Explanation/source
<i><u>Residential inhalation of soil or sediment scenario</u></i>		
Chronic daily intake (mg/kg-d) = $[(CS \times IR \times EF)/AT] \times [1/VF + 1/PEF] \times [(ED_c/BW_c) + (ED_a/BW_a)]$		
Intake (pCi) = $[CS \times CF \times IR \times EF \times (1/VF + 1/PEF)] \times [ED_c + ED_a]$		
CS = Concentration in soil or sediment	Chemical-specific (mg/kg; pCi/g)	Concentration is derived from sample data
IR = Inhalation rate	20 m ³ /day	OSWER Directive (EPA 1991b)
CF = Conversion factor	10 ³ g/kg	Necessary to convert to appropriate units
PEF = Particulate emission factor	4.63 x 10 ⁹ m ³ /kg	RAGS Part B (EPA 1991a)
VF = Volatilization factor	Chemical specific (m ³ /kg)	RAGS Part B (EPA 1991a)
EF = Exposure frequency	350 day/year	OSWER Directive (EPA 1991b)
ED _c = Exposure duration	6 years	Two-part (child and adult) residential exposure for a 30-year duration (OSWER Directive, EPA 1991b)
ED _a	24 years	
BW _c = Body weight	15 kg	Child (OSWER Directive, EPA 1991b)
BW _a	70 kg	Adult (Section 6, RAGS, EPA 1989a)
AT = Averaging time	365 days/year x 30 years	Averaging time for noncarcinogens (EPA 1989a; EPA 1991b)
	365 days/year x 70 years	Averaging time for carcinogens (EPA 1989a; EPA 1991b)

Exhibit 4d. On-site residential exposure scenario

Variable	Value used	Explanation/source
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Residential external exposure scenario

$$\text{Dose (pCi-year/g)} = [\text{CS} \times (1 - \text{Se}) \times \text{Te} \times \text{EF} \times \text{CF} \times \text{ED}]$$

CS	=	Concentration soil or sediment	Chemical-specific (pCi/g)	Concentration is obtained from sample data
EF	=	Exposure frequency	350 days/year	OSWER Directive (EPA 1991b)
CF	=	Conversion factor	(1/365) year/days	Necessary to convert to appropriate units
ED _c	=	Exposure duration	6 years	Two-parts (child and adult) residential exposure for a 30-year duration (OSWER Directive, EPA 1991b)
ED _a			24 years	
Se	=	Gamma shielding factor (unitless)	0.2	RAGS Part B, EPA 1991a; Sect. 4.1.2. (default value)
Te	=	Gamma exposure time factor (unitless)	1.0	RAGS Part B, EPA 1991a; sect. 4.1.2 (default value, based on 24hours/24hours)

Exhibit 5a. On-site residential exposure scenario

Variable	Value used	Explanation/source
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Residential ingestion of surface water or groundwater scenario

$$\text{Chronic daily intake (mg/kg-d)} = [\text{CW} \times \text{IR} \times \text{EF}/\text{AT}] \times [(\text{ED}_c/\text{BW}_c) + (\text{ED}_a/\text{BW}_a)]$$

$$\text{Intake (pCi)} = \text{CW} \times \text{IR} \times \text{EF} \times [\text{ED}_c + \text{ED}_a]$$

CW =	Concentration in water	Chemical-specific (mg/L; pCi/L)	Concentration is obtained from sample data
IR =	Ingestion rate	2 L/day	EPA 1989a; OSWER Directive (EPA 1991b)
EF =	Exposure frequency	350 days/year	OSWER Directive (EPA 1991b)
ED _c =	Exposure duration	6 years	Two-part (child and adult) residential exposure for a 30-year duration (OSWER Directive, EPA 1991b)
ED _a		24 years	
BW _c =	Body weight	15 kg	Child (OSWER Directive, EPA 1991b)
BW _a		70 kg	Adult (Section 6, RAGS, EPA 1989a)
AT =	Averaging time	365 days/year × 30 years	Averaging time for noncarcinogens (EPA 1989a; EPA 1991b)
		365 days/year × 70 years	Averaging time for carcinogens (EPA 1989a; EPA 1991b)

Exhibit 5b. On-site residential exposure scenario

Variable		Value used	Explanation/source
<u>Residential dermal contact with surface water or groundwater (while showering) scenario</u>			
Chronic daily intake(mg/kg-d) = [CW x CF x PC x ET x EF/AT] x[(SA _c x ED _c /BW _c)+(SA _a x ED _a /BW _a)]			
CW =	Concentration in water	Chemical-specific (mg/L)	Concentration is obtained from sample data
CF =	Conversion factors	m/100cm x 1000L/ m ³	Necessary to convert to appropriate units
SA _c =	Available surface area	0.728 m ²	Average total body surface area for a child
SA _a		1.94 m ²	and for an adult, respectively (Dermal Exposure Assessment, EPA 1992a)
PC =	Permeability constant	Chemical-specific (cm/hour)	Dermal Exposure Assessment (EPA 1992a)
ET =	Exposure time	0.25 hours/day	Showering 15 minutes/day, Dermal Exposure Assessment (EPA 1992a)
EF =	Exposure frequency	350 days/year	OSWER Directive (EPA 1991b)
ED _c =	Exposure duration	6 years	Two-part (child and adult) residential exposure
ED _a		24 years	for 30-year duration (OSWER Directive, EPA 1991b)
BW _c =	Body weight	15 kg	Child (OSWER Directive, EPA 1991b)
BW _a		70 kg	Adult (Section 6, RAGS, EPA 1989a)
AT =	Averaging time	365 days/year x 30 years	Averaging time for noncarcinogens (EPA 1989a; EPA 1991b)
		365 days/year x 70 years	Averaging time for carcinogens (EPA 1989a; EPA 1991b)

Exhibit 5c. On-site residential exposure scenario

Variable	Value used	Explanation/source
<i>Residential inhalation of surface water or groundwater (while showering) scenario</i>		
Chronic daily intake (mg/kg-d) = $[(CW \times IR \times K \times EF \times ET)/(AT)] \times [(ED_c/BW_c) + (ED_a/BW_a)]$		
Intake (pCi) = $CW \times IR \times K \times EF \times ET \times [ED_c + ED_a]$		
CW = Concentration in water	Chemical-specific (mg/L; pCi/L)	Concentration is obtained from sample data
IR = Inhalation rate	0.6 m ³ /hour	Inhalation rate while showering for all age groups (EPA 1989a)
K = Volatilization factor	0.0005 x 1000 L/m ³	(EPA 1989a)
ET = Exposure time	0.25 hours/day	Showering 15 minutes/day, Dermal Exposure Assessment (EPA 1992a)
EF = Exposure frequency	350 days/year	OSWER Directive (EPA 1991b)
ED _c = Exposure duration	6 years	Two-part (child and adult) residential exposure for a 30-year duration (OSWER Directive, EPA 1991b)
ED _a	24 years	
BW _c = Body weight	15 kg	Child (OSWER Directive, EPA 1991b)
BW _a	70 kg	Adult (Section 6, RAGS, EPA 1989a)
AT = Averaging time	365 days/year x 30 years	Averaging time for noncarcinogens (EPA 1989a; EPA 1991b)
	365 days/year x 70 years	Averaging time for carcinogens (EPA 1989a; EPA 1991b)

Exhibit 6. On-site residential exposure scenario

Variable	Value used	Explanation/source
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Residential inhalation of tritium from groundwater (shower+bathroom+house) scenario

$$\text{Intake (pCi)} = \text{CW} \times \text{IEF} \times \text{ED}$$

CW =	Concentration in water	Chemical-specific (pCi/L)	Concentration is obtained from data in Exhibit 9c
IEF =	Inhalation exposure factor	60.91 L/year	The sum of the Inhalation exposure factors for shower, bathroom and house (Subsec. 3.4.2.2)
ED =	Exposure duration	30 years	Residential exposure for a 30-year duration (OSWER Directive, EPA 1991c)

Exhibit 7. On-site residential exposure scenario

Variable	Value used	Explanation/source
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Residential ingestion of homegrown produce pathway

$$\text{Chronic daily intake (mg/kg-d)} = [(CV \times FI \times IR \times EF)/AT] \times [(ED_c/BW_c) + (ED_a/BW_a)]$$

$$\text{Intake (pCi)} = [CV \times CF \times EF \times IR \times FI \times (ED_c + ED_a)]$$

CV =	Concentration in produce (leafy vegetables)	Chemical-specific (mg/kg; pCi/g)	Concentration is calculated from sample data, using B_v values
IR =	Ingestion rate	0.080 kg/day	OSWER Directive (EPA 1991b)
CF =	Conversion factor	10^3 g/kg	Necessary to convert to appropriate units
FI =	Fraction ingested	1 (unitless)	Maximum value used; equivalent to 100%
EF =	Exposure frequency	350 days/year	OSWER Directive (EPA 1991b)
ED _c =	Exposure duration	6 years	Two parts (child and adults) exposure for 30-years of exposure duration (OSWER Directive, EPA 1991b)
ED _a		24 years	
BW _c =	Body Weight	15 kg	Child (OSWER Directive, EPA 1991b)
BW _a		70 kg	Adult (Section 6, RAGS, EPA 1989a)
AT =	Averaging time	365 days/year × 30 years	Averaging time for noncarcinogens (EPA 1989a; EPA 1991b)

Exhibit 8a. On-site excavation exposure scenario

Variable	Value used	Explanation/source
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Excavation ingestion of soil or sediment pathway

$$\text{Chronic daily intake (mg/kg-d)} = [\text{CS} \times \text{FI} \times \text{EF} \times \text{ED} \times \text{IR} / (\text{AT} \times \text{BW})]$$

$$\text{Intake (pCi)} = \text{CS} \times \text{CF} \times \text{EF} \times \text{ED} \times \text{IR}$$

CS	=	Concentration in soil, or sediment	Chemical-specific (mg/kg; pCi/g)	Concentration is derived from sample data
IR	=	Ingestion rate	0.00005 kg/day	OSWER Directive (EPA 1991b)
CF	=	Conversion factor	10 ³ g/kg	Necessary to convert to appropriate units
FI	=	Fraction ingested	1 (unitless)	Maximum value used; equivalent to 100%
EF	=	Exposure frequency	83.33 days/year	4 months/year for 24 hours/day of a 250 days/year (i.e., (4/12) x 250 days/year)
ED	=	Exposure duration	1 year	OSWER Directive, (EPA 1991b)
BW	=	Body Weight	70 kg	Adult (Section 6, RAGS, EPA 1989a)
AT	=	Averaging time	365 d/year x 25 years	Averaging time for noncarcinogens (EPA 1989a; EPA 1991b)
			365 d/year x 70 years	Averaging time for carcinogens (EPA 1989a; EPA 1991b)

Exhibit 8b. On-site excavation exposure scenario

Variable	Value used	Explanation/source
<u>Excavation dermal contact with soil or sediment pathway</u>		
Chronic daily intake (mg/kg-d) = [CS x CF x AF x ABS x EF x ED x SA / (AT x BW)]		
CS =	Concentration in soil or sediment	Chemical-specific (mg/kg) Concentration is derived from sample data
CF =	Conversion factors	$(10^{-6} \text{ kg/mg}) \times (10^4 \text{ cm}^2/\text{m}^2)$ Necessary to convert to appropriate units
SA =	Available surface area	0.316 m ² /day Average surface area for head, hands, forearms, for a male adult (Dermal Exposure Assessment, EPA 1992a)
AF =	Adherence factor	1.0 mg/cm ² Adherence factor for soil (EPA Region IV New Interim Guidance, 2/11/92)
ABS =	Absorption factor	0.001 (unitless) 0.01 (unitless) Equivalent to 0.1% for inorganics and 1.0% for organics (EPA Region IV New Interim Guidance, 2/11/92)
EF =	Exposure frequency	83.33 days/year 4 months/year for 24 hours/day of a 250 days/year (i.e., $(4/12) \times 250 \text{ days/year}$)
ED =	Exposure duration	1 year OSWER Directive, (EPA 1991b)
BW =	Body Weight	70 kg Adult (Section 6, RAGS, EPA 1989a)
AT =	Averaging time	365 days/year x 25 years Averaging time for noncarcinogens (EPA 1989a; EPA 1991b)
		365 days/year x 70 years Averaging time for carcinogens (EPA 1989a; EPA 1991b)

Exhibit 8c. On-site excavation exposure scenario

Variable	Value used	Explanation/source
<u>Excavation inhalation of soil or sediment pathway</u>		
Chronic daily intake (mg/kg-d) = $[(CS \times EF \times ED \times IR \times (VF^{-1} + PEF^{-1})) / (AT \times BW)]$		
Intake (pCi) = $CS \times ED \times CF \times EF \times IR \times (VF^{-1} + PEF^{-1})$		
CS =	Concentration in soil, or sediment	Chemical-specific (mg/kg; pCi/g) Concentration is derived from sample data
IR =	Inhalation rate	20 m ³ /day OSWER Directive (EPA 1991b)
VF =	Volatilization Factor	Chemical-specific (m ³ /kg) EPA letter from E.W. Akin to C.W. McGinn, 2/2/93
PEF =	Particulate emission factor	4.63×10^9 (m ³ /kg) EPA letter from E.W. Akin to C.W. McGinn, 2/2/93
CF =	Conversion factor	10 ³ g/kg Necessary to convert to appropriate units
EF =	Exposure frequency	27.78 days/year 4 months/year for 8 hours/day of a 250 days/year (i.e., (4/12) x (8/24) x 250 days/year)
ED =	Exposure duration	25 years (OSWER Directive, EPA 1991b)
BW =	Body Weight	70 kg Adult (Section 6, RAGS, EPA 1989a)
AT =	Averaging time	365 days/year x 25 years Averaging time for noncarcinogens (EPA 1989a; EPA 1991b)
		365 days/year x 70 years Averaging time for carcinogens (EPA 1989a; EPA 1991b)

Exhibit 8d. On-site excavation exposure scenario

Variable	Value used	Explanation/source
<u>Excavation external exposure pathway</u>		
Dose (pCi-year/g) = CS x (1-Se) x Te x ED x EF x CF		
CS = Concentration in soil or sediment	Chemical-specific (pCi/g)	Concentration is derived from sample data
CF = Conversion factor	(1/365) year/days	Necessary to convert to appropriate units
EF = Exposure frequency	27.78 days/year	4 months/year for 8 hours/day of a 250 days/year (i.e., (4/12) x (8/24) x 250 days/year)
ED = Exposure duration	25 years	(OSWER Directive, EPA 1991b)
Se = Gamma shielding factor (unitless)	0.2	RAGS Part B, EPA 1991a; sect. 4.1.2 (default value)
Te = Gamma exposure time factor (unitless)	0.3	EPA memo from E.W. Akin to C.W. McGinn, 2/2/93 (based on 8 hours/ day)

**Exhibit 9a. Carcinogenic risk for WAG 5 soil COPCs
(Excavation, industrial, and residential scenarios)**

Analyte	Concentration (mg/kg,pCi/g)	Ingestion risk	Ingestion of produce risk	Dermal risk	Inhalation risk	External risk	Total risk
Excavation scenario							
FS							
Inorganics							
Mercury	4.30E+00						
Organics							
Aroclor 1260	1.80E-01	3.20E-09		2.30E-09			5.50E-09
Radionuclides							
Co-60	1.80E+02	1.10E-08			1.10E-11	9.40E-05	9.40E-05
Cs-137	3.60E+01	4.20E-09			2.70E-13	4.40E-06	4.40E-06
Pb-212	1.50E+00	3.40E-11			2.50E-14	2.60E-08	2.60E-08
Ra-226	3.60E+00	1.80E-09			5.80E-06	1.30E-06	7.10E-06
Th-232	1.90E+00	9.50E-11			2.10E-11	3.00E-12	1.20E-10
Total Radioactive Strontium	1.20E+02	1.80E-08			2.90E-12	0.00E+00	1.80E-08
U-233/234	7.30E+00	4.90E-10			7.40E-11	1.30E-11	5.70E-10
U-238	7.00E+00	8.20E-10			1.40E-10	1.50E-08	1.60E-08
Total pathway		4.00E-08		2.30E-09	5.80E-06	1.00E-04	1.10E-04
NHFT							
Organics							
Di-n-butyl Phthalate	1.30E-01						
Toluene	1.00E-03						
Radionuclides							
Am-241	1.10E-01	1.10E-10			1.40E-12	3.30E-11	1.50E-10
Pu-238	2.60E-01	2.40E-10			4.00E-12	4.50E-13	2.40E-10
Ra-228	1.60E+00	6.70E-10			4.30E-13	2.80E-07	2.80E-07
Th-228	1.70E+00	3.80E-10			5.10E-11	5.70E-07	5.70E-07
Th-230	1.30E+00	6.90E-11			1.40E-11	4.20E-12	8.80E-11
Th-232	1.60E+00	7.70E-11			1.70E-11	2.50E-12	9.70E-11
U-233/234	9.70E-01	6.50E-11			9.80E-12	1.80E-12	7.60E-11
Total pathway		1.60E-09			9.80E-11	8.50E-07	8.60E-07
OHFP							
Inorganics							
Cadmium	1.50E+00				1.90E-12		1.90E-12

Exhibit 9a. (continued)

Analyte	Concentration (mg/kg;pCi/g)	Ingestion risk	Ingestion of produce risk	Dermal risk	Inhalation risk	External risk	Total risk
Organics							
Aroclor 1254	3.20E-02	5.70E-10		4.00E-10			9.80E-10
Aroclor 1260	9.60E-03	1.70E-10		1.20E-10			2.90E-10
Heptachlor Epoxide	5.40E-04	1.10E-11		1.00E-11	1.10E-15		2.10E-11
Toluene	1.00E-03						
Radionuclides							
Am-241	3.50E-01	3.50E-10			4.40E-12	1.10E-10	4.60E-10
Co-60	6.20E-01	3.80E-11			3.60E-14	3.20E-07	3.20E-07
Cs-137	1.10E+03	1.30E-07			8.50E-12	1.40E-04	1.40E-04
Ra-228	1.40E+00	5.70E-10			3.70E-13	2.40E-07	2.40E-07
Th-228	1.50E+00	3.50E-10			4.60E-11	5.20E-07	5.20E-07
Th-230	1.40E+00	7.50E-11			1.60E-11	4.50E-12	9.50E-11
Total Radioactive Strontium	6.50E+02	9.80E-08			1.60E-11	0.00E+00	9.80E-08
U-233/234	8.90E-01	5.90E-11			9.00E-12	1.60E-12	7.00E-11
Total pathway		2.30E-07		5.30E-10	1.00E-10	1.40E-04	1.40E-04
OHFT							
Inorganics							
Silver	4.30E+00						
Organics							
Bis(2-Ethylhexyl) Phthalate	1.10E-01	3.60E-12		1.20E-11			1.60E-11
Cyanide	6.70E-01						
Toluene	2.00E-03						
Radionuclides							
Am-241	2.50E-01	2.50E-10			3.20E-12	7.60E-11	3.30E-10
Cs-137	5.80E+00	6.80E-10			4.30E-14	7.10E-07	7.10E-07
Pu-238	8.70E-01	8.00E-10			1.30E-11	1.50E-12	8.20E-10
Ra-226	1.30E+00	6.70E-10			2.20E-06	4.90E-07	2.60E-06
Ra-228	1.90E+00	7.70E-10			5.00E-13	3.30E-07	3.30E-07
Th-228	1.50E+00	3.50E-10			4.60E-11	5.20E-07	5.20E-07
Th-232	1.30E+00	6.70E-11			1.50E-11	2.10E-12	8.30E-11
U-233/234	1.20E+00	8.00E-11			1.20E-11	2.20E-12	9.40E-11
Total pathway		3.70E-09		1.20E-11	2.20E-06	2.00E-06	4.20E-06

PWSB

Exhibit 9a. (continued)

Analyte	Concentration (mg/kg;pCi/g)	Ingestion risk	Inhalation of produce risk	Dermal risk	Inhalation risk	External risk	Total risk
Inorganics							
Barium	1.90E+02						
Organics							
Aroclor 1260	1.00E-02	1.80E-10		1.30E-10			3.10E-10
Bis(2-Ethylhexyl) Phthalate	5.70E-02	1.90E-12		6.20E-12			8.00E-12
Chloroform	2.00E-03	2.80E-14		9.00E-14	8.50E-12		8.60E-12
Radionuclides							
Am-241	3.50E-01	3.50E-10			4.40E-12	1.00E-10	4.60E-10
Cm-243	1.80E-01	1.40E-10			1.80E-12	1.80E-09	1.90E-09
Cs-137	2.00E+00	2.30E-10			1.50E-14	2.40E-07	2.40E-07
K-40	3.50E+01	1.60E-09			1.00E-13	1.10E-06	1.10E-06
Pu-238	4.20E+00	3.80E-09			6.30E-11	7.10E-12	3.90E-09
Ra-226	1.70E+00	8.50E-10			2.70E-06	6.20E-07	3.40E-06
Ra-228	1.60E+00	6.90E-10			4.40E-13	2.90E-07	2.90E-07
Th-228	1.90E+00	4.40E-10			5.80E-11	6.50E-07	6.50E-07
Th-232	1.70E+00	8.70E-11			1.90E-11	2.70E-12	1.10E-10
Th-234	7.30E+00	1.20E-10			9.10E-14	1.60E-09	1.70E-09
Total Radioactive Strontium	3.20E+00	4.70E-10			7.60E-14	0.00E+00	4.70E-10
U-233/234	8.10E-01	5.40E-11			8.20E-12	1.50E-12	6.40E-11
Total pathway		9.00E-09		1.30E-10	2.70E-06	2.90E-06	5.70E-06
SW3							
Inorganics							
Zinc	3.20E+02						
Organics							
Aroclor 1254	9.30E-02	1.70E-09		1.20E-09			2.80E-09
Aroclor 1260	7.80E-02	1.40E-09		9.80E-10			2.40E-09
Radionuclides							
Am-241	1.20E+00	1.20E-09			1.50E-11	3.70E-10	1.60E-09
Cs-137	6.90E+00	8.10E-10			5.10E-14	8.40E-07	8.40E-07
Pu-238	3.20E-01	2.90E-10			4.80E-12	5.40E-13	2.90E-10
Pu-239/240	1.80E+00	1.70E-09			2.60E-11	1.80E-12	1.70E-09
Ra-228	1.20E+00	5.00E-10			3.20E-13	2.10E-07	2.10E-07
Th-228	1.60E+00	3.70E-10			4.90E-11	5.60E-07	5.60E-07

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Exhibit 9a. (continued)

Analyte	Concentration (mg/kg;pCi/g)	Ingestion risk	Ingestion of produce risk	Dermal risk	Inhalation risk	External risk	Total risk
Ac-228	1.00E+00	2.10E-12			1.00E-14	1.80E-07	1.80E-07
Am-241	6.80E+00	6.80E-09			8.40E-11	2.00E-09	8.90E-09
Cm-243/244	3.60E+01	2.40E-08			3.00E-10	6.50E-11	2.40E-08
Cs-137	3.50E+02	4.10E-08			2.60E-12	4.30E-05	4.30E-05
Pb-212	1.90E+00	4.40E-11			3.20E-14	3.20E-08	3.20E-08
Pb-214	6.00E-01	4.20E-13			6.80E-16	2.30E-08	2.30E-08
Pu-238	8.90E-01	8.10E-10			1.30E-11	1.50E-12	8.30E-10
Pu-239/240	7.90E-01	7.60E-10			1.20E-11	8.20E-13	7.70E-10
Ra-228	1.30E+00	5.50E-10			3.50E-13	2.30E-07	2.30E-07
Th-228	1.60E+00	3.70E-10			4.90E-11	5.50E-07	5.50E-07
Th-230	4.40E+00	2.40E-10			4.90E-11	1.40E-11	3.00E-10
Tl-208	1.00E+00	7.50E-14			1.90E-18	7.90E-07	7.90E-07
Total Radioactive Strontium	1.00E+04	1.50E-06			2.50E-10	0.00E+00	1.50E-06
U-232	5.30E-01	8.20E-11			1.20E-11	1.50E-12	9.60E-11
Total pathway		1.60E-06		5.50E-10	7.80E-10	4.50E-05	4.60E-05
SWSA55W							
Inorganics							
Barium	3.20E+02						
Manganese	2.30E+03						
Organics							
Aroclor 1260	1.40E+00	2.50E-08		1.80E-08			4.20E-08
Chloroform	1.00E-03	1.40E-14		4.50E-14	4.20E-12		4.30E-12
Radionuclides							
Ac-228	2.30E+00	4.80E-12			2.30E-14	4.00E-07	4.00E-07
Bi-214	8.20E-01	4.40E-13			6.70E-16	2.60E-07	2.60E-07
Cs-137	7.50E+01	8.70E-09			5.50E-13	9.10E-06	9.10E-06
I-129	3.30E+00	2.60E-09			1.50E-13	8.20E-10	3.40E-09
K-40	3.10E+01	1.40E-09			9.10E-14	1.00E-06	1.00E-06
Pb-210	6.10E+00	1.70E-08			9.50E-12	5.90E-11	1.70E-08
Pb-212	1.60E+00	3.80E-11			2.70E-14	2.80E-08	2.80E-08
Pb-214	1.40E+00	9.90E-13			1.60E-15	5.50E-08	5.50E-08
Ra-226	1.30E+00	6.60E-10			2.10E-06	4.80E-07	2.60E-06
Ra-228	2.10E+00	8.90E-10			5.70E-13	3.80E-07	3.80E-07

Exhibit 9a. (continued)

Analyte	Concentration (mg/kg;pCi/g)	Ingestion risk	Ingestion of produce risk	Dermal risk	Inhalation risk	External risk	Total risk
Th-228	1.40E+00	3.30E-10			4.30E-11	4.90E-07	4.90E-07
Th-232	2.20E+00	1.10E-10			2.40E-11	3.40E-12	1.40E-10
Tl-208	1.40E+00	1.00E-13			2.70E-18	1.10E-06	1.10E-06
Total Radioactive Strontium	5.20E+03	7.80E-07			1.30E-10	0.00E+00	7.80E-07
U-233/234	9.90E+00	6.60E-10			1.00E-10	1.80E-11	7.80E-10
U-238	5.00E+00	5.80E-10			1.00E-10	1.10E-08	1.20E-08
Total pathway		8.40E-07		1.80E-08	2.10E-06	1.30E-05	1.60E-05

WOC

Inorganics

Mercury 8.10E-01

Organics

Aroclor 1260 4.10E-02 7.40E-10 5.20E-10 1.30E-09

Radionuclides

Ac-228	1.80E+00	3.70E-12			1.80E-14	3.20E-07	3.20E-07
Co-57	2.30E+00	5.60E-12			7.30E-15	2.70E-08	2.70E-08
Co-60	3.60E+01	2.20E-09			2.10E-12	1.90E-05	1.90E-05
Cs-134	4.00E-02	6.80E-12			4.40E-16	1.30E-08	1.30E-08
Cs-137	5.50E+03	6.40E-07			4.10E-11	6.70E-04	6.70E-04
Na-22	1.50E+00	4.20E-11			2.80E-15	6.60E-07	6.60E-07
Pb-212	1.40E+00	3.20E-11			2.30E-14	2.40E-08	2.40E-08
Pb-214	1.40E+00	9.90E-13			1.60E-15	5.50E-08	5.50E-08
Ra-228	1.80E+00	7.50E-10			4.80E-13	3.20E-07	3.20E-07
Th-228	2.20E+00	5.00E-10			6.70E-11	7.50E-07	7.50E-07
Th-232	1.80E+00	9.00E-11			2.00E-11	2.80E-12	1.10E-10
Tl-208	2.00E+00	1.50E-13			3.90E-18	1.60E-06	1.60E-06
Total Radioactive Strontium	3.80E+02	5.70E-08			9.20E-12	0.00E+00	5.70E-08
Total pathway		7.00E-07		5.20E-10	1.40E-10	6.90E-04	6.90E-04

Industrial scenario

FS

Inorganics

Mercury 4.30E+00

Organics

Aroclor 1260 1.80E-01 2.40E-07 1.70E-07 4.10E-07

Exhibit 9a. (continued)

Analyte	Concentration (mg/kg;pCi/g)	Ingestion risk	Ingestion of produce risk	Dermal risk	Inhalation risk	External risk	Total risk
Radionuclides							
Co-60	1.80E+02	8.40E-07			7.90E-10	7.10E-03	7.10E-03
Cs-137	3.60E+01	3.20E-07			2.00E-11	3.30E-04	3.30E-04
Pb-212	1.50E+00	2.60E-09			1.90E-12	1.90E-06	1.90E-06
Ra-226	3.60E+00	1.40E-07			4.30E-04	9.90E-05	5.30E-04
Th-232	1.90E+00	7.10E-09			1.60E-09	2.30E-10	8.90E-09
Total Radioactive Strontium	1.20E+02	1.40E-06			2.20E-10	0.00E+00	1.40E-06
U-233/234	7.30E+00	3.70E-08			5.50E-09	1.00E-09	4.30E-08
U-238	7.00E+00	6.10E-08			1.10E-08	1.20E-06	1.20E-06
Total pathway		3.00E-06		1.70E-07	4.30E-04	7.50E-03	7.90E-03
NHFT							
Organics							
Di-n-butyl Phthalate	1.30E-01						
Toluene	1.00E-03						
Radionuclides							
Am-241	1.10E-01	8.30E-09			1.00E-10	2.50E-09	1.10E-08
Pu-238	2.60E-01	1.80E-08			3.00E-10	3.30E-11	1.80E-08
Ra-228	1.60E+00	5.00E-08			3.20E-11	2.10E-05	2.10E-05
Th-228	1.70E+00	2.90E-08			3.80E-09	4.30E-05	4.30E-05
Th-230	1.30E+00	5.20E-09			1.10E-09	3.20E-10	6.60E-09
Th-232	1.60E+00	5.80E-09			1.30E-09	1.80E-10	7.30E-09
U-233/234	9.70E-01	4.80E-09			7.40E-10	1.30E-10	5.70E-09
Total pathway		1.20E-07			7.30E-09	6.40E-05	6.40E-05
OHFP							
Inorganics							
Cadmium	1.50E+00				1.40E-10		1.40E-10
Organics							
Aroclor 1254	3.20E-02	4.30E-08		3.00E-08			7.30E-08
Aroclor 1260	9.60E-03	1.30E-08		9.10E-09			2.20E-08
Heptachlor Epoxide	5.40E-04	8.60E-10		7.50E-10	8.00E-14		1.60E-09
Toluene	1.00E-03						
Radionuclides							
Am-241	3.50E-01	2.70E-08			3.30E-10	7.90E-09	3.50E-08

Exhibit 9a. (continued)

Analyte	Concentration (mg/kg;pCi/g)	Ingestion risk	Ingestion of produce risk	Dermal risk	Inhalation risk	External risk	Total risk
Co-60	6.20E-01	2.90E-09			2.70E-12	2.40E-05	2.40E-05
Cs-137	1.10E+03	1.00E-05			6.30E-10	1.00E-02	1.00E-02
Ra-228	1.40E+00	4.30E-08			2.80E-11	1.80E-05	1.80E-05
Th-228	1.50E+00	2.60E-08			3.50E-09	3.90E-05	3.90E-05
Th-230	1.40E+00	5.60E-09			1.20E-09	3.40E-10	7.10E-09
Total Radioactive Strontium	6.50E+02	7.40E-06			1.20E-09	0.00E+00	7.40E-06
U-233/234	8.90E-01	4.50E-09			6.80E-10	1.20E-10	5.30E-09
Total pathway		1.80E-05		4.00E-08	7.60E-09	1.00E-02	1.10E-02

OHFT

Inorganics

Silver 4.30E+00

Organics

Bis(2-Ethylhexyl) Phthalate 1.10E-01 2.70E-10 9.00E-10 1.20E-09

Cyanide 6.70E-01

Toluene 2.00E-03

Radionuclides

Am-241 2.50E-01 1.90E-08 2.40E-10 5.70E-09 2.50E-08

Cs-137 5.80E+00 5.10E-08 3.20E-12 5.30E-05 5.30E-05

Pu-238 8.70E-01 6.00E-08 9.90E-10 1.10E-10 6.10E-08

Ra-226 1.30E+00 5.00E-08 1.60E-04 3.70E-05 2.00E-04

Ra-228 1.90E+00 5.80E-08 3.70E-11 2.50E-05 2.50E-05

Th-228 1.50E+00 2.60E-08 3.40E-09 3.90E-05 3.90E-05

Th-232 1.30E+00 5.00E-09 1.10E-09 1.60E-10 6.30E-09

U-233/234 1.20E+00 6.00E-09 9.10E-10 1.60E-10 7.10E-09

Total pathway 2.80E-07 9.00E-10 1.60E-04 1.50E-04 3.10E-04

PWSB

Inorganics

Barium 1.90E+02

Organics

Aroclor 1260 1.00E-02 1.30E-08 9.40E-09 2.30E-08

Bis(2-Ethylhexyl) Phthalate 5.70E-02 1.40E-10 4.60E-10 6.00E-10

Chloroform 1.00E-03 1.10E-12 3.40E-12 3.20E-10 3.20E-10

Radionuclides

Exhibit 9a. (continued)

Analyte	Concentration (mg/kg;pCi/g)	Ingestion risk	Ingestion of produce risk	Dermal risk	Inhalation risk	External risk	Total risk
Am-241	3.50E-01	2.60E-08			3.30E-10	7.80E-09	3.40E-08
Cm-243	1.80E-01	1.10E-08			1.40E-10	1.30E-07	1.40E-07
Cs-137	2.00E+00	1.80E-08			1.10E-12	1.80E-05	1.80E-05
K-40	3.50E+01	1.20E-07			7.70E-12	8.50E-05	8.60E-05
Pu-238	4.20E+00	2.90E-07			4.70E-09	5.30E-10	2.90E-07
Ra-226	1.70E+00	6.40E-08			2.10E-04	4.70E-05	2.50E-04
Ra-228	1.60E+00	5.10E-08			3.30E-11	2.20E-05	2.20E-05
Th-228	1.90E+00	3.30E-08			4.30E-09	4.90E-05	4.90E-05
Th-232	1.70E+00	6.50E-09			1.40E-09	2.10E-10	8.10E-09
Th-234	7.30E+00	9.10E-09			6.80E-12	1.20E-07	1.30E-07
Total Radioactive Strontium	3.20E+00	3.60E-08			5.70E-12	0.00E+00	3.60E-08
U-233/234	8.10E-01	4.10E-09			6.10E-10	1.10E-10	4.80E-09
Total pathway		6.80E-07		9.90E-09	2.10E-04	2.20E-04	4.30E-04

SW3

Inorganics

Zinc 3.20E+02

Organics

Aroclor 1254	9.30E-02	1.30E-07	8.80E-08	2.10E-07
Aroclor 1260	7.80E-02	1.00E-07	7.40E-08	1.80E-07

Radionuclides

Am-241	1.20E+00	9.30E-08	1.20E-09	2.80E-08	1.20E-07	
Cs-137	6.90E+00	6.00E-08	3.80E-12	6.30E-05	6.30E-05	
Pu-238	3.20E-01	2.20E-08	3.60E-10	4.00E-11	2.20E-08	
Pu-239/240	1.80E+00	1.30E-07	2.00E-09	1.40E-10	1.30E-07	
Ra-228	1.20E+00	3.80E-08	2.40E-11	1.60E-05	1.60E-05	
Th-228	1.60E+00	2.80E-08	3.70E-09	4.20E-05	4.20E-05	
Th-230	1.70E+00	6.70E-09	1.40E-09	4.10E-10	8.50E-09	
Total Radioactive Strontium	3.70E+00	4.20E-08	6.80E-12	0.00E+00	4.20E-08	
U-232	1.50E-01	1.70E-09	2.60E-10	3.10E-11	2.00E-09	
U-233/234	5.70E+00	2.80E-08	4.30E-09	7.70E-10	3.30E-08	
Total pathway		6.80E-07	1.60E-07	1.30E-08	1.20E-04	1.20E-04

SWSA 5N

Organics

Exhibit 9a. (continued)

Analyte	Concentration (mg/kg;pCi/g)	Ingestion risk	Ingestion of produce risk	Dermal risk	Inhalation risk	External risk	Total risk
1,2-Benzenedicarboxylic Acid, Diethyl Ester	3.00E-01						
2-Butanone	3.00E-03						
Aroclor 1260	2.60E-02	3.50E-08		2.50E-08			6.00E-08
Bis(2-Ethylhexyl) Phthalate	4.50E-02	1.10E-10		3.70E-10			4.80E-10
Di-n-butyl Phthalate	7.10E-02						
Methylene Chloride	5.00E-03	6.60E-12		4.40E-12			1.10E-11
Radionuclides							
Ac-228	2.10E+00	3.30E-10			1.60E-12	2.80E-05	2.80E-05
Bi-212	2.60E+00	2.50E-10			5.00E-13	7.00E-06	7.00E-06
Bi-214	9.40E-01	3.80E-11			5.80E-14	2.30E-05	2.30E-05
I-129	5.70E+00	3.40E-07			2.00E-11	1.10E-07	4.50E-07
Pb-212	1.50E+00	2.50E-09			1.80E-12	1.90E-06	1.90E-06
Pb-214	1.00E+00	5.50E-11			8.80E-14	3.00E-06	3.00E-06
Ra-223	5.60E-01	1.10E-08			5.10E-11	5.90E-07	6.00E-07
Ra-228	2.20E+00	6.70E-08			4.30E-11	2.90E-05	2.90E-05
Th-228	1.80E+00	3.10E-08			4.00E-09	4.50E-05	4.50E-05
Th-232	2.10E+00	8.00E-09			1.70E-09	2.50E-10	1.00E-08
Tl-208	1.60E+00	9.00E-12			2.30E-16	9.50E-05	9.50E-05
Total pathway		4.90E-07		2.50E-08	5.90E-09	2.30E-04	2.30E-04
SWSA SSE							
Inorganics							
Antimony	6.20E+00						
Manganese	3.30E+03						
Organics							
Aroclor 1260	4.40E-02	5.90E-08		4.10E-08			1.00E-07
Chloroform	1.00E-03	1.10E-12		3.40E-12	3.20E-10		3.20E-10
Radionuclides							
Ac-228	1.00E+00	1.60E-10			7.60E-13	1.30E-05	1.30E-05
Am-241	6.80E+00	5.10E-07			6.30E-09	1.50E-07	6.70E-07
Cm-243/244	3.60E+01	1.80E-06			2.30E-08	4.90E-09	1.80E-06
Cs-137	6.70E+03	5.90E-05			3.70E-09	5.90E-02	5.90E-02
Pb-212	1.90E+00	3.30E-09			2.40E-12	2.40E-06	2.40E-06

Exhibit 9a. (continued)

Analyte	Concentration (mg/kg;pCi/g)	Ingestion risk	Ingestion of produce risk	Dermal risk	Inhalation risk	External risk	Total risk
Pb-214	6.00E-01	3.20E-11			5.10E-14	1.80E-06	1.80E-06
Pu-238	8.90E-01	6.10E-08			1.00E-09	1.10E-10	6.20E-08
Pu-239/240	7.90E-01	5.70E-08			8.80E-10	6.10E-11	5.80E-08
Ra-228	1.30E+00	4.10E-08			2.70E-11	1.70E-05	1.80E-05
Th-228	1.60E+00	2.80E-08			3.60E-09	4.10E-05	4.10E-05
Th-230	4.40E+00	1.80E-08			3.70E-09	1.10E-09	2.30E-08
Tl-208	1.00E+00	5.60E-12			1.50E-16	5.90E-05	5.90E-05
Total Radioactive Strontium	1.00E+04	1.20E-04			1.90E-08	0.00E+00	1.20E-04
U-232	5.30E-01	6.20E-09			9.30E-10	1.10E-10	7.20E-09
Total pathway		1.80E-04		4.10E-08	6.20E-08	5.90E-02	6.00E-02
SWSASSW							
Inorganics							
Barium	3.60E+02						
Manganese	2.70E+03						
Organics							
Aroclor 1260	1.20E+00	1.60E-06		1.10E-06			2.70E-06
Chloroform	1.00E-03	1.10E-12		3.40E-12	3.20E-10		3.20E-10
Radionuclides							
Ac-228	2.30E+00	3.60E-10			1.70E-12	3.00E-05	3.00E-05
Bi-214	8.20E-01	3.30E-11			5.00E-14	2.00E-05	2.00E-05
Cs-137	8.40E+01	7.40E-07			4.70E-11	7.70E-04	7.70E-04
K-40	3.20E+01	1.10E-07			7.20E-12	8.00E-05	8.00E-05
Pb-212	1.70E+00	2.90E-09			2.10E-12	2.20E-06	2.20E-06
Pb-214	1.40E+00	7.40E-11			1.20E-13	4.10E-06	4.10E-06
Ra-226	1.50E+00	5.50E-08			1.80E-04	4.00E-05	2.20E-04
Ra-228	2.00E+00	6.20E-08			4.00E-11	2.60E-05	2.70E-05
Th-228	1.50E+00	2.60E-08			3.40E-09	3.80E-05	3.80E-05
Th-232	2.20E+00	8.20E-09			1.80E-09	2.60E-10	1.00E-08
Tl-208	1.40E+00	7.90E-12			2.00E-16	8.30E-05	8.30E-05
Total Radioactive Strontium	5.20E+03	5.90E-05			9.40E-09	0.00E+00	5.90E-05
U-233/234	9.90E+00	5.00E-08			7.50E-09	1.40E-09	5.80E-08
U-238	5.00E+00	4.40E-08			7.60E-09	8.20E-07	8.70E-07
Total pathway		6.10E-05		1.10E-06	1.80E-04	1.10E-03	1.30E-03

Exhibit 9a. (continued)

Analyte	Concentration (mg/kg;pCi/g)	Ingestion risk	Ingestion of produce risk	Dermal risk	Inhalation risk	External risk	Total risk
WOC							
Inorganics							
Mercury	8.10E-01						
Organics							
Aroclor 1260	4.10E-02	5.50E-08		3.90E-08			9.40E-08
Radionuclides							
Ac-228	1.80E+00	2.80E-10			1.40E-12	2.40E-05	2.40E-05
Co-57	2.30E+00	4.20E-10			5.50E-13	2.00E-06	2.00E-06
Co-60	3.60E+01	1.70E-07			1.60E-10	1.40E-03	1.40E-03
Cs-134	4.00E-02	5.10E-10			3.30E-14	9.50E-07	9.50E-07
Cs-137	5.50E+03	4.80E-05			3.00E-09	4.90E-02	4.90E-02
Na-22	1.50E+00	3.20E-09			2.10E-13	4.90E-05	4.90E-05
Pb-212	1.40E+00	2.40E-09			1.80E-12	1.80E-06	1.80E-06
Pb-214	1.40E+00	7.40E-11			1.20E-13	4.10E-06	4.10E-06
Ra-228	1.80E+00	5.60E-08			3.60E-11	2.40E-05	2.40E-05
Th-228	2.20E+00	3.80E-08			5.00E-09	5.60E-05	5.60E-05
Th-232	1.80E+00	6.70E-09			1.50E-09	2.10E-10	8.40E-09
Tl-208	2.00E+00	1.10E-11			2.90E-16	1.20E-04	1.20E-04
Total Radioactive Strontium	3.80E+02	4.30E-06			6.90E-10	0.00E+00	4.30E-06
Total pathway		5.30E-05		3.90E-08	1.00E-08	5.00E-02	5.00E-02
Residential scenario							
FS							
Inorganics							
Mercury	4.30E+00						
Organics							
Aroclor 1260	1.80E-01	2.20E-06	8.10E-07	5.40E-07			3.50E-06
Radionuclides							
Co-60	1.80E+02	3.40E-06	2.10E-05		1.30E-09	3.50E-02	3.50E-02
Cs-137	3.60E+01	1.30E-06	1.70E-06		3.40E-11	1.70E-03	1.70E-03
Pb-212	1.50E+00	1.00E-08	4.70E-07		3.20E-12	9.70E-06	1.00E-05
Ra-226	3.60E+00	5.40E-07	5.10E-07		7.30E-04	5.00E-04	1.20E-03
Th-232	1.90E+00	2.90E-08	8.00E-08		2.60E-09	1.10E-09	1.10E-07
Total Radioactive Strontium	1.20E+02	5.40E-06	7.30E-04		3.60E-10	0.00E+00	7.30E-04

Exhibit 9a. (continued).

Analyte	Concentration (mg/kg;pCi/g)	Ingestion risk	Ingestion of produce risk	Dermal risk	Inhalation risk	External risk	Total risk
U-233/234	7.30E+00	1.50E-07	2.50E-07		9.30E-09	5.00E-09	4.10E-07
U-238	7.00E+00	2.50E-07	4.10E-07		1.80E-08	5.80E-06	6.50E-06
Total pathway		1.30E-05	7.50E-04	5.40E-07	7.30E-04	3.70E-02	3.90E-02
NHFT							
Organics							
Di-n-butyl Phthalate	1.30E-01						
Toluene	1.00E-03						
Radionuclides							
Am-241	1.10E-01	3.40E-08	5.60E-09		1.70E-10	1.30E-08	5.20E-08
Pu-238	2.60E-01	7.30E-08	1.20E-08		5.00E-10	1.70E-10	8.50E-08
Ra-228	1.60E+00	2.00E-07	1.90E-07		5.40E-11	1.10E-04	1.10E-04
Th-228	1.70E+00	1.20E-07	3.20E-07		6.40E-09	2.20E-04	2.20E-04
Th-230	1.30E+00	2.10E-08	5.90E-08		1.80E-09	1.60E-09	8.30E-08
Th-232	1.60E+00	2.30E-08	6.60E-08		2.10E-09	9.30E-10	9.20E-08
U-233/234	9.70E-01	2.00E-08	3.30E-08		1.20E-09	6.70E-10	5.40E-08
Total pathway		4.90E-07	6.90E-07		1.20E-08	3.20E-04	3.20E-04
OHFP							
Inorganics							
Cadmium	1.50E+00				4.20E-10		4.20E-10
Organics							
Aroclor 1254	3.20E-02	3.90E-07	6.30E-07	9.50E-08			1.10E-06
Aroclor 1260	9.60E-03	1.20E-07	4.30E-08	2.90E-08			1.90E-07
Heptachlor Epoxide	5.40E-04	7.70E-09	1.10E-06	2.40E-09	2.30E-13		1.10E-06
Toluene	1.00E-03						
Radionuclides							
Am-241	3.50E-01	1.10E-07	1.80E-08		5.50E-10	4.00E-08	1.70E-07
Co-60	6.20E-01	1.20E-08	7.30E-08		4.50E-12	1.20E-04	1.20E-04
Cs-137	1.10E+03	4.00E-05	5.40E-05		1.10E-09	5.10E-02	5.10E-02
Ra-228	1.40E+00	1.70E-07	1.60E-07		4.70E-11	9.20E-05	9.20E-05
Th-228	1.50E+00	1.10E-07	3.00E-07		5.80E-09	2.00E-04	2.00E-04
Th-230	1.40E+00	2.30E-08	6.30E-08		2.00E-09	1.70E-09	9.00E-08
Total Radioactive Strontium	6.50E+02	3.00E-05	4.00E-03		2.00E-09	0.00E+00	4.00E-03
U-233/234	8.90E-01	1.80E-08	3.00E-08		1.10E-09	6.20E-10	5.00E-08

Exhibit 9a. (continued)

Analyte	Concentration (mg/kg;pCi/g)	Ingestion risk	Ingestion of produce risk	Dermal risk	Inhalation risk	External risk	Total risk
Total pathway		7.10E-05	4.00E-03	1.30E-07	1.30E-08	5.20E-02	5.60E-02
OHFT							
Inorganics							
Silver	4.30E+00						
Organics							
Bis(2-Ethylhexyl) Phthalate	1.10E-01	2.40E-09	3.40E-11	2.80E-09			5.30E-09
Cyanide	6.70E-01						
Toluene	2.00E-03						
Radionuclides							
Am-241	2.50E-01	7.70E-08	1.30E-08		4.00E-10	2.90E-08	1.20E-07
Cs-137	5.80E+00	2.00E-07	2.70E-07		5.40E-12	2.70E-04	2.70E-04
Pu-238	8.70E-01	2.40E-07	4.00E-08		1.70E-09	5.60E-10	2.80E-07
Ra-226	1.30E+00	2.00E-07	1.90E-07		2.70E-04	1.90E-04	4.60E-04
Ra-228	1.90E+00	2.30E-07	2.20E-07		6.30E-11	1.20E-04	1.20E-04
Th-228	1.50E+00	1.00E-07	2.90E-07		5.80E-09	1.90E-04	2.00E-04
Th-232	1.30E+00	2.00E-08	5.70E-08		1.80E-09	8.00E-10	7.90E-08
U-233/234	1.20E+00	2.40E-08	4.00E-08		1.50E-09	8.30E-10	6.70E-08
Total pathway		1.10E-06	1.10E-06	2.80E-09	2.70E-04	7.70E-04	1.00E-03
PWSB							
Inorganics							
Barium	1.90E+02						
Organics							
Aroclor 1260	1.00E-02	1.20E-07	4.50E-08	3.00E-08			2.00E-07
Bis(2-Ethylhexyl) Phthalate	5.70E-02	1.20E-09	1.70E-11	1.50E-09			2.70E-09
Chloroform	1.00E-03	9.50E-12	3.50E-09	1.10E-11	9.20E-10		4.40E-09
Radionuclides							
Am-241	3.50E-01	1.10E-07	1.80E-08		5.50E-10	3.90E-08	1.60E-07
Cm-243	1.80E-01	4.30E-08	7.20E-08		2.30E-10	6.60E-07	7.80E-07
Cs-137	2.00E+00	7.10E-08	9.40E-08		1.90E-12	9.20E-05	9.20E-05
K-40	3.50E+01	4.80E-07	1.20E-04		1.30E-11	4.30E-04	5.50E-04
Pu-238	4.20E+00	1.20E-06	1.90E-07		7.90E-09	2.70E-09	1.40E-06
Ra-226	1.70E+00	2.60E-07	2.40E-07		3.50E-04	2.40E-04	5.80E-04
Ra-228	1.60E+00	2.10E-07	1.90E-07		5.60E-11	1.10E-04	1.10E-04

Exhibit 9a. (continued)

Analyte	Concentration (mg/kg;pCi/g)	Ingestion risk	Ingestion of produce risk	Dermal risk	Inhalation risk	External risk	Total risk
Th-228	1.90E+00	1.30E-07	3.70E-07		7.30E-09	2.40E-04	2.50E-04
Th-232	1.70E+00	2.60E-08	7.30E-08		2.40E-09	1.00E-09	1.00E-07
Th-234	7.30E+00	3.70E-08	1.00E-07		1.10E-11	5.90E-07	7.30E-07
Total Radioactive Strontium	3.20E+00	1.40E-07	1.90E-05		9.60E-12	0.00E+00	1.90E-05
U-233/234	8.10E-01	1.60E-08	2.70E-08		1.00E-09	5.60E-10	4.50E-08
Total pathway		2.80E-06	1.40E-04	3.10E-08	3.50E-04	1.10E-03	1.60E-03
SW3							
Inorganics							
Zinc	3.20E+02						
Organics							
Aroclor 1254	9.30E-02	1.10E-06	1.80E-06	2.80E-07			3.20E-06
Aroclor 1260	7.80E-02	9.40E-07	3.50E-07	2.30E-07			1.50E-06
Radionuclides							
Am-241	1.20E+00	3.70E-07	6.20E-08		1.90E-09	1.40E-07	5.80E-07
Cs-137	6.90E+00	2.40E-07	3.30E-07		6.40E-12	3.20E-04	3.20E-04
Pu-238	3.20E-01	8.70E-08	1.50E-08		6.00E-10	2.00E-10	1.00E-07
Pu-239/240	1.80E+00	5.10E-07	8.50E-08		3.30E-09	6.90E-10	6.00E-07
Ra-228	1.20E+00	1.50E-07	1.40E-07		4.10E-11	8.00E-05	8.00E-05
Th-228	1.60E+00	1.10E-07	3.20E-07		6.20E-09	2.10E-04	2.10E-04
Th-230	1.70E+00	2.70E-08	7.60E-08		2.30E-09	2.10E-09	1.10E-07
Total Radioactive Strontium	3.70E+00	1.70E-07	2.30E-05		1.10E-11	0.00E+00	2.30E-05
U-232	1.50E-01	6.90E-09	1.10E-08		4.40E-10	1.60E-10	1.90E-08
U-233/234	5.70E+00	1.10E-07	1.90E-07		7.20E-09	3.90E-09	3.10E-07
Total pathway		3.90E-06	2.60E-05	5.10E-07	2.20E-08	6.10E-04	6.40E-04
SWSA 5N							
Organics							
1,2-Benzenedicarboxylic Acid, Diethyl Ester	3.00E-01						
2-Butanone	3.00E-03						
Aroclor 1260	2.60E-02	3.10E-07	1.20E-07	7.80E-08			5.10E-07
Bis(2-Ethylhexyl) Phthalate	4.50E-02	9.90E-10	1.40E-11	1.20E-09			2.20E-09
Di-n-butyl Phthalate	7.10E-02						
Methylene Chloride	5.00E-03	5.90E-11	5.20E-08	1.40E-11			5.20E-08

Exhibit 9a. (continued)

Analyte	Concentration (mg/kg;pCi/g)	Ingestion risk	Ingestion of produce risk	Dermal risk	Inhalation risk	External risk	Total risk
Radionuclides							
Ac-228	2.10E+00	1.30E-09	2.20E-09		2.70E-12	1.40E-04	1.40E-04
Bi-212	2.60E+00	1.00E-09	6.80E-08		8.40E-13	3.50E-05	3.50E-05
Bi-214	9.40E-01	1.50E-10	1.00E-08		9.70E-14	1.10E-04	1.10E-04
I-129	5.70E+00	1.40E-06	1.80E-05		3.40E-11	5.40E-07	2.00E-05
Pb-212	1.50E+00	1.00E-08	4.60E-07		3.10E-12	9.40E-06	9.90E-06
Pb-214	1.00E+00	2.20E-10	1.00E-08		1.50E-13	1.50E-05	1.50E-05
Ra-223	5.60E-01	4.50E-08	4.20E-08		8.50E-11	3.00E-06	3.10E-06
Ra-228	2.20E+00	2.70E-07	2.50E-07		7.30E-11	1.40E-04	1.40E-04
Th-228	1.80E+00	1.20E-07	3.40E-07		6.80E-09	2.30E-04	2.30E-04
Th-232	2.10E+00	3.20E-08	9.00E-08		2.90E-09	1.30E-09	1.30E-07
Tl-208	1.60E+00	3.60E-11	4.80E-09		3.90E-16	4.80E-04	4.80E-04
Total pathway		2.20E-06	2.00E-05	7.90E-08	9.90E-09	1.20E-03	1.20E-03
SWSA SSE							
Inorganics							
Antimony	6.20E+00						
Manganese	3.30E+03						
Organics							
Aroclor 1260	4.40E-02	5.30E-07	2.00E-07	1.30E-07			8.60E-07
Chloroform	1.00E-03	9.50E-12	3.50E-09	1.10E-11	9.20E-10		4.40E-09
Radionuclides							
Ac-228	1.00E+00	6.30E-10	1.10E-09		1.30E-12	6.70E-05	6.70E-05
Am-241	6.80E+00	2.10E-06	3.40E-07		1.10E-08	7.60E-07	3.20E-06
Cm-243/244	3.60E+01	7.20E-06	1.20E-05		3.80E-08	2.50E-08	1.90E-05
Cs-137	6.70E+03	2.40E-04	3.20E-04		6.20E-09	2.70E-01	2.70E-01
Pb-212	1.90E+00	1.30E-08	6.00E-07		4.00E-12	1.20E-05	1.30E-05
Pb-214	6.00E-01	1.30E-10	5.80E-09		8.50E-14	8.80E-06	8.80E-06
Pu-238	8.90E-01	2.50E-07	4.10E-08		1.70E-09	5.70E-10	2.90E-07
Pu-239/240	7.90E-01	2.30E-07	3.80E-08		1.50E-09	3.10E-10	2.70E-07
Ra-228	1.30E+00	1.70E-07	1.60E-07		4.50E-11	8.80E-05	8.80E-05
Th-228	1.60E+00	1.10E-07	3.10E-07		6.10E-09	2.10E-04	2.10E-04
Th-230	4.40E+00	7.20E-08	2.00E-07		6.20E-09	5.40E-09	2.80E-07
Tl-208	1.00E+00	2.30E-11	3.00E-09		2.50E-16	3.00E-04	3.00E-04

Exhibit 9a. (continued)

Analyte	Concentration (mg/kg;pCi/g)	Ingestion risk	Ingestion of produce risk	Dermal risk	Inhalation risk	External risk	Total risk
Ac-228	1.80E+00	1.10E-09	1.90E-09		2.30E-12	1.20E-04	1.20E-04
Co-57	2.30E+00	1.70E-09	1.10E-08		9.20E-13	1.00E-05	1.00E-05
Co-60	3.60E+01	6.80E-07	4.30E-06		2.60E-10	7.10E-03	7.10E-03
Cs-134	4.00E-02	2.10E-09	2.80E-09		5.50E-14	4.80E-06	4.80E-06
Cs-137	5.50E+03	1.90E-04	2.60E-04		5.10E-09	2.20E-01	2.20E-01
Na-22	1.50E+00	1.30E-08	4.30E-07		3.50E-13	2.50E-04	2.50E-04
Pb-212	1.40E+00	9.70E-09	4.40E-07		3.00E-12	9.00E-06	9.50E-06
Pb-214	1.40E+00	3.00E-10	1.40E-08		2.00E-13	2.10E-05	2.10E-05
Ra-228	1.80E+00	2.30E-07	2.10E-07		6.10E-11	1.20E-04	1.20E-04
Th-228	2.20E+00	1.50E-07	4.30E-07		8.40E-09	2.80E-04	2.80E-04
Th-232	1.80E+00	2.70E-08	7.60E-08		2.50E-09	1.10E-09	1.10E-07
Tl-208	2.00E+00	4.50E-11	6.00E-09		4.90E-16	6.00E-04	6.00E-04
Total Radioactive Strontium	3.80E+02	1.70E-05	2.30E-03		1.20E-09	0.00E+00	2.30E-03
Total pathway		2.10E-04	2.60E-03	1.20E-07	1.70E-08	2.30E-01	2.30E-01

**Exhibit 9b. Carcinogenic risk for WAG 5 sediment COPCs
(Industrial and residential scenarios)**

Analyte	Concentration (mg/kg,pCi/g)	Ingestion risk	Dermal risk	Inhalation risk	External risk	Total risk
Industrial scenario						
D1						
Inorganics						
Chromium VI	3.30E+01			2.20E-08		2.20E-08
Manganese	4.90E+03					
Mercury	1.40E-01					
Nickel	6.60E+01					
Silver	2.30E+00					
Organics						
Aroclor 1260	8.30E-01	1.10E-06	7.80E-07			1.90E-06
Radionuclides						
Ac-228	1.40E+00	2.20E-10		1.10E-12	1.90E-05	1.90E-05
Am-241	6.50E-01	4.90E-08		6.10E-10	1.50E-08	6.40E-08
Bi-212	1.50E+00	1.50E-10		2.90E-13	4.00E-06	4.00E-06
Bi-214	8.60E-01	3.50E-11		5.30E-14	2.10E-05	2.10E-05
Co-60	3.10E-01	1.50E-09		1.40E-12	1.20E-05	1.20E-05
Pb-212	1.30E+00	2.20E-09		1.60E-12	1.70E-06	1.70E-06
Pb-214	9.30E-01	1.60E-09		1.20E-12	1.20E-06	1.20E-06
Ra-223	3.70E-01	7.40E-09		3.30E-11	3.90E-07	4.00E-07
Radon 219	4.70E-01			6.30E-16	3.40E-07	3.40E-07
Th-230	3.20E+00	1.30E-08		2.70E-09	7.80E-10	1.60E-08
Th-234	1.10E+01	1.40E-08		1.00E-11	1.80E-07	1.90E-07
Total Radioactive Strontium	1.30E+00	1.50E-08		2.40E-12	0.00E+00	1.50E-08
Tritium	2.30E+03	3.90E-08		5.30E-12	0.00E+00	3.90E-08
U-233/234	8.80E+00	4.40E-08		6.70E-09	1.20E-09	5.20E-08
U-235	3.60E-01	1.80E-09		2.60E-10	3.90E-07	4.00E-07
U-238	1.30E+01	1.10E-07		1.90E-08	2.10E-06	2.20E-06
Total pathway		1.40E-06	7.80E-07	5.20E-08	6.20E-05	6.40E-05
D2						
Inorganics						
Arsenic	1.40E+01			1.10E-08		1.10E-08
Barium	1.60E+03					

Exhibit 9b. (continued)

Analyte	Concentration (mg/kg;pCi/g)	Ingestion risk	Dermal risk	Inhalation risk	External risk	Total risk
Chromium VI	2.20E+01			1.50E-08		1.50E-08
Manganese	4.30E+04					
Organics						
Aroclor 1260	8.50E-02	1.10E-07	8.00E-08			1.90E-07
Vinyl Chloride	1.00E+00	3.40E-07	2.20E-07	2.50E-03		2.50E-03
Radionuclides						
Ac-228	2.30E+00	3.60E-10		1.70E-12	3.00E-05	3.00E-05
Bi-212	1.70E+00	1.60E-10		3.30E-13	4.60E-06	4.60E-06
Bi-214	1.20E+00	4.80E-11		7.30E-14	2.90E-05	2.90E-05
Cm-243/244	5.50E+00	2.80E-07		3.50E-09	7.60E-10	2.80E-07
Co-60	6.30E-01	3.00E-09		2.80E-12	2.50E-05	2.50E-05
I-129	1.40E+01	8.30E-07		4.90E-11	2.60E-07	1.10E-06
Pb-212	1.70E+00	2.90E-09		2.10E-12	2.20E-06	2.20E-06
Pb-214	1.20E+00	2.10E-09		1.50E-12	1.50E-06	1.50E-06
Pu-238	3.10E+01	2.20E-06		3.60E-08	4.00E-09	2.20E-06
Ra-223	9.10E-01	1.80E-08		8.20E-11	9.60E-07	9.70E-07
Ra-224	4.90E+00	5.80E-08		1.70E-10	5.10E-07	5.70E-07
Ra-226	2.90E+00	1.10E-07		3.50E-04	8.00E-05	4.30E-04
Radon 219	1.20E+00			1.60E-15	8.80E-07	8.80E-07
Tl-208	1.40E+00	7.90E-12		2.00E-16	8.30E-05	8.30E-05
Total Radioactive Strontium	1.30E+03	1.50E-05		2.30E-09	0.00E+00	1.50E-05
U-233/234	1.60E+01	8.00E-08		1.20E-08	2.20E-09	9.40E-08
U-235	4.10E-01	2.10E-09		3.00E-10	4.50E-07	4.50E-07
U-238	2.40E+00	2.10E-08		3.60E-09	3.90E-07	4.20E-07
Total pathway		1.90E-05	3.00E-07	2.90E-03	2.60E-04	3.10E-03
D3						
Inorganics						
Chromium VI	1.80E+01			1.20E-08		1.20E-08
Mercury	9.00E-02					
Selenium	1.70E+00					
Organics						
Chloroform	2.00E-03	2.10E-12	6.70E-12	6.40E-10		6.40E-10
Radionuclides						

Exhibit 9b. (continued)

Analyte	Concentration (mg/kg,pCi/g)	Ingestion risk	Dermal risk	Inhalation risk	External risk	Total risk
Ac-228	1.50E+00	2.30E-10		1.10E-12	2.00E-05	2.00E-05
Bi-214	9.10E-01	3.70E-11		5.60E-14	2.20E-05	2.20E-05
I-129	1.30E+00	7.70E-08		4.60E-12	2.40E-08	1.00E-07
Pb-210	2.70E+00	5.60E-07		3.20E-10	2.00E-09	5.60E-07
Pb-212	1.40E+00	2.40E-09		1.80E-12	1.80E-06	1.80E-06
Pb-214	1.00E+00	1.70E-09		1.30E-12	1.30E-06	1.30E-06
Tl-208	1.10E+00	6.20E-12		1.60E-16	6.50E-05	6.50E-05
Total pathway		6.40E-07	6.70E-12	1.30E-08	1.10E-04	1.10E-04

OHFP

Inorganics

Chromium VI	3.80E+01			2.50E-08		2.50E-08
Mercury	3.10E+00					
Silver	5.90E+00					
Zinc	1.50E+02					

Organics

Aroclor 1254	2.30E+00	3.10E-06	2.20E-06			5.30E-06
Aroclor 1260	6.30E-01	8.50E-07	6.00E-07			1.40E-06

Radionuclides

Am-241	8.80E+02	6.60E-05		8.20E-07	2.00E-05	8.70E-05
Cm-243/244	2.40E+04	1.20E-03		1.60E-05	3.30E-06	1.20E-03
Co-60	6.30E+03	2.90E-05		2.70E-08	2.20E-01	2.20E-01
Cs-137	3.70E+06	3.20E-02		2.10E-06	1.00E+00	1.00E+00
Pu-238	1.20E+03	8.40E-05		1.40E-06	1.60E-07	8.50E-05
Pu-239/240	6.40E+02	4.60E-05		7.10E-07	5.00E-08	4.70E-05
Th-228	1.70E+02	3.00E-06		4.00E-07	4.40E-03	4.50E-03
Th-230	3.10E+02	1.30E-06		2.60E-07	7.60E-08	1.60E-06
Total Radioactive Strontium	7.40E+05	8.30E-03		1.30E-06	0.00E+00	8.30E-03
U-232	3.80E+01	4.30E-07		6.60E-08	7.90E-09	5.10E-07
Total pathway		4.10E-02	2.80E-06	2.30E-05	1.00E+00	1.00E+00

PWSB

Inorganics

Antimony	2.80E+01					
Chromium VI	6.40E+01			4.30E-08		4.30E-08

Exhibit 9b. (continued)

Analyte	Concentration (mg/kg;pCi/g)	Ingestion risk	Dermal risk	Inhalation risk	External risk	Total risk
Mercury	2.80E+01					
Zinc	1.60E+03					
Organics						
4-Methyl Phenol	2.60E+01					
Aroclor 1248	1.20E+00	1.60E-06	1.10E-06			2.70E-06
Aroclor 1254	1.30E+00	1.80E-06	1.30E-06			3.00E-06
Radionuclides						
Am-241	1.20E+03	8.80E-05		1.10E-06	2.60E-05	1.20E-04
Cm-243/244	1.10E+03	5.50E-05		7.10E-07	1.50E-07	5.60E-05
Co-60	5.90E+03	2.80E-05		2.60E-08	2.10E-01	2.10E-01
Cs-137	1.80E+04	1.60E-04		9.90E-09	1.50E-01	1.50E-01
Eu-152	9.60E+02	6.30E-07		3.10E-09	1.60E-02	1.60E-02
Eu-154	5.80E+02	5.40E-07		2.40E-09	1.10E-02	1.10E-02
Pu-238	1.20E+02	8.50E-06		1.40E-07	1.60E-08	8.60E-06
Pu-239/240	1.40E+02	1.00E-05		1.60E-07	1.10E-08	1.00E-05
Th-228	3.80E+02	6.60E-06		8.70E-07	9.80E-03	9.80E-03
Total Radioactive Strontium	1.20E+05	1.30E-03		2.20E-07	0.00E+00	1.30E-03
U-232	3.20E+02	3.70E-06		5.60E-07	6.70E-08	4.30E-06
U-238	1.10E+02	9.50E-07		1.70E-07	1.80E-05	1.90E-05
Total pathway		1.70E-03	2.40E-06	4.00E-06	3.50E-01	3.50E-01
Residential scenario						
D1						
Inorganics						
Chromium VI	3.30E+01			6.50E-08		6.50E-08
Manganese	4.90E+03					
Mercury	1.40E-01					
Nickel	6.60E+01					
Silver	2.30E+00					
Organics						
Aroclor 1260	8.30E-01	1.00E-05	2.50E-06			1.20E-05
Radionuclides						
Ac-228	1.40E+00	8.80E-10		1.80E-12	9.30E-05	9.30E-05
Am-241	6.50E-01	2.00E-07		1.00E-09	7.30E-08	2.70E-07

Exhibit 9b. (continued)

Analyte	Concentration (mg/kg;pCi/g)	Ingestion risk	Dermal risk	Inhalation risk	External risk	Total risk
Bi-212	1.50E+00	5.90E-10		4.90E-13	2.00E-05	2.00E-05
Bi-214	8.60E-01	1.40E-10		8.90E-14	1.00E-04	1.00E-04
Co-60	3.10E-01	5.90E-09		2.30E-12	6.20E-05	6.20E-05
Pb-212	1.30E+00	9.00E-09		2.70E-12	8.40E-06	8.40E-06
Pb-214	9.30E-01	6.40E-09		2.00E-12	6.00E-06	6.00E-06
Ra-223	3.70E-01	3.00E-08		5.60E-11	2.00E-06	2.00E-06
Radon 219	4.70E-01			1.10E-15	1.70E-06	1.70E-06
Th-230	3.20E+00	5.20E-08		4.50E-09	3.90E-09	6.00E-08
Th-234	1.10E+01	5.50E-08		1.70E-11	8.90E-07	9.40E-07
Total Radioactive Strontium	1.30E+00	5.90E-08		3.90E-12	0.00E+00	5.90E-08
Tritium	2.30E+03	1.60E-07		8.90E-12	0.00E+00	1.60E-07
U-233/234	8.80E+00	1.80E-07		1.10E-08	6.10E-09	1.90E-07
U-235	3.60E-01	7.30E-09		4.40E-10	2.00E-06	2.00E-06
U-238	1.30E+01	4.50E-07		3.20E-08	1.10E-05	1.10E-05
Total pathway		1.10E-05	2.50E-06	1.10E-07	3.10E-04	3.30E-04
D2						
Inorganics						
Arsenic	1.40E+01			3.30E-08		3.30E-08
Barium	1.60E+03					
Chromium VI	2.20E+01			4.30E-08		4.30E-08
Manganese	4.30E+04					
Organics						
Aroclor 1260	8.50E-02	1.00E-06	2.50E-07			1.30E-06
Vinyl Chloride	1.00E+00	3.10E-06	6.90E-07	7.30E-03		7.30E-03
Radionuclides						
Ac-228	2.30E+00	1.40E-09		2.90E-12	1.50E-04	1.50E-04
Bi-212	1.70E+00	6.60E-10		5.50E-13	2.30E-05	2.30E-05
Bi-214	1.20E+00	1.90E-10		1.20E-13	1.40E-04	1.40E-04
Cm-243/244	5.50E+00	1.10E-06		6.00E-09	3.80E-09	1.10E-06
Co-60	6.30E-01	1.20E-08		4.60E-12	1.20E-04	1.20E-04
I-129	1.40E+01	3.30E-06		8.20E-11	1.30E-06	4.60E-06
Pb-212	1.70E+00	1.20E-08		3.60E-12	1.10E-05	1.10E-05
Pb-214	1.20E+00	8.30E-09		2.50E-12	7.70E-06	7.70E-06

Exhibit 9b. (continued)

Analyte	Concentration (mg/kg,pCi/g)	Ingestion risk	Dermal risk	Inhalation risk	External risk	Total risk
Pu-238	3.10E+01	8.70E-06		6.00E-08	2.00E-08	8.80E-06
Ra-223	9.10E-01	7.30E-08		1.40E-10	4.80E-06	4.90E-06
Ra-224	4.90E+00	2.30E-07		2.90E-10	2.60E-06	2.80E-06
Ra-226	2.90E+00	4.40E-07		5.90E-04	4.00E-04	9.90E-04
Radon 219	1.20E+00			2.70E-15	4.40E-06	4.40E-06
Tl-208	1.40E+00	3.20E-11		3.40E-16	4.20E-04	4.20E-04
Total Radioactive Strontium	1.30E+03	5.90E-05		3.90E-09	0.00E+00	5.90E-05
U-233/234	1.60E+01	3.20E-07		2.00E-08	1.10E-08	3.50E-07
U-235	4.10E-01	8.30E-09		5.00E-10	2.30E-06	2.30E-06
U-238	2.40E+00	8.50E-08		6.10E-09	2.00E-06	2.10E-06
Total pathway		7.70E-05	9.40E-07	7.90E-03	1.30E-03	9.30E-03
D3						
Inorganics						
Chromium VI	1.80E+01			3.40E-08		3.40E-08
Mercury	9.00E-02					
Selenium	1.70E+00					
Organics						
Chloroform	2.00E-03	1.90E-11	2.10E-11	1.80E-09		1.90E-09
Radionuclides						
Ac-228	1.50E+00	9.50E-10		1.90E-12	1.00E-04	1.00E-04
Bi-214	9.10E-01	1.50E-10		9.40E-14	1.10E-04	1.10E-04
I-129	1.30E+00	3.10E-07		7.60E-12	1.20E-07	4.30E-07
Pb-210	2.70E+00	2.20E-06		5.30E-10	9.90E-09	2.30E-06
Pb-212	1.40E+00	9.70E-09		3.00E-12	9.00E-06	9.00E-06
Pb-214	1.00E+00	6.90E-09		2.10E-12	6.40E-06	6.50E-06
Tl-208	1.10E+00	2.50E-11		2.70E-16	3.30E-04	3.30E-04
Total pathway		2.60E-06	2.10E-11	3.70E-08	5.60E-04	5.60E-04
OHFP						
Inorganics						
Chromium VI	3.80E+01			7.30E-08		7.30E-08
Mercury	3.10E+00					
Silver	5.90E+00					
Zinc	1.50E+02					

Exhibit 9b. (continued)

Analyte	Concentration (mg/kg;pCi/g)	Ingestion risk	Dermal risk	Inhalation risk	External risk	Total risk
Organics						
Aroclor 1254	2.30E+00	2.80E-05	6.90E-06			3.50E-05
Aroclor 1260	6.30E-01	7.60E-06	1.90E-06			9.50E-06
Radionuclides						
Am-241	8.80E+02	2.70E-04		1.40E-06	9.90E-05	3.70E-04
Cm-243/244	2.40E+04	4.90E-03		2.60E-05	1.70E-05	5.00E-03
Co-60	6.30E+03	1.20E-04		4.60E-08	7.10E-01	7.10E-01
Cs-137	3.70E+06	1.20E-01		3.50E-06	1.00E+00	1.00E+00
Pu-238	1.20E+03	3.40E-04		2.30E-06	7.90E-07	3.40E-04
Pu-239/240	6.40E+02	1.90E-04		1.20E-06	2.50E-07	1.90E-04
Th-228	1.70E+02	1.20E-05		6.70E-07	2.20E-02	2.20E-02
Th-230	3.10E+02	5.10E-06		4.40E-07	3.80E-07	5.90E-06
Total Radioactive Strontium	7.40E+05	3.30E-02		2.20E-06	0.00E+00	3.30E-02
U-232	3.80E+01	1.80E-06		1.10E-07	4.00E-08	1.90E-06
U-233	1.60E+03	3.20E-05		2.10E-06	1.50E-06	3.50E-05
Total pathway		1.60E-01	8.70E-06	4.00E-05	1.00E+00	1.00E+00
PWSB						
Inorganics						
Antimony	2.80E+01					
Chromium VI	6.40E+01			1.20E-07		1.20E-07
Mercury	2.80E+01					
Zinc	1.60E+03					
Organics						
4-Methyl Phenol	2.60E+01					
Aroclor 1248	1.20E+00	1.40E-05	3.60E-06			1.80E-05
Aroclor 1254	1.30E+00	1.60E-05	4.00E-06			2.00E-05
Radionuclides						
Am-241	1.20E+03	3.50E-04		1.80E-06	1.30E-04	4.90E-04
Cm-243/244	1.10E+03	2.20E-04		1.20E-06	7.60E-07	2.20E-04
Co-60	5.90E+03	1.10E-04		4.30E-08	6.90E-01	6.90E-01
Cs-137	1.80E+04	6.30E-04		1.70E-08	5.60E-01	5.60E-01
Eu-152	9.60E+02	2.50E-06		5.20E-09	7.70E-02	7.70E-02
Eu-154	5.80E+02	2.20E-06		4.00E-09	5.30E-02	5.30E-02

Exhibit 9b. (continued)

Analyte	Concentration (mg/kg;pCi/g)	Ingestion risk	Dermal risk	Inhalation risk	External risk	Total risk
Pu-238	1.20E+02	3.40E-05		2.40E-07	7.90E-08	3.40E-05
Pu-239/240	1.40E+02	4.10E-05		2.70E-07	5.60E-08	4.20E-05
Th-228	3.80E+02	2.60E-05		1.50E-06	4.80E-02	4.80E-02
Total Radioactive Strontium	1.20E+05	5.40E-03		3.60E-07	0.00E+00	5.40E-03
U-232	3.20E+02	1.50E-05		9.40E-07	3.40E-07	1.60E-05
U-238	1.10E+02	3.80E-06		2.80E-07	9.00E-05	9.50E-05
Total pathway		6.90E-03	7.50E-06	6.80E-06	8.90E-01	8.90E-01

Exhibit 9c. Carcinogenic risk for WAG 5 groundwater COPCs - Residential scenario

Analyte	Concentration (mg/L;pCi/l)	Ingestion risk	Ingestion of produce risk	Dermal risk	Inhalation risk	Total risk
Residential scenario						
FS						
Inorganics						
Barium	9.30E-01					
Beryllium	6.20E-03	5.40E-04	3.40E-05	8.70E-05		6.60E-04
Manganese	2.30E+00					
Nickel	1.70E-01					
Vanadium	1.40E-01					
Radionuclides						
Am-241	4.20E-01	2.10E-06	1.30E-07			2.30E-06
Ra-226	3.00E+00	7.60E-06	4.90E-07			8.10E-06
Ra-228	4.30E+00	9.00E-06	5.90E-07			9.60E-06
Th-228	3.20E+01	3.70E-05	2.30E-06			3.90E-05
Th-230	2.40E+01	6.60E-06	4.10E-07			7.00E-06
Th-232	3.50E+01	8.80E-06	5.60E-07			9.40E-06
Tritium	1.10E+05	1.20E-04	4.70E-05		2.10E-05	1.90E-04
Total pathway		7.40E-04	8.60E-05	8.70E-05	2.10E-05	9.30E-04
OHFP						
Organics						
1,1-Dichloroethane	8.00E-03					
1,2-Dichloroethane	3.00E-03	5.60E-06	8.40E-07	4.70E-08	2.10E-07	6.70E-06
Carbon Tetrachloride	9.00E-03	2.40E-05	1.90E-06	1.30E-06	3.60E-07	2.70E-05
Chloroform	2.50E-02	3.10E-06	3.40E-07	2.20E-07	1.50E-06	5.20E-06
Nitrate	1.10E+00					
Trichloroethene	7.00E-03	1.60E-06	7.80E-05	2.70E-07	3.20E-08	8.00E-05
Radionuclides						
C-14	1.20E+03	2.40E-05	9.70E-06			3.30E-05
Cm-243/244	4.40E+00	1.50E-05	9.30E-07			1.60E-05
Co-60	8.90E+01	2.80E-05	1.90E-06			3.00E-05
Cs-137	1.70E+03	1.00E-03	6.50E-05			1.10E-03
Pu-238	5.40E-01	2.50E-06	1.60E-07			2.70E-06
Ra-226	4.90E-01	1.20E-06	8.10E-08			1.30E-06
Ra-228	2.50E+02	5.30E-04	3.40E-05			5.70E-04

Exhibit 9c. (continued)

Analyte	Concentration (mg/l;pCi/l)	Ingestion risk	Ingestion of produce risk	Dermal risk	Inhalation risk	Total risk
Tc-99	4.20E+01	1.10E-06	4.50E-07			1.60E-06
Th-234	1.70E+02	1.50E-05	5.90E-07			1.50E-05
Total Radioactive Strontium	2.70E+04	2.00E-02	1.70E-03			2.10E-02
Tritium	2.00E+06	2.20E-03	8.60E-04		3.70E-04	3.50E-03
U-233/234	9.00E+00	3.00E-06	1.90E-07			3.20E-06
Total pathway		2.40E-02	2.70E-03	1.80E-06	3.70E-04	2.70E-02
PWSB						
Organics						
Acetone	1.20E-02					
Bis(2-Ethylhexyl) Phthalate	8.20E-02	2.30E-05	1.50E-06	4.60E-06		2.90E-05
Radionuclides						
Am-241	1.30E-01	6.50E-07	4.10E-08			7.00E-07
Ra-226	2.20E-01	5.60E-07	3.60E-08			6.00E-07
Ra-228	1.10E+00	2.40E-06	1.50E-07			2.50E-06
Th-228	4.00E-01	4.70E-07	2.90E-08			4.90E-07
Tritium	1.20E+04	1.40E-05	5.20E-06		2.30E-06	2.20E-05
U-233/234	7.20E-01	2.40E-07	1.50E-08			2.60E-07
U-238	3.90E-01	2.30E-07	1.40E-08			2.50E-07
Total pathway		4.20E-05	6.90E-06	4.60E-06	2.30E-06	5.60E-05
SWSA 5N						
Inorganics						
Barium	9.20E-01					
Beryllium	2.30E-03	2.00E-04	1.30E-05	3.20E-05		2.50E-04
Manganese	2.30E+00					
Nickel	1.50E-01					
Vanadium	5.30E-02					
Organics						
Bis(2-Ethylhexyl) Phthalate	1.30E-02	3.70E-06	2.30E-07	7.40E-07		4.70E-06
Methylene Chloride	1.60E-02	2.40E-06	4.30E-07	1.90E-08		2.90E-06
Radionuclides						
Am-241	3.20E+00	1.60E-05	1.00E-06			1.70E-05
C-14	1.20E+02	2.30E-06	9.70E-07			3.30E-06
Cm-243	2.30E-01	9.30E-07	5.80E-08			9.90E-07

Exhibit 9c. (continued)

Analyte	Concentration (mg/l;pCi/l)	Ingestion risk	Ingestion of produce risk	Dermal risk	Inhalation risk	Total risk
Cm-243/244	3.90E+01	1.30E-04	8.20E-06			1.40E-04
K-40	6.20E+02	1.40E-04	1.20E-05			1.60E-04
Pb-212	3.40E+01	3.90E-06	2.50E-07			4.20E-06
Pu-238	5.50E-01	2.60E-06	1.60E-07			2.70E-06
Ra-226	3.10E+00	7.90E-06	5.10E-07			8.40E-06
Ra-228	1.70E+01	3.60E-05	2.30E-06			3.80E-05
Tc-99	2.30E+01	6.20E-07	2.50E-07			8.70E-07
Th-228	2.80E+00	3.20E-06	2.00E-07			3.40E-06
Th-230	1.90E+00	5.30E-07	3.30E-08			5.60E-07
Th-232	2.90E+00	7.30E-07	4.60E-08			7.80E-07
Th-234	4.90E+02	4.10E-05	1.70E-06			4.30E-05
Tritium	2.20E+03	2.50E-06	9.50E-07		4.20E-07	3.90E-06
U-233/234	2.80E+00	9.50E-07	5.90E-08			1.00E-06
U-238	2.30E+00	1.40E-06	8.50E-08			1.50E-06
Total pathway		6.00E-04	4.20E-05	3.30E-05	4.20E-07	6.80E-04
SWSA SSE						
Inorganics						
Manganese	2.30E+01					
Organics						
1,1-Dichloroethene	5.50E-03	6.70E-05	8.20E-06	9.70E-07	5.10E-06	8.20E-05
1,2-Dichloroethane	4.00E-03	7.40E-06	1.10E-06	6.30E-08	2.80E-07	8.90E-06
Benzene	2.00E-03	1.20E-06	1.20E-07	4.10E-08	4.40E-08	1.40E-06
Bis(2-Ethylhexyl) Phthalate	5.00E-03	1.40E-06	2.80E-07	2.80E-07		2.00E-06
Chloroform	1.00E-03	1.20E-07	1.40E-08	8.90E-09	6.20E-08	2.10E-07
Trichloroethene	3.00E-02	6.70E-06	1.20E-06	1.10E-06	1.40E-07	9.10E-06
Vinyl Chloride	1.40E-02	5.30E-04	8.90E-05	6.20E-06	3.10E-06	6.30E-04
Radionuclides						
Am-241	1.50E+05	5.30E-01	4.60E-02			5.50E-01
Bi-212	5.30E+02	3.50E-06	7.50E-10			3.50E-06
C-14	4.30E+02	8.20E-06	3.50E-06			1.20E-05
Cd-109	3.70E+02	6.10E-05	4.90E-06			6.60E-05
Cm-243/244	1.00E+01	3.50E-05	2.10E-06			3.70E-05
Pu-238	9.30E+04	3.50E-01	2.70E-02			3.70E-01

Exhibit 9c. (continued)

Analyte	Concentration (mg/l;pCi/l)	Ingestion risk	Ingestion of produce risk	Dermal risk	Inhalation risk	Total risk
Pu-239/240	1.60E+03	7.80E-03	4.90E-04			8.30E-03
Ra-226	1.30E+03	3.30E-03	2.10E-04			3.50E-03
Ra-228	2.10E+01	4.30E-05	2.90E-06			4.60E-05
Tc-99	1.60E+02	4.40E-06	1.70E-06			6.10E-06
Th-228	4.50E+01	5.20E-05	3.20E-06			5.50E-05
Th-230	1.80E+00	5.00E-07	3.10E-08			5.30E-07
Th-231	3.50E+02	3.00E-06	1.40E-08			3.00E-06
Total Radioactive Strontium	2.80E+03	2.10E-03	1.70E-04			2.30E-03
Tritium	6.50E+07	7.10E-02	2.80E-02		1.20E-02	1.10E-01
U-232	7.50E-01	5.90E-07	3.70E-08			6.20E-07
U-233/234	1.30E+03	4.40E-04	2.80E-05			4.60E-04
U-238	1.80E+00	1.00E-06	6.70E-08			1.10E-06
Total pathway		7.20E-01	9.80E-02	8.70E-06	1.20E-02	7.50E-01
SWSA5SW						
Inorganics						
Barium	4.60E-01					
Manganese	5.10E+00					
Organics						
Benzene	1.00E-03	5.90E-07	6.00E-08	2.10E-08	2.20E-08	6.90E-07
Bis(2-Ethylhexyl) Phthalate	2.20E-01	6.30E-05	3.90E-06	1.20E-05		7.90E-05
Carbon Tetrachloride	6.00E-03	1.60E-05	1.30E-06	8.60E-07	2.40E-07	1.80E-05
Chloroform	1.00E-03	1.20E-07	1.40E-08	8.90E-09	6.20E-08	2.10E-07
Tetrachloroethene	1.10E-01					
Vinyl Chloride	2.30E-02	9.00E-04	1.50E-04	1.10E-05	5.30E-06	1.10E-03
Radionuclides						
Am-241	2.10E+00	1.10E-05	6.70E-07			1.10E-05
C-14	4.70E+02	8.80E-06	3.80E-06			1.30E-05
Ca-45	2.80E+02	5.80E-06	5.20E-07			6.30E-06
Cm-243/244	1.50E+00	5.20E-06	3.20E-07			5.50E-06
Co-60	4.10E+01	1.30E-05	8.70E-07			1.40E-05
K-40	1.00E+03	2.30E-04	1.90E-05			2.50E-04
Pb-212	5.30E+01	6.10E-06	3.90E-07			6.50E-06
Pu-238	1.50E+00	7.20E-06	4.40E-07			7.60E-06

Exhibit 9c. (continued)

Analyte	Concentration (mg/l;pCi/l)	Ingestion risk	Ingestion of produce risk	Dermal risk	Inhalation risk	Total risk
Ra-226	2.40E+00	6.10E-06	4.00E-07			6.50E-06
Ra-228	5.40E+01	1.10E-04	7.40E-06			1.20E-04
Th-228	1.30E+01	1.50E-05	9.30E-07			1.60E-05
Th-230	6.50E+00	1.80E-06	1.10E-07			1.90E-06
Th-232	9.00E+00	2.30E-06	1.40E-07			2.40E-06
Th-234	1.70E+02	1.50E-05	5.90E-07			1.50E-05
Total Radioactive Strontium	3.40E+02	2.60E-04	2.10E-05			2.80E-04
Tritium	8.10E+06	9.20E-03	3.50E-03		1.50E-03	1.40E-02
U-233/234	6.20E+00	2.10E-06	1.30E-07			2.20E-06
U-238	4.30E+00	2.50E-06	1.60E-07			2.70E-06
Total pathway		1.10E-02	3.70E-03	2.40E-05	1.50E-03	1.60E-02
WOC						
Inorganics						
Barium	8.70E-01					
Manganese	8.00E-01					
Organics						
1,1-Dichloroethene	5.00E-03	6.10E-05	7.50E-06	8.70E-07	4.60E-06	7.40E-05
1,2-Dichloroethene (Total)	1.90E+00					
Benzene	1.90E-02	1.10E-05	1.10E-06	3.90E-07	4.20E-07	1.30E-05
Vinyl Chloride	2.60E+00	9.50E-02	1.60E-02	1.20E-03	5.90E-04	1.10E-01
Radionuclides						
C-14	1.10E+03	2.10E-05	8.20E-06			3.00E-05
Pu-239/240	1.70E-01	8.20E-07	5.20E-08			8.70E-07
Th-228	1.70E+00	2.00E-06	1.20E-07			2.10E-06
Th-234	1.00E+03	8.40E-05	3.50E-06			8.70E-05
Tritium	4.40E+04	5.00E-05	1.90E-05		8.50E-06	7.80E-05
Total pathway		9.50E-02	1.60E-02	1.20E-03	6.00E-04	1.10E-01

Exhibit 9d. Carcinogenic risk for WAG 5 surface water COPCs - Residential scenario

Analyte	Concentration (mg/l;pCi/l)	Ingestion risk	Dermal risk	Inhalation risk	Total risk
High Base					
D1					
Inorganics					
Manganese	2.60E-01	-	-	-	-
Radionuclides					
Pu-238	2.90E-01	-	-	-	-
Total-Radioactive-Strontium	2.40E+01	-	-	-	-
Tritium	2.40E+02	-	-	3.00E-08	3.00E-08
U-233/234	2.70E+01	-	-	-	-
U-238	4.50E+01	-	-	-	-
Total-pathway	-	-	-	3.00E-08	3.00E-08
D2					
Inorganics					
Manganese	2.60E+00	-	-	-	-
Radionuclides					
C-14	3.20E+02	-	-	-	-
Total Radioactive Strontium	2.50E+03	-	-	-	-
Tritium	3.10E+04	-	-	3.80E-06	3.80E-06
U-233/234	3.70E+00	-	-	-	-
Total pathway	-	-	-	3.80E-06	3.80E-06
D3					
Inorganics					
Manganese	2.40E-01	-	-	-	-
Radionuclides					
Tritium	9.60E+00	-	-	9.94E-10	9.94E-10
Total pathway	-	-	-	9.94E-10	9.94E-10
High Base Storm					
D1					
Organics					
2-Butanone	7.00E-03	-	-	-	-
Bis(2-Ethylhexyl) Phthalate	4.00E-03	-	-	-	-
Radionuclides					
Th-230	5.30E+00	-	-	-	-

Exhibit 9d. (continued)

Analyte	Concentration (mg/l;pCi/l)	Ingestion - risk	Dermal - risk	Inhalation - risk	Total - - risk
Total Radioactive Strontium	1.60E+01	-	-	-	-
Tritium	1.10E+02	-	-	1.40E-08	1.40E-08
U-233/234	5.10E+01	-	-	-	-
U-238	8.10E+01	-	-	-	-
Total pathway	-	-	-	1.40E-08	1.40E-08

D2

Organics

1,1-Dichloroethane	2.00E-03	-	-	-	-
1,2-Dichloroethene (Total)	3.00E-03	-	-	-	-
Bis(2-Ethylhexyl) Phthalate	6.00E-03	-	-	-	-
Trichloroethene	1.00E-03	-	-	4.60E-09	4.60E-09

Radionuclides

C-14	1.20E+02	-	-	-	-
Pu-238	1.40E+01	-	-	-	-
Tc-99	3.80E+01	-	-	-	-
Th-230	1.00E+01	-	-	-	-
Total Radioactive Strontium	1.40E+03	-	-	-	-
Tritium	1.70E+04	-	-	2.10E-06	2.10E-06
Total pathway	-	-	-	2.10E-06	2.10E-06

D3

Radionuclides

Total Radioactive Strontium	5.70E+01	-	-	-	-
Total pathway	-	-	-	-	-

Impoundment

OHFP

Organics

Bis(2-Ethylhexyl) Phthalate	1.00E-03	-	-	-	-
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Radionuclides

Am-241	3.90E-01	-	-	-	-
Cm-243/244	1.60E+01	-	-	-	-
Co-60	1.50E+02	-	-	-	-
Cs-137	2.50E+04	-	-	-	-
Pu-238	3.20E-01	-	-	-	-

Exhibit 9d. (continued)

Analyte	Concentration (mg/l;pCi/l)	Ingestion - risk	Dermal - risk	Inhalation - risk	Total - - risk
Pu-239/240	5.10E-01	-	-	-	-
Tc-99	4.30E+01	-	-	-	-
Total Radioactive Strontium	9.00E+04	-	-	-	-
Tritium	5.40E+00	-	-	6.70E-10	6.70E-10
U-232	3.30E+00	-	-	-	-
U-233/234	1.00E+02	-	-	-	-
Total pathway	-	-	-	6.70E-10	6.70E-10
PWSB					
Organics					
Bromomethane	2.00E-03	-	-	-	-
Radionuclides					
Am-241	5.00E-01	-	-	-	-
Cm-243/244	5.10E+00	-	-	-	-
Co-60	1.30E+02	-	-	-	-
Cs-137	4.90E+01	-	-	-	-
Total Radioactive Strontium	6.00E+03	-	-	-	-
Tritium	4.40E-01	-	-	5.40E-11	5.40E-11
U-232	2.20E+01	-	-	-	-
U-233/234	2.60E+02	-	-	-	-
U-238	4.80E+00	-	-	-	-
Total pathway	-	-	-	5.40E-11	5.40E-11
Low Base					
D1					
Radionuclides					
Pb-212	2.10E+01	-	-	-	-
Total Radioactive Strontium	3.00E+01	-	-	-	-
Tritium	5.10E+02	-	-	6.30E-08	6.30E-08
U-233/234	1.00E+01	-	-	-	-
U-238	1.90E+01	-	-	-	-
Total pathway	-	-	-	6.30E-08	6.30E-08
D2					
Inorganics					
Manganese	2.90E+00	-	-	-	-

Exhibit 9d. (continued)

Analyte	Concentration (mg/l;pCi/l)	Ingestion - risk	Dermal - risk	Inhalation - risk	Total - - risk
Radionuclides					
Am-241	9.30E+00	-	-	-	-
C-14	1.80E+02	-	-	-	-
Pu-238	1.80E+01	-	-	-	-
Ra-228	1.60E+03	-	-	-	-
Total Radioactive Strontium	1.80E+03	-	-	-	-
Tritium	3.90E+03	-	-	4.80E-07	4.80E-07
U-233/234	3.20E+00	-	-	-	-
Total pathway	-	-	-	4.80E-07	4.80E-07
D3					
Radionuclides					
Tritium	1.10E+01	-	-	1.13E-09	1.13E-09
Total pathway	-	-	-	1.13E-09	1.13E-09
Low Base Storm					
D1					
Organics					
Bis(2-Ethylhexyl) Phthalate	1.00E-03	-	-	-	-
Radionuclides					
Tritium	1.20E+02	-	-	1.50E-08	1.50E-08
U-233/234	1.10E+01	-	-	-	-
U-238	1.70E+01	-	-	-	-
Total pathway	-	-	-	1.50E-08	1.50E-08
D2					
Inorganics					
Manganese	3.00E+00	-	-	-	-
Radionuclides					
Am-241	9.00E-01	-	-	-	-
C-14	1.80E+02	-	-	-	-
Pu-238	1.90E+01	-	-	-	-
Total Radioactive Strontium	2.10E+03	-	-	-	-
Tritium	4.40E+04	-	-	5.40E-06	5.40E-06
U-233/234	6.20E+00	-	-	-	-
Total pathway	-	-	-	5.40E-06	5.40E-06

Exhibit 9d. (continued)

Analyte	Concentration (mg/l;pCi/l)	Ingestion - risk	Dermal - risk	Inhalation - risk	Total - - risk
D3					
Inorganics					
Manganese	3.60E-01	-	-	-	-
Organics					
Bis(2-Ethylhexyl) Phthalate	3.00E-03	-	-	-	-
Radionuclides					
Am-241	7.40E-02	-	-	-	-
Total pathway	-	-	-	-	-

**Exhibit 10a. Noncarcinogenic hazard quotients for WAG 5 soil COPCs
(Excavation, industrial, and residential scenarios)**

Analyte	Concentration (mg/kg)	Ingestion HQ	Ingestion of produce HQ	Dermal HQ	Inhalation HQ	Total HI
Excavation scenario						
FS						
Inorganics						
Mercury	4.30E+00	2.30E-03		2.10E-03	7.60E-07	4.40E-03
Organics						
Aroclor 1260	1.80E-01					
Total pathway		2.30E-03		2.10E-03	7.60E-07	4.40E-03
NHFT						
Organics						
Di-n-butyl Phthalate	1.30E-01	2.10E-07		1.30E-07		3.50E-07
Toluene	1.00E-03	8.20E-10		6.40E-10	2.30E-08	2.40E-08
Total pathway		2.10E-07		1.30E-07	2.30E-08	3.70E-07
OHFP						
Inorganics						
Cadmium	1.50E+00	2.40E-04		1.50E-03		1.70E-03
Organics						
Aroclor 1254	3.20E-02					
Aroclor 1260	9.60E-03					
Heptachlor Epoxide	5.40E-04	6.80E-06		5.90E-06		1.30E-05
Toluene	1.00E-03	8.20E-10		6.40E-10	2.30E-08	2.40E-08
Total pathway		2.40E-04		1.50E-03	2.30E-08	1.70E-03
OHFT						
Inorganics						
Silver	4.30E+00	1.40E-04		4.90E-05		1.90E-04
Organics						
Bis(2-Ethylhexyl) Phthalate	1.10E-01	9.00E-07		3.00E-06		3.90E-06
Cyanide	6.70E-01	5.50E-06		8.70E-06		1.40E-05
Toluene	2.00E-03	1.60E-09		1.30E-09	4.50E-08	4.80E-08
Total pathway		1.50E-04		6.00E-05	4.50E-08	2.10E-04
PWSB						
Inorganics						
Barium	1.90E+02	4.50E-04		4.10E-04	2.10E-05	8.80E-04
Organics						

Exhibit 10a. (continued)

Analyte	Concentration (mg/kg)	Ingestion HQ	Ingestion of produce HQ	Dermal HQ	Inhalation HQ	Total HI
Aroclor 1260	1.00E-02					
Bis(2-Ethylhexyl) Phthalate	5.70E-02	4.60E-07		1.50E-06		2.00E-06
Chloroform	2.00E-03	3.30E-08		1.00E-07		1.40E-07
Total pathway		4.50E-04		4.10E-04	2.10E-05	8.80E-04
SW3						
Inorganics						
Zinc	3.20E+02	1.70E-04		5.50E-05		2.30E-04
Organics						
Aroclor 1254	9.30E-02					
Aroclor 1260	7.80E-02					
Total pathway		1.70E-04		5.50E-05		2.30E-04
SWSA 5N						
Inorganics						
Selenium	2.30E+00	7.40E-05		1.10E-05		8.40E-05
Organics						
2-Butanone	3.00E-03	8.20E-10		6.40E-10	2.80E-08	2.90E-08
Aroclor 1260	2.60E-02					
Methylene Chloride	5.00E-03	1.40E-08		9.00E-09	4.10E-08	6.40E-08
Total pathway		7.40E-05		1.10E-05	6.90E-08	8.40E-05
SWSA 5SE						
Inorganics						
Antimony	6.20E+00	2.50E-03		8.00E-03		1.10E-02
Manganese	3.30E+03	3.80E-03		6.00E-03	3.50E-03	1.30E-02
Organics						
Aroclor 1260	4.40E-02					
Chloroform	1.00E-03	1.60E-08		5.20E-08		6.80E-08
Total pathway		6.30E-03		1.40E-02	3.50E-03	2.40E-02
SWSA5SW						
Inorganics						
Barium	3.20E+02	7.40E-04		6.70E-04	3.40E-05	1.40E-03
Manganese	2.30E+03	2.70E-03		4.30E-03	2.50E-03	9.50E-03
Organics						
Aroclor 1260	1.40E+00					

Exhibit 10a. (continued)

Analyte	Concentration (mg/kg)	Ingestion HQ	Ingestion of produce HQ	Dermal HQ	Inhalation HQ	Total HI
Bis(2-Ethylhexyl) Phthalate	1.10E-01	2.70E-06		9.00E-06		1.20E-05
Cyanide	6.70E-01	1.60E-05		2.60E-05		4.20E-05
Toluene	2.00E-03	4.90E-09		3.90E-09	1.40E-07	1.40E-07
Total pathway		4.40E-04		1.80E-04	1.40E-07	6.20E-04
PWSB						
Inorganics						
Barium	1.90E+02	1.30E-03		1.20E-03	6.20E-05	2.60E-03
Organics						
Aroclor 1260	1.00E-02					
Bis(2-Ethylhexyl) Phthalate	5.70E-02	1.40E-06		4.60E-06		6.00E-06
Chloroform	1.00E-03	4.90E-08		1.50E-07		2.00E-07
Total pathway		1.30E-03		1.20E-03	6.20E-05	2.60E-03
SW3						
Inorganics						
Zinc	3.20E+02	5.20E-04		1.70E-04		6.90E-04
Organics						
Aroclor 1254	9.30E-02					
Aroclor 1260	7.80E-02					
Total pathway		5.20E-04		1.70E-04		6.90E-04
SWSA 5N						
Organics						
1,2-Benzenedicarboxylic Acid, Diethyl Ester	3.00E-01	1.80E-07		1.20E-07		3.00E-07
2-Butanone	3.00E-03	2.40E-09		1.90E-09	8.30E-08	8.70E-08
Aroclor 1260	2.60E-02					
Bis(2-Ethylhexyl) Phthalate	4.50E-02	1.10E-06		3.70E-06		4.80E-06
Di-n-butyl Phthalate	7.10E-02	3.50E-07		2.20E-07		5.70E-07
Methylene Chloride	5.00E-03	4.10E-08		2.70E-08	1.20E-07	1.90E-07
Total pathway		1.70E-06		4.00E-06	2.10E-07	5.90E-06
SWSA 5SE						
Inorganics						
Antimony	6.20E+00	7.60E-03		2.40E-02		3.20E-02
Manganese	3.30E+03	1.10E-02		1.80E-02	1.00E-02	4.00E-02

Exhibit 10a. (continued)

Analyte	Concentration (mg/kg)	Ingestion HQ	Ingestion of produce HQ	Dermal HQ	Inhalation HQ	Total HI
Organics						
Aroclor 1260	4.40E-02					
Chloroform	1.00E-03	4.90E-08		1.50E-07		2.00E-07
Total pathway		1.90E-02		4.20E-02	1.00E-02	7.10E-02
SWSASSW						
Inorganics						
Barium	3.60E+02	2.50E-03		2.30E-03	1.20E-04	4.90E-03
Manganese	2.70E+03	9.50E-03		1.50E-02	8.70E-03	3.30E-02
Organics						
Aroclor 1260	1.20E+00					
Chloroform	1.00E-03	4.90E-08		1.50E-07		2.00E-07
Total pathway		1.20E-02		1.70E-02	8.80E-03	3.80E-02
WOC						
Inorganics						
Mercury	8.10E-01	1.30E-03		1.20E-03	4.30E-07	2.50E-03
Organics						
Aroclor 1260	4.10E-02					
Total pathway		1.30E-03		1.20E-03	4.30E-07	2.50E-03
Residential scenario						
FS						
Inorganics						
Mercury	4.30E+00	5.20E-02	1.00E+01	1.70E-02	5.60E-06	1.00E+01
Organics						
Aroclor 1260	1.80E-01					
Total pathway		5.20E-02	1.00E+01	1.70E-02	5.60E-06	1.00E+01
NHFT						
Organics						
Di-n-butyl Phthalate	1.30E-01	4.70E-06	1.40E-05	1.10E-06		2.00E-05
Toluene	1.00E-03	1.80E-08	2.40E-06	5.10E-09	1.70E-07	2.60E-06
Total pathway		4.80E-06	1.60E-05	1.10E-06	1.70E-07	2.20E-05
OHFP						
Inorganics						
Cadmium	1.50E+00	5.30E-03	1.50E+00	1.20E-02		1.50E+00

Exhibit 10a. (continued)

Analyte	Concentration (mg/kg)	Ingestion HQ	Ingestion of produce HQ	Dermal HQ	Inhalation HQ	Total HI
Organics						
Aroclor 1254	3.20E-02					
Aroclor 1260	9.60E-03					
Heptachlor Epoxide	5.40E-04	1.50E-04	2.10E-02	4.70E-05		2.10E-02
Toluene	1.00E-03	1.80E-08	2.40E-06	5.10E-09	1.70E-07	2.60E-06
Total pathway		5.50E-03	1.50E+00	1.20E-02	1.70E-07	1.60E+00
OHFT						
Inorganics						
Silver	4.30E+00	3.10E-03	2.40E-01	3.90E-04		2.50E-01
Organics						
Bis(2-Ethylhexyl) Phthalate	1.10E-01	2.00E-05	2.80E-07	2.40E-05		4.40E-05
Cyanide	6.70E-01	1.20E-04	8.60E-01	6.80E-05		8.60E-01
Toluene	2.00E-03	3.70E-08	4.90E-06	1.00E-08	3.30E-07	5.20E-06
Total pathway		3.30E-03	1.10E+00	4.80E-04	3.30E-07	1.10E+00
PWSB						
Inorganics						
Barium	1.90E+02	1.00E-02	7.80E-01	3.20E-03	1.50E-04	8.00E-01
Organics						
Aroclor 1260	1.00E-02					
Bis(2-Ethylhexyl) Phthalate	5.70E-02	1.00E-05	1.50E-07	1.20E-05		2.30E-05
Chloroform	1.00E-03	3.70E-07	1.30E-04	4.10E-07		1.30E-04
Total pathway		1.00E-02	7.90E-01	3.20E-03	1.50E-04	8.00E-01
SW3						
Inorganics						
Zinc	3.20E+02	3.90E-03	8.10E-01	4.40E-04		8.20E-01
Organics						
Aroclor 1254	9.30E-02					
Aroclor 1260	7.80E-02					
Total pathway		3.90E-03	8.10E-01	4.40E-04		8.20E-01
SWSA 5N						
Organics						
1,2-Benzenedicarboxylic Acid, Diethyl Ester	3.00E-01	1.40E-06	2.60E-04	3.10E-07		2.60E-04

Exhibit 10a. (continued)

Analyte	Concentration (mg/kg)	Ingestion HQ	Ingestion of produce HQ	Dermal HQ	Inhalation HQ	Total HI
2-Butanone	3.00E-03	1.80E-08	6.40E-05	5.10E-09	2.00E-07	6.40E-05
Aroclor 1260	2.60E-02					
Bis(2-Ethylhexyl) Phthalate	4.50E-02	8.20E-06	1.10E-07	9.60E-06		1.80E-05
Di-n-butyl Phthalate	7.10E-02	2.60E-06	7.60E-06	5.80E-07		1.10E-05
Methylene Chloride	5.00E-03	3.00E-07	2.70E-04	7.10E-08	3.00E-07	2.70E-04
Total pathway		1.30E-05	6.00E-04	1.10E-05	5.00E-07	6.30E-04
SWSA SSE						
Inorganics						
Antimony	6.20E+00	5.70E-02	3.20E-01	6.30E-02		4.40E-01
Manganese	3.30E+03	8.50E-02	1.30E+00	4.70E-02	2.50E-02	1.50E+00
Organics						
Aroclor 1260	4.40E-02					
Chloroform	1.00E-03	3.70E-07	1.30E-04	4.10E-07		1.30E-04
Total pathway		1.40E-01	1.70E+00	1.10E-01	2.50E-02	1.90E+00
SWSA5SW						
Inorganics						
Barium	3.60E+02	1.90E-02	1.50E+00	6.00E-03	2.80E-04	1.50E+00
Manganese	2.70E+03	7.10E-02	1.10E+00	4.00E-02	2.10E-02	1.20E+00
Organics						
Aroclor 1260	1.20E+00					
Chloroform	1.00E-03	3.70E-07	1.30E-04	4.10E-07		1.30E-04
Total pathway		9.00E-02	2.60E+00	4.60E-02	2.10E-02	2.70E+00
WOC						
Inorganics						
Mercury	8.10E-01	9.90E-03	2.00E+00	3.10E-03	1.10E-06	2.00E+00
Organics						
Aroclor 1260	4.10E-02					
Total pathway		9.90E-03	2.00E+00	3.10E-03	1.10E-06	2.00E+00

**Exhibit 10b. Noncarcinogenic hazard quotients for WAG 5 sediment COPCs
(Industrial and residential scenarios)**

Analyte	Concentration (mg/kg)	Ingestion HQ	Dermal HQ	Inhalation HQ	Total HI
Industrial scenario					
D1					
Inorganics					
Chromium VI	3.30E+01	3.30E-03	1.00E-02		1.40E-02
Manganese	4.90E+03	1.70E-02	2.70E-02	1.60E-02	6.00E-02
Mercury	1.40E-01	2.20E-04	2.00E-04	7.30E-08	4.20E-04
Nickel	6.60E+01	1.60E-03	3.80E-04		2.00E-03
Silver	2.30E+00	2.30E-04	7.90E-05		3.00E-04
Organics					
Aroclor 1260	8.30E-01				
Total pathway		2.20E-02	3.80E-02	1.60E-02	7.60E-02
D2					
Inorganics					
Arsenic	1.40E+01	2.30E-02	3.50E-03		2.60E-02
Barium	1.60E+03	1.10E-02	1.00E-02	5.10E-04	2.20E-02
Chromium VI	2.20E+01	2.20E-03	6.80E-03		9.00E-03
Manganese	4.30E+04	1.50E-01	2.40E-01	1.40E-01	5.20E-01
Organics					
Aroclor 1260	8.50E-02				
Vinyl Chloride	1.00E+00				
Total pathway		1.80E-01	2.60E-01	1.40E-01	5.80E-01
D3					
Inorganics					
Chromium VI	1.80E+01	1.70E-03	5.40E-03		7.20E-03
Mercury	9.00E-02	1.50E-04	1.30E-04	4.80E-08	2.80E-04
Selenium	1.70E+00	1.70E-04	2.40E-05		1.90E-04
Organics					
Chloroform	2.00E-03	9.80E-08	3.10E-07		4.10E-07
Total pathway		2.00E-03	5.60E-03	4.80E-08	7.60E-03
OHFP					
Inorganics					
Chromium VI	3.80E+01	3.70E-03	1.20E-02		1.50E-02

Exhibit 10b. (continued)

Analyte	Concentration (mg/kg)	Ingestion HQ	Dermal HQ	Inhalation HQ	Total HQ
Mercury	3.10E+00	5.10E-03	4.60E-03	1.70E-06	9.70E-03
Silver	5.90E+00	5.80E-04	2.00E-04		7.80E-04
Zinc	1.50E+02	2.50E-04	7.90E-05		3.30E-04
Organics					
Aroclor 1254	2.30E+00				
Aroclor 1260	6.30E-01				
Total pathway		9.60E-03	1.70E-02	1.70E-06	2.70E-02
PWSB					
Inorganics					
Antimony	2.80E+01	3.40E-02	1.10E-01		1.40E-01
Chromium VI	6.40E+01	6.30E-03	2.00E-02		2.60E-02
Mercury	2.80E+01	4.50E-02	4.00E-02	1.50E-05	8.50E-02
Zinc	1.60E+03	2.60E-03	8.20E-04		3.40E-03
Organics					
4-Methyl Phenol	2.60E+01	2.50E-03	1.60E-03		4.20E-03
Aroclor 1248	1.20E+00				
Aroclor 1254	1.30E+00				
Total pathway		9.00E-02	1.70E-01	1.50E-05	2.60E-01
Residential scenario					
D1					
Inorganics					
Chromium VI	3.30E+01	2.40E-02	2.70E-02		5.10E-02
Manganese	4.90E+03	1.30E-01	7.10E-02	3.80E-02	2.40E-01
Mercury	1.40E-01	1.70E-03	5.30E-04	1.80E-07	2.20E-03
Nickel	6.60E+01	1.20E-02	9.90E-04		1.30E-02
Silver	2.30E+00	1.70E-03	2.10E-04		1.90E-03
Organics					
Aroclor 1260	8.30E-01				
Total pathway		1.70E-01	1.10E-01	3.80E-02	3.10E-01
D2					
Inorganics					
Arsenic	1.40E+01	1.70E-01	9.20E-03		1.80E-01
Barium	1.60E+03	8.40E-02	2.70E-02	1.20E-03	1.10E-01

Exhibit 10b. (continued)

Analyte	Concentration (mg/kg)	Ingestion HQ	Dermal HQ	Inhalation HQ	Total HQ
Chromium VI	2.20E+01	1.60E-02	1.80E-02		3.40E-02
Manganese	4.30E+04	1.10E+00	6.20E-01	3.30E-01	2.10E+00
Organics					
Aroclor 1260	8.50E-02				
Vinyl Chloride	1.00E+00				
Total pathway		1.40E+00	6.70E-01	3.30E-01	2.40E+00
D3					
Inorganics					
Chromium VI	1.80E+01	1.30E-02	1.40E-02		2.70E-02
Mercury	9.00E-02	1.10E-03	3.40E-04	1.20E-07	1.40E-03
Selenium	1.70E+00	1.20E-03	6.30E-05		1.30E-03
Organics					
Chloroform	2.00E-03	7.30E-07	8.10E-07		1.50E-06
Total pathway		1.50E-02	1.40E-02	1.20E-07	3.00E-02
OHFP					
Inorganics					
Chromium VI	3.80E+01	2.70E-02	3.10E-02		5.80E-02
Mercury	3.10E+00	3.80E-02	1.20E-02	4.00E-06	5.00E-02
Silver	5.90E+00	4.30E-03	5.30E-04		4.80E-03
Zinc	1.50E+02	1.90E-03	2.10E-04		2.10E-03
Organics					
Aroclor 1254	2.30E+00				
Aroclor 1260	6.30E-01				
Total pathway		7.10E-02	4.3E-02	4.00E-06	1.10E-01
PWSB					
Inorganics					
Antimony	2.80E+01	2.50E-01	2.80E-01		5.30E-01
Chromium VI	6.40E+01	4.70E-02	5.20E-02		9.90E-02
Mercury	2.80E+01	3.40E-01	1.10E-01	3.60E-05	4.50E-01
Zinc	1.60E+03	1.90E-02	2.20E-03		2.20E-02
Organics					
4-Methyl Phenol	2.60E+01	1.90E-02	4.20E-03		2.30E-02
Aroclor 1248	1.20E+00				

Exhibit 10b. (continued)

Analyte	Concentration (mg/kg)	Ingestion HQ	Dermal HQ	Inhalation HQ	Total HQ
Aroclor 1254	1.30E+00				
Total pathway		6.70E-01	4.50E-01	3.60E-05	1.10E+00

Exhibit 10c. Noncarcinogenic hazard quotients for WAG 5 groundwater COPCs - Residential scenario

Analyte	Concentration (mg/l)	Ingestion HQ	Ingestion of produce HQ	Dermal HQ	Inhalation HQ	Total HI
Residential scenario						
FS						
Inorganics						
Barium	9.30E-01	6.30E-01	4.60E-02	1.50E-02		6.90E-01
Beryllium	6.20E-03	5.90E-02	3.70E-03	9.50E-03		7.20E-02
Chromium VI	2.40E-01	2.30E+00	1.60E-01	1.90E-01		2.50E00
Manganese	2.30E+00	2.20E+01	1.40E+00	8.90E-01		2.40E+01
Nickel	1.70E-01	3.90E-01	2.70E-02	2.30E-03		4.20E-01
Vanadium	1.40E-01	9.50E-01	6.00E-02	1.50E-01		1.20E+00
Total pathway		2.60E+01	1.70E+00	1.30E+00		2.80E+01
OHFP						
Organics						
1,1-Dichloroethane	8.00E-03	3.80E-03	4.60E-04	5.40E-05	1.00E-04	4.40E-03
1,2-Dichloroethane	3.00E-03					
Carbon Tetrachloride	9.00E-03	6.10E-01	5.00E-02	3.30E-02		6.90E-01
Chloroform	2.50E-02	1.20E-01	1.30E-02	8.50E-03		1.40E-01
Nitrate	1.10E+00	3.30E-02	2.10E-03			3.50E-02
Trichloroethene	7.00E-03					
Total pathway		7.70E-01	6.50E-02	4.20E-02	1.00E-04	8.70E-01
PWSB						
Inorganics						
Chromium VI	4.00E-03	3.80E-02	2.60E-03	3.10E-03		4.10E-02
Organics						
Acetone	1.20E-02	5.50E-03	5.40E-03	6.10E-06		1.10E-02
Bis(2-Ethylhexyl) Phthalate	8.20E-02	1.90E-01	1.20E-02	3.90E-02		2.50E-01
Total pathway		2.40E-01	2.00E-02	4.20E-02		2.80E-01
SWSA 5N						
Inorganics						
Barium	9.20E-01	6.30E-01	4.50E-02	1.40E-02		6.90E-01
Beryllium	2.30E-03	2.20E-02	1.40E-03	3.50E-03		0.027
Chromium VI	1.10E-01	1.00E+00	7.20E-02	8.30E-02		1.10E+00
Manganese	2.30E+00	2.20E+01	1.40E+00	8.70E-01		2.40E+01
Nickel	1.50E-01	3.60E-01	2.40E-02	2.10E-03		0.38

9

Exhibit 10c. (continued)

Analyte	Concentration (mg/l)	Ingestion HQ	Ingestion of produce HQ	Dermal HQ	Inhalation HQ	Total HI
Barium	8.70E-01	5.90E-01	4.30E-02	1.40E-02		6.50E-01
Manganese	8.00E-01	7.60E+00	4.90E-01	3.00E-01		8.40E+00
Organics						
1,1-Dichloroethene	5.00E-03	2.60E-02	3.20E-03	3.80E-04		3.00E-02
1,2-Dichloroethene (Total)	1.90E+00	1.00E+01	1.50E+00			1.20E+01
Benzene	1.90E-02					
Vinyl Chloride	2.60E+00					
Total pathway		1.80E+01	2.10E+00	3.20E-01		2.10E+01

Exhibit 10d. Noncarcinogenic hazard quotients for WAG 5 surface water COPCs - Residential scenario

Analyte	Concentration (mg/l)	Ingestion HQ	Dermal HQ	Inhalation HQ	Total HI
High Base					
D1					
Inorganics					
Manganese	2.60E-01				
D2					
Inorganics					
Manganese	2.60E+00				
D3					
Inorganics					
Manganese	2.40E-01				
High Base Storm					
D1					
Organics					
2-Butanone	7.00E-03			4.40E-05	4.40E-05
Bis(2-Ethylhexyl) Phthalate	4.00E-03				
D2					
Organics					
1,1-Dichloroethane	2.00E-03			2.50E-05	2.50E-05
1,2-Dichloroethene (Total)	3.00E-03				
Bis(2-Ethylhexyl) Phthalate	6.00E-03				
Trichloroethene	1.00E-03				
Impoundment					
OHFP					
Organics					
Bis(2-Ethylhexyl) Phthalate	1.00E-03				
PWSB					
Organics					
Bromomethane	2.00E-03			2.50E-03	2.50E-03
Low Base					
D2					
Inorganics					
Manganese	2.90E+00				
Low Base Storm					

Exhibit 10d. (continued)

Analyte	Concentration (mg/kg)	Ingestion HQ	Dermal HQ	Inhalation HQ	Total HI
D1					
Organics					
Bis(2-Ethylhexyl) Phthalate	1.00E-03				
D2					
Inorganics					
Manganese	3.00E+00				
D3					
Inorganics					
Manganese	3.60E-01				
Organics					
Bis(2-Ethylhexyl) Phthalate	3.00E-03				
Radionuclides					
Am-241	7.40E-02				

**Exhibit 11a. COCs for WAG 5 soils and associated carcinogenic risks for contributing pathways
(Excavation, industrial, and residential scenarios)**

Analyte	Concentration (mg/kg;pCi/g)	Ingestion risk	Ingestion of produce risk	Inhalation risk	External risk
Excavation scenario					
FS					
Co-60	1.80E+02				9.40E-05
Cs-137	3.60E+01				4.40E-06
Ra-226	3.60E+00				1.30E-06
OHFP					
Cs-137	1.10E+03				1.40E-04
WOC					
Co-60	3.60E+01				1.90E-05
Cs-137	5.50E+03				6.70E-04
Tl-208	2.00E+00				1.60E-06
Industrial scenario					
FS					
Co-60	1.80E+02				7.10E-03
Cs-137	3.60E+01				3.30E-04
Pb-212	1.50E+00				1.90E-06
Ra-226	3.60E+00			4.30E-04	9.90E-05
U-238	7.00E+00				1.20E-06
OHFP					
Co-60	6.20E-01				2.40E-05
Cs-137	1.10E+03				1.00E-02
Ra-228	1.40E+00				1.80E-05
Th-228	1.50E+00				3.90E-05
OHFT					
Cs-137	5.80E+00				5.30E-05
Ra-226	1.30E+00			1.6E-04	3.70E-05
Ra-228	1.90E+00				2.50E-05
Th-228	1.50E+00				3.90E-05
PWSB					
Cs-137	2.00E+00				1.80E-05
K-40	3.50E+01				8.50E-05
Ra-226	1.70E+00			2.10E-04	4.70E-05

Exhibit 11a. (continued)

Analyte	Concentration (mg/kg;pCi/g)	Ingestion risk	Ingestion of produce risk	Inhalation risk	External risk
Ra-228	1.60E+00				2.20E-05
Th-228	1.90E+00				4.90E-05
SW3					
Cs-137	6.90E+00				6.30E-05
Ra-228	1.20E+00				1.60E-05
Th-228	1.60E+00				4.20E-05
SWSA5N					
Ac-228	2.10E+00				2.80E-05
Bi-212	2.60E+00				7.00E-06
Bi-214	9.40E-01				2.30E-05
Pb-212	1.50E+00				1.90E-06
Pb-214	1.00E+00				3.00E-06
Ra-228	2.20E+00				2.90E-05
Th-228	1.80E+00				4.50E-05
Tl-208	1.60E+00				9.50E-05
SWSA5SE					
Ac-228	1.00E+00				1.30E-05
Cm-243/244	3.60E+01	1.80E-06			
Cs-137	6.70E+03	5.90E-05			5.90E-02
Pb-212	1.90E+00				2.40E-06
Pb-214	6.00E-01				1.80E-06
Ra-228	1.30E+00				1.70E-05
Th-228	1.60E+00				4.10E-05
Tl-208	1.00E+00				5.90E-05
Total Radioactive Strontium	1.00E+04	1.20E-04			
SWSA5SW					
Ac-228	2.30E+00				3.00E-05
Bi-214	8.20E-01				2.00E-05
Cs-137	8.40E+01				7.70E-04
K-40	3.20E+01				8.00E-05
Pb-212	1.70E+00				2.20E-06
Pb-214	1.40E+00				4.10E-06
Ra-226	1.50E+00			1.80E-04	4.00E-05

Exhibit 11a. (continued)

Analyte	Concentration (mg/kg;pCi/g)	Ingestion risk	Ingestion of produce risk	Inhalation risk	External risk
Ra-228	2.00E+00				2.60E-05
Th-228	1.50E+00				3.80E-05
Tl-208	1.40E+00				8.30E-05
WOC					
Ac-228	1.80E+00				2.40E-05
Co-57	2.30E+00				2.00E-06
Co-60	3.60E+01				1.40E-03
Cs-137	5.50E+03				4.90E-02
Na-22	1.50E+00				4.90E-05
Pb-212	1.40E+00				1.80E-06
Pb-214	1.40E+00				4.10E-06
Ra-228	1.80E+00				2.40E-05
Th-228	2.20E+00				5.60E-05
Tl-208	2.00E+00				1.20E-04
Residential scenario					
FS					
Co-60	1.80E+02		2.10E-05		3.50E-02
Cs-137	3.60E+01		1.70E-06		1.70E-03
Pb-212	1.50E+00				9.70E-06
Ra-226	3.60E+00			7.30E-04	5.00E-04
Total Radioactive Strontium	1.20E+02		7.30E-04		
U-238	7.00E+00				5.80E-06
NHFT					
Ra-228	1.60E+00				1.10E-04
Th-228	1.70E+00				2.20E-04
OHFP					
Heptachlor Epoxide	5.40E-04		1.10E-06		
Co-60	6.20E-01				1.20E-04
Cs-137	1.10E+03		5.40E-05		5.10E-02
Ra-228	1.40E+00				9.20E-05
Th-228	1.50E+00				2.00E-04
Total Radioactive Strontium	6.50E+02		4.00E-03		
OHFT					

Exhibit 11a. (continued)

Analyte	Concentration (mg/kg;pCi/g)	Ingestion risk	Ingestion of produce risk	Inhalation risk	External risk
Cs-137	5.80E+00				2.70E-04
Ra-226	1.30E+00			2.70E-04	1.90E-04
Ra-228	1.90E+00				1.20E-04
Th-228	1.50E+00				1.90E-04
PWSB					
Cs-137	2.00E+00				9.20E-05
K-40	3.50E+01		1.20E-04		4.30E-04
Ra-226	1.70E+00			3.50E-04	2.40E-04
Ra-228	1.60E+00				1.10E-04
Th-228	1.90E+00				2.40E-04
Total Radioactive Strontium	3.20E+00		1.90E-05		
SW3					
Cs-137	6.90E+00				3.20E-04
Ra-228	1.20E+00				8.00E-05
Th-228	1.60E+00				2.10E-04
SWSA5N					
Ac-228	2.10E+00				1.40E-04
Bi-212	2.60E+00				3.50E-05
Bi-214	9.40E-01				1.10E-04
Pb-212	1.50E+00				9.40E-06
Pb-214	1.00E+00				1.50E-05
Ra-223	5.60E-01				3.00E-06
Ra-228	2.20E+00				1.40E-04
Th-228	1.80E+00				2.30E-04
Tl-208	1.60E+00				4.80E-04
SWSA5SE					
Ac-228	1.00E+00				6.70E-05
Am-241	6.80E+00	2.10E-06			
Cm-243/244	3.60E+01	7.20E-06	1.20E-05		
Cs-137	6.70E+03	2.40E-04	3.20E-04		2.70E-01
Pb-212	1.90E+00				1.20E-05
Pb-214	6.00E-01				8.80E-06
Ra-228	1.30E+00				8.80E-05

Exhibit 11a. (continued)

Analyte	Concentration (mg/kg;pCi/g)	Ingestion risk	Ingestion of produce risk	Inhalation risk	External risk
Th-228	1.60E+00				2.10E-04
Tl-208	1.00E+00				3.00E-04
Total Radioactive Strontium	1.00E+04	4.70E-04	6.00E-02		
SWSASSW					
Aroclor 1260	1.20E+00	1.40E-05	5.40E-06		
Ac-228	2.30E+00				1.50E-04
Bi-214	8.20E-01				1.00E-04
Cs-137	8.40E+01	3.00E-06	4.00E-06		3.90E-03
K-40	3.20E+01		1.10E-04		4.00E-04
Pb-212	1.70E+00				1.10E-05
Pb-214	1.40E+00				2.10E-05
Ra-226	1.50E+00			3.00E-04	2.00E-04
Ra-228	2.00E+00				1.30E-04
Th-228	1.50E+00				1.90E-04
Tl-208	1.40E+00				4.20E-04
Total Radioactive Strontium	5.20E+03	2.40E-04	3.10E-02		
U-238	5.00E+00				4.10E-06
WOC					
Ac-228	1.80E+00				1.20E-04
Co-57	2.30E+00				1.00E-05
Co-60	3.60E+01		4.30E-06		7.10E-03
Cs-134	4.00E-02				4.80E-06
Cs-137	5.50E+03	1.90E-04	2.60E-04		2.20E-01
Na-22	1.50E+00				2.50E-04
Pb-212	1.40E+00				9.00E-06
Pb-214	1.40E+00				2.10E-05
Ra-228	1.80E+00				1.20E-04
Th-228	2.20E+00				2.80E-04
Tl-208	2.00E+00				6.00E-04
Total Radioactive Strontium	3.80E+02	1.70E-05	2.30E-03		

**Exhibit 11b. COCs for WAG 5 sediments and associated carcinogenic risks for contributing pathways
(Industrial and residential scenarios)**

Analyte	Concentration (mg/kg;pCi/g)	Ingestion risk	Inhalation risk	External risk
Industrial scenario				
D2				
Ac-228	2.30E+00			3.00E-05
Bi-212	1.70E+00			4.60E-06
Bi-214	1.20E+00			2.90E-05
Co-60	6.30E-01			2.50E-05
Pb-212	1.70E+00			2.20E-06
Pb-214	1.20E+00			1.50E-06
Ra-226	2.90E+00		3.50E-04	8.00E-05
Tl-208	1.40E+00			8.30E-05
Vinyl Chloride	1.00E+00		2.50E-03	
D3				
Ac-228	1.50E+00			2.00E-05
Bi-214	9.10E-01			2.20E-05
Pb-212	1.40E+00			1.80E-06
Pb-214	1.00E+00			1.30E-06
Tl-208	1.10E+00			6.50E-05
OHFP				
Am-241	8.80E+02	6.60E-05		2.00E-05
Aroclor 1254	2.30E+00	3.10E-06		
Cm-243/244	2.40E+04	1.20E-03		3.30E-06
Co-60	6.30E+03	2.90E-05		2.20E-01
Cs-137	3.70E+06	3.20E-02		1.00E+00
Pu-238	1.20E+03	8.40E-05		
Pu-239/240	6.40E+02	4.60E-05		
Th-228	1.70E+02	3.00E-06		4.40E-03
Th-230	3.10E+02	1.30E-06		
Total Radioactive Strontium	7.40E+05	8.30E-03		
PWSB				
Am-241	1.20E+03	8.80E-05		2.60E-05
Aroclor 1248	1.20E+00	1.60E-06		
Aroclor 1254	1.30E+00	1.80E-06		

Exhibit 11b. (continued)

Analyte	Concentration (mg/kg;pCi/g)	Ingestion risk	Inhalation risk	External risk
Cm-243/244	1.10E+03	5.50E-05		
Co-60	5.90E+03	2.80E-05		2.10E-01
Cs-137	1.80E+04	1.60E-04		1.50E-01
Eu-152	9.60E+02			1.60E-02
Eu-154	5.80E+02			1.10E-02
Pu-238	1.20E+02	8.50E-06		
Pu-239/240	1.40E+02	1.00E-05		
Th-228	3.80E+02	6.60E-06		9.80E-03
Total Radioactive Strontium	1.20E+05	1.30E-03		
U-232	3.20E+02	3.70E-06		
U-238	1.10E+02			1.80E-05
Residential scenario				
D1				
Ac-228	1.40E+00			9.30E-05
Bi-212	1.50E+00			2.00E-05
Bi-214	8.60E-01			1.00E-04
Co-60	3.10E-01			6.20E-05
Pb-212	1.30E+00			8.40E-06
Pb-214	9.30E-01			6.00E-06
Ra-223	3.70E-01			2.00E-06
Radon 219	4.70E-01			1.70E-06
U-235	3.60E-01			2.00E-06
U-238	1.30E+01			1.10E-05
D2				
Ac-228	2.30E+00			1.50E-04
Bi-212	1.70E+00			2.30E-05
Bi-214	1.20E+00			1.40E-04
Co-60	6.30E-01			1.20E-04
I-129	1.40E+01			1.30E-06
Pb-212	1.70E+00			1.10E-05
Pb-214	1.20E+00			7.70E-06
Ra-223	9.10E-01			4.80E-06
Ra-224	4.90E+00			2.60E-06

Exhibit 11b. (continued)

Analyte	Concentration (mg/kg;pCi/g)	Ingestion risk	Inhalation risk	External risk
Ra-226	2.90E+00		5.90E-04	4.00E-04
Radon 219	1.20E+00			4.40E-06
Tl-208	1.40E+00			4.20E-04
U-235	4.10E-01			2.30E-06
U-238	2.40E+00			2.00E-06
Vinyl Chloride	1.00E+00		7.30E-03	
D3				
Ac-228	1.50E+00			1.00E-04
Bi-214	9.10E-01			1.10E-04
Pb-212	1.40E+00			9.00E-06
Pb-214	1.00E+00			6.40E-06
Tl-208	1.10E+00			3.30E-04
OHFP				
Am-241	8.80E+02	2.70E-04		9.90E-05
Aroclor 1254	2.30E+00	2.80E-05		
Aroclor 1260	6.30E-01	7.60E-06		
Cm-243/244	2.40E+04	4.90E-03		1.70E-05
Co-60	6.30E+03	1.20E-04		7.10E-03
Cs-137	3.70E+06	1.20E-01		1.00E+00
Pu-238	1.20E+03	3.40E-04		
Pu-239/240	6.40E+02	1.90E-04		
Th-228	1.70E+02	1.20E-05		2.20E-02
Th-230	3.10E+02	5.10E-06		
Total Radioactive Strontium	7.40E+05	3.30E-02		
U-232	3.80E+01	1.80E-06		
U-233	1.60E+03	3.20E-05		1.50E-06
PWSB				
Am-241	1.20E+03	3.50E-04		1.30E-04
Aroclor 1248	1.20E+00	1.40E-05		
Aroclor 1254	1.30E+00	1.60E-05		
Cm-243/244	1.10E+03	2.20E-04		
Co-60	5.90E+03	1.10E-04		6.90E-01
Cs-137	1.80E+04	6.30E-04		5.60E-01

Exhibit 11b. (continued)

Analyte	Concentration (mg/kg,pCi/g)	Ingestion risk	Inhalation risk	External risk
Eu-152	9.60E+02	2.50E-06		7.70E-02
Eu-154	5.80E+02	2.20E-06		5.30E-02
Pu-238	1.20E+02	3.40E-05		
Pu-239/240	1.40E+02	4.10E-05		
Th-228	3.80E+02	2.60E-05		4.80E-02
Total Radioactive Strontium	1.20E+05	5.40E-03		
U-232	3.20E+02	1.50E-05		
U-238	1.10E+02	3.80E-06		9.00E-05

**Exhibit 11c. COCs for WAG 5 groundwater and associated carcinogenic risks for contributing pathways
(Residential scenario)**

Analyte	Concentration (mg/l;pCi/l)	Ingestion risk	Ingestion of produce risk	Dermal risk	Inhalation risk
FS					
Beryllium	6.20E-03	5.40E-04			
Am-241	4.20E-01	2.10E-06			
Ra-226	3.00E+00	7.60E-06			
Ra-228	4.30E+00	9.00E-06			
Th-228	3.20E+01	3.70E-05			
Th-230	2.40E+01	6.60E-06			
Th-232	3.50E+01	8.80E-06			
Tritium	1.10E+05	1.20E-04			
OHFP					
1,2-Dichloroethane	3.00E-03	5.60E-06			
Carbon Tetrachloride	9.00E-03	2.40E-05	1.90E-06		
Chloroform	2.50E-02	3.10E-06			1.50E-06
Trichloroethene	7.00E-03	1.60E-06	7.80E-05		
C-14	1.20E+03	2.40E-05	9.70E-06		
Cm-243/244	4.40E+00	1.50E-05			
Co-60	8.90E+01	2.80E-05	1.90E-06		
Cs-137	1.70E+03	1.00E-03	6.50E-05		
Pu-238	5.40E-01	2.50E-06			
Ra-226	4.90E-01	1.20E-06			
Ra-228	2.50E+02	5.30E-04	3.40E-05		
Tc-99	4.20E+01	1.10E-06			
Th-234	1.70E+02	1.50E-05			
Total Radioactive Strontium	2.70E+04	2.00E-02	1.70E-03		
Tritium	2.00E+06	2.20E-03	8.60E-04		3.70E-04
U-233/234	9.00E+00	3.00E-06			
SWSA5N					
Beryllium	2.30E-03	2.00E-04			
Bis(2-Ethylhexyl) Phthalate	1.30E-02	3.70E-06			
Methylene Chloride	1.60E-02	2.40E-06			
Am-241	3.20E+00	1.60E-05			
C-14	1.20E+02	2.30E-06			

Exhibit 11c. (continued)

Analyte	Concentration (mg/l;pCi/l)	Ingestion risk	Ingestion of produce risk	Dermal risk	Inhalation risk
Cm-243/244	3.90E+01	1.30E-04			
K-40	6.20E+02	1.40E-04			
Pb-212	3.40E+01	3.90E-06			
Pu-238	5.50E-01	2.60E-06			
Ra-226	3.10E+00	7.90E-06			
Ra-228	1.70E+01	3.60E-05			
Th-228	2.80E+00	3.20E-06			
Th-234	4.90E+02	4.10E-05			
Tritium	2.20E+03	2.50E-06			
U-238	2.30E+00	1.40E-06			
SWSA5SE					
1,1-Dichloroethene	5.50E-03	6.70E-05	8.20E-06		5.10E-06
1,2-Dichloroethane	4.00E-03	7.40E-06	1.10E-06		
Benzene	2.00E-03	1.20E-06			
Bis(2-Ethylhexyl) Phthalate	5.00E-03	1.40E-06			
Trichloroethene	3.00E-02	6.70E-06	1.20E-06		
Vinyl Chloride	1.40E-02	5.30E-04	8.90E-05		3.10E-06
Am-241	1.50E+05	5.30E-01	4.60E-02		
Bi-212	5.30E+02	3.50E-06			
C-14	4.30E+02	8.20E-06	3.50E-06		
Cd-109	3.70E+02	6.10E-05	4.90E-06		
Cm-243/244	1.00E+01	3.50E-05	2.10E-06		
Pu-238	9.30E+04	3.50E-01	2.70E-02		
Pu-239/240	1.60E+03	7.80E-03	4.90E-04		
Ra-226	1.30E+03	3.30E-03	2.10E-04		
Ra-228	2.10E+01	4.30E-05	2.90E-06		
Tc-99	1.60E+02	4.40E-06	1.70E-06		
Th-228	4.50E+01	5.20E-05	3.20E-06		
Th-231	3.50E+02	3.00E-06			
Total Radioactive Strontium	2.80E+03	2.10E-03	1.70E-04		
Tritium	6.50E+07	7.10E-02	2.80E-02		1.20E-02
U-233/234	1.30E+03	4.40E-04	2.80E-05		
U-238	1.80E+00	1.00E-06			

Exhibit 11c. (continued)

Analyte	Concentration (mg/l;pCi/l)	Ingestion risk	Ingestion of produce risk	Dermal risk	Inhalation risk
SWSA5SW					
Bis(2-Ethylhexyl) Phthalate	2.20E-01	6.30E-05	3.90E-06		
Carbon Tetrachloride	6.00E-03	1.60E-05	1.30E-06		
Vinyl Chloride	2.30E-02	9.00E-04	1.50E-04		5.30E-06
Am-241	2.10E+00	1.10E-05			
C-14	4.70E+02	8.80E-06	3.80E-06		
Ca-45	2.80E+02	5.80E-06			
Cm-243/244	1.50E+00	5.20E-06			
Co-60	4.10E+01	1.30E-05			
K-40	1.00E+03	2.30E-04	1.90E-05		
Pb-212	5.30E+01	6.10E-06			
Pu-238	1.50E+00	7.20E-06			
Ra-226	2.40E+00	6.10E-06			
Ra-228	5.40E+01	1.10E-04	7.40E-06		
Th-228	1.30E+01	1.50E-05			
Th-230	6.50E+00	1.80E-06			
Th-232	9.00E+00	2.30E-06			
Th-234	1.70E+02	1.50E-05			
Total Radioactive Strontium	3.40E+02	2.60E-04	2.10E-05		
Tritium	8.10E+06	9.20E-03	3.50E-03		1.50E-03
U-233/234	6.20E+00	2.10E-06			
U-238	4.30E+00	2.50E-06			
WOC					
1,1-Dichloroethene	5.00E-03	6.10E-05	7.50E-06		4.60E-06
Benzene	1.90E-02	1.10E-05	1.10E-06		
Vinyl Chloride	2.60E+00	9.50E-02	1.60E-02	1.20E-03	5.90E-04
C-14	1.10E+03	2.10E-05	8.20E-06		
Th-228	1.70E+00	2.00E-06			
Th-234	1.00E+03	8.40E-05	3.50E-06		
Tritium	4.40E+04	5.00E-05	1.90E-05		8.50E-06

Exhibit 12. COCs for WAG 5 and associated noncarcinogenic hazard quotients for pathways of concern (Soil, sediment, and groundwater)

Analyte	Concentration (mg/Kg)	Ingestion HQ	Ingestion of produce HQ	Dermal HQ
Residential scenario				
Soil				
FS				
Mercury	4.30E +00		1.00E+01	
OHFP				
Cadmium	1.50E+00		1.50E+00	
OHFT				
Silver	4.30E+00		2.40E-01	
Cyanide	6.70E-01		8.60E-01	
SWSASSE				
Antimony	6.20E+00		3.20E-01	
Manganese	3.30E+03		1.30E+00	
SWSASSW				
Barium	3.60E+02		1.50E+00	
Manganese	2.70E+03		1.10E+00	
WOC				
Mercury	8.10E-01		2.00E+00	
Sediment				
D2				
Arsenic	1.40E+01	1.70E-01		
Manganese	4.30E+04	1.10E+00		
Groundwater				
FS				
Barium	9.30E-01	6.30E-01		
Chromium VI	2.40E-01	2.30E+00	1.60E-01	1.90E-01
Manganese	2.30E+00	2.20E+01	1.40E+00	8.90E-01
Nickel	1.70E-01	3.90E-01		
Vanadium	1.40E-01	9.50E-01		1.50E-01
SWSA5N				
Barium	9.20E-01	6.30E-01		
Chromium VI	1.10E-01	1.00E+00		

Exhibit 12 (continued)

Analyte	Concentration (mg/Kg)	Ingestion HQ	Ingestion of produce HQ	Dermal HQ
Manganese	2.30E+00	2.20E+01	1.40E+00	
Nickel	1.50E-01	3.60E-01		
Vanadium	5.30E-02	3.60E-01		
SWSA5SE				
Chromium VI	1.00E-01	9.60E-01		
Manganese	2.30E+01	2.10E+02	1.40E+01	8.60E+00
SWSA5SW				
Barium	4.60E-01	3.10E-01		
Chromium VI	7.40E-02	7.00E-01		
Manganese	5.10E+00	4.90E+01	3.10E+00	2.00E+00
Bis(2-Ethylhexyl)Phthalate	2.20E-01	5.20E-01		1.00E-01
Carbon Tetrachloride	6.00E-03	4.10E-01		
Tetrachloroethene	1.10E-01	5.40E-01		3.20E-01
WOC				
Barium	8.70E-01	5.90E-01		
Manganese	8.00E-01	7.60E+00	4.90E-01	3.00E-01
1,2-Dichloroethene (Total)	1.90E+00	1.00E+01	1.50E+00	

**Exhibit 13a. Total cumulative risk and HI summary for WAG 5 soil COPCs
(Excavation, industrial and residential scenarios)**

Area	Risk/HI	Ingestion	Produce ingestion	Dermal	Inhalation	External	Cumulative
Excavation scenario							
FS	Risk					1.00E-04	1.10E-04
OHFP	Risk					1.40E-04	1.40E-04
WOC	Risk					6.90E-04	6.90E-04
Industrial scenario							
FS	Risk				4.30E-04	7.50E-03	7.90E-03
OHFP	Risk					1.00E-02	1.10E-02
OHFT	Risk				1.60E-04	1.50E-04	3.10E-04
PWSB	Risk				2.10E-04	2.20E-04	4.30E-04
SW3	Risk					1.20E-04	1.20E-04
SWSA5N	Risk					2.30E-04	2.30E-04
SWSA5SE	Risk	1.80E-04				5.90E-02	6.00E-02
SWSA5SW	Risk				1.80E-04	1.10E-03	1.30E-03
WOC	Risk					5.00E-02	5.00E-02
Residential scenario							
FS	Risk		7.50E-04		7.30E-04	3.70E-02	3.90E-02
	HI	5.20E-02	1.00E+01	1.70E-02			1.00E+01
NHFT	Risk					3.20E-04	3.20E-04
OHFP	Risk		4.00E-03			5.20E-02	5.60E-02
	HI	5.50E-03	1.50E+00	1.20E-02			1.60E+00
OHFT	Risk				2.70E-04	7.70E-04	1.00E-03
	HI	3.30E-03	1.10E+00	4.80E-04			1.10E+00
PWSB	Risk		1.40E-04		3.50E-04	1.10E-03	1.60E-03
SW3	Risk					6.10E-04	6.40E-04
SWSA5N	Risk					1.20E-03	1.20E-03
SWSA5SE	Risk	7.10E-04	6.10E-02			2.70E-01	3.10E-01
	HI	1.40E-01	1.70E+00	1.10E-01	2.50E-02		1.90E+00
SWSA5SW	Risk	2.50E-04	3.10E-02		3.00E-04	5.50E-03	3.70E-02
	HI	9.00E-02	2.60E+00	4.60E-02	2.10E-02		2.70E+00
WOC	Risk	2.10E-04	2.60E-03			2.30E-01	2.30E-01
	HI	9.90E-03	2.00E+00	3.10E-03			3.00E+00

**Exhibit 13b. Total cumulative risk and HI summary for WAG 5 sediment COPCs
(Industrial and residential scenarios)**

Area	Risk/HI	Ingestion	Dermal	Inhalation	External	Cumulative
Industrial scenario						
D2	Risk	1.90E-05	3.00E-07	2.90E-03	2.60E-04	3.10E-03
D3	Risk	6.40E-07	6.70E-12	1.30E-08	1.10E-04	1.10E-04
OHFP	Risk	4.10E-02	2.80E-06	2.30E-05	1.00E+00	1.00E+00
PWSB	Risk	1.70E-03	2.40E-06	4.00E-06	3.50E-01	3.50E-01
Residential scenario						
D1	Risk	1.10E-05	2.50E-06	1.10E-07	3.10E-04	3.30E-04
D2	Risk	7.70E-05	9.40E-07	7.90E-03	1.30E-03	9.30E-03
	HI	1.40E+00	6.70E-01	3.30E-01		2.40E+00
D3	Risk	2.60E-06	2.10E-11	3.70E-08	5.60E-04	5.60E-04
OHFP	Risk	1.60E-01	8.70E-06	4.00E-05	1.00E+00	1.00E+00
PWSB	Risk	6.90E-03	7.50E-06	6.80E-06	8.90E-01	8.90E-01

**Exhibit 13c. Total cumulative risk and HI summary for WAG 5 groundwater COPCs
(Residential scenario)**

Area	Risk/Hi	Ingestion	Produce ingestion	Dermal	Inhalation	Cumulative
Residential scenario						
FS	Risk	7.40E-04				9.30E-04
	HI	2.60E+01	1.70E+00	1.30E+00		2.80E+01
OHFP	Risk	2.40E-02	2.70E-03		3.70E-04	2.70E-02
SWSASN	Risk	6.00E-04				1.20E-03
	HI	2.40E+01	1.60E+00	1.00E+00		2.50E+01
SWSASSE	Risk	7.20E-01	9.80E-02		1.20E-02	7.50E-01
	HI	2.20E+02	1.40E+01	8.70E+00		2.20E+02
SWSASSW	Risk	1.10E-02	3.70E-03		1.50E-03	1.60E-02
	HI	5.10E+01	3.30E+00	2.50E+00		5.40E+01
WOC	Risk	9.50E-02	1.60E-03	1.20E-03	6.00E-04	2.30E-01
	HI	1.80E+01	2.10E+00			2.10E+01

**Exhibit 14. WAG 5 RGOs for soil, sediment, and groundwater
(Excavation, industrial, and residential scenarios)**

Analyte	RGO Basis	RGO Excluding Ingestion of Produce	Driving Pathway Excluding Ingestion of Produce	RGO Including Ingestion of Produce	Driving Pathway Including Ingestion of Produce	Twice Mean Background (TMBG)	Units
Excavation							
Soil							
Co-60	Risk	1.90E+00	External		External	1.90E-02	PCI/G
Cs-137	Risk	8.20E+00	External		External	1.40E+00	PCI/G
Ra-226	Risk	5.10E-01	External		External	1.50E+00	PCI/G
Tl-208	Risk	1.30E+00	External		External		PCI/G
Industrial							
Sediment							
Aroclor 1248	Risk	4.40E-01	Ingestion		Ingestion	1.90E-01	MG/KG
Aroclor 1254	Risk	4.40E-01	Ingestion		Ingestion	3.90E-01	MG/KG
Vinyl Chloride	Risk	4.10E-04	Inhalation		Inhalation	2.40E-02	MG/KG
Ac-228	Risk	7.60E-02	External		External		PCI/G
Am-241	Risk	1.00E+01	Ingestion, External		Ingestion, External		PCI/G
Bi-212	Risk	3.70E-01	External		External		PCI/G
Bi-214	Risk	4.10E-02	External		External		PCI/G
Cm-243/244	Risk	2.00E+01	Ingestion, External		Ingestion, External		PCI/G
Co-60	Risk	2.90E-02	Ingestion, External		Ingestion, External		PCI/G
Cs-137	Risk	1.20E-01	Ingestion, External		Ingestion, External		PCI/G
Eu-152	Risk	6.10E-02	External		External	3.30E+01	PCI/G
Eu-154	Risk	5.40E-02	External		External		PCI/G
Pb-212	Risk	7.80E-01	External		External		PCI/G
Pb-214	Risk	7.80E-01	External		External		PCI/G
Pu-238	Risk	1.40E+01	Ingestion		Ingestion		PCI/G
Pu-239/240	Risk	1.40E+01	Ingestion		Ingestion		PCI/G
Ra-226	Risk	6.80E-03	Inhalation, External		Inhalation, External	1.60E+00	PCI/G
Th-228	Risk	3.90E-02	Ingestion, External		Ingestion, External	2.70E+00	PCI/G

Exhibit 14. (continued)

Analyte	RGO Basis	RGO Excluding Ingestion of Produce	Driving Pathway Excluding Ingestion of Produce	RGO Including Ingestion of Produce	Driving Pathway Including Ingestion of Produce	Twice Mean Background (TMBG)	Units
Th-230	Risk	1.90E+02	Ingestion		Ingestion	2.10E+00	PCI/G
Tl-208	Risk	1.70E-02	External		External		PCI/G
Total Radioactive Strontium	Risk	8.90E+01	Ingestion		Ingestion	1.30E+00	PCI/G
U-232	Risk	7.40E+01	Ingestion		Ingestion		PCI/G
U-233	Risk	1.70E+02	Ingestion		Ingestion		PCI/G
U-238	Risk	5.70E+00	External		External	2.10E+00	PCI/G
Sell							
Ac-228	Risk	7.60E-02	External		External		PCI/G
Bi-212	Risk	3.70E-01	External		External		PCI/G
Bi-214	Risk	4.10E-02	External		External		PCI/G
Cm-243/244	Risk	2.00E+01	Ingestion		Ingestion	2.80E+00	PCI/G
Co-57	Risk	1.20E+00	External		External	1.50E-02	PCI/G
Co-60	Risk	2.50E-02	External		External	1.90E-02	PCI/G
Cs-137	Risk	1.10E-01	Ingestion, External		Ingestion, External	1.40E+00	PCI/G
K-40	Risk	4.00E-01	External		External	3.20E+01	PCI/G
Na-22	Risk	3.00E-02	External		External		PCI/G
Pb-212	Risk	7.80E-01	External		External		PCI/G
Pb-214	Risk	3.40E-01	External		External		PCI/G
Ra-226	Risk	6.80E-03	Inhalation, External		Inhalation, External	1.50E+00	PCI/G
Ra-228	Risk	7.50E-02	External		External		PCI/G
Th-228	Risk	3.90E-02	External		External	1.50E+00	PCI/G
Tl-208	Risk	1.70E-02	External		External		PCI/G
Total Radioactive Strontium	Risk	8.90E+01	Ingestion		Ingestion	1.90E+00	PCI/G
U-238	Risk	5.70E+00	External		External	2.30E+00	PCI/G
Groundwater							
Barium	HQ	1.40E-01	Ingestion		Ingestion	5.00E-01	MGL

Residential

Exhibit 14. (continued)

Analyte	RGO Basis	RGO Excluding Ingestion of Produce	Driving Pathway Excluding Ingestion of Produce	RGO Including Ingestion of Produce	Driving Pathway Including Ingestion of Produce	Twice Mean Background (TMBG)	Units
Beryllium	Risk	9.80E-06	Ingestion		Ingestion	3.20E-03	MG/L
Chromium VI	HQ	9.70E-03	Ingestion, Dermal	9.20E-03	Ingestion, Ingestion of produce, Dermal		MG/L
Manganese	HQ	1.00E-02	Ingestion, Dermal	9.50E-03	Ingestion, Ingestion of produce, Dermal	2.40E-01	MG/L
Nickel	HQ	4.20E-02	Ingestion		Ingestion	1.40E-02	MG/L
Vanadium	HQ	1.30E-02	Ingestion, Dermal		Ingestion, Dermal	5.30E-03	MG/L
1,1-Dichloroethene	Risk	7.50E-05	Ingestion, Inhalation	6.80E-05	Ingestion, Ingestion of produce, Inhalation	1.00E-02	MG/L
1,2-Dichloroethane	Risk	5.20E-04	Ingestion	4.50E-04	Ingestion, Ingestion of produce	1.00E-02	MG/L
1,2-Dichloroethene (Total)	HQ	1.90E-02	Ingestion	1.70E-02	Ingestion, Ingestion of produce	1.00E-02	MG/L
Benzene	Risk	1.60E-03	Ingestion	1.40E-03	Ingestion, Ingestion of produce	9.30E-03	MG/L
Bis(2-Ethylhexyl) Phthalate	Risk	2.90E-03	Ingestion	2.80E-03	Ingestion, Ingestion of produce	1.40E-02	MG/L
Carbon Tetrachloride	Risk	3.50E-04	Ingestion	3.30E-04	Ingestion, Ingestion of produce	1.00E-02	MG/L
Chloroform	Risk	5.10E-03	Ingestion, Inhalation		Ingestion, Inhalation	1.00E-02	MG/L
Methylene Chloride	Risk	6.50E-03	Ingestion		Ingestion	9.30E-03	MG/L
Tetrachloroethene	HQ	1.30E-02	Ingestion, Dermal		Ingestion, Dermal	9.60E-03	MG/L
Trichloroethene	Risk	3.70E-03	Ingestion	3.30E-03	Ingestion, Ingestion of produce	1.00E-02	MG/L
Vinyl Chloride	Risk	2.70E-05	Ingestion, Inhalation, Dermal	2.30E-05	Ingestion, Ingestion of produce, Inhalation, Dermal	2.00E-02	MG/L
Am-241	Risk	2.80E-01	Ingestion	2.70E-01	Ingestion, Ingestion of produce		PCI/L
Bi-212	Risk	1.50E+02	Ingestion		Ingestion		PCI/L
C-14	Risk	5.30E+01	Ingestion	3.70E+01	Ingestion, Ingestion of produce		PCI/L
Ca-45	Risk	4.80E+01	Ingestion		Ingestion		PCI/L
Cd-109	Risk	6.00E+00	Ingestion	5.60E+00	Ingestion, Ingestion of produce		PCI/L
Cm-243/244	Risk	3.00E-01	Ingestion	2.80E-01	Ingestion, Ingestion of produce		PCI/L
Co-60	Risk	3.20E+00	Ingestion	3.00E+00	Ingestion, Ingestion of produce	4.30E+01	PCI/L
Cs-137	Risk	1.70E+00	Ingestion	1.60E+00	Ingestion, Ingestion of produce	1.20E+01	PCI/L
K-40	Risk	4.30E+00	Ingestion	4.00E+00	Ingestion, Ingestion of produce		PCI/L
Pb-212	Risk	8.70E+00	Ingestion		Ingestion		PCI/L

Exhibit 14. (continued)

Analyte	RGO Basis	RGO Excluding Ingestion of Produce	Driving Pathway Excluding Ingestion of Produce	RGO Including Ingestion of Produce	Driving Pathway Including Ingestion of Produce	Twice Mean Background (TM/BO)	Units
Pu-238	Risk	2.70E-01	Ingestion	2.50E-01	Ingestion, Ingestion of produce		PC/L
Pu-239/240	Risk	2.10E-01	Ingestion	1.90E-01	Ingestion, Ingestion of produce		PC/L
Ra-226	Risk	4.00E-01	Ingestion	3.70E-01	Ingestion, Ingestion of produce		PC/L
Ra-228	Risk	4.80E-01	Ingestion	4.50E-01	Ingestion, Ingestion of produce		PC/L
Tc-99	Risk	3.70E+01	Ingestion	2.60E+01	Ingestion, Ingestion of produce		PC/L
Th-228	Risk	8.70E-01	Ingestion	8.20E-01	Ingestion, Ingestion of produce		PC/L
Th-230	Risk	3.70E+00	Ingestion		Ingestion		PC/L
Th-231	Risk	1.20E+02	Ingestion		Ingestion		PC/L
Th-232	Risk	4.00E+00	Ingestion		Ingestion		PC/L
Th-234	Risk	1.20E+01	Ingestion	1.10E+01	Ingestion, Ingestion of produce		PC/L
Total Radioactive Strontium	Risk	1.30E+00	Ingestion	1.20E+00	Ingestion, Ingestion of produce	1.00E+01	PC/L
Tritium	Risk	7.60E+02	Ingestion, Inhalation	5.70E+02	Ingestion, Ingestion of produce, Inhalation	2.40E+03	PC/L
U-233/234	Risk	3.00E+00	Ingestion	2.80E+00	Ingestion, Ingestion of produce		PC/L
U-238	Risk	1.70E+00	Ingestion		Ingestion		PC/L
Sediment							
Arsenic	HQ	7.80E+00	Ingestion		Ingestion	1.20E+01	MG/KG
Manganese	HQ	2.10E+03	Ingestion		Ingestion	3.00E+03	MG/KG
Aroclor 1248	Risk	6.60E-02	Ingestion		Ingestion	1.90E-01	MG/KG
Aroclor 1254	Risk	6.60E-02	Ingestion		Ingestion	3.90E-01	MG/KG
Aroclor 1260	Risk	6.60E-02	Ingestion		Ingestion	3.90E-01	MG/KG
Vinyl Chloride	Risk	1.40E-04	Inhalation		Inhalation	2.40E-02	MG/KG
Ac-228	Risk	1.50E-02	External		External		PCI/G
Am-241	Risk	2.40E+00	Ingestion, External		Ingestion, External		PCI/G
Bi-212	Risk	7.40E-02	External		External		PCI/G
Bi-214	Risk	8.20E-03	External		External		PCI/G
Cm-243/244	Risk	4.90E+00	Ingestion, External		Ingestion, External		PCI/G
Co-60	Risk	8.60E-03	Ingestion, External		Ingestion, External		PCI/G

Exhibit 14. (continued)

Analyte	RG0 Basis	RG0 Excluding Ingestion of Produce	Driving Pathway Excluding Ingestion of Produce	RG0 Including Ingestion of Produce	Driving Pathway Including Ingestion of Produce	Twice Mean Background (TMBG)	Units
Cs-137	Risk	3.20E-02	Ingestion, External		Ingestion, External	3.30E+01	PCI/G
Eu-152	Risk	1.30E-02	Ingestion, External		Ingestion, External		PCI/G
Eu-154	Risk	1.10E-02	Ingestion, External		Ingestion, External		PCI/G
I-129	Risk	3.00E+00	External		External		PCI/G
Pb-212	Risk	1.60E-01	External		External		PCI/G
Pb-214	Risk	1.60E-01	External		External		PCI/G
Pu-238	Risk	3.60E+00	Ingestion		Ingestion		PCI/G
Pu-239/240	Risk	3.40E+00	Ingestion		Ingestion		PCI/G
Ra-223	Risk	1.90E-01	External		External		PCI/G
Ra-224	Risk	1.70E+00	External		External	2.40E+00	PCI/G
Ra-226	Risk	2.90E-03	Inhalation, External		Inhalation, External	1.60E+00	PCI/G
Radon 219	Risk	2.70E-01	External		External		PCI/G
Th-228	Risk	7.80E-03	Ingestion, External		Ingestion, External	2.70E+00	PCI/G
Th-230	Risk	5.30E+01	Ingestion		Ingestion	2.10E+00	PCI/G
Tl-208	Risk	3.30E-03	External		External		PCI/G
Total Radioactive Strontium	Risk	2.20E+01	Ingestion		Ingestion	1.30E+00	PCI/G
U-232	Risk	2.00E+01	Ingestion		Ingestion		PCI/G
U-233	Risk	4.50E+01	Ingestion, External		Ingestion, External		PCI/G
U-235	Risk	1.80E-01	External		External		PCI/G
U-238	Risk	1.20E+00	Ingestion, External		Ingestion, External	2.10E+00	PCI/G
Soil							
Antimony	HQ			1.40E+00	Ingestion of produce	4.40E-01	MG/KG
Barium	HQ			2.40E+01	Ingestion of produce	2.40E+02	MG/KG
Cadmium	HQ			9.50E-02	Ingestion of produce	4.40E-01	MG/KG
Manganese	HQ			2.20E+02	Ingestion of produce	2.40E+03	MG/KG
Mercury	HQ			4.10E-02	Ingestion of produce	5.90E-01	MG/KG
Silver	HQ			1.70E+00	Ingestion of produce	4.00E+00	MG/KG

Exhibit 14. (continued)

Analyte	RGO Basis	RGO Excluding Ingestion of Produce	Driving Pathway Excluding Ingestion of Produce	RGO Including Ingestion of Produce	Driving Pathway Including Ingestion of Produce	Twice Mean Background (TMBG)	Units
Aroclor 1260	Risk	6.60E-02	Ingestion	5.10E-02	Ingestion, Ingestion of produce	1.60E-01	MG/KG
Cyanide	HQ			7.80E-02	Ingestion of produce	4.90E-01	MG/KG
Heptachlor Epoxide	Risk			5.10E-04	Ingestion of produce	8.20E-03	MG/KG
Ac-228	Risk	1.50E-02	External		External		PCI/G
Am-241	Risk	2.40E+00	Ingestion		Ingestion	8.10E-02	PCI/G
Bi-212	Risk	7.40E-02	External		External		PCI/G
Bi-214	Risk	8.20E-03	External		External		PCI/G
Cm-243/244	Risk	4.90E+00	Ingestion	1.90E+00	Ingestion, Ingestion of produce	2.80E+00	PCI/G
Co-57	Risk	2.30E-01	External		External		PCI/G
Co-60	Risk	5.10E-03	External	5.00E-03	Ingestion of produce, External	1.50E-02	PCI/G
Cs-134	Risk	8.40E-03	External		External	1.90E-02	PCI/G
Cs-137	Risk	2.20E-02	Ingestion, External	2.20E-02	Ingestion, Ingestion of produce, External	1.40E+00	PCI/G
K-40	Risk	8.00E-02	External	6.30E-02	Ingestion of produce, External	3.20E+01	PCI/G
Na-22	Risk	6.00E-03	External		External		PCI/G
Pb-212	Risk	1.60E-01	External		External		PCI/G
Pb-214	Risk	6.80E-02	External		External		PCI/G
Ra-223	Risk	1.90E-01	External		External		PCI/G
Ra-226	Risk	2.90E-03	Inhalation, External		Inhalation, External	1.50E+00	PCI/G
Ra-228	Risk	1.50E-02	External		External		PCI/G
Th-228	Risk	7.80E-03	External		External	1.50E+00	PCI/G
Tl-208	Risk	3.30E-03	External		External		PCI/G
Total Radioactive Strontium	Risk	2.20E+01	Ingestion	1.60E-01	Ingestion, Ingestion of produce	1.90E+00	PCI/G
U-238	Risk	1.20E+00	External		External	2.30E+00	PCI/G
Surface Water							
Bis(2-Ethylhexyl) Phthalate	Risk	2.90E-03	Ingestion		Ingestion	2.00E-02	MG/L
Am-241	Risk	2.00E-01	Ingestion		Ingestion		PCI/L
C-14	Risk	5.30E+01	Ingestion		Ingestion		PCI/L

Exhibit 14. (continued)

Analyte	RGO Basis	RGO Excluding Ingestion of Produce	Driving Pathway Excluding Ingestion of Produce	RGO Including Ingestion of Produce	Driving Pathway Including Ingestion of Produce	Twice Mean Background (TMBG)	Units
Ca-45	Risk	4.80E+01	Ingestion		Ingestion		PC/L
Pu-238	Risk	2.20E-01	Ingestion		Ingestion		PC/L
Th-230	Risk	3.70E+00	Ingestion		Ingestion	4.30E+00	PC/L
Total Radioactive Strontium	Risk	1.30E+00	Ingestion		Ingestion		PC/L
Tritium	Risk	7.60E+02	Ingestion, Inhalation		Ingestion, Inhalation	1.60E+03	PC/L

**Exhibit 15. Fissile Storage Area RGOs for soil, sediment, and groundwater of WAG 5
(Excavation, industrial, and residential scenarios)**

Exposure Pathway RGOs								
Analyte	Representative Concentration	RGO Basis	Ingestion	Ingestion of Produce	Inhalation	Dermal Contact	External	Units
Excavation								
Soil								
Co-60	1.8E+02	Risk					1.9E+00	PCI/G
Cs-137	3.6E+01	Risk					8.2E+00	PCI/G
Ra-226	3.6E+00	Risk					5.1E-01	PCI/G
Industrial								
Soil								
Co-60	1.8E+02	Risk					2.5E-02	PCI/G
Cs-137	3.6E+01	Risk					1.1E-01	PCI/G
Pb-212	1.5E+00	Risk					7.8E-01	PCI/G
Ra-226	3.6E+00	Risk			6.8E-03		6.8E-03	PCI/G
U-238	7.0E+00	Risk					5.7E+00	PCI/G
Residential								
Groundwater								
Barium	9.3E-01	HQ	1.4E-01					MG/L
Beryllium	6.2E-03	Risk	9.8E-06					MG/L
Chromium VI	2.4E-01	HQ	9.7E-03	9.2E-03		9.7E-03		MG/L
Manganese	2.3E+00	HQ	1.0E-02	9.5E-03		1.0E-02		MG/L
Nickel	1.7E-01	HQ	4.2E-02					MG/L
Vanadium	1.4E-01	HQ	1.3E-02			1.3E-02		MG/L
Am-241	4.2E-01	Risk	2.0E-01					PCI/L
Ra-226	3.0E+00	Risk	4.0E-01					PCI/L
Ra-228	4.3E+00	Risk	4.8E-01					PCI/L
Th-228	3.2E+01	Risk	8.7E-01					PCI/L
Th-230	2.4E+01	Risk	3.7E+00					PCI/L
Th-232	3.5E+01	Risk	4.0E+00					PCI/L
Tritium	1.1E+05	Risk	7.6E+02					PCI/L
Soil								
Mercury	4.3E+00	HQ		4.1E-02				MG/KG
Co-60	1.8E+02	Risk		5.1E-03			5.1E-03	PCI/G
Cs-137	3.6E+01	Risk		2.2E-02			2.2E-02	PCI/G
Pb-212	1.5E+00	Risk					1.6E-01	PCI/G
Ra-226	3.6E+00	Risk			2.9E-03		2.9E-03	PCI/G
Total Radioactive Strontium	1.2E+02	Risk		1.6E-01				PCI/G
U-238	7.0E+00	Risk					1.2E+00	PCI/G

**Exhibit 16. New Hydrofracture Tank RGOs for soil of WAG 5
(Residential scenario)**

Analyte	Representative Concentration	RGO Basis	Exposure Pathway RGOs for					Units
			Ingestion	Ingestion of Produce	Inhalation	Dermal Contact	External	
			Residential					
Soil								
Ra-228	1.6E+00	Risk					1.5E-02	PCI/G
Th-228	1.7E+00	Risk					7.8E-03	PCI/G

**Exhibit 17. Old Hydrofracture Pond RGOs for soil, sediment, and groundwater of WAG 5
(Excavation, industrial, and residential scenarios)**

Exposure Pathway RGOs								
Analyte	Representative Concentration	RGO Basis	Exposure Pathway RGOs					Units
			Ingestion	Ingestion of Produce	Inhalation	Dermal Contact	External	
Excavation								
Soil								
Cs-137	1.1E+03	Risk					8.2E+00	PCI/G
Industrial								
Sediment								
Aroclor 1254	2.3E+00	Risk	4.4E-01					MG/KG
Am-241	8.8E+02	Risk	1.0E+01				1.0E+01	PCI/G
Cm-243/244	2.4E+04	Risk	2.0E+01				2.0E+01	PCI/G
Co-60	6.3E+03	Risk	2.9E-02				2.9E-02	PCI/G
Cs-137	3.7E+06	Risk	3.7E+00				3.7E+00	PCI/G
Pu-238	1.2E+03	Risk	1.4E+01					PCI/G
Pu-239/240	6.4E+02	Risk	1.4E+01					PCI/G
Th-228	1.7E+02	Risk	3.9E-02				3.9E-02	PCI/G
Th-230	3.1E+02	Risk	1.9E+02					PCI/G
Total Radioactive Strontium	7.4E+05	Risk	8.9E+01					PCI/G
U-233	1.6E+03	Risk	1.7E+02					PCI/G
Soil								
Co-60	6.2E-01	Risk					2.5E-02	PCI/G
Cs-137	1.1E+03	Risk					1.1E-01	PCI/G
Ra-228	1.4E+00	Risk					7.5E-02	PCI/G
Th-228	1.5E+00	Risk					3.9E-02	PCI/G
Residential								
Groundwater								
1,2-Dichloroethane	3.0E-03	Risk	5.2E-04					MG/L
Carbon Tetrachloride	9.0E-03	Risk	3.5E-04	3.3E-04				MG/L
Chloroform	2.5E-02	Risk	5.1E-03		5.1E-03			MG/L
Trichloroethene	7.0E-03	Risk	3.7E-03	8.8E-05				MG/L
C-14	1.2E+03	Risk	5.3E+01	3.8E+01				PCI/L
Cm-243/244	4.4E+00	Risk	3.0E-01					PCI/L
Co-60	8.9E+01	Risk	3.2E+00	3.0E+00				PCI/L
Cs-137	1.7E+03	Risk	1.7E+00	1.6E+00				PCI/L
Pu-238	5.4E-01	Risk	2.2E-01					PCI/L
Ra-226	4.9E-01	Risk	4.0E-01					PCI/L
Ra-228	2.5E+02	Risk	4.8E-01	4.5E-01				PCI/L
Tc-99	4.2E+01	Risk	3.7E+01					PCI/L
Th-234	1.7E+02	Risk	1.2E+01					PCI/L

Exhibit 17. (continued)

Analyte	Representative Concentration	RGO Basis	Exposure Pathway RGOs					Units
			Ingestion	Ingestion of Produce	Inhalation	Dermal Contact	External	
Total Radioactive Strontium	2.7E+04	Risk	1.3E+00	1.2E+00				PCI/L
Tritium	2.0E+06	Risk	7.6E+02	5.7E+02	7.6E+02			PCI/L
U-233/234	9.0E+00	Risk	3.0E+00					PCI/L
Sediment								
Aroclor 1254	2.3E+00	Risk	6.6E-02					MG/KG
Aroclor 1260	6.3E-01	Risk	6.6E-02					MG/KG
Am-241	8.8E+02	Risk	2.4E+00				2.4E+00	PCI/G
Cm-243/244	2.4E+04	Risk	4.9E+00				4.9E+00	PCI/G
Co-60	6.3E+03	Risk	8.8E-03				8.8E-03	PCI/G
Cs-137	3.7E+06	Risk	3.7E+00				3.7E+00	PCI/G
Pu-238	1.2E+03	Risk	3.6E+00					PCI/G
Pu-239/240	6.4E+02	Risk	3.4E+00					PCI/G
Th-228	1.7E+02	Risk	7.8E-03				7.8E-03	PCI/G
Th-230	3.1E+02	Risk	5.3E+01					PCI/G
Total Radioactive Strontium	7.4E+05	Risk	2.2E+01					PCI/G
U-232	3.8E+01	Risk	2.0E+01					PCI/G
U-233	1.6E+03	Risk	4.5E+01				4.5E+01	PCI/G
Soil								
Cadmium	1.5E+00	HQ		9.5E-02				MG/KG
Heptachlor Epoxide	5.4E-04	Risk		5.1E-04				MG/KG
Co-60	6.2E-01	Risk					5.1E-03	PCI/G
Cs-137	1.1E+03	Risk		2.2E-02			2.2E-02	PCI/G
Ra-228	1.4E+00	Risk					1.5E-02	PCI/G
Th-228	1.5E+00	Risk					7.8E-03	PCI/G
Total Radioactive Strontium	6.5E+02	Risk		1.6E-01				PCI/G

**Exhibit 18. Old Hydrofracture Tank RGOs for soil of WAG 5
(Industrial and residential scenarios)**

Analyte	Representative Concentration	RGO Basis	Exposure Pathway RGOs					Units
			Ingestion	Ingestion of Produce	Inhalation	Dermal Contact	External	
			Industrial					
Soll								
Cs-137	5.8E+00	Risk					1.1E-01	PCI/G
Ra-226	1.3E+00	Risk			6.8E-03		6.8E-03	PCI/G
Ra-228	1.9E+00	Risk					7.5E-02	PCI/G
Th-228	1.5E+00	Risk					3.9E-02	PCI/G
Residential								
Soll								
Silver	4.3E+00	HQ		1.7E+00				MG/KG
Cyanide	6.7E-01	HQ		7.8E-02				MG/KG
Cs-137	5.8E+00	Risk					2.2E-02	PCI/G
Ra-226	1.3E+00	Risk			2.9E-03		2.9E-03	PCI/G
Ra-228	1.9E+00	Risk					1.5E-02	PCI/G
Th-228	1.5E+00	Risk					7.8E-03	PCI/G

**Exhibit 19. Process Waste Sludge Basin RGOs for soil and sediment of WAG 5
(Industrial and residential scenarios)**

Exposure Pathway RGOs								
Analyte	Representative Concentration	RGO Basis						Units
			Ingestion	Ingestion of Produce	Inhalation	Dermal Contact	External	
Industrial								
Sediment								
Aroclor 1248	1.2E+00	Risk	4.4E-01					MG/KG
Aroclor 1254	1.3E+00	Risk	4.4E-01					MG/KG
Am-241	1.2E+03	Risk	1.0E+01				1.0E+01	PCI/G
Cm-243/244	1.1E+03	Risk	2.0E+01					PCI/G
Co-60	5.9E+03	Risk	2.9E-02				2.9E-02	PCI/G
Cs-137	1.8E+04	Risk	1.2E-01				1.2E-01	PCI/G
Eu-152	9.6E+02	Risk					6.1E-02	PCI/G
Eu-154	5.8E+02	Risk					5.4E-02	PCI/G
Pu-238	1.2E+02	Risk	1.4E+01					PCI/G
Pu-239/240	1.4E+02	Risk	1.4E+01					PCI/G
Th-228	3.8E+02	Risk	3.9E-02				3.9E-02	PCI/G
Total Radioactive Strontium	1.2E+05	Risk	8.9E+01					PCI/G
U-232	3.2E+02	Risk	7.4E+01					PCI/G
U-233	3.7E+03	Risk	1.7E+02					PCI/G
U-238	1.1E+02	Risk					5.7E+00	PCI/G
Soil								
Cs-137	2.0E+00	Risk					1.1E-01	PCI/G
K-40	3.5E+01	Risk					4.0E-01	PCI/G
Ra-226	1.7E+00	Risk			6.8E-03		6.8E-03	PCI/G
Ra-228	1.6E+00	Risk					7.5E-02	PCI/G
Th-228	1.9E+00	Risk					3.9E-02	PCI/G
Residential								
Sediment								
Aroclor 1248	1.2E+00	Risk	6.6E-02					MG/KG
Aroclor 1254	1.3E+00	Risk	6.6E-02					MG/KG
Am-241	1.2E+03	Risk	2.4E+00				2.4E+00	PCI/G
Cm-243/244	1.1E+03	Risk	4.9E+00					PCI/G
Co-60	5.9E+03	Risk	8.6E-03				8.6E-03	PCI/G
Cs-137	1.8E+04	Risk	3.2E-02				3.2E-02	PCI/G
Eu-152	9.6E+02	Risk	1.3E-02				1.3E-02	PCI/G
Eu-154	5.8E+02	Risk	1.1E-02				1.1E-02	PCI/G
Pu-238	1.2E+02	Risk	3.6E+00					PCI/G
Pu-239/240	1.4E+02	Risk	3.4E+00					PCI/G
Th-228	3.8E+02	Risk	7.9E-03				7.9E-03	PCI/G

Exhibit 19. (continued)

Analyte	Representative Concentration	RGO Basis	Exposure Pathway RGOs				Units
			Ingestion	Ingestion of Produce	Inhalation	Dermal Contact	External
Total Radioactive Strontium	1.2E+05	Risk	2.2E+01				PCI/G
U-232	3.2E+02	Risk	2.0E+01				PCI/G
U-233	3.7E+03	Risk	4.5E+01				4.5E+01 PCI/G
U-238	1.1E+02	Risk	1.2E+00				1.2E+00 PCI/G
Soil							
Cs-137	2.0E+00	Risk					2.2E-02 PCI/G
K-40	3.5E+01	Risk		6.3E-02			8.0E-02 PCI/G
Ra-226	1.7E+00	Risk			2.9E-03		2.9E-03 PCI/G
Ra-228	1.6E+00	Risk					1.5E-02 PCI/G
Th-228	1.9E+00	Risk					7.8E-03 PCI/G
Total Radioactive Strontium	3.2E+00	Risk		1.6E-01			PCI/G

**Exhibit 20. Surface Water Area 3 RGOs for soil of WAG 5
(Industrial and residential scenarios)**

Exposure Pathway RGOs								
Analyte	Representative Concentration	RGO Basis	Ingestion	Ingestion of Produce	Inhalation	Dermal Contact	External	Units
Industrial								
Soil								
Cs-137	6.9E+00	Risk					1.1E-01	PCI/G
Ra-228	1.2E+00	Risk					7.5E-02	PCI/G
Th-228	1.6E+00	Risk					3.9E-02	PCI/G
Residential								
Soil								
Cs-137	6.9E+00	Risk					2.2E-02	PCI/G
Ra-228	1.2E+00	Risk					1.5E-02	PCI/G
Th-228	1.6E+00	Risk					7.8E-03	PCI/G

**Exhibit 21. Solid Waste Storage Area 5 North RGOs for soil and groundwater of WAG 5
(Industrial and residential scenarios)**

Exposure Pathway RGOs								
Analyte	Representative Concentration	RGO Basis	Ingestion	Ingestion of Produce	Inhalation	Dermal Contact	External	Units
Industrial								
Soil								
Ac-228	2.1E+00	Risk					7.6E-02	PCI/G
Bi-212	2.6E+00	Risk					3.7E-01	PCI/G
Bi-214	9.4E-01	Risk					4.1E-02	PCI/G
Pb-212	1.5E+00	Risk					7.8E-01	PCI/G
Pb-214	1.0E+00	Risk					3.4E-01	PCI/G
Ra-228	2.2E+00	Risk					7.5E-02	PCI/G
Th-228	1.8E+00	Risk					3.9E-02	PCI/G
Tl-208	1.6E+00	Risk					1.7E-02	PCI/G
Residential								
Groundwater								
Barium	9.2E-01	HQ	1.4E-01					MG/L
Beryllium	2.3E-03	Risk	9.8E-06					MG/L
Chromium VI	1.1E-01	HQ	9.7E-03					MG/L
Manganese	2.3E+00	HQ	1.0E-02	9.5E-03		1.0E-02		MG/L
Nickel	1.5E-01	HQ	4.2E-02					MG/L
Vanadium	5.3E-02	HQ	1.3E-02					MG/L
Bis(2-Ethylhexyl) Phthalate	1.3E-02	Risk	2.9E-03					MG/L
Methylene Chloride	1.6E-02	Risk	6.5E-03					MG/L
Am-241	3.2E+00	Risk	2.0E-01					PCI/L
C-14	1.2E+02	Risk	5.3E+01					PCI/L
Cm-243/244	3.9E+01	Risk	3.0E-01					PCI/L
K-40	6.2E+02	Risk	4.3E+00					PCI/L
Pb-212	3.4E+01	Risk	8.7E+00					PCI/L
Pu-238	5.5E-01	Risk	2.2E-01					PCI/L
Ra-226	3.1E+00	Risk	4.0E-01					PCI/L
Ra-228	1.7E+01	Risk	4.8E-01					PCI/L
Th-228	2.8E+00	Risk	8.7E-01					PCI/L
Th-234	4.9E+02	Risk	1.2E+01					PCI/L
Tritium	2.2E+03	Risk	7.6E+02					PCI/L
U-238	2.3E+00	Risk	1.7E+00					PCI/L
Soil								
Ac-228	2.1E+00	Risk					1.5E-02	PCI/G
Bi-212	2.6E+00	Risk					7.4E-02	PCI/G
Bi-214	9.4E-01	Risk					8.2E-03	PCI/G

Exhibit 21. (continued)

Analyte	Representative Concentration	RGO Basis	Exposure Pathway RGOs				External	Units
			Ingestion	Ingestion of Produce	Inhalation	Dermal Contact		
Pb-212	1.5E+00	Risk					1.6E-01	PCI/G
Pb-214	1.0E+00	Risk					6.8E-02	PCI/G
Ra-223	5.6E-01	Risk					1.9E-01	PCI/G
Ra-228	2.2E+00	Risk					1.5E-02	PCI/G
Th-228	1.8E+00	Risk					7.8E-03	PCI/G
Tl-208	1.6E+00	Risk					3.3E-03	PCI/G

**Exhibit 22. Solid Waste Storage Area 5 South East RGOs for soil and groundwater of WAG 5
(Industrial and residential scenarios)**

Analyte	Representative Concentration	RGO Basis	Exposure Pathway RGOs					Units
			Ingestion	Ingestion of Produce	Inhalation	Dermal Contact	External	
Industrial								
Soil								
Ac-228	1.0E+00	Risk					7.6E-02	PCI/G
Cm-243/244	3.6E+01	Risk	2.0E+01					PCI/G
Cs-137	6.7E+03	Risk	1.1E-01				1.1E-01	PCI/G
Pb-212	1.9E+00	Risk					7.8E-01	PCI/G
Pb-214	6.0E-01	Risk					3.4E-01	PCI/G
Ra-228	1.3E+00	Risk					7.5E-02	PCI/G
Th-228	1.6E+00	Risk					3.9E-02	PCI/G
Tl-208	1.0E+00	Risk					1.7E-02	PCI/G
Total Radioactive Strontium	1.0E+04	Risk	8.9E+01					PCI/G
Residential								
Groundwater								
Chromium VI	1.0E-01	HQ	9.7E-03					MG/L
Manganese	2.3E+01	HQ	1.0E-02	9.5E-03		1.0E-02		MG/L
1,1-Dichloroethene	5.5E-03	Risk	7.5E-05	6.8E-05	7.5E-05			MG/L
1,2-Dichloroethane	4.0E-03	Risk	5.2E-04	4.5E-04				MG/L
Benzene	2.0E-03	Risk	1.6E-03					MG/L
Bis(2-Ethylhexyl) Phthalate	5.0E-03	Risk	2.9E-03					MG/L
Trichloroethene	3.0E-02	Risk	3.7E-03	3.3E-03				MG/L
Vinyl Chloride	1.4E-02	Risk	2.5E-05	2.2E-05	2.5E-05			MG/L
Am-241	1.5E+05	Risk	2.8E-01	2.7E-01				PCI/L
Bi-212	5.3E+02	Risk	1.5E+02					PCI/L
C-14	4.3E+02	Risk	5.3E+01	3.7E+01				PCI/L
Cd-109	3.7E+02	Risk	6.0E+00	5.6E+00				PCI/L
Cm-243/244	1.0E+01	Risk	3.0E-01	2.8E-01				PCI/L
Pu-238	9.3E+04	Risk	2.7E-01	2.5E-01				PCI/L
Pu-239/240	1.6E+03	Risk	2.1E-01	1.9E-01				PCI/L
Ra-226	1.3E+03	Risk	4.0E-01	3.7E-01				PCI/L
Ra-228	2.1E+01	Risk	4.8E-01	4.5E-01				PCI/L
Tc-99	1.6E+02	Risk	3.7E+01	2.6E+01				PCI/L
Th-228	4.5E+01	Risk	8.7E-01	8.2E-01				PCI/L
Th-231	3.5E+02	Risk	1.2E+02					PCI/L
Total Radioactive Strontium	2.8E+03	Risk	1.3E+00	1.2E+00				PCI/L
Tritium	6.5E+07	Risk	7.9E+02	6.0E+02	7.9E+02			PCI/L
U-233/234	1.3E+03	Risk	3.0E+00	2.8E+00				PCI/L

Exhibit 22. (continued)

Analyte	Representative Concentration	RGO Basis	Exposure Pathway RGOs					Units
			Ingestion	Ingestion of Produce	Inhalation	Dermal Contact	External	
U-238	1.8E+00	Risk	1.7E+00					PCI/L
Soil								
Antimony	6.2E+00	HQ		1.4E+00				MG/KG
Manganese	3.3E+03	HQ		2.2E+02				MG/KG
Ac-228	1.0E+00	Risk					1.5E-02	PCI/G
Am-241	6.8E+00	Risk	2.4E+00					PCI/G
Cm-243/244	3.6E+01	Risk	4.9E+00	1.9E+00				PCI/G
Cs-137	6.7E+03	Risk	2.5E-02	2.5E-02			2.5E-02	PCI/G
Pb-212	1.9E+00	Risk					1.6E-01	PCI/G
Pb-214	6.0E-01	Risk					6.8E-02	PCI/G
Ra-228	1.3E+00	Risk					1.5E-02	PCI/G
Th-228	1.6E+00	Risk					7.8E-03	PCI/G
Tl-208	1.0E+00	Risk					3.3E-03	PCI/G
Total Radioactive Strontium	1.0E+04	Risk	2.2E+01	1.7E-01				PCI/G

**Exhibit 23. Solid Waste Storage Area 5 South West RGOs for soil and groundwater of WAG 5
(Industrial and residential scenarios)**

			Exposure Pathway RGOs					
Analyte	Representative Concentration	RGO Basis						Units
			Ingestion	Ingestion of Produce	Inhalation	Dermal Contact	External	
Industrial								
Soil								
Ac-228	2.3E+00	Risk					7.6E-02	PCI/G
Bi-214	8.2E-01	Risk					4.1E-02	PCI/G
Cs-137	8.4E+01	Risk					1.1E-01	PCI/G
K-40	3.2E+01	Risk					4.0E-01	PCI/G
Pb-212	1.7E+00	Risk					7.8E-01	PCI/G
Pb-214	1.4E+00	Risk					3.4E-01	PCI/G
Ra-226	1.5E+00	Risk			6.8E-03		6.8E-03	PCI/G
Ra-228	2.0E+00	Risk					7.5E-02	PCI/G
Th-228	1.5E+00	Risk					3.9E-02	PCI/G
Tl-208	1.4E+00	Risk					1.7E-02	PCI/G
Residential								
Groundwater								
Barium	4.6E-01	HQ	1.4E-01					MG/L
Chromium VI	7.4E-02	HQ	9.7E-03					MG/L
Manganese	5.1E+00	HQ	1.0E-02	9.5E-03		1.0E-02		MG/L
Bis(2-Ethylhexyl) Phthalate	2.2E-01	HQ	2.9E-03	2.8E-03		3.5E-02		MG/L
Carbon Tetrachloride	6.0E-03	HQ	3.5E-04	3.3E-04				MG/L
Tetrachloroethene	1.1E-01	HQ	1.3E-02			1.3E-02		MG/L
Trichloroethene	1.6E-02	Risk	3.7E-03					MG/L
Vinyl Chloride	2.3E-02	Risk	2.5E-05	2.2E-05	2.5E-05			MG/L
Am-241	2.1E+00	Risk	2.0E-01					PCI/L
C-14	4.7E+02	Risk	5.3E+01	3.7E+01				PCI/L
Ca-45	2.8E+02	Risk	4.8E+01					PCI/L
Cm-243/244	1.5E+00	Risk	3.0E-01					PCI/L
Co-60	4.1E+01	Risk	3.2E+00					PCI/L
K-40	1.0E+03	Risk	4.3E+00	4.0E+00				PCI/L
Pb-212	5.3E+01	Risk	8.7E+00					PCI/L
Pu-238	1.5E+00	Risk	2.2E-01					PCI/L
Ra-226	2.4E+00	Risk	4.0E-01					PCI/L
Ra-228	5.4E+01	Risk	4.8E-01	4.5E-01				PCI/L
Th-228	1.3E+01	Risk	8.7E-01					PCI/L
Th-230	6.5E+00	Risk	3.7E+00					PCI/L
Th-232	9.0E+00	Risk	4.0E+00					PCI/L
Th-234	1.7E+02	Risk	1.2E+01					PCI/L

Exhibit 23. (continued)

Analyte	Representative Concentration	RGO Basis	Exposure Pathway RGOs					Units
			Ingestion	Ingestion of Produce	Inhalation	Dermal Contact	External	
Total Radioactive Strontium	3.4E+02	Risk	1.3E+00	1.2E+00				PCI/L
Tritium	8.1E+06	Risk	7.6E+02	5.7E+02	7.6E+02			PCI/L
U-233/234	6.2E+00	Risk	3.0E+00					PCI/L
U-238	4.3E+00	Risk	1.7E+00					PCI/L
Soil								
Barium	3.6E+02	HQ		2.4E+01				MG/KG
Manganese	2.7E+03	HQ		2.2E+02				MG/KG
Aroclor 1260	1.2E+00	Risk	6.6E-02	5.1E-02				MG/KG
Ac-228	2.3E+00	Risk					1.5E-02	PCI/G
Bi-214	8.2E-01	Risk					8.2E-03	PCI/G
Cs-137	8.4E+01	Risk	2.2E-02	2.2E-02			2.2E-02	PCI/G
K-40	3.2E+01	Risk		6.3E-02			8.0E-02	PCI/G
Pb-212	1.7E+00	Risk					1.6E-01	PCI/G
Pb-214	1.4E+00	Risk					6.8E-02	PCI/G
Ra-226	1.5E+00	Risk			2.9E-03		2.9E-03	PCI/G
Ra-228	2.0E+00	Risk					1.5E-02	PCI/G
Th-228	1.5E+00	Risk					7.8E-03	PCI/G
Tl-208	1.4E+00	Risk					3.3E-03	PCI/G
Total Radioactive Strontium	5.2E+03	Risk	2.2E+01	1.7E-01				PCI/G
U-238	5.0E+00	Risk					1.2E+00	PCI/G

**Exhibit 24. White Oak Creek RGOs for soil and groundwater of WAG 5
(Excavation, industrial, and residential scenarios)**

(Excavation, Industrial, and Residential scenarios)								
Exposure Pathway RGOs								
Analyte	Representative Concentration	RGO Basis						Units
			Ingestion	Ingestion of Produce	Inhalation	Dermal Contact	External	
Excavation								
Soil								
Co-60	3.6E+01	Risk					1.9E+00	PCI/G
Cs-137	5.5E+03	Risk					8.2E+00	PCI/G
Tl-208	2.0E+00	Risk					1.3E+00	PCI/G
Industrial								
Soil								
Ac-228	1.8E+00	Risk					7.6E-02	PCI/G
Co-57	2.3E+00	Risk					1.2E+00	PCI/G
Co-60	3.6E+01	Risk					2.5E-02	PCI/G
Cs-137	5.5E+03	Risk					1.1E-01	PCI/G
Na-22	1.5E+00	Risk					3.0E-02	PCI/G
Pb-212	1.4E+00	Risk					7.8E-01	PCI/G
Pb-214	1.4E+00	Risk					3.4E-01	PCI/G
Ra-228	1.8E+00	Risk					7.5E-02	PCI/G
Th-228	2.2E+00	Risk					3.9E-02	PCI/G
Tl-208	2.0E+00	Risk					1.7E-02	PCI/G
Residential								
Groundwater								
Barium	8.7E-01	HQ	1.4E-01					MG/L
Manganese	8.0E-01	HQ	1.0E-02	9.5E-03				MG/L
1,1-Dichloroethene	5.0E-03	Risk	7.5E-05	6.8E-05	7.5E-05			MG/L
1,2-Dichloroethene (Total)	1.9E+00	HQ	1.9E-02	1.7E-02				MG/L
Benzene	1.9E-02	Risk	1.6E-03	1.4E-03				MG/L
Trichloroethene	1.8E-02	Risk	3.7E-03					MG/L
Vinyl Chloride	2.6E+00	Risk	2.7E-05	2.3E-05	2.7E-05	2.7E-05		MG/L
C-14	1.1E+03	Risk	5.3E+01	3.8E+01				PCI/L
Th-228	1.7E+00	Risk	8.7E-01					PCI/L
Th-234	1.0E+03	Risk	1.2E+01	1.1E+01				PCI/L
Tritium	4.4E+04	Risk	7.6E+02	5.7E+02	7.6E+02			PCI/L
Soil								
Mercury	8.1E-01	HQ		4.1E-02				MG/KG
Ac-228	1.8E+00	Risk					1.5E-02	PCI/G
Co-57	2.3E+00	Risk					2.3E-01	PCI/G
Co-60	3.6E+01	Risk		5.0E-03			5.1E-03	PCI/G
Cs-134	4.0E-02	Risk					8.4E-03	PCI/G

Exhibit 24. (continued)

Analyte	Representative Concentration	RGO Basis	Exposure Pathway RGOs					Units
			Ingestion	Ingestion of Produce	Inhalation	Dermal Contact	External	
Cs-137	5.5E+03	Risk	2.5E-02	2.5E-02			2.5E-02	PCI/G
Na-22	1.5E+00	Risk					6.0E-03	PCI/G
Pb-212	1.4E+00	Risk					1.6E-01	PCI/G
Pb-214	1.4E+00	Risk					6.8E-02	PCI/G
Ra-228	1.8E+00	Risk					1.5E-02	PCI/G
Th-228	2.2E+00	Risk					7.8E-03	PCI/G
Tl-208	2.0E+00	Risk					3.3E-03	PCI/G
Total Radioactive Strontium	3.8E+02	Risk	2.2E+01	1.6E-01				PCI/G

**Exhibit 25. Drainage D1 RGOs for sediment of WAG 5
(Residential scenario)**

(Residential scenario)								
Exposure Pathway RGOs								
Analyte	Representative Concentration	RGO Basis	Ingestion	Ingestion of Produce	Inhalation	Dermal Contact	External	Units
Sediment								
Ac-228	1.4E+00	Risk					1.5E-02	PCI/G
Bi-212	1.5E+00	Risk					7.4E-02	PCI/G
Bi-214	8.6E-01	Risk					8.2E-03	PCI/G
Co-60	3.1E-01	Risk					5.1E-03	PCI/G
Pb-212	1.3E+00	Risk					1.6E-01	PCI/G
Pb-214	9.3E-01	Risk					1.6E-01	PCI/G
Ra-223	3.7E-01	Risk					1.9E-01	PCI/G
Radon 219	4.7E-01	Risk					2.7E-01	PCI/G
U-235	3.6E-01	Risk					1.8E-01	PCI/G
U-238	1.3E+01	Risk					1.2E+00	PCI/G

**Exhibit 26. Drainage D2 RGOs for sediment of WAG 5
(Industrial and residential scenarios)**

Analyte	Representative Concentration	RGO Basis	Exposure Pathway RGOs					Units
			Ingestion	Ingestion of Produce	Inhalation	Dermal Contact	External	
Industrial								
Sediment								
Vinyl Chloride	1.0E+00	Risk			4.1E-04			MG/KG
Ac-228	2.3E+00	Risk					7.6E-02	PCI/G
Bi-212	1.7E+00	Risk					3.7E-01	PCI/G
Bi-214	1.2E+00	Risk					4.1E-02	PCI/G
Co-60	6.3E-01	Risk					2.5E-02	PCI/G
Pb-212	1.7E+00	Risk					7.8E-01	PCI/G
Pb-214	1.2E+00	Risk					7.8E-01	PCI/G
Ra-226	2.9E+00	Risk			6.8E-03		6.8E-03	PCI/G
Tl-208	1.4E+00	Risk					1.7E-02	PCI/G
Residential								
Sediment								
Arsenic	1.4E+01	HQ	7.8E+00					MG/KG
Manganese	4.3E+04	HQ	2.1E+03					MG/KG
Vinyl Chloride	1.0E+00	Risk			1.4E-04			MG/KG
Ac-228	2.3E+00	Risk					1.5E-02	PCI/G
Bi-212	1.7E+00	Risk					7.4E-02	PCI/G
Bi-214	1.2E+00	Risk					8.2E-03	PCI/G
Co-60	6.3E-01	Risk					5.1E-03	PCI/G
I-129	1.4E+01	Risk					3.0E+00	PCI/G
Pb-212	1.7E+00	Risk					1.6E-01	PCI/G
Pb-214	1.2E+00	Risk					1.6E-01	PCI/G
Ra-223	9.1E-01	Risk					1.9E-01	PCI/G
Ra-224	4.9E+00	Risk					1.7E+00	PCI/G
Ra-226	2.9E+00	Risk			2.9E-03		2.9E-03	PCI/G
Radon 219	1.2E+00	Risk					2.7E-01	PCI/G
Tl-208	1.4E+00	Risk					3.3E-03	PCI/G
U-235	4.1E-01	Risk					1.8E-01	PCI/G
U-238	2.4E+00	Risk					1.2E+00	PCI/G

**Exhibit 27. Drainage D3 RGOs for sediment of WAG 5
(Industrial and residential scenarios)**

(Industrial and Residential scenarios)								
Exposure Pathway RGOs								
Analyte	Representative Concentration	RGO Basis						Units
			Ingestion	Ingestion of Produce	Inhalation	Dermal Contact	External	
Industrial								
Sediment								
Ac-228	1.5E+00	Risk					7.6E-02	PCI/G
Bi-214	9.1E-01	Risk					4.1E-02	PCI/G
Pb-212	1.4E+00	Risk					7.8E-01	PCI/G
Pb-214	1.0E+00	Risk					7.8E-01	PCI/G
Tl-208	1.1E+00	Risk					1.7E-02	PCI/G
Residential								
Sediment								
Ac-228	1.5E+00	Risk					1.5E-02	PCI/G
Bi-214	9.1E-01	Risk					8.2E-03	PCI/G
Pb-212	1.4E+00	Risk					1.6E-01	PCI/G
Pb-214	1.0E+00	Risk					1.6E-01	PCI/G
Tl-208	1.1E+00	Risk					3.3E-03	PCI/G

Exhibit 28. Estimated future carcinogenic risk from exposure to radioactive COCs in soils of the different areas of WAG 5 as a function of time using RESRAD 5.19 - Residential scenario

Contaminants	External risk	Inhalation risk	Ingestion of produce risk	Ingestion risk	total risk
FS					
T = 0 years					
Co-60	2.79E-02	5.21E-07	9.49E-05	2.66E-06	2.80E-02
Cs-137	1.30E-03	1.32E-08	1.77E-05	9.93E-07	1.31E-03
Pb-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Ra-226	3.89E-04	2.08E-07	7.60E-06	4.26E-07	3.97E-04
Sr-90	0.00E+00	1.44E-07	5.70E-04	4.26E-06	5.74E-04
Th-230	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
U-234	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
U-238	4.54E-06	7.03E-06	2.18E-07	1.93E-07	1.20E-05
Total	2.96E-02	7.91E-06	6.90E-04	8.53E-06	3.03E-02
T = 1 year					
Co-60	2.44E-02	4.57E-07	8.32E-05	2.33E-06	2.45E-02
Cs-137	1.27E-03	1.29E-08	1.73E-05	9.71E-07	1.28E-03
Pb-210	3.17E-10	8.49E-09	3.23E-07	7.15E-08	4.04E-07
Ra-226	3.88E-04	2.08E-07	7.58E-06	4.25E-07	3.96E-04
Sr-90	0.00E+00	1.39E-07	5.53E-04	4.13E-06	5.57E-04
Th-230	8.65E-20	4.98E-17	5.28E-19	1.14E-18	5.15E-17
U-234	1.07E-14	9.90E-12	3.52E-13	3.11E-13	1.06E-11
U-238	4.52E-06	7.00E-06	2.17E-07	1.93E-07	1.19E-05
Total	2.61E-02	7.83E-06	6.62E-04	8.13E-06	2.68E-02
T = 3 years					
Co-60	1.88E-02	3.51E-07	6.40E-05	1.79E-06	1.88E-02
Cs-137	1.21E-03	1.23E-08	1.65E-05	9.27E-07	1.23E-03
Pb-210	9.17E-10	2.46E-08	9.29E-07	2.07E-07	1.16E-06
Ra-226	3.86E-04	2.07E-07	7.54E-06	4.22E-07	3.94E-04
Sr-90	0.00E+00	1.31E-07	5.21E-04	3.90E-06	5.25E-04
Th-230	7.75E-19	4.46E-16	4.69E-18	1.02E-17	4.62E-16
U-234	3.18E-14	2.95E-11	1.05E-12	9.28E-13	3.15E-11
U-238	4.49E-06	6.96E-06	2.15E-07	1.91E-07	1.19E-05
Total	2.04E-02	7.68E-06	6.10E-04	7.44E-06	2.10E-02

Exhibit 28. (continued)

Contaminants	External risk	Inhalation risk	Ingestion of produce risk	Ingestion risk	total risk
T = 10 years					
Co-60	7.47E-03	1.40E-07	2.54E-05	7.13E-07	7.49E-03
Cs-137	1.03E-03	1.05E-08	1.41E-05	7.88E-07	1.04E-03
Pb-210	2.71E-09	7.26E-08	2.74E-06	6.12E-07	3.42E-06
Ra-226	3.78E-04	2.03E-07	7.39E-06	4.14E-07	3.86E-04
Sr-90	0.00E+00	1.07E-07	4.24E-04	3.17E-06	4.27E-04
Th-230	8.47E-18	4.88E-15	5.12E-17	1.12E-16	5.05E-15
U-234	1.03E-13	9.61E-11	3.40E-12	3.02E-12	1.03E-10
U-238	4.39E-06	6.80E-06	2.11E-07	1.87E-07	1.16E-05
Total	8.88E-03	7.33E-06	4.74E-04	5.88E-06	9.37E-03
T = 30 years					
Co-60	5.37E-04	1.00E-08	1.83E-06	5.12E-08	5.38E-04
Cs-137	6.47E-04	6.59E-09	8.86E-06	4.96E-07	6.57E-04
Pb-210	5.87E-09	1.57E-07	5.93E-06	1.32E-06	7.41E-06
Ra-226	3.57E-04	1.92E-07	6.99E-06	3.91E-07	3.65E-04
Sr-90	0.00E+00	5.91E-08	2.35E-04	1.75E-06	2.36E-04
Th-230	7.30E-17	4.20E-14	4.40E-16	9.62E-16	4.35E-14
U-234	2.90E-13	2.70E-10	9.55E-12	8.48E-12	2.88E-10
U-238	4.11E-06	6.36E-06	1.97E-07	1.75E-07	1.08E-05
Total	1.55E-03	6.78E-06	2.58E-04	4.19E-06	1.81E-03
T = 100 years					
Co-60	5.33E-08	9.97E-13	1.82E-10	5.09E-12	5.35E-08
Cs-137	1.28E-04	1.31E-09	1.75E-06	9.82E-08	1.30E-04
Pb-210	7.72E-09	2.07E-07	7.80E-06	1.74E-06	9.76E-06
Ra-226	2.94E-04	1.57E-07	5.74E-06	3.22E-07	3.00E-04
Sr-90	0.00E+00	7.45E-09	2.96E-05	2.21E-07	2.98E-05
Th-230	6.96E-16	4.01E-13	4.20E-15	9.18E-15	4.15E-13
U-234	7.67E-13	7.13E-10	2.52E-11	2.24E-11	7.61E-10
U-238	3.26E-06	5.04E-06	1.56E-07	1.39E-07	8.59E-06
Total	4.25E-04	5.42E-06	4.50E-05	2.52E-06	4.78E-04
T = 300 years					
Co-60	1.95E-19	3.65E-24	6.65E-22	1.86E-23	1.96E-19
Cs-137	1.25E-06	1.28E-11	1.71E-08	9.60E-10	1.27E-06

Exhibit 28. (continued)

Contaminants	External risk	Inhalation risk	Ingestion of produce risk	Ingestion risk	total risk
Pb-210	4.64E-09	1.24E-07	4.68E-06	1.05E-06	5.86E-06
Ra-226	1.68E-04	8.98E-08	3.27E-06	1.83E-07	1.71E-04
Sr-90	0.00E+00	2.01E-11	7.96E-08	5.95E-10	8.03E-08
Th-230	4.13E-15	2.38E-12	2.49E-14	5.44E-14	2.46E-12
U-234	1.19E-12	1.10E-09	3.90E-11	3.46E-11	1.18E-09
U-238	1.68E-06	2.60E-06	8.04E-08	7.14E-08	4.42E-06
Total	1.70E-04	2.81E-06	8.13E-06	1.30E-06	1.83E-04
T = 1000 years					
Co-60	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Cs-137	1.16E-13	1.18E-18	1.58E-15	8.85E-17	1.17E-13
Pb-210	6.50E-10	1.74E-08	6.57E-07	1.47E-07	8.21E-07
Ra-226	2.35E-05	1.26E-08	4.59E-07	2.57E-08	2.40E-05
Sr-90	0.00E+00	2.04E-20	8.08E-17	6.04E-19	8.14E-17
Th-230	1.32E-14	7.59E-12	7.95E-14	1.74E-13	7.85E-12
U-234	3.86E-13	3.59E-10	1.27E-11	1.13E-11	3.83E-10
U-238	1.64E-07	2.54E-07	7.87E-09	6.99E-09	4.33E-07
Total	2.36E-05	2.85E-07	1.12E-06	1.80E-07	2.52E-05
NHFT					
T = 0 years					
Ra-228	4.13E-05	1.61E-08	2.03E-07	1.14E-08	4.15E-05
Th-228	8.47E-05	1.93E-06	3.01E-09	6.63E-09	8.66E-05
Total	1.26E-04	1.95E-06	2.06E-07	1.80E-08	1.28E-04
T = 1 year					
Ra-228	3.65E-05	1.42E-08	1.79E-07	1.00E-08	3.67E-05
Th-228	8.16E-05	1.86E-06	3.00E-09	6.40E-09	8.35E-05
Total	1.18E-04	1.88E-06	1.82E-07	1.64E-08	1.20E-04
T = 3 years					
Ra-228	2.86E-05	1.11E-08	1.40E-07	7.86E-09	2.87E-05
Th-228	7.13E-05	1.63E-06	2.61E-09	5.59E-09	7.29E-05
Total	9.98E-05	1.64E-06	1.43E-07	1.34E-08	1.02E-04
T = 10 years					
Ra-228	1.21E-05	4.71E-09	5.94E-08	3.33E-09	1.22E-05
Th-228	3.44E-05	7.84E-07	1.26E-09	2.69E-09	3.51E-05

Exhibit 28. (continued)

Contaminants	External risk	Inhalation risk	Ingestion of produce risk	Ingestion risk	total risk
Total	4.65E-05	7.88E-07	6.06E-08	6.02E-09	4.73E-05
T = 30 years					
Ra-228	1.04E-06	4.05E-10	5.10E-09	2.86E-10	1.04E-06
Th-228	3.03E-06	6.92E-08	1.11E-10	2.38E-10	3.10E-06
Total	4.07E-06	6.96E-08	5.21E-09	5.24E-10	4.15E-06
T = 100 years					
Ra-228	1.93E-10	7.53E-14	9.49E-13	5.32E-14	1.94E-10
Th-228	5.64E-10	1.29E-11	2.06E-14	4.42E-14	5.77E-10
Total	7.58E-10	1.30E-11	9.70E-13	9.74E-14	7.72E-10
T = 300 years					
Ra-228	4.24E-21	1.65E-24	2.08E-23	1.17E-24	4.27E-21
Th-228	1.24E-20	2.83E-22	4.52E-25	9.71E-25	1.27E-20
Total	1.66E-20	2.84E-22	2.13E-23	2.14E-24	1.69E-20
T = 1000 years					
Ra-228	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Th-228	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
OHFP					
T = 0 years					
Co-60	9.60E-05	1.72E-09	3.27E-07	9.17E-09	9.63E-05
Cs-137	3.96E-02	3.88E-07	5.42E-04	3.04E-05	4.02E-02
Ra-228	7.31E-05	1.79E-08	2.46E-06	1.38E-07	7.57E-05
Sr-90	0.00E+00	7.47E-07	3.09E-03	2.31E-05	3.11E-03
Th-228	1.51E-04	2.17E-06	3.71E-08	8.13E-08	1.53E-04
Total	3.99E-02	3.32E-06	3.63E-03	5.36E-05	4.36E-02
T = 1 year					
Co-60	8.41E-05	1.51E-09	2.87E-07	8.03E-09	8.44E-05
Cs-137	3.87E-02	3.79E-07	5.29E-04	2.97E-05	3.92E-02
Ra-228	6.46E-05	1.58E-08	2.18E-06	1.22E-07	6.70E-05
Sr-90	0.00E+00	7.26E-07	3.00E-03	2.24E-05	3.02E-03
Th-228	1.46E-04	2.09E-06	3.69E-08	7.82E-08	1.48E-04
Total	3.90E-02	3.21E-06	3.53E-03	5.23E-05	4.26E-02
T = 3 years					

Exhibit 28. (continued)

Contaminants	External risk	Inhalation risk	Ingestion of produce risk	Ingestion risk	total risk
Co-60	6.47E-05	1.16E-09	2.20E-07	6.17E-09	6.49E-05
Cs-137	3.69E-02	3.62E-07	5.05E-04	2.83E-05	3.75E-02
Ra-228	5.06E-05	1.24E-08	1.70E-06	9.55E-08	5.24E-05
Sr-90	0.00E+00	6.84E-07	2.82E-03	2.11E-05	2.84E-03
Th-228	1.27E-04	1.82E-06	3.20E-08	6.81E-08	1.29E-04
Total	3.72E-02	2.88E-06	3.33E-03	4.96E-05	4.06E-02
T = 10 years					
Co-60	2.57E-05	4.62E-10	8.76E-08	2.46E-09	2.58E-05
Cs-137	3.14E-02	3.08E-07	4.30E-04	2.41E-05	3.19E-02
Ra-228	2.14E-05	5.25E-09	7.22E-07	4.04E-08	2.22E-05
Sr-90	0.00E+00	5.56E-07	2.30E-03	1.72E-05	2.31E-03
Th-228	6.09E-05	8.74E-07	1.53E-08	3.27E-08	6.18E-05
Total	3.15E-02	1.74E-06	2.73E-03	4.13E-05	3.43E-02
T = 30 years					
Co-60	1.85E-06	3.32E-11	6.30E-09	1.77E-10	1.85E-06
Cs-137	1.98E-02	1.94E-07	2.71E-04	1.52E-05	2.01E-02
Ra-228	1.84E-06	4.51E-10	6.20E-08	3.48E-09	1.91E-06
Sr-90	0.00E+00	3.08E-07	1.27E-03	9.49E-06	1.28E-03
Th-228	5.37E-06	7.71E-08	1.35E-09	2.89E-09	5.46E-06
Total	1.98E-02	5.79E-07	1.54E-03	2.47E-05	2.14E-02
T = 100 years					
Co-60	1.84E-10	3.30E-15	6.26E-13	1.75E-14	1.84E-10
Cs-137	3.92E-03	3.83E-08	5.36E-05	3.00E-06	3.97E-03
Ra-228	3.42E-10	8.39E-14	1.15E-11	6.46E-13	3.55E-10
Sr-90	0.00E+00	3.88E-08	1.60E-04	1.20E-06	1.61E-04
Th-228	1.00E-09	1.43E-11	2.52E-13	5.38E-13	1.01E-09
Total	3.92E-03	7.71E-08	2.14E-04	4.20E-06	4.13E-03
T = 300 years					
Co-60	6.72E-22	1.21E-26	2.29E-24	6.42E-26	6.74E-22
Cs-137	3.83E-05	3.74E-10	5.23E-07	2.93E-08	3.88E-05
Ra-228	7.51E-21	1.84E-24	2.53E-22	1.42E-23	7.78E-21
Sr-90	0.00E+00	1.05E-10	4.31E-07	3.22E-09	4.35E-07
Th-228	2.19E-20	3.15E-22	5.52E-24	1.18E-23	2.23E-20

Exhibit 28. (continued)

Contaminants	External risk	Inhalation risk	Ingestion of produce risk	Ingestion risk	total risk
Total	3.83E-05	4.79E-10	9.55E-07	3.25E-08	3.92E-05
T = 1000 years					
Co-60	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Cs-137	3.53E-12	3.45E-17	4.83E-14	2.70E-15	3.58E-12
Ra-228	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Sr-90	0.00E+00	1.06E-19	4.38E-16	3.27E-18	4.41E-16
Th-228	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total	3.53E-12	3.46E-17	4.87E-14	2.71E-15	3.58E-12
OHFT					
T = 0 years					
Cs-137	2.09E-04	2.01E-09	2.86E-06	1.60E-07	2.12E-04
Pb-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Ra-226	1.40E-04	7.12E-08	2.74E-06	1.54E-07	1.43E-04
Ra-228	9.92E-05	2.40E-08	3.34E-06	1.87E-07	1.03E-04
Th-228	1.51E-04	2.14E-06	3.71E-08	8.13E-08	1.53E-04
Total	6.00E-04	2.23E-06	8.98E-06	5.82E-07	6.11E-04
T = 1 year					
Cs-137	2.04E-04	1.97E-09	2.79E-06	1.56E-07	2.07E-04
Pb-210	1.14E-10	2.90E-09	1.17E-07	2.58E-08	1.46E-07
Ra-226	1.40E-04	7.10E-08	2.74E-06	1.53E-07	1.43E-04
Ra-228	8.77E-05	2.12E-08	2.96E-06	1.66E-07	9.09E-05
Th-228	1.60E-04	2.26E-06	4.08E-08	8.59E-08	1.62E-04
Total	5.92E-04	2.36E-06	8.64E-06	5.87E-07	6.03E-04
T = 3 years					
Cs-137	1.95E-04	1.88E-09	2.67E-06	1.49E-07	1.98E-04
Pb-210	3.31E-10	8.40E-09	3.36E-07	7.48E-08	4.19E-07
Ra-226	1.39E-04	7.06E-08	2.72E-06	1.52E-07	1.42E-04
Ra-228	6.86E-05	1.66E-08	2.31E-06	1.30E-07	7.11E-05
Th-228	1.54E-04	2.17E-06	3.90E-08	8.27E-08	1.56E-04
Total	5.56E-04	2.27E-06	8.07E-06	5.89E-07	5.67E-04
T = 10 years					
Cs-137	1.66E-04	1.60E-09	2.27E-06	1.27E-07	1.68E-04
Pb-210	9.78E-10	2.48E-08	9.88E-07	2.21E-07	1.23E-06

Exhibit 28. (continued)

Contaminants	External risk	Inhalation risk	Ingestion of produce risk	Ingestion risk	total risk
Ra-226	1.37E-04	6.93E-08	2.67E-06	1.50E-07	1.39E-04
Ra-228	2.91E-05	7.02E-09	9.79E-07	5.49E-08	3.01E-05
Th-228	8.12E-05	1.15E-06	2.05E-08	4.37E-08	8.24E-05
Total	4.13E-04	1.25E-06	6.92E-06	5.96E-07	4.21E-04
T = 30 years					
Cs-137	1.04E-04	1.01E-09	1.43E-06	7.99E-08	1.06E-04
Pb-210	2.12E-09	5.37E-08	2.14E-06	4.78E-07	2.67E-06
Ra-226	1.29E-04	6.55E-08	2.52E-06	1.41E-07	1.32E-04
Ra-228	2.50E-06	6.03E-10	8.42E-08	4.72E-09	2.59E-06
Th-228	7.29E-06	1.03E-07	1.84E-09	3.92E-09	7.40E-06
Total	2.43E-04	2.24E-07	6.17E-06	7.08E-07	2.50E-04
T = 100 years					
Cs-137	2.06E-05	1.99E-10	2.82E-07	1.58E-08	2.09E-05
Pb-210	2.79E-09	7.08E-08	2.82E-06	6.30E-07	3.52E-06
Ra-226	1.06E-04	5.38E-08	2.07E-06	1.16E-07	1.08E-04
Ra-228	4.65E-10	1.12E-13	1.57E-11	8.77E-13	4.81E-10
Th-228	1.36E-09	1.92E-11	3.41E-13	7.30E-13	1.38E-09
Total	1.27E-04	1.25E-07	5.17E-06	7.62E-07	1.33E-04
T = 300 years					
Cs-137	2.02E-07	1.94E-12	2.76E-09	1.55E-10	2.05E-07
Pb-210	1.67E-09	4.25E-08	1.69E-06	3.78E-07	2.11E-06
Ra-226	6.05E-05	3.07E-08	1.18E-06	6.62E-08	6.18E-05
Ra-228	1.02E-20	2.46E-24	3.44E-22	1.93E-23	1.06E-20
Th-228	2.98E-20	4.21E-22	7.49E-24	1.60E-23	3.02E-20
Total	6.07E-05	7.32E-08	2.88E-06	4.45E-07	6.41E-05
T = 1000 years					
Cs-137	1.86E-14	1.79E-19	2.55E-16	1.43E-17	1.89E-14
Pb-210	2.35E-10	5.96E-09	2.37E-07	5.30E-08	2.96E-07
Ra-226	8.48E-06	4.30E-09	1.66E-07	9.28E-09	8.66E-06
Ra-228	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Th-228	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total	8.48E-06	1.03E-08	4.03E-07	6.23E-08	8.95E-06

PWSB

Exhibit 28. (continued)

Contaminants	External risk	inhalation risk	Ingestion of produce risk	Ingestion risk	total risk
T = 0 years					
K-40	3.40E-04	5.10E-09	5.08E-05	3.79E-07	3.91E-04
Pb-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Ra-226	1.84E-04	9.78E-08	3.59E-06	2.01E-07	1.87E-04
Ra-228	8.35E-05	2.12E-08	2.81E-06	1.58E-07	8.65E-05
Th-228	1.92E-04	2.84E-06	4.71E-08	1.03E-07	1.94E-04
Total	7.99E-04	2.96E-06	5.72E-05	8.41E-07	8.60E-04
T = 1 year					
K-40	3.30E-04	4.95E-09	4.93E-05	3.69E-07	3.80E-04
Pb-210	1.50E-10	3.98E-09	1.53E-07	3.38E-08	1.90E-07
Ra-226	1.83E-04	9.75E-08	3.58E-06	2.01E-07	1.87E-04
Ra-228	7.39E-05	1.87E-08	2.49E-06	1.40E-07	7.65E-05
Th-228	1.79E-04	2.66E-06	4.54E-08	9.64E-08	1.82E-04
Total	7.67E-04	2.78E-06	5.56E-05	8.39E-07	8.26E-04
T = 3 years					
K-40	3.12E-04	4.67E-09	4.65E-05	3.48E-07	3.59E-04
Pb-210	4.33E-10	1.15E-08	4.39E-07	9.78E-08	5.49E-07
Ra-226	1.82E-04	9.69E-08	3.56E-06	1.99E-07	1.86E-04
Ra-228	5.78E-05	1.46E-08	1.95E-06	1.09E-07	5.99E-05
Th-228	1.51E-04	2.24E-06	3.82E-08	8.13E-08	1.53E-04
Total	7.03E-04	2.37E-06	5.25E-05	8.35E-07	7.58E-04
T = 10 years					
K-40	2.54E-04	3.81E-09	3.79E-05	2.83E-07	2.92E-04
Pb-210	1.28E-09	3.40E-08	1.29E-06	2.89E-07	1.62E-06
Ra-226	1.79E-04	9.50E-08	3.49E-06	1.96E-07	1.82E-04
Ra-228	2.45E-05	6.20E-09	8.25E-07	4.62E-08	2.54E-05
Th-228	7.01E-05	1.04E-06	1.77E-08	3.77E-08	7.12E-05
Total	5.27E-04	1.18E-06	4.36E-05	8.52E-07	5.73E-04
T = 30 years					
K-40	1.42E-04	2.13E-09	2.12E-05	1.58E-07	1.63E-04
Pb-210	2.77E-09	7.37E-08	2.80E-06	6.25E-07	3.50E-06
Ra-226	1.69E-04	8.99E-08	3.30E-06	1.85E-07	1.72E-04
Ra-228	2.10E-06	5.33E-10	7.09E-08	3.97E-09	2.18E-06

Exhibit 28. (continued)

Contaminants	External risk	Inhalation risk	Ingestion of produce risk	Ingestion risk	total risk
Th-228	6.14E-06	9.11E-08	1.55E-09	3.30E-09	6.24E-06
Total	3.19E-04	2.57E-07	2.73E-05	9.76E-07	3.47E-04
T = 100 years					
K-40	1.84E-05	2.76E-10	2.75E-06	2.05E-08	2.12E-05
Pb-210	3.65E-09	9.71E-08	3.68E-06	8.24E-07	4.61E-06
Ra-226	1.39E-04	7.38E-08	2.71E-06	1.52E-07	1.42E-04
Ra-228	3.91E-10	9.91E-14	1.32E-11	7.39E-13	4.05E-10
Th-228	1.14E-09	1.69E-11	2.88E-13	6.14E-13	1.16E-09
Total	1.57E-04	1.71E-07	9.14E-06	9.96E-07	1.67E-04
T = 300 years					
K-40	5.39E-08	8.07E-13	8.04E-09	6.01E-11	6.20E-08
Pb-210	2.19E-09	5.83E-08	2.21E-06	4.95E-07	2.77E-06
Ra-226	7.91E-05	4.21E-08	1.55E-06	8.66E-08	8.08E-05
Ra-228	8.59E-21	2.18E-24	2.89E-22	1.62E-23	8.90E-21
Th-228	2.51E-20	3.72E-22	6.32E-24	1.35E-23	2.55E-20
Total	7.92E-05	1.00E-07	3.77E-06	5.81E-07	8.36E-05
T = 1000 years					
K-40	7.31E-17	1.10E-21	1.09E-17	8.16E-20	8.41E-17
Pb-210	3.07E-10	8.17E-09	3.10E-07	6.93E-08	3.88E-07
Ra-226	1.11E-05	5.90E-09	2.17E-07	1.21E-08	1.13E-05
Ra-228	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Th-228	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total	1.11E-05	1.41E-08	5.27E-07	8.15E-08	1.17E-05
SW 3					
T = 0 years					
Cs-137	2.48E-04	2.54E-09	3.40E-06	1.90E-07	2.52E-04
Th-228	1.61E-04	2.42E-06	3.96E-08	8.67E-08	1.64E-04
Total	4.10E-04	2.42E-06	3.44E-06	2.77E-07	4.16E-04
T = 1 year					
Cs-137	2.43E-04	2.49E-09	3.32E-06	1.86E-07	2.46E-04
Th-228	1.12E-04	1.69E-06	2.76E-08	6.04E-08	1.14E-04
Total	3.55E-04	1.69E-06	3.35E-06	2.46E-07	3.60E-04
T = 3 years					

Exhibit 28. (continued)

Contaminants	External risk	Inhalation risk	Ingestion of produce risk	Ingestion risk	total risk
Cs-137	2.32E-04	2.37E-09	3.17E-06	1.78E-07	2.35E-04
Th-228	5.44E-05	8.17E-07	1.34E-08	2.93E-08	5.52E-05
Total	2.86E-04	8.19E-07	3.18E-06	2.07E-07	2.90E-04
T = 10					
Cs-137	1.97E-04	2.02E-09	2.70E-06	1.51E-07	2.00E-04
Th-228	4.31E-06	6.47E-08	1.06E-09	2.32E-09	4.37E-06
Total	2.01E-04	6.67E-08	2.70E-06	1.53E-07	2.04E-04
T = 30 years					
Cs-137	1.24E-04	1.27E-09	1.70E-06	9.51E-08	1.26E-04
Th-228	3.07E-09	4.61E-11	7.54E-13	1.65E-12	3.12E-09
Total	1.24E-04	1.32E-09	1.70E-06	9.51E-08	1.26E-04
T = 100 years					
Cs-137	2.46E-05	2.52E-10	3.36E-07	1.88E-08	2.49E-05
Th-228	2.97E-20	4.46E-22	7.29E-24	1.60E-23	3.01E-20
Total	2.46E-05	2.52E-10	3.36E-07	1.88E-08	2.49E-05
T = 300 years					
Cs-137	2.40E-07	2.46E-12	3.28E-09	1.84E-10	2.43E-07
Th-228	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total	2.40E-07	2.46E-12	3.28E-09	1.84E-10	2.43E-07
T = 1000 years					
Cs-137	2.21E-14	2.27E-19	3.03E-16	1.70E-17	2.24E-14
Th-228	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total	2.21E-14	2.27E-19	3.03E-16	1.70E-17	2.24E-14
SWSASN					
T = 0 years					
Ra-228	1.15E-04	2.96E-08	3.87E-06	2.17E-07	1.19E-04
Th-228	1.81E-04	2.73E-06	4.46E-08	9.76E-08	1.84E-04
Total	2.96E-04	2.76E-06	3.91E-06	3.14E-07	3.03E-04
T = 1 year					
Ra-228	1.02E-04	2.62E-08	3.42E-06	1.92E-07	1.05E-04
Th-228	1.90E-04	2.86E-06	4.84E-08	1.02E-07	1.93E-04
Total	2.91E-04	2.88E-06	3.47E-06	2.94E-07	2.98E-04
T = 3 years					

Exhibit 28. (continued)

Contaminants	External risk	Inhalation risk	Ingestion of produce risk	Ingestion risk	total risk
Ra-228	7.95E-05	2.05E-08	2.68E-06	1.50E-07	8.23E-05
Th-228	1.80E-04	2.72E-06	4.57E-08	9.69E-08	1.83E-04
Total	2.60E-04	2.74E-06	2.72E-06	2.47E-07	2.65E-04
T = 10 years					
Ra-228	3.37E-05	8.67E-09	1.13E-06	6.36E-08	3.49E-05
Th-228	9.42E-05	1.42E-06	2.38E-08	5.07E-08	9.57E-05
Total	1.28E-04	1.43E-06	1.16E-06	1.14E-07	1.31E-04
T = 30 years					
Ra-228	2.89E-06	7.45E-10	9.75E-08	5.46E-09	3.00E-06
Th-228	8.44E-06	1.27E-07	2.13E-09	4.54E-09	8.58E-06
Total	1.13E-05	1.28E-07	9.96E-08	1.00E-08	1.16E-05
T = 100 years					
Ra-228	5.38E-10	1.39E-13	1.81E-11	1.02E-12	5.57E-10
Th-228	1.57E-09	2.37E-11	3.96E-13	8.45E-13	1.60E-09
Total	2.11E-09	2.38E-11	1.85E-11	1.86E-12	2.15E-09
T = 300 years					
Ra-228	1.18E-20	3.04E-24	3.98E-22	2.23E-23	1.22E-20
Th-228	3.45E-20	5.20E-22	8.69E-24	1.85E-23	3.50E-20
Total	4.63E-20	5.23E-22	4.07E-22	4.08E-23	4.73E-20
T = 1000 years					
Ra-228	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Th-228	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SWSASSE					
T = 0 years					
Cs-137	2.41E-01	2.49E-06	3.30E-03	1.85E-04	2.45E-01
Sr-90	0.00E+00	1.21E-05	4.75E-02	3.55E-04	4.78E-02
Th-228	1.61E-04	2.44E-06	3.96E-08	8.67E-08	1.64E-04
Total	2.41E-01	1.70E-05	5.08E-02	5.40E-04	2.93E-01
T = 1 year					
Cs-137	2.36E-01	2.43E-06	3.22E-03	1.81E-04	2.39E-01
Sr-90	0.00E+00	1.18E-05	4.61E-02	3.44E-04	4.64E-02
Th-228	1.12E-04	1.70E-06	2.76E-08	6.04E-08	1.14E-04

Exhibit 28. (continued)

Contaminants	External risk	Inhalation risk	Ingestion of produce risk	Ingestion risk	total risk
Total	2.36E-01	1.59E-05	4.93E-02	5.25E-04	2.86E-01
T = 3 years					
Cs-137	2.25E-01	2.32E-06	3.08E-03	1.73E-04	2.28E-01
Sr-90	0.00E+00	1.11E-05	4.34E-02	3.25E-04	4.38E-02
Th-228	5.44E-05	8.22E-07	1.34E-08	2.93E-08	5.53E-05
Total	2.25E-01	1.42E-05	4.65E-02	4.97E-04	2.72E-01
T = 10 years					
Cs-137	1.91E-01	1.97E-06	2.62E-03	1.47E-04	1.94E-01
Sr-90	0.00E+00	9.01E-06	3.53E-02	2.64E-04	3.56E-02
Th-228	4.31E-06	6.51E-08	1.06E-09	2.32E-09	4.37E-06
Total	1.91E-01	1.10E-05	3.79E-02	4.11E-04	2.30E-01
T = 30 years					
Cs-137	1.21E-01	1.24E-06	1.65E-03	9.23E-05	1.22E-01
Sr-90	0.00E+00	4.99E-06	1.95E-02	1.46E-04	1.97E-02
Th-228	3.07E-09	4.64E-11	7.54E-13	1.65E-12	3.12E-09
Total	1.21E-01	6.23E-06	2.12E-02	2.38E-04	1.42E-01
T = 100 years					
Cs-137	2.38E-02	2.46E-07	3.26E-04	1.83E-05	2.42E-02
Sr-90	0.00E+00	6.28E-07	2.46E-03	1.84E-05	2.48E-03
Th-228	2.97E-20	4.48E-22	7.29E-24	1.60E-23	3.01E-20
Total	2.38E-02	8.74E-07	2.79E-03	3.67E-05	2.67E-02
T = 300 years					
Cs-137	2.33E-04	2.40E-09	3.19E-06	1.79E-07	2.36E-04
Sr-90	0.00E+00	1.69E-09	6.64E-06	4.96E-08	6.69E-06
Th-228	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total	2.33E-04	4.09E-09	9.82E-06	2.28E-07	2.43E-04
T = 1000 years					
Cs-137	2.15E-11	2.22E-16	2.94E-13	1.65E-14	2.18E-11
Sr-90	0.00E+00	1.72E-18	6.73E-15	5.03E-17	6.78E-15
Th-228	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total	2.15E-11	2.23E-16	3.01E-13	1.65E-14	2.18E-11

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T = 0 years

Exhibit 28. (continued)

Contaminants	External risk	Inhalation risk	Ingestion of produce risk	Ingestion risk	total risk
Cs-137	3.02E-03	3.11E-08	4.14E-05	2.32E-06	3.07E-03
K-40	3.11E-04	4.74E-09	4.64E-05	3.47E-07	3.58E-04
Pb-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Ra-226	1.62E-04	8.77E-08	3.17E-06	1.77E-07	1.65E-04
Ra-228	1.04E-04	2.69E-08	3.52E-06	1.97E-07	1.08E-04
Sr-90	0.00E+00	6.28E-06	2.47E-02	1.85E-04	2.49E-02
Th-228	1.51E-04	2.28E-06	3.72E-08	8.13E-08	1.54E-04
Tl-204	2.19E-08	3.55E-11	2.09E-07	2.35E-09	2.33E-07
Total	3.75E-03	8.71E-06	2.48E-02	1.88E-04	2.87E-02
T = 1 year					
Cs-137	2.96E-03	3.04E-08	4.04E-05	2.27E-06	3.00E-03
K-40	3.02E-04	4.60E-09	4.51E-05	3.37E-07	3.48E-04
Pb-210	1.32E-10	3.57E-09	1.35E-07	2.98E-08	1.68E-07
Ra-226	1.62E-04	8.75E-08	3.16E-06	1.77E-07	1.65E-04
Ra-228	9.23E-05	2.38E-08	3.11E-06	1.74E-07	9.56E-05
Sr-90	0.00E+00	6.10E-06	2.40E-02	1.79E-04	2.41E-02
Th-228	1.63E-04	2.45E-06	4.17E-08	8.75E-08	1.65E-04
Tl-204	8.37E-09	1.36E-11	7.99E-08	8.96E-10	8.92E-08
Total	3.67E-03	8.70E-06	2.41E-02	1.82E-04	2.79E-02
T = 3 years					
Cs-137	2.82E-03	2.90E-08	3.86E-05	2.16E-06	2.86E-03
K-40	2.85E-04	4.34E-09	4.25E-05	3.18E-07	3.28E-04
Pb-210	3.82E-10	1.03E-08	3.87E-07	8.63E-08	4.84E-07
Ra-226	1.61E-04	8.70E-08	3.14E-06	1.76E-07	1.64E-04
Ra-228	7.23E-05	1.86E-08	2.43E-06	1.36E-07	7.48E-05
Sr-90	0.00E+00	5.75E-06	2.26E-02	1.69E-04	2.28E-02
Th-228	1.59E-04	2.40E-06	4.04E-08	8.56E-08	1.62E-04
Tl-204	1.22E-09	1.98E-12	1.17E-08	1.31E-10	1.30E-08
Total	3.50E-03	8.30E-06	2.27E-02	1.72E-04	2.63E-02
T = 10 years					
Cs-137	2.40E-03	2.47E-08	3.28E-05	1.84E-06	2.43E-03
K-40	2.32E-04	3.54E-09	3.47E-05	2.59E-07	2.67E-04
Pb-210	1.13E-09	3.05E-08	1.14E-06	2.55E-07	1.43E-06

Exhibit 28. (continued)

Contaminants	External risk	Inhalation risk	Ingestion of produce risk	Ingestion risk	total risk
Ra-226	1.58E-04	8.53E-08	3.08E-06	1.73E-07	1.61E-04
Ra-228	3.06E-05	7.88E-09	1.03E-06	5.78E-08	3.17E-05
Sr-90	0.00E+00	4.67E-06	1.84E-02	1.37E-04	1.85E-02
Th-228	8.53E-05	1.29E-06	2.15E-08	4.59E-08	8.66E-05
Tl-204	1.45E-12	2.34E-15	1.38E-11	1.55E-13	1.54E-11
Total	2.91E-03	6.11E-06	1.84E-02	1.40E-04	2.15E-02
T = 30 years					
Cs-137	1.51E-03	1.55E-08	2.07E-05	1.16E-06	1.53E-03
K-40	1.30E-04	1.98E-09	1.94E-05	1.45E-07	1.49E-04
Pb-210	2.44E-09	6.61E-08	2.47E-06	5.52E-07	3.09E-06
Ra-226	1.49E-04	8.06E-08	2.91E-06	1.63E-07	1.52E-04
Ra-228	2.63E-06	6.77E-10	8.86E-08	4.97E-09	2.72E-06
Sr-90	0.00E+00	2.59E-06	1.02E-02	7.60E-05	1.02E-02
Th-228	7.68E-06	1.16E-07	1.94E-09	4.13E-09	7.80E-06
Tl-204	6.33E-21	1.02E-23	6.04E-20	6.77E-22	6.74E-20
Total	1.80E-03	2.87E-06	1.02E-02	7.80E-05	1.21E-02
T = 100 years					
Cs-137	2.99E-04	3.07E-09	4.09E-06	2.29E-07	3.03E-04
K-40	1.68E-05	2.56E-10	2.51E-06	1.88E-08	1.94E-05
Pb-210	3.22E-09	8.71E-08	3.25E-06	7.27E-07	4.07E-06
Ra-226	1.22E-04	6.62E-08	2.39E-06	1.34E-07	1.25E-04
Ra-228	4.89E-10	1.26E-13	1.65E-11	9.23E-13	5.07E-10
Sr-90	0.00E+00	3.26E-07	1.28E-03	9.58E-06	1.29E-03
Th-228	1.43E-09	2.15E-11	3.60E-13	7.68E-13	1.45E-09
Tl-204	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total	4.38E-04	4.83E-07	1.29E-03	1.07E-05	1.74E-03
T = 300 years					
Cs-137	2.92E-06	3.00E-11	4.00E-08	2.24E-09	2.96E-06
K-40	4.93E-08	7.51E-13	7.35E-09	5.49E-11	5.67E-08
Pb-210	1.93E-09	5.23E-08	1.95E-06	4.36E-07	2.44E-06
Ra-226	6.98E-05	3.78E-08	1.36E-06	7.64E-08	7.13E-05
Ra-228	1.07E-20	2.77E-24	3.62E-22	2.03E-23	1.11E-20
Sr-90	0.00E+00	8.79E-10	3.45E-06	2.58E-08	3.48E-06

Exhibit 28. (continued)

Contaminants	External risk	Inhalation risk	Ingestion of produce risk	Ingestion risk	total risk
Th-228	3.13E-20	4.73E-22	7.90E-24	1.69E-23	3.18E-20
Tl-204	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total	7.28E-05	9.10E-08	6.81E-06	5.41E-07	8.02E-05
T = 1000 years					
Cs-137	2.69E-13	2.77E-18	3.69E-15	2.07E-16	2.73E-13
K-40	6.69E-17	1.02E-21	9.98E-18	7.46E-20	7.70E-17
Pb-210	2.71E-10	7.33E-09	2.74E-07	6.12E-08	3.43E-07
Ra-226	9.78E-06	5.30E-09	1.91E-07	1.07E-08	9.99E-06
Ra-228	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Sr-90	0.00E+00	8.91E-19	3.50E-15	2.62E-17	3.53E-15
Th-228	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Tl-204	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total	9.78E-06	1.26E-08	4.65E-07	7.19E-08	1.03E-05
WOC					
T = 0 years					
Co-60	5.57E-03	1.06E-07	1.90E-05	5.32E-07	5.59E-03
Cs-137	1.98E-01	2.04E-06	2.71E-03	1.52E-04	2.01E-01
Na-22	1.94E-04	1.41E-10	2.24E-07	1.01E-08	1.95E-04
Ra-228	9.40E-05	2.43E-08	3.17E-06	1.77E-07	9.73E-05
Sr-90	0.00E+00	4.61E-07	1.80E-03	1.35E-05	1.82E-03
Th-228	2.22E-04	3.36E-06	5.45E-08	1.19E-07	2.25E-04
Total	2.04E-01	5.99E-06	4.54E-03	1.66E-04	2.09E-01
T = 1 year					
Co-60	4.89E-03	9.26E-08	1.66E-05	4.67E-07	4.90E-03
Cs-137	1.94E-01	2.00E-06	2.65E-03	1.48E-04	1.96E-01
Na-22	1.47E-04	1.06E-10	1.69E-07	7.58E-09	1.47E-04
Ra-228	8.31E-05	2.15E-08	2.80E-06	1.57E-07	8.61E-05
Sr-90	0.00E+00	4.47E-07	1.75E-03	1.31E-05	1.76E-03
Th-228	2.06E-04	3.12E-06	5.22E-08	1.11E-07	2.09E-04
Total	1.99E-01	5.68E-06	4.42E-03	1.62E-04	2.03E-01
T = 3 years					
Co-60	3.75E-03	7.12E-08	1.28E-05	3.59E-07	3.77E-03
Cs-137	1.85E-01	1.91E-06	2.53E-03	1.42E-04	1.87E-01

Exhibit 28. (continued)

Contaminants	External risk	Inhalation risk	Ingestion of produce risk	Ingestion risk	total risk
Na-22	8.33E-05	6.03E-11	9.60E-08	4.30E-09	8.34E-05
Ra-228	6.50E-05	1.68E-08	2.19E-06	1.23E-07	6.74E-05
Sr-90	0.00E+00	4.22E-07	1.65E-03	1.23E-05	1.66E-03
Th-228	1.72E-04	2.61E-06	4.35E-08	9.26E-08	1.75E-04
Total	1.89E-01	5.02E-06	4.19E-03	1.55E-04	1.93E-01
T = 10 years					
Co-60	1.49E-03	2.83E-08	5.09E-06	1.43E-07	1.50E-03
Cs-137	1.57E-01	1.62E-06	2.15E-03	1.20E-04	1.59E-01
Na-22	1.15E-05	8.34E-12	1.33E-08	5.95E-10	1.15E-05
Ra-228	2.75E-05	7.12E-09	9.28E-07	5.20E-08	2.85E-05
Sr-90	0.00E+00	3.43E-07	1.34E-03	1.00E-05	1.35E-03
Th-228	7.90E-05	1.20E-06	1.99E-08	4.25E-08	8.03E-05
Total	1.59E-01	3.20E-06	3.50E-03	1.31E-04	1.62E-01
T = 30 years					
Co-60	1.07E-04	2.03E-09	3.66E-07	1.03E-08	1.08E-04
Cs-137	9.89E-02	1.02E-06	1.35E-03	7.58E-05	1.00E-01
Na-22	4.03E-08	2.92E-14	4.65E-11	2.08E-12	4.03E-08
Ra-228	2.37E-06	6.12E-10	7.97E-08	4.47E-09	2.45E-06
Sr-90	0.00E+00	1.90E-07	7.43E-04	5.55E-06	7.48E-04
Th-228	6.91E-06	1.05E-07	1.74E-09	3.72E-09	7.02E-06
Total	9.90E-02	1.32E-06	2.10E-03	8.14E-05	1.01E-01
T = 100 years					
Co-60	1.07E-08	2.02E-13	3.63E-11	1.02E-12	1.07E-08
Cs-137	1.96E-02	2.02E-07	2.68E-04	1.50E-05	1.99E-02
Na-22	1.03E-16	7.43E-23	1.18E-19	5.30E-21	1.03E-16
Ra-228	4.40E-10	1.14E-13	1.48E-11	8.31E-13	4.56E-10
Sr-90	0.00E+00	2.39E-08	9.36E-05	7.00E-07	9.43E-05
Th-228	1.29E-09	1.95E-11	3.24E-13	6.91E-13	1.31E-09
Total	1.96E-02	2.26E-07	3.61E-04	1.57E-05	1.99E-02
T = 300 years					
Co-60	3.90E-20	7.39E-25	1.33E-22	3.73E-24	3.91E-20
Cs-137	1.91E-04	1.98E-09	2.62E-06	1.47E-07	1.94E-04
Na-22	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Exhibit 28. (continued)

Contaminants	External risk	Inhalation risk	Ingestion of produce risk	Ingestion risk	total risk
Ra-228	9.66E-21	2.50E-24	3.26E-22	1.82E-23	1.00E-20
Sr-90	0.00E+00	6.44E-11	2.52E-07	1.89E-09	2.54E-07
Th-228	2.82E-20	4.27E-22	7.11E-24	1.52E-23	2.87E-20
Total	1.91E-04	2.04E-09	2.87E-06	1.49E-07	1.94E-04
T = 1000 years					
Co-60	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Cs-137	1.76E-11	1.82E-16	2.41E-13	1.35E-14	1.79E-11
Na-22	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Ra-228	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Sr-90	0.00E+00	6.54E-20	2.56E-16	1.91E-18	2.58E-16
Th-228	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total	1.76E-11	1.82E-16	2.42E-13	1.35E-14	1.79E-11

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C. TOXICITY PROFILES

APPENDIX C

Toxicity Profiles for WAG 5 Contaminants of Concern

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C. TOXICITY PROFILES FOR WAG 5 CONTAMINANTS OF CONCERN

Toxicity profiles for the contaminants of concern identified for the risk assessment are presented in this section. EPA classifies all radionuclides as Group A carcinogens based on their property of emitting ionizing radiation and on the extensive weight of evidence provided by epidemiological studies of high-dose-radiation-induced cancers in humans. Ionizing radiations have sufficient energy that their interactions with matter produce an ejected electron and positively charged ions known as free radicals, which are highly reactive and may combine with other elements or compounds within a cell to produce toxins or otherwise disrupt the chemical balance. Ionizing radiation has been implicated in damage to the genetic material of cells that result in mutations or other deleterious effects. Radionuclides are characterized by the type and energy level of the radiation emitted. Radiation emissions fall into two major categories: particulate (electrons, alpha particles, beta particles, protons) and electromagnetic radiation (gamma and X rays). Interested readers should refer to Subsect. 5.5.4.3 or any Radiation Detection text book for more details.

The following summary presents the chemical specific information of COPCs. Carcinogenic and noncarcinogenic health effects are included, also. Information presented in this section are based on data from human and animal research and from occupational studies to characterize likely health effects from exposure to COPCs.

C.1 INORGANICS

C.1.1 Antimony

Antimony (Sb) is a naturally occurring metal that is used in various manufacturing processes. It exists in valence states of 3 and 5 (Budavari, 1989; ATSDR, 1990). Antimony is a common urban air pollutant (Beliles, 1979). Exposure to antimony may be via inhalation, oral, and dermal routes (ATSDR, 1990).

Antimony is sparingly absorbed following ingestion or inhalation (Felicetti et al., 1974a; Gerber et al., 1982; ATSDR, 1990). Both gastrointestinal and pulmonary absorption are a function of compound solubility. Antimony is transported in the blood, its distribution varying among species and dependent on its valence state (Felicetti et al., 1974b). Antimony is not metabolized but may bind to macromolecules and react covalently with sulfhydryl and phosphate groups (ATSDR, 1990). Excretion of antimony is primarily via the urine and feces, and is also dependent upon valence state (Cooper et al., 1968; Ludersdorf et al., 1987; ATSDR, 1990).

Acute oral exposure of humans and animals to high doses of antimony or antimony-containing compounds (antimonials) may cause gastrointestinal disorders (vomiting, diarrhea), respiratory difficulties, and death at extremely high doses (Bradley and Frederick, 1941; Beliles, 1979; ATSDR, 1990). Subchronic and chronic oral exposure may affect hematologic parameters (ATSDR, 1990). Long-term exposure to high doses of antimony or antimonials has been shown to adversely affect longevity in animals (Schroeder et al., 1970). Limited data suggest that prenatal and postnatal exposure of rats to antimony interferes with vasomotor responses (Marmo et al., 1987; Rossi et al., 1987).

Acute inhalation exposure of humans may cause gastrointestinal disorders (probably due to ingestion of airborne antimony) (ATSDR, 1990). Exposure of animals to high concentrations of antimony and antimonials (especially stibine gas) may result in pulmonary edema and death (Price et al., 1979). Long-term occupational exposure of humans has resulted in electrocardiac disorders, respiratory disorders, and possibly increased mortality (Renes, 1953; Breiger et al., 1954). Antimony levels for these occupational exposure evaluations ranged from 2.2 to 11.98 mg Sb/m³. Based on limited data, occupational exposure of women to metallic antimony and several antimonials has reportedly caused alterations in the menstrual cycle and an increased incidence of spontaneous abortions (Belyaeva, 1967). Reproductive dysfunction has been demonstrated in rats exposed to antimony trioxide (Belyaeva, 1967).

No data were available indicating that dermal exposure of humans to antimony or its compounds results in adverse effects. However dermal application of high doses of antimony oxide (1,584 mg Sb/kg) resulted in the death of rabbits within one day (IBTL, 1972). Eye irritation due to exposure to stibine gas and several antimony oxides has been reported for humans (Stevenson, 1965; Potkonjak and Pavlovich, 1983).

The EPA (EPA, 1991, 1992) has calculated subchronic and chronic oral reference doses (RfDs) of 4E-4 mg/kg/day based on decreased longevity and alteration of blood chemistry in rats chronically exposed to potassium antimony tartrate in the drinking water (5 ppm equivalent to 0.35 mg Sb/kg/day). An uncertainty factor of 1,000 was applied: 10 for extrapolation from a lowest-observed-adverse-effect-level (LOAEL) to a no-observed-adverse-effect-level (NOAEL), 10 for extrapolation from animal data, and 10 for protection of sensitive populations.

The primary target organ for acute oral exposure to antimony appears to be the gastrointestinal tract (irritation, diarrhea, vomiting) and targets for long-term exposure are the blood (hematological disorders) and liver (mild hepatotoxicity) (ATSDR, 1990). Inhalation exposure to antimony affects the respiratory tract (pneumoconiosis, restrictive airway disorders), with secondary targets being the cardiovascular system (altered blood pressure and electrocardiograms) and kidneys (histological changes) (Renes, 1953; Breiger et al., 1954). Only limited evidence exists for reproductive disorders due to antimony exposure (Belyaeva, 1967).

Although some data indicate that long-term exposure of rats to antimony trioxide and trisulfide increased the incidence of lung tumors (Wong et al., 1979; Watt, 1980; Groth et al., 1986; Bio/dynamics, 1989), the EPA has not evaluated antimony or antimonials for carcinogenicity and a Weight-of-Evidence classification is currently unavailable.

C.1.2 Arsenic

Arsenic is a metallic, steel-gray, crystalline, brittle, trivalent and pentavalent, solid, poisonous element. It is commonly used in pesticides. Trivalent compounds are generally more toxic and more likely to have systemic effects than the less soluble compounds which are more likely to cause chronic pulmonary effects if inhaled.

Water soluble inorganic arsenic compounds are absorbed through the gastrointestinal tract and lungs. Symptoms of acute inorganic arsenic poisoning in humans are nausea, anorexia, vomiting, epigastric and abdominal pain, and diarrhea. In addition, dermatitis, muscle cramps, cardiac

abnormalities, hepatotoxicity, bone marrow suppression and hematologic abnormalities, vascular lesions, and peripheral neuropathy have also been reported. Severe exposures can result in acute encephalopathy, congestive heart failure, stupor, convulsions, paralysis, coma, and death. Occupational exposure studies show a clear correlation between exposure to arsenic and lung cancer mortality (BEIAS 1993; ATSDR 1989a).

C.1.3 Barium

The soluble salts of barium, an alkaline earth metal, are toxic in mammalian systems. They are absorbed rapidly from the gastrointestinal tract and are deposited in the muscles, lungs and bone. Barium is excreted primarily in the feces.

At low doses, barium acts as a muscle stimulant and at higher doses affects the nervous system eventually leading to paralysis. Acute and subchronic oral doses of barium cause vomiting and diarrhea, followed by decreased heart rate and elevated blood pressure. Higher doses result in cardiac irregularities, weakness, tremors, anxiety and dyspnea. A drop in serum potassium may account for some of the symptoms. Death can occur from cardiac and respiratory failure. Acute doses around 0.8 grams can be fatal to humans.

Subchronic and chronic oral or inhalation exposure primarily affects the cardiovascular system resulting in elevated blood pressure. A LOAEL of 0.51 mg barium/kg/day based on increased blood pressure was observed in chronic oral rat studies (Perry et al., 1983), whereas human studies identified a NOAEL of 0.21 mg barium/kg/day (Wones et al., 1990; Brenniman and Levy, 1984). The human data were used by the EPA to calculate a chronic and subchronic oral reference dose (RfD) of 0.07 mg/kg/day (EPA, 1991, 1992). In the Wones et al. study, human volunteers were given barium up to 10 mg/L in drinking water for 10 weeks. No clinically significant effects were observed. An epidemiological study was conducted by Brenniman and Levy in which human populations ingesting 2 to 10 mg/L of barium in drinking water were compared to a population ingesting 0 to 0.2 mg/L. No significant individual differences were seen; however, a significantly higher mortality rate from all combined cardiovascular diseases was observed with the higher barium level in the 65+ age group. The average barium concentration was 7.3 mg/L, which corresponds to a dose of 0.20 mg/kg/day. Confidence in the oral RfD is rated medium by the EPA.

Subchronic and chronic inhalation exposure of human populations to barium-containing dust can result in a benign pneumoconiosis called "baritosis." This condition is often accompanied by an elevated blood pressure but does not result in a change in pulmonary function. Exposure to an air concentration of 5.2 mg/m³ for 4 hours/day for 6 months has been reported to result in elevated blood pressure and decreased body weight gain in rats (Tarasenko et al., 1977). Reproduction and developmental effects were also observed. Increased fetal mortality was seen after untreated females were mated with males treated with 5.2 mg/m³ of barium. Similar results were obtained with female rats treated with 13.4 mg/m³. The NOAEL for developmental effects was 1.15 mg/m³. An inhalation reference concentration (RfC) of 0.005 mg/m³ for subchronic and 0.0005 mg/m³ for chronic exposure was calculated by the EPA based on the NOAEL for developmental effects (EPA, 1992). These effects have not been substantiated in humans or other animal systems.

Barium has not been evaluated by the EPA for evidence of human carcinogenic potential (EPA, 1991).

C.1.4 Beryllium

Beryllium is present in the earth's crust, in emissions from coal combustion, in surface water and soil, and in house dust, food, drinking water, and cigarette smoke (EPA, 1987a). However, the highest risk for exposure occurs among workers employed in beryllium manufacturing, fabricating, or reclamation industries (ATSDR, 1988). Workers encounter dusts and fumes of many different beryllium compounds; the current occupational standard for worker exposure to beryllium is $2 \mu\text{g}/\text{m}^3$ during an 8-hour workshift (OSHA, 1989).

Inhaled beryllium is absorbed slowly and localizes mainly in the lungs, bone, liver and kidneys (Stiefel et al., 1980; Reeves et al., 1967; Reeves and Vorwald, 1967; Zorn et al., 1988; Tepper et al., 1961; Meehan and Smyth, 1967). Ingested beryllium undergoes limited absorption and localizes in liver, kidneys, lungs, stomach, spleen and the large and small intestines (Crowley et al., 1949; Furchner et al., 1973; Watanabe et al., 1985). Significant absorption of beryllium or its compounds through intact skin is unlikely because of its chemical properties (EPA, 1987b). Beryllium per se is not biotransformed, but soluble salts may be converted to less soluble compounds in the lung (EPA, 1987b). Most orally administered beryllium passes through the gastrointestinal tract unabsorbed and is excreted in the feces (Reeves, 1965), whereas inhaled water-soluble beryllium salts are excreted mainly by the kidneys (Zorn et al., 1988).

Limited data indicate that the oral toxicity of beryllium is low. No adverse effects were noted in mice given 5 ppm beryllium in the drinking water in a lifetime bioassay (Schroeder and Mitchener, 1975a,b). The dose (converted to $0.54 \text{ mg}/\text{kg bw}/\text{day}$) was the no-adverse-effect level (NOAEL) used in the calculation of the chronic oral RfD for beryllium of $0.005 \text{ mg}/\text{kg}/\text{day}$ (EPA, 1991a).

In contrast, the toxicity of inhaled beryllium is well-documented. Humans inhaling "massive" doses of beryllium compounds (such as the water soluble sulfate, fluoride, chloride, and oxide) may develop acute berylliosis (Constantinidis, 1978). ATSDR (1988) estimated that, based on existing data, the disease could develop at levels ranging from approximately $2\text{-}1000 \mu\text{g Be}/\text{m}^3$. This disease usually develops shortly after exposure and is characterized by rhinitis, pharyngitis, and/or tracheobronchitis, and may progress to severe pulmonary symptoms. The severity of acute beryllium toxicity correlates with exposure levels, and the disease is now rarely observed in the United States because of improved industrial hygiene (Zorn et al., 1988; Kriebel et al., 1988b).

Humans inhaling beryllium may also develop chronic berylliosis which, in contrast to acute berylliosis, is highly variable in onset, is more likely to be fatal, and can develop a few months to ≥ 20 years after exposure (Constantinidis, 1978; Hall et al., 1959; Kriebel et al., 1988b). Chronic beryllium disease is a systemic disease that primarily affects the lungs and is characterized by the development of non-caseating granulomas. The disease most likely results from a hypersensitivity response to beryllium as evidenced by positive patch tests (Nishimura, 1966) and positive lymphocyte transformation tests (Williams and Williams (1983) in exposed individuals. Granulomas may also appear in the skin, liver, spleen, lymph nodes, myocardium, skeletal muscles, kidney, bone, and salivary glands (Kriebel et al., 1988b; Freiman and Hardy, 1970).

Epidemiologic studies have suggested that beryllium and its compounds could be human carcinogens. In a study that covered 15 regions of the U.S., Berg and Burbank (1972) found a

significant correlation between cancers of the breast, bone and uterus and the concentration and detection frequency of beryllium in drinking water. However, imperfect analytical and sampling methods used in the study prompted the EPA (1986b) to conclude that these results are not proof of cause-and-effect relationships between cancer and beryllium in drinking water. Studies in workers exposed to beryllium, mostly via inhalation, have shown significant increases in observed over expected lung cancer incidences (Bayliss et al., 1971; Bayliss and Lainhart, 1972; Bayliss and Wagoner, 1977; Wagoner et al., 1980; Mancuso, 1970; 1979; 1980). The EPA (1986a), in evaluating the total database for the association of lung cancer with occupational exposure to beryllium, noted several limitations, but concluded that the results must be considered to be at least suggestive of a carcinogenic risk to humans. In laboratory studies, beryllium sulfate caused increased incidences of pulmonary tumors in rats and rhesus monkeys (Vorwald, 1953, 1962, 1968; Vorwald et al., 1955, 1966; Schepers et al., 1957; Reeves and Deitch, 1969).

Based on sufficient evidence for animals and inadequate evidence for humans, beryllium has been placed in the EPA weight-of-evidence classification B2, probable human carcinogen (EPA, 1991a). For inhalation exposure, the unit risk value is $2.4E-3 (\mu\text{g}/\text{m}^3)^{-1}$, and the slope factor is $8.4 (\text{mg}/\text{kg}/\text{day})^{-1}$ (EPA, 1991b). For oral exposure, the unit risk value is $1.2E-4 (\mu\text{g}/\text{L})^{-1}$ and the slope factor is $4.3 (\text{mg}/\text{kg}/\text{day})^{-1}$ (EPA, 1991a).

C.1.5 Boron

Boron exists in the earth's crust with an average proportion of only 10 parts per million. It is on the same scale of abundance as lead. Most natural boron is compounded with sodium, hydrogen, and water to form the mineral borax.

Toxicological studies on borax and boric acid (Weir, 1972) on groups of 4 male and 4 female dogs were carried out. The animals were fed borax and boric acid in the diet for 2 years. The NOAEL was established at 350 ppm of boron equivalents ($8.8 \text{ g}/\text{kg}/\text{day}$), highest dose tested. In an additional study, dogs were fed 1170 ppm ($29 \text{ mg}/\text{kg}/\text{day}$) for 38 weeks. At this dose, severe testicular atrophy and spermatogenic arrest occurred.

Groups of 35 male and 35 female rats were fed borax and boric acid in the diet for 2 years at boron-equivalent doses of 117, 350, and 1170 ppm (5.9 , 17.5 or $58.5 \text{ mg B}/\text{kg}/\text{day}$). No treatment-related effects were seen at 5.9 or $17.5 \text{ mg}/\text{kg}/\text{day}$, so the highest NOAEL is $17.5 \text{ mg}/\text{kg}/\text{day}$. The LOAEL is $58.5 \text{ mg}/\text{kg}/\text{day}$, based on the following: significantly decreased testes weights and testes-to-body weight ratios; atrophied seminiferous epithelium; and decreased tubular size in the testes. Brain and brain-to-body weight ratios were also significantly decreased.

Schroeder and Mitchener (1975) reported a lifetime study in which mice were administered boron in drinking water at $5 \text{ mg}/\text{L}$ (equivalent to $8.1 \text{ mg B}/\text{kg}/\text{day}$). No effects were observed with regard to body weight, longevity or survival. The NOAEL in this study was $8.1 \text{ mg}/\text{kg}/\text{day}$.

A referenced lifetime dog study provides both a NOAEL and a LOAEL and examines many biological endpoints, but has a limited number of experimental animals; it rates a medium confidence. Several sub-chronic, chronic and reproductive toxicity studies provide supportive data, but developmental data do not exist; hence the data base rates a medium level of confidence. Medium confidence in the RfD follows.

Reference concentration for chronic inhalation exposure (RfC) is not available at this time. This substance/agent has been evaluated by the EPA for evidence of human carcinogenic potential. This does not imply that this agent is necessarily a carcinogen. The evaluation for this chemical is under review by an inter-office Agency work group. A risk assessment summary will be included on IRIS when the review has been completed.

C.1.6 Cadmium

Cadmium is a naturally occurring metal that is used in various chemical forms in metallurgical and other industrial processes, and in the production of pigments. Environmental exposure can occur via the diet and drinking water (ATSDR, 1989).

Cadmium is absorbed more efficiently by the lungs (30 to 60%) than by the gastrointestinal tract, the latter being a saturable process (Nordberg et al., 1985). Cadmium is transported in the blood and widely distributed in the body but accumulates primarily in the liver and kidneys (Goyer, 1991). Cadmium burden (especially in the kidneys and liver) tends to increase in a linear fashion up to about 50 or 60 years of age after which the body burden remains somewhat constant. Metabolic transformations of cadmium are limited to its binding to protein and nonprotein sulfhydryl groups, and various macromolecules, such as metallothionein, which is especially important in the kidneys and liver (ATSDR, 1989). Cadmium is excreted primarily in the urine.

Acute oral exposure to 20-30 g have caused fatalities in humans. Exposure to lower amounts may cause gastrointestinal irritation, vomiting, abdominal pain, and diarrhea (ATSDR, 1989). An asymptomatic period of one-half to one hour may precede the onset of clinical signs. Oral LD₅₀ values in animals range from 63 to 1125 mg/kg, depending on the cadmium compound (USAF, 1990). Longer term exposure to cadmium primarily affects the kidneys, resulting in tubular proteinosis although other conditions such as "itai-itai" disease may involve the skeletal system. Cadmium involvement in hypertension is not fully understood (Goyer, 1991).

Inhalation exposure to cadmium and cadmium compounds may result in effects including headache, chest pains, muscular weakness, pulmonary edema, and death (USAF, 1990). The 1-minute and 10-minute lethal concentration of cadmium for humans has been estimated to be about 2,500 and 250 mg/m³, respectively (Barrett et al., 1947; Beton et al., 1966). An 8-hour TWA (time-weighted-average) exposure level of 5 mg/m³ has been estimated for lethal effects of inhalation exposure to cadmium, and exposure to 1 mg/m³ is considered to be immediately dangerous to human health (Friberg, 1950). Renal toxicity (tubular proteinosis) may also result from inhalation exposure to cadmium (Goyer, 1991).

Chronic oral RfDs of 5E-4 and 1E-3 mg/kg/day have been established for cadmium exposure via drinking water and food, respectively (EPA, 1991). Both values reflect incorporation of an uncertainty factor of 10. The RfDs are based on an extensive data base regarding toxic kinetics and toxicity in both human and animals, the critical effect being renal tubular proteinuria. Confidence in the RfD and data base is high. Inhalation RfC values are currently not available.

The target organ for cadmium toxicity via oral exposure is the kidney (Goyer, 1991). For inhalation exposure, both the lungs and kidneys are target organs for cadmium-induced toxicity (ATSDR, 1989; Goyer, 1991).

There is limited evidence from epidemiologic studies for cadmium-related respiratory tract cancer (ATSDR, 1989). An inhalation unit risk of $1.8\text{E-}3$ ($\mu\text{g}/\text{m}^3$)⁻¹ and an inhalation slope factor of $6.1\text{E+}0$ ($\text{mg}/\text{kg}/\text{day}$)⁻¹ are based on respiratory tract cancer associated with occupational exposure (EPA, 1985). Based on limited evidence from multiple occupational exposure studies and adequate animal data, cadmium is placed in weight-of-evidence group B1 - probable human carcinogen.

C.1.7 Chromium, Chromium III, and Chromium VI

Elemental chromium does not occur in nature but is present in ores—primarily chromite. Chromium exhibits several oxidation states, but the most prominent of these is chromium VI and chromium III. Chromium VI in the environment is manmade as a result of industrial emissions; in solution, chromium VI exists as hydrochromate, chromate, and dichromate ionic species and reacts over time to form chromium III. Chromium VI is much more mobile and toxic than is chromium III. Chromium is useful in glucose and cholesterol metabolism and therefore is an essential element to humans and animals. Nonoccupational exposure to the metal occurs via the ingestion of chromium-containing food and water, whereas occupational exposure occurs via inhalation. Workers are exposed to chromium during its use in the production of dichromate; the chemical, stainless steel, refractory, and chromium-plating industries; and the production and use of alloys (BEIAS 1993).

Chromium enters the body through the lungs, gastrointestinal tract, and, to a lesser extent, the skin. Inhalation is the most important route for occupational exposure. Workers exposed to chromium have developed nasal irritation, nasal ulcers, perforation of the nasal septum, and hypersensitivity reactions and "chrome holes" of the skin. Among the general population, contact dermatitis has been associated with the use of bleaches and detergents. Inhalation of chromium compounds has been associated with the development of cancer in workers in the chromate industry. Evidence also suggests an increased risk in developing nasal, pharyngeal, and gastrointestinal carcinomas. Based on sufficient evidence reporting that humans and animals are at risk of developing cancer, chromium VI has been assigned an EPA weight-of-evidence classification of A, human carcinogen (BEIAS 1993).

C.1.8 Cyanide

Cyanide most commonly occurs as hydrogen cyanide and its salts—sodium and potassium cyanide. Cyanides are both man-made and naturally occurring substances. They are found in several plant species as cyanogenic glycosides and are produced by certain bacteria, fungi, and algae. In very small amounts, cyanide is a necessary requirement in the human diet. Cyanides are released to the environment from industrial sources and car emissions (ATSDR, 1989).

Cyanides are readily absorbed by the inhalation, oral, and dermal routes of exposure. The central nervous system (CNS) is the primary target organ for cyanide toxicity. Neurotoxicity has been observed in humans and animals following ingestion and inhalation of cyanides. Cardiac and respiratory effects, possibly CNS-mediated, have also been reported. Short-term exposure to high concentrations produces almost immediate collapse, respiratory arrest, and death (Hartung, 1982; EPA, 1985). Symptoms resulting from occupational exposure to lower concentrations include breathing difficulties, nervousness, vertigo, headache, nausea, vomiting, precordial pain, and electrocardiogram (EKG) abnormalities (Carmelo, 1955; El Ghawabi et al., 1975; Sandberg, 1967;

Wuthrich, 1954). Thyroid toxicity has been observed in humans and animals following oral and inhalation exposure to cyanides (Philbrick et al., 1979; EPA, 1984). In animal studies, cyanides have produced fetotoxicity and teratogenic effects, including exencephaly, encephalocele, and rib abnormalities (Doherty et al., 1982; Frakes et al., 1986; Tewe and Maner, 1981b; Willhite, 1982).

Reference doses (RfDs) have been calculated for subchronic and chronic oral exposure to cyanide and several cyanide compounds (EPA, 1990a-e; 1991a-e). The values, derived from a single study, are based on a no-observed-adverse-effect level (NOAEL) of 10.8 mg/kg/day for cyanide in a 2-year dietary study with rats (Howard and Hanzal, 1955). The subchronic and chronic oral RfDs are 0.02 mg/kg/day for cyanide; 0.04 mg/kg/day for sodium cyanide, calcium cyanide, and cyanogen; 0.0 mg/kg/day for potassium cyanide, chlorine cyanide, and zinc cyanide; 0.1 mg/kg/day for silver cyanide; and 0.2 mg/kg/day for potassium silver cyanide. Data were insufficient to derive a reference concentration (RfC) for cyanide.

No suitable cancer bioassays or epidemiological studies are available to assess the carcinogenicity of cyanide. Therefore, EPA (1991b) has placed cyanide in weight-of-evidence group D, not classifiable as to human carcinogenicity.

6.1.9 Lead

Lead is a naturally occurring bluish-gray metal found in small quantities in the Earth's crust. Lead and its compounds can be detected in all parts of the environment (e.g., in plants and animals used for human consumption and in air, drinking water, rivers, lakes, oceans, dust, and soil). Lead used by industry comes from mined ores or from recycled scrap metal (ATSDR 1988b).

Lead has a wide range of uses. Its primary use is in the manufacture of storage batteries. Other applications include its use in the production of ammunition, miscellaneous metal products (e.g., sheet lead, solder, and pipes), and various chemicals, including gasoline additives, tetraethyl lead, and tetramethyl lead (ATSDR 1988b).

General population exposure to lead and its compounds results from breathing air, drinking water, and eating many foods that contain lead. Breathing or ingesting dust and dirt laden with lead is also a source of exposure. Skin contact with dust and dirt containing lead is also expected to occur on a daily basis, but uptake by the skin is not substantial. During the normal use of lead-containing products, little skin contact is expected to take place. Exposure to certain lead compounds that are additives can occur while pumping gasoline containing these additives and possibly during use of some do-it-yourself fuel additives. Children, especially those who are preschool age, are at particular risk to lead exposure since they commonly put their hands, toys, and other items in their mouths. These items frequently come in contact with lead-containing dust and dirt, and as a result, children consume large amounts of lead. In some cases, children may ingest nonfood items such as paint chips and dirt. These items may contain large amounts of lead (ATSDR 1988b).

Little of the lead ingested by adults enters the blood and other parts of the body. However, a much greater proportion of the lead ingested by children enters the blood and other body parts. Exposure of a expectant mother to lead results in the transfer of lead to the fetus and may cause preterm birth, reduced birth weight, and decreased intelligence quotient (IQ) in the infant. Lead exposure may also decrease IQ scores and reduce the growth of young children. At high levels of

exposure, lead can severely damage the brain and kidneys in adults and children, cause abortion, and damage the male reproductive system. The effects of lead are the same regardless of whether it enters the body through breathing or ingestion (ATSDR 1988b).

C.1.10 Manganese

Manganese is an essential trace element in humans, which can elicit a variety of serious toxic responses upon prolonged exposure to elevated concentrations either orally or by inhalation. The central nervous system is the primary target. Initial symptoms are headache, insomnia, disorientation, anxiety, lethargy and memory loss. These symptoms progress with continued exposure and eventually include motor disturbances, tremors and difficulty in walking, similar to symptoms seen in Parkinsonism. These motor difficulties are most often irreversible. Based on human epidemiological studies, 0.8 mg/kg/day for drinking water exposure and 0.34 mg/m³ in air for inhalation exposure have been estimated as lowest-observed-adverse-effect levels (LOAELs) for central nervous system effects.

Effects on reproduction (decreased fertility, impotence) have been observed in humans with inhalation exposure and in animals with oral exposure at the same or similar doses that initiate the central nervous system effects. An increased incidence of coughs, colds, dyspnea during exercise, bronchitis and altered lung ventilatory parameters have also been seen in humans and animals with inhalation exposure. A possible effect on the immune system may account for some of the respiratory symptoms.

A reference dose (RfD) of 0.10 mg/kg/day for both chronic and subchronic oral exposure has been calculated by the EPA from a human no-observed-adverse-effect level (NOAEL) of 0.14 mg/kg/day, which was determined from a series of epidemiological studies (Schroeder et al., 1966; WHO, 1973; NRC, 1989). Large populations with different concentrations of manganese in their drinking water were examined. No adverse effects that were attributable to manganese were seen in any of these groups. The RfD was derived from these studies without uncertainty factors since manganese is essential in human nutrition and the exposure of the most sensitive groups was included in the population examined. Confidence in the oral RfD is rated medium by the EPA.

A reference concentration (RfC) of 0.4 ug/m³ for both chronic and subchronic inhalation exposure was calculated from a human LOAEL of 0.34 mg/m³ for respiratory and psychomotor disturbances from an epidemiological study by Roels et al. (1987). The study population was occupationally exposed to airborne manganese dust with a median concentration of 0.97 mg/m³ for 1 to 19 years with a mean duration of 7.1 years. Neurological examinations, psychomotor tests, lung function tests, blood tests and urine tests were used to determine the possible effects of exposure. The LOAEL was calculated by expanding the dose to continuous exposure. Confidence in the inhalation RfC is rated medium by the EPA.

There are some conflicting data on possible carcinogenesis following injections of manganese chloride and manganese sulfate in mice. However, the EPA weight-of-evidence classification is: D, not classifiable as to human carcinogenicity based on no evidence in humans and inadequate evidence in animals.

C.1.11 Mercury

Mercury is a naturally occurring element existing in multiple forms and in various oxidation states. It is used in a wide variety of products and processes. In the environment, mercury may undergo transformations among its various forms and among its oxidation states. Exposure to mercury may occur in both occupational and environmental settings, the latter primarily involving dietary exposure (ATSDR, 1989).

Absorption, distribution, metabolism, and excretion of mercury is dependent upon its form and oxidation state (ATSDR, 1989; Goyer, 1991). Organic mercurials are more readily absorbed than are inorganic forms. An oxidation-reduction cycle is involved in the metabolism of mercury and mercury compounds by both animals and humans (ATSDR, 1989). The urine and feces are primary excretory routes. The elimination half-life is 35 to 90 days for elemental mercury and mercury vapor, and about 40 days for inorganic salts (Goyer, 1991).

Ingestion of mercury metal is usually without effect (Goldwater, 1972). Ingestion of inorganic salts may cause severe gastrointestinal irritation, renal failure and death with acute lethal doses in humans ranging from 1-4 g (ATSDR, 1989). Mercuric (divalent) salts are usually more toxic than are mercurous (monovalent) salts (Goyer, 1991). Mercury is also known to induce hypersensitivity reactions such as contact dermatitis and acrodynia (pink disease) (Mathesson et al., 1980). Inhalation of mercury vapor may cause irritation of the respiratory tract, renal disorders, CNS effects characterized by neurobehavioral changes, peripheral nervous system toxicity, renal toxicity (immunologic glomerular disease), and death (ATSDR, 1989).

Toxicity resulting from subchronic and chronic exposure to mercury and mercury compounds usually involves the kidneys and/or nervous system, the specific target and effect being dependent on the form of mercury (ATSDR, 1989). Organic mercury, especially methyl mercury, rapidly enters the central nervous system (CNS) resulting in behavioral and neuromotor disorders (ATSDR, 1989; Goyer, 1991). The developing CNS is especially sensitive to this effect, as documented by the epidemiologic studies in Japan and Iraq where ingestion of methyl mercury-contaminated food resulted in severe toxicity and death in adults and severe CNS effects in infants (Bakir et al., 1973; Amin-Zaki et al., 1974; Harada et al., 1978). Blood mercury levels of $<10 \mu\text{g/dL}$ and $300 \mu\text{g/dL}$ corresponded to mild effects and death, respectively (Bakir et al., 1973). Teratogenic effects due to organic or inorganic mercury exposure do not appear to be well documented for humans or animals, although some evidence exists for mercury-induced menstrual cycle disturbances and spontaneous abortions (Derobert and Tara, 1950; Amin-Zaki, 1974; ATSDR, 1989).

A subchronic and chronic oral RfD of 0.0003 mg/kg/day for methyl mercury is based on the ambient level required to produce a blood mercury level of 200 ng Hg/mL (EPA, 1991a, 1992). A subchronic and chronic oral RfD of 0.0003 mg/kg/day for inorganic mercury has been proposed and is based on immunologic glomerulonephritis (EPA, 1992). A Lowest-Observed-Adverse-Effect-Level (LOAEL) of $0.317 \text{ mg Hg/kg/day}$ for inorganic mercury was identified in the key study (Bernaudin et al., 1981). No-Observed-Adverse-Effect-Levels (NOAELs) were not available for oral exposure to inorganic mercury or methyl mercury. A subchronic and chronic inhalation RfC of 0.0003 mg Hg/m^3 for inorganic mercury has been proposed (EPA, 1992) and is based on neurological disorders (increased frequency of intention tremors) following long-term occupational exposure to mercury vapor (Fawer et al., 1983). The LOAELs for subchronic and chronic inhalation

exposures to inorganic mercury are 0.32 and 0.03 mg Hg/m³, respectively. NOAELs were unavailable. An inhalation RfC for methyl mercury has not been determined.

No data were available regarding the carcinogenicity of mercury in humans or animals. The EPA has placed inorganic mercury in weight-of-evidence classification D, not classifiable as to human carcinogenicity (EPA 1991b). Methyl mercury has not been evaluated by the EPA for evidence of human carcinogenic potential and no carcinogenicity slope factors have been calculated.

C.1.12 Nickel

Nickel is a naturally occurring element that may exist in various mineral forms. Nickel is used in a wide variety of applications including metallurgical processes and electrical components, such as batteries (ATSDR, 1988; USAF, 1990). There is some evidence that nickel may be an essential trace element for mammals.

The absorption of nickel is dependent on its physicochemical form, with water soluble forms being more readily absorbed. The metabolism of nickel involves conversion to various chemical forms and binding to various ligands (ATSDR, 1988). Nickel is excreted in the urine and feces with relative amounts for each route being dependent on the route of exposure and chemical form. Most nickel enters the body via food and water consumption, although inhalation exposure in occupational settings is a primary route for nickel-induced toxicity.

In large doses (>0.5 g) some forms of nickel may be acutely toxic to humans when taken orally (Daldrup et al., 1983; Sunderman et al., 1988). Oral LD₅₀ values for rats range from 67 mg Ni/kg (nickel sulfate hexahydrate) to > 9,000 mg Ni/kg (nickel powder) (ATSDR, 1988). Toxic effects of oral exposure to nickel usually involve the kidneys with some evidence from animal studies showing a possible developmental/reproductive toxicity effect (ATSDR, 1988; Goyer, 1991).

Inhalation exposure to some nickel compounds will cause toxic effects in the respiratory tract and immune system (ATSDR, 1988; Goyer, 1991). Inhalation LC₅₀ values for animals range from 0.97 mg Ni/m³ for rats (6-hour exposure) to 15 mg Ni/m³ for guinea pigs (time not specified) (USAF, 1990). Acute inhalation exposure of humans to nickel may produce headache, nausea, respiratory disorders and death (Goyer, 1991). Asthmatic conditions have also been documented for inhalation exposure to nickel (Goyer, 1991). Soluble nickel compounds tend to be more toxic than insoluble compounds (Goyer, 1991). Nickel carbonyl is known to be extremely toxic to humans upon acute inhalation exposure (Goyer, 1991).

Sensitivity reactions to nickel are well documented and usually involve contact dermatitis reactions resulting from contact with nickel-containing items such as cooking utensils, jewelry, coins, etc (ATSDR, 1988).

A chronic and subchronic oral RfD of 0.02 mg/kg/day for soluble nickel salts is based on changes in organ and body weights of rats receiving dietary nickel sulfate hexahydrate (5 mg/kg/day) for two years (EPA, 1991a). A No-Observed-Adverse-Effects-Level (NOAEL) and Lowest-Observed-Adverse-Effects-Level (LOAEL) of 5 mg/kg/day and 50 mg/kg/day, respectively, were reported in the key study (Ambrose et al., 1976). An uncertainty factor of 300 reflects interspecies extrapolation uncertainty, protection of sensitive populations, and a modifying factor

of 3 for a database deficient in reproductive/developmental studies. An inhalation RfC for soluble nickel salts is under review and not currently available.

The primary target organs for nickel-induced systemic toxicity are the lungs and upper respiratory tract for inhalation exposure and the kidneys for oral exposure (ATSDR, 1988; Goyer, 1991). Other target organs include the cardiovascular system, immune system and the blood.

Epidemiologic studies have shown that occupational inhalation exposure to nickel dust (primarily nickel subsulfide) at refineries has resulted in increased incidences of pulmonary and nasal cancer (NAS, 1975; Enterline and Marsh, 1982; ATSDR, 1988). Inhalation studies using rats have also shown nickel subsulfide or nickel carbonyl to be carcinogenic (Sunderman et al., 1959; Sunderman and Donnelly, 1965; Ottolenghi et al., 1974). Based on these data, the EPA has classified nickel subsulfide and nickel refinery dust in weight-of-evidence group A, Human Carcinogen. Carcinogenicity slope factors of $1.7E+0$ and $8.4E-01$ (mg/kg/day)⁻¹ and unit risks of 4.8×10^{-4} (μg/m³)⁻¹ and 2.4×10^{-4} (μg/m³)⁻¹ have been calculated for nickel subsulfide and nickel refinery dust, respectively (EPA, 1991a). Based on an increased incidence of pulmonary carcinomas and malignant tumors in animals exposed to nickel carbonyl by inhalation or by intravenous injection, this compound had been placed in weight-of-evidence group B2, probable human carcinogen. No unit risk values were available for nickel carbonyl.

C.1.13 Nitrate/Nitrite

Nitrates occur naturally in soil, water, air, and plant material. The levels of nitrates in soil and water can be increased with the use of commercial nitrogenous fertilizers and the subsequent return of waste from grazing animals. Nitrates find their way into crops in amounts based on the genetic character of the species. Spinach, carrots, and beets contain relatively high levels of nitrates. Environmental and land-management practices also play a roll in nitrate uptake. Nitrogen compounds contained in industrial waste can also be converted to nitrates by the nitrogen cycle and contaminate soil and surface water (WHO 1978).

Nitrites are formed by the action of bacteria during the formation of nitrates. Concentrations in plant, soil, and water are usually low. During storage of vegetables at room temperature, bacteria can convert nitrates to nitrites at high levels (3600 mg/kg) (WHO 1978). Nitrite levels in food are allowed to be 0.01%. Nitrates and nitrites are extensively used to prevent growth of toxic-producing bacteria in meat. *Clostridium botulinum* is one of the bacteria of concern because it causes botulism.

The health risk to humans is based on clinical and epidemiological studies. The main toxic effect of nitrate/nitrite exposure is due to ingestion, causing development of methemoglobinemia (irreversible bonding of oxygen to hemoglobin). Health risks are related to high levels in drinking water and food. In healthy adults, the intake of nitrates and nitrites is harmless. Infants are the most vulnerable group. Intestinal bacteria, such as *Bacillus subtilis*, reduce nitrates to nitrites. Intestinally absorbed nitrite reacts with hemoglobin to form methemoglobin which is converted to oxyhemoglobin by NADH-methemoglobin reductase. However, this enzyme pathway is not developed in infants. Microbes in the infant's intestinal system or food may convert nitrates to nitrites causing methemoglobinemia. The most common way for infants to be exposed to high levels of nitrates is by reconstituting dry milk formula with contaminated water or by feeding infants vegetables stored at room temperature. Nitrate levels of 50 ppm in well water may cause

methemoglobin in infants. Nitrates and nitrites in healthy adults are quickly filtered out by the kidneys. Other toxic reactions are vasodilation, loss of blood pressure, cyanosis, vomiting, coma, respiratory failure, or death (Arena 1974).

C.1.14 Selenium

Selenium is an essential human nutrient. It is found in the environment as sodium selenite or sodium selenate. Most selenium exposure comes from foods. Selenium is used industrially in the manufacture of rectifiers and photoelectric cells. Selenium disulfide is a common ingredient in anti-dandruff shampoos (ATSDR 1989f).

The study of selenium toxicity in humans has been conducted in areas of the world where selenium occurs naturally in very high concentrations. Persons consuming food and water from these regions chronically have experienced hair loss, deformed nails, jaundice, chronic gastrointestinal disturbances, edema, vertigo and fatigue. In cattle and other livestock selenium toxicity is characterized by the "blind staggers" and hoof deformities. Anemia and liver damage have been reported in laboratory animals from chronic high doses of selenium compounds. Selenium compounds except selenium disulfide are not known to cause cancer (ATSDR 1989f).

C.1.15 Silver

Silver is a relatively rare metal that occurs naturally in the earth's crust and is released to the environment from various industrial sources. Human exposure to silver and silver compounds can occur orally, dermally, or by inhalation. Silver is found in most tissues, but has no known physiologic function.

In humans, accidental or intentional ingestion of large doses of silver nitrate has produced corrosive damage of the gastrointestinal tract, abdominal pain, diarrhea, vomiting, shock, convulsions, and death (EPA, 1985). Respiratory irritation was noted following acute inhalation exposure to silver or silver compounds. Silver nitrate solutions are highly irritating to the skin, mucous membranes, and eyes (Stokinger, 1981).

Ingestion, inhalation, or dermal absorption of silver may cause argyria, the most common indicator of long-term exposure to silver or silver compounds in humans. Argyria is a gray or blue-gray, permanent discoloration of the skin and mucous membranes that is not a toxic effect per se, but is considered cosmetically disfiguring. Chronic inhalation exposure of workers to silver oxide and silver nitrate dusts resulted in upper and lower respiratory irritation, deposition of granular silver-containing deposits in the eyes, impaired night vision, and abdominal pain (Rosenman et al., 1979). Mild allergic responses have been attributed to dermal contact with silver (ATSDR, 1990).

In long-term oral studies with experimental animals, silver compounds have produced slight thickening of the basement membranes of the renal glomeruli, growth depression, shortened lifespan, and granular silver-containing deposits in skin, eyes, and internal organs (Matuk et al., 1981; Olcott, 1948, 1950). Hypoactivity was seen in rats subchronically exposed to silver nitrate in drinking water (Rungby and Danscher, 1984).

A Reference Dose (RfD) of 0.005 mg/kg/day for subchronic and chronic exposure was calculated from a lowest-observed-adverse-effect level (LOAEL) of 0.014 mg/kg/day for argyria observed in patients receiving i.v. injections of silver arsphenamine (EPA, 1992a,b). Data are presently insufficient to derive a Reference Concentration (RfC) for silver (EPA, 1992a).

Data adequate for evaluating the carcinogenicity of silver to humans or animals by ingestion, inhalation, or other routes of exposure were not found. Based on EPA guidelines, silver is placed in weight-of-evidence group D, not classifiable as to human carcinogenicity (EPA, 1992a).

C.1.16 Vanadium

Vanadium is a metallic element that occurs in six oxidation states and numerous inorganic compounds. Some of the more important compounds are vanadium pentoxide (V_2O_5), sodium metavanadate ($NaVO_3$), sodium orthovanadate (Na_3VO_4), vanadyl sulfate ($VOSO_4$), and ammonium vanadate (NH_4VO_3). Vanadium is used primarily as an alloying agent in steels and non-ferrous metals (ATSDR, 1990). Vanadium compounds are also used as catalysts and in chemical, ceramic or specialty applications.

Vanadium compounds are poorly absorbed through the gastrointestinal system (0.5-2% of dietary amount) (NRCC, 1980; ICRP, 1960; Byrne and Kosta, 1978), but slightly more readily absorbed through the lungs (20-25%) (ICRP, 1960; Davies and Bennett, 1983). Absorbed vanadium is widely distributed in the body, but short-term localization occurs primarily in bone, kidneys, and liver (Vouk, 1979; Roshchin et al., 1980; Parker et al., 1980; Sharma et al., 1980; Wiegmann et al., 1982). In the body, vanadium can undergo changes in oxidation state (interconversion of vanadyl (+4) and vanadate (+5) forms) and it can also bind with blood protein (transferin) (Harris et al., 1984). Vanadium is excreted primarily in the feces following oral exposures and primarily in the urine following inhalation exposures (Tipton et al., 1969; ATSDR, 1990).

The toxicity of vanadium depends on its physico-chemical state; particularly on its valence state and solubility. Based on acute toxicity, pentavalent NH_4VO_3 has been reported to be more than twice as toxic as trivalent VCl_3 and more than 6 times as toxic as divalent VI_2 . Pentavalent V_2O_5 has been reported to be more than 5 times as toxic as trivalent V_2O_3 (Roschin, 1967). In animals, acutely toxic oral doses cause vasoconstriction, diffuse desquamative enteritis, congestion and fatty degeneration of the liver, congestion and focal hemorrhages in the lungs and adrenal cortex (Gosselin et al., 1984). Minimal effects seen after subchronic oral exposures to animals include diarrhea, altered renal function, and decreases in erythrocyte counts, hemoglobin, and hematocrit (Domingo et al., 1985; Zaporowska and Wasilewski, 1990). In humans, intestinal cramps and diarrhea may occur following subchronic oral exposures. These studies indicate that for subchronic and chronic oral exposures the primary targets are the digestive system, kidneys, and blood.

Reference Doses (RfD) for chronic oral exposures are: 0.007 mg/kg/day for vanadium; 0.009 mg/kg/day for vanadium pentoxide; 0.02 mg/kg/day for vanadyl sulfate; and 0.001 mg/kg/day for sodium metavanadate (EPA, 1987, 1991a,b). The subchronic RfDs for these compounds are the same as the chronic RfDs, except for sodium metavanadate, which is 0.01 mg/kg/day (EPA, 1987, 1991a,b).

Inhalation exposures to vanadium and vanadium compounds result primarily in adverse effects to the respiratory system (Sax, 1984; ATSDR, 1990). In laboratory studies, minimal effects (throat irritation and coughing) occurred after an 8-hr exposure to 0.1 mg V/m³ (Zenz and Berg, 1967). In studies on workers occupationally exposed to vanadium, the most common reported symptoms were: irritation of the respiratory tract, conjunctivitis, dermatitis, cough, bronchospasm, pulmonary congestion, and bronchitis (Symanski, 1939; Sjoberg, 1950, 1951, 1955, 1956; Vintinner et al., 1955; Lewis 1959; Tebrock and Machle, 1968; Roshchin, 1968; Kiviluoto et al., 1981b). Quantitative data are; however, insufficient to derive a subchronic or chronic inhalation Reference Concentration (RfC) for vanadium or vanadium compounds.

There is little evidence that vanadium or vanadium compounds are reproductive toxins or teratogens. There is also no evidence that any vanadium compound is carcinogenic; however, very few adequate studies are available for evaluation. Vanadium has not been classified as to carcinogenicity by the EPA (1991a).

C.1.17 Zinc

Zinc is used primarily in galvanized metals and metal alloys, but zinc compounds also have wide commercial applications as chemical intermediates, catalysts, pigments, vulcanization activators and accelerators in the rubber industry, UV stabilizers, and supplements in animal feeds and fertilizers. They are also used in rayon manufacture, smoke bombs, soldering fluxes, mordants for printing and dyeing, wood preservatives, mildew inhibitors, deodorants, antiseptics, and astringents (Lloyd, 1984; ATSDR, 1989). In addition, zinc phosphide is used as a rodenticide.

Zinc is an essential element with recommended daily allowances ranging from 5 mg for infants to 15 mg for adult males (NRC, 1989).

Gastrointestinal absorption of zinc is variable (20-80%) and depends on the chemical compound as well as on zinc levels in the body and dietary concentrations of other nutrients (EPA, 1984). In individuals with normal zinc levels in the body, gastrointestinal absorption is 20-30% (ATSDR, 1989). Information on pulmonary absorption is limited and complicated by the potential for gastrointestinal absorption due to mucociliary clearance from the respiratory tract and subsequent swallowing. Zinc is present in all tissues with the highest concentrations in the prostate, kidney, liver, heart, and pancreas. Zinc is a vital component of many metalloenzymes such as carbonic anhydrase, which regulates CO₂ exchange (Stokinger, 1981). Homeostatic mechanisms involving metallothionein in the mucosal cells of the gastrointestinal tract regulate zinc absorption and excretion (ATSDR, 1989).

In humans, acutely toxic oral doses of zinc cause nausea, vomiting, diarrhea, and abdominal cramps and in some cases gastric bleeding (Elinder, 1986; Moore, 1978; ATSDR, 1989). Ingestion of zinc chloride can cause burning in the mouth and throat, vomiting, pharyngitis, esophagitis, hypocalcemia, and elevated amylase activity indicative of pancreatitis (Chobanian, 1981). Zinc phosphide, which releases phosphine gas under acidic conditions in the stomach, can cause vomiting, anorexia, abdominal pain, lethargy, hypotension, cardiac arrhythmias, circulatory collapse, pulmonary edema, seizures, renal damage, leukopenia, and coma and death in days to weeks (Mack, 1989). The estimated fatal dose is 40 mg/kg. Animals dosed orally with zinc compounds develop pancreatitis, gastrointestinal and hepatic lesions, and diffuse nephrosis.

Gastrointestinal upset has also been reported in individuals taking daily dietary zinc supplements for up to 6 weeks (Samman and Roberts, 1987). There is also limited evidence that the human immune system may be impaired by subchronic exposures (Chandra, 1984). In animals, gastrointestinal and hepatic lesions, (Allen et al., 1983; Brink et al., 1959); pancreatic lesions (Maita et al., 1981; Drinker et al., 1927a); anemia (ATSDR, 1989; Fox and Jacobs, 1986; Maita et al., 1981); and diffuse nephrosis (Maita et al., 1981; Allen et al., 1983) have been observed following subchronic oral exposures.

Chronic oral exposures to zinc have resulted in hypochromic microcytic anemia associated with hypoceruloplasminemia, hypocupremia, and neutropenia in some individuals (Prasad et al., 1978; Porter et al., 1977). Anemia and pancreatitis were the major adverse effects observed in chronic animal studies (Aughey et al., 1977; Drinker et al., 1927a; Walters and Roe, 1965; Sutton and Nelson, 1937). Teratogenic effects have not been seen in animals exposed to zinc; however, high oral doses can affect reproduction and fetal growth (Ketcheson et al., 1969; Schlicker and Cox 1967, 1968; Sutton and Nelson, 1937).

The reference dose for chronic oral exposure to zinc is under review by EPA; the currently accepted RfD for both subchronic and chronic exposures is 0.2 mg/kg/day based on clinical data demonstrating zinc-induced copper deficiency and anemia in patients taking zinc sulfate for the treatment of sickle cell anemia (EPA, 1992). The chronic oral RfD for zinc phosphide is 0.0003 mg/kg/day (EPA, 1991a), and the subchronic RfD is 0.003 mg/kg/day (EPA, 1992).

Under occupational exposure conditions, inhalation of zinc compounds (mainly zinc oxide fumes) can result in a condition identified as "metal fume fever," which is characterized by nasal passage irritation, cough, rales, headache, altered taste, fever, weakness, hyperpnea, sweating, pains in the legs and chest, leukocytosis, reduced lung volume, and decreased diffusing capacity of carbon monoxide (ATSDR, 1989; Bertholf, 1988). Inhalation of zinc chloride can result in nose and throat irritation, dyspnea, cough, chest pain, headache, fever, nausea and vomiting, and respiratory disorders such as pneumonitis and pulmonary fibrosis (ITII, 1988; ATSDR, 1989; Nemery, 1990). Pulmonary inflammation and changes in lung function have also been observed in inhalation studies on animals (Amur et al., 1982; Lam et al., 1985; Drinker and Drinker, 1928).

Although "metal fume fever" occurs in occupationally exposed workers, it is primarily an acute and reversible effect that is unlikely to occur under chronic exposure conditions when zinc air concentrations are less than 8-12 mg/m³ (ATSDR, 1989). Gastrointestinal distress, as well as enzyme changes indicative of liver dysfunction, have also been reported in workers occupationally exposed to zinc (NRC, 1979; Stokinger, 1981; EPA, 1991a; Guja, 1973; Badawy et al., 1987a); however, it is unclear as to what extent these effects might have been caused by pulmonary clearance, and subsequent gastrointestinal absorption. Consequently, there are no clearly defined toxic effects that can be identified as resulting specifically from pulmonary absorption following chronic low level inhalation exposures. Animal data for chronic inhalation exposures are not available. An inhalation reference concentration has not been derived for zinc or zinc compounds (U.S. EPA, 1992).

No case studies or epidemiologic evidence has been presented to suggest that zinc is carcinogenic in humans by the oral or inhalation route (EPA, 1991a). In animal studies, zinc sulfate in drinking water or zinc oleate in the diet of mice for a period of one year did not result in a

statistically significant increase in hepatomas, malignant lymphomas, or lung adenomas (Walters and Roe, 1965); however, in a 3-year, 5-generation study on tumor-resistant and tumor-susceptible strains of mice, exposure to zinc in drinking water resulted in increased frequencies of tumors from the F₀ to the F₄ generation in the tumor-resistant strain (from 0.8 to 25.7%, vs. 0.0004% in the controls), and higher tumor frequencies in two tumor-susceptible strains (43.4% and 32.4% vs. 15% in the controls) (Halme, 1961).

Zinc is placed in weight-of-evidence Group D, not classifiable as to human carcinogenicity due to inadequate evidence in humans and animals (EPA, 1991a).

C.2 ORGANICS

C.2.1 Acetone

Acetone is a widely used laboratory solvent. It is used in the production of lubricating oil and in the manufacture of pesticides and pharmaceuticals. In the chemical analyses from many hazardous waste sites, acetone is considered to be laboratory contaminant. The levels found at this site are high enough to warrant investigation. Exposure to acetone results in irritation of the eyes, nose and throat, headaches, dizziness, and dermatitis. Degeneration of the kidneys has been shown in animal exposure studies. There is no evidence that acetone is a carcinogen or mutagen (Sittig 1981).

C.2.2 Benzene

Benzene is absorbed via ingestion, inhalation, and skin application. Experimental data indicate that animals can absorb up to 95% of oral doses and that humans can absorb up to 80% of inhaled benzene (after 5 minutes of exposure) (Sabourin et al., 1987; Srobova et al., 1950). Humans may absorb benzene vapors through the skin as well as the lungs; of the total dose absorbed by the two routes, an estimated 22-36% enters the body through the skin (Susten, 1985).

Autopsy of a youth who died while sniffing benzene revealed that the chemical was distributed to the urine, stomach, bile, liver, kidney, abdominal fat, and brain (Winek and Collum, 1971). The depots for benzene and its metabolites in animals are similar to those in humans, and in addition, include the fetus and placenta, bone marrow, Zymbal gland, and oral and nasal cavities (Ghantous and Danielsson, 1986; Rickert et al., 1979; Low et al., 1989).

Numerous studies indicate that the metabolism of benzene is required for its toxicity (Kalf et al., 1987). The liver is the main site for the metabolism of benzene; the bone marrow, a minor site (ATSDR, 1992). Phenol, hydroquinone, catechol, and benzene oxide are the major metabolites (Kalf et al., 1987; Snyder, 1987). The metabolite(s) of benzene that are responsible for its toxicity have not been positively identified, but likely candidates include muconaldehyde, quinones, and free radicals generated by oxidizing enzymes (Henderson et al., 1989; Snyder, 1987).

Benzene is eliminated either unchanged in expired air or as metabolites in the urine (ATSDR, 1992). The proportions of the administered dose excreted by each route and the half-times for excretion are dependent on route, dose, and duration of exposure.

Lethal oral doses of benzene are estimated to be 10 mL in humans; oral LD₅₀ values for benzene in rats range from 0.93 to 5.96 g/kg (Cornish and Ryan, 1965; Withey and Hall, 1975). These data indicate that benzene is of low acute toxicity (O'Bryan and Ross, 1986).

Limited data show that nonlethal oral doses of benzene can impact the nervous, hematological, and immunological systems. Ingested benzene produces symptoms of neurotoxicity at acute doses of 2 mL for humans and 325 mg/kg for rats (Thienes and Haley, 1972; Clayton and Clayton, 1981; Cornish and Ryan, 1965). A four week exposure of mice to ≥ 8 mg of benzene/kg/day in the drinking water induced the synthesis and catabolism of monoamine neurotransmitters and produced dose-related decreases in red-blood cell parameters and lymphocyte numbers (Hsieh et al., 1988b). Rats and mice that were treated with benzene by gavage for 103 weeks developed a dose-related lymphocytopenia (LOAEL, 25 mg/kg/day) and mice had hyperplasia of the bone marrow and lymphoid depletion of the splenic follicles and thymus (100 mg/kg/day) (Huff et al., 1989).

Inhalation of benzene vapor concentrations of 20,000 ppm for 5-10 minutes can be fatal to humans; death results from central nervous system depression (Clayton and Clayton, 1981). The estimated LC₅₀ value for the rat is 13,700 ppm (Drew and Fouts, 1974).

As with orally administered benzene, the targets for nonlethal concentrations of inhaled benzene include the nervous, hematological, and immunological systems. Neurological symptoms in humans may appear at exposure concentrations of 700 ppm (Clayton and Clayton, 1981). In animals, 1 week of exposure to 300 ppm induced behavioral effects (Drew and Fouts, 1974), and one to four weeks of exposure to benzene concentrations ranging from 21-50 ppm suppressed the bone marrow (NOAEL, 10 ppm) (Cronkite et al., 1985; Toft et al., 1982), the cellular immune response (NOAEL, 10 ppm) (Rosenthal and Snyder, 1985), and the humoral immune response (LOAEL, 50 ppm) (Aoyama, 1986).

Subchronic and chronic exposures to benzene vapors induce a progressive depletion of the bone marrow and dysfunction of the hematopoietic system. Early symptoms of bone marrow depression include leukopenia, anemia or thrombocytopenia, or a combination of the three (Snyder, 1984). A group of workers exposed to benzene concentrations of 30 and 150 ppm for 4 months to 1 year had increased incidences of pancytopenia (Aksoy et al., 1971; Aksoy et al., 1972; Aksoy and Erdem, 1978). A group of patients who had been exposed to benzene concentrations of 150 to 650 ppm for 4 months to 15 years exhibited severe blood dyscrasias and eight of the 32 patients died with thrombocytopenic hemorrhage and infection (Aksoy et al., 1972). The human data are supported by animal data showing bone marrow suppression in mice and rats exposed to benzene concentrations ranging from 10 ppm for 24 weeks to 300 ppm for 13 weeks (Baarson et al., 1984; Ward et al., 1985).

Benzene may also have long-term effects on the central nervous system. Workers exposed to benzene for 0.5 to 4 years exhibited EEG changes and atypical sleep activity consistent with neurotoxicity (Kellerova, 1985). Others exposed to benzene concentrations of 210 ppm for 6-8 years had peripheral nerve damage (Baslo and Aksoy, 1982).

In humans, benzene crosses the placenta and is present in the cord blood in amounts equal to those in maternal blood (Dowty et al., 1976); however, studies of the effects of benzene on human reproduction and development have been confounded by the presence of other chemicals in the

environment (USAF, 1989). Benzene does produce developmental effects (fetal toxicity, but not malformations) in the offspring of treated animals, mostly at maternally toxic doses (Nawrot and Staples, 1979; Seidenberg et al., 1986; Keller and Snyder, 1988).

Reference doses/concentrations for benzene have not been established. An oral risk assessment for benzene will be reviewed by an EPA work group and an inhalation risk assessment is currently under review (EPA, 1992a).

Benzene is carcinogenic in humans and animals by inhalation and in animals by the oral route of exposure. Occupational exposure to benzene has been associated mainly with increased incidences of acute myeloblastic or erythroblastic leukemias and chronic myeloid and lymphoid leukemias among workers (Aksoy, 1989). Workers at risk were exposed in one study to 8-hour TWA concentrations ranging from 10 to 100 ppm (Rinsky et al., 1981) and in another to 8-hour TWA concentrations ranging from <2 to >25 ppm (Ott et al., 1978). In a historical prospective mortality study of chemical workers, Yin et al. (1987) described a dose-response relationship between exposure to benzene and lymphatic and hematopoietic cancers, which adds strength to the association between exposure in the workplace and cancer development. Studies in animals have demonstrated an association between oral and inhalation exposure to benzene and the development of a variety of tumors, including lymphoma and carcinomas of the Zymbal gland, oral cavity, mammary gland, ovaries, lung, and skin (Huff et al., 1989; Maltoni et al., 1989). In one study C57Bl/BNL mice had increased incidences of leukemia, lymphoma, and solid tumors after exposure to 300 ppm for only 16 weeks (Cronkite et al., 1985; Cronkite, 1983).

Based on "several studies of increased incidence of nonlymphocytic leukemia from occupational exposure, increased incidence of neoplasia in rats and mice exposed by inhalation and gavage, and some supporting data," benzene has been placed in the EPA weight-of-evidence classification A, human carcinogen (EPA, 1991a). The oral and inhalation slope factors for benzene are $2.9\text{E-}2$ (mg/kg/day)⁻¹ and the oral and inhalation unit risk values are $8.3\text{E-}7$ and $8.3\text{E-}6$, respectively, based on the studies of Ott et al. (1978), Rinsky et al. (1981), and Wong et al. (1983) (EPA, 1992a,b).

C.2.3 *Bis*(2-ethylhexyl)phthalate

Bis(2-ethylhexyl)phthalate is a colorless oily liquid that is extensively used as a plasticizer in a wide variety of industrial, domestic and medical products. It is an environmental contaminant and has been detected in ground water, surface water, drinking water, air, soil, plants, fish and animals (Sittig, 1985; Sandmeyer and Kirwin, 1978). It is rapidly absorbed from the gastrointestinal tract primarily as mono(2-ethylhexyl)phthalate (Pollack et al., 1985; Teirlynck and Belpaire, 1985). The diester can be absorbed through the skin and from the lungs (Elsisi et al., 1989; Pegg, 1982). It is rapidly metabolized in the blood and tissues to the monoester, which can be excreted as a glucuronide conjugate or further hydrolyzed to phthalic acid and excreted (Kluwe, 1982; Albro et al., 1982).

Animal studies have indicated that the primary target organs are the liver and kidneys (Carpenter et al., 1953; EPA, 1987a,b); however, higher doses are reported to result in testicular effects and decreased hemoglobin and packed cell volume (Kluwe et al., 1982; Gray et al., 1977). The primary intracellular effects of *bis*(2-ethylhexyl)phthalate in the liver and kidneys are an

increase in the smooth endoplasmic reticulum and a proliferation in the number and size of peroxisomes (Kluwe et al., 1982; Reddy and Lalwani, 1983; Tomaszewski et al., 1986). An epidemiological study reported no toxic effects from occupational exposure to air concentrations of *bis*(2-ethylhexyl)phthalate up to 0.16 mg/m^3 (Thiess et al., 1978). Other studies on occupational exposures to mixtures of phthalate esters containing *bis*(2-ethylhexyl)phthalate have reported polyneuritis and sensory-motor polyneuropathy with decreased thrombocytes, leukocytes and hemoglobin in some exposed workers (Milkov et al., 1973; Gilioli et al., 1978). Developmental toxicity studies with rats and mice have shown that *bis*(2-ethylhexyl)phthalate is fetotoxic and teratogenic when given orally during gestation (Wolkowski-Tyl et al., 1984a and b; Shiota and Mima, 1985). Oral exposure has also been shown to result in decreased sperm count in rats (Siddipui and Srivastava, 1992).

A Reference Dose (RfD) of 0.02 mg/kg/day for both subchronic and chronic oral exposure was calculated from a lowest-observed-adverse-effect level (LOAEL) of 19 mg/kg/day based on increased relative liver weight in guinea pigs given 0, 19, or $64 \text{ mg bis(2-ethylhexyl)phthalate/kg/day}$ for 12 months in their diet (Carpenter et al., 1953; EPA, 1992 a,b). A Reference Concentration (RfC) for inhalation exposure is not available (EPA, 1992b).

Bis(2-ethylhexyl)phthalate is known to induce the proliferation of peroxisomes, which has been associated with carcinogenesis (Rao and Reddy, 1991). Dose-dependent, statistically-significant increases in the incidences of hepatocellular carcinomas and combined carcinomas and adenomas were seen in mice and rats exposed to *bis*(2-ethylhexyl)phthalate in their diet for 103 weeks (Kluwe, et al., 1982). An increased incidence of neoplastic nodules and hepatocellular carcinomas was also reported in rats (Rao et al., 1990).

Based on EPA guidelines, *bis*(2-ethylhexyl)phthalate was assigned to weight-of-evidence Group B2, probable human carcinogen, on the basis of an increased incidence of liver tumors in rats and mice. A carcinogenicity slope factor (q_1^*) of $0.014 (\text{mg/kg/day})^{-1}$ for oral exposure was based on the combined incidence of hepatocellular carcinomas and adenomas in male mice (Kluwe, et al., 1982; EPA, 1992b). A drinking water unit risk of $4.0\text{E-}7 (\mu\text{g/L})^{-1}$ was calculated based on the q_1^* . A quantitative estimation of carcinogenic risk from inhalation exposure is not available (EPA, 1992b).

C.2.4 Carbon Tetrachloride

Humans are sensitive to carbon tetrachloride intoxication by oral, inhalation and dermal routes. Oral and inhalation exposure to high concentrations of carbon tetrachloride results in acute central nervous system effects including dizziness, vertigo, headache, depression, confusion, incoordination and, in severe cases, respiratory failure, coma and death. Gastrointestinal problems including nausea, abdominal pain and diarrhea, often accompany these narcotic effects. Liver and kidney damage can appear after the acute symptoms subside. All symptoms can occur following a single oral or inhalation exposure. Milder narcotic effects followed by liver and kidney damage have been reported following dermal exposure. Although an inhalation exposure of about 1000 ppm for a few minutes to hours will cause the narcotic effects in 100% of the population, large variations in sensitivity are seen. Alcohol intake greatly increases human sensitivity to carbon tetrachloride; consequently, exposure to 250 ppm for 15 minutes can be life threatening to an alcoholic.

Subchronic and chronic exposure to doses as low as 10 ppm can result in liver and kidney damage (Sax and Lewis, 1989; ATSDR, 1989). Lung damage has also been reported in animals and humans but is not route specific and is believed to be secondary to kidney damage (Sax and Lewis, 1989). Prolonged exposure has been observed to cause visual effects in both humans and animals. Changes in the visual field, reduced corneal sensitivity, subnormal dark adaption, and changes in color perception have been reported in humans exposed by inhalation to a minimum concentration of 6.4 ppm, 1 hour/day for an average of 7.7 years. Increased hepatic enzyme activities indicative of liver damage have also been observed (Smyth et al., 1936; Barnes and Jones, 1967; Moeller, 1973; ATSDR, 1989).

Maternal toxicity and fetotoxic effects have been reported in rats following oral or inhalation exposure to carbon tetrachloride during gestation (Wilson, 1954; Schwetz et al., 1974). Repeated inhalation exposure of male rats to carbon tetrachloride concentrations of 200 ppm or greater has been reported to cause degeneration of the testicular germinal epithelium as well as severe liver and kidney damage (Adams et al., 1952).

A subchronic reference dose (RfD_s) of 0.007 mg/kg/day has been calculated for oral exposure from a no-observed-adverse-effect level (NOAEL) of 0.71 mg/kg/day determined in a 12-week rat study (EPA, 1992a). Significantly higher doses caused minimal liver damage (Bruckner et al., 1986). A dose of 7.1 mg/kg/day was considered a lowest-observed-adverse-effect level (LOAEL). A chronic reference dose (RfD_c) of 0.0007 mg/kg/day was calculated by adding an additional uncertainty factor of 10 to account for the use of a subchronic study. Confidence in the oral RfD values is rated medium by EPA (1992b).

A chronic or subchronic reference concentration (RfC) for inhalation exposure is currently under development by the EPA.

Although data for the carcinogenicity of carbon tetrachloride in humans are inconclusive, there is ample evidence in animals that the chemical can cause liver cancer. Hepatocellular carcinomas have been induced in hamsters, rats and mice after oral carbon tetrachloride treatment for 16 to 76 weeks. Liver tumors have also been demonstrated in rats following inhalation exposure, but the doses were not quantitatively established. The EPA weight-of-evidence classification for both oral and inhalation exposure is B2, probable human carcinogen based on adequate animal evidence. Carcinogenicity slope factors of $0.13 \text{ (mg/kg/day)}^{-1}$ for oral exposure and $0.053 \text{ (mg/kg/day)}^{-1}$ for inhalation exposure have been calculated from the oral exposure experiments with hamsters, rats and mice (U.S. EPA, 1992a,b; Della Porta et al., 1961; Edwards et al., 1942; NCI, 1976a, 1976b; Weisburger, 1977). A drinking water unit risk of $3.7 \times 10^{-6} \text{ (}\mu\text{g/L)}^{-1}$ and an inhalation unit risk of $1.5 \times 10^{-5} \text{ (}\mu\text{g/m}^3\text{)}^{-1}$ have also been calculated by U.S.EPA (1992b).

C.2.5 Chloroform

Chloroform is a colorless, volatile liquid that is widely used as a general solvent and as an intermediate in the production of refrigerants, plastics, and pharmaceuticals (Torkelson and Rowe, 1976; IARC, 1976). Chloroform is rapidly absorbed from the lungs and the gastrointestinal tract, and to some extent through the skin. It is extensively metabolized in the body, with carbon dioxide as the major end product. The primary sites of metabolism are the liver and kidneys. Excretion of

chloroform occurs primarily via the lungs, either as unchanged chloroform or as carbon dioxide (ATSDR, 1989).

Target organs for chloroform toxicity are the liver, kidneys, and central nervous system. Liver effects (hepatomegaly, fatty liver, and hepatitis) were observed in individuals occupationally exposed to chloroform (Bomski et al., 1967). Several subchronic and chronic studies by the oral or inhalation routes of exposure documented hepatotoxic effects in rats, mice, and dogs (Palmer et al., 1979; Munson et al., 1979; Heywood et al., 1979). Renal effects were reported in rats and mice following oral and inhalation exposures (Roe et al., 1979; Reuber, 1976; Torkelson et al., 1976), but evidence for chloroform-induced renal toxicity in humans is sparse. Chloroform is a central nervous system depressant, inducing narcosis and anesthesia at high concentrations. Lower concentrations may cause irritability, lassitude, depression, gastrointestinal symptoms, and frequent and burning urination (ATSDR, 1989).

Developmental toxicity studies with rodents indicate that inhaled and orally administered chloroform is toxic to dams and fetuses. Possible teratogenic effects were reported in rats and mice exposed to chloroform by inhalation (Schwetz et al., 1974; Murray et al., 1979). Chloroform may cause sperm abnormalities in mice and gonadal atrophy in rats (Palmer et al., 1979; Reuber, 1979; Land et al., 1981).

A Reference Dose (RfD) of 0.01 mg/kg/day for subchronic and chronic oral exposure was calculated from a lowest-observed-adverse-effect level (LOAEL) of 15 mg/kg/day based on fatty cyst formation in the liver of dogs exposed to chloroform for 7.5 years (Heywood et al., 1979). Development of an inhalation Reference Concentration (RfC) is presently under review (EPA, 1992b).

Epidemiological studies indicate a possible relationship between exposure to chloroform present in chlorinated drinking water and cancer of the bladder, large intestine, and rectum. Chloroform is one of several contaminants present in drinking water, but it has not been identified as the sole or primary cause of the excess cancer rate (ATSDR, 1989; EPA, 1985). In animal carcinogenicity studies, positive results included increased incidences of renal epithelial tumors in male rats, hepatocellular carcinomas in male and female mice, and kidney tumors in male mice (Jorgensen et al., 1985; Roe et al., 1979; NCI, 1976).

Based on EPA guidelines, chloroform was assigned to weight-of-evidence Group B2, probable human carcinogen, on the basis of an increased incidence of several tumor types in rats and in three strains of mice. The carcinogen slope factor (q_1^*) for chloroform is $6.1\text{E-}3$ (mg/kg/day) $^{-1}$ for oral exposure (EPA, 1992b) and $8.1\text{E-}2$ ($\mu\text{g}/\text{m}^3$) $^{-1}$ for inhalation exposure (EPA, 1992a). An inhalation unit risk of $2.3\text{E-}5$ ($\mu\text{g}/\text{m}^3$) $^{-1}$ is based on hepatocellular carcinomas in mice in an oral gavage study (EPA, 1992b).

C.2.6 1,1-Dichloroethene

Groups of 48 each male and female Sprague-Dawley rats (Spartan substrain) were administered 50, 100, or 200 ppm 1,1-dichloroethylene in drinking water for a period of 2 years. Control groups of 80 animals/sex were maintained for the same period. Daily intake was calculated by the authors to be 7, 10, or 20 mg/kg bw/day for males and 9, 14, or 30 mg/kg bw/day for females. There were

no treatment-related effects on mortality, body or organ weight, clinical chemistry, urinalysis, hematology, or numbers of tumors. The only pathologic findings were of hepatic lesions, generally characterized by minimal mid-zonal hepatocellular fatty change and hepatocellular swelling. These findings were noted in rats of all female treatment groups. In male rats, only the 200 ppm treatment group showed a statistically significant increase in the incidence of hepatocellular swelling, but this trend was also observed in animals receiving 100 ppm 1,1-dichloroethylene.

As part of this same study, beagle dogs (4/sex/group) were administered 6.25, 12.5, or 25 mg/kg bw/day in gelatin capsules. Treatment for 97 days had no effect. This study, as well as a review of the available data, indicate that the liver is the most sensitive target organ and, furthermore, that rats are the most sensitive species. The drinking water exposure reported by Quast et al. (1983) offers a more suitable model for potential human exposure to 1,1-dichloroethylene than does the NTP bioassay wherein animals were gavaged. It is, therefore, appropriate to set an RfD based on the LOAEL of 9 mg/kg bw/day for hepatic lesions in female rats.

Risk is presented in a drinking water or air concentration providing cancer risks of 1 in 10,000, 1 in 100,000 or 1 in 1,000,000. Background Document 2 (Service Code 5) provides details on the rationale and methods used to derive the carcinogenicity values found in IRIS.

C.2.7 1,2-Dichloroethene

1,2-Dichloroethene exists in two isomeric forms, *cis*-1,2-dichloroethene and *trans*-1,2-dichloroethene, that are colorless, volatile liquids with a slightly acrid odor. Although not used extensively in industry, 1,2-dichloroethene is used in the production of other chlorinated solvents and as a solvent for dyes, perfumes and lacquers (Sax and Lewis, 1989; Budavari et al., 1989). Humans are exposed to 1,2-dichloroethene primarily by inhalation, but exposure can also occur by oral and dermal routes.

Limited information exists on the absorption, distribution, and excretion of 1,2-dichloroethene in either humans or animals. *In vitro* studies have shown that the mixed function oxidases will metabolize 1,2-dichloroethene; the final metabolic products being dependent on the initial isomer of 1,2-dichloroethene (Costa and Ivanetich, 1984; Henschler, 1977; Lieberman and Ortiz, 1977).

Information on the toxicity of 1,2-dichloroethene in humans and animals is limited. Workers acutely exposed to 1,2-dichloroethene have been reported to suffer from drowsiness, dizziness, nausea, fatigue and eye irritation (ATSDR, 1990). Acute and subchronic oral and inhalation studies of *trans*-1,2-dichloroethene and acute inhalation studies of *cis*-1,2-dichloroethene indicate that the liver is the primary target organ in animals; toxicity being expressed by increased activities of liver associated enzymes, fatty degeneration and necrosis (McCauley et al., n.d.; Barnes et al., 1985; Freundt et al., 1977). Secondary target organs include the central nervous system and lung.

On the basis of an unpublished study describing decreased hemoglobin and hematocrits in rats treated by gavage for 90 days, EPA (1990a,b) assigned a subchronic and chronic oral reference dose (RfD) for *cis*-1,2-dichloroethene of 1E-1 mg/kg/day and 1E-2 mg/kg/day, respectively. The RfD's were derived from a no-adverse-effect-level/lowest-adverse-effect-level (NOAEL/LOAEL) of 32 mg/kg/day. An inhalation reference concentration (RfC) for *cis*-1,2-dichloroethene has not been derived.

Subchronic and chronic RfD's of 2E-1 mg/kg/day and 2E-2 mg/kg/day, respectively, for *trans*-1,2-dichloroethene have been calculated. The RfD's were derived from a LOAEL of 175 mg/kg/day based on the increase of serum alkaline phosphatase activity in mice that received *trans*-1,2-dichloroethene in their drinking water (EPA, 1990a,b). An RfC for *trans*-1,2-dichloroethene has not been derived.

No information was available concerning the chronic, developmental, or reproductive toxicity of *cis*-1,2-dichloroethene or *trans*-1,2-dichloroethene. No cancer bioassays or epidemiological studies were available to assess the carcinogenicity of 1,2-dichloroethene. EPA (1990a,b) has placed *cis*-1,2-dichloroethene in weight-of-evidence group D; not classifiable as to human carcinogenicity, based on the lack of human or animal carcinogenicity data and on essentially negative mutagenicity data. *trans*-1,2-Dichloroethene has not been classified.

C.2.8 Methylene Chloride

Methylene chloride (CH_2Cl_2 , CAS No. 75-09-2), also known as dichloromethane is a colorless volatile liquid with a penetrating ether-like odor. In industry, methylene chloride is widely used as a solvent in paint removers, degreasing agents, and aerosol propellants; as a polyurethane foam-blowing agent; and as a process solvent in the pharmaceutical industry. The compound is also used as an extraction solvent for spice oleoresins, hops, and caffeine (ATSDR, 1989; IARC, 1986).

Methylene chloride is readily absorbed from the lungs, the gastrointestinal tract, and to some extent through the skin. Metabolism of methylene chloride produces CO_2 and CO, which readily binds with blood hemoglobin to form carboxyhemoglobin (CO-Hb). The primary adverse health effects associated with methylene chloride exposure are central nervous system (CNS) depression and mild liver effects. Neurological symptoms described in individuals occupationally exposed to methylene chloride included headaches, dizziness, nausea, memory loss, paresthesia, tingling hands and feet, and loss of consciousness (Welch, 1987). Major effects following acute inhalation exposure include fatigue, irritability, analgesia, narcosis, and death (ATSDR, 1989). CNS effects have also been demonstrated in animals following acute exposure to methylene chloride (Weinstein et al., 1972; Berger and Fodor, 1968).

Impaired liver function has been associated with occupational exposure to methylene chloride (Welch, 1987). Liver effects have also been documented in a number of inhalation studies with laboratory animals. Subchronic exposure of rats, mice, dogs, and monkeys caused mild hepatic effects such as cytoplasmic vacuolization and fatty changes (EPA, 1983; Haun et al., 1972; Weinstein and Diamond, 1972; Heppel, 1944). Hepatocellular foci, fatty changes, and necrosis were reported following chronic inhalation exposure of rats and mice (Nitschke et al., 1986a; NTP, 1986). Chronic oral exposure to methylene chloride via drinking water resulted in histopathological alterations of the liver in rats and mice (NCA, 1982, 1983). In addition, inhalation exposure of rats caused nonspecific degenerative and regenerative changes in the kidneys (EPA, 1983; Haun et al., 1972).

A subchronic and chronic oral reference dose (RfD) of 6E-2 mg/kg/day for methylene chloride has been calculated by EPA (1993a,b). This value is based on a NOAEL of 5.85 mg/kg/day derived from a chronic drinking water study with rats (NCA, 1982). This same study was adapted for the

derivation of the subchronic and chronic reference concentration (RfC) of $3\text{E}+0 \text{ mg/m}^3$ (NOAEL, 694.8 mg/m^3) (EPA, 1993a).

Studies of workers exposed to methylene chloride have not recorded a significant increase in cancer cases above the number of cases expected for nonexposed workers (Hearne et al., 1987; Ott et al., 1983a; Friedlander et al., 1978). However, long-term inhalation studies with rats and mice demonstrated that methylene chloride causes cancer in laboratory animals. Mice exposed via inhalation to high concentrations of methylene chloride (2000 or 4000 ppm) exhibited a significant increase of malignant liver and lung tumors compared with nonexposed controls (NTP, 1986). Rats of both sexes exposed to concentrations of methylene chloride ranging from 500 to 4000 ppm showed increases of benign mammary tumors (Nitschke et al., 1988a; NTP, 1986; Burek et al., 1984). An inhalation study with rats and hamsters revealed sarcomas of the salivary gland in male rats, but not in female rats or hamsters (Burek et al., 1984). Liver tumors observed in rats and mice that ingested methylene chloride in drinking water for 2 years provided suggestive evidence of carcinogenicity (NCA, 1982, 1983). Based on inadequate evidence of carcinogenicity in humans and on sufficient evidence in animals, EPA (1993b) has placed methylene chloride in weight-of-evidence group B2, probable human carcinogen. A slope factor and unit risk of $7.5\text{E}-3 (\text{mg/kg/day})^{-1}$ and $2.1\text{E}-7 (\mu\text{g/L})^{-1}$, respectively, (EPA, 1993b) was derived for oral exposure to methylene chloride. The inhalation unit risk is $4.7\text{E}-7 (\mu\text{g/m}^3)^{-1}$ (EPA, 1993b).

C.2.9 Polychlorinated Biphenyls (Aroclor-1254 and Aroclor-1260)

Polychlorinated biphenyls (PCBs) are a group of man-made chemicals that contain 209 individual compounds (known as congeners); they are either oily liquids or solids and are colorless to light yellow without any known smell or taste. Seven types of PCBs mixtures include 35% of all the different PCBs commercially produced and 98% of PCBs sold in the United States since 1970. Some commercial PCB mixtures are known in the United States by their industrial trade name, Aroclor (i.e., Aroclor-1254, Aroclor-1260). The name Aroclor-1254 signifies that the molecule contains 12 carbon atoms (the first two digits) and approximately 54% chlorine by weight (the second two digits). PCBs don't burn easily and are a good insulating material; therefore, they have been used widely as coolants and lubricants in transformers, capacitors, and other electrical equipment. However, in 1977, manufacture of PCBs stopped in the United States because evidence showed that PCBs tend to build up in the environment and cause harmful effects (ATSDR 1993a).

In the past, PCBs entered the environment through their manufacture and use. Today, they can enter the environment from poorly maintained hazardous waste sites; illegal or improper dumping of PCB wastes; leaks or releases from electrical transformers containing PCBs; and disposal of PCB-containing consumer products into municipal landfills rather than into landfills designed for hazardous waste. PCBs can exist in air as both solid and liquid aerosols and as vapor that eventually returns to the land and water by settling or washout by snow or rainwater. Even extremely small amounts of PCBs can remain in water for several years, and they will bind strongly with soil and remain bonded for several years (ATSDR 1993a).

PCBs can be ingested or inhaled and can cause skin and nose irritations. Although several health effects as a result of exposure to PCBs have been seen in rats (i.e., liver damage and sometimes death after ingesting large amounts of PCBs for a short period and liver, stomach, and thyroid gland injuries; anemia; acne; and damaged reproduction organs after ingesting smaller

amounts of PCBs but for a longer period), little conclusive evidence concerning the effects of PCBs on humans is available. In addition, rats that ate certain PCB mixtures throughout their lives developed liver cancers; however, it is not known if the same effects would occur in people. After inhalation exposure, workers have exhibited respiratory tract and eye irritation, coughs, and tightness of the chest, as well as gastrointestinal symptoms (anorexia, weight loss, nausea, vomiting, and abdominal pain); none of these symptoms were reported in a great quantity and therefore results are inconclusive (ATSDR 1993a).

Studies of PCB-exposed workers provide inconclusive evidence for exposure-related cancer; however, an excess risk of cancer of the liver, biliary tract, and gall bladder has been reported in workers in two capacitor plants where PCB mixtures are commonly used. The International Agency for Research on Cancer has determined that PCBs are *probably* carcinogenic to humans, and the EPA has determined that PCBs are probable human carcinogens (ATSDR 1993a).

C.2.10 Tetrachloroethylene

Tetrachloroethylene (CAS No. 127-18-4) is a halogenated aliphatic hydrocarbon with a vapor pressure of 17.8 mm Hg at 25°C (EPA, 1982). The chemical is used primarily as a solvent in industry and, less frequently, in commercial dry-cleaning operations (ATSDR, 1990). Occupational exposure to tetrachloroethylene occurs via inhalation, resulting in systemic effects, and via dermal contact, resulting in local effects. Exposure to the general population can occur through contaminated air, food and water (ATSDR, 1990).

The respiratory tract is the primary route of entry for tetrachloroethylene (NTP, 1986; EPA, 1988). The chemical is rapidly absorbed by this route and reaches an equilibrium in the blood within 3 hours after the initiation of exposure (Hake and Stewart, 1977). Tetrachloroethylene is also significantly absorbed by the gastrointestinal (GI) tract, but not through the skin (Koppel et al., 1985; ATSDR, 1990). The chemical accumulates in tissues with high lipid content, where the half-life is estimated to be 55 hours (Stewart, 1969; ATSDR, 1990), and has been identified in perirenal fat, brain, liver, placental tissue, and amniotic fluid (Savolainen et al., 1977). The proposed first step for the biotransformation of tetrachloroethylene is the formation of an epoxide thought to be responsible for the carcinogenic potential of the chemical (Henschler and Hoos, 1982; Calabrese and Kenyon, 1991). Tetrachloroethylene is excreted mainly unchanged through the lungs, regardless of route of administration (NTP, 1986). The urine and feces comprise secondary routes of excretion (Monster et al., 1979; Ohtsuki et al., 1983). The major urinary metabolite of tetrachloroethylene, trichloroacetic acid, is formed via the cytochrome P-450 system (ATSDR, 1990).

The main targets of tetrachloroethylene toxicity are the liver and kidney by both oral and inhalation exposure, and the central nervous system by inhalation exposure. Acute exposure to high concentrations of the chemical (estimated to be greater than 1500 ppm for a 30-minute exposure) may be fatal to humans (Torkelson and Rowe, 1981). Chronic exposure causes respiratory tract irritation, headache, nausea, sleeplessness, abdominal pains, constipation, cirrhosis of the liver, hepatitis, and nephritis in humans; and microscopic changes in renal tubular cells, squamous metaplasia of the nasal epithelium, necrosis of the liver, and congestion of the lungs in animals (Chmielewski et al., 1976; Coler and Rossmiller, 1953; Stewart et al., 1970; von Ottingen, 1964; Stewart, 1969; NTP, 1986).

Some epidemiology studies have found an association between inhalation exposure to tetrachloroethylene and an increased risk for spontaneous abortion, idiopathic infertility, and sperm abnormalities among dry-cleaning workers, but others have not found similar effects (Kyyronen et al, 1989; van der Gulden and Zielhuis, 1989). The adverse effects in humans are supported in part by the results of animal studies in which tetrachloroethylene induced fetotoxicity (but did not cause malformations) in the offspring of treated dams (Schwetz et al., 1975; Beliles et al., 1980; Nelson et al., 1980).

Reference doses (RfDs) for subchronic and chronic oral exposure to tetrachloroethylene are $1\text{E-}1$ mg/kg/day and $1\text{E-}2$ mg/kg/day, respectively (Buben and Flaherty, 1985; EPA, 1990; 1992a). These values are based on hepatotoxicity observed in mice given ≥ 100 mg tetrachloroethylene/kg body weight for 6 weeks and a no-observed-adverse effect level (NOAEL) of 20 mg/kg.

Epidemiology studies of dry cleaning and laundry workers have demonstrated excesses in mortality due to various types of cancer, including liver cancer, but the data are regarded as inconclusive because of various confounding factors (Lyng and Thygesen, 1990; EPA, 1988). The tenuous finding of an excess of liver tumors in humans is strengthened by the results of carcinogenicity bioassays in which tetrachloroethylene, administered either orally or by inhalation, induced hepatocellular tumors in mice (NCI, 1977; NTP, 1986). The chemical also induced mononuclear cell leukemia and renal tubular cell tumors in rats. Tetrachloroethylene was negative for tumor initiation in a dermal study and for tumor induction in a pulmonary tumor assay (Van Duuren et al., 1979; Theiss et al., 1977).

Although EPA's Science Advisory Board recommended a weight-of-evidence classification of C-B2 continuum (C = possible human carcinogen; B2 = probable human carcinogen), the agency has not adopted a current position on the weight-of-evidence classification (EPA, 1992b). In an earlier evaluation, tetrachloroethylene was assigned to weight-of-evidence Group B2, probable human carcinogen, based on sufficient evidence from oral and inhalation studies for carcinogenicity in animals and no or inadequate evidence for carcinogenicity to humans (NCI, 1977; NTP, 1986; EPA, 1987). The unit risk and slope factor values for tetrachloroethylene have been withdrawn from IRIS and HEAST. The upper bound risk estimates from the 1985 Health Assessment Document (EPA, 1985) as amended by inhalation values from the 1987 addendum (EPA, 1987) have not yet been verified by the IRIS-CRAVE Workgroup. For oral exposure, the slope factor is $5.2\text{E-}2$ (mg/kg/day) $^{-1}$; the unit risk is $1.5\text{E-}6$ ($\mu\text{g/L}$) $^{-1}$. For inhalation exposure, the slope factor is $2.0\text{E-}3$ (mg/kg/day) $^{-1}$; the unit risk ranges from $2.9\text{E-}7$ to $9.5\text{E-}7$ ($\mu\text{g/m}^3$) $^{-1}$ with a geometric mean of $5.8\text{E-}7$ ($\mu\text{g/m}^3$) $^{-1}$ (EPA, 1987). When the Agency makes a decision about weight-of-evidence, the CRAVE-IRIS verification will be completed and the information put on IRIS (EPA, 1992b).

C.2.11 Vinyl Chloride

Vinyl chloride (CAS Reg. No. 75-01-4), a colorless gas, is a halogenated aliphatic hydrocarbon with the empirical formula of $\text{C}_2\text{H}_3\text{Cl}$. It is used primarily as an intermediate in the manufacture of polyvinyl chloride (PVC); limited quantities are used as a refrigerant and as an intermediate in the production of chlorinated compounds (ATSDR, 1989).

Vinyl chloride is rapidly absorbed from the gastrointestinal tract and lungs. Metabolism of vinyl chloride occurs primarily in the liver via oxidation by hepatic microsomal enzymes to polar

compounds which can be conjugated with glutathione and/or cysteine. These covalently bound metabolites are then excreted in the urine (EPA, 1980, 1985).

In humans and animals, vinyl chloride is a CNS depressant, inducing narcosis and anesthesia at high concentrations (Torkelson and Rowe, 1981; Patty et al., 1930). Nonneoplastic toxic effects observed in workers exposed by inhalation to vinyl chloride include hepatotoxicity, acroosteolysis and scleroderma, and Raynaud's syndrome, a vascular disorder of the extremities. Also reported were abnormalities of CNS function, high blood pressure, and occasional pulmonary effects (ATSDR, 1989; EPA, 1985; Lloyd et al., 1984; Langauer-Lewowicka et al., 1983; Waxweiler et al., 1977). The evidence for potential developmental effects in humans (increased fetal loss and birth defects) is equivocal (ATSDR, 1989; Waxweiler et al., 1977; Infante et al., 1976). Occupational exposure to vinyl chloride has been associated with reduced sexual function in both sexes and gynecological effects in women (Makarov, 1984; Makarov et al., 1984).

For the oral route of exposure, the primary target organ of vinyl chloride toxicity in animals is the liver. Chronic oral administration of 1.7-14.1 mg/kg/day of vinyl chloride induced dose-related increases in nonneoplastic lesions of the liver of rats (Feron et al., 1981). In addition to the CNS, target organs for inhalation exposure include the liver, kidneys, lungs, spleen, and testes. Subchronic inhalation studies with rodents documented hepatic effects at concentrations as low as 50 ppm (Sokal et al., 1980) and degenerative changes of the liver and kidneys at ≥ 500 ppm (Torkelson et al., 1961). Exposure to higher concentrations caused proliferative changes in the lungs of mice (Suzuki, 1980), extensive liver and kidney damage in rats and guinea pigs, cerebral and cerebellar nephrosis in rats, and degeneration of the spleen in guinea pigs (Prodan et al., 1975; Viola, 1971). Subchronic exposure of rats to 100 ppm vinyl chloride produced significantly decreased testes weights and testicular regeneration (Bi et al., 1985). Evidence of developmental toxicity was seen in rats exposed to vinyl chloride during the first trimester of gestation (Ungvary et al., 1978).

Neither an oral reference dose (RfD) nor an inhalation reference concentration (RfC) have been derived for vinyl chloride (EPA, 1992).

The carcinogenicity of vinyl chloride in humans has been demonstrated in a number of epidemiological studies and case reports, many of which associated occupational exposure to vinyl chloride to the development of angiosarcomas of the liver. In addition to liver cancer, exposure to vinyl chloride also has been linked to an increased risk of lung, brain, hematopoietic, and digestive tract cancers (EPA, 1985; Heldaas et al., 1984; IARC, 1979; Byren et al., 1976; Waxweiler et al., 1976; Monson et al., 1974). Vinyl chloride has been shown to be carcinogenic in numerous animal studies. Inhalation exposure to vinyl chloride induced an increased incidence of liver angiosarcomas; kidney nephroblastomas; and lung, brain, and forestomach tumors in rodents (Maltoni et al., 1980, 1981; Feron et al., 1981; Hong et al., 1981; Suzuki, 1978; Lee et al., 1977, 1978). Oral administration of vinyl chloride induced liver, lung, and kidney tumors in rodents (Feron et al., 1981; Maltoni, 1977). Angiosarcomas observed in offspring of rats exposed by inhalation during gestation indicates that vinyl chloride has the potential to initiate cancer *in utero* (Radike et al., 1988).

EPA has classified vinyl chloride as a Group A chemical, human carcinogen (EPA, 1985). A slope factor of $1.9\text{E}+0$ (mg/kg/day) $^{-1}$ and a drinking water unit risk of $5.4\text{E}-5$ ($\mu\text{g/L}$) $^{-1}$ was calculated

for oral exposure to vinyl chloride (EPA, 1992). For inhalation exposure, the slope factor and inhalation unit risk are $3.0\text{E-}1 \text{ (mg/kg/day)}^{-1}$ and $8.4\text{E-}5 \text{ (}\mu\text{g/m}^3\text{)}^{-1}$, respectively. The oral slope factor and inhalation unit risk are currently under review and may be subject to change (EPA, 1992).

C.3 RADIONUCLIDES

Radionuclides are unstable atoms of chemical elements that will emit charged particles to achieve a more stable state. These charged particles are termed "alpha and beta radiation" and "neutral gamma rays." Interaction of these charged particles (and gamma rays) with matter will produce ionization events, or radiation, which may cause living cell tissue damage. Because the deposition of energy by ionizing radiation is a random process, sufficient energy may be deposited (in a critical volume) within a cell and result in cell modification or death (ICRP 1991). In addition, ionizing radiation has sufficient energy that interactions with matter will produce an ejected electron and a positively charged ion (known as free radicals) that are highly reactive and may combine with other elements, or compounds within a cell, to produce toxins or otherwise disrupt the overall chemical balance of the cell (EPA 1991d). These free radicals can also react with deoxyribonucleic acid (DNA), causing genetic damage, cancer induction, or even cell death.

Radionuclides are characterized by the type and energy level of the radiation emitted. Radiation emissions fall into two major categories: particulate (electrons, alpha particles, beta particles, and protons) or electromagnetic radiation (gamma and x rays) (ATSDR 1989b). Therefore, all radionuclides are classified by the EPA as Group A carcinogens based on their property of emitting ionizing radiation and on the extensive weight of evidence provided by epidemiological studies of humans with cancers induced by high doses of radiation. Alpha particles are emitted at a characteristic energy level for differing radionuclides. The alpha particle has a charge of +2 and a comparably large size. Alpha particles have the ability to react (and/or ionize) with other molecules, but they have very little penetrating power and lack the ability to pass through a piece of paper or human skin. However, alpha-emitting radionuclides are of concern when there is a potential for inhalation or ingestion of the radionuclide. Alpha particles are directly ionizing and deposit their energy in dense concentrations [termed high linear energy transfer (high LET)], resulting in short paths of highly localized ionization reactions. The probability of cell damage increases as a result of the increase in ionization events occurring in smaller areas; this may also be the reason for increased cancer incidence caused by inhalation of radon gas. In addition, the cancer incidence in smokers may be directly attributed to the naturally occurring alpha emitter, polonium-210, in common tobacco products (Hammonds and Hoffman 1992).

Beta emissions generally refer to beta negative particle emissions. Radionuclides with an excess of neutrons achieve stability by beta decay. Beta radiation, like alpha radiation, is directly ionizing but, unlike alpha activity, beta particles deposit their energy along a longer track length (low-LET), resulting in more space between ionization events (Hammonds and Hoffman 1992). Beta-emitting radionuclides can cause injury to the skin and superficial body tissue but are most destructive when inhaled or ingested. Many beta emitters are similar chemically to naturally occurring essential nutrients and will therefore tend to accumulate in certain specific tissues. For example, strontium-90 is chemically similar to calcium and, as a result, accumulates in the bones, where it causes continuous exposure. The health effects of beta particle emissions depend upon the target organ. Those seeking the bones would cause a prolonged exposure to the bone marrow and affect blood cell

formation, possibly resulting in leukemia, other blood disorders, or bone cancers. Those seeking the liver would result in liver diseases or cancer, while those seeking the thyroid would cause thyroid and metabolic disorders. In addition, beta radiation may lead to damage of genetic material (DNA), causing hereditary defects.

Gamma emissions are the energy that has been released from transformations of the atomic nucleus. Gamma emitters and x-rays behave similarly but differ in their origin: gamma emissions originate in nuclear transformations, and x-rays result from changes in the orbiting electron structure. Radionuclides that emit gamma radiation can induce internal and external effects. Gamma rays have high penetrating ability in living tissue and are capable of reaching all internal body organs. Without such sufficient shielding as lead, concrete, or steel, gamma radiation can penetrate the body from the outside and does not require ingestion or inhalation to penetrate sensitive organs. Gamma rays are characterized as low-LET radiation, as is beta radiation; however, the behavior of beta radiation differs from that of gamma radiation in that beta particles deposit most of their energy in the medium through which they pass, while gamma rays often escape the medium because of higher energies, thereby creating difficulties in determining actual internal exposure. For this reason, direct whole-body measurements are necessary to detect gamma radiation, while urine/fecal analyses are usually effective in detecting beta radiation (Hammonds and Hoffman 1992).

People receive gamma radiation continuously from naturally occurring radioactive decay processes going on in the earth's surface, from radiation naturally occurring inside their bodies, from the atmosphere as fallout from nuclear testing or explosions, and from space or cosmic sources. Cesium-137 (from nuclear fallout) decays to barium-137, the highest contributor to fallout-induced gamma radiation (NCRP 1977). Beta radiation from the soil is a less penetrating form of radiation but has many contributing sources. Potassium-40, cesium-137, lead-214, and bismuth-214 are among the most common environmental beta emitters. Tritium is also a beta emitter but contributes little to the soil beta radiation because of the low energy of its emission and its low concentration in the atmosphere (NCRP 1977). Alpha radiation is also emitted by the soil but is not measurable more than a few centimeters from the ground surface. The majority of alpha emissions are attributable to radon-222 and radon-220 and their decay products (NCRP 1977). This contributes to what is called background exposure to radiation (ATSDR 1989b).

The general health effects of radiation can be divided into stochastic (related to dose) and nonstochastic (not related to dose) effects. The risk of development of cancer from exposure to radiation is a stochastic effect. Examples of nonstochastic effects include acute radiation syndrome and cataract formation, which occur only at high levels of exposures (Killough and Eckerman 1983).

Radiation can damage cells in different ways. It can cause damage to DNA within the cell, and the cell either may not be able to recover from this type of damage or may survive but function abnormally. If an abnormally functioning cell divides and reproduces, a tumor or mutation in the tissue may develop. The rapidly dividing cells that line the intestines and stomach and the blood cells in bone marrow are extremely sensitive to this damage. Organ damage results from the damage caused to the individual cells. This type of damage has been reported with doses of 10 to 500 rads (0.1 to 5.0 gray, in SI units). Acute radiation sickness is seen only after doses of >50 rads (0.5 gray) which is a dose rate usually achieved only in a nuclear accident (ATSDR 1989b).

When the radiation-damaged cells are reproductive cells, genetic damage can occur in the offspring of the person exposed. The developing fetus is especially sensitive to radiation. The type of malformation that may occur is related to the stage of fetal development and the cells that are differentiating at the time of exposure. Radiation damage to children exposed in the womb is related to the dose the pregnant mother receives. Mental retardation is a possible effect of fetal radiation exposure (ATSDR 1989b).

The most widely studied population that has had known exposure to radiation is the atomic bomb survivors of Hiroshima and Nagasaki, Japan. Data indicate an increase in the rate of leukemia and cancers in this population. However, the rate at which cancer incidence is significantly affected by low radiation exposures, such as results of exposure to natural background and industrially contaminated sites, is still undergoing study and is uncertain (Hammonds and Hoffman 1992). In studies conducted to determine the rate of cancer and leukemia increase, as well as genetic defects, several radionuclides must be considered.

C.3.1 Americium-241

Americium was first discovered in 1944 at the Metallurgical Laboratory, the forerunner of Argonne National Laboratory. The isotope is named after America because europium, a similar rare-earth element, was named after the continent of its discovery. ^{241}Am is used in high-precision devices and smoke detectors. It decays via alpha-particle emission to ^{237}Np .

Few data exist on the distribution of americium in humans, although measurable amounts have been distributed world-wide as a result of nuclear weapons testing (ICRP 1987). The limited data gathered from experimental animals suggest that "americium behaves like plutonium with regard to initial partition between liver and skeleton" (ICRP 1987). For dosimetry purposes, all isotopes of americium are assumed "uniformly distributed over bone surface at all times following their deposition to the skeleton" (ICRP 1987).

C.3.2 Cesium-134 and -137

Cesium occurs in nature as cesium-133 in the aluminosilicates, pollucite (a hydrated silicate of aluminum and cesium) and lepidolite; in the borate, rhodizite; and in other sources (Budavari 1989, Klaassen 1986). Cesium-137 is one of the artificial isotopes of cesium and is one of the principal radionuclides present in reactor effluent under normal operations. Cesium-137 may also be produced in nuclear and thermonuclear explosions, through which it would be a primary contributor to human exposure through fallout radiation, assimilation through the food chain, or beta dose to the skin (Budavari 1989, Klaassen 1986). In addition, cesium-137, along with strontium-90, is one of the most important fission products that was widely distributed in near-surface soils because of historical weapons testing. Measurable concentrations still exist in the soil today, almost exclusively in the upper 15 cm of soil; these concentrations decrease roughly exponentially with depth.

Cesium-137 may also have important roles in medical treatments (a teletherapy source or intercavitary or interstitial radiation source in treatment of malignancies) and as an encapsulated energy source (Budavari 1989, Casarett 1968). Cesium-137 decays to and reaches radioactive equilibrium with its daughter product, barium-137m (Budavari 1989, Casarett 1968). Barium-137m

is a very short-lived gamma emitter that can contribute to external gamma exposure (Budavari 1989).

C.3.3 Cobalt-60

Nuclear reactors produce ^{60}Co from the neutron activation of stable atoms of cobalt. These cobalt atoms are present as a corrosion impurity in the water used as the primary coolant of the reactor (Eichloz 1983). With a radioactive half-life of 5.27 years, ^{60}Co decays by emitting a 0.314 MeV beta particle and two gamma-rays exhibiting energies of 1.33 and 1.17 MeV (Kocher 1981).

Through weathering, cobalt may be taken into solution in small amounts through bacteriological activity similar to that causing the dissolution of manganese. With terrestrial fate, the availability of cobalt is primarily regulated by pH and is usually found in soils as divalent cobalt. At low pH, cobalt oxidizes to trivalent cobalt and is often found associated with iron. A lower pH enhances the leaching and plant uptake of cobalt.

As a radioactive form of an essential element, ^{60}Co is used in medical diagnoses for the absence of an intrinsic factor (pernicious anemia) or other defects of intestinal vitamin B_{12} absorption. It is also used as a radiation source for cancer therapy.

Important routes of human exposure to ^{60}Co are external exposure to gamma radiation, ingestion of contaminated foods or water, and inhalation of contaminated particulate matter. Radiological damage may occur to the gastrointestinal/respiratory tract during absorption of ^{60}Co depending on the chemical form. Critical or target body organs include the whole body, lungs, gastrointestinal tract, and lower large intestine. Internally absorbed ^{60}Co is assumed to be uniformly distributed throughout the body. Symptoms of cobalt exposure include, but are not limited to, interstitial lung disease and pulmonary symptoms, interstitial fibrosis, respiratory disease, liver and spleen enlargement, and nonstochastic effects. In addition, cobalt and certain derivatives have been found to be carcinogenic under certain experimental conditions.

C.3.4 Curium-244

Curium is a transuranic element. All transuranic elements are radioactive and mainly alpha emitters. An intensely radioactive isotope, ^{244}Cm has a half life of 17.6 years. The annual limit on intake (ALI) set by the ICRP for the inhalation and ingestion of ^{244}Cm is 4×10^2 Bq for inhalation with a derived air concentration of 2×10^{-1} Bq/ m^3 for 40 hours/week. The ALI for ingestion is 1×10^2 Bq (Metivier 1988).

The toxicity of transuranic elements has only been studied in animals because acute toxicity has not been observed in man for these elements and epidemiologic studies have not produced positive results (Voelz et al. 1985). The kinetics of transuranic element absorption, translocation, and excretion depend on the physical and chemical properties of individual elements and are also affected by the quantity of radionuclide intake. For this reason, data derived from animals given large amounts of transuranic elements must be considered with caution (Metivier 1988).

C.3.5 Europium-152 and -154

Europium-152 and europium-154 are both beta and gamma emitters with half-lives of 12 and 16 years, respectively.

Europium is a lanthanide; that is, it follows lanthanum in the periodic table. Lanthanides are also known as rare earth elements. Although rare earth elements are considered to be only mildly toxic, they do induce a few effects in humans, such as sensitivity to heat, itching, and skin lesions (Haley 1979, Venugopal and Luckey 1978). Suppression of the reticuloendothelial system in experimental animals has also been demonstrated (Lazar 1973). Haley (1979) described the toxic symptoms of the rare earth elements in laboratory animals as writhing, ataxia, labored respiration, walking on toes with arched back, and sedation. Hypotension and death by cardiovascular collapse coupled with respiratory paralysis were noted for all elements (Arvela 1979).

C.3.6 Plutonium-238 and -239

Plutonium is a predominantly man-made radioactive metal that is produced from nuclear reactions with uranium. Plutonium-238 has been used as a nuclear power source for satellites and in thermoelectric generation systems in spacecraft, cardiac pacemakers, and other power sources (Harley 1980, NEA/OECD 1981). Plutonium-239 is mostly associated with nuclear weapons production and testing. It is generated in irradiated uranium fuel when neutrons are captured by ^{238}U nuclei. Commerce and the military principally use ^{238}Pu and ^{239}Pu because of their ease of production and long radioactive half-lives (86 and 24,000 years, respectively). Both ^{238}Pu and ^{239}Pu are artificial, alpha-emitting isotopes of plutonium; ^{238}Pu decays to radioactive ^{234}U via alphas of 5.5 MeV, and ^{239}Pu decays to radioactive ^{235}U via alphas of 5.1 MeV.

Atmospheric testing of nuclear weapons has been the main source of plutonium dispersion in the environment, while accidents and routine releases from weapons production facilities are the primary sources of localized contamination. Plutonium released to the atmosphere reaches the earth's surface through wet and dry deposition to the soil and surface water. Once in these media, plutonium can sorb to soil and sediment particles or bioaccumulate in terrestrial and aquatic food chains.

Because of the low solubility of plutonium isotopes, inhalation of contaminated dust particles is considered to be the most harmful means of human exposure. Plutonium that has been inhaled may be absorbed through the lungs and be deposited in other body tissues. Subsequent translocation of some of the plutonium from the lungs to tissues and organs distant from the site of entry results in radiation damage to these tissues as well as to the lung. Liver and bone are the primary sites of plutonium deposition (ICRP 1990). The assumed biological retention half-lives of plutonium isotopes accumulated in the liver and bone of the human body are 20 and 50 years, respectively (ICRP 1990). Therefore, after a single exposure, plutonium isotopes reside in the body for a long time, resulting in prolonged exposure of body organs to alpha radiation (EPA 1977). The permissible health levels for plutonium are the lowest of all the radioactive elements. This is occasioned by the concentration of plutonium directly on bone surfaces rather than the more uniform bone distribution shown by other heavy elements. This increases the possibility of damage from equivalent activities of plutonium and has led to adoption of extremely low permissible levels (Sax and Irving 1987).

Inhaled ^{238}Pu is solubilized and subsequently translocated from the lung to the bone and liver (Gillett et al. 1988). Inhaled ^{239}Pu dioxide is insoluble and retained primarily in the lungs and associated lymph nodes (Muggenburg et al. 1987, Park et al. 1988). In laboratory tests with plutonium and animals, the pattern of nonmalignant toxicity among the species tested was similar (i.e., radiation pneumonitis and pulmonary fibrosis occurred in the higher radiation dose groups in all species tested); however, species differences in the induction of cancer were apparent. With the exception of Syrian hamsters, cancer developed in animals in the lower exposure groups or in animals that survived initial radiation damage to the lungs (ATSDR 1990).

C.3.7 Radium-226

Radium is a naturally occurring radioactive element that exists in several isotopic forms. The radium isotopes are formed from the decay of uranium and thorium. Radium-226 is formed from uranium-238 and uranium-234, and radium-226 has the longest half-life of the radium isotopes (radium-228, radium-224, and radium-223). In general, the activity concentration of radium-226 measured in most soils and rocks is comparable to those of uranium-238 and uranium-234, suggesting that radium does not tend to migrate from either of its uranium precursors under stable conditions. Radium-226 is primarily an alpha and gamma emitter (Budavari 1989, Casarett 1968).

Radium has been used as a component of luminous paints for clock and instrument dials. It has also been used in the treatment of cancer, in radiography, and in research. Radium is released into the environment in coal fly ash and in uranium mining and processing wastes. The background level of radium in industrial regions in soil is about 8.1 pCi/g. Clays and soil components generally retard the movement of radium in the environment, but acidic processing wastes can enhance its movement. Radium may bioaccumulate in plants and animals, and exposure through the food chain is possible (Budavari 1989, Casarett 1968).

Many environmental problems can be directly attributed to the decay products or daughters of radium. The primary daughters are isotopes of radon—a colorless, odorless, radioactive gas. Radon gas can infiltrate basements and water systems, resulting in significant exposure via inhalation pathways (Budavari 1989, Casarett 1968).

C.3.8 Strontium-90

Strontium-90 is a beta-emitting radionuclide with a half-life of 28.6 years and a maximum energy of 0.546 MeV (Kocher 1981). It decays to ^{90}Y , which is also a beta emitter with a half-life of 64 hours and a maximum energy of 2.27 MeV (Turner 1986). Beta particles from ^{90}Y and ^{90}Sr must be considered when assessing the potential effects of ^{90}Sr . Concentrations of ^{90}Sr in the environment are related to nuclear weapons testing and production with more strontium deposited in the northern hemisphere than the southern. Atmospheric deposition of ^{90}Sr on land and its transfer to humans by ingestion is the most important pathway of human exposure. Concentrations in milk and grain products decline rapidly following deposition, while concentrations in fruits and vegetables decline more slowly because of the soil concentrations of strontium. Once ^{90}Sr enters waterways, the most important pathway of human exposure is ingestion of water and fish. It is assumed that approximately 30% of ingested ^{90}Sr is absorbed through the gastrointestinal tract (ICRP 1990).

Strontium-90 resembles calcium and accumulates in the bones where it causes continuous beta radiation exposures. Strontium-90 causes a prolonged exposure to the bone marrow and impacts blood cell formation, possibly resulting in leukemia, other blood disorders, or bone cancers. Strontium ingestion or inhalation exposes the large intestine to beta radiation.

C.3.9 Technetium-99

Technetium-99 is an abundant, man-made radionuclide that is mobile in ecosystems. It is a beta emitter, emitting low-linear energy (LET) ionizing radiation, known to be carcinogenic to humans. As a pure beta emitter, it poses an insignificant external hazard. Assimilation of technetium following ingestion is high (50%), but retention in animal tissues appears low (SAIC 1993).

The potential health effects associated with exposure to low-level radiation include an increase in the probability of cancer induction and possible genetic effects. The major health concern associated with radiation is cancer induction; the risk of hereditary effects is much lower. Technetium-99 has been classified by the EPA as a Group A (human carcinogen) carcinogen (SAIC 1993).

C.3.10 Thallium-208

Thallium-208 is an artificial radioactive isotope occurring near the end of the ^{232}Th radioactive decay series. It is a beta and gamma emitter with a radioactive half-life of 3.05 minutes.

Thallium is a rare but ubiquitous element with no known beneficial functions. In nature it does not occur in the elemental state but is present as a trace compound in many minerals mainly associated with potassium and rubidium. The metal is obtained from flue dust residues of zinc, lead, and copper smelters and as a by-product of cadmium and sulfuric acid production. The mean abundance of thallium in the earth's crust is approximately 1 ppm (Sabbioni and Manzo 1980). Thallium occurs in small amounts in almost all living organisms. Natural levels in plants are reported as being between 0.01 and 3800 ppm ash weight, with 0.5 ppm being typical for most species (Sabbioni and Manzo 1980).

C.3.11 Thorium-228, -230, -232, and -234

Thorium is a naturally occurring, radioactive metal. Small amounts of thorium are present in all rocks, soil, above-ground and underground water, plants, and animals. These small amounts of thorium contribute to the weak background radiation for such substances. Soil commonly contains an average of about 6 ppm of soil. Rocks in some underground mines may also contain thorium in a more concentrated form. After these rocks are mined, thorium is usually concentrated and changes into thorium dioxide or other chemical forms. Thorium-bearing rock that has had most of the thorium removed from it is called "depleted" ore or tailings (ATSDR 1990b).

Thorium is a metallic element of the actinide series. It exists in several isotopic forms. The isotope thorium-232 is a naturally occurring element that is radioactive. It decays through the emission of a series of alpha and beta particles, gamma radiation, and the formation of daughter products, finally yielding the stable isotope of lead, lead-208. Isotopes thorium-234 and thorium-230 are produced during the decay of naturally occurring uranium-238, the isotope thorium-228

during the decay of thorium-232, and the isotopes thorium-231 and thorium-227 during the decay of uranium-235. Of these naturally produced isotopes of thorium, only thorium-232, thorium-230, and thorium-228 have long enough half-lives to be environmentally significant. More than 99.99% of natural thorium is thorium-232; the rest is thorium-230 and thorium-228 (ATSDR 1990b).

Thorium is used to make ceramics, lantern mantles, and metals used in the aerospace industry and in nuclear reactions. Thorium can also be used as a fuel for generating nuclear energy. More than 30 years ago, thorium oxides were used in hospitals to make certain kinds of diagnostic X-ray photographs (ATSDR 1990b).

Because thorium is found almost everywhere, most people in the United States eat some thorium with their food every day. Normally, little of the thorium in lakes, rivers, and oceans gets into the fish or seafood used commercially. More thorium may be found near uncontrolled hazardous waste sites that contain thorium which might not have been disposed of properly. Consequently, people living near one of these sites may be exposed to slightly more thorium as a result of inhaling windblown dust containing thorium or eating food grown in soil contaminated with thorium. Larger-than-normal amounts of thorium might also enter the environment through accidental releases from thorium processing plants (ATSDR 1990b).

Breathing dust contaminated with thorium is the primary pathway for thorium exposure to the body. A large portion of this dustborne thorium will be eliminated by normal bodily functions (urine/feces); however, a small amount of thorium will be taken up by the blood and subsequently transmitted to the bones. Breathing thorium dust may cause an increased chance of developing lung disease and cancer of the lung or pancreas many years after being exposed. Changes in genetic material have also been shown to occur in workers who breathed thorium dust. Liver diseases and effects on the blood have been found in people injected to take special X rays. Many types of cancer have been shown to occur in these people many years after thorium was injected in their bodies. Since thorium is radioactive and may be stored in bone for a long time, bone cancer is also a potential concern for people exposed to thorium. Animal studies have shown that breathing in thorium may result in lung damage. Other studies in animals suggest drinking massive amounts of thorium can cause death from metal poisoning. The presence of large amounts of thorium in the environment could result in exposure to more hazardous radioactive decay products of thorium, such as radium and thoron, which is an isotope of radon. Thorium is not known to cause birth defects or to affect childbearing abilities (ATSDR 1990b).

C.3.12 Tritium

Tritium is the heaviest and only radioactive isotope of hydrogen. This radionuclide is widely distributed throughout the environment because of its ubiquitous form in "tritiated" water and its persistence in the environment.

The naturally occurring levels of ^3H are the result of cosmic ray interactions in the atmosphere. Additional sources are from fallout from weapons testing, which diminished as a result of limited nuclear tests and from waste by-products of nuclear power reactors. The world inventory of natural tritium due to cosmic ray interactions is estimated to be 70 MCi, corresponding to a production rate of 4 MCi/y. Estimates of the production rate by ternary fission in nuclear reactors ranges from 12

to 20 Ci per megawatts (thermal) per day. The half life of tritium is 12.3 years, and it into the nonradioactive isotope ^1H decays by alpha emission.

Transfer of tritiated water from the atmosphere to the surface of the earth occurs mainly by precipitation and vapor exchange. The mean residence time of tritiated water vapor in the atmosphere ranges from 21 to 40 days.

Several pathways are available by which tritium as a gas or as tritiated water can reach the human body. It can be absorbed in either form by entry across the skin or the lungs, or it can be ingested in drinking water or water in food. Inhalation of tritiated water vapor is distributed in the body fluids within seconds. Skin uptake of tritium is equally important to the intake by inhalation. Ingested tritiated water is almost completely absorbed by the gastrointestinal tract and quickly appears in the venous blood. The rate at which tritium is eliminated from the body has an important influence on the radiation dose following exposure to tritium in any chemical form.

One major concern is that incorporation of tritium into DNA may result in undesirable genetic or somatic effects. An important case demonstrated fatal consequences for repeated exposure for long periods of time to high concentrations of tritium gas. No evidence suggests a significant bioconcentration process for tritium in either plants or animals (NCRP report no. 62, 1979).

C.3.13 Uranium-234, -235, -238

Naturally occurring uranium is a lustrous, silver-colored, radioactive, malleable, and ductile metal. Uranium is almost exclusively used as a fuel for nuclear energy; however, it can be used in pigments, ceramics, and photographic chemical processes. The three naturally occurring isotopes of uranium are uranium-238 (>99%), uranium-235 (about 0.72%), and uranium-234 (0.06%). The half-lives of uranium-234, uranium-235, and uranium-238 are $2.4\text{E}+05$ years, $7.0\text{E}+07$ years, and $4.5\text{E}+09$ years, respectively. The average concentration of uranium in the Earth's crust is between 2 and 4 ppm. Some ores contain more concentrated uranium deposits. These deposits are mined and then the percentage of uranium-235 is increased by an enrichment process. The enriched uranium-235 is more radioactive and of great use as a nuclear reactor fuel or weapon component.

Alpha, beta, and gamma radiation are emitted during the decay of uranium. Loss of alpha particles can give rise to other radioactive elements such as thorium-230, radium-226, radon-222, and polonium-218. Radon is a significant daughter isotope because it is colorless and odorless and, as a gas, can leak into basements or foundations. Significant exposure by inhalation of radon gas can occur unknowingly. Deposition of radon and its daughters onto the lungs exposes them to alpha radiation, increasing the probability of cancer. Radium has been known to produce bone sarcomas in radium dial painters resulting in death. The final decay for uranium-238 and uranium-234 is stable lead-206, and the final decay for uranium-235 is stable lead-207 (ATSDR 1989c).

Uranium may be released into the air by natural processes such as volcanic eruption or resuspension of soil. The combustion of fossil fuels is a potential contamination route. Coal and shale oils have varying levels of uranium depending on ore location. Subsequent burning can concentrate the levels of uranium. Groundwater and surface water releases of uranium are primarily caused by the disposal of uranium mining waste, disposal of nuclear reactor waste, and reactor emissions. Soil naturally contains uranium, but levels may be concentrated by the addition of

mining waste and nuclear facility waste. Carrots, potatoes, and other root vegetables contain higher levels of uranium than leafy vegetables. Higher levels of uranium have also been found in cattle that graze near nuclear facilities (ATSDR 1989c).

Concentrated uranium is a highly toxic element both chemically and radiologically. Kidney damage is the primary toxic effect of uranium. Chemical exposure to uranium may cause dermatitis, weight loss, acute necrotic arterial lesions, and possibly liver damage (Sanders 1986). Spontaneous ignition of finely divided uranium at room temperature is a dangerous physical property. Radiological effects are more prominent if uranium is inhaled and subsequently absorbed in the blood stream. Radioactivity in natural uranium is quite low and exists in food, water, and even in human bones. However, exposure to enriched uranium may cause damage to somatic cells resulting in tumors or cause damage to reproductive cells, affecting the next generation. Higher incidence of lung cancer have been observed in uranium mine workers. Exposure to radionuclides with greater specific-activity and shorter half-life increases the risk for developing cancer (ATSDR 1989c).

D. WAG-WIDE ANALYSIS

APPENDIX D

TABLES PRESENTING WAG-WIDE ANALYSES RESULTS

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Table D.1a. Comparison of WAG 5 Soil MD with TMBG values-Residential Scenario

Analyte	Frequency of detection	Mean Concentration (MC)	Maximum Detection (MD)	Mean Background (MBG)	Twice Mean Background (TMBG)	Does MD exceed TMBG ?	Units
Aluminum	39/39	2.22E+04	3.31E+04	2.5E+04	5.0E+04	NO	MG/KG
Antimony	1/4	4.63E+00	6.20E+00	2.2E-01	4.4E-01	YES	MG/KG
Arsenic	38/39	3.58E+00	1.16E+01	6.4E+00	1.3E+01	NO	MG/KG
Barium	39/39	1.40E+02	4.79E+02	1.2E+02	2.4E+02	YES	MG/KG
Beryllium	36/39	1.12E+00	2.00E+00	1.0E+00	2.1E+00	NO	MG/KG
Cadmium	1/39	4.28E-01	2.00E+00	2.2E-01	4.4E-01	YES	MG/KG
Calcium	39/39	1.28E+04	2.46E+05	1.3E+03	2.6E+03	YES	MG/KG
Chromium	39/39	3.04E+01	4.34E+01	2.6E+01	5.1E+01	NO	MG/KG
Cobalt	38/39	2.08E+01	5.27E+01	1.9E+01	3.7E+01	YES	MG/KG
Copper	36/39	1.93E+01	3.19E+01	1.9E+01	3.8E+01	NO	MG/KG
Iron	39/39	3.07E+04	4.39E+04	3.3E+04	6.7E+04	NO	MG/KG
Lead	39/39	1.77E+01	3.85E+01	2.2E+01	4.4E+01	NO	MG/KG
Magnesium	39/39	5.93E+03	2.26E+04	3.7E+03	7.3E+03	YES	MG/KG
Manganese	39/39	1.10E+03	4.71E+03	1.2E+03	2.4E+03	YES	MG/KG
Mercury	12/39	5.77E-02	4.30E+00	3.0E-01	5.9E-01	YES	MG/KG
Nickel	37/39	2.89E+01	4.19E+01	2.9E+01	5.8E+01	NO	MG/KG
Potassium	39/39	2.19E+03	3.35E+03	2.9E+03	5.7E+03	NO	MG/KG
Selenium	5/30	4.60E-01	2.00E+00	6.6E-01	1.3E+00	YES	MG/KG
Silver	21/39	1.42E+00	5.00E+00	2.0E+00	4.0E+00	YES	MG/KG
Sodium	14/39	6.45E+01	6.22E+02				MG/KG
Thallium	2/39	2.49E-01	3.70E-01	4.4E-01	8.7E-01	NO	MG/KG
Vanadium	38/39	2.88E+01	3.76E+01	3.8E+01	7.6E+01	NO	MG/KG
Zinc	39/39	6.59E+01	3.21E+02	6.0E+01	1.2E+02	YES	MG/KG
1,1,1-Trichloroethane	0/80	1.22E-02		5.0E-03	1.0E-02		MG/KG
1,1-Dichloroethane	0/80	1.22E-02		5.0E-03	1.0E-02		MG/KG
1,2-Benzenedicarboxylic Acid, Diethyl Ester	2/38	3.88E-01	3.00E-01				MG/KG
1,2-Dichloroethene (Total)	1/80	1.21E-02	3.00E-03				MG/KG
2-Butanone	4/80	1.23E-02	2.10E-02	8.4E-02	1.7E-01	NO	MG/KG
4,4'-DDD	1/38	3.91E-03	8.20E-04	8.2E-03	1.6E-02	NO	MG/KG
Acetone	12/80	2.91E-02	6.50E-01	3.8E-02	7.6E-02	YES	MG/KG
Aroclor 1254	2/38	1.27E-02	9.30E-02	8.2E-02	1.6E-01	NO	MG/KG
Aroclor 1260	9/38	2.17E-02	1.20E+00	8.2E-02	1.6E-01	YES	MG/KG

Table D.1a. (continued)

Analyte	Frequency of detection	Mean Concentration (MC)	Maximum Detection (MD)	Mean Background (MBG)	Twice Mean Background (TMBG)	Does MD exceed TMBG ?	Units
Benzo(k)Fluoranthene	1/38	3.89E-01	4.90E-02	4.1E-02	8.1E-02	NO	MG/KG
Bis(2-Ethylhexyl) Phthalate	5/38	3.56E-01	1.10E-01				MG/KG
Butyl Benzyl Phthalate	2/38	3.72E-01	5.20E-02				MG/KG
Carbon Tetrachloride	0/80	1.22E-02		5.0E-03	1.0E-02		MG/KG
Chlordane, Gamma-	1/38	2.06E-03	1.30E-03				MG/KG
Chloroform	3/80	1.18E-02	1.00E-03	5.3E-03	1.1E-02	NO	MG/KG
Chloromethane	1/80	1.21E-02	2.00E-03	1.0E-02	2.0E-02	NO	MG/KG
Cyanide	2/35	5.74E-01	7.00E-01	2.4E-01	4.9E-01	YES	MG/KG
Di-n-butyl Phthalate	8/38	3.41E-01	4.40E-01				MG/KG
Endrin	1/38	3.90E-03	5.10E-04	8.2E-03	1.6E-02	NO	MG/KG
Ethylbenzene	2/80	1.21E-02	1.20E-02	5.0E-03	1.0E-02	YES	MG/KG
Fluoranthene	1/38	3.89E-01	4.30E-02	3.5E-01	7.0E-01	NO	MG/KG
Heptachlor Epoxide	1/38	2.04E-03	5.40E-04	4.1E-03	8.2E-03	NO	MG/KG
Methylene Chloride	2/80	1.16E-02	5.00E-03	5.0E-03	1.0E-02	NO	MG/KG
Pyrene	2/38	3.80E-01	5.20E-02	9.5E-01	1.9E+00	NO	MG/KG
Styrene	2/80	1.20E-02	3.00E-03	5.0E-03	1.0E-02	NO	MG/KG
Tetrachloroethene	1/80	1.21E-02	3.00E-03	5.0E-03	1.0E-02	NO	MG/KG
Toluene	10/80	1.13E-02	2.00E-02	5.0E-03	1.0E-02	YES	MG/KG
Total Organic Carbon	13/13	3.99E+03	1.36E+04				MG/KG
Trichloroethene	0/80	1.22E-02		5.0E-03	1.0E-02		MG/KG
p-Nitrophenol	2/38	9.16E-01	8.20E-02				MG/KG
Ac-228	11/11	1.73E+00	2.40E+00				PCI/G
Alpha Particle	39/40	3.78E+01	3.80E+02				PCI/G
Am-241	14/21	1.88E-01	6.78E+00	4.0E-02	8.1E-02	YES	PCI/G
Beta Particle	40/40	5.63E+02	1.59E+04				PCI/G
Bi-212	2/2	2.25E+00	2.60E+00				PCI/G
Bi-214	2/2	8.80E-01	9.40E-01				PCI/G
C-14	3/39	6.65E-02	2.77E+01				PCI/G
Ca-45	3/3	3.92E+02	5.30E+02				PCI/G
Cm-242	0/16	-1.86E-02					PCI/G
Cm-243	1/4	1.41E-01	1.80E-01	5.9E-02	1.2E-01	YES	PCI/G
Cm-243/244	4/16	2.72E-02	3.56E+01	1.4E+00	2.8E+00	YES	PCI/G

Table D.1a. (continued)

Analyte	Frequency of detection	Mean Concentration (MC)	Maximum Detection (MD)	Mean Background (MBG)	Twice Mean Background (TMBG)	Does MD exceed TMBG ?	Units
Co-57	1/1	2.30E+00	2.30E+00	7.3E-03	1.5E-02	YES	PCI/G
Co-60	6/6	2.44E+02	1.80E+02	9.7E-03	1.9E-02	YES	PCI/G
Cs-134	1/1	4.00E-02	4.00E-02				PCI/G
Cs-137	31/40	1.30E+01	6.80E+03	7.2E-01	1.4E+00	YES	PCI/G
I-129	1/1	5.70E+00	5.70E+00				PCI/G
K-40	40/40	2.36E+01	3.51E+01	1.6E+01	3.2E+01	YES	PCI/G
Na-22	1/1	1.50E+00	1.50E+00				PCI/G
Pb-212	14/14	1.44E+00	1.90E+00				PCI/G
Pb-214	11/11	1.01E+00	1.40E+00				PCI/G
Pu-238	11/20	2.25E-01	4.15E+00	8.3E-02	1.7E-01	YES	PCI/G
Pu-239/240	4/20	2.08E-02	1.77E+00	2.9E-02	5.9E-02	YES	PCI/G
Ra-223	1/1	5.60E-01	5.60E-01				PCI/G
Ra-226	37/40	1.13E+00	3.60E+00	7.7E-01	1.5E+00	YES	PCI/G
Ra-228	34/40	1.64E+00	2.40E+00				PCI/G
Sn-126	3/3	3.27E-01	4.60E-01				PCI/G
Tc-99	3/23	8.33E-02	1.30E+00				PCI/G
Th-228	28/29	1.59E+00	2.20E+00	7.5E-01	1.5E+00	YES	PCI/G
Th-230	19/23	1.12E+00	4.37E+00	6.2E-01	1.2E+00	YES	PCI/G
Th-232	36/36	1.43E+00	2.40E+00	7.1E-01	1.4E+00	YES	PCI/G
Th-234	2/3	2.77E+00	7.30E+00	1.7E+00	3.4E+00	YES	PCI/G
Tl-208	9/9	1.37E+00	2.00E+00				PCI/G
Total Radioactive Strontium	29/40	1.65E+01	1.03E+04	9.7E-01	1.9E+00	YES	PCI/G
Tritium	31/39	2.60E+00	1.86E+03	4.2E-02	8.4E-02	YES	PCI/G
U-232	2/13	2.22E-02	5.32E-01				PCI/G
U-233	1/1	1.05E+01	1.05E+01	1.0E+00	2.1E+00	YES	PCI/G
U-233/234	21/22	1.66E+00	9.90E+00				PCI/G
U-235/236	0/12	2.56E-02		3.1E-02	6.2E-02		PCI/G
U-238	22/23	1.36E+00	7.00E+00	1.2E+00	2.3E+00	YES	PCI/G

Table D.1b. Comparison of WAG 5 sediment MD with TMBG values-Residential Scenario

Analyte	Frequency of detection	Mean Concentration (MC)	Maximum Detection (MD)	Mean Background (MBG)	Twice Mean Background (TMBG)	Does MD exceed TMBG ?	Units
Aluminum	13/13	9.15E+03	1.67E+04	1.4E+04	2.8E+04	NO	MG/KG
Antimony	1/14	1.75E+01	2.76E+01	4.0E+00	8.0E+00	YES	MG/KG
Arsenic	14/14	5.86E+00	1.40E+01	6.1E+00	1.2E+01	YES	MG/KG
Barium	14/14	3.54E+02	1.71E+03	1.8E+02	3.6E+02	YES	MG/KG
Beryllium	9/14	1.22E+00	1.70E+00	1.1E+00	2.3E+00	NO	MG/KG
Cadmium	0/14	1.71E+00		1.6E+00	3.2E+00		MG/KG
Calcium	14/14	1.50E+05	2.74E+05	2.6E+03	5.2E+03	YES	MG/KG
Chromium	14/14	3.02E+01	6.39E+01				MG/KG
Cobalt	10/14	2.77E+01	5.74E+01	2.2E+01	4.4E+01	YES	MG/KG
Copper	12/14	4.94E+01	1.91E+02	2.0E+01	4.1E+01	YES	MG/KG
Iron	14/14	6.38E+04	1.03E+05	4.5E+04	9.1E+04	YES	MG/KG
Lead	14/14	5.33E+01	1.66E+02	2.0E+01	4.0E+01	YES	MG/KG
Magnesium	14/14	3.09E+04	1.03E+05	2.8E+03	5.7E+03	YES	MG/KG
Manganese	14/14	7.80E+03	4.26E+04	1.5E+03	3.0E+03	YES	MG/KG
Mercury	12/14	2.12E+00	2.94E+01				MG/KG
Nickel	9/14	3.33E+01	7.06E+01	2.6E+01	5.1E+01	YES	MG/KG
Potassium	10/14	1.59E+03	2.09E+03	2.3E+03	4.7E+03	NO	MG/KG
Selenium	2/14	5.30E-01	1.90E+00	5.0E-01	1.0E+00	YES	MG/KG
Silver	6/14	4.25E+00	7.30E+00	8.8E-01	1.8E+00	YES	MG/KG
Sodium	4/14	4.73E+02	2.59E+03	8.1E+01	1.6E+02	YES	MG/KG
Thallium	2/14	3.80E-01	4.70E+00	3.0E-01	6.0E-01	YES	MG/KG
Vanadium	9/14	2.19E+01	2.81E+01	2.7E+01	5.5E+01	NO	MG/KG
Zinc	13/14	2.71E+02	1.59E+03	6.7E+01	1.3E+02	YES	MG/KG
1,1-Dichloroethane	3/25	1.45E-02	1.40E-01	5.8E-03	1.2E-02	YES	MG/KG
1,1-Dichloroethene	2/24	1.51E-02	2.80E-02	5.8E-03	1.2E-02	YES	MG/KG
1,2-Dichloroethane	1/25	9.51E-02	4.90E-02	5.8E-03	1.2E-02	YES	MG/KG
1,2-Dichloroethene (Total)	3/25	2.72E-03	2.10E+00	5.8E-03	1.2E-02	YES	MG/KG
2-Butanone	13/25	1.28E-01	1.10E+00	1.2E-02	2.4E-02	YES	MG/KG
4-Methyl Phenol	4/14	8.27E-01	2.60E+01	4.1E-01	8.2E-01	YES	MG/KG
4-Methyl-2-Pentanone	1/25	1.08E-01	2.00E-03	1.2E-02	2.4E-02	NO	MG/KG
Acetone	12/25	3.73E-01	4.90E+00	1.2E-02	2.4E-02	YES	MG/KG
Aroclor 1248	2/14	1.27E-02	1.20E+00	9.7E-02	1.9E-01	YES	MG/KG

Table D.1b. (continued)

Analyte	Frequency of detection	Mean Concentration (MC)	Maximum Detection (MD)	Mean Background (MBG)	Twice Mean Background (TMBG)	Does MD exceed TMBG ?	Units
Aroclor 1254	5/14	1.59E-01	2.30E+00	2.0E-01	3.9E-01	YES	MG/KG
Aroclor 1260	7/14	1.46E-01	8.30E-01	2.0E-01	3.9E-01	YES	MG/KG
Benzene	2/25	1.01E-02	1.10E-02	5.8E-03	1.2E-02	NO	MG/KG
Bis(2-Ethylhexyl) Phthalate	2/14	4.77E-01	1.00E+00	4.6E-01	9.2E-01	YES	MG/KG
Carbolic Acid	4/14	7.62E-01	3.30E+01	4.1E-01	8.2E-01	YES	MG/KG
Carbon Disulfide	1/25	1.08E-01	2.00E-03	5.8E-03	1.2E-02	NO	MG/KG
Chloroform	1/25	1.08E-01	2.00E-03	5.8E-03	1.2E-02	NO	MG/KG
Sulfide	5/9	1.54E+01	2.36E+01	1.6E+01	3.2E+01	NO	MG/KG
Toluene	5/25	7.38E-03	1.00E-02	5.8E-03	1.2E-02	NO	MG/KG
Total Organic Carbon	4/4	1.74E+04	4.30E+04				MG/KG
Trichloroethene	2/25	6.44E-03	7.00E-03	5.8E-03	1.2E-02	NO	MG/KG
Vinyl Chloride	2/25	4.80E-04	1.10E+00	1.2E-02	2.4E-02	YES	MG/KG
Xylene (Total)	3/25	1.55E-02	2.70E-02	5.8E-03	1.2E-02	YES	MG/KG
Ac-228	6/6	1.86E+00	2.30E+00				PCI/G
Alpha Particle	15/15	2.77E+04	8.07E+04	2.2E+01	4.3E+01	YES	PCI/G
Am-241	10/11	9.51E+01	1.17E+03				PCI/G
Beta Particle	15/15	3.54E+07	7.94E+06	2.7E+01	5.3E+01	YES	PCI/G
Bi-212	2/2	1.60E+00	1.70E+00				PCI/G
Bi-214	5/5	8.95E-01	1.20E+00				PCI/G
C-14	9/14	6.78E+01	2.56E+02				PCI/G
Ca-45	3/3	6.67E+01	9.20E+01				PCI/G
Cm-242	2/8	3.22E-01	3.54E-01				PCI/G
Cm-243/244	8/8	3.45E+04	2.44E+04				PCI/G
Co-60	14/14	1.86E+03	6.83E+03				PCI/G
Cs-137	15/15	2.95E+07	3.72E+06	1.6E+01	3.3E+01	YES	PCI/G
Eu-152	1/2	7.74E+02	9.61E+02				PCI/G
Eu-154	1/3	3.50E+02	5.79E+02				PCI/G
Eu-155	1/1	1.50E-01	1.50E-01				PCI/G
I-129	4/4	8.03E+00	1.40E+01				PCI/G
K-40	9/9	1.56E+01	2.45E+01	2.0E+01	4.1E+01	NO	PCI/G
Pb-210	1/1	2.70E+00	2.70E+00				PCI/G
Pb-212	6/6	1.48E+00	1.70E+00				PCI/G

Table D.1b. (continued)

Analyte	Frequency of detection	Mean Concentration (MC)	Maximum Detection (MD)	Mean Background (MBG)	Twice Mean Background (TMBG)	Does MD exceed TMBG ?	Units
Pb-214	6/6	1.00E+00	1.20E+00				PCI/G
Pu-238	9/10	1.34E+02	1.22E+03				PCI/G
Pu-239/240	7/10	3.25E+01	6.39E+02				PCI/G
Ra-223	3/3	6.73E-01	9.10E-01				PCI/G
Ra-224	4/5	3.29E+00	4.90E+00	1.2E+00	2.4E+00	YES	PCI/G
Ra-226	8/15	1.32E+00	3.00E+00	7.9E-01	1.6E+00	YES	PCI/G
Ra-228	9/15	1.82E+00	2.30E+00	1.3E+00	2.7E+00	NO	PCI/G
Radon 219	3/3	8.70E-01	1.20E+00				PCI/G
Sn-126	2/2	2.35E-01	2.80E-01				PCI/G
Tc-99	9/10	3.58E+00	1.20E+01				PCI/G
Th-228	15/15	4.52E+02	3.88E+02	1.3E+00	2.7E+00	YES	PCI/G
Th-230	13/13	4.35E+01	3.09E+02	1.0E+00	2.1E+00	YES	PCI/G
Th-231	1/1	5.30E-01	5.30E-01				PCI/G
Th-232	15/15	3.69E+00	5.28E+01	1.2E+00	2.4E+00	YES	PCI/G
Th-234	2/2	6.40E+00	1.10E+01	1.1E+00	2.3E+00	YES	PCI/G
Tl-208	5/5	1.22E+00	1.40E+00				PCI/G
Total Radioactive Strontium	15/15	8.17E+08	7.35E+05	6.7E-01	1.3E+00	YES	PCI/G
Tritium	14/14	1.53E+03	2.34E+03	5.0E+01	1.0E+02	YES	PCI/G
U-232	6/6	2.27E+02	3.21E+02				PCI/G
U-233	6/6	2.61E+03	4.76E+03				PCI/G
U-233/234	7/7	7.18E+00	1.60E+01	1.3E+00	2.5E+00	YES	PCI/G
U-235	5/7	2.46E-01	4.10E-01				PCI/G
U-235/236	2/6	6.76E+00	8.13E+00	6.0E-01	1.2E+00	YES	PCI/G
U-238	12/13	2.73E+01	1.38E+02	1.0E+00	2.1E+00	YES	PCI/G

Table D.1c. Comparison of WAG 5 Groundwater MD with TMBG values-Residential Scenario

Analyte	Frequency of detection	Mean Concentration (MC)	Maximum Detection (MD)	Mean Background (MBG)	Twice Mean Background (TMBG)	Does MD exceed TMBG ?	Units
Aluminum	35/47	5.45E+00	8.97E+01	3.7E-01	7.4E-01	YES	MG/L
Antimony	1/46	1.63E-02	1.40E-02	2.6E-02	5.2E-02	NO	MG/L
Arsenic	15/47	2.50E-03	1.37E-02	2.6E-02	5.2E-02	NO	MG/L
Barium	47/47	4.30E-01	9.78E-01	2.5E-01	5.0E-01	YES	MG/L
Beryllium	17/47	6.09E-04	6.20E-03	1.6E-03	3.2E-03	YES	MG/L
Boron	7/22	6.16E-02	1.49E+00	1.2E-01	2.4E-01	YES	MG/L
Calcium	47/47	1.13E+02	2.86E+02	8.8E+01	1.8E+02	YES	MG/L
Chromium	25/47	2.49E-02	2.43E-01				MG/L
Cobalt	23/47	1.30E-02	1.93E-01	3.7E-03	7.3E-03	YES	MG/L
Copper	17/47	8.89E-03	1.14E-01	8.1E-03	1.6E-02	YES	MG/L
Iron	41/47	1.41E+01	2.86E+02	5.7E-01	1.1E+00	YES	MG/L
Lead	42/49	2.48E-02	7.52E-01	2.9E-02	5.7E-02	YES	MG/L
Magnesium	47/47	2.04E+01	5.79E+01	1.4E+01	2.7E+01	YES	MG/L
Manganese	44/47	8.32E-01	2.26E+01	1.2E-01	2.4E-01	YES	MG/L
Mercury	10/47	8.35E-05	4.50E-04	5.0E-05	1.0E-04	YES	MG/L
Molybdenum	1/23	7.98E-03	1.33E-02	4.0E-02	8.0E-02	NO	MG/L
Nickel	31/47	3.67E-02	4.16E-01	6.9E-03	1.4E-02	YES	MG/L
Phosphorus	3/22	1.96E-02	2.68E-01	3.0E-01	6.0E-01	NO	MG/L
Potassium	47/47	5.26E+00	2.42E+01	2.2E+00	4.5E+00	YES	MG/L
Selenium	1/41	8.02E-03	5.10E-03	2.3E-02	4.6E-02	NO	MG/L
Silicon	23/23	1.07E+01	6.17E+01	8.3E+00	1.7E+01	YES	MG/L
Silver	10/47	2.42E-03	1.54E-02	5.0E-03	1.0E-02	YES	MG/L
Sodium	47/47	2.20E+01	1.32E+02	1.6E+01	3.1E+01	YES	MG/L
Vanadium	24/47	1.31E-02	1.40E-01	2.7E-03	5.3E-03	YES	MG/L
Zinc	27/47	4.98E-02	1.18E+00	1.3E-02	2.6E-02	YES	MG/L
1,1,1-Trichloroethane	6/50	2.69E-03	1.60E-02	5.0E-03	1.0E-02	YES	MG/L
1,1-Dichloroethane	11/50	3.93E-03	2.10E-02	5.0E-03	1.0E-02	YES	MG/L
1,1-Dichloroethene	4/50	2.88E-03	6.00E-03	5.0E-03	1.0E-02	NO	MG/L
1,2-Dichloroethane	5/50	3.14E-03	4.00E-03	5.0E-03	1.0E-02	NO	MG/L
1,2-Dichloroethene (Total)	18/50	1.03E-02	3.30E+00	5.0E-03	1.0E-02	YES	MG/L
Acetone	1/50	1.06E-02	1.20E-02	6.1E-03	1.2E-02	NO	MG/L
Alkalinity as CaCO3	3/3	3.56E+02	4.07E+02	2.5E+02	5.0E+02	NO	MG/L

Table D.1c. (continued)

Analyte	Frequency of detection	Mean Concentration (MC)	Maximum Detection (MD)	Mean Background (MBG)	Twice Mean Background (TMBG)	Does MD exceed TMBG ?	Units
Benzene	5/50	2.08E-03	2.50E-02	4.7E-03	9.3E-03	YES	MG/L
Bis(2-Ethylhexyl) Phthalate	8/39	3.42E-03	3.10E+00	7.1E-03	1.4E-02	YES	MG/L
Carbon Disulfide	1/50	8.04E-03	1.00E-03	2.0E-03	4.1E-03	NO	MG/L
Carbon Tetrachloride	2/50	2.73E-03	9.00E-03	5.0E-03	1.0E-02	NO	MG/L
Chloride	15/15	1.04E+01	3.44E+01	3.1E+00	6.3E+00	YES	MG/L
Chlorobenzene	1/50	7.96E-03	2.00E-03	5.0E-03	1.0E-02	NO	MG/L
Chloroethane	2/50	9.98E-03	3.00E-03	1.0E-02	2.0E-02	NO	MG/L
Chloroform	3/50	1.38E-03	2.50E-02	5.0E-03	1.0E-02	YES	MG/L
Cyanide	2/43	2.66E-04	4.85E-02	4.7E-09	9.3E-09	YES	MG/L
Dimethyl Phthalate	1/42	4.79E-02	1.60E+00	1.0E-02	2.0E-02	YES	MG/L
Fluoranthene	1/42	9.79E-03	1.00E-03	1.0E-02	2.0E-02	NO	MG/L
Fluoride	8/15	1.49E-01	6.10E-01				MG/L
Methylene Chloride	1/50	9.05E-03	4.80E-02	4.7E-03	9.3E-03	YES	MG/L
Nitrate	6/15	4.57E-01	6.89E+00	1.3E+00	2.7E+00	YES	MG/L
Organic Chloride	1/5	2.08E-01	1.00E+00				MG/L
Phosphate	14/15	6.81E-01	2.20E+00	8.8E-01	1.8E+00	YES	MG/L
Phthalic Acid, Dioctyl Ester	1/42	9.86E-03	4.00E-03	1.0E-02	2.0E-02	NO	MG/L
Pyrene	1/42	9.79E-03	1.00E-03	1.0E-02	2.0E-02	NO	MG/L
Sulfate	15/15	2.50E+01	6.85E+01	3.0E+01	6.1E+01	YES	MG/L
Sulfide	2/27	1.53E-01	2.50E-01				MG/L
TOX	8/11	1.61E-01	1.19E+02	5.2E-03	1.0E-02	YES	MG/L
Tetrachloroethene	10/50	2.77E-03	2.50E-01	4.8E-03	9.6E-03	YES	MG/L
Toluene	1/50	8.04E-03	1.00E-03	4.9E-03	9.7E-03	NO	MG/L
Total Dissolved Solids	15/15	3.72E+02	6.52E+02	3.1E+02	6.1E+02	YES	MG/L
Total Kjeldahl Nitrogen-TKN	33/37	4.32E-01	1.26E+00				MG/L
Total Organic Carbon	8/15	2.00E+00	3.80E+00	9.7E-01	1.9E+00	YES	MG/L
Total Suspended Solids	14/15	6.42E+02	1.46E+03	1.3E+01	2.5E+01	YES	MG/L
Trichloroethene	19/50	6.83E-03	2.10E-01	5.0E-03	1.0E-02	YES	MG/L
Vinyl Chloride	11/50	1.45E-01	4.00E+00	1.0E-02	2.0E-02	YES	MG/L
Xylene (Total)	1/50	8.07E-03	2.00E-03	5.0E-03	1.0E-02	NO	MG/L
Alpha Particle	39/78	1.38E+01	7.51E+06	2.6E+00	5.3E+00	YES	PCI/L
Am-241	28/88	1.30E+04	1.15E+06				

Table D.1c. (continued)

Analyte	Frequency of detection	Mean Concentration (MC)	Maximum Detection (MD)	Mean Background (MBG)	Twice Mean Background (TMBG)	Does MD exceed TMBG ?	Units
Beta Particle	65/83	1.45E+02	6.53E+05	8.0E+00	1.6E+01	YES	PCI/L
Bi-212	2/2	2.98E+02	5.34E+02				PCI/L
Bi-214	2/2	9.84E+01	1.68E+02				PCI/L
C-14	32/78	2.38E+02	2.49E+03				PCI/L
Ca-45	1/8	6.94E+01	2.80E+02				PCI/L
Cd-109	1/1	3.67E+02	3.67E+02				PCI/L
Cm-242	2/42	2.76E-05	5.60E-01				PCI/L
Cm-243	2/22	8.33E-03	4.10E-01				PCI/L
Cm-243/244	25/65	7.14E-01	1.80E+02				PCI/L
Co-60	9/28	3.34E+00	8.85E+01	2.2E+01	4.3E+01	YES	PCI/L
Cs-137	6/89	2.73E-01	2.75E+03	6.2E+00	1.2E+01	YES	PCI/L
Fe-55	1/6	-1.50E+01	5.30E+01				PCI/L
Hg-203	2/2	1.36E+01	1.45E+01				PCI/L
K-40	6/6	4.53E+02	1.01E+03				PCI/L
Mn-54	1/1	8.90E+00	8.90E+00				PCI/L
Pb-212	8/8	2.87E+01	5.26E+01				PCI/L
Pu-238	24/83	1.84E-01	7.77E+05				PCI/L
Pu-239/240	7/83	3.23E-04	1.36E+04				PCI/L
Ra-226	29/58	6.56E-01	7.04E+03				PCI/L
Ra-228	21/49	2.61E+00	3.02E+02				PCI/L
Tc-99	22/55	1.00E+01	5.12E+02				PCI/L
Th-228	26/57	9.62E-01	2.10E+02				PCI/L
Th-230	26/57	5.52E-01	2.40E+01				PCI/L
Th-231	1/1	3.53E+02	3.53E+02				PCI/L
Th-232	28/58	9.11E-01	3.50E+01				PCI/L
Th-234	6/6	3.71E+02	1.00E+03				PCI/L
Total Radioactive Strontium	40/86	2.67E+01	4.15E+04	5.2E+00	1.0E+01	YES	PCI/L
Tritium	79/88	3.25E+05	2.99E+08	1.2E+03	2.4E+03	YES	PCI/L
U-232	2/49	5.35E-05	2.89E+00				PCI/L
U-233/234	51/80	1.21E+00	3.80E+03				PCI/L
U-235	6/57	1.63E-02	3.60E-01				PCI/L
U-235/236	3/23	1.37E-02	3.69E-01				PCI/L
U-238	26/80	1.30E-01	1.24E+01				PCI/L

Table D.1d. Comparison of WAG 5 surface water MD with TMBG values-Residential Scenario

Analyte	Frequency of detection	Mean Concentration (MC)	Maximum Detection (MD)	Mean Background (MBG)	Twice Mean Background (TMBG)	Does MD exceed TMBG ?	Units
High Base							
Aluminum	6/6	5.43E-01	9.72E-01	1.7E-01	3.4E-01	YES	MG/L
Antimony	0/6	1.79E-02		3.0E-02	6.0E-02		MG/L
Arsenic	0/6	2.70E-03		2.0E-03	4.0E-03		MG/L
Barium	6/6	6.52E-02	9.25E-02	4.2E-02	8.3E-02	YES	MG/L
Beryllium	0/6	5.00E-04		1.0E-03	2.0E-03		MG/L
Cadmium	0/6	1.70E-03		5.0E-03	1.0E-02		MG/L
Calcium	6/6	6.16E+01	9.16E+01	3.7E+01	7.4E+01	YES	MG/L
Chromium	0/6	5.80E-03		1.0E-02	2.0E-02		MG/L
Cobalt	0/6	3.80E-03		2.0E-02	4.0E-02		MG/L
Copper	3/6	6.40E-03	1.48E-02	1.2E-02	2.3E-02	NO	MG/L
Iron	6/6	1.01E+00	3.19E+00	4.0E-01	8.1E-01	YES	MG/L
Lead	6/6	6.15E-03	8.70E-03	7.0E-03	1.4E-02	NO	MG/L
Magnesium	6/6	1.24E+01	1.95E+01	5.1E+00	1.0E+01	YES	MG/L
Manganese	6/6	5.31E-01	2.56E+00	1.0E-01	2.1E-01	YES	MG/L
Mercury	0/6	1.00E-04		2.0E-03	4.0E-03		MG/L
Nickel	0/6	6.10E-03		2.0E-02	4.0E-02		MG/L
Potassium	6/6	2.00E+00	3.01E+00	1.0E+00	2.0E+00	YES	MG/L
Selenium	0/6	3.50E-03		2.0E-03	4.0E-03		MG/L
Sodium	6/6	8.47E+00	1.36E+01	3.5E+00	7.0E+00	YES	MG/L
Vanadium	1/6	3.37E-03	3.70E-03	1.0E-02	2.0E-02	NO	MG/L
Zinc	2/6	3.48E-02	1.33E-01	1.1E-01	2.2E-01	NO	MG/L
1,1,1-Trichloroethane	0/5	1.00E-02		5.0E-03	1.0E-02		MG/L
1,1-Dichloroethane	0/5	1.00E-02		5.0E-03	1.0E-02		MG/L
1,1-Dichloroethene	0/5	1.00E-02		5.0E-03	1.0E-02		MG/L
1,2-Dichlorobenzene	0/6	1.00E-02		1.0E-02	2.0E-02		MG/L
1,2-Dichloroethane	0/5	1.00E-02		5.0E-03	1.0E-02		MG/L
1,2-Dichloroethene (Total)	0/5	1.00E-02		5.0E-03	1.0E-02		MG/L
1,2-Dichloropropane	0/5	1.00E-02		5.0E-03	1.0E-02		MG/L
2-Butanone	1/5	8.80E-03	4.00E-03	1.0E-02	2.0E-02	NO	MG/L
4-Methyl Phenol	1/6	9.67E-03	8.00E-03	1.0E-02	2.0E-02	NO	MG/L
4-Methyl-2-Pentanone	1/5	8.20E-03	1.00E-03	1.0E-02	2.0E-02	NO	MG/L

Table D.1d. (continued)

Analyte	Frequency of detection	Mean Concentration (MC)	Maximum Detection (MD)	Mean Background (MBG)	Twice Mean Background (TMBG)	Does MD exceed TMBG ?	Units
Alpha-BHC	0/6	5.00E-05		5.0E-05	1.0E-04		MG/L
Benzene	0/5	1.00E-02		5.0E-03	1.0E-02		MG/L
Benzene, 1,2,4-Trichloro-	0/6	1.00E-02		1.0E-02	2.0E-02		MG/L
Beta-BHC	0/6	5.00E-05		5.0E-05	1.0E-04		MG/L
Bis(2-Ethylhexyl) Phthalate	0/6	1.00E-02		1.0E-02	2.0E-02		MG/L
Bromomethane	0/5	1.00E-02		1.0E-02	2.0E-02		MG/L
Carbon Disulfide	0/5	1.00E-02		5.0E-03	1.0E-02		MG/L
Chloride	4/4	9.45E+00	1.51E+01				MG/L
Chloroform	0/5	1.00E-02		5.0E-03	1.0E-02		MG/L
Delta-BHC	0/6	5.00E-05		5.0E-05	1.0E-04		MG/L
Fluoride	3/4	9.32E-01	1.80E+00				MG/L
Nitrate	2/9	1.90E-01	7.30E-01				MG/L
Phosphate	2/9	3.18E-01	1.34E+00				MG/L
Styrene	0/5	1.00E-02		5.0E-03	1.0E-02		MG/L
Sulfate	4/4	1.04E+02	2.17E+02				MG/L
Tetrachloroethene	0/5	1.00E-02		5.0E-03	1.0E-02		MG/L
Toluene	0/5	1.00E-02		5.0E-03	1.0E-02		MG/L
Total Organic Carbon	6/6	2.14E+00	2.63E+00				MG/L
Trichloroethene	0/5	1.00E-02		5.0E-03	1.0E-02		MG/L
Vinyl Chloride	0/5	1.00E-02		1.0E-02	2.0E-02		MG/L
Xylene (Total)	0/5	1.00E-02		5.0E-03	1.0E-02		MG/L
m-Dichlorobenzene	0/6	1.00E-02		1.0E-02	2.0E-02		MG/L
p-Dichlorobenzene	0/6	1.00E-02		1.0E-02	2.0E-02		MG/L
TOX	5/6	4.93E-02	1.06E-01				MG/L
Total Kjeldahl Nitrogen-TKN	6/6	5.16E-01	7.30E-01				MG/L
Alpha Particle	5/6	1.15E+01	4.70E+01	4.5E+00	8.9E+00	YES	PCI/L
Am-241	0/1	8.60E-02					PCI/L
Beta Particle	5/6	1.52E+03	4.40E+03	4.0E+00	8.0E+00	YES	PCI/L
C-14	2/6	2.20E+02	1.20E+03				PCI/L
Ca-45	2/2	5.80E+02	9.90E+02				PCI/L
Co-60	0/6	2.00E+01					PCI/L
Cs-137	0/6	2.00E+01		2.0E+01	4.0E+01		PCI/L

Table D.1d. (continued)

Analyte	Frequency of detection	Mean Concentration (MC)	Maximum Detection (MD)	Mean Background (MBG)	Twice Mean Background (TMBG)	Does MD exceed TMBG ?	Units
Pu-238	1/1	2.90E-01	2.90E-01				PCI/L
Pu-239/240	0/1	-1.60E-02					PCI/L
Ra-226	0/5	8.80E-02		1.0E+00	2.0E+00		PCI/L
Ra-228	0/4	-2.30E-01		3.0E+00	6.0E+00		PCI/L
Sn-119m	1/1	1.90E+01	1.90E+01				PCI/L
Tc-99	1/3	3.70E+00	3.80E+00				PCI/L
Th-228	1/5	8.80E-01	1.30E+00	1.0E+00	2.0E+00	NO	PCI/L
Th-230	0/5	-5.80E-03		2.1E+00	4.3E+00		PCI/L
Th-232	0/5	2.74E-02		1.0E+00	2.0E+00		PCI/L
Total Radioactive Strontium	5/6	7.50E+02	2.50E+03				PCI/L
Tritium	6/6	1.51E+06	7.60E+06	8.1E+02	1.6E+03	YES	PCI/L
U-233/234	3/5	6.58E+00	2.70E+01	1.0E+00	2.0E+00	YES	PCI/L
U-235	1/5	3.73E-01	1.70E+00				PCI/L
U-238	4/5	9.67E+00	4.50E+01	1.0E+00	2.0E+00	YES	PCI/L
High Base Storm							
Aluminum	2/3	5.35E-01	8.48E-01	1.7E-01	3.4E-01	YES	MG/L
Antimony	0/3	1.22E-02		3.0E-02	6.0E-02		MG/L
Arsenic	0/3	2.20E-03		2.0E-03	4.0E-03		MG/L
Barium	3/3	4.73E-02	5.07E-02	4.2E-02	8.3E-02	NO	MG/L
Beryllium	0/3	3.13E-04		1.0E-03	2.0E-03		MG/L
Cadmium	0/3	1.70E-03		5.0E-03	1.0E-02		MG/L
Calcium	3/3	4.77E+01	7.35E+01	3.7E+01	7.4E+01	NO	MG/L
Chromium	1/3	2.63E-03	2.90E-03	1.0E-02	2.0E-02	NO	MG/L
Cobalt	0/3	2.90E-03		2.0E-02	4.0E-02		MG/L
Copper	0/3	4.50E-03		1.2E-02	2.3E-02		MG/L
Iron	2/3	7.56E-01	8.68E-01	4.0E-01	8.1E-01	YES	MG/L
Lead	2/3	2.80E-03	3.70E-03	7.0E-03	1.4E-02	NO	MG/L
Magnesium	3/3	7.29E+00	1.07E+01	5.1E+00	1.0E+01	YES	MG/L
Manganese	3/3	8.81E-02	1.20E-01	1.0E-01	2.1E-01	NO	MG/L
Mercury	0/3	2.00E-04		2.0E-03	4.0E-03		MG/L
Nickel	2/3	5.37E-03	6.00E-03	2.0E-02	4.0E-02	NO	MG/L
Potassium	3/3	1.70E+00	1.98E+00	1.0E+00	2.0E+00	NO	MG/L

Table D.1d. (continued)

Analyte	Frequency of detection	Mean Concentration (MC)	Maximum Detection (MD)	Mean Background (MBG)	Twice Mean Background (TMBG)	Does MD exceed TMBG ?	Units
Selenium	0/3	2.70E-03		2.0E-03	4.0E-03		MG/L
Sodium	1/3	6.96E+00	1.13E+01	3.5E+00	7.0E+00	YES	MG/L
Vanadium	0/3	2.40E-03		1.0E-02	2.0E-02		MG/L
Zinc	3/3	9.70E-03	1.16E-02	1.1E-01	2.2E-01	NO	MG/L
1,1,1-Trichloroethane	0/3	1.00E-02		5.0E-03	1.0E-02		MG/L
1,1-Dichloroethane	1/3	7.33E-03	2.00E-03	5.0E-03	1.0E-02	NO	MG/L
1,1-Dichloroethene	0/3	1.00E-02		5.0E-03	1.0E-02		MG/L
1,2-Dichlorobenzene	0/3	1.00E-02		1.0E-02	2.0E-02		MG/L
1,2-Dichloroethane	0/3	1.00E-02		5.0E-03	1.0E-02		MG/L
1,2-Dichloroethene (Total)	1/3	7.67E-03	3.00E-03	5.0E-03	1.0E-02	NO	MG/L
1,2-Dichloropropane	0/3	1.00E-02		5.0E-03	1.0E-02		MG/L
2-Butanone	1/3	9.00E-03	7.00E-03	1.0E-02	2.0E-02	NO	MG/L
4-Methyl Phenol	0/3	1.00E-02		1.0E-02	2.0E-02		MG/L
4-Methyl-2-Pentanone	0/3	1.00E-02		1.0E-02	2.0E-02		MG/L
Alpha-BHC	0/3	5.00E-05		5.0E-05	1.0E-04		MG/L
Benzene	0/3	1.00E-02		5.0E-03	1.0E-02		MG/L
Benzene, 1,2,4-Trichloro-	0/3	1.00E-02		1.0E-02	2.0E-02		MG/L
Beta-BHC	0/3	5.00E-05		5.0E-05	1.0E-04		MG/L
Bis(2-Ethylhexyl) Phthalate	2/3	5.42E-03	6.00E-03	1.0E-02	2.0E-02	NO	MG/L
Bromomethane	0/3	1.00E-02		1.0E-02	2.0E-02		MG/L
Carbon Disulfide	0/3	1.00E-02		5.0E-03	1.0E-02		MG/L
Chloroform	0/3	1.00E-02		5.0E-03	1.0E-02		MG/L
Delta-BHC	0/3	5.00E-05		5.0E-05	1.0E-04		MG/L
Styrene	0/3	1.00E-02		5.0E-03	1.0E-02		MG/L
Tetrachloroethene	0/3	1.00E-02		5.0E-03	1.0E-02		MG/L
Toluene	0/3	1.00E-02		5.0E-03	1.0E-02		MG/L
Total Organic Carbon	3/3	3.19E+00	5.13E+00				MG/L
Trichloroethene	1/3	7.00E-03	1.00E-03	5.0E-03	1.0E-02	NO	MG/L
Vinyl Chloride	0/3	1.00E-02		1.0E-02	2.0E-02		MG/L
Xylene (Total)	0/3	1.00E-02		5.0E-03	1.0E-02		MG/L
m-Dichlorobenzene	0/3	1.00E-02		1.0E-02	2.0E-02		MG/L
p-Dichlorobenzene	0/3	1.00E-02		1.0E-02	2.0E-02		MG/L

Table D.1d. (continued)

Analyte	Frequency of detection	Mean Concentration (MC)	Maximum Detection (MD)	Mean Background (MBG)	Twice Mean Background (TMBG)	Does MD exceed TMBG ?	Units
Total Kjeldahl Nitrogen-TKN	2/3	2.80E-01	4.10E-01				MG/L
Alpha Particle	3/6	1.28E+01	6.03E+01	4.5E+00	8.9E+00	YES	PCI/L
Am-241	5/6	1.01E-01	1.63E-01				PCI/L
Beta Particle	6/6	9.85E+02	2.82E+03	4.0E+00	8.0E+00	YES	PCI/L
C-14	1/6	1.79E+01	1.18E+02				PCI/L
Cm-243/244	2/6	1.70E-01	6.22E-01				PCI/L
Cs-137	0/6	1.42E+01		2.0E+01	4.0E+01		PCI/L
Pu-238	2/6	2.40E+00	1.40E+01				PCI/L
Pu-239/240	3/6	6.47E-02	1.32E-01				PCI/L
Ra-226	0/6	8.22E-03		1.0E+00	2.0E+00		PCI/L
Ra-228	0/6	7.50E+00		3.0E+00	6.0E+00		PCI/L
Tc-99	1/6	5.98E+00	3.79E+01				PCI/L
Th-228	6/6	9.72E-01	1.67E+00	1.0E+00	2.0E+00	NO	PCI/L
Th-230	6/6	6.37E+00	1.04E+01	2.1E+00	4.3E+00	YES	PCI/L
Th-232	6/6	1.11E+00	3.11E+00	1.0E+00	2.0E+00	YES	PCI/L
Total Radioactive Strontium	6/6	3.59E+02	1.41E+03				PCI/L
Tritium	5/6	7.92E+05	4.15E+06	8.1E+02	1.6E+03	YES	PCI/L
U-232	0/6	-3.33E-04					PCI/L
U-233/234	3/6	8.95E+00	5.14E+01	1.0E+00	2.0E+00	YES	PCI/L
U-235/236	1/6	4.66E-01	2.75E+00	1.0E+00	2.0E+00	YES	PCI/L
U-238	3/6	1.36E+01	8.11E+01	1.0E+00	2.0E+00	YES	PCI/L
Impoundment							
Aluminum	1/1	6.09E+00	6.09E+00	1.7E-01	3.4E-01	YES	MG/L
Antimony	0/1	9.20E-03		3.0E-02	6.0E-02		MG/L
Arsenic	0/1	2.10E-03		2.0E-03	4.0E-03		MG/L
Barium	1/1	5.49E-02	5.49E-02	4.2E-02	8.3E-02	NO	MG/L
Beryllium	0/1	2.00E-04		1.0E-03	2.0E-03		MG/L
Cadmium	0/1	1.00E-03		5.0E-03	1.0E-02		MG/L
Calcium	1/1	2.72E+01	2.72E+01	3.7E+01	7.4E+01	NO	MG/L
Chromium	0/1	4.10E-03		1.0E-02	2.0E-02		MG/L
Cobalt	0/1	3.00E-03		2.0E-02	4.0E-02		MG/L
Copper	1/1	1.26E-02	1.26E-02	1.2E-02	2.3E-02	NO	MG/L

Table D.1d. (continued)

Analyte	Frequency of detection	Mean Concentration (MC)	Maximum Detection (MD)	Mean Background (MBG)	Twice Mean Background (TMBG)	Does MD exceed TMBG ?	Units
Iron	1/1	4.41E-01	4.41E-01	4.0E-01	8.1E-01	NO	MG/L
Lead	0/1	2.50E-03		7.0E-03	1.4E-02		MG/L
Magnesium	1/1	4.87E+00	4.87E+00	5.1E+00	1.0E+01	NO	MG/L
Manganese	1/1	1.92E-01	1.92E-01	1.0E-01	2.1E-01	NO	MG/L
Mercury	0/1	2.00E-04		2.0E-03	4.0E-03		MG/L
Nickel	1/1	4.40E-03	4.40E-03	2.0E-02	4.0E-02	NO	MG/L
Potassium	1/1	3.48E+00	3.48E+00	1.0E+00	2.0E+00	YES	MG/L
Selenium	1/1	3.10E-03	3.10E-03	2.0E-03	4.0E-03	NO	MG/L
Sodium	1/1	4.45E+00	4.45E+00	3.5E+00	7.0E+00	NO	MG/L
Vanadium	1/1	5.20E-03	5.20E-03	1.0E-02	2.0E-02	NO	MG/L
Zinc	1/1	4.01E-02	4.01E-02	1.1E-01	2.2E-01	NO	MG/L
1,1,1-Trichloroethane	0/2	1.00E-02		5.0E-03	1.0E-02		MG/L
1,1-Dichloroethane	0/2	1.00E-02		5.0E-03	1.0E-02		MG/L
1,1-Dichloroethene	0/2	1.00E-02		5.0E-03	1.0E-02		MG/L
1,2-Dichlorobenzene	0/2	1.00E-02		1.0E-02	2.0E-02		MG/L
1,2-Dichloroethane	0/2	1.00E-02		5.0E-03	1.0E-02		MG/L
1,2-Dichloroethene (Total)	0/2	1.00E-02		5.0E-03	1.0E-02		MG/L
1,2-Dichloropropane	0/2	1.00E-02		5.0E-03	1.0E-02		MG/L
2-Butanone	0/2	1.00E-02		1.0E-02	2.0E-02		MG/L
4-Methyl Phenol	0/2	1.00E-02		1.0E-02	2.0E-02		MG/L
4-Methyl-2-Pentanone	0/2	1.00E-02		1.0E-02	2.0E-02		MG/L
Alpha-BHC	0/2	5.00E-05		5.0E-05	1.0E-04		MG/L
Benzene	0/2	1.00E-02		5.0E-03	1.0E-02		MG/L
Benzene, 1,2,4-Trichloro-	0/2	1.00E-02		1.0E-02	2.0E-02		MG/L
Beta-BHC	0/2	5.00E-05		5.0E-05	1.0E-04		MG/L
Bis(2-Ethylhexyl) Phthalate	1/2	5.50E-03	1.00E-03	1.0E-02	2.0E-02	NO	MG/L
Bromomethane	1/2	6.00E-03	2.00E-03	1.0E-02	2.0E-02	NO	MG/L
Carbon Disulfide	0/2	1.00E-02		5.0E-03	1.0E-02		MG/L
Chloride	1/1	8.10E-01	8.10E-01				MG/L
Chloroform	0/2	1.00E-02		5.0E-03	1.0E-02		MG/L
Delta-BHC	0/2	5.00E-05		5.0E-05	1.0E-04		MG/L
Fluoride	1/1	1.40E-01	1.40E-01				MG/L

Table D.1d. (continued)

Analyte	Frequency of detection	Mean Concentration (MC)	Maximum Detection (MD)	Mean Background (MBG)	Twice Mean Background (TMBG)	Does MD exceed TMBG ?	Units
Styrene	1/2	5.50E-03	1.00E-03	5.0E-03	1.0E-02	NO	MG/L
Sulfate	1/1	1.48E+01	1.48E+01				MG/L
Tetrachloroethene	0/2	1.00E-02		5.0E-03	1.0E-02		MG/L
Toluene	0/2	1.00E-02		5.0E-03	1.0E-02		MG/L
Total Organic Carbon	2/2	2.07E+01	3.36E+01				MG/L
Trichloroethene	0/2	1.00E-02		5.0E-03	1.0E-02		MG/L
Vinyl Chloride	0/2	1.00E-02		1.0E-02	2.0E-02		MG/L
Xylene (Total)	0/2	1.00E-02		5.0E-03	1.0E-02		MG/L
m-Dichlorobenzene	0/2	1.00E-02		1.0E-02	2.0E-02		MG/L
p-Dichlorobenzene	0/2	1.00E-02		1.0E-02	2.0E-02		MG/L
Alkalinity as CaCO ₃	2/2	1.80E+01	3.00E+01				MG/L
TOX	0/1	5.00E-03					MG/L
Total Dissolved Solids	2/2	2.05E+02	2.98E+02				MG/L
Total Kjeldahl Nitrogen-TKN	2/2	2.62E+00	4.48E+00				MG/L
Total Suspended Solids	1/2	1.40E+01	1.40E+01				MG/L
Alpha Particle	2/2	3.38E+03	6.38E+03	4.5E+00	8.9E+00	YES	PCI/L
Am-241	2/2	4.47E-01	5.02E-01				PCI/L
Beta Particle	2/2	1.08E+05	2.03E+05	4.0E+00	8.0E+00	YES	PCI/L
C-14	1/2	2.65E+01	4.20E+01				PCI/L
Cm-243/244	2/2	1.07E+01	1.62E+01				PCI/L
Co-60	2/2	1.40E+02	1.52E+02				PCI/L
Cs-137	2/2	1.25E+04	2.50E+04	2.0E+01	4.0E+01	YES	PCI/L
Pu-238	2/2	2.65E-01	3.16E-01				PCI/L
Pu-239/240	1/2	3.18E-01	5.06E-01				PCI/L
Ra-226	0/2	1.21E-01		1.0E+00	2.0E+00		PCI/L
Ra-228	0/2	1.75E+01		3.0E+00	6.0E+00		PCI/L
Tc-99	1/2	2.49E+01	4.32E+01				PCI/L
Th-228	1/2	1.23E+00	8.77E-01	1.0E+00	2.0E+00	NO	PCI/L
Th-230	1/2	2.89E-01	4.87E-01	2.1E+00	4.3E+00	NO	PCI/L
Th-232	0/2	8.10E-03		1.0E+00	2.0E+00		PCI/L
Total Radioactive Strontium	2/2	4.80E+04	9.00E+04				PCI/L
Tritium	2/2	1.48E+04	2.01E+04	8.1E+02	1.6E+03	YES	PCI/L

Table D.1d. (continued)

Analyte	Frequency of detection	Mean Concentration (MC)	Maximum Detection (MD)	Mean Background (MBG)	Twice Mean Background (TMBG)	Does MD exceed TMBG ?	Units
U-232	2/2	1.26E+01	2.18E+01				PCI/L
U-233/234	2/2	1.82E+02	2.62E+02	1.0E+00	2.0E+00	YES	PCI/L
U-235/236	0/2	4.76E-02		1.0E+00	2.0E+00		PCI/L
U-238	2/2	2.87E+00	4.82E+00	1.0E+00	2.0E+00	YES	PCI/L
Low Base							
Aluminum	2/6	6.00E-02	3.19E-01	1.7E-01	3.4E-01	NO	MG/L
Antimony	0/6	1.29E-02		3.0E-02	6.0E-02		MG/L
Arsenic	1/6	2.67E-03	1.30E-03	2.0E-03	4.0E-03	NO	MG/L
Barium	6/6	6.64E-02	1.22E-01	4.2E-02	8.3E-02	YES	MG/L
Beryllium	0/6	2.00E-04		1.0E-03	2.0E-03		MG/L
Cadmium	0/6	1.30E-03		5.0E-03	1.0E-02		MG/L
Calcium	6/6	6.58E+01	1.14E+02	3.7E+01	7.4E+01	YES	MG/L
Chromium	0/6	2.10E-03		1.0E-02	2.0E-02		MG/L
Cobalt	0/6	2.60E-03		2.0E-02	4.0E-02		MG/L
Copper	0/6	3.02E-03		1.2E-02	2.3E-02		MG/L
Iron	5/6	3.91E-01	4.74E+00	4.0E-01	8.1E-01	YES	MG/L
Lead	0/6	2.50E-03		7.0E-03	1.4E-02		MG/L
Magnesium	6/6	1.08E+01	1.52E+01	5.1E+00	1.0E+01	YES	MG/L
Manganese	6/6	4.35E-01	2.93E+00	1.0E-01	2.1E-01	YES	MG/L
Mercury	0/6	2.00E-04		2.0E-03	4.0E-03		MG/L
Nickel	1/6	3.98E-03	6.90E-03	2.0E-02	4.0E-02	NO	MG/L
Potassium	6/6	2.21E+00	2.39E+00	1.0E+00	2.0E+00	YES	MG/L
Selenium	0/6	3.10E-03		2.0E-03	4.0E-03		MG/L
Sodium	6/6	8.54E+00	1.72E+01	3.5E+00	7.0E+00	YES	MG/L
Vanadium	0/6	5.50E-03		1.0E-02	2.0E-02		MG/L
Zinc	2/6	4.75E-03	8.40E-03	1.1E-01	2.2E-01	NO	MG/L
1,1,1-Trichloroethane	0/6	1.00E-02		5.0E-03	1.0E-02		MG/L
1,1-Dichloroethane	0/6	1.00E-02		5.0E-03	1.0E-02		MG/L
1,1-Dichloroethene	0/6	1.00E-02		5.0E-03	1.0E-02		MG/L
1,2-Dichloroethane	0/6	1.00E-02		5.0E-03	1.0E-02		MG/L
1,2-Dichloroethene (Total)	1/6	8.67E-03	2.00E-03	5.0E-03	1.0E-02	NO	MG/L
1,2-Dichloropropane	0/6	1.00E-02		5.0E-03	1.0E-02		MG/L

Table D.1d. (continued)

Analyte	Frequency of detection	Mean Concentration (MC)	Maximum Detection (MD)	Mean Background (MBG)	Twice Mean Background (TMBG)	Does MD exceed TMBG ?	Units
2-Butanone	0/6	1.00E-02		1.0E-02	2.0E-02		MG/L
4-Methyl-2-Pentanone	0/6	1.00E-02		1.0E-02	2.0E-02		MG/L
Benzene	0/6	1.00E-02		5.0E-03	1.0E-02		MG/L
Bromomethane	0/6	1.00E-02		1.0E-02	2.0E-02		MG/L
Carbon Disulfide	0/6	1.00E-02		5.0E-03	1.0E-02		MG/L
Chloroform	0/6	1.00E-02		5.0E-03	1.0E-02		MG/L
Styrene	0/6	1.00E-02		5.0E-03	1.0E-02		MG/L
Tetrachloroethene	0/6	1.00E-02		5.0E-03	1.0E-02		MG/L
Toluene	0/6	1.00E-02		5.0E-03	1.0E-02		MG/L
Trichloroethene	0/6	1.00E-02		5.0E-03	1.0E-02		MG/L
Vinyl Chloride	0/6	1.00E-02		1.0E-02	2.0E-02		MG/L
Xylene (Total)	0/6	1.00E-02		5.0E-03	1.0E-02		MG/L
Alpha Particle	5/6	6.32E+00	1.58E+01	4.5E+00	8.9E+00	YES	PCI/L
Am-241	3/5	4.06E+00	9.30E+00				PCI/L
Beta Particle	6/6	1.32E+03	4.03E+03	4.0E+00	8.0E+00	YES	PCI/L
C-14	1/6	3.03E+00	1.80E+02				PCI/L
Cs-137	0/6	0.00E+00		2.0E+01	4.0E+01		PCI/L
Pb-212	1/1	2.12E+01	2.12E+01				PCI/L
Pu-238	2/6	3.74E+00	1.77E+01				PCI/L
Pu-239/240	0/6	4.17E-02					PCI/L
Ra-226	2/6	1.48E-01	2.80E-01	1.0E+00	2.0E+00	NO	PCI/L
Ra-228	1/1	1.61E+03	1.61E+03	3.0E+00	6.0E+00	YES	PCI/L
Tc-99	2/6	8.86E+00	1.88E+01				PCI/L
Th-228	1/5	3.40E-02	2.60E-01	1.0E+00	2.0E+00	NO	PCI/L
Th-230	0/5	2.80E-02		2.1E+00	4.3E+00		PCI/L
Th-232	0/5	2.40E-02		1.0E+00	2.0E+00		PCI/L
Total Radioactive Strontium	4/5	6.11E+02	1.78E+03				PCI/L
Tritium	5/6	3.30E+05	9.60E+05	8.1E+02	1.6E+03	YES	PCI/L
U-232	0/3	3.67E-02					PCI/L
U-233/234	3/6	2.41E+00	1.04E+01	1.0E+00	2.0E+00	YES	PCI/L
U-235	1/6	1.33E-01	8.00E-01				PCI/L
U-238	1/6	3.21E+00	1.85E+01	1.0E+00	2.0E+00	YES	PCI/L

Table D.1d. (continued)

Analyte	Frequency of detection	Mean Concentration (MC)	Maximum Detection (MD)	Mean Background (MBG)	Twice Mean Background (TMBG)	Does MD exceed TMBG ?	Units
Low Base Storm							
Aluminum	4/22	5.68E-03	3.18E+00	1.7E-01	3.4E-01	YES	MG/L
Antimony	0/22	1.59E-02		3.0E-02	6.0E-02		MG/L
Arsenic	0/22	2.25E-03		2.0E-03	4.0E-03		MG/L
Barium	22/22	5.19E-02	1.09E-01	4.2E-02	8.3E-02	YES	MG/L
Beryllium	0/22	5.25E-04		1.0E-03	2.0E-03		MG/L
Cadmium	0/22	1.49E-03		5.0E-03	1.0E-02		MG/L
Calcium	22/22	4.73E+01	1.23E+02	3.7E+01	7.4E+01	YES	MG/L
Chromium	4/22	1.30E-03	7.10E-03	1.0E-02	2.0E-02	NO	MG/L
Cobalt	0/22	2.76E-03		2.0E-02	4.0E-02		MG/L
Copper	2/22	1.00E-02	2.60E-03	1.2E-02	2.3E-02	NO	MG/L
Iron	3/22	5.82E-03	2.33E-01	4.0E-01	8.1E-01	NO	MG/L
Lead	6/22	2.44E-03	3.90E-03	7.0E-03	1.4E-02	NO	MG/L
Magnesium	22/22	8.13E+00	1.62E+01	5.1E+00	1.0E+01	YES	MG/L
Manganese	17/22	1.38E-01	3.02E+00	1.0E-01	2.1E-01	YES	MG/L
Mercury	0/22	1.86E-04		2.0E-03	4.0E-03		MG/L
Nickel	5/22	2.48E-03	3.78E-02	2.0E-02	4.0E-02	NO	MG/L
Potassium	20/22	3.98E+00	5.34E+00	1.0E+00	2.0E+00	YES	MG/L
Selenium	2/22	2.49E-03	3.00E-03	2.0E-03	4.0E-03	NO	MG/L
Sodium	22/22	5.97E+00	1.77E+01	3.5E+00	7.0E+00	YES	MG/L
Vanadium	0/22	5.09E-03		1.0E-02	2.0E-02		MG/L
Zinc	0/22	1.42E-02		1.1E-01	2.2E-01		MG/L
1,1,1-Trichloroethane	0/6	1.00E-02		5.0E-03	1.0E-02		MG/L
1,1-Dichloroethane	0/6	1.00E-02		5.0E-03	1.0E-02		MG/L
1,1-Dichloroethene	0/6	1.00E-02		5.0E-03	1.0E-02		MG/L
1,2-Dichlorobenzene	0/6	1.00E-02		1.0E-02	2.0E-02		MG/L
1,2-Dichloroethane	0/6	1.00E-02		5.0E-03	1.0E-02		MG/L
1,2-Dichloroethene (Total)	1/6	8.67E-03	2.00E-03	5.0E-03	1.0E-02	NO	MG/L
1,2-Dichloropropane	0/6	1.00E-02		5.0E-03	1.0E-02		MG/L
2-Butanone	0/6	1.00E-02		1.0E-02	2.0E-02		MG/L
4-Methyl Phenol	0/6	1.00E-02		1.0E-02	2.0E-02		MG/L
4-Methyl-2-Pentanone	0/6	1.00E-02		1.0E-02	2.0E-02		MG/L

Table D.1d. (continued)

Analyte	Frequency of detection	Mean Concentration (MC)	Maximum Detection (MD)	Mean Background (MBG)	Twice Mean Background (TMBG)	Does MD exceed TMBG ?	Units
Alpha-BHC	0/6	5.00E-05		5.0E-05	1.0E-04		MG/L
Benzene	0/6	1.00E-02		5.0E-03	1.0E-02		MG/L
Benzene, 1,2,4-Trichloro-	0/6	1.00E-02		1.0E-02	2.0E-02		MG/L
Beta-BHC	0/6	5.00E-05		5.0E-05	1.0E-04		MG/L
Bis(2-Ethylhexyl) Phthalate	3/6	5.97E-03	3.60E-02	1.0E-02	2.0E-02	YES	MG/L
Bromomethane	0/6	1.00E-02		1.0E-02	2.0E-02		MG/L
Carbon Disulfide	0/6	1.00E-02		5.0E-03	1.0E-02		MG/L
Chloroform	0/6	1.00E-02		5.0E-03	1.0E-02		MG/L
Delta-BHC	0/6	5.00E-05		5.0E-05	1.0E-04		MG/L
Nitrate/Nitrite	1/6	2.67E-01	3.50E-01				MG/L
Phosphate	4/6	2.07E-01	3.90E-01				MG/L
Styrene	0/6	1.00E-02		5.0E-03	1.0E-02		MG/L
Tetrachloroethene	0/6	1.00E-02		5.0E-03	1.0E-02		MG/L
Toluene	0/6	1.00E-02		5.0E-03	1.0E-02		MG/L
Total Organic Carbon	6/6	8.15E+00	1.19E+01				MG/L
Trichloroethene	0/6	1.00E-02		5.0E-03	1.0E-02		MG/L
Vinyl Chloride	0/6	1.00E-02		1.0E-02	2.0E-02		MG/L
Xylene (Total)	0/6	1.00E-02		5.0E-03	1.0E-02		MG/L
m-Dichlorobenzene	0/6	1.00E-02		1.0E-02	2.0E-02		MG/L
p-Dichlorobenzene	0/6	1.00E-02		1.0E-02	2.0E-02		MG/L
TOX	6/6	1.60E-02	2.66E-02				MG/L
Total Kjeldahl Nitrogen-TKN	6/6	3.75E-01	5.40E-01				MG/L
Alpha Particle	3/5	6.53E+00	1.79E+01	4.5E+00	8.9E+00	YES	PCI/L
Am-241	3/6	2.12E-01	9.02E-01				PCI/L
Beta Particle	6/6	1.34E+03	4.68E+03	4.0E+00	8.0E+00	YES	PCI/L
C-14	1/6	3.48E+01	1.78E+02				PCI/L
Cm-243/244	0/6	2.98E-02					PCI/L
Cs-137	0/6	1.40E+01		2.0E+01	4.0E+01		PCI/L
Pu-238	2/6	3.63E+00	1.91E+01				PCI/L
Pu-239/240	1/6	5.51E-02	1.99E-01				PCI/L
Ra-226	0/6	5.76E-02		1.0E+00	2.0E+00		PCI/L
Ra-228	1/6	7.99E+00	5.11E+00	3.0E+00	6.0E+00	NO	PCI/L

Table D.1d. (continued)

Analyte	Frequency of detection	Mean Concentration (MC)	Maximum Detection (MD)	Mean Background (MBG)	Twice Mean Background (TMBG)	Does MD exceed TMBG ?	Units
Tc-99	1/6	5.93E+00	3.01E+01				PCI/L
Th-228	6/6	4.72E-01	5.83E-01	1.0E+00	2.0E+00	NO	PCI/L
Th-230	5/6	1.10E+00	2.77E+00	2.1E+00	4.3E+00	NO	PCI/L
Th-232	0/6	-1.39E-02		1.0E+00	2.0E+00		PCI/L
Total Radioactive Strontium	3/5	7.10E+02	2.09E+03				PCI/L
Tritium	6/6	1.89E+06	1.08E+07	8.1E+02	1.6E+03	YES	PCI/L
U-232	0/6	3.92E-02					PCI/L
U-233/234	4/6	3.11E+00	1.06E+01	1.0E+00	2.0E+00	YES	PCI/L
U-235	1/6	1.30E-01	6.83E-01				PCI/L
U-238	3/6	3.02E+00	1.72E+01	1.0E+00	2.0E+00	YES	PCI/L
Seep Location							
Aluminum	14/15	1.84E+00	1.23E+01	1.7E-01	3.4E-01	YES	MG/L
Antimony	1/15	1.54E-02	2.77E-02	3.0E-02	6.0E-02	NO	MG/L
Arsenic	2/15	1.81E-03	3.60E-03	2.0E-03	4.0E-03	NO	MG/L
Barium	15/15	1.37E-01	2.18E-01	4.2E-02	8.3E-02	YES	MG/L
Beryllium	1/15	9.16E-04	4.80E-04	1.0E-03	2.0E-03	NO	MG/L
Boron	1/1	5.38E-01	5.38E-01				MG/L
Cadmium	0/15	2.46E-03		5.0E-03	1.0E-02		MG/L
Calcium	15/15	8.38E+01	1.29E+02	3.7E+01	7.4E+01	YES	MG/L
Chromium	2/15	2.07E-03	1.72E-02	1.0E-02	2.0E-02	NO	MG/L
Cobalt	6/15	5.82E-03	2.93E-01	2.0E-02	4.0E-02	YES	MG/L
Copper	2/15	2.94E-03	7.70E-03	1.2E-02	2.3E-02	NO	MG/L
Iron	15/15	6.92E+00	1.72E+01	4.0E-01	8.1E-01	YES	MG/L
Lead	9/15	4.01E-03	7.50E-03	7.0E-03	1.4E-02	NO	MG/L
Magnesium	15/15	1.54E+01	5.89E+01	5.1E+00	1.0E+01	YES	MG/L
Manganese	15/15	4.00E+00	9.93E+00	1.0E-01	2.1E-01	YES	MG/L
Mercury	2/15	7.71E-05	1.90E-04	2.0E-03	4.0E-03	NO	MG/L
Nickel	5/15	8.42E-03	3.28E-01	2.0E-02	4.0E-02	YES	MG/L
Potassium	15/15	2.27E+00	4.88E+00	1.0E+00	2.0E+00	YES	MG/L
Selenium	1/15	4.06E-03	3.56E-02	2.0E-03	4.0E-03	YES	MG/L
Silicon	1/1	5.65E+00	5.65E+00				MG/L
Sodium	15/15	1.38E+01	3.33E+01	3.5E+00	7.0E+00	YES	MG/L

Table D.1d. (continued)

Analyte	Frequency of detection	Mean Concentration (MC)	Maximum Detection (MD)	Mean Background (MBG)	Twice Mean Background (TMBG)	Does MD exceed TMBG ?	Units
Vanadium	4/15	3.22E-03	1.92E-02	1.0E-02	2.0E-02	NO	MG/L
Zinc	6/15	1.21E-02	3.60E-02	1.1E-01	2.2E-01	NO	MG/L
1,1,1-Trichloroethane	2/15	1.68E-03	2.00E-03	5.0E-03	1.0E-02	NO	MG/L
1,1-Dichloroethane	5/15	8.20E-03	1.40E-02	5.0E-03	1.0E-02	YES	MG/L
1,1-Dichloroethene	1/15	1.00E-02	1.00E-02	5.0E-03	1.0E-02	NO	MG/L
1,2-Dichlorobenzene	2/15	8.93E-03	2.00E-03	1.0E-02	2.0E-02	NO	MG/L
1,2-Dichloroethane	1/15	9.73E-03	6.00E-03	5.0E-03	1.0E-02	NO	MG/L
1,2-Dichloroethene (Total)	10/15	2.72E-02	8.50E-01	5.0E-03	1.0E-02	YES	MG/L
1,2-Dichloropropane	1/15	9.40E-03	1.00E-03	5.0E-03	1.0E-02	NO	MG/L
2-Butanone	0/15	1.00E-02		1.0E-02	2.0E-02		MG/L
4-Methyl Phenol	0/15	1.00E-02		1.0E-02	2.0E-02		MG/L
4-Methyl-2-Pentanone	1/15	9.40E-03	1.00E-03	1.0E-02	2.0E-02	NO	MG/L
Alpha-BHC	1/15	7.33E-05	4.00E-04	5.0E-05	1.0E-04	YES	MG/L
Benzene	1/15	9.47E-03	2.00E-03	5.0E-03	1.0E-02	NO	MG/L
Benzene, 1,2,4-Trichloro-	2/15	5.75E-03	2.40E-02	1.0E-02	2.0E-02	YES	MG/L
Beta-BHC	1/15	5.12E-05	6.80E-05	5.0E-05	1.0E-04	NO	MG/L
Bis(2-Ethylhexyl) Phthalate	1/15	9.47E-03	2.00E-03	1.0E-02	2.0E-02	NO	MG/L
Bromomethane	0/15	1.00E-02		1.0E-02	2.0E-02		MG/L
Carbon Disulfide	1/15	9.40E-03	1.00E-03	5.0E-03	1.0E-02	NO	MG/L
Chloride	15/15	1.65E+01	1.05E+02				MG/L
Chloroform	3/15	8.40E-03	2.00E-03	5.0E-03	1.0E-02	NO	MG/L
Delta-BHC	1/15	6.80E-05	3.20E-04	5.0E-05	1.0E-04	YES	MG/L
Fluoride	14/15	1.34E-01	6.20E-01				MG/L
Nitrate	4/15	1.58E-01	1.91E+00				MG/L
Phosphate	7/15	8.25E-02	3.30E-01				MG/L
Styrene	0/15	1.00E-02		5.0E-03	1.0E-02		MG/L
Sulfate	15/15	2.26E+01	2.02E+02				MG/L
Tetrachloroethene	1/15	1.13E-02	2.90E-02	5.0E-03	1.0E-02	YES	MG/L
Toluene	1/15	1.00E-02	1.00E-02	5.0E-03	1.0E-02	NO	MG/L
Total Organic Carbon	14/15	2.84E+00	9.24E+00				MG/L
Trichloroethene	9/15	9.15E-03	8.90E-02	5.0E-03	1.0E-02	YES	MG/L
Vinyl Chloride	7/15	6.33E-03	7.30E-02	1.0E-02	2.0E-02	YES	MG/L

Table D.1d. (continued)

Analyte	Frequency of detection	Mean Concentration (MC)	Maximum Detection (MD)	Mean Background (MBG)	Twice Mean Background (TMBG)	Does MD exceed TMBG ?	Units
Xylene (Total)	2/15	9.53E-03	1.00E-02	5.0E-03	1.0E-02	NO	MG/L
m-Dichlorobenzene	2/15	8.93E-03	2.00E-03	1.0E-02	2.0E-02	NO	MG/L
p-Dichlorobenzene	2/15	9.60E-03	7.00E-03	1.0E-02	2.0E-02	NO	MG/L
Alkalinity as CaCO ₃	15/15	2.64E+02	4.32E+02				MG/L
TOX	13/15	6.53E-02	5.26E-01				MG/L
Total Dissolved Solids	15/15	3.40E+02	8.39E+02				MG/L
Total Kjeldahl Nitrogen-TKN	15/15	4.21E-01	7.10E-01				MG/L
Total Suspended Solids	12/14	4.51E+01	9.10E+01				MG/L
Alpha Particle	7/15	5.08E+02	7.10E+03	4.5E+00	8.9E+00	YES	PC/L
Am-241	1/3	1.08E+01	3.22E+01				PC/L
Beta Particle	15/15	1.85E+05	1.87E+06	4.0E+00	8.0E+00	YES	PC/L
C-14	10/14	2.71E+02	9.10E+02				PC/L
Ca-45	4/8	3.02E+03	1.50E+04				PC/L
Cm-243/244	0/2	6.15E-01					PC/L
Co-60	1/1	3.38E+01	3.38E+01				PC/L
Cs-137	3/15	2.03E+01	3.93E+01	2.0E+01	4.0E+01	NO	PC/L
K-40	1/3	8.30E+01	1.50E+02				PC/L
Pu-238	0/2	1.70E-01					PC/L
Pu-239/240	0/2	7.00E-02					PC/L
Ra-226	2/11	2.67E-01	6.20E-01	1.0E+00	2.0E+00	NO	PC/L
Ra-228	3/3	5.07E+01	1.10E+02	3.0E+00	6.0E+00	YES	PC/L
Sn-119m	1/1	5.50E+01	5.50E+01				PC/L
Tc-99	11/11	4.14E+02	2.12E+03				PC/L
Th-228	2/10	1.87E-01	2.90E-01	1.0E+00	2.0E+00	NO	PC/L
Th-230	2/11	2.49E-01	2.50E-01	2.1E+00	4.3E+00	NO	PC/L
Th-232	3/11	2.74E+00	2.91E+01	1.0E+00	2.0E+00	YES	PC/L
Th-234	1/1	1.10E+03	1.10E+03	2.6E+02	5.3E+02	YES	PC/L
Total Radioactive Strontium	13/15	9.75E+04	1.06E+06				PC/L
Tritium	15/15	1.20E+07	7.73E+07	8.1E+02	1.6E+03	YES	PC/L
U-233/234	8/14	1.07E+02	1.10E+03	1.0E+00	2.0E+00	YES	PC/L
U-235	2/15	5.46E+00	8.10E+01				PC/L
U-238	8/15	1.27E+02	1.90E+03	1.0E+00	2.0E+00	YES	PC/L

Table D.2a. Toxicity screening for detected inorganic and organic analytes in WAG5 soil
(carcinogenic and noncarcinogenic effects; Inhalation and Ingestion)

Analyte	Maximum det. conc. mg/kg	Inhalation					Ingestion					DROP		
		SF kg-d/mg	RfD mg/kg-d	Noncarc. toxicity score	Carc. toxicity score	% of total noncarc. score	% of total carc. score	SF kg-d/mg	RfD mg/kg-d	Noncarc. toxicity score	Carc. toxicity score		% of total noncarc. score	% of total carc. score
Antimony	6.2E+00		4.0E-04	1.6E+04		12.77								
Arsenic	1.2E+01		3.0E-04	3.9E+04		31.85		5.0E+01			5.8E+02		95.24	
Barium	4.8E+02		7.0E-02	6.8E+03		5.64			1.4E-04	3.4E+06		1.01		
Beryllium	2.0E+00	4.3E+00	5.0E-03	4.0E+02	8.6E+00	0.33	46.32	8.4E+00			1.7E+01		2.76	
Cadmium	2.0E+00		1.0E-03	2.0E+03		1.65		6.1E+00			1.2E+01		2.00	
Manganese	4.7E+03		1.4E-01	3.4E+04		27.71			1.4E-03	3.3E+08		98.98		
Mercury	4.3E+00		3.0E-04	1.4E+04		11.80			8.6E-03	5.0E+04		0.02		
Nickel	4.2E+01		2.0E-02	2.1E+03		1.73								DROP
Selenium	2.0E+00		5.0E-03	4.0E+02		0.33								DROP
Silver	5.0E+00		5.0E-03	1.0E+03		0.82								
Vanadium	3.8E+01		7.0E-03	5.4E+03		4.42								DROP
Zinc	3.2E+02		3.0E-01	1.1E+03		0.88								DROP
1,2-Benzenedicarboxylic Acid, Diethyl Ester	3.0E-01		8.0E-01	3.8E-01		0.00								DROP
1,2-Dichloroethene (Total)	3.0E-03		9.0E-03	3.3E-01		0.00								DROP
2-Butanone	2.1E-02		6.0E-01	3.5E-02		0.00			2.9E-01	7.4E-02		0.00		DROP
4,4'-DDD	8.2E-04	2.4E-01			2.0E-04		0.00							DROP
Acetone	6.5E-01		1.0E-01	6.5E+00		0.01								DROP
Aroclor 1254	9.3E-02	7.7E+00			7.2E-01		3.86							
Aroclor 1260	1.2E+00	7.7E+00			9.2E+00		49.77							
Benzo(k)Fluoranthene	4.9E-02	7.3E-02			3.6E-03		0.02							DROP
Bis(2-Ethylhexyl) Phthalate	1.1E-01	1.4E-02	2.0E-02	5.5E+00	1.5E-03	0.00	0.01							DROP

Table D.2a. (continued)

Analyte	Maximum det. conc. mg/kg	Inhalation					Ingestion							
		SF kg-d/mg	RfD mg/kg-d	Noncarc. toxicity score	Carc. toxicity score	% of total noncarc. score	% of total carc. score	SF kg-d/mg	RfD mg/kg-d	Noncarc. toxicity score	Carc. toxicity score	% of total noncarc. score	% of total carc. score	DROP
Butyl Benzyl Phthalate	5.2E-02		2.0E-01	2.6E-01		0.00								DROP
Chloroform	1.0E-03	6.1E-03	1.0E-02	1.0E-01	6.1E-06	0.00	0.00	8.1E-02			8.1E-05		0.00	DROP
Chloromethane	2.0E-03	1.3E-02			2.6E-05		0.00	6.3E-03			1.3E-05		0.00	DROP
Cyanide	7.0E-01		2.0E-02	3.5E+01		0.03								DROP
Di-n-butyl Phthalate	4.4E-01		1.0E-01	4.4E+00		0.00								DROP
Endrin	5.1E-04		3.0E-04	1.7E+00		0.00								DROP
Ethylbenzene	1.2E-02		1.0E-01	1.2E-01		0.00			2.9E-01	4.2E-02		0.00		DROP
Fluoranthene	4.3E-02		4.0E-02	1.1E+00		0.00								DROP
Heptachlor Epoxide	5.4E-04	9.1E+00	1.3E-05	4.2E+01	4.9E-03	0.03	0.03	9.1E+00			4.9E-03		0.00	DROP
Methylene Chloride	5.0E-03	7.5E-03	6.0E-02	8.3E-02	3.8E-05	0.00	0.00	8.6E-01	5.8E-03			0.00		DROP
Pyrene	5.2E-02		3.0E-02	1.7E+00		0.00								DROP
Styrene	3.0E-03		2.0E-01	1.5E-02		0.00		2.9E-01	1.1E-02			0.00		DROP
Tetrachloroethene	3.0E-03		1.0E-02	3.0E-01		0.00								DROP
Toluene	2.0E-02		2.0E-01	1.0E-01		0.00		1.1E-01	1.8E-01			0.00		DROP

Table D.2b. Toxicity screening for detected radionuclides in WAGS soil
(Ingestion, inhalation and external exposure)

Analyte	Maximum det. conc. (pCi/g)	Ingestion			Inhalation			External exposure			Final decision
		SF (1/pCi)	Toxicity score	% of total toxicity score	SF (1/pCi)	Toxicity score	% of total toxicity score	SF (1/pCi)	Toxicity score	% of total toxicity score	
Ac-228	2.4E+00	5.0E-13	1.2E-12	0.00	2.6E-11	6.2E-11	0.00	2.9E-06	7.0E-06	0.05	DROP
Am-241	6.8E+00	2.4E-10	1.6E-09	0.28	3.2E-08	2.2E-07	6.48	4.9E-09	3.3E-08	0.00	
Bi-212	2.6E+00	3.1E-13	8.1E-13	0.00	6.6E-12	1.7E-11	0.00	5.9E-07	1.5E-06	0.01	DROP
Bi-214	9.4E-01	1.3E-13	1.2E-13	0.00	2.1E-12	2.0E-12	0.00	5.3E-06	5.0E-06	0.03	DROP
C-14	2.8E+01	9.0E-13	2.5E-11	0.00	6.4E-15	1.8E-13	0.00	0.0E+00	0.0E+00	0.00	DROP
Ca-45	5.3E+02	9.9E-13	5.2E-10	0.09	5.1E-12	2.7E-09	0.08	5.8E-18	3.1E-15	0.00	DROP
Cm-243	1.8E-01	1.9E-10	3.4E-11	0.01	2.6E-08	4.7E-09	0.14	1.6E-07	2.9E-08	0.00	DROP
Cm-243/244	3.6E+01	1.6E-10	5.7E-09	0.99	2.2E-08	7.8E-07	23.38	3.0E-11	1.1E-09	0.00	
Co-57	2.3E+00	5.8E-13	1.3E-12	0.00	8.2E-12	1.9E-11	0.00	1.9E-07	4.4E-07	0.00	DROP
Co-60	1.8E+02	1.5E-11	2.7E-09	0.47	1.5E-10	2.7E-08	0.81	8.6E-06	1.5E-03	10.14	
Cs-134	4.0E-02	4.1E-11	1.6E-12	0.00	2.8E-11	1.1E-12	0.00	5.2E-06	2.1E-07	0.00	DROP
Cs-137	6.8E+03	2.8E-11	1.9E-07	33.04	1.9E-11	1.3E-07	3.86	2.0E-06	1.4E-02	89.12	
I-129	5.7E+00	1.9E-10	1.1E-09	0.19	1.2E-10	6.8E-10	0.02	4.1E-09	2.3E-08	0.00	DROP
K-40	3.5E+01	1.1E-11	3.9E-10	0.07	7.6E-12	2.7E-10	0.01	5.4E-07	1.9E-05	0.12	DROP
Na-22	1.5E+00	6.8E-12	1.0E-11	0.00	4.8E-12	7.2E-12	0.00	7.2E-06	1.1E-05	0.07	DROP
Pb-212	1.9E+00	5.5E-12	1.0E-11	0.00	4.3E-11	8.2E-11	0.00	2.8E-07	5.3E-07	0.00	DROP
Pb-214	1.4E+00	1.7E-13	2.4E-13	0.00	2.9E-12	4.1E-12	0.00	6.4E-07	9.0E-07	0.01	DROP
Pu-238	4.2E+00	2.2E-10	9.1E-10	0.16	3.9E-08	1.6E-07	4.83	2.8E-11	1.2E-10	0.00	
Pu-239/240	1.8E+00	2.3E-10	4.1E-10	0.07	3.8E-08	6.7E-08	2.01	1.7E-11	3.0E-11	0.00	
Ra-223	5.6E-01	6.4E-11	3.6E-11	0.01	3.1E-09	1.7E-09	0.05	2.3E-07	1.3E-07	0.00	DROP

Table D.2b. (continued)

Analyte	Maximum det. conc. (pCi/g)	Ingestion			Inhalation			External exposure			Final decision
		SF (I/pCi)	Toxicity score	% of total toxicity score	SF (I/pCi)	Toxicity score	% of total toxicity score	SF (I/pCi)	Toxicity score	% of total toxicity score	
Ra-226	3.6E+00	1.2E-10	4.3E-10	0.07	3.0E-09	1.1E-08	0.32	6.0E-06	2.2E-05	0.14	DROP
Ra-228	2.4E+00	1.0E-10	2.4E-10	0.04	6.9E-10	1.7E-09	0.05	2.9E-06	7.0E-06	0.05	DROP
Sn-126	4.6E-01	5.6E-12	2.6E-12	0.00	7.7E-11	3.5E-11	0.00	3.3E-08	1.5E-08	0.00	DROP
Tc-99	1.3E+00	1.3E-12	1.7E-12	0.00	8.3E-12	1.1E-11	0.00	6.0E-13	7.8E-13	0.00	DROP
Th-228	2.2E+00	5.5E-11	1.2E-10	0.02	7.8E-08	1.7E-07	5.12	5.6E-06	1.2E-05	0.08	
Th-230	4.4E+00	1.3E-11	5.7E-11	0.01	2.9E-08	1.3E-07	3.78	5.4E-11	2.4E-10	0.00	
Th-232	2.4E+00	1.2E-11	2.9E-11	0.00	2.8E-08	6.7E-08	2.01	2.6E-11	6.2E-11	0.00	
Th-234	7.3E+00	4.0E-12	2.9E-11	0.01	3.2E-11	2.3E-10	0.01	3.5E-09	2.6E-08	0.00	DROP
Tl-208	2.0E+00	1.8E-14	3.6E-14	0.00	5.0E-15	1.0E-14	0.00	1.3E-05	2.6E-05	0.17	DROP
Total Radioactive Strontium	1.0E+04	3.6E-11	3.7E-07	64.35	6.2E-11	6.4E-07	19.07	0.0E+00	0.0E+00	0	
Tritium	1.9E+03	5.4E-14	1.0E-10	0.02	7.8E-14	1.5E-10	0.00	0.0E+00	0.0E+00	0	DROP
U-232	5.3E-01	3.7E-11	2.0E-11	0.00	6.0E-08	3.2E-08	0.95	4.6E-11	2.4E-11	1.603597E-7	DROP
U-233	1.1E+01	1.6E-11	1.7E-10	0.03	2.7E-08	2.8E-07	8.46	4.2E-11	4.4E-10	2.8897772E-6	
U-233/234	9.9E+00	1.6E-11	1.6E-10	0.03	2.6E-08	2.6E-07	7.68	3.0E-11	3.0E-10	1.9461763E-6	
U-238	7.0E+00	2.8E-11	2.0E-10	0.03	5.2E-08	3.6E-07	10.87	3.6E-08	2.5E-07	0.0016513012	

Table D. 3a. Toxicity screening for detected inorganic and organic analytes in WAG5 sediment
(carcinogenic and noncarcinogenic effects; Inhalation and Ingestion)

Analyte	Maximum det. conc. mg/kg	Inhalation					Ingestion							
		SF kg-d/mg	RfD mg/kg-d	Noncarc. toxicity score	Carc. toxicity score	% of total noncarc. score	% of total carc. score	SF kg-d/mg	RfD mg/kg-d	Noncarc. toxicity score	Carc. toxicity score	% of total noncarc. score	% of total carc. score	DROP
Antimony	2.8E+01		4.0E-04	6.9E+04		12.47								
Arsenic	1.4E+01		3.0E-04	4.7E+04		8.43	5.0E+01				7.0E+02		99.95	
Barium	1.7E+03		7.0E-02	2.4E+04		4.41		1.4E-04	1.2E+07			0.40		
Chromium	6.4E+01		5.0E-03				4.1E+01							
Manganese	4.3E+04		1.4E-01	3.0E+05		54.98		1.4E-05	3.0E+09			99.59		
Mercury	2.9E+01		3.0E-04	9.8E+04		17.71		8.6E-05	3.4E+05			0.01		
Nickel	7.1E+01		2.0E-02	3.5E+03		0.64								DROP
Selenium	1.9E+00		5.0E-03	3.8E+02		0.07								DROP
Silver	7.3E+00		5.0E-03	1.5E+03		0.26								DROP
Zinc	1.6E+03		3.0E-01	5.3E+03		0.96								DROP
1,1-Dichloroethane	1.4E-01		1.0E-01	1.4E+00		0.00		1.4E-01	9.8E-01		0.00			DROP
1,1-Dichloroethene	2.8E-02	6.0E-01	9.0E-03	3.1E+00	1.7E-02	0.00	1.2E+00				3.4E-02		0.00	DROP
1,2-Dichloroethane	4.9E-02	9.1E-02			4.5E-03		9.1E-02				4.5E-03		0.00	DROP
1,2-Dichloroethene (Total)	2.1E+00		9.0E-03	2.3E+02		0.04								DROP
2-Butanone	1.1E+00		6.0E-01	1.8E+00		0.00		2.9E-01	3.9E+00		0.00			DROP
4-Methyl Phenol	2.6E+01		5.0E-03	5.2E+03		100.00								
4-Methyl-2-Pentanone	2.0E-03		8.0E-02	2.5E-02		0.00		2.3E-02	8.8E-02		0.00			DROP
Acetone	4.9E+00		1.0E-01	4.9E+01		0.01								DROP
Aroclor 1248	1.2E+00	7.7E+00			9.2E+00							26.05		DROP

D-30

Table D. 3a. (continued)

Analyte	Maximum det. conc. mg/kg	Inhalation					Ingestion							
		SF kg-d/mg	RfD mg/kg-d	Noncarc. toxicity score	Carc. toxicity score	% of total noncarc. score	% of total carc. score	SF kg-d/mg	RfD mg/kg-d	Noncarc. toxicity score	Carc. toxicity score	% of total noncarc. score	% of total carc. score	DROP
Aroclor 1254	2.3E+00	7.7E+00		1.8E+01			49.93							
Aroclor 1260	8.3E-01	7.7E+00		6.4E+00			18.02							
Benzene	1.1E-02	2.9E-02		3.2E-04			0.00	2.9E-02			3.2E-04		0.00	DROP
Bis(2-Ethylhexyl) Phthalate	1.0E+00	1.4E-02	2.0E-02	5.0E+01	1.4E-02	0.01	0.04							DROP
Carbolic Acid	3.3E+01		6.0E-01	5.5E+01		0.01								DROP
Carbon Disulfide	2.0E-03		1.0E-01	2.0E-02		0.00			2.9E-03	7.0E-01		0.00		DROP
Chloroform	2.0E-03	6.1E-03	1.0E-02	2.0E-01	1.2E-05	0.00	0.00	8.1E-02			1.6E-04		0.00	DROP
Toluene	1.0E-02		2.0E-01	5.0E-02		0.00			1.1E-01	8.8E-02		0.00		DROP
Trichloroethene	7.0E-03	1.1E-02			7.7E-05		0.00	6.0E-03			4.2E-05		0.00	DROP
Vinyl Chloride	1.1E+00	1.9E+00			2.1E+00		5.89	3.0E-01			3.3E-01		0.05	
Xylene (Total)	2.7E-02		2.0E+00	1.4E-02		0.00								DROP

Table D. 3b. Toxicity screening for detected radionuclides in WAGS sediment
(Ingestion, inhalation and external exposure)

Analyte	Maximum det. conc. (pCi/g)	Ingestion			Inhalation			External exposure		
		SF (1/pCi)	Toxicity score	% of total toxicity score	SF (1/pCi)	Toxicity score	% of total toxicity score	SF (1/pCi)	Toxicity score	% of total toxicity score
Ac-228	2.3E+00	5.0E-13	1.2E-12	0.00	2.6E-11	6.0E-11	0.00	2.9E-06	6.7E-06	0.00
Am-241	1.2E+03	2.4E-10	2.8E-07	0.21	3.2E-08	3.7E-05	3.90	4.9E-09	5.7E-06	0.00
Bi-212	1.7E+00	3.1E-13	5.3E-13	0.00	6.6E-12	1.1E-11	0.00	5.9E-07	1.0E-06	0.00
Bi-214	1.2E+00	1.3E-13	1.6E-13	0.00	2.1E-12	2.5E-12	0.00	5.3E-06	6.4E-06	0.00
C-14	2.6E+02	9.0E-13	2.3E-10	0.00	6.4E-15	1.6E-12	0.00	0.0E+00	0.0E+00	0.00
Ca-45	9.2E+01	9.9E-13	9.1E-11	0.00	5.1E-12	4.7E-10	0.00	5.8E-18	5.3E-16	0.00
Cm-242	3.5E-01	1.3E-11	4.6E-12	0.00	3.9E-09	1.4E-09	0.00	3.4E-11	1.2E-11	0.00
Cm-243/244	2.4E+04	1.6E-10	3.9E-06	2.88	2.2E-08	5.4E-04	55.92	3.0E-11	7.3E-07	0.00
Co-60	6.8E+03	1.5E-11	1.0E-07	0.08	1.5E-10	1.0E-06	0.11	8.6E-06	5.9E-02	0.78
Cs-137	3.7E+06	2.8E-11	1.0E-04	76.90	1.9E-11	7.1E-05	7.36	2.0E-06	7.4E+00	99.11
Eu-152	9.6E+02	2.1E-12	2.0E-09	0.00	1.1E-10	1.1E-07	0.01	3.6E-06	3.5E-03	0.05
Eu-154	5.8E+02	3.0E-12	1.7E-09	0.00	1.4E-10	8.1E-08	0.01	4.1E-06	2.4E-03	0.03
Eu-155	1.5E-01	4.5E-13	6.8E-14	0.00	1.8E-11	2.7E-12	0.00	5.9E-08	8.9E-09	0.00
I-129	1.4E+01	1.9E-10	2.7E-09	0.00	1.2E-10	1.7E-09	0.00	4.1E-09	5.7E-08	0.00
Pb-210	2.7E+00	6.6E-10	1.8E-09	0.00	4.0E-09	1.1E-08	0.00	1.6E-10	4.3E-10	0.00
Pb-212	1.7E+00	5.5E-12	9.4E-12	0.00	4.3E-11	7.3E-11	0.00	2.8E-07	4.8E-07	0.00
Pb-214	1.2E+00	5.5E-12	6.6E-12	0.00	4.3E-11	5.2E-11	0.00	2.8E-07	3.4E-07	0.00
Pu-238	1.2E+03	2.2E-10	2.7E-07	0.20	3.9E-08	4.8E-05	4.96	2.8E-11	3.4E-08	0.00
Pu-239/240	6.4E+02	2.3E-10	1.5E-07	0.11	3.8E-08	2.4E-05	2.53	1.7E-11	1.1E-08	0.00
Ra-223	9.1E-01	6.4E-11	5.8E-11	0.00	3.1E-09	2.8E-09	0.00	2.3E-07	2.1E-07	0.00
Ra-224	4.9E+00	3.8E-11	1.9E-10	0.00	1.2E-09	5.9E-09	0.00	2.3E-08	1.1E-07	0.00

Table D. 3b. (continued)

Analyte	Maximum det. conc. (pCi/g)	Ingestion			Inhalation			External exposure			
		SF (1/pCi)	Toxicity score	% of total toxicity score	SF (1/pCi)	Toxicity score	% of total toxicity score	SF (1/pCi)	Toxicity score	% of total toxicity score	Final decision
Ra-226	3.0E+00	1.2E-10	3.6E-10	0.00	3.0E-09	9.0E-09	0.00	6.0E-06	1.8E-05	0.00	DROP
Radon 219	1.2E+00				4.6E-14	5.5E-14	0.00	1.6E-07	1.9E-07	0.00	DROP
Sn-126	2.8E-01	5.6E-12	1.6E-12	0.00	7.7E-11	2.2E-11	0.00	3.3E-08	9.2E-09	0.00	DROP
Tc-99	1.2E+01	1.3E-12	1.6E-11	0.00	8.3E-12	1.0E-10	0.00	6.0E-13	7.2E-12	0.00	DROP
Th-228	3.9E+02	5.5E-11	2.1E-08	0.02	7.8E-08	3.0E-05	3.15	5.6E-06	2.2E-03	0.03	
Th-230	3.1E+02	1.3E-11	4.0E-09	0.00	2.9E-08	9.0E-06	0.93	5.4E-11	1.7E-08	0.00	DROP
Th-231	5.3E-01	4.0E-13	2.1E-13	0.00	4.9E-13	2.6E-13	0.00	2.3E-09	1.2E-09	0.00	DROP
Th-232	5.3E+01	1.2E-11	6.3E-10	0.00	2.8E-08	1.5E-06	0.15	2.6E-11	1.4E-09	0.00	DROP
Th-234	1.1E+01	4.0E-12	4.4E-11	0.00	3.2E-11	3.5E-10	0.00	3.5E-09	3.9E-08	0.00	DROP
Tl-208	1.4E+00	1.8E-14	2.5E-14	0.00	5.0E-15	7.0E-15	0.00	1.3E-05	1.8E-05	0.00	DROP
Total Radioactive Strontium	7.4E+05	3.6E-11	2.6E-05	19.53	6.2E-11	4.6E-05	4.75	0.0E+00	0.0E+00	0.00	
Tritium	2.3E+03	5.4E-14	1.3E-10	0.00	7.8E-14	1.8E-10	0.00	0.0E+00	0.0E+00	0.00	DROP
U-232	3.2E+02	3.7E-11	1.2E-08	0.01	6.0E-08	1.9E-05	2.01	4.6E-11	1.5E-08	0.00	
U-233	4.8E+03	1.6E-11	7.6E-08	0.06	2.7E-08	1.3E-04	13.39	4.2E-11	2.0E-07	0.00	
U-233/234	1.6E+01	1.6E-11	2.6E-10	0.00	2.6E-08	4.2E-07	0.04	3.0E-11	4.8E-10	0.00	DROP
U-235	4.1E-01	1.6E-11	6.6E-12	0.00	2.5E-08	1.0E-08	0.00	2.4E-07	9.8E-08	0.00	DROP
U-235/236	8.1E+00	1.5E-11	1.2E-10	0.00	2.5E-08	2.0E-07	0.02	2.4E-11	2.0E-10	0.00	DROP
U-238	1.4E+02	2.8E-11	3.9E-09	0.00	5.2E-08	7.2E-06	0.75	3.6E-08	5.0E-06	0.00	DROP

Table D. 4a. Toxicity screening for detected inorganic and organic analytes in WAG5 groundwater
(carcinogenic and noncarcinogenic effects; Inhalation and Ingestion)

Analyte	Maximum det. conc. mg/kg	Inhalation					Ingestion					DROP		
		SF kg-d/mg	RfD mg/kg-d	Noncarc. toxicity score	Carc. toxicity score	% of total noncarc. score	% of total carc. score	SF kg-d/mg	RfD mg/kg-d	Noncarc. toxicity score	Carc. toxicity score		% of total noncarc. score	% of total carc. score
Barium	9.8E-01		7.0E-02	1.4E+01		0.27			1.4E-04	6.8E+03		0.43		DROP
Beryllium	6.2E-03	4.3E+00	5.0E-03	1.2E+00	2.7E-02	0.02	0.35	8.4E+00			5.2E-02		0.46	DROP
Boron	1.5E+00		9.0E-02	1.7E+01		0.32			5.7E-03	2.6E+02		0.02		DROP
Chromium	2.4E-01		5.0E-03	4.9E+01		0.93		4.1E+01			1.0E+01		88.74	DROP
Manganese	2.3E+01		5.0E-03	4.5E+03		86.58			1.4E-05	1.6E+06		99.55		DROP
Mercury	4.5E-04		3.0E-04	1.5E+00		0.03			8.6E-05	5.3E+00		0.00		DROP
Nickel	4.2E-01		2.0E-02	2.1E+01		0.40								DROP
Silver	1.5E-02		5.0E-03	3.1E+00		0.06								DROP
Vanadium	1.4E-01		7.0E-03	2.0E+01		0.38								DROP
Zinc	1.2E+00		3.0E-01	3.9E+00		0.08								DROP
1,1-Dichloroethane	2.1E-02		1.0E-01	2.1E-01		0.00			1.4E-01	1.5E-01		0.00		DROP
1,1-Dichloroethene	6.0E-03	6.0E-01	9.0E-03	6.7E-01	3.6E-03	0.01	0.05	1.2E+00			7.2E-03		0.06	DROP
1,2-Dichloroethane	4.0E-03	9.1E-02			3.6E-04		0.00	9.1E-02			3.6E-04		0.00	DROP
1,2-Dichloroethene (Total)	3.3E+00		9.0E-03	3.7E+02		7.02								DROP
Acetone	1.2E-02		1.0E-01	1.2E-01		0.00								DROP
Benzene	2.5E-02	2.9E-02			7.3E-04		0.01	2.9E-02			7.3E-04		0.01	DROP
Bis(2-Ethylhexyl) Phthalate	3.1E+00	1.4E-02	2.0E-02	1.6E+02	4.3E-02	2.97	0.57							DROP
Carbon Disulfide	1.0E-03		1.0E-01	1.0E-02		0.00			2.9E-03	3.5E-01		0.00		DROP
Carbon Tetrachloride	9.0E-03	1.3E-01	7.0E-04	1.3E+01	1.2E-03	0.25	0.02	5.3E-02			4.8E-04		0.00	DROP

Table D. 4a. (continued)

Analyte	Maximum det. conc. mg/kg	Inhalation					Ingestion					DROP		
		SF kg-d/mg	RfD mg/kg-d	Noncarc. toxicity score	Carc. toxicity score	% of total noncarc. score	% of total carc. score	SF kg-d/mg	RfD mg/kg-d	Noncarc. toxicity score	Carc. toxicity score		% of total noncarc. score	% of total carc. score
Chlorobenzene	2.0E-03		2.0E-02	1.0E-01		0.00			5.7E-03	3.5E-01		0.00		DROP
Chloroethane	3.0E-03								2.9E+00	1.1E-03		0.00		DROP
Chloroform	2.5E-02	6.1E-03	1.0E-02	2.5E+00	1.5E-04	0.05	0.00	8.1E-02			2.0E-03		0.02	DROP
Cyanide	4.9E-02		2.0E-02	2.4E+00		0.05								DROP
Dimethyl Phthalate	1.6E+00		1.0E+01	1.6E-01		0.00								DROP
Fluoranthene	1.0E-03		4.0E-02	2.5E-02		0.00								DROP
Methylene Chloride	4.8E-02	7.5E-03	6.0E-02	8.0E-01	3.6E-04	0.02	0.00		8.6E-01	5.6E-02		0.00		DROP
Nitrate	6.9E+00		1.6E+00	4.3E+00		0.08								DROP
Phthalic Acid, Dioctyl Ester	4.0E-03		2.0E-02	2.0E-01		0.00								DROP
Pyrene	1.0E-03		3.0E-02	3.3E-02		0.00								DROP
Tetrachloroethene	2.5E-01		1.0E-02	2.5E+01		0.48								DROP
Toluene	1.0E-03		2.0E-01	5.0E-03		0.00			1.1E-01	8.8E-03		0.00		DROP
Trichloroethene	2.1E-01	1.1E-02			2.3E-03		0.03	6.0E-03			1.3E-03		0.01	DROP
Vinyl Chloride	4.0E+00	1.9E+00			7.6E+00		98.97	3.0E-01			1.2E+00		10.69	DROP
Xylene (Total)	2.0E-03		2.0E+00	1.0E-03		0.00								DROP

Table D. 4b. Toxicity screening for detected radionuclides in WAG5 groundwater
(Ingestion)

Analyte	Maximum det. conc. (pCi/g)	SF (1/pCi)	Toxicity score	Total toxicity score	% of total toxicity score	DROP
Am-241	1.1E+06	2.4E-10	2.8E-04	58.80	3.2E-08	
Bi-212	5.3E+02	3.1E-13	1.7E-10	0.00	6.6E-12	DROP
Bi-214	1.7E+02	1.3E-13	2.2E-11	0.00	2.1E-12	DROP
C-14	2.5E+03	9.0E-13	2.2E-09	0.00	6.4E-15	DROP
Ca-45	2.8E+02	9.9E-13	2.8E-10	0.00	5.1E-12	DROP
Cd-109	3.7E+02	7.9E-12	2.9E-09	0.00	6.5E-11	DROP
Cm-242	5.6E-01	1.3E-11	7.3E-12	0.00	3.9E-09	DROP
Cm-243	4.1E-01	1.9E-10	7.8E-11	0.00	2.6E-08	DROP
Cm-243/244	1.8E+02	1.6E-10	2.9E-08	0.01	2.2E-08	DROP
Co-60	8.9E+01	1.5E-11	1.3E-09	0.00	1.5E-10	DROP
Cs-137	2.8E+03	2.8E-11	7.7E-08	0.02	1.9E-11	DROP
Fe-55	5.3E+01	2.7E-13	1.4E-11	0.00	8.4E-13	DROP
Hg-203	1.4E+01	6.6E-13	9.6E-12	0.00	4.8E-12	DROP
K-40	1.0E+03	1.1E-11	1.1E-08	0.00	7.6E-12	DROP
Mn-54	8.9E+00	1.1E-12	9.8E-12	0.00	5.3E-12	DROP
Pb-212	5.3E+01	5.5E-12	2.9E-10	0.00	4.3E-11	DROP
Pu-238	7.8E+05	2.2E-10	1.7E-04	36.53	3.9E-08	
Pu-239/240	1.4E+04	2.3E-10	3.1E-06	0.67	3.8E-08	DROP
Ra-226	7.0E+03	1.2E-10	8.4E-07	0.18	3.0E-09	DROP
Ra-228	3.0E+02	1.0E-10	3.0E-08	0.01	6.9E-10	DROP
Tc-99	5.1E+02	1.3E-12	6.7E-10	0.00	8.3E-12	DROP
Th-228	2.1E+02	5.5E-11	1.2E-08	0.00	7.8E-08	DROP
Th-230	2.4E+01	1.3E-11	3.1E-10	0.00	2.9E-08	DROP
Th-231	3.5E+02	4.0E-13	1.4E-10	0.00	4.9E-13	DROP
Th-232	3.5E+01	1.2E-11	4.2E-10	0.00	2.8E-08	DROP
Th-234	1.0E+03	4.0E-12	4.0E-09	0.00	3.2E-11	DROP
Total Radioactive Strontium	4.2E+04	3.6E-11	1.5E-06	0.32	6.2E-11	DROP
Tritium	3.0E+08	5.4E-14	1.6E-05	3.45	7.8E-14	
U-232	2.9E+00	3.7E-11	1.1E-10	0.00	6.0E-08	DROP
U-233/234	3.8E+03	1.6E-11	6.1E-08	0.01	2.6E-08	DROP
U-235	3.6E-01	1.6E-11	5.8E-12	0.00	2.5E-08	DROP
U-235/236	3.7E-01	1.5E-11	5.5E-12	0.00	2.5E-08	DROP
U-238	1.2E+01	2.8E-11	3.5E-10	0.00	5.2E-08	DROP

Table D. 5a. Toxicity screening for detected inorganic and organic analytes in WAGS surface water
(carcinogenic and noncarcinogenic effects; Inhalation and Ingestion)

Analyte	Inhalation						Ingestion							
	Maximum det. conc. mg/kg	SF kg-d/mg	RfD mg/kg-d	Noncarc. toxicity score	Carc. toxicity score	% of total noncarc. score	% of total carc. score	SF kg-d/mg	RfD mg/kg-d	Noncarc. toxicity score	Carc. toxicity score	% of total noncarc. score	% of total carc. score	DROP
High Base														
Barium	9.3E-02		7.0E-02	1.3E+00		0.26			1.4E-04	6.5E+02		0.36		DROP
Manganese	2.6E+00		5.0E-03	5.1E+02		99.34			1.4E-05	1.8E+05		99.64		
2-Butanone	4.0E-03		6.0E-01	6.7E-03		0.00			2.9E-01	1.4E-02		0.00		DROP
4-Methyl Phenol	8.0E-03		5.0E-03	1.6E+00		0.31								DROP
4-Methyl-2-Pentanone	1.0E-03		8.0E-02	1.3E-02		0.00			2.3E-02	4.4E-02		0.00		DROP
Nitrate	7.3E-01		1.6E+00	4.6E-01		0.09								DROP
High Base Storm														
1,1-Dichloroethane	2.0E-03		1.0E-01	2.0E-02		3.01			1.4E-01	1.4E-02		36.36		
1,2-Dichloroethene (Total)	3.0E-03		9.0E-03	3.3E-01		50.13								
2-Butanone	7.0E-03		6.0E-01	1.2E-02		1.75			2.9E-01	2.5E-02		63.64		
Bis(2-Ethylhexyl) Phthalate	6.0E-03	1.4E-02	2.0E-02	3.0E-01	8.4E-05	45.11	88.42							
Trichloroethene	1.0E-03	1.1E-02			1.1E-05		11.58	6.0E-03			6.0E-06		100.00	
Impoundment														
Bis(2-Ethylhexyl) Phthalate	1.0E-03	1.4E-02	2.0E-02	5.0E-02	1.4E-05	3.37	100.00							
Bromomethane	2.0E-03		1.4E-03	1.4E+00		96.29			1.4E-03	1.4E+00		99.75		
Styrene	1.0E-03		2.0E-01	5.0E-03		0.34			2.9E-01	3.5E-03		0.25		DROP
Low Base														
Barium	1.2E-01		7.0E-02	1.7E+00		0.30			1.4E-04	8.5E+02		0.41		DROP
Manganese	2.9E+00		5.0E-03	5.9E+02		99.67			1.4E-05	2.1E+05		99.59		

Table D. 5a. (continued)

Table D: SAs (continued)														
Analyte	Maximum det. conc. mg/kg	Inhalation					Ingestion							
		SF kg-d/mg	RfD mg/kg-d	Noncarc. toxicity score	Carc. toxicity score	% of total noncarc. score	% of total carc. score	SF kg-d/mg	RfD mg/kg-d	Noncarc. toxicity score	Carc. toxicity score	% of total noncarc. score	% of total carc. score	DROP
1,2-Dichloroethene (Total)	2.0E-03		9.0E-03	2.2E-01		0.04								DROP
							Low Base Storm							
Barium	1.1E-01		7.0E-02	1.6E+00		0.26				1.4E-04	7.6E+02	0.36		DROP
Manganese	3.0E+00		5.0E-03	6.0E+02		99.41				1.4E-05	2.1E+05	99.64		DROP
1,2-Dichloroethene (Total)	2.0E-03		9.0E-03	2.2E-01		0.04								DROP
Bis(2-Ethylhexyl) Phthalate	3.6E-02	1.4E-02	2.0E-02	1.8E+00	5.0E-04	0.30	100.00							
							Seep Location							
Barium	2.2E-01		7.0E-02	3.1E+00		0.15				1.4E-04	1.5E+03	0.22		DROP
Boron	5.4E-01		9.0E-02	6.0E+00		0.28				5.7E-03	9.4E+01	0.01		DROP
Manganese	9.9E+00		5.0E-03	2.0E+03		93.63				1.4E-05	7.0E+05	99.77		DROP
Nickel	3.3E-01		2.0E-02	1.6E+01		0.77								DROP
Selenium	3.6E-02		5.0E-03	7.1E+00		0.34								DROP
1,1-Dichloroethane	1.4E-02		1.0E-01	1.4E-01		0.01				1.4E-01	9.8E-02	0.00		DROP
1,1-Dichloroethene	1.0E-02	6.0E-01	9.0E-03	1.1E+00	6.0E-03	0.05	4.02	1.2E+00			1.2E-02		31.71	DROP
1,2-Dichlorobenzene	2.0E-03		9.0E-02	2.2E-02		0.00				5.7E-02	3.5E-02	0.00		DROP
1,2-Dichloroethane	6.0E-03	9.1E-02			5.5E-04		0.37	9.1E-02			5.5E-04		1.44	DROP
1,2-Dichloroethene (Total)	8.5E-01		9.0E-03	9.4E+01		4.45								
1,2-Dichloropropane	1.0E-03	6.8E-02			6.8E-05		0.05			1.1E-03	8.8E-01	0.00		DROP
4-Methyl-2-Pentanone	1.0E-03		8.0E-02	1.3E-02		0.00				2.3E-02	4.4E-02	0.00		DROP
Alpha-BHC	4.0E-04	6.3E+00			2.5E-03		1.69	6.3E+00			2.5E-03		6.66	DROP
Benzene	2.0E-03	2.9E-02			5.8E-05		0.04	2.9E-02			5.8E-05		0.15	DROP

Table D. 5a. (continued)

Analyte	Maximum det. conc. mg/kg	Inhalation						Ingestion						
		SF kg-d/mg	RfD mg/kg-d	Noncarc. toxicity score	Carc. toxicity score	% of total noncarc. score	% of total carc. score	SF kg-d/mg	RfD mg/kg-d	Noncarc. toxicity score	Carc. toxicity score	% of total noncarc. score	% of total carc. score	
Benzene, 1,2,4-Trichloro-	2.4E-02		1.0E-02	2.4E+00		0.11			5.7E-02	4.2E-01		0.00		DROP
Beta-BHC	6.8E-05	1.8E+00			1.2E-04		0.08	1.8E+00			1.2E-04		0.32	DROP
Bis(2-Ethylhexyl) Phthalate	2.0E-03	1.4E-02	2.0E-02	1.0E-01	2.8E-05	0.00	0.02							DROP
Carbon Disulfide	1.0E-03		1.0E-01	1.0E-02		0.00			2.9E-03	3.5E-01		0.00		DROP
Chloroform	2.0E-03	6.1E-03	1.0E-02	2.0E-01	1.2E-05	0.01	0.01	8.1E-02			1.6E-04		0.43	DROP
Nitrate	1.9E+00		1.6E+00	1.2E+00		0.06								DROP
Tetrachloroethene	2.9E-02		1.0E-02	2.9E+00		0.14								DROP
Toluene	1.0E-02		2.0E-01	5.0E-02		0.00			1.1E-01	8.8E-02		0.00		DROP
Trichloroethene	8.9E-02	1.1E-02			9.8E-04		0.66	6.0E-03			5.3E-04		1.41	
Vinyl Chloride	7.3E-02	1.9E+00			1.4E-01		92.96	3.0E-01			2.2E-02		57.87	
Xylene (Total)	1.0E-02		2.0E+00	5.0E-03		0.00								DROP
p-Dichlorobenzene	7.0E-03	2.4E-02			1.7E-04		0.11		2.3E-01	3.1E-02		0.00		DROP

**Table D. 5b. Toxicity screening for detected radionuclides in WAG5 surface water
(Ingestion)**

Analyte	Maximum det. conc. (pCi/g)	SF (1/pCi)	Toxicity score	Total toxicity score	% of total toxicity score	Decision
High Base						
C-14	1.2E+03	9.0E-13	1.1E-09	0.21	6.4E-15	DROP
Ca-45	9.9E+02	9.9E-13	9.8E-10	0.19	5.1E-12	DROP
Pu-238	2.9E-01	2.2E-10	6.4E-11	0.01	3.9E-08	DROP
Tc-99	3.8E+00	1.3E-12	4.9E-12	0.00	8.3E-12	DROP
Total Radioactive Strontium	2.5E+03	3.6E-11	9.0E-08	17.85	6.2E-11	
Tritium	7.6E+06	5.4E-14	4.1E-07	81.39	7.8E-14	
U-233/234	2.7E+01	1.6E-11	4.3E-10	0.09	2.6E-08	DROP
U-235	1.7E+00	1.6E-11	2.7E-11	0.01	2.5E-08	DROP
U-238	4.5E+01	2.8E-11	1.3E-09	0.25	5.2E-08	DROP
High Base Storm						
Am-241	1.6E-01	2.4E-10	3.9E-11	0.01	3.2E-08	DROP
C-14	1.2E+02	9.0E-13	1.1E-10	0.04	6.4E-15	DROP
Cm-243/244	6.2E-01	1.6E-10	1.0E-10	0.04	2.2E-08	DROP
Pu-238	1.4E+01	2.2E-10	3.1E-09	1.09	3.9E-08	
Pu-239/240	1.3E-01	2.3E-10	3.0E-11	0.01	3.8E-08	DROP
Tc-99	3.8E+01	1.3E-12	4.9E-11	0.02	8.3E-12	DROP
Th-230	1.0E+01	1.3E-11	1.4E-10	0.05	2.9E-08	DROP
Th-232	3.1E+00	1.2E-11	3.7E-11	0.01	2.8E-08	DROP
Total Radioactive Strontium	1.4E+03	3.6E-11	5.1E-08	18.03	6.2E-11	
Tritium	4.2E+06	5.4E-14	2.2E-07	79.59	7.8E-14	
U-233/234	5.1E+01	1.6E-11	8.2E-10	0.29	2.6E-08	DROP
U-235/236	2.8E+00	1.5E-11	4.1E-11	0.01	2.5E-08	DROP
U-238	8.1E+01	2.8E-11	2.3E-09	0.81	5.2E-08	DROP
Impoundment						
Am-241	5.0E-01	2.4E-10	1.2E-10	0.00	3.2E-08	DROP
C-14	4.2E+01	9.0E-13	3.8E-11	0.00	6.4E-15	DROP
Cm-243/244	1.6E+01	1.6E-10	2.6E-09	0.07	2.2E-08	DROP
Co-60	1.5E+02	1.5E-11	2.3E-09	0.06	1.5E-10	DROP
Cs-137	2.5E+04	2.8E-11	7.0E-07	17.71	1.9E-11	
Pu-238	3.2E-01	2.2E-10	7.0E-11	0.00	3.9E-08	DROP
Pu-239/240	5.1E-01	2.3E-10	1.2E-10	0.00	3.8E-08	DROP
Tc-99	4.3E+01	1.3E-12	5.6E-11	0.00	8.3E-12	DROP

Table D. 5b. (continued)

Analyte	Maximum det. conc. (pCi/g)	SF (1/pCi)	Toxicity score	Total toxicity score	% of total toxicity score	Decision
Total Radioactive Strontium	9.0E+04	3.6E-11	3.2E-06	81.99	6.2E-11	
Tritium	2.0E+04	5.4E-14	1.1E-09	0.03	7.8E-14	DROP
U-232	2.2E+01	3.7E-11	8.1E-10	0.02	6.0E-08	DROP
U-233/234	2.6E+02	1.6E-11	4.2E-09	0.11	2.6E-08	DROP
U-238	4.8E+00	2.8E-11	1.3E-10	0.00	5.2E-08	DROP
Low Base						
Am-241	9.3E+00	2.4E-10	2.2E-09	0.78	3.2E-08	DROP
C-14	1.8E+02	9.0E-13	1.6E-10	0.06	6.4E-15	DROP
Pb-212	2.1E+01	5.5E-12	1.2E-10	0.04	4.3E-11	DROP
Pu-238	1.8E+01	2.2E-10	3.9E-09	1.37	3.9E-08	
Ra-228	1.6E+03	1.0E-10	1.6E-07	56.75	6.9E-10	
Tc-99	1.9E+01	1.3E-12	2.4E-11	0.01	8.3E-12	DROP
Total Radioactive Strontium	1.8E+03	3.6E-11	6.4E-08	22.52	6.2E-11	
Tritium	9.6E+05	5.4E-14	5.2E-08	18.22	7.8E-14	
U-233/234	1.0E+01	1.6E-11	1.7E-10	0.06	2.6E-08	DROP
U-235	8.0E-01	1.6E-11	1.3E-11	0.00	2.5E-08	DROP
U-238	1.9E+01	2.8E-11	5.2E-10	0.18	5.2E-08	DROP
Low Base Storm						
Am-241	9.0E-01	2.4E-10	2.2E-10	0.03	3.2E-08	DROP
C-14	1.8E+02	9.0E-13	1.6E-10	0.02	6.4E-15	DROP
Pu-238	1.9E+01	2.2E-10	4.2E-09	0.63	3.9E-08	DROP
Pu-239/240	2.0E-01	2.3E-10	4.6E-11	0.01	3.8E-08	DROP
Tc-99	3.0E+01	1.3E-12	3.9E-11	0.01	8.3E-12	DROP
Total Radioactive Strontium	2.1E+03	3.6E-11	7.5E-08	11.34	6.2E-11	
Tritium	1.1E+07	5.4E-14	5.8E-07	87.86	7.8E-14	
U-233/234	1.1E+01	1.6E-11	1.7E-10	0.03	2.6E-08	DROP
U-235	6.8E-01	1.6E-11	1.1E-11	0.00	2.5E-08	DROP
U-238	1.7E+01	2.8E-11	4.8E-10	0.07	5.2E-08	DROP
Seep Location						
Am-241	3.2E+01	2.4E-10	7.7E-09	0.02	3.2E-08	DROP
C-14	9.1E+02	9.0E-13	8.2E-10	0.00	6.4E-15	DROP
Ca-45	1.5E+04	9.9E-13	1.5E-08	0.03	5.1E-12	DROP
Co-60	3.4E+01	1.5E-11	5.1E-10	0.00	1.5E-10	DROP

Table D. 5b. (continued)

Analyte	Maximum det. conc. (pCi/g)	SF (1/pCi)	Toxicity score	Total toxicity score	% of total toxicity score	Decision
K-40	1.5E+02	1.1E-11	1.7E-09	0.00	7.6E-12	DROP
Ra-228	1.1E+02	1.0E-10	1.1E-08	0.03	6.9E-10	DROP
Tc-99	2.1E+03	1.3E-12	2.8E-09	0.01	8.3E-12	DROP
Th-232	2.9E+01	1.2E-11	3.5E-10	0.00	2.8E-08	DROP
Th-234	1.1E+03	4.0E-12	4.4E-09	0.01	3.2E-11	DROP
Total Radioactive Strontium	1.1E+06	3.6E-11	3.8E-05	89.93	6.2E-11	
Tritium	7.7E+07	5.4E-14	4.2E-06	9.79	7.8E-14	
U-233/234	1.1E+03	1.6E-11	1.8E-08	0.04	2.6E-08	DROP
U-235	8.1E+01	1.6E-11	1.3E-09	0.00	2.5E-08	DROP
U-238	1.9E+03	2.8E-11	5.3E-08	0.12	5.2E-08	DROP

Table D. 6a. Comparison of maximum detected concentrations for analytes dropped by toxicity screening in WAG 5 soil with residential PRGs

Analyte	Frequency of det.	Maximum Det. conc. (MD)	PRG for HQ=1.0	PRG for risk=10 ⁻⁴	PRG for risk=10 ⁻⁶	Is MD > PRG for HQ = 1.0	Is MD > PRG for risk=10 ⁻⁴	Units
Ac-228	11/11	2.4E+00		1.4E+00	1.4E-02		YES	PCI/G
Bi-212	2/2	2.6E+00		7.1E+00	7.1E-02		YES	PCI/G
Bi-214	2/2	9.4E-01		7.9E-01	7.9E-03		YES	PCI/G
Co-57	1/1	2.3E+00		2.2E+01	2.2E-01		YES	PCI/G
Cs-134	1/1	4.0E-02		8.0E-01	8.0E-03		YES	PCI/G
I-129	1/1	5.7E+00		3.0E+02	3.0E+00		YES	PCI/G
K-40	40/40	3.5E+01		7.7E+00	7.7E-02		YES	PCI/G
Na-22	1/1	1.5E+00		5.8E-01	5.8E-03		YES	PCI/G
Pb-212	14/14	1.9E+00		1.5E+01	1.5E-01		YES	PCI/G
Pb-214	11/11	1.4E+00		6.5E+00	6.5E-02		YES	PCI/G
Ra-223	1/1	5.6E-01		1.8E+01	1.8E-01		YES	PCI/G
Ra-226	37/40	3.6E+00		6.9E-01	6.9E-03		YES	PCI/G
Ra-228	34/40	2.4E+00		1.4E+00	1.4E-02		YES	PCI/G
Tl-208	9/9	2.0E+00		3.2E-01	3.2E-03		YES	PCI/G

Table D. 6b. Comparison of maximum detected concentrations for analytes dropped by toxicity screening in WAG 5 sediment with residential PRGs

Analyte	Frequency of det.	Maximum Det. conc. (MD)	PRG for HQ=1.0	PRG for risk=10 ⁻⁴	PRG for risk=10 ⁻⁶	Is MD > PRG for HQ = 1.0	Is MD > PRG for risk=10 ⁻⁴	Units
Ac-228	6/6	2.3E+00		1.4E+00	1.4E-02		YES	PCI/G
Bi-212	2/2	1.7E+00		7.1E+00	7.1E-02		YES	PCI/G
Bi-214	5/5	1.2E+00		7.9E-01	7.9E-03		YES	PCI/G
Co-60	14/14	6.8E+03		4.8E-01	4.8E-03		YES	PCI/G
Eu-152	1/2	9.6E+02		1.2E+00	1.2E-02		YES	PCI/G
Eu-154	1/3	5.8E+02		1.0E+00	1.0E-02		YES	PCI/G
I-129	4/4	1.4E+01		3.0E+02	3.0E+00		YES	PCI/G
Pb-210	1/1	2.7E+00		1.2E+02	1.2E+00		YES	PCI/G
Pb-212	6/6	1.7E+00		1.5E+01	1.5E-01		YES	PCI/G
Pb-214	6/6	1.2E+00		1.5E+01	1.5E-01		YES	PCI/G
Ra-223	3/3	9.1E-01		1.8E+01	1.8E-01		YES	PCI/G
Ra-224	4/5	4.9E+00		1.7E+02	1.7E+00		YES	PCI/G
Ra-224(2)	4/5	4.9E+00		1.8E+00	1.8E-02		YES	PCI/G
Ra-226	8/15	3.0E+00		6.9E-01	6.9E-03		YES	PCI/G
Ra-226+D(2)	8/15	3.0E+00		2.9E-01	2.9E-03		YES	PCI/G
Radon 219	3/3	1.2E+00		2.7E+01	2.7E-01		YES	PCI/G
Th-230	13/13	3.1E+02		5.2E+03	5.2E+01		YES	PCI/G
Tl-208	5/5	1.4E+00		3.2E-01	3.2E-03		YES	PCI/G
U-235	5/7	4.1E-01		1.7E+01	1.7E-01		YES	PCI/G
U-238	12/13	1.4E+02		1.1E+02	1.1E+00		YES	PCI/G

Table D. 6c. Comparison of maximum detected concentrations for analytes dropped by toxicity screening in WAG 5 groundwater with residential PRGs

Analyte	Frequency of det.	Maximum Det. conc. (MD)	PRG for HQ=1.0	PRG for risk=10 ⁻⁴	PRG for risk=10 ⁻⁴	Is MD > PRG for HQ = 1.0	Is MD > PRG for risk=10 ⁻⁴	Units
Beryllium	17/47	6.2E-03	1.5E-01	1.7E-03	1.7E-05		YES	MG/L
1,1-Dichloroethene	4/50	6.0E-03	3.2E-01	1.7E-03	1.7E-05		YES	MG/L
1,2-Dichloroethane	5/50	4.0E-03		2.0E-02	2.0E-04		YES	MG/L
Benzene	5/50	2.5E-02		6.1E-02	6.1E-04		YES	MG/L
Carbon Tetrachloride	2/50	9.0E-03	2.4E-02	2.5E-02	2.5E-04		YES	MG/L
Chloroform	3/50	2.5E-02	3.4E-01	2.7E-02	2.7E-04		YES	MG/L
Methylene Chloride	1/50	4.8E-02	1.7E+00	1.1E+00	1.1E-02		YES	MG/L
Tetrachloroethene	10/50	2.5E-01	2.1E-01			YES		MG/L
Trichloroethene	19/50	2.1E-01		7.7E-01	7.7E-03		YES	MG/L
Bi-212	2/2	5.3E+02		1.5E+04	1.5E+02		YES	PC/L
C-14	32/78	2.5E+03		5.3E+03	5.3E+01		YES	PC/L
Ca-45	1/8	2.8E+02		4.8E+03	4.8E+01		YES	PC/L
Cd-109	1/1	3.7E+02		6.0E+02	6.0E+00		YES	PC/L
Cm-243	2/22	4.1E-01		2.5E+01	2.5E-01		YES	PC/L
Cm-243/244	25/65	1.8E+02		3.0E+01	3.0E-01		YES	PC/L
Co-60	9/28	8.9E+01		3.2E+02	3.2E+00		YES	PC/L
Cs-137	6/89	2.8E+03		1.7E+02	1.7E+00		YES	PC/L
K-40	6/6	1.0E+03		4.3E+02	4.3E+00		YES	PC/L
Pb-212	8/8	5.3E+01		8.7E+02	8.7E+00		YES	PC/L
Pu-239/240	7/83	1.4E+04		2.1E+01	2.1E-01		YES	PC/L
Ra-226	29/58	7.0E+03		4.0E+01	4.0E-01		YES	PC/L
Ra-228	21/49	3.0E+02		4.8E+01	4.8E-01		YES	PC/L
Tc-99	22/55	5.1E+02		3.7E+03	3.7E+01		YES	PC/L
Th-228	26/57	2.1E+02		8.7E+01	8.7E-01		YES	PC/L
Th-230	26/57	2.4E+01		3.7E+02	3.7E+00		YES	PC/L
Th-231	1/1	3.5E+02		1.2E+04	1.2E+02		YES	PC/L
Th-232	28/58	3.5E+01		4.0E+02	4.0E+00		YES	PC/L
Th-234	6/6	1.0E+03		1.2E+03	1.2E+01		YES	PC/L
Total Radioactive Strontium	40/86	4.2E+04		1.3E+02	1.3E+00		YES	PC/L
U-232	2/49	2.9E+00		1.3E+02	1.3E+00		YES	PC/L
U-233/234	51/80	3.8E+03		3.0E+02	3.0E+00		YES	PC/L
U-238	26/80	1.2E+01		1.7E+02	1.7E+00		YES	PC/L

Table D. 6d. Comparison of maximum detected concentrations for analytes dropped by toxicity screening in WAG 5 surface water with residential PRGs

Analyte	Frequency of det.	Maximum Det. conc. (MD)	PRG for HQ=1.0	PRG for risk=10 ⁻⁴	PRG for risk=10 ⁻⁶	Is MD > PRG for HQ = 1.0	Is MD > PRG for risk=10 ⁻⁴	Units	Event
Benzene	1/15	2.0E-03		6.1E-02	6.1E-04		YES	MG/L	Seep Location
Beta-BHC	1/15	6.8E-05		4.7E-03	4.7E-05		YES	MG/L	Seep Location
Chloroform	3/15	2.0E-03	3.4E-01	2.7E-02	2.7E-04		YES	MG/L	Seep Location
p-Dichlorobenzene	2/15	7.0E-03	2.2E+00	3.2E-01	3.2E-03		YES	MG/L	Seep Location
Am-241	2/2	5.0E-01		2.0E+01	2.0E-01		YES	PCI/L	Impoundment
Am-241	3/5	9.3E+00		2.0E+01	2.0E-01		YES	PCI/L	Low Base
Am-241	3/6	9.0E-01		2.0E+01	2.0E-01		YES	PCI/L	Low Base Storm
Am-241	1/3	3.2E+01		2.0E+01	2.0E-01		YES	PCI/L	Seep Location
C-14	2/6	1.2E+03		5.3E+03	5.3E+01		YES	PCI/L	High Base
C-14	1/6	1.2E+02		5.3E+03	5.3E+01		YES	PCI/L	High Base Storm
C-14	1/6	1.8E+02		5.3E+03	5.3E+01		YES	PCI/L	Low Base
C-14	1/6	1.8E+02		5.3E+03	5.3E+01		YES	PCI/L	Low Base Storm
C-14	10/14	9.1E+02		5.3E+03	5.3E+01		YES	PCI/L	Seep Location
Ca-45	2/2	9.9E+02		4.8E+03	4.8E+01		YES	PCI/L	High Base
Ca-45	4/8	1.5E+04		4.8E+03	4.8E+01		YES	PCI/L	Seep Location
Cm-243/244	2/6	6.2E-01		3.0E+01	3.0E-01		YES	PCI/L	High Base Storm
Cm-243/244	2/2	1.6E+01		3.0E+01	3.0E-01		YES	PCI/L	Impoundment
Co-60	2/2	1.5E+02		3.2E+02	3.2E+00		YES	PCI/L	Impoundment
Co-60	1/1	3.4E+01		3.2E+02	3.2E+00		YES	PCI/L	Seep Location
K-40	1/3	1.5E+02		4.3E+02	4.3E+00		YES	PCI/L	Seep Location
Pb-212	1/1	2.1E+01		8.7E+02	8.7E+00		YES	PCI/L	Low Base
Pu-238	1/1	2.9E-01		2.2E+01	2.2E-01		YES	PCI/L	High Base
Pu-238	2/2	3.2E-01		2.2E+01	2.2E-01		YES	PCI/L	Impoundment
Pu-238	2/6	1.9E+01		2.2E+01	2.2E-01		YES	PCI/L	Low Base Storm
Pu-239/240	1/2	5.1E-01		2.1E+01	2.1E-01		YES	PCI/L	Impoundment
Ra-228	3/3	1.1E+02		4.8E+01	4.8E-01		YES	PCI/L	Seep Location
Tc-99	1/6	3.8E+01		3.7E+03	3.7E+01		YES	PCI/L	High Base Storm
Tc-99	1/2	4.3E+01		3.7E+03	3.7E+01		YES	PCI/L	Impoundment
Tc-99	11/11	2.1E+03		3.7E+03	3.7E+01		YES	PCI/L	Seep Location
Th-230	6/6	1.0E+01		3.7E+02	3.7E+00		YES	PCI/L	High Base Storm
Th-232	3/11	2.9E+01		4.0E+02	4.0E+00		YES	PCI/L	Seep Location

Table D. 6d. (continued)

Analyte	Frequency of det.	Maximum Det. conc. (MD)	PRG for HQ=1.0	PRG for risk=10 ⁻⁴	PRG for risk=10 ⁻⁶	Is MD > PRG for HQ = 1.0	Is MD > PRG for risk=10 ⁻⁴	Units	Event
Th-234	1/1	1.1E+03		1.2E+03	1.2E+01		YES	PCI/L	Seep Location
Tritium	2/2	2.0E+04		8.8E+04	8.8E+02		YES	PCI/L	Impoundment
U-232	2/2	2.2E+01		1.3E+02	1.3E+00		YES	PCI/L	Impoundment
U-233/234	3/5	2.7E+01		3.0E+02	3.0E+00		YES	PCI/L	High Base
U-233/234	3/6	5.1E+01		3.0E+02	3.0E+00		YES	PCI/L	High Base Storm
U-233/234	2/2	2.6E+02		3.0E+02	3.0E+00		YES	PCI/L	Impoundment
U-233/234	3/6	1.0E+01		3.0E+02	3.0E+00		YES	PCI/L	Low Base
U-233/234	4/6	1.1E+01		3.0E+02	3.0E+00		YES	PCI/L	Low Base Storm
U-233/234	8/14	1.1E+03		3.0E+02	3.0E+00		YES	PCI/L	Seep Location
U-235	2/15	8.1E+01		3.0E+02	3.0E+00		YES	PCI/L	Seep Location
U-238	4/5	4.5E+01		1.7E+02	1.7E+00		YES	PCI/L	High Base
U-238	3/6	8.1E+01		1.7E+02	1.7E+00		YES	PCI/L	High Base Storm
U-238	2/2	4.8E+00		1.7E+02	1.7E+00		YES	PCI/L	Impoundment
U-238	1/6	1.9E+01		1.7E+02	1.7E+00		YES	PCI/L	Low Base
U-238	3/6	1.7E+01		1.7E+02	1.7E+00		YES	PCI/L	Low Base Storm
U-238	8/15	1.9E+03		1.7E+02	1.7E+00		YES	PCI/L	Seep Location

Table D. 7a. Analytes in WAG 5 soil eliminated from COPC list

Analyte	Frequency of detection	Reason for elimination from COPC list
Aluminum	39/39	B
Arsenic	38/39	B
Beryllium	36/39	B
Calcium	39/39	E
Chromium	39/39	B
Copper	36/39	E
Iron	39/39	E
Lead	39/39	B
Magnesium	39/39	E
Nickel	37/39	B
Potassium	39/39	E
Selenium	5/30	T
Silver	21/39	T
Sodium	14/39	E
Thallium	2/39	B
Vanadium	38/39	B
Zinc	39/39	T
1,2-Benzenedicarboxylic Acid, Diethyl Ester	2/38	T
1,2-Dichloroethene (Total)	1/80	T
2-Butanone	4/80	T
4,4'-DDD	1/38	T
Acetone	12/80	T
Benzo(k)Fluoranthene	1/38	T
Bis(2-Ethylhexyl) Phthalate	5/38	T
Butyl Benzyl Phthalate	2/38	T
Chloroform	3/80	T
Chloromethane	1/80	T

Table D. 7a. (continued)

Analyte	Frequency of detection	Reason for elimination from COPC list
Cyanide	2/35	T
Di-n-butyl Phthalate	8/38	T
Endrin	1/38	T
Ethylbenzene	2/80	T
Fluoranthene	1/38	T
Heptachlor Epoxide	1/38	T
Methylene Chloride	2/80	T
Pyrene	2/38	T
Styrene	2/80	T
Tetrachloroethene	1/80	T
Toluene	10/80	T
C-14	3/39	T
Ca-45	3/3	T
Cm-243	1/4	T
Sn-126	3/3	T
Tc-99	3/23	T
Th-234	2/3	T
Tritium	31/39	T
U-232	2/13	T

Table D. 7b. Analytes in WAG 5 sediment eliminated from COPC list

Analyte	Frequency of detection	Reason for elimination from COPC list
Aluminum	13/13	B
Beryllium	9/14	B
Calcium	14/14	E
Copper	12/14	E
Iron	14/14	E
Magnesium	14/14	E
Nickel	9/14	T
Potassium	10/14	E
Selenium	2/14	T
Silver	6/14	T
Sodium	4/14	E
Vanadium	9/14	B
Zinc	13/14	T
1,1-Dichloroethane	3/25	T
1,1-Dichloroethene	2/24	T
1,2-Dichloroethane	1/19	T
1,2-Dichloroethene (Total)	3/25	T
2-Butanone	13/25	T
4-Methyl-2-Pentanone	1/25	T
Acetone	12/25	T
Benzene	2/25	T
Bis(2-Ethylhexyl) Phthalate	2/14	T
Carbolic Acid	4/14	T
Carbon Disulfide	1/25	T
Chloroform	1/25	T
Toluene	5/25	T
Trichloroethene	2/25	T
Xylene (Total)	3/25	T

Table D. 7b. (continued)

Analyte	Frequency of detection	Reason for elimination from COPC list
C-14	9/14	T
Ca-45	3/3	T
Cm-242	2/8	T
Eu-155	1/1	T
K-40	9/9	B
Ra-228	9/15	B
Sn-126	2/2	T
Tc-99	9/10	T
Th-231	1/1	T
Th-232	15/15	T
Th-234	2/2	T
Tritium	14/14	T
U-233/234	7/7	T
U-235/236	2/6	T

Table D. 7c. Analytes in WAG 5 groundwater eliminated from COPC list

Analyte	Frequency of detection	Reason for elimination from COPC list
Antimony	1/46	B
Arsenic	15/47	B
Barium	47/47	T
Boron	7/22	T
Calcium	47/47	E
Copper	17/47	E
Iron	41/47	E
Magnesium	47/47	E
Mercury	10/47	T
Molybdenum	1/23	B
Nickel	31/47	T
Phosphorus	3/22	E
Potassium	47/47	E
Selenium	1/41	B
Silver	10/47	T
Sodium	47/47	E
Vanadium	24/47	T
Zinc	27/47	T
1,1-Dichloroethane	11/50	T
Acetone	1/50	T
Carbon Disulfide	1/50	T
Chlorobenzene	1/50	T
Chloroethane	2/50	T
Cyanide	2/43	T
Dimethyl Phthalate	1/42	T
Fluoranthene	1/42	T
Nitrate	6/15	T
Phthalic Acid, Dioctyl Ester	1/42	T

Table D. 7c. (continued)

Analyte	Frequency of detection	Reason for elimination from COPC list
Pyrene	1/42	T
Toluene	1/50	T
Xylene (Total)	1/50	T
Bi-214	2/2	T
Cm-242	2/42	T
Fe-55	1/6	T
Hg-203	2/2	T
Mn-54	1/1	T
U-235	6/57	T
U-235/236	3/23	T

Table D. 7d. Analytes in WAG 5 surface water eliminated from COPC list

Analyte	Frequency of detection	Reason for elimination from COPC list
High Base		
Barium	6/6	T
Calcium	6/6	E
Copper	3/6	E
Iron	6/6	E
Lead	6/6	B
Magnesium	6/6	E
Potassium	6/6	E
Sodium	6/6	E
Vanadium	1/6	B
Zinc	2/6	B
2-Butanone	1/5	T
4-Methyl Phenol	1/6	T
4-Methyl-2-Pentanone	1/5	T
Nitrate	2/9	T
Tc-99	1/3	T
Th-228	1/5	B
U-235	1/5	T
High Base Storm		
Barium	3/3	B
Calcium	3/3	E
Chromium	1/3	B
Copper	0/3	E
Iron	2/3	E
Lead	2/3	B
Magnesium	3/3	E
Manganese	3/3	B
Nickel	2/3	B

Potassium	3/3	E
Sodium	1/3	E
Zinc	3/3	B
Am-241	5/6	T
Pu-239/240	3/6	T
Th-228	6/6	B
Th-232	6/6	T
U-235/236	1/6	T

Impoundment

Barium	1/1	B
Calcium	1/1	E
Copper	1/1	E
Iron	1/1	E
Magnesium	1/1	E
Manganese	1/1	B
Nickel	1/1	B
Potassium	1/1	E
Selenium	1/1	B
Sodium	1/1	E
Vanadium	1/1	B
Zinc	1/1	B
Styrene	1/2	T
C-14	1/2	T
Th-228	1/2	B
Th-230	1/2	B

Low Base

Aluminum	2/6	B
Arsenic	1/6	B
Barium	6/6	T
Calcium	6/6	E
Copper	0/6	E

Table D. 7d. (continued)

Analyte	Frequency of detection	Reason for elimination from COPC list
Iron	5/6	E
Magnesium	6/6	E
Nickel	1/6	B
Potassium	6/6	E
Sodium	6/6	E
Zinc	2/6	B
1,2-Dichloroethene (Total)	1/6	T
Ra-226	2/6	B
Tc-99	2/6	T
Th-228	1/5	B
U-235	1/6	T
Low Base Storm		
Barium	22/22	T
Calcium	22/22	E
Chromium	4/22	B
Copper	2/22	E
Iron	3/22	E
Lead	6/22	B
Magnesium	22/22	E
Nickel	5/22	B
Potassium	20/22	E
Selenium	2/22	B
Sodium	22/22	E
1,2-Dichloroethene (Total)	1/6	T
Pu-239/240	1/6	T
Ra-228	1/6	B
Tc-99	1/6	T
Th-228	6/6	B

Table D. 7d. (continued)

Analyte	Frequency of detection	Reason for elimination from COPC list
Th-230	5/6	B
U-235	1/6	T
Seep Location		
Antimony	1/15	B
Arsenic	2/15	B
Barium	15/15	T
Beryllium	1/15	B
Boron	1/1	T
Calcium	15/15	E
Chromium	2/15	B
Copper	2/15	E
Iron	15/15	E
Lead	9/15	B
Magnesium	15/15	E
Mercury	2/15	B
Nickel	5/15	T
Potassium	15/15	E
Selenium	1/15	T
Sodium	15/15	E
Vanadium	4/15	B
Zinc	6/15	B
1,1-Dichloroethane	5/15	T
1,2-Dichlorobenzene	2/15	T
1,2-Dichloropropane	1/15	T
4-Methyl-2-Pentanone	1/15	T
Benzene, 1,2,4-Trichloro-	2/15	T
Bis(2-Ethylhexyl) Phthalate	1/15	T
Carbon Disulfide	1/15	T

Table D. 7d. (continued)

Analyte	Frequency of detection	Reason for elimination from COPC list
Nitrate	4/15	T
Tetrachloroethene	1/15	T
Toluene	1/15	T
Xylene (Total)	2/15	T
Cs-137	3/15	B
Ra-226	2/11	B
Th-228	2/10	B
Th-230	2/11	B

Table D. 8a. Chronic Daily Intake and doses for soil COPC of WAG 5
(Excavation, industrial, and residential scenarios)

Analyte	Carcinogenic effects (CDI)					Noncarcinogenic effects(CDI)			
	Ingestion (mg/kg-d;pCi)	Produce ingestion (mg/kg-d;pCi)	Dermal (mg/kg-d)	Inhalation (mg/kg-d;pCi)	External (pCi-y/g)	Ingestion (mg/kg-d;pCi)	Produce ingestion (mg/kg-d;pCi)	Dermal (mg/kg-d)	Inhalation (mg/kg-d;pCi)
Excavation scenario									
Antimony	1.4E-08		9.1E-10	1.3E-12		1.0E-06		6.4E-08	9.4E-11
Barium	3.7E-07		2.3E-08	3.4E-11		2.6E-05		1.6E-06	2.4E-09
Cadmium	1.1E-09		7.0E-11	1.0E-13		7.7E-08		4.9E-09	7.2E-12
Manganese	3.0E-06		1.9E-07	2.8E-10		2.1E-04		1.3E-05	1.9E-08
Mercury	2.5E-10		1.6E-11	2.3E-14		1.7E-08		1.1E-09	1.6E-12
Aroclor 1254	1.1E-10		6.6E-11	9.8E-15		7.4E-09		4.6E-09	6.9E-13
Aroclor 1260	1.0E-10		6.6E-11	9.7E-15		7.3E-09		4.6E-09	6.8E-13
Ac-228	8.2E+00			7.7E-04	1.2E-01				
Am-241	1.8E+00			1.7E-04	2.6E-02				
Bi-212	1.1E+01			1.0E-03	1.6E-01				
Bi-214	3.9E+00			3.6E-04	5.6E-02				
Cm-243/244	3.0E+00			2.8E-04	4.4E-02				
Co-57	9.6E+00			8.9E-04	1.4E-01				
Co-60	7.5E+02			7.0E-02	1.1E+01				
Cs-134	1.7E-01			1.6E-05	2.4E-03				
Cs-137	1.1E+02			1.1E-02	1.7E+00				
I-129	2.4E+01			2.2E-03	3.5E-01				
K-40	1.0E+02			9.8E-03	1.5E+00				
Na-22	6.2E+00			5.8E-04	9.1E-02				
Pb-210	2.5E+01			2.4E-03	3.7E-01				
Pb-212	6.3E+00			5.9E-04	9.2E-02				

Table D. 8a. (continued)

Analyte	Carcinogenic effects (CDI)					Noncarcinogenic effects (CDI)			
	Ingestion (mg/kg-d;pCi)	Produce ingestion (mg/kg-d;pCi)	Dermal (mg/kg-d)	Inhalation (mg/kg-d;pCi)	External (pCi-y/g)	Ingestion (mg/kg-d;pCi)	Produce ingestion (mg/kg-d;pCi)	Dermal (mg/kg-d)	Inhalation (mg/kg-d;pCi)
Pb-214	4.5E+00			4.2E-04	6.6E-02				
Pu-238	2.0E+00			1.9E-04	2.9E-02				
Pu-239/240	6.4E-01			6.0E-05	9.4E-03				
Ra-223	2.3E+00			2.2E-04	3.4E-02				
Ra-226	5.1E+00			4.8E-04	7.4E-02				
Ra-228	7.5E+00			7.0E-04	1.1E-01				
Th-228	6.9E+00			6.5E-04	1.0E-01				
Th-230	6.3E+00			5.9E-04	9.3E-02				
Th-232	6.6E+00			6.1E-04	9.6E-02				
Tl-208	6.3E+00			5.9E-04	9.2E-02				
Total Radioactive Strontium	1.7E+02			1.5E-02	2.4E+00				
U-232	1.6E+00			1.5E-04	2.3E-02				
U-233/234	8.9E+00			8.3E-04	1.3E-01				
U-238	7.0E+00			6.5E-04	1.0E-01				
Industrial scenario									
Antimony	1.1E-06		6.8E-08	1.0E-10		3.0E-06		1.9E-07	2.8E-10
Barium	2.8E-05		1.7E-06	2.6E-09		7.7E-05		4.9E-06	7.2E-09
Cadmium	8.5E-08		5.4E-09	7.9E-12		2.4E-07		1.5E-08	2.2E-11
Manganese	2.3E-04		1.5E-05	2.1E-08		6.4E-04		4.1E-05	6.0E-08
Mercury	2.0E-08		1.3E-09	1.9E-12		5.6E-08		3.6E-09	5.3E-12
Aroclor 1254	7.9E-09		5.0E-09	7.4E-13		2.2E-08		1.4E-08	2.1E-12
Aroclor 1260	7.2E-09		4.5E-09	6.7E-13		2.0E-08		1.3E-08	1.9E-12

Table D. 8a. (continued)

Analyte	Carcinogenic effects (CDI)					Noncarcinogenic effects(CDI)			
	Ingestion (mg/kg-d;pCi)	Produce ingestion (mg/kg-d;pCi)	Dermal (mg/kg-d)	Inhalation (mg/kg-d;pCi)	External (pCi-y/g)	Ingestion (mg/kg-d;pCi)	Produce ingestion (mg/kg-d;pCi)	Dermal (mg/kg-d)	Inhalation (mg/kg-d;pCi)
Ac-228	6.1E+02			5.7E-02	8.9E+00				
Am-241	1.3E+02			1.2E-02	2.0E+00				
Bi-212	8.1E+02			7.6E-02	1.2E+01				
Bi-214	2.9E+02			2.7E-02	4.3E+00				
Cm-243/244	2.3E+02			2.1E-02	3.3E+00				
Co-57	7.2E+02			6.7E-02	1.1E+01				
Co-60	5.6E+04			5.3E+00	8.2E+02				
Cs-134	1.3E+01			1.2E-03	1.8E-01				
Cs-137	1.1E+04			1.1E+00	1.7E+02				
I-129	1.8E+03			1.7E-01	2.6E+01				
K-40	7.9E+03			7.4E-01	1.2E+02				
Na-22	4.7E+02			4.4E-02	6.8E+00				
Pb-212	4.8E+02			4.5E-02	7.0E+00				
Pb-214	3.6E+02			3.4E-02	5.3E+00				
Pu-238	1.5E+02			1.4E-02	2.2E+00				
Pu-239/240	4.8E+01			4.5E-03	7.0E-01				
Ra-223	1.8E+02			1.6E-02	2.6E+00				
Ra-226	4.0E+02			3.7E-02	5.8E+00				
Ra-228	5.6E+02			5.2E-02	8.2E+00				
Th-228	5.3E+02			4.9E-02	7.7E+00				
Th-230	4.8E+02			4.5E-02	7.0E+00				
Th-232	4.9E+02			4.6E-02	7.1E+00				

Table D. 8a. (continued)

Analyte	Carcinogenic effects (CDI)					Noncarcinogenic effects (CDI)			
	Ingestion (mg/kg-d;pCi)	Produce ingestion (mg/kg-d;pCi)	Dermal (mg/kg-d)	Inhalation (mg/kg-d;pCi)	External (pCi-y/g)	Ingestion (mg/kg-d;pCi)	Produce ingestion (mg/kg-d;pCi)	Dermal (mg/kg-d)	Inhalation (mg/kg-d;pCi)
Tl-208	4.9E+02			4.6E-02	7.2E+00				
Total Radioactive Strontium	1.5E+04			1.4E+00	2.2E+02				
U-233	3.3E+03			3.1E-01	4.8E+01				
U-233/234	7.0E+02			6.5E-02	1.0E+01				
U-238	5.3E+02			5.0E-02	7.8E+00				
Residential scenario									
Antimony	9.7E-06	5.0E-05	2.2E-07	2.9E-10		2.3E-05	1.2E-04	5.0E-07	6.9E-10
Barium	2.5E-04	1.3E-03	5.5E-06	7.5E-09		5.8E-04	3.0E-03	1.3E-05	1.7E-08
Cadmium	7.6E-07	1.5E-05	1.7E-08	2.3E-11		1.8E-06	3.5E-05	4.0E-08	5.4E-11
Manganese	2.1E-03	4.3E-01	4.6E-05	6.3E-08		4.8E-03	1.0E+00	1.1E-04	1.5E-07
Mercury	1.8E-07	2.8E-05	4.0E-09	5.5E-12		4.2E-07	6.6E-05	9.4E-09	1.3E-11
Aroclor 1254	7.1E-08	1.2E-07	1.6E-08	2.2E-12		1.7E-07	2.7E-07	3.7E-08	5.0E-12
Aroclor 1260	6.4E-08	2.4E-08	1.4E-08	1.9E-12		1.5E-07	5.6E-08	3.3E-08	4.5E-12
Ac-228	2.5E+03	1.4E+02		9.6E-02	4.3E+01				
Am-241	5.4E+02	3.6E+02		2.1E-02	9.8E+00				
Bi-212	3.3E+03	7.7E+04		1.3E-01	6.0E+01				
Bi-214	1.2E+03	2.8E+04		4.6E-02	2.2E+01				
Cm-243/244	9.1E+02	6.1E+02		3.5E-02	1.7E+01				
Co-57	2.9E+03	5.8E+04		1.1E-01	5.3E+01				
Co-60	2.3E+05	4.5E+06		8.8E+00	4.1E+03				
Cs-134	5.0E+01	1.0E+03		2.0E-03	9.2E-01				
Cs-137	4.6E+04	1.2E+06		1.8E+00	8.4E+02				

Table D. 8a. (continued)

Analyte	Carcinogenic effects (CDI)					Noncarcinogenic effects(CDI)			
	Ingestion (mg/kg-d;pCi)	Produce ingestion (mg/kg-d;pCi)	Dermal (mg/kg-d)	Inhalation (mg/kg-d;pCi)	External (pCi-y/g)	Ingestion (mg/kg-d;pCi)	Produce ingestion (mg/kg-d;pCi)	Dermal (mg/kg-d)	Inhalation (mg/kg-d;pCi)
I-129	7.2E+03	9.6E+04		2.8E-01	1.3E+02				
K-40	3.2E+04	6.4E+06		1.2E+00	5.8E+02				
Na-22	1.9E+03	6.3E+04		7.4E-02	3.5E+01				
Pb-212	1.9E+03	1.3E+04		7.5E-02	3.5E+01				
Pb-214	1.5E+03	9.7E+03		5.7E-02	2.7E+01				
Pu-238	6.1E+02	2.0E+02		2.4E-02	1.1E+01				
Pu-239/240	1.9E+02	6.5E+01		7.5E-03	3.5E+00				
Ra-223	7.1E+02	1.9E+04		2.7E-02	1.3E+01				
Ra-226	1.6E+03	9.3E+04		6.2E-02	2.9E+01				
Ra-228	2.3E+03	6.0E+04		8.8E-02	4.1E+01				
Th-228	2.1E+03	1.3E+05		8.2E-02	3.9E+01				
Th-230	1.9E+03	6.5E+02		7.5E-02	3.5E+01				
Th-232	2.0E+03	6.6E+02		7.6E-02	3.6E+01				
Tl-208	2.0E+03	5.3E+03		7.7E-02	3.6E+01				
Total Radioactive Strontium	6.0E+04	1.2E+07		2.3E+00	1.1E+03				
U-233	1.3E+04	1.8E+04		5.1E-01	2.4E+02				
U-233/234	2.8E+03	3.7E+03		1.1E-01	5.1E+01				
U-238	2.1E+03	3.7E+03		8.4E-02	3.9E+01				

Table D. 8b. Chronic Daily Intake and doses for sediment COPCs of WAG 5
(Industrial and residential Scenarios)

Analyte	Carcinogenic effects (CDI)				Noncarcinogenic effects(CDI)		
	Ingestion (mg/kg-pCi/g)	Dermal (mg/k-d)	Inhalation (mg/kg-d-pCi)	External (pCi-y/g)	Ingestion (mg/kg-pCi/g)	Dermal (mg/k-d)	Inhalation (mg/kg-d-pCi)
Industrial scenario							
Antimony	4.6E-06	2.9E-07	4.3E-10		1.3E-05	8.2E-07	1.2E-09
Arsenic	1.4E-06	8.8E-08	1.3E-10		3.9E-06	2.5E-07	3.7E-10
Barium	8.9E-05	5.6E-06	8.3E-09		2.5E-04	1.6E-05	2.3E-08
Chromium VI	6.6E-06	4.1E-07	6.1E-10		1.8E-05	1.2E-06	1.7E-09
Manganese	3.4E-03	2.1E-04	3.2E-07		9.5E-03	6.0E-04	8.9E-07
Mercury	1.2E-06	7.9E-08	1.2E-10		3.5E-06	2.2E-07	3.3E-10
4-Methyl Phenol	4.5E-06	2.9E-06	4.2E-10		1.3E-05	8.0E-06	1.2E-09
Aroclor 1248	8.9E-08	5.6E-08	8.3E-12		2.5E-07	1.6E-07	2.3E-11
Aroclor 1254	1.5E-07	9.6E-08	1.4E-11		4.3E-07	2.7E-07	4.0E-11
Aroclor 1260	4.6E-08	2.9E-08	4.3E-12		1.3E-07	8.1E-08	1.2E-11
Vinyl Chloride	4.7E-08	3.0E-08	2.2E-03		1.3E-07	8.4E-08	6.1E-03
Ac-228	6.8E+02		6.4E-02	9.9E+00			
Am-241	2.2E+05		2.0E+01	3.2E+03			
Bi-212	5.3E+02		5.0E-02	7.8E+00			
Bi-214	3.2E+02		3.0E-02	4.7E+00			
Cm-243/244	7.6E+06		7.1E+02	1.1E+05			
Co-60	9.6E+05		9.0E+01	1.4E+04			
Cs-137	1.2E+09		1.1E+05	1.7E+07			
Eu-152	3.0E+05		2.8E+01	4.4E+03			
Eu-154	1.8E+05		1.7E+01	2.6E+03			
I-129	4.4E+03		4.1E-01	6.4E+01			

Table D. 8b.(continued)

ANALYTE	Carcinogenic effects (CDI)				Noncarcinogenic effects(CDI)		
	Ingestion (mg/kg-pCi/g)	Dermal (mg/k-d)	Inhalation (mg/kg-d,pCi)	External (pCi-y/g)	Ingestion (mg/kg-pCi/g)	Dermal (mg/k-d)	Inhalation (mg/kg-d,pCi)
Pb-210	8.4E+02		7.9E-02	1.2E+01			
Pb-212	5.0E+02		4.6E-02	7.2E+00			
Pb-214	3.6E+02		3.4E-02	5.3E+00			
Pu-238	1.0E+05		9.4E+00	1.5E+03			
Pu-239/240	1.6E+05		1.5E+01	2.3E+03			
Ra-223	2.8E+02		2.7E-02	4.2E+00			
Ra-224	1.5E+03		1.4E-01	2.2E+01			
Ra-226	5.4E+02		5.0E-02	7.8E+00			
Radon 219	3.8E+02		3.5E-02	5.5E+00			
Th-228	1.2E+05		1.1E+01	1.8E+03			
Th-230	6.0E+04		5.6E+00	8.8E+02			
Tl-208	4.1E+02		3.9E-02	6.0E+00			
Total Radioactive Strontium	2.3E+08		2.1E+04	3.4E+06			
U-232	9.9E+04		9.2E+00	1.4E+03			
U-233	1.1E+06		9.9E+01	1.5E+04			
U-235	1.2E+02		1.1E-02	1.8E+00			
U-238	1.7E+04		1.6E+00	2.5E+02			
Residential scenario							
Antimony	4.1E-05	9.2E-07	1.3E-09		9.6E-05	2.1E-06	2.9E-09
Arsenic	1.3E-05	2.8E-07	3.8E-10		2.9E-05	6.5E-07	8.9E-10
Barium	7.9E-04	1.8E-05	2.4E-08		1.9E-03	4.1E-05	5.6E-08
Chromium VI	5.9E-05	1.3E-06	1.8E-09		1.4E-04	3.1E-06	4.2E-09

Table D. 8b.(continued)

ANALYTE	Carcinogenic effects (CDI)				Noncarcinogenic effects(CDI)		
	Ingestion (mg/kg;pCi/g)	Dermal (mg/k-d)	Inhalation (mg/kg-d;pCi)	External (pCi-y/g)	Ingestion (mg/kg;pCi/g)	Dermal (mg/k-d)	Inhalation (mg/kg-d;pCi)
Manganese	3.0E-02	6.8E-04	9.2E-07		7.1E-02	1.6E-03	2.2E-06
Mercury	1.1E-05	2.5E-07	3.4E-10		2.6E-05	5.8E-07	7.9E-10
4-Methyl Phenol	4.1E-05	9.1E-06	1.2E-09		9.5E-05	2.1E-05	2.9E-09
Aroclor 1248	8.0E-07	1.8E-07	2.4E-11		1.9E-06	4.1E-07	5.6E-11
Aroclor 1254	1.4E-06	3.0E-07	4.1E-11		3.2E-06	7.1E-07	9.6E-11
Aroclor 1260	4.1E-07	9.2E-08	1.2E-11		9.6E-07	2.1E-07	2.9E-11
Vinyl Chloride	4.2E-07	9.4E-08	6.4E-03		9.9E-07	2.2E-07	1.5E-02
Ac-228	2.7E+03		1.1E-01	5.0E+01			
Am-241	8.8E+05		3.4E+01	1.6E+04			
Bi-212	2.1E+03		8.3E-02	3.9E+01			
Bi-214	1.3E+03		5.1E-02	2.4E+01			
Cm-243/244	3.1E+07		1.2E+03	5.6E+05			
Co-60	3.9E+06		1.5E+02	7.1E+04			
Cs-137	4.7E+09		1.8E+05	8.6E+07			
Eu-152	1.2E+06		4.7E+01	2.2E+04			
Eu-154	7.3E+05		2.8E+01	1.3E+04			
I-129	1.8E+04		6.9E-01	3.2E+02			
Pb-210	3.4E+03		1.3E-01	6.2E+01			
Pb-212	2.0E+03		7.8E-02	3.7E+01			
Pb-214	1.5E+03		5.6E-02	2.7E+01			
Pu-238	4.1E+05		1.6E+01	7.4E+03			
Pu-239/240	6.3E+05		2.4E+01	1.1E+04			

Table D. 8b.(continued)

ANALYTE	Carcinogenic effects (CDI)				Noncarcinogenic effects(CDI)		
	Ingestion (mg/kgpCi/g)	Dermal (mg/k-d)	Inhalation (mg/kg-d;pCi)	External (pCi-y/g)	Ingestion (mg/kg;pCi/g)	Dermal (mg/k-d)	Inhalation (mg/kg-d;pCi)
Ra-223	1.1E+03		4.5E-02	2.1E+01			
Ra-224	6.1E+03		2.4E-01	1.1E+02			
Ra-226	2.2E+03		8.4E-02	3.9E+01			
Radon 219	1.5E+03		5.9E-02	2.8E+01			
Th-228	4.9E+05		1.9E+01	8.9E+03			
Th-230	2.4E+05		9.4E+00	4.4E+03			
Tl-208	1.7E+03		6.5E-02	3.0E+01			
Total Radioactive Strontium	9.3E+08		3.6E+04	1.7E+07			
U-232	4.0E+05		1.5E+01	7.3E+03			
U-233	4.3E+06		1.7E+02	7.8E+04			
U-235	4.8E+02		1.9E-02	8.8E+00			
U-238	6.8E+04		2.7E+00	1.2E+03			

Table D. 8c. Chronic Daily Intakes for WAG 5 groundwater COPC-Residential Scenario

Analytes	Carcinogenic Effects (CDI)				Noncarcinogenic Effects (CDI)			
	Ingestion (mg/l-d,pCi)	Produce ingestion (mg/l-d,pCi)	Dermal (mg/l-d)	Inhalation (mg/l-d,pCi)	Ingestion (mg/l-d,pCi)	Produce ingestion (mg/l-d,pCi)	Dermal (mg/l-d)	Inhalation (mg/l-d,pCi)
Beryllium	2.2E-05	1.2E-04	3.5E-08		5.1E-05	2.8E-04	8.2E-08	
Chromium VI	1.0E-03	5.5E-03	1.6E-06		2.3E-03	1.3E-02	3.7E-06	
Manganese	3.1E-02	1.9E-01	5.0E-05		7.2E-02	4.3E-01	1.2E-04	
1,1-Dichloroethene	8.5E-05	5.5E-04	1.2E-06	3.2E-06	2.0E-04	1.3E-03	2.8E-06	7.4E-06
1,2-Dichloroethane	7.6E-05	5.3E-04	6.5E-07	2.9E-06	1.8E-04	1.2E-03	1.5E-06	6.7E-06
1,2-Dichloroethene (Total)	5.1E-04	5.6E-03			1.2E-03	1.3E-02		
Benzene	7.6E-05	4.7E-04	2.6E-06	2.9E-06	1.8E-04	1.1E-03	6.0E-06	6.7E-06
Bis(2-Ethylhexyl) Phthalate	2.7E-04	2.8E-03	1.0E-05		6.4E-04	6.5E-03	2.4E-05	
Carbon Tetrachloride	1.2E-04	7.1E-04	4.3E-06	4.6E-06	2.8E-04	1.7E-03	1.0E-05	1.1E-05
Chloroform	7.1E-05	4.5E-04	1.0E-06	2.6E-06	1.6E-04	1.0E-03	2.4E-06	6.2E-06
Methylene Chloride	2.1E-04	1.5E-03	1.5E-06	7.8E-06	4.9E-04	3.6E-03	3.5E-06	1.8E-05
Tetrachloroethene	1.3E-04	7.7E-04	7.8E-05		3.0E-04	1.8E-03	1.8E-04	
Trichloroethene	2.1E-04	1.3E-03	5.4E-06	7.9E-06	4.9E-04	2.9E-03	1.3E-05	1.8E-05
Vinyl Chloride	6.2E-03	4.5E-02	7.3E-05	2.3E-04	1.4E-02	1.0E-01	1.7E-04	5.4E-04
Am-241	7.3E+08	4.0E+09						
Bi-212	1.1E+07	2.0E+05						
C-14	1.0E+07	5.5E+07						
Ca-45	2.7E+06	1.4E+07						
Cd-109	7.7E+06	4.2E+07						
Cm-243	3.7E+03	2.1E+04						
Cm-243/244	4.5E+04	2.5E+05						

Table D. 8c. (continued)

Analytes	Carcinogenic Effects (CDI)				Noncarcinogenic Effects (CDI)		
	Ingestion (mg/l-d;pCi)	Produce ingestion (mg/l-d;pCi)	Dermal (mg/l-d)	Inhalation (mg/l-d;pCi)	Ingestion (mg/l-d;pCi)	Produce ingestion (mg/l-d;pCi)	Dermal (mg/l-d)
Co-60	2.9E+05	1.6E+06					
Cs-137	5.2E+04	2.9E+05					
K-40	1.9E+07	1.1E+08					
Pb-212	9.4E+05	1.7E+05					
Pu-238	1.7E+04	9.6E+04					
Pu-239/240	7.7E+02	4.3E+03					
Ra-226	3.1E+04	1.8E+05					
Ra-228	1.2E+05	6.7E+05					
Tc-99	4.3E+05	4.7E+06					
Th-228	4.3E+04	2.3E+05					
Th-230	2.3E+04	1.3E+05					
Th-231	7.4E+06	3.1E+06					
Th-232	3.9E+04	2.1E+05					
Th-234	1.5E+07	5.7E+07					
Total Radioactive Strontium	1.6E+06	9.0E+06					
Tritium	1.5E+10	8.1E+10		1.7E+09			
U-232	7.8E+03	4.3E+04					
U-233/234	4.2E+04	2.3E+05					
U-238	6.1E+03	3.4E+04					

Table D. 8d. Chronic Daily Intakes for WAG 5 surface water COPC- Residential Scenario

Analyte	Concentration (mg/l;pCi/l)	Carcinogenic Effects (CDI)			Noncarcinogenic Effects (CDI)		
		Ingestion (mg/l-d;pCi)	Dermal (mg/l-d)	Inhalation (mg/l-d;pCi)	Ingestion (mg/l-d;pCi)	Dermal (mg/l-d;pCi)	Inhalation (mg/l-d;pCi)
High Base							
Manganese	3.3E-02	5.3E-05		7.6E-02		1.2E-04	
C-14	1.3E+07						
Ca-45	2.1E+07						
Pu-238	6.1E+03						
Total Radioactive Strontium	3.3E+07						
Tritium	8.4E+10						
U-233/234	3.7E+05						
U-238	6.0E+05						
High Base Storm							
1,1-Dichloroethane	4.1E-05	5.8E-07	1.5E-06	9.5E-05		1.4E-06	3.6E-06
1,2-Dichloroethene (Total)	6.1E-05			1.4E-04			
2-Butanone	1.4E-04	2.5E-07	5.3E-06	3.3E-04		5.8E-07	1.2E-05
Bis(2-Ethylhexyl) Phthalate	1.2E-04	4.6E-06		2.8E-04		1.1E-05	
Trichloroethene	2.0E-05	5.2E-07	7.6E-07	4.7E-05		1.2E-06	1.8E-06
C-14	1.2E+06						
Cm-243/244	7.8E+03						
Pu-238	1.5E+05						
Tc-99	4.0E+05						
Th-230	2.0E+05						
Total Radioactive Strontium	1.7E+07						
Tritium	4.5E+10						

Table D. 8d. (continued)

Analyte--	Concentration (mg/l;pCi/l)	Carcinogenic Effects (CDI)			Noncarcinogenic Effects (CDI)		
		Ingestion (mg/l-d;pCi)	Dermal (mg/l-d)	Inhalation (mg/l-d;pCi)	Ingestion (mg/l-d;pCi)	Dermal (mg/l-d;pCi)	Inhalation (mg/l-d;pCi)
U-233/234	5.5E+05						
U-238	8.6E+05						
Bis(2-Ethylhexyl) Phthalate	2.0E-05	7.7E-07		4.7E-05		1.8E-06	
Bromomethane	4.1E-05	2.3E-07		9.3E-05		5.3E-07	3.6E-06
Am-241	1.1E+04		1.5E-06				
Cm-243/244	3.4E+05						
Co-60	3.2E+06						
Cs-137	5.3E+08						
Pu-238	6.6E+03						
Pu-239/240	1.1E+04						
Tc-99	9.1E+05						
Total Radioactive Strontium	1.9E+09						
Tritium	4.2E+08						
U-232	4.6E+05						
U-233/234	5.5E+06						
U-238	1.0E+05						
Manganese	6.0E-02	9.6E-05		1.4E-01		2.2E-04	
Am-241	1.6E+05						
C-14	1.6E+06						
Pb-212	4.4E+05						

Low Base

Table D. 8d. (continued)

Analyte--	Concentration (mg/l;pCi/l)	Carcinogenic Effects (CDI)			Noncarcinogenic Effects (CDI)		
		Ingestion (mg/l-d;pCi)	Dermal (mg/l-d)	Inhalation (mg/l-d;pCi)	Ingestion (mg/l-d;pCi)	Dermal (mg/l-d;pCi)	Inhalation (mg/l-d;pCi)
Pu-238	2.0E+05						
Ra-228	3.4E+07						
Total Radioactive Strontium	2.7E+07						
Tritium	1.5E+10						
U-233/234	1.2E+05						
U-238	2.0E+05						
Low Base Storm							
Manganese	7.1E-03	1.1E-05		1.7E-02		2.7E-05	
Bis(2-Ethylhexyl) Phthalate	3.7E-04	1.4E-05		8.5E-04		3.2E-05	
Am-241	1.0E+04						
C-14	1.9E+06						
Pu-238	2.1E+05						
Total Radioactive Strontium	3.2E+07						
Tritium	1.2E+11						
U-233/234	1.4E+05						
U-238	1.8E+05						

Table D. 9a. COPCs evaluated quantitatively* for WAG 5 soil

Analyte	Frequency of Detection	Representative Concentration ^b	Units
Antimony	1/4	6.2E+00	MG/KG
Barium	39/39	1.6E+02	MG/KG
Cadmium	1/39	4.9E-01	MG/KG
Manganese	39/39	1.3E+03	MG/KG
Mercury	12/39	1.2E-01	MG/KG
Aroclor 1254	2/38	4.5E-02	MG/KG
Aroclor 1260	9/38	4.1E-02	MG/KG
Ac-228	11/11	2.0E+00	PCI/G
Am-241	14/21	4.3E-01	PCI/G
Bi-212	2/2	2.6E+00	PCI/G
Bi-214	2/2	9.4E-01	PCI/G
Cm-243/244	4/16	7.2E-01	PCI/G
Co-57	1/1	2.3E+00	PCI/G
Co-60	6/6	1.8E+02	PCI/G
Cs-134	1/1	4.0E-02	PCI/G
Cs-137	31/40	3.6E+01	PCI/G
I-129	1/1	5.7E+00	PCI/G
K-40	40/40	2.5E+01	PCI/G
Na-22	1/1	1.5E+00	PCI/G
Pb-212	14/14	1.5E+00	PCI/G
Pb-214	11/11	1.2E+00	PCI/G
Pu-238	11/20	4.8E-01	PCI/G
Pu-239/240	4/20	1.5E-01	PCI/G
Ra-223	1/1	5.6E-01	PCI/G
Ra-226	37/40	1.3E+00	PCI/G
Ra-228	34/40	1.8E+00	PCI/G
Th-228	28/29	1.7E+00	PCI/G
Th-230	19/23	1.5E+00	PCI/G

Table D. 9a. (continued)

Analyte	Frequency of Detection	Representative Concentration ^b	Units
Th-232	36/36	1.6E+00	PCI/G
Tl-208	9/9	1.6E+00	PCI/G
Total Radioactive Strontium	29/40	4.7E+01	PCI/G
U-233	1/1	1.1E+01	PCI/G
U-233/234	21/22	2.2E+00	PCI/G
U-238	22/23	1.7E+00	PCI/G

^a Analytes evaluated quantitatively have at least one detected value with an EPA-approved slope factor and/or reference dose.

^b The representative concentration is the smallest of two values : the maximum detected concentration versus the upper 95% confidence limit on the mean concentration (EPA 1989a)

Table D. 9b. COPCs evaluated quantitatively^a for WAG 5 sediment

Analyte	Frequency of Detection	Representative Concentration ^b	Units
Antimony	1/14	2.6E+01	MG/KG
Arsenic	14/14	8.0E+00	MG/KG
Barium	14/14	5.1E+02	MG/KG
Chromium VI	14/14	3.8E+01	MG/KG
Manganese	14/14	1.9E+04	MG/KG
Mercury	12/14	7.1E+00	MG/KG
4-Methyl Phenol	4/4	2.6E+01	MG/KG
Aroclor 1248	2/14	5.1E-01	MG/KG
Aroclor 1254	5/14	8.7E-01	MG/KG
Aroclor 1260	7/14	2.6E-01	MG/KG
Vinyl Chloride	2/25	2.7E-01	MG/KG
Ac-228	6/6	2.2E+00	PCI/G
Am-241	10/11	7.0E+02	PCI/G
Bi-212	2/2	1.7E+00	PCI/G
Bi-214	5/5	1.0E+00	PCI/G
Cm-243/244	8/8	2.4E+04	PCI/G
Co-60	14/14	3.1E+03	PCI/G
Cs-137	15/15	3.7E+06	PCI/G
Eu-152	1/2	9.6E+02	PCI/G
Eu-154	1/3	5.8E+02	PCI/G
I-129	4/4	1.4E+01	PCI/G
Pb-210	1/1	2.7E+00	PCI/G
Pb-212	6/6	1.6E+00	PCI/G
Pb-214	6/6	1.2E+00	PCI/G
Pu-238	9/10	3.2E+02	PCI/G
Pu-239/240	7/10	5.0E+02	PCI/G
Ra-223	3/3	9.1E-01	PCI/G
Ra-224	4/5	4.9E+00	PCI/G

Table D. 9b. (continued)

Analyte	Frequency of Detection	Representative Concentration ^b	Units
Ra-226	8/15	1.7E+00	PCI/G
Radon 219	3/3	1.2E+00	PCI/G
Th-228	15/15	3.9E+02	PCI/G
Th-230	13/13	1.9E+02	PCI/G
Tl-208	5/5	1.3E+00	PCI/G
Total Radioactive Strontium	15/15	7.4E+05	PCI/G
U-232	6/6	3.2E+02	PCI/G
U-233	6/6	3.4E+03	PCI/G
U-235	5/7	3.8E-01	PCI/G
U-238	12/13	5.4E+01	PCI/G

^a Analytes evaluated quantitatively have at least one detected value with an EPA-approved slope factor and/or reference dose.

^b The representative concentration is the smallest of two values: the maximum detected concentration versus the upper 95% confidence limit on the mean concentration (EPA 1989a)

Table D. 9c. COPCs evaluated quantitatively^a for WAG 5 groundwater

Analyte	Frequency of Detection	Representative Concentration ^b	Units
Beryllium	17/47	1.1E-03	MG/L
Chromium VI	25/47	4.9E-02	MG/L
Manganese	44/47	1.5E+00	MG/L
1,1-Dichloroethene	4/50	4.2E-03	MG/L
1,2-Dichloroethane	5/50	3.7E-03	MG/L
1,2-Dichloroethene (Total)	18/50	2.5E-02	MG/L
Benzene	5/50	3.8E-03	MG/L
Bis(2-Ethylhexyl) Phthalate	8/39	1.3E-02	MG/L
Carbon Tetrachloride	2/50	6.0E-03	MG/L
Chloroform	3/50	3.5E-03	MG/L
Methylene Chloride	1/50	1.0E-02	MG/L
Tetrachloroethene	10/50	6.4E-03	MG/L
Trichloroethene	19/50	1.0E-02	MG/L
Vinyl Chloride	11/50	3.1E-01	MG/L
Am-241	28/88	3.5E+04	PC/L
Bi-212	2/2	5.3E+02	PC/L
C-14	32/78	4.8E+02	PC/L
Ca-45	1/8	1.3E+02	PC/L
Cd-109	1/1	3.7E+02	PC/L
Cm-243	2/22	1.8E-01	PC/L
Cm-243/244	25/65	2.2E+00	PC/L
Co-60	9/28	1.4E+01	PC/L
Cs-137	6/89	2.5E+00	PC/L
K-40	6/6	8.9E+02	PC/L
Pb-212	8/8	4.5E+01	PC/L
Pu-238	24/83	8.3E-01	PC/L
Pu-239/240	7/83	3.7E-02	PC/L
Ra-226	29/58	1.5E+00	PC/L

Table D. 9c. (continued)

Analyte	Frequency of Detection	Representative Concentration ^b	Units
Ra-228	21/49	5.8E+00	PCI/L
Tc-99	22/55	2.1E+01	PCI/L
Th-228	26/57	2.0E+00	PCI/L
Th-230	26/57	1.1E+00	PCI/L
Th-231	1/1	3.5E+02	PCI/L
Th-232	28/58	1.8E+00	PCI/L
Th-234	6/6	7.4E+02	PCI/L
Total Radioactive Strontium	40/86	7.4E+01	PCI/L
Tritium	79/88	7.0E+05	PCI/L
U-232	2/49	3.7E-01	PCI/L
U-233/234	51/80	2.0E+00	PCI/L
U-238	26/80	2.9E-01	PCI/L

^a Analytes evaluated quantitatively have at least one detected value with an EPA-approved slope factor and/or reference dose.

^b The representative concentration is the smallest of two values : the maximum detected concentration versus the upper 95% confidence limit on the mean concentration (EPA 1989a)

Table D. 9d. COPCs evaluated quantitatively^a for WAG 5 surface water

Analyte	Frequency of Detection	Representative Concentration ^b	Units
High Base			
Manganese	6/6	1.6E+00	MG/L
C-14	2/6	6.3E+02	PC/L
Ca-45	2/2	9.9E+02	PC/L
Pu-238	1/1	2.9E-01	PC/L
Total Radioactive Strontium	5/6	1.6E+03	PC/L
Tritium	6/6	4.0E+06	PC/L
U-233/234	3/5	1.8E+01	PC/L
U-238	4/5	2.9E+01	PC/L
High Base Storm			
1,1-Dichloroethane	1/3	2.0E-03	MG/L
1,2-Dichloroethene (Total)	1/3	3.0E-03	MG/L
2-Butanone	1/3	7.0E-03	MG/L
Bis(2-Ethylhexyl) Phthalate	2/3	6.0E-03	MG/L
Trichloroethene	1/3	1.0E-03	MG/L
C-14	1/6	5.9E+01	PC/L
Cm-243/244	2/6	3.7E-01	PC/L
Pu-238	2/6	7.1E+00	PC/L
Tc-99	1/6	1.9E+01	PC/L
Th-230	6/6	9.6E+00	PC/L
Total Radioactive Strontium	6/6	8.0E+02	PC/L
Tritium	5/6	2.2E+06	PC/L
U-233/234	3/6	2.6E+01	PC/L
U-238	3/6	4.1E+01	PC/L
Impoundment			
Bis(2-Ethylhexyl) Phthalate	1/2	1.0E-03	MG/L
Bromomethane	1/2	2.0E-03	MG/L
Am-241	2/2	5.0E-01	PC/L

Table D. 9d. (continued)

Analyte	Frequency of Detection	Representative Concentration ^b	Units
Cm-243/244	2/2	1.6E+01	PC/L
Co-60	2/2	1.5E+02	PC/L
Cs-137	2/2	2.5E+04	PC/L
Pu-238	2/2	3.2E-01	PC/L
Pu-239/240	1/2	5.1E-01	PC/L
Tc-99	1/2	4.3E+01	PC/L
Total Radioactive Strontium	2/2	9.0E+04	PC/L
Tritium	2/2	2.0E+04	PC/L
U-232	2/2	2.2E+01	PC/L
U-233/234	2/2	2.6E+02	PC/L
U-238	2/2	4.8E+00	PC/L
Low Base			
Manganese	6/6	2.9E+00	MG/L
Am-241	3/5	7.8E+00	PC/L
C-14	1/6	7.7E+01	PC/L
Pb-212	1/1	2.1E+01	PC/L
Pu-238	2/6	9.5E+00	PC/L
Ra-228	1/1	1.6E+03	PC/L
Total Radioactive Strontium	4/5	1.3E+03	PC/L
Tritium	5/6	7.1E+05	PC/L
U-233/234	3/6	5.8E+00	PC/L
U-238	1/6	9.4E+00	PC/L
Low Base Storm			
Manganese	17/22	3.5E-01	MG/L
Bis(2-Ethylhexyl) Phthalate	3/6	1.8E-02	MG/L
Am-241	3/6	4.9E-01	PC/L
C-14	1/6	9.3E+01	PC/L
Pu-238	2/6	9.9E+00	PC/L

Table D. 9d. (continued)

Analyte	Frequency of Detection	Representative Concentration ^b	Units
Total Radioactive Strontium	3/5	1.5E+03	PCIL
Tritium	6/6	5.5E+06	PCIL
U-233/234	4/6	6.7E+00	PCIL
U-238	3/6	8.7E+00	PCIL
Seep Location			
Manganese	15/15	9.6E+00	MG/L
1,1-Dichloroethene	1/15	1.0E-02	MG/L
1,2-Dichloroethane	1/15	6.0E-03	MG/L
1,2-Dichloroethene (Total)	10/15	6.4E-02	MG/L
Alpha-BHC	1/15	1.1E-04	MG/L
Benzene	1/15	2.0E-03	MG/L
Beta-BHC	1/15	5.3E-05	MG/L
Chloroform	3/15	2.0E-03	MG/L
Trichloroethene	9/15	1.8E-02	MG/L
Vinyl Chloride	7/15	1.2E-02	MG/L
p-Dichlorobenzene	2/15	7.0E-03	MG/L
Am-241	1/3	3.2E+01	PCIL
C-14	10/14	4.1E+02	PCIL
Ca-45	4/8	6.9E+03	PCIL
Co-60	1/1	3.4E+01	PCIL
K-40	1/3	1.5E+02	PCIL
Ra-228	3/3	1.1E+02	PCIL
Tc-99	11/11	8.1E+02	PCIL
Th-232	3/11	7.5E+00	PCIL
Th-234	1/1	1.1E+03	PCIL
Total Radioactive Strontium	13/15	2.3E+05	PCIL
Tritium	15/15	2.2E+07	PCIL
U-233/234	8/14	2.5E+02	PCIL

Table D. 9d. (continued)

Analyte	Frequency of Detection	Representative Concentration ^b	Units
U-235	2/15	1.5E+01	PC/L
U-238	8/15	3.5E+02	PC/L

^a Analytes evaluated quantitatively have at least one detected value with an EPA-approved slope factor and/or reference dose.

^b The representative concentration is the smallest of two values : the maximum detected concentration versus the upper 95% confidence limit on the mean concentration (EPA 1989a)

Table D. 10a. COPCs evaluated qualitatively^a for WAG 5 soil

Analyte	Frequency of Detection	Representative Concentration ^b	Units
Cobalt	38/39	2.3E+01	MG/KG
Chlordane, Gamma-	1/38	1.3E-03	MG/KG
Total Organic Carbon	13/13	8.4E+03	MG/KG
p-Nitrophenol	2/38	8.2E-02	MG/KG
Alpha Particle	39/40	5.2E+01	PCI/G
Beta Particle	40/40	1.2E+03	PCI/G

^a Analytes evaluated qualitatively have at least one detected value, however, no EPA-approved slope factor and/or reference dose are currently available.

^b The representative concentration is the smallest of two values : the maximum detected concentration versus the upper 95% confidence limit on the mean concentration (EPA 1989a).

Table D. 10b. COPCs evaluated qualitatively^a for WAG 5 sediment

Analyte	Frequency of Detection	Representative Concentration ^b	Units
Cobalt	10/14	3.5E+01	MG/KG
Lead	14/14	8.6E+01	MG/KG
Thallium	2/14	1.8E+00	MG/KG
Sulfide	5/9	1.8E+01	MG/KG
Total Organic Carbon	4/4	3.9E+04	MG/KG
Alpha Particle	15/15	8.1E+04	PCI/G
Beta Particle	15/15	7.9E+06	PCI/G

^a Analytes evaluated qualitatively have at least one detected value, however, no EPA-approved slope factor and/or reference dose are currently available.

^bThe representative concentration is the smallest of two values : the maximum detected concentration versus the upper 95% confidence limit on the mean concentration (EPA 1989a).

Table D. 10c. COPCs evaluated qualitatively^a for WAG 5 groundwater

Analyte	Frequency of Detection	Representative Concentration ^b	Units
Aluminum	35/47	1.4E+01	MG/L
Cobalt	23/47	2.5E-02	MG/L
Lead	42/49	4.0E-02	MG/L
Silicon	23/23	1.3E+01	MG/L
1,1,1-Trichloroethane	6/50	4.2E-03	MG/L
Alkalinity as CaCO ₃	3/3	4.1E+02	MG/L
Chloride	15/15	1.6E+01	MG/L
Fluoride	8/15	2.4E-01	MG/L
Organic Chloride	1/5	6.3E-01	MG/L
Phosphate	14/15	1.1E+00	MG/L
Sulfate	15/15	3.1E+01	MG/L
Sulfide	2/27	2.4E-01	MG/L
TOX	8/11	8.9E-01	MG/L
Total Dissolved Solids	15/15	4.4E+02	MG/L
Total Kjeldahl Nitrogen-TKN	33/37	5.5E-01	MG/L
Total Organic Carbon	8/15	2.5E+00	MG/L
Total Suspended Solids	14/15	1.2E+03	MG/L
Alpha Particle	39/78	3.4E+01	PCIL
Beta Particle	65/83	2.7E+02	PCIL

^a Analytes evaluated qualitatively have at least one detected value, however, no EPA-approved slope factor and/or reference dose are currently available.

^b The representative concentration is the smallest of two values : the maximum detected concentration versus the upper 95% confidence limit on the mean concentration (EPA 1989a).

Table D. 10d. COPCs evaluated qualitatively^a for WAG 5 surface water

Analyte	Frequency of Detection	Representative Concentration ^b	Units
High Base			
Aluminum	6/6	8.1E-01	MG/L
Chloride	4/4	1.5E+01	MG/L
Fluoride	3/4	1.8E+00	MG/L
Phosphate	2/9	6.0E-01	MG/L
Sulfate	4/4	2.2E+02	MG/L
Total Organic Carbon	6/6	2.5E+00	MG/L
TOX	5/6	1.0E-01	MG/L
Total Kjeldahl Nitrogen-TKN	6/6	6.0E-01	MG/L
Alpha Particle	5/6	2.7E+01	PC/L
Beta Particle	5/6	3.1E+03	PC/L
Sn-119m	1/1	1.9E+01	PC/L
High Base Storm			
Aluminum	2/3	8.5E-01	MG/L
Total Organic Carbon	3/3	5.1E+00	MG/L
Total Kjeldahl Nitrogen-TKN	2/3	4.1E-01	MG NH3-N/L
Alpha Particle	3/6	3.2E+01	PC/L
Beta Particle	6/6	2.0E+03	PC/L
Impoundment			
Aluminum	1/1	6.1E+00	MG/L
Chloride	1/1	8.1E-01	MG/L
Fluoride	1/1	1.4E-01	MG/L
Sulfate	1/1	1.5E+01	MG/L
Total Organic Carbon	2/2	3.4E+01	MG/L
Alkalinity as CaCO3	2/2	3.0E+01	MG/L
Total Dissolved Solids	2/2	3.0E+02	MG/L
Total Kjeldahl Nitrogen-TKN	2/2	4.5E+00	MG/L

Table D.10d. (continued)

Analyte	Frequency of Detection	Representative Concentration ^b	Units
Total Suspended Solids	1/2		MG/L
Alpha Particle	2/2	6.4E+03	PC/L
Beta Particle	2/2	2.0E+05	PC/L
Low Base			
Alpha Particle	5/6	1.1E+01	PC/L
Beta Particle	6/6	2.6E+03	PC/L
Low Base Storm			
Aluminum	4/22	1.5E-01	MG/L
Nitrate/Nitrite	1/6	3.0E-01	MG/L
Phosphate	4/6	3.7E-01	MG/L
Total Organic Carbon	6/6	1.1E+01	MG/L
TOX	6/6	2.3E-02	MG/L
Total Kjeldahl Nitrogen-TKN	6/6	4.6E-01	MG/L
Alpha Particle	3/5	1.3E+01	PC/L
Beta Particle	6/6	2.9E+03	PC/L
Seep Location			
Aluminum	14/15	3.3E+00	MG/L
Cobalt	6/15	1.5E-02	MG/L
Silicon	1/1	5.7E+00	MG/L
1,1,1-Trichloroethane	2/15	2.0E-03	MG/L
Chloride	15/15	2.7E+01	MG/L
Delta-BHC	1/15	1.0E-04	MG/L
Fluoride	14/15	1.8E-01	MG/L
Phosphate	7/15	1.2E-01	MG/L
Sulfate	15/15	3.4E+01	MG/L
Total Organic Carbon	14/15	3.6E+00	MG/L
m-Dichlorobenzene	2/15	2.0E-03	MG/L
Alkalinity as CaCO ₃	15/15	3.2E+02	MG/L

Table D.10d. (continued)

Analyte	Frequency of Detection	Representative Concentration ^b	Units
TOX	13/15	1.0E-01	MG/L
Total Dissolved Solids	15/15	4.3E+02	MG/L
Total Kjeldahl Nitrogen-TKN	15/15	4.9E-01	MG/L
Total Suspended Solids	12/14	6.7E+01	MG/L
Alpha Particle	7/15	1.3E+03	PCI/L
Beta Particle	15/15	4.2E+05	PCI/L
Sn-119m	1/1	5.5E+01	PCI/L

* Analytes evaluated qualitatively have at least one detected value, however, no EPA-approved slope factor and/or reference dose are currently available.

^bThe representative concentration is the smallest of two values : the maximum detected concentration versus the upper 95% confidence limit on the mean concentration (EPA 1989a).

**Table D. 11a. Carcinogenic risk for WAG 5 soil COPCs
(Excavation, industrial and residential scenarios)**

Analyte	Concentration (mg/kg;pCi/g)	Ingestion risk	Ingestion of produce risk	Dermal risk	Inhalation risk	External risk	Total risk w/o produce ingestion
Excavation scenario							
Antimony	6.2E+00						
Barium	1.6E+02						
Cadmium	4.7E-01				6.3E-13		6.3E-13
Manganese	1.3E+03						
Mercury	1.1E-01						
Aroclor 1254	4.5E-02	8.1E-10		5.7E-10			1.4E-09
Aroclor 1260	4.5E-02	8.0E-10		5.6E-10			1.4E-09
Ac-228	2.0E+00	4.1E-12			2.0E-14	3.5E-07	3.5E-07
Am-241	4.3E-01	4.3E-10			5.3E-12	1.3E-10	5.6E-10
Bi-212	2.6E+00	3.4E-12			6.7E-15	9.3E-08	9.3E-08
Bi-214	9.3E-01	5.0E-13			7.6E-16	3.0E-07	3.0E-07
Cm-243/244	7.2E-01	4.8E-10			6.2E-12	1.3E-12	4.9E-10
Co-57	2.3E+00	5.6E-12			7.3E-15	2.7E-08	2.7E-08
Co-60	1.8E+02	1.1E-08			1.1E-11	9.4E-05	9.4E-05
Cs-134	4.0E-02	6.8E-12			4.4E-16	1.3E-08	1.3E-08
Cs-137	2.7E+01	3.2E-09			2.0E-13	3.3E-06	3.3E-06
I-129	5.7E+00	4.5E-09			2.7E-13	1.4E-09	5.9E-09
K-40	2.5E+01	1.2E-09			7.4E-14	8.3E-07	8.3E-07
Na-22	1.5E+00	4.2E-11			2.8E-15	6.6E-07	6.6E-07
Pb-210	6.1E+00	1.7E-08			9.5E-12	5.9E-11	1.7E-08
Pb-212	1.5E+00	3.5E-11			2.5E-14	2.6E-08	2.6E-08
Pb-214	1.1E+00	7.7E-13			1.2E-15	4.2E-08	4.2E-08
Pu-238	4.8E-01	4.4E-10			7.3E-12	8.2E-13	4.5E-10
Pu-239/240	1.5E-01	1.5E-10			2.3E-12	1.6E-13	1.5E-10
Ra-223	5.6E-01	1.5E-10			6.8E-13	7.8E-09	8.0E-09
Ra-226	1.2E+00	6.1E-10			2.0E-06	4.5E-07	2.4E-06
Ra-228	1.8E+00	7.5E-10			4.8E-13	3.2E-07	3.2E-07
Th-228	1.7E+00	3.8E-10			5.0E-11	5.7E-07	5.7E-07
Th-230	1.5E+00	8.3E-11			1.7E-11	5.0E-12	1.0E-10
Th-232	1.6E+00	7.9E-11			1.7E-11	2.5E-12	9.9E-11
Tl-208	1.5E+00	1.1E-13			2.9E-18	1.2E-06	1.2E-06

Table D. 11a. (continued)

Analyte	Concentration (mg/kg;pCi/g)	Ingestion risk	Ingestion of produce risk	Dermal risk	Inhalation risk	External risk	Total risk w/o produce ingestion
Total Radioactive Strontium	4.0E+01	6.0E-09			9.6E-13	0.0E+00	6.0E-09
U-232	3.7E-01	5.8E-11			8.7E-12	1.0E-12	6.8E-11
U-233/234	2.1E+00	1.4E-10			2.2E-11	3.9E-12	1.7E-10
U-238	1.7E+00	2.0E-10			3.4E-11	3.7E-09	3.9E-09
Total pathway		4.8E-08		1.1E-09	2.0E-06	1.0E-04	1.0E-04
Industrial scenario							
Antimony	6.2E+00						
Barium	1.6E+02						
Cadmium	4.9E-01				4.8E-11		4.8E-11
Manganese	1.3E+03						
Mercury	1.2E-01						
Aroclor 1254	4.5E-02	6.1E-08		4.3E-08			1.0E-07
Aroclor 1260	4.1E-02	5.5E-08		3.9E-08			9.4E-08
Ac-228	2.0E+00	3.1E-10			1.5E-12	2.6E-05	2.6E-05
Am-241	4.3E-01	3.2E-08			4.0E-10	9.6E-09	4.2E-08
Bi-212	2.6E+00	2.5E-10			5.0E-13	7.0E-06	7.0E-06
Bi-214	9.4E-01	3.8E-11			5.8E-14	2.3E-05	2.3E-05
Cm-243/244	7.2E-01	3.6E-08			4.6E-10	9.9E-11	3.7E-08
Co-57	2.3E+00	4.2E-10			5.5E-13	2.0E-06	2.0E-06
Co-60	1.8E+02	8.4E-07			7.9E-10	7.1E-03	7.1E-03
Cs-134	4.0E-02	5.1E-10			3.3E-14	9.5E-07	9.5E-07
Cs-137	3.6E+01	3.2E-07			2.0E-11	3.3E-04	3.3E-04
I-129	5.7E+00	3.4E-07			2.0E-11	1.1E-07	4.5E-07
K-40	2.5E+01	8.7E-08			5.6E-12	6.2E-05	6.2E-05
Na-22	1.5E+00	3.2E-09			2.1E-13	4.9E-05	4.9E-05
Pb-212	1.5E+00	2.6E-09			1.9E-12	2.0E-06	2.0E-06
Pb-214	1.2E+00	6.1E-11			9.8E-14	3.4E-06	3.4E-06
Pu-238	4.8E-01	3.3E-08			5.5E-10	6.1E-11	3.4E-08
Pu-239/240	1.5E-01	1.1E-08			1.7E-10	1.2E-11	1.1E-08
Ra-223	5.6E-01	1.1E-08			5.1E-11	5.9E-07	6.0E-07
Ra-226	1.3E+00	4.7E-08			1.5E-04	3.5E-05	1.9E-04

Table D. 11a. (continued)

Analyte	Concentration (mg/kg;pCi/g)	Ingestion risk	Ingestion of produce risk	Dermal risk	Inhalation risk	External risk	Total risk w/o produce ingestion
Ra-228	1.8E+00	5.6E-08			3.6E-11	2.4E-05	2.4E-05
Th-228	1.7E+00	2.9E-08			3.8E-09	4.3E-05	4.3E-05
Th-230	1.5E+00	6.2E-09			1.3E-09	3.8E-10	7.9E-09
Th-232	1.6E+00	5.8E-09			1.3E-09	1.9E-10	7.3E-09
Tl-208	1.6E+00	8.8E-12			2.3E-16	9.3E-05	9.3E-05
Total Radioactive Strontium	4.7E+01	5.3E-07			8.6E-11	0.0E+00	5.3E-07
U-233	1.1E+01	5.3E-08			8.3E-09	2.0E-09	6.3E-08
U-233/234	2.2E+00	1.1E-08			1.7E-09	3.1E-10	1.3E-08
U-238	1.7E+00	1.5E-08			2.6E-09	2.8E-07	3.0E-07
Total pathway		2.6E-06		8.2E-08	1.5E-04	7.8E-03	7.9E-03
Residential scenario							
Antimony	6.2E+00						
Barium	1.6E+02						
Cadmium	4.9E-01				1.4E-10		1.4E-10
Manganese	1.3E+03						
Mercury	1.2E-01						
Aroclor 1254	4.5E-02	5.5E-07	8.9E-07	1.4E-07			6.8E-07
Aroclor 1260	4.1E-02	4.9E-07	1.8E-07	1.2E-07			6.2E-07
Ac-228	2.0E+00	1.2E-09	7.2E-11		2.5E-12	1.3E-04	1.3E-04
Am-241	4.3E-01	1.3E-07	8.6E-08		6.7E-10	4.8E-08	1.8E-07
Bi-212	2.6E+00	1.0E-09	2.4E-08		8.4E-13	3.5E-05	3.5E-05
Bi-214	9.4E-01	1.5E-10	3.6E-09		9.7E-14	1.1E-04	1.1E-04
Cm-243/244	7.2E-01	1.5E-07	9.7E-08		7.8E-10	5.0E-10	1.5E-07
Co-57	2.3E+00	1.7E-09	3.4E-08		9.2E-13	1.0E-05	1.0E-05
Co-60	1.8E+02	3.4E-06	6.8E-05		1.3E-09	3.5E-02	3.5E-02
Cs-134	4.0E-02	2.1E-09	4.1E-08		5.5E-14	4.8E-06	4.8E-06
Cs-137	3.6E+01	1.3E-06	3.4E-05		3.4E-11	1.7E-03	1.7E-03
I-129	5.7E+00	1.4E-06	1.8E-05		3.4E-11	5.4E-07	1.9E-06
K-40	2.5E+01	3.5E-07	7.0E-05		9.4E-12	3.1E-04	3.1E-04
Na-22	1.5E+00	1.3E-08	4.3E-07		3.5E-13	2.5E-04	2.5E-04
Pb-212	1.5E+00	1.1E-08	7.1E-08		3.2E-12	9.9E-06	9.9E-06

Table D. 11a. (continued)

Analyte	Concentration (mg/kg;pCi/g)	Ingestion risk	Ingestion of produce risk	Dermal risk	Inhalation risk	External risk	Total risk w/o produce ingestion
Pb-214	1.2E+00	2.5E-10	1.7E-09		1.6E-13	1.7E-05	1.7E-05
Pu-238	4.8E-01	1.3E-07	4.4E-08		9.2E-10	3.1E-10	1.3E-07
Pu-239/240	1.5E-01	4.5E-08	1.5E-08		2.9E-10	6.0E-11	4.5E-08
Ra-223	5.6E-01	4.5E-08	1.2E-06		8.5E-11	3.0E-06	3.0E-06
Ra-226	1.3E+00	1.9E-07	1.1E-05		2.6E-04	1.7E-04	4.3E-04
Ra-228	1.8E+00	2.3E-07	6.0E-06		6.1E-11	1.2E-04	1.2E-04
Th-228	1.7E+00	1.2E-07	7.2E-06		6.4E-09	2.2E-04	2.2E-04
Th-230	1.5E+00	2.5E-08	8.4E-09		2.2E-09	1.9E-09	2.9E-08
Th-232	1.6E+00	2.4E-08	7.9E-09		2.1E-09	9.3E-10	2.7E-08
Tl-208	1.6E+00	3.6E-11	9.5E-11		3.8E-16	4.7E-04	4.7E-04
Total Radioactive Strontium	4.7E+01	2.1E-06	4.3E-04		1.4E-10	0.0E+00	2.1E-06
U-233	1.1E+01	2.1E-07	2.8E-07		1.4E-08	1.0E-08	2.4E-07
U-233/234	2.2E+00	4.5E-08	6.0E-08		2.8E-09	1.5E-09	4.9E-08
U-238	1.7E+00	6.0E-08	1.0E-07		4.3E-09	1.4E-06	1.5E-06
Total pathway		1.1E-05	6.5E-04	2.6E-0 7	2.6E-04	3.8E-02	3.9E-02

Table D. 11b. Carcinogenic risk for WAG 5 sediment COPCs
(Industrial and residential scenarios)

Analyte	Concentration (mg/kg;pCi/g)	Ingestion risk	Dermal risk	Inhalation risk	External risk	Total risk
Industrial scenario						
Antimony	2.6E+01					
Arsenic	8.0E+00			6.5E-09		6.5E-09
Barium	5.1E+02					
Chromium VI	3.8E+01			2.5E-08		2.5E-08
Manganese	1.9E+04					
Mercury	7.1E+00					
4-Methyl Phenol	2.6E+01					
Aroclor 1248	5.1E-01	6.8E-07	4.8E-07			1.2E-06
Aroclor 1254	8.7E-01	1.2E-06	8.2E-07			2.0E-06
Aroclor 1260	2.6E-01	3.5E-07	2.5E-07			6.0E-07
Vinyl Chloride	2.7E-01	9.0E-08	5.7E-08	6.6E-04		6.6E-04
Ac-228	2.2E+00	3.4E-10		1.7E-12	2.9E-05	2.9E-05
Am-241	7.0E+02	5.2E-05		6.5E-07	1.6E-05	6.9E-05
Bi-212	1.7E+00	1.6E-10		3.3E-13	4.6E-06	4.6E-06
Bi-214	1.0E+00	4.2E-11		6.3E-14	2.5E-05	2.5E-05
Cm-243/244	2.4E+04	1.2E-03		1.6E-05	3.3E-06	1.2E-03
Co-60	3.1E+03	1.4E-05		1.3E-08	1.1E-01	1.1E-01
Cs-137	3.7E+06	3.2E-02		2.1E-06	1.0E+00	1.0E+00
Eu-152	9.6E+02	6.3E-07		3.1E-09	1.6E-02	1.6E-02
Eu-154	5.8E+02	5.4E-07		2.4E-09	1.1E-02	1.1E-02
I-129	1.4E+01	8.3E-07		4.9E-11	2.6E-07	1.1E-06
Pb-210	2.7E+00	5.6E-07		3.2E-10	2.0E-09	5.6E-07
Pb-212	1.6E+00	2.7E-09		2.0E-12	2.0E-06	2.0E-06
Pb-214	1.2E+00	2.0E-09		1.4E-12	1.5E-06	1.5E-06
Pu-238	3.2E+02	2.2E-05		3.7E-07	4.1E-08	2.3E-05
Pu-239/240	5.0E+02	3.6E-05		5.5E-07	3.9E-08	3.6E-05
Ra-223	9.1E-01	1.8E-08		8.2E-11	9.6E-07	9.7E-07
Ra-224	4.9E+00	5.8E-08		1.7E-10	5.1E-07	5.7E-07
Ra-226	1.7E+00	6.4E-08		2.1E-04	4.7E-05	2.5E-04
Radon 219	1.2E+00			1.6E-15	8.8E-07	8.8E-07
Th-228	3.9E+02	6.7E-06		8.8E-07	9.9E-03	9.9E-03

Table D. 11b. (continued)

Analyte	Concentration (mg/kg;pCi/g)	Ingestion risk	Dermal risk	Inhalation risk	External risk	Total risk
Th-230	1.9E+02	7.8E-07		1.6E-07	4.7E-08	9.9E-07
Tl-208	1.3E+00	7.4E-12		1.9E-16	7.8E-05	7.8E-05
Total Radioactive Strontium	7.4E+05	8.3E-03		1.3E-06	0.0E+00	8.3E-03
U-232	3.2E+02	3.6E-06		5.5E-07	6.6E-08	4.3E-06
U-233	3.4E+03	1.7E-05		2.7E-06	6.5E-07	2.0E-05
U-235	3.8E-01	1.9E-09		2.8E-10	4.2E-07	4.2E-07
U-238	5.4E+01	4.7E-07		8.2E-08	8.9E-06	9.5E-06
Total pathway		4.1E-02	1.6E-06	8.9E-04	1.0E+00	1.0E+00
Residential scenario						
Antimony	2.6E+01					
Arsenic	8.0E+00			1.9E-08		1.9E-08
Barium	5.1E+02					
Chromium VI	3.8E+01			7.3E-08		7.3E-08
Manganese	1.9E+04					
Mercury	7.1E+00					
4-Methyl Phenol	2.6E+01					
Aroclor 1248	5.1E-01	6.1E-06	1.5E-06			7.6E-06
Aroclor 1254	8.7E-01	1.0E-05	2.6E-06			1.3E-05
Aroclor 1260	2.6E-01	3.2E-06	7.8E-07			4.0E-06
Vinyl Chloride	2.7E-01	8.1E-07	1.8E-07	1.9E-03		1.9E-03
Ac-228	2.2E+00	1.4E-09		2.8E-12	1.5E-04	1.5E-04
Am-241	7.0E+02	2.1E-04		1.1E-06	7.9E-05	2.9E-04
Bi-212	1.7E+00	6.6E-10		5.5E-13	2.3E-05	2.3E-05
Bi-214	1.0E+00	1.7E-10		1.1E-13	1.3E-04	1.3E-04
Cm-243/244	2.4E+04	4.9E-03		2.6E-05	1.7E-05	5.0E-03
Co-60	3.1E+03	5.8E-05		2.3E-08	4.6E-01	4.6E-01
Cs-137	3.7E+06	1.2E-01		3.5E-06	1.0E+00	1.0E+00
Eu-152	9.6E+02	2.5E-06		5.2E-09	7.7E-02	7.7E-02
Eu-154	5.8E+02	2.2E-06		4.0E-09	5.3E-02	5.3E-02
I-129	1.4E+01	3.4E-06		8.2E-11	1.3E-06	4.7E-06
Pb-210	2.7E+00	2.2E-06		5.3E-10	9.9E-09	2.3E-06
Pb-212	1.6E+00	1.1E-08		3.3E-12	1.0E-05	1.0E-05
Pb-214	1.2E+00	8.0E-09		2.4E-12	7.4E-06	7.4E-06

Table D. 11b. (continued)

Analyte	Concentration (mg/kg;pCi/g)	Ingestion risk	Dermal risk	Inhalation risk	External risk	Total risk
Pu-238	3.2E+02	8.9E-05		6.2E-07	2.1E-07	9.0E-05
Pu-239/240	5.0E+02	1.4E-04		9.3E-07	2.0E-07	1.5E-04
Ra-223	9.1E-01	7.3E-08		1.4E-10	4.8E-06	4.9E-06
Ra-224	4.9E+00	2.3E-07		2.9E-10	2.6E-06	2.8E-06
Ra-226	1.7E+00	2.6E-07		3.5E-04	2.4E-04	5.8E-04
Radon 219	1.2E+00			2.7E-15	4.4E-06	4.4E-06
Th-228	3.9E+02	2.7E-05		1.5E-06	4.9E-02	4.9E-02
Th-230	1.9E+02	3.1E-06		2.7E-07	2.4E-07	3.7E-06
Tl-208	1.3E+00	3.0E-11		3.2E-16	3.9E-04	3.9E-04
Total Radioactive Strontium	7.4E+05	3.3E-02		2.2E-06	0.0E+00	3.3E-02
U-232	3.2E+02	1.5E-05		9.3E-07	3.3E-07	1.6E-05
U-233	3.4E+03	6.8E-05		4.5E-06	3.3E-06	7.6E-05
U-235	3.8E-01	7.7E-09		4.7E-10	2.1E-06	2.1E-06
U-238	5.4E+01	1.9E-06		1.4E-07	4.5E-05	4.7E-05
Total pathway		1.6E-01	5.1E-06	2.3E-03	1.0E+00	1.0E+00

Table D. 11c. Carcinogenic risk for WAG 5 groundwater COPCs (Residential scenario)

Analyte	Concentration (mg/l;pCi/l)	Ingestion risk	Ingestion of produce risk	Dermal risk	Inhalation risk	Total risk w/o produce ingestion
Beryllium	1.1E-03	9.4E-05	5.2E-04	1.5E-05		1.1E-04
Chromium VI	4.9E-02					
Manganese	1.5E+00					
1,1-Dichloroethene	4.2E-03	5.1E-05	3.3E-04	7.3E-07	3.8E-06	5.5E-05
1,2-Dichloroethane	3.7E-03	6.9E-06	4.8E-05	5.9E-08	2.6E-07	7.2E-06
1,2-Dichloroethene (Total)	2.5E-02					
Benzene	3.8E-03	2.2E-06	1.4E-05	7.7E-08	8.3E-08	2.4E-06
Bis(2-Ethylhexyl) Phthalate	1.3E-02	3.8E-06	3.9E-05	7.6E-07		4.6E-06
Carbon Tetrachloride	6.0E-03	1.6E-05	9.3E-05	8.6E-07	2.4E-07	1.7E-05
Chloroform	3.5E-03	4.3E-07	2.7E-06	3.1E-08	2.1E-07	6.8E-07
Methylene Chloride	1.0E-02	1.6E-06	1.2E-05	1.2E-08		1.6E-06
Tetrachloroethene	6.4E-03					
Trichloroethene	1.0E-02	2.3E-06	1.4E-05	4.0E-07	4.7E-08	2.8E-06
Vinyl Chloride	3.1E-01	1.2E-02	8.1E-02	1.4E-04	7.0E-05	1.2E-02
Am-241	3.5E+04	1.6E-01	6.2E-01			1.6E-01
Bi-212	5.3E+02	3.5E-06	6.1E-08			3.5E-06
C-14	4.8E+02	9.0E-06	5.0E-05			9.0E-06
Ca-45	1.3E+02	2.6E-06	1.4E-05			2.6E-06
Cd-109	3.7E+02	6.1E-05	3.3E-04			6.1E-05
Cm-243	1.8E-01	7.1E-07	3.9E-06			7.1E-07
Cm-243/244	2.2E+00	7.3E-06	4.0E-05			7.3E-06
Co-60	1.4E+01	4.3E-06	2.4E-05			4.3E-06
Cs-137	2.5E+00	1.5E-06	8.2E-06			1.5E-06
K-40	8.9E+02	2.0E-04	1.2E-03			2.0E-04
Pb-212	4.5E+01	5.2E-06	9.2E-07			5.2E-06
Pu-238	8.3E-01	3.8E-06	2.1E-05			3.8E-06
Pu-239/240	3.7E-02	1.8E-07	9.8E-07			1.8E-07
Ra-226	1.5E+00	3.8E-06	2.1E-05			3.8E-06
Ra-228	5.8E+00	1.2E-05	6.7E-05			1.2E-05
Tc-99	2.1E+01	5.6E-07	6.1E-06			5.6E-07
Th-228	2.0E+00	2.3E-06	1.3E-05			2.3E-06

Table D.11c. (continued)

Analyte	Concentration (mg/l;pCi/l)	Ingestion risk	Ingestion of produce risk	Dermal risk	Inhalation risk	Total risk w/o produce ingestion
Th-230	1.1E+00	3.0E-07	1.6E-06			3.0E-07
Th-231	3.5E+02	3.0E-06	1.2E-06			3.0E-06
Th-232	1.8E+00	4.6E-07	2.6E-06			4.6E-07
Th-234	7.4E+02	6.2E-05	2.3E-04			6.2E-05
Total Radioactive Strontium	7.4E+01	5.6E-05	3.2E-04			5.6E-05
Tritium	7.0E+05	7.9E-04	4.4E-03		1.3E-04	9.2E-04
U-232	3.7E-01	2.9E-07	1.6E-06			2.9E-07
U-233/234	2.0E+00	6.7E-07	3.7E-06			6.7E-07
U-238	2.9E-01	1.7E-07	9.4E-07			1.7E-07
Total pathway		1.7E-01	6.5E-01	1.6E-04	2.1E-04	1.7E-01

Table D. 11d. Carcinogenic risk for WAG 5 surface water COPCs-Residential scenario

Analyte	Concentration (mg/l;pCi/l)	Ingestion risk	Dermal risk	Inhalation risk	Total risk
High Base					
Manganese	1.6E+00				
C-14	6.3E+02	1.2E-05			1.2E-05
Ca-45	9.9E+02	2.1E-05			2.1E-05
Pu-238	2.9E-01	1.3E-06			1.3E-06
Total Radioactive Strontium	1.6E+03	1.2E-03			1.2E-03
Tritium	4.0E+06	4.5E-03			4.5E-03
U-233/234	1.8E+01	5.9E-06			5.9E-06
U-238	2.9E+01	1.7E-05			1.7E-05
Total pathway		5.8E-03			5.8E-03
High Base Storm					
1,1-Dichloroethane	2.0E-03				
1,2-Dichloroethene (Total)	3.0E-03				
2-Butanone	7.0E-03				
Bis(2-Ethylhexyl) Phthalate	6.0E-03	1.7E-06	3.4E-07		2.0E-06
Trichloroethene	1.0E-03	2.2E-07	3.8E-08	4.6E-09	2.7E-07
C-14	5.9E+01	1.1E-06			1.1E-06
Cm-243/244	3.7E-01	1.3E-06			1.3E-06
Pu-238	7.1E+00	3.3E-05			3.3E-05
Tc-99	1.9E+01	5.3E-07			5.3E-07
Th-230	9.6E+00	2.6E-06			2.6E-06
Total Radioactive Strontium	8.0E+02	6.1E-04			6.1E-04
Tritium	2.2E+06	2.4E-03			2.4E-03
U-233/234	2.6E+01	8.8E-06			8.8E-06
U-238	4.1E+01	2.4E-05			2.4E-05
Total pathway		3.1E-03	3.8E-07	4.6E-09	3.1E-03
Impoundment					
Bis(2-Ethylhexyl) Phthalate	1.0E-03	2.8E-07	5.6E-08		3.4E-07
Bromomethane	2.0E-03				
Am-241	5.0E-01	2.5E-06			2.5E-06
Cm-243/244	1.6E+01	5.4E-05			5.4E-05
Co-60	1.5E+02	4.8E-05			4.8E-05

Table D. 11d. (continued)

Analyte	Concentration (mg/l;pCi/l)	Ingestion risk	Dermal risk	Inhalation risk	Total risk
Cs-137	2.5E+04	1.5E-02			1.5E-02
Pu-238	3.2E-01	1.5E-06			1.5E-06
Pu-239/240	5.1E-01	2.4E-06			2.4E-06
Tc-99	4.3E+01	1.2E-06			1.2E-06
Total Radioactive Strontium	9.0E+04	6.6E-02			6.6E-02
Tritium	2.0E+04	2.3E-05			2.3E-05
U-232	2.2E+01	1.7E-05			1.7E-05
U-233/234	2.6E+02	8.8E-05			8.8E-05
U-238	4.8E+00	2.8E-06			2.8E-06
Total pathway		8.0E-02	5.6E-08		8.0E-02
Low Base					
Manganese	2.9E+00				
Am-241	7.8E+00	4.0E-05			4.0E-05
C-14	7.7E+01	1.5E-06			1.5E-06
Pb-212	2.1E+01	2.4E-06			2.4E-06
Pu-238	9.5E+00	4.4E-05			4.4E-05
Ra-228	1.6E+03	3.4E-03			3.4E-03
Total Radioactive Strontium	1.3E+03	9.8E-04			9.8E-04
Tritium	7.1E+05	8.0E-04			8.0E-04
U-233/234	5.8E+00	1.9E-06			1.9E-06
U-238	9.4E+00	5.5E-06			5.5E-06
Total pathway		5.3E-03			5.3E-03
Low Base Storm					
Manganese	3.5E-01				
Bis(2-Ethylhexyl) Phthalate	1.8E-02	5.1E-06	1.0E-06		6.1E-06
Am-241	4.9E-01	2.5E-06			2.5E-06
C-14	9.3E+01	1.8E-06			1.8E-06
Pu-238	9.9E+00	4.6E-05			4.6E-05
Total Radioactive Strontium	1.5E+03	1.2E-03			1.2E-03
Tritium	5.5E+06	6.2E-03			6.2E-03
U-233/234	6.7E+00	2.2E-06			2.2E-06
U-238	8.7E+00	5.1E-06			5.1E-06
Total pathway		7.4E-03	1.0E-06		7.5E-03

**Table D. 12a. Noncarcinogenic hazard quotients for WAG 5 soil COPCs
(Excavation, industrial, and residential scenarios)**

Analyte	Concentration (mg/kg)	Ingestion HQ	Ingestion of produce HQ	Dermal HQ	Inhalation HQ	Total HI w/o produce ingestion
Excavation scenario						
Antimony	6.2E+00	2.5E-03		8.0E-03		1.1E-02
Barium	1.6E+02	3.7E-04		3.3E-04	1.7E-05	7.1E-04
Cadmium	4.7E-01	7.7E-05		4.9E-04		5.6E-04
Manganese	1.3E+03	1.5E-03		2.3E-03	1.4E-03	5.2E-03
Mercury	1.1E-01	5.7E-05		5.2E-05	1.9E-08	1.1E-04
Aroclor 1254	4.5E-02					
Aroclor 1260	4.5E-02					
Total pathway		4.5E-03		1.1E-02	1.4E-03	1.7E-02
Industrial scenario						
Antimony	6.2E+00	7.6E-03		2.4E-02		3.2E-02
Barium	1.6E+02	1.1E-03		9.9E-04	5.0E-05	2.1E-03
Cadmium	4.9E-01	2.4E-04		1.5E-03		1.7E-03
Manganese	1.3E+03	4.6E-03		7.3E-03	4.2E-03	1.6E-02
Mercury	1.2E-01	1.9E-04		1.7E-04	6.1E-08	3.6E-04
Aroclor 1254	4.5E-02					
Aroclor 1260	4.1E-02					
Total pathway		1.4E-02		3.4E-02	4.3E-03	5.2E-02
Residential scenario						
Antimony	6.2E+00	5.7E-02	2.9E-01	6.3E-02		1.2E-01
Barium	1.6E+02	8.2E-03	4.3E-02	2.6E-03	1.2E-04	1.1E-02
Cadmium	4.9E-01	1.8E-03	3.5E-02	4.0E-03		5.7E-03
Manganese	1.3E+03	3.4E-02	7.1E+00	1.9E-02	1.0E-02	6.4E-02
Mercury	1.2E-01	1.4E-03	2.2E-01	4.5E-04	1.5E-07	1.8E-03
Aroclor 1254	4.5E-02					
Aroclor 1260	4.1E-02					
Total pathway		1.0E-01	7.7E+00	8.9E-02	1.0E-02	2.0E-01

**Table D. 12b. Noncarcinogenic hazard quotients for WAG 5 sediment COPCs
(Industrial and residential scenarios)**

Analyte	Concentration (mg/kg)	Ingestion HQ	Dermal HQ	Inhalation HQ	Total HI
Industrial scenario					
Antimony	2.6E+01	3.2E-02	1.0E-01		1.3E-01
Arsenic	8.0E+00	1.3E-02	2.0E-03		1.5E-02
Barium	5.1E+02	3.5E-03	3.2E-03	1.6E-04	6.9E-03
Chromium VI	3.8E+01	3.7E-03	1.2E-02		1.5E-02
Manganese	1.9E+04	6.8E-02	1.1E-01	6.2E-02	2.4E-01
Mercury	7.1E+00	1.2E-02	1.0E-02	3.8E-06	2.2E-02
4-Methyl Phenol	2.6E+01	2.5E-03	1.6E-03		4.2E-03
Aroclor 1248	5.1E-01				
Aroclor 1254	8.7E-01				
Aroclor 1260	2.6E-01				
Vinyl Chloride	2.7E-01				
Total pathway		1.3E-01	2.4E-01	6.2E-02	4.3E-01
Residential scenario					
Antimony	2.6E+01	2.4E-01	2.7E-01		5.1E-01
Arsenic	8.0E+00	9.7E-02	5.3E-03		1.0E-01
Barium	5.1E+02	2.6E-02	8.4E-03	3.9E-04	3.5E-02
Chromium VI	3.8E+01	2.7E-02	3.1E-02		5.8E-02
Manganese	1.9E+04	5.1E-01	2.8E-01	1.5E-01	9.4E-01
Mercury	7.1E+00	8.7E-02	2.8E-02	9.2E-06	1.1E-01
4-Methyl Phenol	2.6E+01	1.9E-02	4.2E-03		2.3E-02
Aroclor 1248	5.1E-01				
Aroclor 1254	8.7E-01				
Aroclor 1260	2.6E-01				
Vinyl Chloride	2.7E-01				
Total pathway		1.0E+00	6.3E-01	1.5E-01	1.8E+00

Table D. 12c. Noncarcinogenic hazard quotients for WAG 5 groundwater COPCs (Residential scenario)

Analyte	Concentration (mg/l)	Ingestion HQ	Ingestion of produce HQ	Dermal HQ	Inhalation HQ	Total HI w/o produce ingestion
Beryllium	1.1E-03	1.0E-02	5.7E-02	1.6E-03		1.2E-02
Chromium VI	4.9E-02	4.6E-01	2.6E+00	3.7E-02		5.0E-01
Manganese	1.5E+00	1.4E+01	8.7E+01	5.8E-01		1.5E+01
1,1-Dichloroethene	4.2E-03	2.2E-02	1.4E-01	3.1E-04		2.2E-02
1,2-Dichloroethane	3.7E-03					
1,2-Dichloroethene (Total)	2.5E-02	1.3E-01	1.5E+00			1.3E-01
Benzene	3.8E-03					
Bis(2-Ethylhexyl) Phthalate	1.3E-02	3.2E-02	3.2E-01	6.3E-03		3.8E-02
Carbon Tetrachloride	6.0E-03	4.1E-01	2.4E+00	2.2E-02		4.3E-01
Chloroform	3.5E-03	1.6E-02	1.0E-01	1.2E-03		1.8E-02
Methylene Chloride	1.0E-02	8.1E-03	6.0E-02	6.2E-05	2.1E-05	8.2E-03
Tetrachloroethene	6.4E-03	3.0E-02	1.8E-01	1.8E-02		4.8E-02
Trichloroethene	1.0E-02					
Vinyl Chloride	3.1E-01					
Total pathway		1.6E+01	9.4E+01	6.7E-01	2.1E-05	1.6E+01

Table D. 12d. Noncarcinogenic hazard quotients for WAG 5 surface water COPCs-Residential scenario

Analyte	Concentration (mg/l)	Ingestion HQ	Dermal HQ	Inhalation HQ	Total HI
High Base					
Manganese	1.6E+00	1.5E+01	6.1E-01		1.6E+01
Total pathway		1.5E+01	6.1E-01		1.6E+01
High Base Storm					
1,1-Dichloroethane	2.0E-03	9.5E-04	1.4E-05	2.5E-05	9.9E-04
1,2-Dichloroethene (Total)	3.0E-03	1.6E-02			1.6E-02
2-Butanone	7.0E-03	5.5E-04	1.2E-06	4.4E-05	6.0E-04
Bis(2-Ethylhexyl) Phthalate	6.0E-03	1.4E-02	2.8E-03		1.7E-02
Trichloroethene	1.0E-03				
Total pathway		3.2E-02	2.8E-03	6.9E-05	3.4E-02
Impoundment					
Bis(2-Ethylhexyl) Phthalate	1.0E-03	2.4E-03	4.7E-04		2.8E-03
Bromomethane	2.0E-03	6.8E-02	3.8E-04	2.5E-03	7.1E-02
Total pathway		7.0E-02	8.5E-04	2.5E-03	7.4E-02
Low Base					
Manganese	2.9E+00	2.8E+01	1.1E+00		2.9E+01
Total pathway		2.8E+01	1.1E+00		2.9E+01
Low Base Storm					
Manganese	3.5E-01	3.3E+00	1.3E-01		3.5E+00
Bis(2-Ethylhexyl) Phthalate	1.8E-02	4.3E-02	8.5E-03		5.1E-02
Total pathway		3.4E+00	1.4E-01		3.5E+00

**Table D. 13a. RGOs for the soil of WAG5
(Excavation, industrial, and residential scenarios)**

Excavation, industrial, and residential scenarios					
Analyte	concentration (pCi/g, mg/Kg)	Risk-based RGOs (pCi/g, mg/Kg)			HQ-based RGOs (pCi/g, mg/Kg)
		Produce ingestion	Inhalation	External	Produce ingestion
Excavation scenario					
Co-60	1.80E+02			1.90E+00	
Cs-137	2.70E+01			8.20E+00	
Tl-208	1.50E+00			1.30E+00	
Industrial scenario					
Ac-228	2.00E+00			7.60E-02	
Bi-212	2.60E+00			3.70E-01	
Bi-214	9.40E-01			4.10E-02	
Co-57	2.30E+00			1.20E+00	
Co-60	1.80E+02			2.50E-02	
Cs-137	3.60E+01			1.10E-01	
K-40	2.50E+01			4.00E-01	
Na-22	1.50E+00			3.00E-02	
Pb-212	1.50E+00			7.80E-01	
Pb-214	1.20E+00			3.40E-01	
Ra-226	1.30E+00		6.80E-03	6.80E-03	
Ra-228	1.80E+00			7.50E-02	
Th-228	1.70E+00			3.90E-02	
Tl-208	1.60E+00			1.70E-02	
Residential scenario					
Antimony	6.20E+00				1.50E+00
Manganese	1.30E+03				1.80E+01
Mercury	1.20E-01				5.20E-02
Ac-228	2.00E+00			1.50E-02	
Bi-212	2.60E+00			7.40E-02	
Bi-214	9.40E-01			8.20E-03	
Co-57	2.30E+00			2.30E-01	
Co-60	1.80E+02	5.10E-03		5.10E-03	
Cs-134	4.00E-02			8.40E-03	
Cs-137	3.60E+01	2.10E-02		2.20E-02	
I-129	5.70E+00	2.80E-01			

Table D. 13a. (continued)

Analyte	concentration (pCi/g, mg/Kg)	Risk-based RGOs (pCi/g, mg/Kg)			HQ-based RGOs (pCi/g, mg/Kg)
		Produce ingestion	Inhalation	External	Produce ingestion
K-40	2.50E+01	6.60E-02		8.00E-02	
Na-22	1.50E+00			6.00E-03	
Pb-212	1.50E+00			1.60E-01	
Pb-214	1.20E+00			6.80E-02	
Ra-223	5.60E-01	1.30E-01		1.90E-01	
Ra-226	1.30E+00	2.90E-03	2.90E-03	2.90E-03	
Ra-228	1.80E+00	1.40E-02		1.50E-02	
Th-228	1.70E+00	7.50E-03		7.80E-03	
Tl-208	1.60E+00			3.30E-03	
Total Radioactive Strontium	4.70E+01	1.10E-01			
U-238	1.70E+00			1.20E+00	

**Table D. 13b. RGOs for the sediment of WAG5
(Industrial and residential scenarios)**

(Industrial and Residential scenarios)					
Analyte	concentration (pCi/g; mg/Kg)	Risk-based RGOs (pCi/g; mg/Kg)			HQ-based RGOs (pCi/g; mg/Kg)
		Ingestion	Inhalation	External	Produce ingestion
Industrial scenario					
Ac-228	2.20E+00			7.60E-02	
Am-241	7.00E+02	1.00E+01		1.00E+01	
Aroclor 1254	8.70E-01	4.40E-01			
Bi-212	1.70E+00			3.70E-01	
Bi-214	1.00E+00			4.10E-02	
Cm-243/244	2.40E+04	2.00E+01	2.00E+01	2.00E+01	
Co-60	3.10E+03	2.70E-02		2.70E-02	
Cs-137	3.70E+06	3.70E+00	3.70E+00	3.70E+00	
Eu-152	9.60E+02			6.10E-02	
Eu-154	5.80E+02			5.40E-02	
Pb-212	1.60E+00			7.80E-01	
Pb-214	1.20E+00			7.80E-01	
Pu-238	3.20E+02	1.40E+01			
Pu-239/240	5.00E+02	1.40E+01			
Ra-226	1.70E+00		6.80E-03	6.80E-03	
Th-228	3.90E+02	3.90E-02		3.90E-02	
Tl-208	1.30E+00			1.70E-02	
Total Radioactive Strontium	7.40E+05	8.90E+01	8.90E+01		
U-232	3.20E+02	7.40E+01			
U-233	3.40E+03	1.70E+02	1.70E+02		
U-238	5.40E+01			5.70E+00	
Vinyl Chloride	2.70E-01		4.10E-04		
Residential scenario					
Antimony	2.60E+01				5.20E+00
Manganese	1.90E+04				2.10E+03
Ac-228	2.20E+00			1.50E-02	
Am-241	7.00E+02	2.40E+00	2.40E+00	2.40E+00	
Aroclor 1248	5.10E-01	6.60E-02			
Aroclor 1254	8.70E-01	6.60E-02			
Aroclor 1260	2.60E-01	6.60E-02			

Table D. 13b. (continued)

Analyte	Representative concentration (pCi/g, mg/Kg)	Risk-based RGOs (pCi/g, mg/Kg)			HQ-based RGOs (pCi/g, mg/Kg)
		Produce ingestion	Inhalation	External	Produce ingestion
Bi-212	1.70E+00			7.40E-02	
Bi-214	1.00E+00			8.20E-03	
Cm-243/244	2.40E+04	4.90E+00	4.90E+00	4.90E+00	
Co-60	3.10E+03	6.70E-03		6.70E-03	
Cs-137	3.70E+06	3.70E+00	3.70E+00	3.70E+00	
Eu-152	9.60E+02	1.30E-02		1.30E-02	
Eu-154	5.80E+02	1.10E-02		1.10E-02	
I-129	1.40E+01	3.00E+00		3.00E+00	
Pb-210	2.70E+00	1.20E+00			
Pb-212	1.60E+00			1.60E-01	
Pb-214	1.20E+00			1.60E-01	
Pu-238	3.20E+02	3.60E+00			
Pu-239/240	5.00E+02	3.40E+00			
Ra-223	9.10E-01			1.90E-01	
Ra-224	4.90E+00			1.70E+00	
Ra-226	1.70E+00		2.90E-03	2.90E-03	
Radon 219	1.20E+00			2.70E-01	
Th-228	3.90E+02	8.00E-03	8.00E-03	8.00E-03	
Th-230	1.90E+02	5.30E+01			
Tl-208	1.30E+00			3.30E-03	
Total Radioactive Strontium	7.40E+05	2.20E+01	2.20E+01		
U-232	3.20E+02	2.00E+01			
U-233	3.40E+03	4.50E+01	4.50E+01	4.50E+01	
U-235	3.80E-01			1.80E-01	
U-238	5.40E+01	1.20E+00		1.20E+00	
Vinyl Chloride	2.70E-01		1.40E-04		

Table D. 13c. RGOs for the groundwater of WAG5- Residential scenario

Analyte	concentration (pCi/L; mg/L)	Risk-based RGOs (pCi/L; mg/L)				HQ-based RGOs (pCi/L; mg/L)	
		Ingestion	Produce Ingestion	Inhalation	Dermal	ingestion	Produce ingestion
Chromium VI	4.90E-02					9.70E-03	1.60E-03
Manganese	1.50E+00					1.00E-02	1.50E-03
Tetrachloroethene	6.40E-03						2.80E-03
Beryllium	1.10E-03	9.80E-06	1.70E-06		9.80E-06		
1,1-Dichloroethene	4.20E-03	7.50E-05	1.10E-05	7.50E-05			2.50E-03
1,2-Dichloroethane	3.70E-03	5.20E-04	6.70E-05			1.90E-02	1.60E-03
Benzene	3.80E-03	1.60E-03	2.30E-04				
Bis(2-Ethylhexyl) Phthalate	1.30E-02	2.90E-03	3.10E-04				3.70E-03
Carbon Tetrachloride	6.00E-03	3.50E-04	5.50E-05			1.40E-03	2.10E-04
Chloroform	3.50E-03		1.00E-03				2.90E-03
Methylene Chloride	1.00E-02	6.50E-03	7.80E-04				
Trichloroethene	1.00E-02	3.70E-03	6.20E-04				
Vinyl Chloride	3.10E-01	2.60E-05	3.30E-06	2.60E-05	2.60E-05		
Am-241	3.50E+04	2.20E-01	5.10E-02				
Bi-212	5.30E+02	1.50E+02					
C-14	4.80E+02	5.30E+01	8.10E+00				
Ca-45	1.30E+02	4.80E+01	7.80E+00				
Cd-109	3.70E+02	6.00E+00	9.40E-01				
Cm-243	1.80E-01		3.80E-02				
Cm-243/244	2.20E+00	3.00E-01	4.50E-02				
Co-60	1.40E+01	3.20E+00	4.90E-01				
Cs-137	2.50E+00	1.70E+00	2.60E-01				
K-40	8.90E+02	4.30E+00	6.30E-01				
Pb-212	4.50E+01	8.70E+00					
Pu-238	8.30E-01	2.20E-01	3.30E-02				
Ra-226	1.50E+00	4.00E-01	6.00E-02				
Ra-228	5.80E+00	4.80E-01	7.30E-02				
Tc-99	2.10E+01		3.10E+00				
Th-228	2.00E+00	8.70E-01	1.30E-01				
Th-230	1.10E+00		5.60E-01				
Th-231	3.50E+02	1.20E+02	8.40E+01				

Table D. 13c. (continued)

Analyte	concentration (pCi/g; mg/Kg)	Risk-based RGOs (pCi/g; mg/Kg)				HQ-based RGOs (pCi/g; mg/Kg)	
		Ingestion	Produce Ingestion	Inhalation	Dermal	ingestion	Produce ingestion
Th-232	1.80E+00		6.10E-01				
Th-234	7.40E+02	1.20E+01	2.60E+00				
Total Radioactive Strontium	7.40E+01	1.30E+00	2.00E-01				
Tritium	7.00E+05	7.60E+02	1.30E+02	7.60E+02			
U-232	3.70E-01		2.00E-01				
U-233/234	2.00E+00		4.50E-01				

Table D. 13d. RGOs for the surface water of WAG5- Residential scenario

Analyte	concentration (pCi/L; mg/L)	Risk-based RGOs (pCi/L; mg/L)	HQ-based RGOs (pCi/L; mg/L)	
		Ingestion	ingestion	Dermal
High Base				
Manganese	1.60E+00		1.00E-02	
C-14	6.30E+02	5.30E+01		
Ca-45	9.90E+02	4.80E+01		
Pu-238	2.90E-01	2.20E-01		
Total Radioactive Strontium	1.60E+03	1.30E+00		
Tritium	4.00E+06	8.80E+02		
U-233/234	1.80E+01	3.00E+00		
U-238	2.90E+01	1.70E+00		
High Base Storm				
Bis(2-Ethylhexyl) Phthalate	6.00E-03	2.90E-03		
C-14	5.90E+01	5.30E+01		
Cm-243/244	3.70E-01	3.00E-01		
Pu-238	7.10E+00	2.20E-01		
Th-230	9.60E+00	3.70E+00		
Total Radioactive Strontium	8.00E+02	1.30E+00		
Tritium	2.20E+06	8.80E+02		
U-233/234	2.60E+01	3.00E+00		
U-238	4.10E+01	1.70E+00		
Impoundment				
Am-241	5.00E-01	2.00E-01		
Cm-243/244	1.60E+01	3.00E-01		
Co-60	1.50E+02	3.20E+00		
Cs-137	2.50E+04	1.70E+00		
Pu-238	3.20E-01	2.20E-01		
Pu-239/240	5.10E-01	2.10E-01		
Tc-99	4.30E+01	3.70E+01		
Total Radioactive Strontium	9.00E+04	1.40E+00		
Tritium	2.00E+04	8.80E+02		
U-232	2.20E+01	1.30E+00		
U-233/234	2.60E+02	3.00E+00		

Table D. 13d. (continued)

Analyte	concentration (pCi/L; mg/L)	Risk-based RGOs (pCi/L; mg/L)	HQ-based RGOs (pCi/L; mg/L)	
		Ingestion	ingestion	Dermal
U-238	4.80E+00	1.70E+00		
Low Base				
Manganese	2.90E+00		1.00E-02	1.00E-02
Am-241	7.80E+00	2.00E-01		
C-14	7.70E+01	5.30E+01		
Pb-212	2.10E+01	8.70E+00		
Pu-238	9.50E+00	2.20E-01		
Ra-228	1.60E+03	4.80E-01		
Total Radioactive Strontium	1.30E+03	1.30E+00		
Tritium	7.10E+05	8.80E+02		
U-233/234	5.80E+00	3.00E+00		
U-238	9.40E+00	1.70E+00		
Low Base Storm				
Manganese	3.50E-01		1.00E-02	
Bis(2-Ethylhexyl) Phthalate	1.80E-02	2.90E-03		
Am-241	4.90E-01	2.00E-01		
C-14	9.30E+01	5.30E+01		
Pu-238	9.90E+00	2.20E-01		
Total Radioactive Strontium	1.50E+03	1.30E+00		
Tritium	5.50E+06	8.80E+02		
U-233/234	6.70E+00	3.00E+00		
U-238	8.70E+00	1.70E+00		

10

11

12

APPENDIX C2

CONTENTS

ABBREVIATIONS	C2-v
LIST OF FIGURES	C2-vii
LIST OF TABLES	C2-ix
C2. BASELINE ECOLOGICAL RISK ASSESSMENT REPORT	C2-1
C2.1 ECOLOGICAL HAZARD IDENTIFICATION	C2-1
C2.1.1 Ecological Assessment Endpoints	C2-1
C2.1.1.1 Assessment endpoints	C2-1
C2.1.1.2 Measurement endpoints	C2-4
C2.1.2 Environmental Description	C2-6
C2.1.3 Sources	C2-6
C2.1.3.1 Source history	C2-6
C2.1.3.2 Source data	C2-9
C2.1.3.3 Sources of exposure	C2-9
C2.1.4 Conceptual Models	C2-10
C2.1.4.1 Current baseline state	C2-10
C2.1.4.2 Hypothetical future case	C2-11
C2.1.5 Summary of Hazard Identification	C2-12
C2.2 EXPOSURE ASSESSMENT	C2-13
C2.2.1 Characterization of Exposure Environment and Routes	C2-13
C2.2.2 Quantification of Exposure	C2-14
C2.2.2.1 Current case	C2-14
C2.2.2.2 Future case	C2-27
C2.3 EFFECTS ASSESSMENT	C2-30
C2.3.1 Conventional Toxicity Data	C2-30
C2.3.1.1 Toxicological benchmarks	C2-30
C2.3.1.2 Ecotoxicological profiles	C2-34
C2.3.2 Media Toxicity Data	C2-58
C2.3.2.1 Plant toxicity tests	C2-58
C2.3.2.2 Earthworm toxicity tests	C2-60
C2.3.2.3 <i>Ceriodaphnia</i> toxicity test	C2-60
C2.3.3 Biological Survey Data	C2-62
C2.3.3.1 Earthworm bioaccumulation survey	C2-62
C2.3.3.2 Fish	C2-64
C2.3.3.3 Benthic macroinvertebrates	C2-68
C2.4. RISK CHARACTERIZATION	C2-70
C2.4.1. Risk Characterization for Contaminant Screening	C2-70
C2.4.1.1. Risk Characterization from Contaminant Toxicity .	C2-71
C2.4.1.2 Risk Characterization from Media Toxicity Tests ..	C2-71
C2.4.1.3 Risk Characterization from Biological	
Surveys	C2-71
C2.4.1.4 Weight of Evidence	C2-71
C2.4.1.5 Uncertainties	C2-75

C2.4.1.6. Threatened and Endangered Species	C2-75
C2.4.2. Risk Characterization for Current Conditions	C2-76
C2.4.2.1. Plants	C2-76
C2.4.2.2. Soil Invertebrates	C2-83
C2.4.2.3. Soil Microorganisms and Microbial Processes	C2-86
C2.4.2.4. Vermivorous Wildlife	C2-88
C2.4.2.5. Fish	C2-92
C2.4.2.6. Benthic Macroinvertebrates	C2-96
C2.4.3. Risk Characterization for Future Conditions	C2-102
C2.4.3.1. Plants	C2-102
C2.4.3.2. Soil Invertebrates	C2-102
C2.4.3.3. Soil Microorganisms and Microbial Processes	C2-102
C2.4.3.4. Vermivorous Wildlife	C2-103
C2.4.3.5. Fish	C2-106
C2.4.3.6. Benthic Macroinvertebrates	C2-106
C2.4.4. Contribution to WAG 2 Risk	C2-106
C2.4.4.1. Plants	C2-107
C2.4.4.2. Soil Invertebrates	C2-107
C2.4.4.3. Soil Microorganisms and Microbial Processes	C2-108
C2.4.4.4. Vermivorous Wildlife	C2-108
C2.4.4.5. Fish	C2-109
C2.4.4.6. Benthic Macroinvertebrates	C2-134
C2.4.5. Uncertainties	C2-137
C2.4.5.1. Terrestrial and Wetland Plants	C2-137
C2.4.5.2. Soil Invertebrates	C2-138
C2.4.5.3. Soil Microorganisms and Microbial Processes	C2-140
C2.4.5.4. Vermivorous Wildlife	C2-140
C2.4.5.5. Fish	C2-142
C2.4.5.6. Benthic Macroinvertebrates	C2-142
C2.5. RISK-BASED REMEDIAL ACTION OBJECTIVES	C2-144
C2.5.1 Risk-based Remedial Action Objectives for Soil	C2-144
C2.5.1.1 Terrestrial plants	C2-145
C2.5.1.2 Soil invertebrates	C2-145
C2.5.1.4 Vermivorous wildlife	C2-145
C2.5.1.5 Summary	C2-148
C2.5.2 Risk-based Remedial Action Objectives for Surface Water .	C2-149
C2.5.2.1 Fish	C2-149
C2.5.2.2 Wetland plants	C2-150
C2.5.2.3 Summary	C2-151
C2.5.3 Risk-based Remedial Action Objectives for Sediment	C2-151
C2.6. SUMMARY AND RECOMMENDATIONS	C2-153
C2.6.1. Current Case	C2-154
C2.6.2. Future Case	C2-156
C2.6.3. Contributions to WAG 2 Risk	C2-156
C2.6.4. Remedial Recommendations	C2-158
REFERENCES	C2-160

ABBREVIATIONS

ANOVA	a one-way analysis of variance
ARAR	applicable or relevant and appropriate requirement
CLP PQL	Contract Laboratory Program Practical Quantitation Limit
COPC	contaminant of potential concern
ER-M	effects range medium
ER-L	effects range low
EPA	U.S. Environmental Protection Agency
FFA	Federal Facilities Agreement
HFIR	High Flux Isotope Reactor
HQ	hazard quotient
IAEA	International Atomic Energy Agency
LLW	low-level waste
LOAEL	lowest observed adverse effects level
MEK	Melton Branch kilometer
NAWQC	National Ambient Water Quality Criteria
NHF	New Hydrofracture Facility
NOAEL	no observed adverse effects level
OHF	Old Hydrofracture Facility
ORNL	Oak Ridge National Laboratory
ORR	Oak Ridge Reservation
OU	operating unit
PAH	polychlorinated aromatic hydrocarbons
PCB	polychlorinated biphenyl
PWSB	Process Waste Sludge Basin
PWTP	Process Waste Treatment Plant
RBRAO	risk-based remedial action objective
RI	remedial investigation
RH	remote handled
SQB	sediment quality benchmark
SQG	sediment quality guideline
SWMU	solid waste management unit
SWSA	solid waste storage area
T&E	threatened and endangered
TRU	transuranic
UCL	upper confidence limit
WCK	White Oak Creek kilometer
WAG	waste area grouping

LIST OF FIGURES

C2.1	WAG 5 ecological conceptual model: current baseline state	C2-199
C2.2	WAG 5 ecological conceptual model: hypothetical future state	C2-200
C2.3	Aquatic toxicity testing locations on WAG 5	C2-201
C2.4	WAG 5 earthworm sampling locations	C2-202
C2.5	Fish community density in White Oak Creek, locations 3.9, 5.1, and 6.8	C2-203
C2.6	Fish community density in White Oak Creek, locations 2.3, 2.9, and 3.4	C2-204
C2.7	Fish community density in Melton Branch, locations 0.6, 1.4, and 2.1	C2-205
C2.8	Fish and benthic macroinvertebrate communities sampling sites in White Oak Creek and Melton Branch	C2-206
C2.9	Summary of the effects of water from study sites along White Oak Creek on the survival of fish embryos in a series of medaka embryo-larval test conducted 1991–1993	C2-207
C2.10	Estimation of risk-based remedial action objectives	C2-208

LIST OF TABLES

C2.1	Parameters for estimation of exposure for vermivorous wildlife on WAG 5	C2-211
C2.2	Estimated contaminant exposure for American woodcock at the background location	C2-214
C2.3	Estimated contaminant exposure for short-tailed shrews at the background location	C2-218
C2.4	Estimated contaminant exposure and hazard assessment for American woodcock at the WW area	C2-222
C2.5	Estimated contaminant exposure and hazard assessment for short-tailed shrews at the WW area	C2-224
C2.6	Parameters used in the calculation of dose to small fish	C2-226
C2.7	Radionuclide activities at on-site and off-site surface water locations, calculated dose to small fish, and resulting hazard quotients	C2-228
C2.8	Radionuclide activities in undiluted seep water, calculated dose to small fish, and resulting hazard quotients	C2-233
C2.9	Parameters used in the calculation of dose to small invertebrates living 100% of the time within the sediment	C2-237
C2.10	Parameters used in the calculation of dose to molluscs and large benthic macroinvertebrates living 100% of the time within the sediment ..	C2-239
C2.11	Estimated contaminant exposure and hazard assessment for American woodcock at the OHF area	C2-241
C2.12	Estimated contaminant exposure and hazard assessment for short-tailed shrew at the OHF area	C2-243
C2.13	Estimated contaminant exposure and hazard assessment for American woodcock at the NHF area	C2-245
C2.14	Estimated contaminant exposure and hazard assessment for short-tailed shrew at the NHF area	C2-247
C2.15	Estimated contaminant exposure and hazard assessment for American woodcock at the SB area	C2-249

C2.16	Estimated contaminant exposure and hazard assessment for the short-tailed shrew at the SB area	C2-251
C2.17	Estimated contaminant exposure and hazard assessment for the American woodcock at the S5 area	C2-253
C2.18	Estimated contaminant exposure and hazard assessment for the short-tailed shrew at the S5 area	C2-255
C2.19	Estimated contaminant exposure and hazard assessment for the American woodcock at the TRU area	C2-257
C2.20	Estimated contaminant exposure and hazard assessment for the short-tailed shrew at the TRU area	C2-259
C2.21	Estimated NOAELs for the short-tailed shrew in WAG 5	C2-261
C2.22	Estimated NOAELs for the American woodcock in WAG 5	C2-265
C2.23	Summary of aquatic toxicological benchmarks used in this assessment	C2-267
C2.24	Descriptions of the ecotoxicological screening benchmarks for aquatic biota	C2-269
C2.25	Toxicological benchmarks for evaluating contaminants of potential concern in sediment-associated biota	C2-271
C2.26	Descriptions for the ecotoxicological screening benchmarks for benthic biota exposed to contaminated sediments	C2-272
C2.27	Characteristics of soil used in cabbage seedling tests	C2-273
C2.28	Cabbage seedling test growth results for WAG 5 soils	C2-273
C2.29	Frequency table for cabbage seed germination	C2-273
C2.30	Frequency table for morphological appearance	C2-274
C2.31	Results of 14-d earthworm test on WAG 5 soils	C2-274
C2.32	Correspondence of aquatic toxicity sampling sites to WAG 5 sampling locations	C2-274
C2.33	Results of <i>ceriodaphnia</i> toxicity tests of WAG 5 water samples during test period 1 and test period 2	C2-275
C2.34	Results of <i>ceriodaphnia</i> toxicity test of water from WAG 5 site 6	C2-275
C2.35	Summary of results of water quality analyses, WAG 5 sites, for toxicity tests conducted during Dec. 12-18, 1991	C2-276

C2.36	Summary of results of water quality analyses, WAG 5 sites, for toxicity tests conducted during Feb. 27–March 5, 1992	C2-276
C2.37	Summary of results of water quality analyses, WAG 5 site 6, for the toxicity tests conducted during April 30–May 7, 1992	C2-277
C2.38	Summary of physical and chemical properties for WAG 5 earthworm sampling locations	C2-278
C2.39	Comparison of soil from earthworm sampling locations to 2 × background values	C2-279
C2.40	Mean soil and worm contaminant concentrations for all sites from WAG 5	C2-285
C2.41	Summary results of linear regressions of earthworm contaminant concentrations on soil contaminant concentrations	C2-288
C2.42	Soil-earthworm contaminant uptake factors for earthworms from WAG 5	C2-288
C2.43	Annual production rates in White Oak Creek and Melton Branch for spring 1992 to spring 1993	C2-289
C2.44	Information provided by differential sediment quality triad responses	C2-290
C2.45	Comparison of soil concentrations at WAG 5 units to screening benchmarks for toxicity to plants, earthworms, and soil microorganisms in soil	C2-291
C2.46	Contaminants measured at concentrations greater than in background soils but for which there are no toxicity benchmarks	C2-292
C2.47	Summary of risk characterization for terrestrial plants by area	C2-295
C2.48	Comparison of seep contaminant concentrations at WAG 5 units to screening benchmarks for toxicity to plants in solutions	C2-297 ,
C2.49	Contaminants measured at concentrations greater than in background seeps but for which there are no toxicity benchmarks	C2-299
C2.50	Summary of risk characterization for wetland plants by seep	C2-302
C2.51	Summary of risk characterization for soil invertebrates by area	C2-312
C2.52	Comparison of maximum total contaminant concentrations from on-site surface water locations to aquatic benchmarks	C2-315
C2.53	Comparison of maximum dissolved metal concentrations from on-site surface water locations to aquatic benchmarks	C2-317

C2.54	On-site surface water summary of risk characterization for fish in drainages D1 and D2	C2-318
C2.55	Contaminant concentrations in sediment, benchmarks, screening values, and calculated hazard quotients	C2-319
C2.56	Radionuclide activity in sediment and calculated dose to large benthic macroinvertebrates	C2-321
C2.57	Estimated contribution of contaminants to off-site exposure of vermivorous wildlife	C2-328
C2.58	Comparison of maximum total contaminant concentrations from off-site surface water locations to aquatic benchmarks	C2-330
C2.59	Comparison of maximum dissolved metal concentrations from off-site surface water locations to aquatic benchmarks	C2-333
C2.60	Off-site surface water summary of risk characterization for fish in White Oak Creek and Melton Branch	C2-334
C2.61	Comparison of total contaminant concentrations in undiluted seep water to aquatic benchmarks	C2-337
C2.62	Comparison of dissolved metal concentrations in undiluted seep water to aquatic benchmarks	C2-345
C2.63	Off-site seep water summary of risk characterization for fish	C2-349
C2.64	Comparison of contaminant exposure estimates at sites where HQs >1 to estimated LOAELs for determination of sites requiring remediation	C2-358
C2.65	Comparison of exposure estimation using upper 95% confidence interval and maximum detected values	C2-360
C2.66	Comparison of WW soils data to RBRAOS and background values	C2-362
C2.67	Comparison of sediment concentrations to RBRAOs for the benthic macroinvertebrates	C2-363
C2.68	Summary of ecological risks identified for terrestrial endpoints	C2-364
C2.69	Summary of ecological risks identified for wetland plants	C2-366
C2.70	Summary of ecological risks identified for fish	C2-367
C2.71	Summary of ecological risks identified for benthic invertebrates	C2-367

C2. BASELINE ECOLOGICAL RISK ASSESSMENT REPORT

The purpose of this ecological risk assessment is to characterize the baseline ecological risks as far as is possible with the existing data. This baseline ecological risk assessment is structured in terms of the standard paradigm for risk assessment (NRC 1983; Risk Assessment Forum 1992). It begins with a hazard identification phase (also termed problem formulation) that defines the contaminant sources, the receiving environment, and the assessment endpoints. It follows with an analytical phase consisting of exposure assessment and effects assessment. The results of these analyses are then combined in a risk characterization.

The assessment is performed in two phases: a screening phase and a definitive phase. The screening phase is intended to reduce the list of chemicals detected on the site to a subset of chemicals that constitute a hazard that is worthy of more detailed assessment. It does this by comparing conservative point estimates of exposure concentrations to background concentrations and to ecotoxicological screening benchmarks. The definitive phase uses all available evidence to characterize the risks. It integrates the full distribution of exposure concentrations with the distribution of relevant ecotoxicological responses for the chemicals retained by the screening assessment. It combines the results of that integration with the results of toxicity testing and biological surveys in a risk characterization based on the weight of evidence. These two phases are presented in parallel in this document. For example, the screening benchmarks for the screening phase and the toxicity profiles for the definitive phase are both presented in the section on effects assessment (Sect. C2.3).

C2.1 ECOLOGICAL HAZARD IDENTIFICATION

This section discusses the attributes and selection of appropriate ecological endpoints, describes the ecological setting at operating units (OUs) within Waste Area Grouping (WAG) 5, provides information on the sources and hazards to which organisms may be exposed, and integrates this information into a conceptual model that portrays the interaction among sources and endpoints at the sites. The information provided here sets the stage for the exposure assessment section (Sect. C2.2) that follows.

C2.1.1 Ecological Assessment Endpoints

The hazard identification phase of an ecological risk assessment must identify both the assessment endpoints, which are explicit statements of the characteristics of the environment that are to be protected, and the measurement endpoints, which are quantitative summaries of a measurement or series of measurements that are related to effects on an assessment endpoint.

C2.1.1.1 Assessment endpoints

The following assessment endpoints for terrestrial risks have been selected for this assessment:

1. toxicity to plants resulting in a reduction in abundance or production,
2. toxicity to soil/litter invertebrates or processes resulting in a reduction in abundance, or function, and
3. toxicity to vermivorous wildlife resulting in a reduction in population abundance or production.

Although WAG 5 is essentially a terrestrial site with few aquatic resources, as a source OU, contaminants from WAG 5 may affect the adjacent aquatic integrator OU, WAG 2. To assess risks to aquatic biota in WAG 2 resulting from exposure to contaminants from WAG 5, two additional assessment endpoints were selected:

4. toxicity to benthic macroinvertebrate biota resulting in a reduction in species richness or abundance and
5. toxicity to fish resulting in a reduction in species richness or abundance.

These assessment endpoints are those that have been agreed are appropriate for source OUs on the Oak Ridge Reservation (ORR) by the Federal Facilities Agreement (FFA) parties (Suter et al. 1994). The criteria for selection of the entities are those recommended by the U.S. Environmental Protection Agency (EPA) (Risk Assessment Forum 1992), plus considerations of scale and practical considerations.

The appropriate properties of the entities selected by these criteria depend on the level of organization of the entity and the criteria that led to their selection.

Organism level—In general, protection of individual organisms is appropriate only for threatened and endangered species. Because none of these species occurs on or significantly utilizes WAG 5 (see Sect. B1.7.3), no organism-level properties are used for assessment endpoints.

Population level—The appropriate endpoint properties for populations of endpoint species are abundance and production.

Community level—The appropriate endpoint properties for endpoint communities are species richness and abundance. The measure of abundance will vary among communities. Because the plant communities of source OUs are largely artificial and because they are maintained for their ability to retard erosion, the abundance of the herbaceous plant community may be expressed as biomass per unit area and productivity replaces species richness as an endpoint property.

Ecosystem level—Some ecosystems such as wetlands are valued for their properties as ecosystems rather than their composition as communities. Specifically protected properties of wetlands are provision of habitat for wetland dependent species, hydrological regulation, and retention or recycling of nutrients. No other endpoint ecosystem types have been identified. However, some components of ecosystems are clearly ecologically relevant for their role in ecosystem processes, but not for their population or community properties. The soil heterotrophic community is a prominent example. Properties of the soil biota that might be endpoint properties include rates of carbon and nitrogen mineralization and rates of

transformation of nitrogen and sulfur.

Finally, the level of effects on these properties of the endpoint entities that is considered to be potentially significant is 20% as agreed by the FFA parties (Suter et al. 1994). This level is consistent with current regulatory practice. Other effects levels might be used if exceptionally important populations or communities are at risk, but that is not the case on WAG 5.

The selected endpoints are explained below.

1. The terrestrial plant community is considered to be an appropriate endpoint community because it is ecologically important, susceptible, and has a scale appropriate to the site. The ecological significance comes from the fact that the plant community is responsible for primary production. This community is susceptible because it would be directly exposed to the contaminants in the soil. Finally, the scale is appropriate because plants are immobile and because a distinct plant community exists at the site. The chosen characteristics of this endpoint are abundance and production.

2. Soil community is considered to be an appropriate endpoint because it is ecologically important, susceptible, and has a scale appropriate to the site. The primary value of this community is its functional role in decomposition and energy and nutrient cycling. The soil community is highly exposed to contaminated soil. The inherent sensitivity of soil processes to contaminants is low, but the sensitivity of particular taxa including earthworms is largely unknown. Earthworms are probably the most important soil invertebrate in promoting soil fertility (Edwards 1964). Their feeding and burrowing activities act to break down organic matter resulting in release of nutrients and to improve aeration, drainage, and aggregation of soil. Earthworms are also important components of the diets of many animals. Because of their small size and relative immobility, soil communities and earthworms can be assessed on the scale of small subunits of OUs. The chosen characteristics of this endpoint are abundance and function.

3. Vermivorous wildlife are considered to be an appropriate endpoint because they are susceptible, and, in the case of shrews, have a scale appropriate to the site. Because vermivorous wildlife consume large volumes of invertebrates, they are highly exposed and susceptible to contaminants bioaccumulated by soil invertebrates. In addition, shrews, amphibians, and reptiles burrow and are in close physical contact with soil and may take up contaminants directly through ingestion or dermal contact. These species, however, are not known to play any particularly significant role in the ecosystems that they inhabit. Because many vermivores have limited home ranges the OU is an appropriate scale to assess risks to their populations. The chosen characteristics of the endpoint are abundance or production of the local populations of American woodcock (*Scolopax minor*) and short-tailed shrew (*Blarina brevicauda*). Although the woodcock population does not have a scale appropriate to the site and would be included in the reservation-wide assessment under the new strategy for ecological risk assessment, they are included here as agreed earlier by the FFA parties (Ashwood et al. 1994).

4. The benthic invertebrate community is considered to be an appropriate endpoint community because they are highly susceptible and have a scale appropriate to the downstream aquatic integrator OU (WAG 2). The high susceptibility is due to the association of these organisms with the sediment, which is the repository of most of the contaminants of

potential concern. In addition, the insects and crustaceans that dominate this community are sensitive to a variety of contaminants. Because these organisms are sedentary, their scale is highly appropriate to the scale of the site. The chosen characteristics of the endpoint are species richness and abundance of the community.

5. The fish community is considered to be an appropriate endpoint community because it is ecologically important, susceptible, and has a scale appropriate to the downstream aquatic integrator OU (WAG 2). The ecological significance comes from the fact that much of the energy flow passes through fishes, and fishes are a major nutrient reservoir in those systems. The chosen characteristics of the endpoint are species richness and abundance of the community.

Two standard assessment endpoints for the ORR are not used here (Suter et al. 1994). First, the endpoint for protection of threatened and endangered (T&E) species was not used because the T&E species survey did not reveal any occupation or use of the site by such species. Second, there is not a specific endpoint for protection of wetlands. Under the baseline scenario, the only hazard to wetlands is that posed by the contaminants. These are covered by the other endpoints. In particular, the concentrations of chemicals in seep waters are compared with concentrations causing phytotoxic effects in solution cultures as a means of estimating effects on the plant communities of wetlands and to concentrations causing effects on aquatic organisms. The special protection of wetlands becomes a distinct issue in the feasibility study where destruction of wetlands by remedial actions must be considered.

The exclusion of taxa or communities as assessment endpoints does not mean that they will be unprotected. Rather, it is assumed that protection of the most important or susceptible taxa will result in protection of all taxa. In addition, toxicity data concerning some excluded taxa are included in the screening benchmarks, and data concerning toxic effects on nonendpoint taxa are used as appropriate to help estimate and interpret direct and indirect effects on endpoint species. Finally, the National Ambient Water Quality Criteria, which are incorporated as screening benchmarks and as applicable or relevant and appropriate regulation, include effects on amphibians and other aquatic species to the extent that they are available.

C2.1.1.2 Measurement endpoints

Three basic types of effects data are potentially available to serve as measurement endpoints: results of biological surveys, toxicity tests performed on media from WAG 5, and toxicity test endpoints for chemicals found in WAG 5. Measurement endpoints will be presented below for each assessment endpoint.

Terrestrial plants

Biological survey data—Qualitative only.

Media toxicity data—Cabbage seedling tests on soil from WAG-5. These tests measure germination and growth and are assumed represent toxicity to species at the site.

Single chemical toxicity data—EC20s for growth or production of vascular plants or equivalent chronic toxicity thresholds for contaminants of concern in soil. These test endpoints are assumed to correspond to the assessment endpoint for this community. That is, the sensitivity distribution of the test species is assumed to approximate the distribution of WAG 5 species, and exceedence of the test endpoints is assumed to correspond to 20% reductions in population abundance or productivity, with some

uncertainty.

Soil/Litter invertebrates and processes

Biological survey data—Abundance of earthworms from six locations in and around WAG 5. This measurement endpoint is assumed to be a direct estimate of the assessment endpoint for this community.

Media toxicity data—Earthworm survival tests on soil from WAG 5. These tests measure 14-day survival and are assumed to represent toxicity to species at the site.

Single chemical toxicity data—EC20s for growth or production of soil invertebrates or processes or equivalent chronic toxicity thresholds for contaminants of concern in soil. These test endpoints are assumed to correspond to the assessment endpoint for this community. That is, the sensitivity distribution of the test species is assumed to approximate the distribution of WAG 5 species, and exceedence of the test endpoints is assumed to correspond to 20% reductions in population abundance or productivity with some uncertainty.

Terrestrial wildlife

Biological survey data—None.

Media toxicity data—None.

Single chemical toxicity data—chronic toxicity thresholds for contaminants of concern in birds and mammals with greater weight given to data from long-term feeding studies with wildlife species. Preference was given to tests that included reproductive endpoints. These test endpoints are assumed to correspond to the assessment endpoint after allometric scaling for the endpoint species, American woodcock and short-tailed shrew.

Benthic invertebrates

Biological survey data—Species richness and abundance of benthic invertebrates reported from WAG 2. These measurement endpoints are assumed to be direct estimates of the assessment endpoint for this community.

Media toxicity data—None.

Single chemical toxicity data—Toxicity data were compiled from a variety of sources. For inorganic contaminants, the primary source of data was co-occurrence data compiled by National Oceanic and Atmospheric Administration. For organic contaminants, chronic toxicity thresholds expressed as chronic values were used or freshwater invertebrates. These test endpoints correspond to the assessment endpoint for this community. That is, the sensitivity distribution of the test species is assumed to approximate the distribution of species exposed to sediments from WAG 5, and exceedence of the chronic values is assumed to correspond to 20% reduction in population abundance or greater, with some uncertainty.

Fishes

Biological survey data—The species richness and abundance of fishes from WAG 2. These measurement endpoints are assumed to be direct estimates of the assessment endpoint for this community.

Media toxicity data—toxicity detected in the *Ceriodaphnia dubia* 7-day survival and reproduction tests using water from seeps and drainages within and around WAG 5 are taken to be indicative of toxicity to fish as well as invertebrates (EPA 1985a).

Single chemical toxicity data—Chronic toxicity thresholds for freshwater fish expressed as chronic EC20s or chronic values. These test endpoints correspond to the assessment endpoint for this community. That is, the sensitivity distribution of the test species is

assumed to approximate the distribution of species exposed to waters from WAG 5, and exceedence of the chronic values and EC20s are assumed to correspond to 20% reductions in abundance or greater, with some uncertainty.

C2.1.2 Environmental Description

WAG 5 is approximately 32 ha in size, of which ~ 20 ha is composed of 13 solid waste management units (SWMUs). The SWMUs are primarily covered with grass, concrete, gravel, or industrial structures. For the purposes of this ecological risk assessment, WAG 5 has been divided into six units: WAG 5 Wide, Solid Waste Storage Area (SWSA) 5, Transuranic (TRU) Waste Storage Area, Old Hydrofracture Facility (OHF), New Hydrofracture Facilities (NHF), and the Process Waste Sludge Basin (PWSB) (Fig. B1.27). Detailed descriptions of the environment and habitats in each of these areas are presented in Sect. B1.7.1.

The definition of areas to be assessed in the ecological risk assessment differs from that employed elsewhere in this RI. While study areas for the human health risk assessment and other tasks in this RI are defined primarily by hydrology (surface water drainage and ground water divides; see Vol. 1, Sect. 3.1), areas assessed in the ecological risk assessment are defined according to available habitat and area history. As stated above, habitat on the five of the six areas (SWSA 5, TRU, OHF, NHF, and PWSB) consists of lawns, pavement, or industrial structures. At each of these locations, wastes were disposed or stored or other waste management-related activities occurred. In contrast, the sixth area (WAG 5 Wide) is largely undisturbed (waste related activities were minimal). As a result, the habitat is primarily deciduous forest. Because the presence of biota in an area (and therefore exposure to and risks from contaminants) is dependant on past use of a site and available habitat, this approach was determined to be most appropriate for the ecological endpoints.

C2.1.3 Sources

C2.1.3.1 Source history

The approach of the source history section is to discuss past waste disposal activities and possible contaminants found in each area within WAG 5. The objective of this section is to indicate the possible sources of contamination in each area which could contribute to ecological exposure and risk. Buildings within WAG 5 which were utilized for the storage and processing of waste are not addressed in this section, unless discharge or leakage of contaminants into the environment have been documented. For greater detail on historical releases, waste processes, and contaminant inventories see Sect. B2.

Transuranic Waste Storage Area

Since October 1970, TRU waste (i.e., gloves, wipes, equipment, sludges, etc.) has been stored in SWSA 5 North in stainless steel drums, mild steel boxes, concrete casks, or stainless steel lined wells. Most of these waste containers are stored in the buildings within the TRU waste storage area. However, the Remote Handled- (RH-) TRU Retrievable Storage Area, located west of Building 7834, was used for storing concrete casks and metal-boxed wastes in 10-ft deep trenches. These trenches were used from 1970 through 1979. A total of 23 trenches enclosing 151 casks (4 trenches had no records) contained waste contaminated with Am-241, Cf-252, Cm-244, Cs-137, Pu-239, Pu-241, Sr-90, U-233, and U-235 (Bechtel 1988).

RH-TRU waste was disposed of in trench and auger hole burial grounds to the east and west of Building 7823. Small TRU-contaminated waste packages with high external gamma exposure rates have been placed in steel or brass capsules in stainless steel lined auger holes located at the north-west corner of the TRU Waste Storage Area. Volumes and activities of isotopes in waste buried in trenches and buildings are unknown (Bechtel 1988).

Process Waste Sludge Basin

The basin was used for the storage of sludge produced by the Oak Ridge National Laboratory (ORNL) Process Waste Treatment Plant (PWTP) from 1976 to 1981. The sludge remained in the basin while supernatant was pumped back to the PWTP. Sludge constituents have been identified as ferrous sulfate, ferric hydroxide, and fission products. As much as 50 Ci may be contained in the 4 ft layer of sediment (Bechtel 1988). A radiological analysis of the sludge showed cobalt-60 concentrations of $8.9 \mu\text{Ci/L}$ (Francis and Sealand 1987 as cited by Bechtel 1992). The basin has a polyvinyl chloride liner over the compacted clay bottom, suggesting that seepage from the basin is unlikely. However, there has been no verification of the integrity of the liner or the clay layer (Bechtel 1988).

SWSA 5

SWSA 5 includes trenches, auger holes, an undefined trench area, and a dump area (Fig. B1.27). SWSA 5 has been used for routine disposal of low level waste (LLW) and nonretrievable TRU waste. During operations of SWSA 5, waste accepted for disposal included poorly characterized solid LLW wastes generated by the ORNL Main Plant facilities from 1959 to 1973, and wastes from approximately 50 different agencies from 1955 to 1963, when ORNL was designated as the Southern Regional Burial Ground by the Atomic Energy Commission. Existing records indicate $3.0 \times 10^6 \text{ ft}^3$ of waste containing approximately 200,000 Ci of radioactivity have been buried in SWSA 5. The buried waste was primarily solid LLW, but before the designation of the northern portion as the TRU Waste Storage Area in 1970, an unknown quantity of TRU wastes were also buried in SWSA 5. Excluding the undefined trench and dump area, there are approximately 230 trenches within SWSA 5. The trenches are 10 to 15 ft deep, 10 to 12 ft wide, and 40 to 500 ft long (Bechtel 1988).

Auger holes were utilized for disposal of high activity and fissile waste. The "undefined area" was used for disposal of segregated alpha-contaminated waste which was buried in trenches and covered with concrete. All records of this undefined area, and most for the auger holes, were destroyed by a fire. The dump area was reported to be a pit dug 2 ft above the groundwater table and filled with alpha-beta contaminated soil from the White Wing Scrap Yard and unidentified pieces of equipment. An aerial radiological study identified a cobalt-60 source near the dump area ravine. Contaminants in containerized wastes include: Sr-90, Cs-137, Co-60, Cm-244, Pu-238, Ru-106, and H-3; while Sr-90 and H-3 are primarily found in the groundwater. Contaminants and quantities in noncontainerized waste are unknown (Bechtel 1988).

Drainage D-2 drains surface water and contaminants from the burial grounds within SWSA 5 to Melton Branch. Seeps are also found in the southern and western areas of SWSA 5. Tritium, strontium, gross alpha, and gross beta have historically been found in surface water from these seeps (Miller 1993). Sources of contaminants in the surface water (i.e., drainage D-2 and seeps) may include the trenches, auger holes, "undefined area", and dump area.

Old Hydrofracture Facility

The OHF was constructed in 1963. Between 1964 and 1979, the OHF was used for the permanent disposal of liquid radioactive waste in low permeability shale formations at well bore depths between 780 and 950 ft. The grout mixture was composed of cement, special clays, and radioactive liquid or sludge waste. The OHF impoundment was used as an emergency storage basin for grout during the hydrofracture operation. In 1965 and 1977, pump system malfunctions caused unknown quantities of radioactive grout to be diverted to the impoundment. In the winter of 1984-85, the impoundment received drilling fluid and drill cuttings from core borings that penetrated radioactive grout sheets underlying the impoundment. Approximately 30 ft³ of sediment within the impoundment was received from these bore corings. Historical data indicate that sediment contaminants include Sr-90, Cs-134, Cs-137, Co-60, inorganics, and polychlorinated biphenyls (PCBs). The surface water contains phenols, Endrin, Methoxychlor, and Toxaphene in addition to the above contaminants (Bechtel 1988).

The T-4 waste pit is known to be contaminated with grout containing Sr-90, Cs-137, Co-60, Pu-239, Pu-238, Am-241, and Cm-244 from experimental injections. This pit is made up of three individual concrete cells that have the potential for leaking contaminated material to the surrounding environment (Bechtel 1988).

OHF Waste Storage Tanks contained liquid waste which, during operations, was to be blended with grout for hydrofracture injections. The OHF was discontinued in 1980, and all tanks are considered inactive. Soil and water contamination (gamma and beta, respectively) have been reported outside of the tanks due to possible leakage over the years (Bechtel 1988).

An OHF observation well, located in the southern part of the OHF, leaked in 1968 releasing 0.7 Ci of Sr-90 to Melton Branch. A 8700 L waste slurry was also released near building 7852 in 1977. The waste slurry contained Sr-90, Cs-137, Ru-106, Co-60, Pu, U, TRU isotopes, and various rare earth elements. Many underground pipelines and buried conduits, connecting buildings, tanks, bins, and pits throughout the OHF, are assumed to be contaminated with fixed and removable radionuclides (Bechtel 1988).

New Hydrofracture Facility

Following closure of the OHF in 1979, the NHF was constructed and used to inject radioactive waste from June 1982 through January 1984. LLW/TRU waste sludges from WAG 1 were stored in the LLW Concentrate Storage Tanks. Liquid and sludge (unknown contaminants and volumes) are stored in the Emergency Waste Storage Tank and Pilot Sluicing Tank. Bulk solid storage tanks, located east of Building 7860 and next to blending tanks, are believed to be uncontaminated (Bechtel 1988).

WAG 5 Wide

Surface water and contaminants in drainage D-1 flows southwestward into White Oak Creek. Historical data indicates that some areas of drainage D-1 have high gross alpha and gross beta contamination (Morrisey et al. 1994) and high concentrations of tritium during storm flow (Bechtel 1993). Potential sources of contaminants are from the trenches and "classified burial ground" found in the TRU Waste Storage Area. Additional sources include

contaminants from waste buried in the trenches and auger holes at the northern area of SWSA 5 South, and the Old Landfill (SWMU 5.14), which straddles the boundary of the WAG 5 Wide and SWSA 5 areas (see Fig. A1.1). Contaminants are transported in surface and groundwater from the sources downslope to drainage D-1.

Existing data indicate that groundwater flows from recharge areas at higher elevations to discharge areas along surface water drainages in and along the boundary of WAG 5. (Bechtel 1992). Moore (1988) concludes that 90 to 95 % of all groundwater flows through an intermittently saturated stormflow zone that discharges to seeps and streams. Solomon et al. (1989) found that more than 50 % of contaminants were transported in the stormflow zone from SWSA 5 to adjacent streams (e.g., Melton Branch) during both high- and low-flow conditions.

C2.1.3.2 Source data

Data for this assessment were collected by Bechtel National Inc. during 1991 through 1994. The investigation was conducted to determine the nature and extent of contamination within the boundaries of WAG 5, to assess potential for off-site migration of contaminants, and to evaluate the risks to human health and the environment from exposure to the contaminants.

Abiotic data used for the ecological risk assessment included: contaminant concentrations in soil from all six areas; sediment from drainages D-1 and D-2, OHF impoundment, and the Process Waste Sludge Basin; and surface water from OHF impoundment, seeps, and drainages D-1 and D-2 during four different flow regimes. Biological data included: media toxicity tests (earthworm, plant, and *Ceriodaphnia* toxicity tests) and contaminant accumulation in earthworms at six different locations in the SWSA 5 and WAG 5 Wide areas.

Contaminants tested for and detected in abiotic media (soil, sediment, surface water) are reported in Table 1a of the Human Health Risk Assessment (Sect. C1). Background data used for comparison of soil, sediment, and surface water were the same as those used in the Human Health Risk Assessment and are reported in Tables 2a, 2b, and 2d of Sect. C1.

C2.1.3.3 Sources of exposure

Contaminated soil may be a source of exposure to the plant, soil heterotroph, and wildlife communities found within the WAG 5 boundary. Contaminants in the surface soil may be taken up by plants and soil microbes. Soil heterotrophs and wildlife may be directly exposed to contaminants in the soil through dermal contact or ingestion.

Surface water within drainages D-1 and D-2 may be a source of exposure to fish, benthic macroinvertebrates, plants, and terrestrial wildlife communities. Contaminated water may be respired by the fish and benthic macroinvertebrates, or ingested by local and transient mammals and birds. Surface water from seeps may be a source of exposure to plants, while seeps and OHF impoundment may be a source of exposure to local and transient wildlife communities. Contaminants in surface water flowing from drainages D-1 and D-2 to White Oak Creek and Melton Branch, respectively, are sources of exposure to benthic macroinvertebrate and fish communities within WAG 2.

Contaminated sediment within drainages D-1 and D-2 may be a source of exposure for

the fish and benthic macroinvertebrate communities within the tributaries. Sediment from the tributaries may also be a source of exposure within WAG 2 due to sediment transport into White Oak Creek and Melton Branch during high flow or storm flow conditions. Sediments containing contaminants may be ingested by fish and invertebrates. Interstitial water, which may be in equilibrium with sediment contaminants, may be respired by benthic macroinvertebrates.

Invertebrates may be a source of exposure to vermivores/insectivores. Annelids and other invertebrates consuming contaminated soil and plant material may accumulate contaminants and then be consumed by shrews or other vermivores.

C2.1.4 Conceptual Models

The ecological conceptual model graphically represents the relationships between the contaminant sources and the endpoint receptors. It integrates the information in the other subsections of the hazard identification and presents them graphically. It is not intended to show all of the possible sources, routes of transport, modes of exposure, or effects. Rather, it includes the only identified Comprehensive Environmental Response, Compensation, and Liability Act source, the receptors that are designated as assessment endpoint species or communities, and the major routes that result in exposure to contaminants from WAG 5. This section presents ecological conceptual models for two baseline cases, the current state and a hypothetical future state in which the site has been abandoned and reverts to forest through natural succession.

C2.1.4.1 Current baseline state

Currently WAG 5 consists predominantly of a mowed fescue lawn beneath which are buried waste materials (i.e., SWSA 5). There are also industrial facilities and fringing wooded areas along the border with the integrator WAG that includes the White Oak Creek, Melton Branch, and Melton Branch Tributary Floodplains (WAG 2) and along two ephemeral drainages that divide the waste disposal areas. Movement of contaminants from the wastes has resulted in contamination of surface soil, ground water, and storm drainage (Fig. C2.1).

The contaminants in water move into WAG 2 through runoff, seeps, and springs, resulting in exposure to fish and benthic invertebrates in WAG 2 (Fig. C2.1). The contribution of toxicity from these sources to the aquatic communities of WAG 2 will be assessed for WAG 5, but the full significance of these contributions will be apparent only when the risk assessments for WAG 2 reveal the total effects of all inputs. That is, aqueous emissions from WAG 5 may be insignificant alone but may contribute to significant effects of the integrated DOE releases.

Contaminants in soil are available for uptake by plants and soil invertebrates. There is some use of the site by large mobile species such as whitetail deer and wild turkeys but because these organisms cannot be clearly associated with the site and they may be exposed to multiple WAGs, risks to such species will be assessed as part of the reservation-wide assessment. Small mammal abundance in the contaminated grasslands is low because mowed fescue lawns provide poor habitat. Talmage and Walton (1991) were able to trap significant numbers of small mammals in the wooded and brushy areas surrounding WAG 4 (a site similar and near to WAG 5) but not on the lawns of the burial ground. Because small mammals could not be sampled in sufficient numbers to characterize the distribution of

exposure on the site, they are not included. Similarly, small birds make relatively little use of the site due to the lack of cover and nesting sites, and there is not a population of WAG 5 associated birds that could be sampled and assessed. Therefore, the terrestrial portion of the ecological conceptual model focuses on the proximate receptors which can be associated with the site, plants and soil invertebrates.

The fringing wooded areas and wooded areas along the drainages (i.e., the WAG 5 Wide area) are logically part of the integrator OU, WAG 2, rather than the source OU, WAG 5. Because they are secondarily contaminated rather than being primary sources of contaminants, they would not be subject to source control remedial actions like the rest of WAG 5. Because these wooded areas do receive some leachate from the sources in WAG 5, they are conceptually part of the integrator OU, WAG 2, but are in WAG 5 by administrative happenstance. Although they constitute good habitat, they are not sufficiently large to support distinct populations of plants or vertebrate wildlife. However, if distinct contaminated areas are identified in the woodlands on WAG 5, they will be assessed using the conceptual model for hypothetical future state of WAG 5, which is discussed below.

C2.1.4.2 Hypothetical future case

If the U.S. government ceased to exist or abrogated responsibility for the Oak Ridge Reservation, and if no other governmental entity assumed responsibility, and if no agricultural, residential, or industrial development occurred on the site, WAG 5 would revert to mixed deciduous forest. This is the hypothetical future baseline case for the ecological risk assessment (Fig. C2.2).

The conceptual model for this case is more complex because the habitat quality of the site would be greatly improved relative to the current case. All of the routes in the current case would continue to operate, and the route to the aquatic communities in WAG 2 would be substantially unchanged (greater transpiration would decrease aqueous flow). However, in addition to uptake of contaminants from surface soil, deep-rooted trees could take up contaminants from shallow ground water. Contaminants taken up in this manner and translocated to the above-ground parts would enter the litter layer and surface soil thereby creating a route from ground water to surface soil. Due to improved habitat quality provided by increased vegetation cover, the site would be occupied by shrews and ground feeding birds that would consume soil and litter invertebrates. These species are expected to be highly exposed to contaminants in soil that bioaccumulate through food, and are likely to be among the most susceptible wildlife species.

In forests, herbivores (which are predominantly insects) will receive exposure only through contaminants in plants. Therefore, their contaminant exposure would be lower than soil/litter invertebrates, which receive exposure from both the litter and soil. In East Tennessee forests, tree-canopy and bark-foraging birds are the primary consumer of herbivorous insects. These birds would have lower exposures than litter foragers (e.g., shrews, ground-feeding birds) because their food would be less contaminated and they would experience less incidental consumption of soil so they should not be particularly susceptible. Similarly, omnivores such as *Peromyscus* are not exceptionally susceptible. Vertebrate forest predators such as bobcats and broadwinged hawks could not be particularly associated with the site because they have large home ranges. In addition, contaminated prey (from this site) would comprise only a portion of their diet, thus limiting their exposure. Risks to these wide-ranging species must be assessed at a larger spatial scale (i.e., reservation wide).

C2.1.5 Summary of Hazard Identification

This ecological risk assessment evaluates the hazard that WAG 5 contaminants may pose to seven endpoints: terrestrial plants, soil invertebrates, soil microbes and microbial processes, vermivorous wildlife (i.e., short-tailed shrew and American woodcock), wetland plants, fish, and benthic invertebrates. Risks to each terrestrial endpoint are assessed for each of six specific areas of WAG 5; risks to each aquatic endpoint (wetland plants, fish, and benthic invertebrates) are assessed for each of three drainages and 15 seeps associated with WAG 5. In addition to evaluating risks that WAG 5 presents in its present condition, risks to all endpoints are assessed for a hypothetical future case in which control and management of the site ceases, succession occurs and a deciduous forest becomes established. Finally, the potential contribution that contaminants in WAG 5 may make to off-site (i.e., WAG 2) risks in two streams and their floodplains is assessed for each endpoint.

C2.2 EXPOSURE ASSESSMENT

This section describes the modes of exposure that occur on the operable unit, the ways in which exposure is estimated, and the available exposure data for ecological risk assessment. It is organized in terms of the endpoints for which exposure must be estimated (wildlife, fish, benthic invertebrates, soil invertebrates, and plants) and the types of exposures associated with the different lines of evidence (media analyses, body burden analyses, media toxicity tests, and biological surveys). This introductory section addresses issues that are common to all endpoints.

Estimation of exposure to measured contaminant concentrations requires that the data from multiple measurements distributed over space and time be reduced to a single exposure value to be used in the screening calculations. There is no guidance from regulatory agencies on how this should be done. Therefore, we have selected procedures based on the guidance for human health risk assessment and on logic, as explained below. The guidance for human health risk assessment at Comprehensive Environmental Response, Compensation, and Liability Act sites calls for assessment of reasonable maximally exposed individuals.

Plants, soil invertebrates, and sediment-exposed invertebrates—These relatively immobile organisms do not integrate their exposures over space like wildlife or humans. Rather, they are exposed to contaminant concentrations at a single location. Therefore, the reasonable maximally exposed individual is the one completing its life cycle in the most contaminated location. That exposure is estimated by the maximum observed concentration.

Wildlife—Because wildlife are exposed to a variety of sources on a site including food, surface water, and soil, and because they are mobile and use various portions of the site, they integrate contamination in both space and time. Therefore, the upper 95% confidence bound was determined to be the most appropriate exposure summarization value.

Fish and water-exposed invertebrates—Fish and invertebrates in small stream segments like White Oak Creek or Melton Branch do not spatially integrate the exposure environment like wildlife. However, unlike sedentary organisms in soils or sediments, they are not exposed to a relatively constant concentration. Rather, they average their exposure over time as the concentrations in water change with changes in leaching or in dilution. Therefore, we use the upper 95th percentile on the estimate of the mean (i.e., the upper 95% confidence bound) which can be thought of as a reasonably conservative estimate of the time-averaged exposure.

Note that these discussions of exposure values for individuals do not negate the definitions of endpoints in terms of populations and communities (Sect. C2.1.1). These values are used in the calculation of hazard quotients in the screening portion of the assessments. The actual characterization of risks in Sect. C2.4 will consider the complete distributions of exposures when estimating risks to the endpoint populations and communities.

C2.2.1 Characterization of Exposure Environment and Routes

The primary contaminant exposure routes for each assessment endpoint are listed below.

Plants—The main exposure route for plants is uptake of contaminants from the soil through the roots. This may occur in a passive mode as the plant takes up water for respiration or by active uptake mechanisms. Volatile organic contaminants in the soil may

potentially enter the plant through leaf stomata or the plant cuticle. Another potential route of exposure is through association of contaminants with airborne soil particles (dust). The contaminants may become solubilized and enter the plant.

Soil/litter invertebrates and processes—The main exposure routes for earthworms are uptake through the outer cuticle and ingestion of soil during feeding. Contaminants in soil solution are in contact with and may pass through the cuticle of the earthworm. Worms may also ingest large amounts of soil during feeding so that contaminants come in contact with and may be absorbed by the earthworm gut. Volatile organic compounds in soil air may be in contact with and taken up by earthworms. The main exposure route for soil heterotrophic microbes is uptake through the outer cell membrane of soil pore water containing contaminants.

Wildlife—Potential routes of exposure for terrestrial wildlife endpoint species include ingestion of food (either plant or animal) and surface water, and inhalation of contaminated air or particles. In addition, some species may ingest soil incidentally while foraging or purposefully to meet nutrient needs. The total exposure experienced by terrestrial wildlife is represented by the sum of the exposures from each individual source (e.g., food, water, air).

Fish—The primary exposure route for fish is respiration of contaminated water. Fish may also receive direct exposure through dermal absorption. Indirect exposure occurs through the consumption of contaminated fish and macroinvertebrates.

Benthic macroinvertebrates—The primary route of exposure for benthic macroinvertebrates is absorption and respiration of sediment pore water. Another direct exposure pathway is through ingestion of contaminated sediment. Ingestion of contaminated food is an indirect exposure pathway.

C2.2.2 Quantification of Exposure

C2.2.2.1 Current case

C2.2.2.1.1 Plants

Terrestrial plants. Vegetation growing in all areas of WAG 5 are exposed to contaminants in the soil. Concentrations of analytes in the soil derived from double acid-extractions (nitric and hydrochloric) generally represent the total potential reservoir of elements and compounds, not that to which the plants are exposed at any one time. Some metal elements are more readily available for uptake by plants than others, depending on the solubility of the source compound, and interactions with soil constituents (organic matter and clay) and with other contaminants. Organic contaminants may interact strongly with soil organic matter and therefore be of limited availability for plant uptake.

An accurate quantitative analysis of the exposure of plants to the inorganic and organic contaminants in the soils of WAG 5 would require information about important soil parameters (e.g., types and quantities of clay and organic components, pH, moisture status) and characteristics of the contaminant compounds (e.g., water solubility, and lipid solubility in the case of organic compounds). For the sake of the assessment, we assume that measured soil concentrations are estimates of exposure equivalent to soil concentrations causing toxic effects in laboratory studies. For naturally occurring elements, this assumption may

significantly overestimate exposure.

Contaminants will have distinctive vertical distributions in soil that reflect interactions between the soil and the contaminant as controlled by the chemical and physical nature of the soil and the quantity and chemical nature of the contaminant. The exposure of plant roots to a contaminant in the soil will depend on these abiotic factors and the growth characteristics of individual plants, such as rooting depth and density. In the absence of data on root distribution, it is assumed that the plants are rooted entirely in the zone from which the soil was sampled for analysis (i.e., the top 15 cm), and therefore, all plants are relying on that zone for their immediate water and nutrient requirements. This is a reasonable assumption given the typical rooting pattern of plants.

There are two other routes which we have no data to address. These are exposure to volatile organic compounds in the air above and in the soil, and contaminants in dust particles deposited on above-ground plant parts. These routes are assumed to contribute negligibly to plant exposure on WAG 5.

The toxicity of contaminants in the soils to cabbage seedlings was evaluated by growing plants from seed for 14 d in soils of WAG 5. A 14 d exposure approximates a subchronic on-site exposure. This test assesses the effects of mixed site contaminants on seed germination and growth (root extension) cabbage, the plant species used as a model for plants at WAG 5. A detailed discussion of the application and results of these tests are presented in Sect. C2.3.2.1.

Wetland plants. Plants growing in seep areas are exposed to contaminants in the water. Although the discharge in many of these seeps is seasonal, we will make the conservative assumption that plants growing at these locations are exposed to contaminants in the water throughout the year. We also make the assumption that the entire root systems of plants growing in seep areas are exposed to contaminants in the seep drainage, and that this is the only significant source of contaminants for the plants.

Total recoverable concentrations of inorganic and organic contaminants were measured in unfiltered samples of seep drainage at WAG 5. Concentrations of dissolved contaminants were measured in WAG 5 seep drainage but not in background seep samples. Data from the unfiltered samples were used for the screening. Information from filtered samples was introduced in the risk characterization phase if it served to clarify the degree of risk posed to plants by contaminants in the seep drainage.

C2.2.2.1.2 Soil invertebrates

Earthworms are known to take up many inorganic and organic soil contaminants. Availability of contaminants for uptake from the soil is controlled by soil characteristics, however, van Gestel (1992) concludes that, with the exception of extremes in pH, it is not possible presently to predict metal availability on the basis of soil variables. Availability of contaminants from plant litter in varying degrees of decomposition is also complex and poorly understood. The feeding and burrowing habits of earthworms determine their exposure to chemicals in soil and litter. Geophagus organisms (those taking in large amounts of soil during feeding on well-decomposed organic material) and those living on or near the surface may be more exposed to organic chemicals than worms feeding on litter pulled down into burrows in the subsoil (Curl et al. 1987). Earthworms may also be exposed to contaminants by dermal

contact with soil and pore water. It is not possible or necessary to distinguish and quantify the exposure to earthworms by way of these two routes. Another possible route for which we have no data is exposure to volatile organic compounds in the soil air. Exposure through this pathway is assumed to be negligible.

It is assumed that the earthworms are spending their entire life span in soil with contaminant levels represented by those in the soils sampled for analyses (Sect. C2.4.2.2). These concentrations will be used to assess potential negative impacts of contaminated soils on earthworm populations.

Earthworms in the vicinity of SWSA 5 were sampled for chemical analysis as described in Sect. C2.3.3.1. A comparison of the numbers of earthworms retrieved during a defined sampling period at the contaminated and reference sites gives an indication of the effects of contaminants on earthworm populations in this portion of WAG 5. The exposure of these worms is assumed to be represented by analyses of soils collected at the sites where the worms were sampled.

The toxic effects of soil contaminants on growth and reproduction of earthworms was evaluated by rearing *Eisenia foetida* for 14 d in soils of WAG 5. A 14 d test duration approximates an acute on-site exposure. This test assesses the effects of mixed site contaminants on growth (mass gain) and survival of *E. foetida*, the earthworm used as a model for soil invertebrates at WAG 5. A detailed discussion of the application and results of this test are presented in Sect. C2.3.2.2.

Exposure estimation for radionuclide contaminants

Radionuclide dose rate estimates for earthworms was calculated using methodology adapted from Blaylock et al. (1993). Estimation of radionuclide exposure for earthworms is similar to that for fish (see Sect. C2.2.2.1.5), except earthworms are immersed in soil rather than water. In addition, soil-earthworm uptake factors, necessary to estimate body burdens, were not available for most radionuclides. Because soil-earthworm bioconcentration factors for metals are generally less than one, to be conservative, body burdens were assumed to be equivalent to soil concentrations. Because exposure from water was very small relative to that from soil, all dose estimates are based solely on exposure from soil. Assumptions used to estimate radionuclide doses to earthworms are as follows:

- earthworms are underground 100% of the time;
- exposure to alpha and beta radiation is strictly internal;
- radionuclide body burdens (concentrations) for earthworms are equivalent to the concentrations found in soil; and
- all radionuclides are equally distributed throughout the bodies of earthworms.

Using the assumptions described above, alpha, beta, and gamma doses (in uGy/h) for earthworms were estimated for each radionuclide observed in each area. Total radionuclide doses (sum of alpha, beta, and gamma for all radionuclides) for earthworms in each of the six areas are as follows:

Area	Earthworm
WAG 5 Wide	0.643 uGy/h
OHF	8.40 uGy/h
NHF	0.069 uGy/h
PWSB	1.2 uGy/h
SWSA 5	5750 uGy/h
TRU	0.096 uGy/h

C2.2.2.1.3 Soil microorganisms and microbial processes

The same abiotic soil and chemical factors considered in the quantification of exposure of plants and earthworms to contaminants are applicable to the quantification of exposure of soil microbes and microbial processes to contaminants in the soils of WAG 5. Microorganisms are exposed to contaminants dissolved in soil pore water. However, data on contaminant concentrations in soil pore water are not available. Another route for which we have no data is exposure to volatile organic compounds in the soil air.

For the sake of the assessment, we assume that all phases in the soil are in equilibrium, and that the partitioning coefficients are approximately constant. This assumption permits us to use the measured soil concentrations as estimates of exposure for comparison to soil concentrations causing toxic effects.

It is assumed that the microbes are spending their entire life span in soil with contaminant levels represented by those in the soils sampled for analyses. These concentrations will be used to assess potential negative impacts of contaminated soils on microorganisms and microbial processes.

C2.2.2.1.4 Vermivorous wildlife

As outlined in the current-case conceptual model (see Sect. C2.1.4.1), the industrial and waste burial areas of WAG 5 (e.g., the OHF, NHF, PWSB, SWSA 5, and TRU areas), are assumed to provide little habitat for vermivorous wildlife because they consist of paved or graveled surfaces, buildings, or mown lawns. At the present time, suitable habitat for vermivorous wildlife is present only in the wooded areas surrounding the industrial and waste burial areas (e.g., the WAG 5 Wide area). In Sect. C2.1.4.1 it was stated that risks to vermivorous wildlife would be assessed for the fringing wooded areas only if contamination is identified within these areas. Because surface water and soil contamination in excess of background levels was observed in the WAG 5 Wide area, vermivorous wildlife may be exposed to contaminants at the current time and therefore must be assessed as part of the current case scenario. Suitable habitat is not currently available in the OHF, NHF, PWSB, SWSA 5, and TRU areas, therefore exposure of vermivorous wildlife to contaminants is not believed to be occurring at the current time. Because habitat quality, and therefore contaminant exposure and risk, may increase in the future, exposure to wildlife using these areas will be assessed as part of the future case scenario (see Sect. C2.2.2.2.4).

Generalized wildlife exposure model for nonradionuclide contaminants

As terrestrial wildlife move through the environment, they may be exposed to contamination via three pathways: oral, dermal, or inhalation. Oral exposure occurs through the consumption of contaminated food, water, or soil. Dermal exposure occurs when contaminants are absorbed directly through the skin. Inhalation exposure occurs when volatile compounds or fine particulates are respired into the lungs. The total exposure experienced by an individual is the sum exposure from all three pathways or:

$$E_{\text{total}} = E_{\text{oral}} + E_{\text{dermal}} + E_{\text{inhal}} \quad (1)$$

Where:

E_{total}	=	exposure from all pathways
E_{oral}	=	oral exposure
E_{dermal}	=	dermal exposure
E_{inhal}	=	exposure through inhalation

The primary contaminants found in WAG 5, metals and radionuclides, are unlikely to be absorbed through skin (Camner and Philipson 1979; Watters et al. 1980). In addition, feathers and fur of birds and mammals further reduce the likelihood of significant dermal exposure by limiting the contact of skin with contaminated media. Therefore, dermal exposure is assumed to be negligible at WAG 5. Inhalation of contaminants is also assumed to be negligible at WAG 5. This is because minimal volatile organic carbons are present and most contaminated areas at the site are either capped, paved, or vegetated, therefore exposure of contaminated surface soils to winds and resulting aerial suspension of contaminated dust particulates is minimized.

Because contaminant exposure experienced by wildlife through both the dermal and inhalation pathways is negligible, the majority of exposure must be attributed to the oral exposure pathway. Equation 1 can therefore be simplified to:

$$E_{\text{total}} \approx E_{\text{oral}} \quad (2)$$

Oral exposure experienced by wildlife may come from multiple sources. They may consume contaminated food (either plant or animal), drink contaminated water, or ingest soil. Soil ingestion may be incidental while foraging or grooming or purposeful to meet nutrient needs. The total oral exposure experienced by an individual is the sum of the exposures attributable to each source and may be described as:

$$E_{\text{total}} \approx E_{\text{food}} + E_{\text{water}} + E_{\text{soil}} \quad (3)$$

Where:

E_{total}	=	total exposure from all pathways
E_{food}	=	exposure from food consumption
E_{water}	=	exposure from water consumption
E_{soil}	=	exposure from soil consumption

For exposure estimates to be useful in the assessment of risk to wildlife, they must be expressed in terms of a body weight-normalized daily dose or mg contaminant per kg body weight per day (mg/kg/d). Exposure estimates expressed in this manner may then be compared

to toxicological benchmarks for wildlife, such as those derived by Opresko et al. (1994), or to doses reported in the toxicological literature. Estimation of the daily contaminant dose an individual may receive from a particular medium for a particular contaminant may be calculated using the following equation:

$$E_j = \sum_{i=1}^m \left(\frac{IR_i \times C_{ij}}{BW} \right) \quad (4)$$

where:

E_j	=	total exposure to contaminant (j) (mg/kg/d)
m	=	total number of ingested media (e.g., food, water, or soil)
IR_i	=	consumption rate for medium (i) (kg/d or L/d)
C_{ij}	=	concentration contaminant (j) in medium (i) (mg/kg or L)
BW	=	body weight of endpoint species (kg)

Data and assumptions

Parameters for endpoint species. Two species of vermivorous wildlife were identified as endpoints in Sect. C2.1.1, American woodcock and short-tailed shrew. Species-specific parameters necessary to estimate exposure using the equation described above are listed in Table C2.1.

Contaminant concentrations in abiotic and biotic media

Contaminant concentrations in soil, water, and food are needed to estimate exposure. As stated above, the 95% upper control limit (UCL) is the most appropriate value to use to conservatively estimate exposure of wildlife. Soil data used to estimate exposure consisted of the 95% UCL for contaminants observed in surface soil samples from within each of the six areas (WAG 5 Wide, OHF, NHF, PWSB, SWSA 5, and TRU). Concentrations of contaminants in food (earthworms) were estimated using the 95% UCL for soil from each area and the soil-earthworm contaminant uptake factors developed for WAG 5 (see Sect. C2.3.3.1) Because the site-specific uptake factors estimate worm concentrations in mg/kg dry weight and vermivores do not consume dry worms, a dry weight to wet weight conversion was applied. The water content of earthworms is assumed to be 84%, as reported by EPA (1993a). Wet weight contaminant concentrations in worms were estimated as follows:

$$C_{wet} = C_{dry} \times P_{dry}$$

where:

C_{wet}	=	contaminant concentration in worms (mg/kg wet weight)
C_{dry}	=	contaminant concentration in worms (mg/kg dry weight)
P_{dry}	=	proportion of dry worm content (0.16)

Water data consisted of 95% UCL for contaminants observed in surface water samples (seeps, impoundments, and intermittent streams) obtained from within a 100 m radius of the bounds of each area. (Due to the proximity of areas to each other, data from some water

sampling locations were used to calculate 95% UCLs for more than one area.) Data were grouped in this manner because surface water was not present within the boundaries of all six areas. Therefore it was assumed that wildlife would travel up to 100 m to find water. While data from seeps and impoundments consisted of single observations, data from the streams consisted of observations from various flow regimes (e.g. high base, low base, etc.). Mean contaminant concentrations were calculated for each stream. These mean values from each stream were then combined with the single observations from both seeps and impoundments to calculate a 95% UCL for each area. A list of the sampling locations used to calculate 95% UCLs for each area is presented below:

<u>Area</u>	<u>Sample locations</u>
WAG 5 Wide	SW001, SW003, SP001, SP002, SP003, SP004, SP015, and SP016
OHF	SW006, SWOHF, and SP005
NHF	SW006
PWSB	SD015
SWSA 5	SW002, SW003, SP003, SP006, SP007, SP008, SP009, SP011, SP012, SP014, SP015, SP016, and SP017
TRU	SP001 and SP002

To determine if the contaminant exposure experienced by American woodcock and short-tailed shrews at WAG 5 exceeded that in background areas, exposure estimates were calculated for both species using twice the mean of the background values for both soil and water. Background concentrations of contaminants in food (earthworms) were estimated using the soil-earthworm contaminant uptake factors developed for WAG 5 (see Sect. C2.3.3.1) and background soil concentrations in Table 2a of the human health risk assessment (Sect. C1).

To estimate contaminant exposure experienced by American woodcock in the WAG 5 Wide area, the following assumptions were made:

- (1) body weight = 0.198 kg
- (2) food consumption = 0.15 kg/d
- (3) water consumption = 0.02 L/d
- (4) soil consumption = 0.0156 kg/d
- (5) diet consists 100% of earthworms
- (6) 100% of the habitat available is suitable and
- (7) Home range is smaller than the size of the contaminated area (i.e., 100% of time is spent within the contaminated area)

To estimate contaminant exposure experienced by short-tailed shrews in the WAG 5 Wide area, the following assumptions were made:

- (1) body weight = 0.015 kg
- (2) food consumption = 0.009 kg/d
- (3) water consumption = 0.033 L/d
- (4) soil consumption = 0.00117 kg/d
- (5) while diet consists 31.4% of earthworms, contaminant concentration in earthworms is representative of that in all other food types. Therefore 100% of the diet is assumed to have contaminant concentration represented by that estimated for earthworms.
- (6) 100% of the habitat available is suitable and
- (7) Home range is smaller than the size of the contaminated area (i.e. 100% of time is spent

- (7) Home range is smaller than the size of the contaminated area (i.e. 100% of time is spent within the contaminated area)

Using Equation 4 and the assumptions and data described above, exposure to non-radionuclide contaminants was estimated for American woodcock and short-tailed shrews using the background and WAG 5 Wide areas. Exposure estimates for all non-radionuclide analytes detected in background samples are presented in Tables C2.2 and C2.3. Exposure estimates for all contaminants where either site exposure exceeded background or for which a toxicological benchmark was available are presented in Tables C2.4 and C2.5. For woodcock, exposure to 20 contaminants exceeded background. For shrews, exposure to 21 contaminants exceeded background.

Exposure estimation for radionuclide contaminants

Radionuclide dose rate estimates for vermivorous wildlife were calculated using methodology adapted from Blaylock et al. (1993). Because bioconcentration factors, necessary to estimate body burdens, were not available, to be conservative, body burdens were assumed to be equivalent to soil concentrations. Because exposure from water was very small relative to that from soil, all dose estimates are based solely on exposure from soil. Assumptions used to estimate radionuclide doses to shrews and woodcock are as follows:

- shrews are underground 100% of the time;
- woodcock are sitting on the ground 50% of the time;
- exposure to alpha and beta radiation is strictly internal;
- radionuclide body burdens (concentrations) for both shrews and woodcock are equivalent to the concentrations found in soil; and
- all radionuclides are evenly distributed throughout the bodies of shrews and woodcock.

Using the assumptions described above, alpha, beta, and gamma doses (in uGy/h) for shrews and woodcock were estimated for each radionuclide observed in each area. Total radionuclide doses (sum of alpha, beta, and gamma for all radionuclides) for woodcock and shrews in each of the six areas are as follows:

Area	Woodcock	Shrew
WAG 5 Wide	0.536 uGy/h	0.643 uGy/h

C2.2.2.1.5 Fish

Fish in WAG 5 and WAG 2 may be exposed to contaminants in the surface water. On-site exposure is limited to drainages D1 and D2, while off-site exposure includes fish populations in White Oak Creek and Melton Branch. Seeps in and around WAG 5 are bank discharges without standing water, are ephemeral, or are too small to sustain fish populations. Seeps contribute to risk in WAG 2 and were evaluated using *Ceriodaphnia* toxicity tests and by comparing chemical concentrations and radionuclide activities to toxicological benchmarks. Although fish are able to migrate relatively freely within White Oak Creek, Melton Branch, and the WAG 5 tributaries, no attempt was made to apportion exposure over multiple sites. That is, each site was assumed to represent 100% exposure for the associated fish community.

Samples for contaminant analysis were collected at the two on-site surface water locations

(drainages D1 and D2), four off-site surface water locations on Melton Branch and its tributary, and at 15 WAG 5 seeps (see Fig. A2.15). The six surface water stations were sampled under each of four flow regimes: high base, low base, high base storm, and low base storm. Although as many as four samples were collected at some sites under at least one flow regime, contaminant concentrations for most stations and flow regimes are represented by a single sample. Seeps were also sampled only once for contaminant analysis. Given that upper 95% confidence limits could not be calculated for most sites and flow regimes, the maximum detected concentration was used for the comparisons to toxicity data in the screening portion of the assessment. For risk characterization, the full data set was considered.

As a point of reference, seep flow rates were compared to flow rates at either White Oak Creek or Melton Branch weir. Both flow rates are dependent on the same hydrologic conditions. That is, seep and stream flow should both be high during the wet-season and low during the dry-season. If available, to be conservative seep flow rates at the time of sample collection were compared to the minimum daily flow rate for 1993 in the appropriate main stream channel. For example, if the minimum downstream flow rate is 4 L/min and the seep contributes 1 L/min, the observed dilution factor is four. If the measured concentration of a chemical in that seep is 20 times higher than the lowest benchmark, it is reasonable to assume that this seep is toxicologically problematic for fish inhabiting the main stream channel. Although conservative assumptions are made (e.g., many seeps are dry part of the year) this is not intended to be a worst case estimate of in-stream exposure.

Total recoverable and dissolved contaminant concentrations were determined for all analytes, except volatile and semi-volatile organic compounds, in samples from the WAG 5 sites. Only total recoverable concentrations were available for background samples. Therefore, total recoverable concentrations were used for all sites such that metal and naturally occurring radionuclides could be screened against background. Total concentrations are more conservative because the bioavailable fraction is generally less than the total recoverable concentration. Total metal concentrations, for example, typically include 30 to 95% particle bound material (HECD 1992). Also, literature-derived toxicity data are based on laboratory studies using contaminants dissolved in filtered water. Therefore, if the total concentration exceeded background and benchmarks the dissolved phase concentration was evaluated.

Media toxicity data are the result of controlled tests using contaminated site media and standard test organisms. *Ceriodaphnia* toxicity tests were conducted using water from the two on-site surface water stations (drainages D1 and D2) and five seeps (SP002, SP004, SP006, SP008, and SP009). Fathead minnow tests were not conducted for this assessment because they have been found to be less indicative of toxicity in this watershed. All sites, except seep SP006, were tested twice during two test periods (December 12-18, 1991, and February 27-March 5, 1992). For health and safety reasons seep SP006 was sampled only once, on April 29, and tested from April 30-May 7, 1992. Three sites scheduled to be tested were not sampled because they were too radiologically contaminated to be tested in the aquatic toxicology laboratory (OHF pond and the process waste sludge basin) or inaccessible to personnel (seep SP0001). Sampling was conducted on a planned schedule during high base flow conditions and did not include storm events that may have elevated dissolved and suspended contaminant concentrations.

The test data summarize the effects of exposures to all contaminants in the water at the times the tests were conducted. Test water was analyzed only for basic water quality parameters (pH, conductivity, and hardness) to ensure that apparent toxicity is not due to

fundamental water characteristics. With the exception of SP006, sample water was not filtered prior to testing and was collected daily for renewal. SP006 was collected only once, filtered and stored under refrigeration for the remainder of the test period.

Biological surveys result in demographic data for the biota naturally occurring at the site. These data summarize the effects of actual exposures to all contaminants on the aquatic communities surveyed. However, because exposures are not controlled, they can not be quantitatively specified. It must be assumed that the surveyed communities consist of organisms that have been exposed for their entire life cycles to the physical and chemical conditions at the site. This could include episodic events that may or may not have been included in the aqueous sampling program.

Surveys of fish communities in Melton Branch and White Oak Creek were conducted in the spring (April-May) and fall (October-November) of each year from 1985 through 1993 (see Sect. 3.2.5.2.2 and Fig. 3.2.5.2.2.-1). Surveys were conducted at three locations on Melton Branch: above drainage D2 at Melton Branch kilometer (MEK) 0.6, above the tributary to Melton Branch that borders the eastern side of WAG 5 but below the tributary from High Flux Isotope Reactor (HFIR) (MEK 1.4), and above the HFIR tributary (MEK 2.1). Surveys were conducted at five locations on White Oak Creek: at White Oak Creek kilometer (WCK) 2.3 which is below the White Oak Creek and Melton Branch confluence, below drainage D1 and above the Melton branch confluence at WCK 2.9, just above WAG 5 at WCK 3.4, and near the headwaters at WCK 6.8. WCK 6.8 is above all known contaminant inputs and is used as a reference site.

Radionuclides

The dose rate to fish from all radionuclides detected in seeps and surface water was calculated using the formulas presented in Blaylock et. al. (1993). Total dose rate (uGy/h) is the sum of all internal and external exposures:

$$D_{\text{Total}} = D_{\text{Int}} + D_{\text{Ext}}$$

Alpha, beta, and gamma emitters may all contribute to internal exposure but only beta and gamma emitters are sources of external radiation exposure.

A radionuclide may emit more than one type of radiation. Therefore, the internal dose from a nuclide is the sum of the doses from each type of emission. For all three types of emissions the internal dose rate (D_{Int}) in uGy/h to a small fish (2.0 grams and $3.1 \times 1.6 \times 0.78$ cm) is given by the following equation:

$$D_{\text{Int}} = 5.76 \times 10^{-4} E n \Phi C_o$$

Where

- E is the average energy of the alpha, beta, or gamma emission (MeV).
- n is the proportion of transitions producing an emission of energy E; this is conservatively assumed to be 1 for this assessment.
- Φ is the absorbed fraction.
- C_o is the concentration of the radionuclide in the organism (Bq/kg wet weight)

and

$$C_o = 3.7 \times 10^{-2} C_w \text{ BCF}$$

Where

3.7×10^{-2} is the pCi to Bq conversion factor.
 C_w is the concentration in water (pCi/L).
 BCF is the bioconcentration factor (unitless).

Emitted energies for all nuclides were taken from Blaylock et.al. (1993) and International Commission on Radiological Protection Report No. 38 (1983). Alpha emissions from radionuclides within the organism are completely absorbed by the body giving an absorbed fraction (Φ) of 1. For beta and gamma emissions the absorbed fraction is a function of emission energy and organism size. The absorbed fractions of beta and gamma emissions in a small fish were taken from Blaylock et al.(1993) Figures A.4 and A.1, respectively. Bioconcentration factors (BCFs) for all nuclides, except Ca-45 and Sn-119m, were taken from Blaylock et.al. (1993) or International Atomic Energy Agency (1982). The BCF for strontium was used as an estimate of the BCF for calcium. A suitable BCF for tin was not found. The emitted energies, absorbed fractions, and BCFs used in this assessment are presented in Table C2.6.

The external dose from a nuclide is the sum of the doses from the beta and gamma emissions. For both types of emissions the external dose rate (D_{Ext}) in uGy/h to a small fish is given by the following equation:

$$D_{\text{Ext}} = 5.76 \times 10^{-4} E n (1-\Phi) C_w$$

The nuclide specific parameters are the same as presented for internal exposure and the concentration in water (C_w) is converted to Bq/L.

For each location and flow regime the internal, external, and total dose rates were calculated for each nuclide and then added together. The result is a total dose rate for each location and flow regime. All dose rates for surface water and seep locations included in this assessment are presented in Tables C2.7 and C2.8, respectively.

C2.2.2.1.6 Benthic macroinvertebrates

Benthic macroinvertebrates (except those that live on rocks) live in or on contaminated sediments. Sediment-associated biota may be exposed to contaminated sediment and the associated pore water. Benthic macroinvertebrates may absorb or respire contaminated pore water and may ingest contaminated sediment and sediment-associated food. Compared to surface water, sediment contaminant concentrations have low temporal variability. Also, benthic macroinvertebrate communities are less mobile than water-column species. Therefore, it was assumed that sediment-associated biota received 100% of their exposure to contaminated sediment at each sampling location. In addition, the maximally exposed sediment-associated organism could receive 100% of its exposure from the most contaminated sediment at a location. Therefore, in the screening portion of the assessment, the maximum detected concentration was used to compare the sediment concentrations to the conventional toxicity data. For the risk characterization, the full data set was used.

Conventional toxicity data are developed from several different approaches including spiked sediment bioassays, equilibrium partitioning, apparent effects thresholds and bioeffects/contaminant co-occurrence methods. These conventional toxicity data were used in the development of ecotoxicological benchmarks (see Sect. C2.3.1.1.6) and are expressed as sediment concentrations of contaminants which cause adverse biological effects.

Contaminant concentrations in whole sediment were available for four locations from the D-1 drainage (SD001, SD002, SD003, and SD004), four locations in the D-2 drainage (SD005, SD006, SD007, and SD008), and one location from the D-3 drainage (SD009; see Fig. A2.14). Contaminants that did not exceed twice the background concentration were not carried through the exposure assessment. Contaminants that did not have background values were retained as COPCs. Ecological risks associated with sediments from the Sludge Basin and OHF pond were not assessed because these impoundments are isolated from other surface waters and were not considered to be waters-of-the-state and because these ponds are isolated from other surface waters, they are unlikely to contribute to risks to benthic invertebrates in WAG 2. In addition, because on-site aquatic endpoints were not included in the ecological conceptual model for WAG 5 agreed to by the FFA parties (Ashwood et al. 1993), risks associated with these ponds were not assessed.

The chemical analyses for this assessment were for whole sediment-associated contaminants and did not differentiate between sediment-bound concentrations and pore water concentrations. Although the toxicities of arsenic, chromium, and mercury are dependent upon their chemical species, most of the available toxicity data, and the resulting benchmarks used in the assessment (Hull and Suter 1994), are expressed as the total inorganic concentrations in sediment.

The bioavailability of contaminants in sediment can be affected by physical conditions, including the redox potential, cation exchange capacity, and organic carbon content. Organic carbon content of the sediment was determined at three locations: SD008, SD003 and SD009. Sample locations in close proximity to these sites were assumed to have the same organic carbon content. Therefore, it was assumed that sediments at SD005, SD006, SD007, and SD008 had 4.3% organic carbon, based on the organic carbon measurement at SD008. Also, the organic carbon content of 1.2% measured at SD003 was used for SD001, SD002, SD003, and SD004. The organic carbon content of 1.5% at SD009 was used only for that sample location.

No sediment was collected for toxicity testing and no biological surveys of benthic macroinvertebrates were done in WAG 5. However, benthic community surveys are conducted in WAG 2 as part of the ORNL Biological Monitoring and Abatement Program. Survey locations near WAG 5 include MEK 0.6 (near SWSA 5), MEK 1.2 upstream of WAG 5, and WCK 2.9 and 2.3 which are at and below WAG 5, respectively. The results of these surveys are important in the assessment of off-site risks resulting from contaminant releases from WAG 5.

Radionuclides

The dose rate of radionuclides in the sediment were calculated for exposures to (1) small benthic organisms (mass of 1.6×10^{-5} kg and with dimensions of $0.62 \times 0.31 \times 0.16$ cm) and (2) large benthic macroinvertebrates (1 g mass and dimensions of $2.5 \times 1.2 \times 0.62$ cm). It was assumed that the organisms spent 100% of the time buried in the sediment. The proportion

of transitions (n) was conservatively assumed to be one for all nuclides. Parameters used for dose calculations are presented in Tables C2.9 and C2.10 for small and large benthic macroinvertebrates, respectively.

Dose rate for beta emitters

External beta radiation is insignificant relative to internal beta radiation for these benthic organisms. Internal dose rate was calculated assuming the sediment inside the gut of the benthic organism contains the same level of radionuclides as the sediment external to the organism. Therefore, internal dose rate is calculated by:

$$D_{\beta} = 5.76 \times 10^{-4} E_{\beta} n \Phi C_s \quad \mu\text{Gy/h}$$

Where

- E_{β} is the average energy of the β -particle (MeV)
- n is the proportion of transitions producing a beta-particle of energy E (MeV)
- Φ is the absorbed fraction from Figure A.4 in Blaylock et al. (1993)
- C_s is the concentration of the radionuclide in the sediment (Bq/kg wet weight)

Dose rate for alpha emitters

It is assumed that external α -radiation from sediment is insignificant for these benthic organisms. The internal dose rate from alpha emitters is calculated using the same equation as for beta emitters and substituting the average energy of the alpha particle (MeV) for E. For alpha radiation, all of the energy is absorbed within the organism and therefore Φ equals 1. Therefore, the dose rate to large and small macroinvertebrates is the same and is calculated by:

$$D_{\alpha} = 5.76 \times 10^{-4} E_{\alpha} n C_s \quad \mu\text{Gy/h}$$

Gamma emitters:

Both internal and external exposure can be significant for gamma emitters because they have much greater penetration. Greater penetration increases external exposure but it reduces internal exposure because less of the emitted energy is absorbed by the organism.

Internal Dose Rate

Internal exposure from gamma emitters is calculated using the same basic formula as for beta emitters:

$$D = 5.76 \times 10^{-4} E_{\gamma} n \Phi C_s \quad \mu\text{Gy/h}$$

Internal dose rate is calculated only for large benthic macroinvertebrates because small invertebrates are too small to absorb gamma radiation.

External Dose Rate

The external dose rate from sediment may be calculated from:

$$D = 5.76 \times 10^{-4} E_y n (1-\Phi) C_s \mu\text{Gy/h}$$

Because the absorbed fraction Φ is practically the same for small and large macroinvertebrates, only dose rates for large macroinvertebrates were calculated and assumed to be the same for the small invertebrates.

C2.2.2.2 Future case

Because succession of WAG 5 to mixed deciduous forest under the hypothetical future case would not substantially alter the exposures for fish or benthic macroinvertebrates, and because no source is expected to increase its flux to surface waters, no future case was assessed for these endpoints.

C2.2.2.2.1 Plants

Terrestrial plants. The future state vegetation of WAG 5, under conditions of no institutional controls and natural succession of the vegetation, would be mixed deciduous woodland. Deep rooted trees may be exposed to higher concentrations of buried contaminants than the shallow-rooted grasses presently occupying most of the area. Also, roots may enter wastes and take up contaminants directly. As a result, exposure of terrestrial plants to contaminants may increase in the future. However, because contaminants in the trenches are not characterized, the nature and magnitude of future exposure cannot be defined.

Wetland plants. Exposure of plants to contaminants in the seeps may remain unchanged or decrease if the volume of seepage is reduced by the increased evapotranspiration resulting from reforestation.

C2.2.2.2.2 Soil invertebrates

Under future conditions, deep-rooted trees may accumulate chemicals directly from wastes or from deeper soil and deposit them on the surface in the form of leaf litter. As a result, earthworms and other soil and litter dwelling arthropods may be exposed to higher concentrations of contaminants in the surface soil and litter layer. However, because contaminants in the trenches are not characterized, the nature and magnitude of future exposure cannot be defined.

C2.2.2.2.3 Soil microorganisms and microbial processes

Under future conditions, deep-rooted trees may accumulate chemicals directly from wastes or from deeper soil and deposit them on the surface in the form of leaf litter. As a result, soil microorganisms may be exposed to higher concentrations of contaminants in the surface soil and litter layer. However, because contaminants in the trenches are not characterized, the nature and magnitude of future exposure cannot be defined.

C2.2.2.2.4 Vermivorous wildlife

In the future case scenario outlined in Sect. C2.1.4.1, it is assumed that institutional control of the ORR and maintenance of the mown lawns on WAG 5 has ceased and that the area has been allowed to revert to mixed deciduous forest. Because habitat quality on the OU will have increased, use of the site and therefore contaminant exposure and risk are

expected to increase. Therefore, all areas of WAG 5 are included in this case.

Contaminant exposure experienced by vermivorous wildlife (American woodcock and short-tailed shrew) in the future case was estimated using the generalized exposure model, life history parameters, contaminant concentration data, and assumptions described in Sect. C2.2.2.1.4. Contaminant concentrations were assumed to be unchanged.

Exposure estimation for nonradionuclide contaminants

Using Equation 4 and the assumptions and data outlined in Sect. C2.2.2.1.4, contaminant exposure was estimated for American woodcock and short-tailed shrews using the OHF, NHF, PWSB, SWSA 5, and TRU areas. Exposure estimates are presented only for those contaminants where either site exposure exceeded background or for which a toxicological benchmark was available. Because available habitat should not differ between the current case and future case scenarios for the WAG 5 Wide area, the future case exposure in the WAG 5 Wide area was assumed to be identical to that experienced in the current case (see Sect. C2.2.2.1.4).

OHF For woodcock, exposure to 13 contaminants exceeded background (Table C2.11). For shrews, exposure to 12 contaminants exceeded background (Table C2.12).

NHF For woodcock and shrews, exposure to 12 contaminants exceeded background (Tables C2.13 and C2.14).

PWSB For woodcock, exposure to seven contaminants exceeded background (Table C2.15). For shrews, exposure to six contaminants exceeded background (Table C2.16).

SWSA 5 For woodcock, exposure to 19 contaminants exceeded background (Table C2.17). For shrews, exposure to 18 contaminants exceeded background (Table C2.18).

TRU For woodcock, exposure to 10 contaminants exceeded background (Table C2.19). For shrews, exposure to nine contaminants exceeded background (Table C2.20).

Exposure estimation for radionuclide contaminants

Using the assumptions described above (see Sect. C2.2.2.1.4), alpha, beta, and gamma doses (in uGy/h) for shrews and woodcock were estimated for each radionuclide observed in each area. Total radionuclide doses (sum of alpha, beta, and gamma for all radionuclides) for woodcock and shrews in the remaining five areas are as follows:

C2-29

Area	Woodcock	Shrew
OHF	4.57 uGy/h	8.40 uGy/h
NHF	0.067 uGy/h	0.069 uGy/h
PWSB	1.19 uGy/h	1.2 uGy/h
SWSA 5	5732 uGy/h	5750 uGy/h
TRU	0.053 uGy/h	0.096 uGy/h

C2.3 EFFECTS ASSESSMENT

Ecological effects assessment involves the identification of known effects of contaminants on receptors using biological survey data, ambient media toxicity tests, and conventional toxicity data. This section discusses the three sources of evidence that will be used in the risk characterization section (Sect. C2.4) to evaluate risks to surface-water and sediment-associated biota, terrestrial plants, soil invertebrates, soil microbes, and terrestrial wildlife.

In the conventional toxicity section (Sect. C2.3.1) the types, development, and interpretation of appropriate toxicological benchmarks are discussed and available toxicity data relevant to the endpoint organisms is summarized in toxicity profiles for contaminants of potential concern. Conventional toxicity data consists of published values for toxicity of contaminants to test species. These data are generally not readily useful for ecological risk assessment. They are used in development of toxicological benchmarks applied in the initial phases of risk assessment to determine if biological effects are likely. By comparing contaminant concentrations measured in media at a site to the benchmarks, the likelihood that contaminants pose a risk can be estimated. Contaminant concentrations or exposure doses are compared to benchmarks to compute hazard quotients used in risk evaluation. These comparisons are contaminant specific.

The media toxicity section (Sect. C2.3.2) describes the results of aquatic and soil toxicity tests performed on soil from WAG 5 and surface water from WAG 5 and WAG 2. These tests are not contaminant specific, but their results provide direct evidence regarding the toxicity to the test organisms of combination of contaminants on the site in site media.

The biological survey section (Sect. C2.3.3) discusses the results of fish, benthic macroinvertebrate and soil invertebrate surveys, and studies of contaminant bioaccumulation in earthworms and fish. The surveys provide direct evidence of the impact of contaminants at the site on fish and invertebrates and the contribution of WAG 5 to toxicity in WAG 2. The bioaccumulation data indicate the potential for transfer of contaminants through the food chain and possible exposure to higher level consumers.

C2.3.1 Conventional Toxicity Data

C2.3.1.1 Toxicological benchmarks

C2.3.1.1.1 Terrestrial and wetland plants

Contaminant concentrations in soils and seep drainage were compared to toxicological benchmarks in order to screen out chemicals that do not constitute a hazard to plants and therefore do not require detailed risk characterization. Tests conducted in natural soils are assumed to be representative of the exposure of plants to contaminants measured in WAG 5 soils. Tests conducted in nutrient and mineral solutions are assumed to be representative of exposures of plants to contaminants in the vicinity of seeps and springs.

Growth and yield parameters were used for two reasons. First, they are the most common class of response parameters reported from phytotoxicity studies thereby using those parameters allowed for derivation of reasonably consistent benchmarks for a large number of contaminants. Second, growth and yield measurements are direct estimates of the

assessment endpoint for plants. Twenty percent reduction in growth or yield was used as the threshold for significant effects to be consistent with other screening benchmarks for ecological risk assessment and because the FFA parties adopted this level of effects for ecological endpoints (Suter et al. 1994).

Derivation of benchmarks

The method used for deriving soil benchmarks (Will and Suter 1994a) is based on the National Oceanographic and Atmospheric Administration's method for deriving the effects range low (ER-L) (Long and Morgan 1991) which has been recommended as a sediment screening benchmark by EPA Region IV. The ER-L is the tenth percentile of the distribution of various toxic effects thresholds for various organisms in sediments.

The phytotoxicity benchmarks were derived by rank ordering EC_{20} values for plant growth or production and then picking a number that approximated the tenth percentile (Will and Suter 1994a). As with the ER-Ls, statistical fitting was not used because there was seldom sufficient data and because these benchmarks are to be used as screening values and do not require the consistency and precision of regulatory criteria. Screening benchmarks for phytotoxic effects of contaminants present in soils of the WAG 5 units are presented in Table C2.45. Screening benchmarks for phytotoxic effects of contaminants present in seeps of the WAG 5 units are presented in Table C2.48.

C2.3.1.1.2 Soil invertebrates

Contaminant concentrations in soils were compared to toxicological benchmarks for earthworms in order to screen out chemicals that do not constitute a hazard to soil invertebrates and therefore do not require detailed risk characterization.

References used for the derivation of benchmarks were reports of toxicity tests of individual chemicals in laboratory, greenhouse, or field settings. Only experiments in which earthworms were exposed to soil (natural or artificial mixture of natural components), soil/litter microcosms, or manure were considered. Twenty percent reduction in growth, reproduction, or activity was used as the threshold for significant effects to be consistent with other screening benchmarks for ecological risk assessment and because the FFA parties adopted this level of effects for ecological endpoints (Suter et al. 1994).

The toxicity benchmarks were derived by the same method used for plants (Sect. C2.3.1.1.1), that is by rank ordering the EC_{20} values and then picking a number that approximated the tenth percentile (Will and Suter 1994b). Screening benchmarks for toxic effects of contaminants present in WAG 5 soils are presented in Table C2.45.

C2.3.1.1.3 Soil microorganisms and microbial processes

Contaminant concentrations in soils were compared to toxicological benchmarks for soil microorganisms and microbial processes in order to screen out chemicals that do not constitute a hazard to this endpoint and therefore do not require detailed risk characterization. An assessor must realize that the soil and microbial characteristics play a large part in toxicity and incorporate these site-specific considerations in the evaluation of the potential hazards of a chemical. If a chemical concentration exceeds the screening benchmark, more analysis is needed to determine the hazards posed by that chemical. If, however, the

chemical concentration falls below the benchmark, the chemical may be ignored during further study unless public concern or ancillary evidence suggest that it should be retained.

Data on the toxic response of microorganisms were collected for inorganic elements and organic compounds. Measures of effects of soil-borne chemicals on microorganisms include growth, respiration, nitrogen transformations (denitrification, mineralization, and nitrification), C mineralization, P mineralization, cellulolytic activity, oxidation of hydrogen gas, alpha-glucosidase synthesis, and other enzyme activities. No one activity is accepted as adequate for characterizing the response of the soil microbial community to toxic stress because of the many soil and microbial factors affecting them at the micro-environment level.

Most of the research used to establish benchmarks was conducted in the laboratory with native soil microflora in small samples of soil or soil/litter microcosms. Exposure durations were one and one-half hours to one and one-half years. Metals tested were mixed into the soil in the form of salts. Bacteria, actinomycetes, and fungi are included and evaluated together. Tests conducted in culture media are not included because they are not directly relevant to the soil environment.

Derivation of the toxicity benchmarks for microbes and microbial processes, and establishment of confidence levels is described in Will and Suter (1994b) and is the same as described for plants. Screening benchmarks for toxic effects of contaminants present in soils of the WAG 5 units are presented in Table C2.45.

C2.3.1.1.4 Vermivorous wildlife

To determine if the contaminant exposure experienced by vermivorous wildlife that use WAG 5 could produce adverse effects, exposure estimates from Sect. C2.2.2 were compared with no observed adverse effects levels (NOAELs) derived according to the methods outlined by Opreško et al. (1994) and EPA (1993d).

Toxicological studies of the effects of contaminants observed at WAG 5 were obtained from the open literature. Due to differences in physiology between birds and mammals, separate studies were located (if available) for each wildlife class. Only studies of the effects of long-term, chronic oral exposures, whether in food, water, or by oral intubation, were used. To make the NOAELs relevant to possible population effects, preference was given to studies that evaluated effects on reproductive parameters. In the absence of a reproduction endpoint, studies that considered effects on growth, survival, and longevity were used.

In cases where a NOAEL for a specific chemical was not available, but a lowest observed adverse effects level (LOAEL) had been determined experimentally or where the NOAEL was from a subchronic study, the chronic NOAEL was estimated. We followed EPA's (1993d) suggested use of uncertainty factors of 1 to 10 for subchronic to chronic NOAEL and LOAEL to NOAEL estimation.

Smaller animals have higher metabolic rates and are usually more resistant to toxic chemicals because of more rapid rates of detoxification. It has been shown that metabolism is proportional to body surface area which, for lack of direct measurements, can be expressed in terms of body weight (bw) raised to the $2/3$ power ($bw^{2/3}$) (EPA 1980a). If the dose (d) itself has been calculated in terms of unit body weight (i.e., mg/kg), then the dose per unit body surface area (D) equates to:

$$D = \frac{d \times bw}{bw^{3/4}} = d \times bw^{1/4}$$

The assumption is that the effective dose per body surface area for species "a" and "b" would be equivalent. Therefore, knowing the body weights of two species and the dose (d_b) producing a given effect in species "b," the dose (d_a) producing the same effect in species "a" can be determined. Using this approach, if a NOAEL was available for the test species ($NOAEL_t$), the equivalent NOAEL for a wildlife species ($NOAEL_w$) was calculated by using the adjustment factor for differences in body size:

$$NOAEL_w = NOAEL_t \left(\frac{bw_t}{bw_w} \right)^{1/4}$$

This methodology is equivalent to that the EPA uses in their carcinogenicity assessments and Reportable Quantity documents for adjusting from animal data to an equivalent human dose.

NOAELs were derived for short-tailed shrews and woodcock. Of the 118 contaminants for which wildlife exposure estimates were calculated, 44 mammalian and 23 avian NOAELs have been derived. Mammalian and avian NOAELs and experimental information used to estimate wildlife NOAELs (e.g. test species, test endpoints, citation, etc.) are listed in Tables C2.21 and C2.22.

Radiological benchmark

A dose rate (42 μ Gy/h or 100 mrad/day) is recommended for terrestrial biota by the Atomic Energy Act (1992), which is not expected to result in appreciable reduction in fertility or fecundity of natural populations. That dose rate is used as the radiological benchmark in this assessment.

C2.3.1.1.5 Fish

Contaminant concentrations in surface water are compared to the toxicological benchmarks in order to assess the ecological risks to aquatic biota. A series of benchmarks of differing conservatism are used. Nonexceedence of screening benchmarks suggests no hazard. Exceedence of an increasing number of benchmarks constitutes increasing evidence of hazard. The benchmarks used in this assessment are presented in Table C2.23.

Toxicological benchmarks for aquatic biota

Although there are no values designated as aquatic screening benchmarks by the EPA or state agencies, there are a variety of test endpoints and derived values that may be appropriate estimates of a threshold for potential risks to aquatic biota. Some of these are more conservative than others or more inclusive of the range of taxa and processes that may be affected. Therefore, we screen the aqueous chemical concentrations against a suite of alternative benchmarks. These benchmarks are explained briefly in Table C2.24 and in more detail in Suter and Mabrey (1994).

Radiological benchmark

A dose rate (400 $\mu\text{Gy/h}$ or 1 rad/day) is recommended for aquatic biota by the National Council on Radiation Protection (1991), which is not expected to result in appreciable reduction in fertility or fecundity of natural populations. That dose rate is used as the radiological benchmark in this assessment.

C2.3.1.1.6 Benthic macroinvertebrates

To make decisions as to whether a chemical or biological measurement of sediment quality indicates impairment, site-specific data may be compared with benchmarks that indicate whether sediment quality is acceptable (Hull and Suter 1994). The benchmarks used for inorganic contaminants in this assessment are presented in Table C2.25. Because benchmarks for nonionic organic contaminants are calculated according to organic carbon content of the sediment, the benchmark is presented in the appropriate table when calculating hazard quotients. These benchmarks are outlined in Table C2.26. The methods for derivation and more detailed discussion are provided in Hull and Suter (1994).

Radionuclides

The dose rate benchmark used in this assessment was 1 rad/day (400 $\mu\text{Gy/h}$) which is the limit recommended by the National Council on Radiation Protection and Measurements (NCRP 1991) for protection from effects at the population level.

C2.3.1.2 Ecotoxicological profiles

C2.3.1.2.1 Terrestrial and wetland plants

Several elements for which analytical data are available are plant macronutrients and there is no evidence of potential plant toxicity. Therefore, no benchmarks have been established for these elements and no toxicity profiles will be given. They include calcium, magnesium, potassium, and sulfur (as sulfate). Toxicity profiles are presented for chemicals occurring in soil at maximum concentrations exceeding benchmarks and background for toxicity to plants (See Tables C2.43 and C2.46). In some cases there is insufficient information available from which to derive a benchmark. If possible, we present information on related chemicals, or on experimental growth media contaminant levels that did not elicit negative growth responses. Contaminants for which we have no information to offer include 1,2 dichloroethene, tetrachloroethane, acetone, vinyl chloride, styrene, 2-butanone, ethylbenzene, and sodium. Because the suite of chemicals is essentially the same for all areas within the WAG, contaminants will not be discussed by area. If a chemical is of concern in one medium (soil or water) and not in the other, the toxicity profile addresses toxicity only in that medium.

Aluminum. Aluminum interferes with cell division in roots, decreases root respiration, fixes P in unavailable forms in roots, interferes with uptake, transport, and use of Ca, Mg, P, K, and water, and interferes with enzyme activities (Foy et al. 1978). Symptoms of toxicity include stubby, brittle roots, stunting, late maturity, and collapse of growing points. Seedlings are more susceptible to damage from Al toxicity than are older plants. Twenty-five to 70% reductions in root and shoot weight of vegetables have been observed at <1 ppm in solution at pH 4.7 (Wheeler and Follett 1991). The benchmark for plants growing in solution is 0.2 ppm Al.

Antimony. Antimony has low mobility and bioavailability under normal soil conditions where it is adsorbed to Fe- and Mn hydroxides. It is considered a nonessential metal (Kabata-Pendias and Pendias 1984). The only information found on phytotoxicity of Sb in soil was a secondary reference noting undefined, qualitative phytotoxic effects on plants grown in a surface soil at 5 ppm Sb (Kloke 1979). This is the benchmark concentration for antimony in soil.

Aroclor 1260. No information was found on toxicity to plants of the PCB Aroclor 1260. Streck and Weber (1980) reported reductions in leaf fresh weight and plant height of redroot pigweed grown in soil containing 40 ppm Aroclor 1254.

Alpha and delta BHC. There is insufficient data from which to derive benchmarks for alpha and delta BHC. Eno and Everett (1958) measured 70 to 90% reductions in top and root weights of beans grown in soil to which 50 ppm BHC (unspecified) had been added, but growth was not affected by 12.5 ppm.

Barium. Barium is commonly present in plants but is not an essential component of plant tissues. It is taken up easily from acid soils (Kabata-Pendias and Pendias 1984). Mechanisms of toxicity may include competition with Ca for root uptake (Wallace and Romney 1971). Chaudhry et al. (1977) measured a 38% reduction in shoot growth of barley grown in soil containing 500 ppm Ba. There are phytotoxicity data for Ba in solution.

Cobalt. Cobalt in soils is strongly sorbed on Mn and Al oxides, clay and organic matter and has low bioavailability. It is not known to be essential to plants except legumes in symbiosis with N_2 -fixing microorganisms. Toxicity symptoms due to excess Co are typical of Fe deficiency induced chlorosis and necrosis, and root tip damage (Wallace et al. 1977a). There appears to be inhibition of mitosis and chromosome damage (Aller et al. 1990). Less than 0.1 ppm of Co in solution reduced growth of beans (22%) and chrysanthemums (55%) (Wallace et al. 1977a; Patel, et al. 1976), and 25 ppm in to soil had an undefined phytotoxic effect (Lincoln 1978). The benchmark for Co in solution is 0.06 ppm.

Di-n-butyl phthalate. Di-n-butyl phthalate has a very low vapor pressure and is non-ionic. It is biologically and chemically decomposed in soil. Di-n-butyl phthalate may be produced in plants (some phthalate esters are known to be) and it is metabolically degraded by plants and animals (Overcash et al. 1982).

Overcash et al. (1982) evaluated the phytotoxic effect of di-n-butyl phthalate on growth of fescue, corn and soybeans and found fresh weights of corn and soybeans were reduced 25 to 45% by 200 ppm in soil. Soybean seed germination was also reduced 55% at this concentration which is the benchmark for this compound in soil.

Iron. Iron is the key metal required for energy transformations and organic Fe complexes are involved in photosynthetic electron transfer. Plant symptoms of toxicity are not specific and differ among plant species and growth stages and include stunted top and root growth (Foy et al. 1978). As little as 10 ppm in solution produced an undefined phytotoxic effect (Wallihan 1966), and this concentration is the benchmark for Fe in solution.

Manganese. Manganese occurs in relatively high concentrations in soils as oxides and hydroxides, nodules, and coatings on other soil particles. These forms are not readily available to plants. Manganese is essential for plant growth. It is involved in N assimilation, as a

catalyst in plant metabolism, and functions with Fe in the synthesis of chlorophyll (Labanauskas 1966). Toxicity symptoms include marginal chlorosis and necrosis of leaves, and root browning. Excess Mn interferes with enzymes, decreases respiration, and is involved in the destruction of auxin (Foy et al. 1978). Growth of beans was reduced 29% by the addition of 500 ppm Mn to soil (Wallace, et al. 1977b). Wong and Bradshaw (1982) measured a 70% reduction in root length of ryegrass in response to 0.75 ppm in solution. The benchmark for Mn in soil is 500 ppm, and in solution, 4 ppm.

Mercury. Mercury in soil is strongly associated with organic matter and, to a lesser extent, clay and Fe and Mn oxides. In general, little Hg is found in soil solution available to plants. In well-drained, neutral to mildly acidic mineral soils. There was no primary reference data describing toxicity of Hg to plants grown in soil. Kloeke (1979) report unspecified toxic effects on plants grown in a surface soil with the addition of 0.3 ppm Hg and this has been chosen as the benchmark concentration for all mercury species (inorganic and organic) in soil.

Nickel. Nickel is not generally considered to be an essential element for plants. However it may be required by nodulated legumes for internal N transport as part of the urease enzyme (Aller et al. 1990). Symptoms of Ni toxicity are generally Fe-deficiency induced chlorosis and foliar necrosis (Khalid and Tinsley 1980). Excess nickel affects nutrient absorption by roots, root development, and metabolism, and it inhibits photosynthesis and transpiration. Nickel can replace Co and other heavy metals located at active sites in metallo-enzymes and disrupt their functioning. Wong and Bradshaw (1982) measured a 30% decrease in root length of rye grass when grown in nutrient solution with 0.13 ppm Ni. Leaf and stem weights of chrysanthemum seedlings were 25% reduced when grown in nutrient solution with 0.59 ppm Ni (Patel et al. 1976). Wallace (1979) measured severe decreases (90 and 70%) in root and leaf weights of bush bean seedlings when grown nutrient solution with 1.2 ppm Ni. The benchmark for nickel in solution is 0.2 ppm.

Polychlorinated aromatic hydrocarbons (PAHs). The PAHs detected in soils of WAG 5 are: benzo(k)fluoranthene, fluoranthene, and pyrene. PAHs are ubiquitous constituents of plants and some are thought to act as plant growth regulators (Deubert et al. 1979). Deubert et al. (1979) report a stimulation in the growth of wheat and corn when seeds were soaked in solution containing up to 0.02 ppm benzo(a)pyrene (BaP) before planting. Wagner and Wagner-Hering (1971) found no effect of 3,4-benzfluoranthene on wheat growth at a soil concentration of 6.3 ppm.

Selenium. Selenium in soils occurs as selenite [Se(IV)] which is rapidly and nearly completely fixed by Fe hydroxides and oxides. These forms are not readily bioavailable. Selenium is not proven to be essential for plant growth. Toxicity symptoms include chlorosis, stunting and yellowing of the leaves. The mechanism of toxicity is thought to be indiscriminate replacement of S by Se in proteins and nucleic acids with disruptions in metabolism (Trelease et al. 1960). Wan et al. (1988) measured 30 to 85% reductions in shoot weight of alfalfa grown in soils containing 1.5 ppm Se. Shoot weights of alfalfa (Soltanpour and Workman 1980) and sorghum (Carlson et al. 1991) were reduced approximately 25-90% and 55% by 2 and 1 ppm Se in various soils. The benchmark concentration for Se in soil is 1 ppm.

Silver. Silver is not commonly found in soil and is immobile and not bioavailable above pH four because it is complexed by humic substances and forms other insoluble compounds. When taken up by plants, silver remains in the root system precipitated with phosphate or chloride. The toxicity of Ag is related to the binding potential of Ag^+ ions to enzymes and

other active molecules at cell surfaces (Cooper and Jolly 1970). There was no primary reference data showing toxicity of Ag to plants grown in soil. The benchmark is based on a report of unspecified toxic effects on plants grown in a surface soil with the addition of 2 ppm Ag (Linzon 1978).

Trichloroethene. There is no information on which to base soil or solution phytotoxicity benchmarks for TCE at this time. Walton et al. (1992) reported no reduction in the biomass of soybean seedlings grown in soil containing 1600 ppm TCE. This is far higher than the maximum concentration found in the seeps of WAG 5 (0.09 ppm), however, confident extrapolation of effects data from experiments performed in soil to field water data is not possible.

Zinc. Zinc in soil is associated with Fe and Al oxides and is slowly available to plants. It is also adsorbed by the exchange complexes of clays and organic matter. Zinc has a part in many enzymes, and is involved in disease protection and metabolism of carbohydrates and proteins. Toxicity symptoms include chlorosis and depressed plant growth (Chapman 1966). It acts to inhibit CO₂ fixation, phloem transport of carbohydrates, and alter membrane permeability (Collins 1981). Seed production of soybean was reduced about 30% by the addition of 25 ppm to soil (Aery and Sakar 1991). Lata and Veer (1990) measured reductions of approximately 45 and 25% in weights of spinach and coriander with 87 ppm in soil. The benchmark concentration for Zn in soil is 50 ppm.

C2.3.1.2.2 Soil invertebrates

Calcium, magnesium, and potassium are available are considered essential for growth of earthworms and there is no evidence of potential toxicity. Therefore, no benchmarks have been established for these elements and no toxicity profiles will be given. There was no information found on toxicity of PAHs, antimony or silver to earthworms.

Earthworms are known to take up many inorganic and organic soil contaminants. Organic contaminants may undergo oxidation by the cytochrome P-450 and other enzyme systems. Earthworms may also bind xenobiotics and their metabolites in unextractable forms (Stenersen 1992). Very little is known about mechanisms of toxicity of chemicals in earthworms.

Aroclor 1260. There is insufficient data with which to establish a benchmark for Aroclor 1260. Larsen et al. (1992) reported that 150 ppm Askarel (a mixture of PCBs) in two agricultural soils was not toxic to *L. rubellus*. Diercxsens et al. (1985) do not report toxicity symptoms in earthworms living in field soil containing 140 ppm PCBs.

Cobalt. There is insufficient data with which to establish a benchmark for Co. Hartenstein et al. (1981) found that Co added to activated sludge at 800 ppm induced a 50% reduction in live weight of *E. foetida*.

Manganese. There is no information on which to base a toxicity benchmark for Mn at this time. Hartenstein et al. (1981) found no reduction in live weight of *E. foetida* in activated sludge to which up to 15,000 ppm Mn (acetate form) was added. Ireland (1979) describes earthworms living in soils containing 1330 ppm Mn with no toxicity symptoms reported.

Mercury. Abbasi and Soni (1983) found survival and reproduction of *Octochaetus pattoni* reduced 65 and 40% by 0.5 ppm Hg (HgCl_2). The effect of methyl mercury on survival and segment regeneration of *E. foetida* was investigated by Beyer et al. (1985). Methyl mercury chloride at 12.5 ppm Hg reduced survival by 21% and the ability to regenerate excised segments by 69%.

It is not possible to evaluate the relative toxicity of forms of Hg based on these two studies using very different systems and two families of earthworms. The benchmark of 0.1 ppm was established by applying a safety factor of 5 to the lowest concentration tested by Abbasi and Soni (1983) of 0.5 ppm Hg.

Selenium. Fischer and Koszorus (1992) found that 77 ppm of selenium severely reduced the number of cocoons produced by *Eisenia foetida* in a combination of peaty marshland soil and horse manure (1:1) by 70%. The benchmark of 70 ppm is derived from this study.

Zinc. Spurgeon et al. (1994) kept adult *E. foetida* in contaminated OECD artificial soil to test the effects of Zn on survival and growth of the earthworms. The EC_{50} for cocoon production was 276 ppm and the benchmark is 200 ppm.

C2.3.1.2.3 Microorganisms and microbial processes

There is little information on the mechanisms of toxicity of contaminants to soil microorganisms. It has been reported that metal ions may inhibit enzyme reactions by complexing the substrate, by combining with the protein active group of the enzyme, or by reacting with the enzyme-substrate complex (Juma and Tabatabai 1977). There is no information on toxicity of PCBs, PAHs, or antimony.

Cobalt. Lighthart et al. (1977) measured reduced respiration of native soil microflora in soil/litter microcosms by about 25% at 1362 ppm Co. The benchmark is 1000 ppm Co.

Manganese. Liang and Tabatabai (1977) measured 25% reduction in N mineralization by native soil microflora at 275 ppm Mn. Premi and Cornfield (1969) found nitrification by native soil microflora to be inhibited 65% by 100 ppm Mn. The benchmark is 100 ppm Mn.

Mercury. van Faassen (1973) investigated the effects of an inorganic and an organic mercury compound on N mineralization and nitrification by native soil microflora. Inorganic Hg reduced nitrification at 100 ppm Hg (40%) and organic mercury reduced nitrification at 10 ppm Hg (57%). Landa and Fang (1978) found a 87% decrease in carbon mineralization by native soil microflora at 0.1 ppm Hg in inorganic form. Fifty ppm Hg (inorganic) reduced urease activity in soil (Bremner and Douglas 1971). It is not possible to evaluate the relative toxicity of forms of Hg based on the limited studies available. The benchmark is 0.1 ppm Hg.

Selenium. Al-Khafaji and Tabatabai (1979) found that 198 ppm Se reduced arylsulfatase activity in soil by 26%. The benchmark is 100 ppm Se.

Silver. Bremner and Douglas (1971) evaluated the effects of Ag on urease activity and found that 50 ppm decreased activity by 60 to 65%. The benchmark is 50 ppm Ag.

Zinc. Zinc at 300 ppm reduced dehydrogenase activity of the native soil microflora in soil from the Rocky Mountain Arsenal by 30% (Rogers and Li 1985). Bollag and Barabasz (1979)

found that denitrification activity by three soil-dwelling *Pseudomonas* species of bacteria in autoclaved soil, and by native soil microflora, was reduced 22 to 35% by 250 ppm Zn. Denitrification in another species of this organism was decreased 30% at 50 ppm Zn. Premi and Cornfield (1969; 1969/1970) investigated the effects of Zn added to soil and measured 45 to 55% inhibition of nitrification at 100 ppm Zn. The benchmark is 100 ppm Zn.

C2.3.1.2.4 Vermivorous wildlife

Antimony. Antimony (CAS No. 7440-36-0) is a naturally occurring metalloid element (displaying both metallic and nonmetallic properties) existing in valence states of 3 and 5 (Budavari 1989; ATSDR 1990a). Metallic antimony and a few trivalent antimony compounds are the most significant regarding exposure potential and toxicity (ATSDR 1990a). Antimony (Sb) is used in metallurgical processes, paints and enamels, various textiles, rubber, and fire retardation (antimony trioxide). Some antimonials such as potassium antimony tartrate have been used medicinally as parasitocides (Beliles 1979).

Antimony is only slowly absorbed from the gastrointestinal tract. Based on animal data, gastrointestinal absorption of antimony was estimated to be 2 to 7% (Felicetti et al. 1974; Gerber et al. 1982). The specific chemical form will determine the absorption efficiency of ingested antimony. The primary target organ for acute oral exposure to antimony appears to be the gastrointestinal tract (irritation, diarrhea, vomiting) and targets for long-term exposure are the blood (hematological disorders) and liver (mild hepatotoxicity) (ATSDR 1990a). Inhalation exposure to antimony affects the respiratory tract (pneumoconiosis, restrictive airway disorders), with secondary targets being the cardiovascular system (altered blood pressure and electrocardiograms) and kidneys (histological changes) (Renes 1953; Breiger et al. 1954). Only limited evidence exists for reproductive disorders due to antimony exposure (Belyaeva 1967).

Toxic effects ranging from gastrointestinal disorders to death have been documented for animals following acute oral exposure to antimonials. Bradley and Frederick (1941) reported that a single dose (300 mg Sb/kg) of the organic antimonial, potassium antimony tartrate, induced myocardial infarction and death in rats. However, several studies using inorganic antimonials (metallic antimony, antimony oxide, or antimony trioxide) reported that doses as high as 27,410 mg Sb/kg were not fatal to rats (ATSDR 1990a).

Subchronic (24-week) exposure of rats to metallic antimony at doses of 500 to 1,000 mg/kg/day decreased plasma protein levels, hemoglobin levels, and hematocrit (Sungawa 1981; Hiraoka 1986). Sungawa (1981) also reported mild hepatotoxicity in rats receiving 418 mg Sb/kg/day (as antimony trioxide) or 500 mg Sb/kg/day (as metallic antimony). A decrease in red blood cell count was reported by Sungawa (1981) for rats given 418 mg Sb/kg/day (as antimony trioxide) for 24 weeks, and an increase reported by Smyth and Thompson (1945) in rats treated with same compound at a dose of 894 mg Sb/kg/day for 30 days. Fleming (1982) reported that dogs receiving antimony trioxide (6,644 mg Sb/kg/day) for 32 days exhibited severe weight loss, vomiting, and muscle weakness and dyskinesia of the hind limbs. A lower dose (84 mg Sb/kg/day) produced severe diarrhea. Using data from Fleming (1982), ATSDR (1990a) reported a NOAEL of 501 mg Sb/kg for rats receiving the compound for 20 days. Exposure of CD-1 mice to potassium antimony tartrate in the drinking water (5 ppm for 540 days) significantly reduced the lifespan of both males and females (Kanisawa and Schroeder 1969). Schroeder et al. (1968) also provided data showing that long-

term exposure of mice to 5 ppm potassium antimony tartrate in the drinking water resulted in decreased lifespan.

Barium. The soluble salts of barium, an alkaline earth metal, are toxic in mammalian systems. At low doses, barium acts as a muscle stimulant and at higher doses affects the nervous system eventually leading to paralysis. The LD_{50} for rats is listed as 630 mg/kg for barium carbonate, 118 mg/kg for barium chloride, and 921 mg/kg for barium acetate (Lewis and Sweet 1984). In a study of short-term toxicity, Borzelleca et al. (1988) exposed rats to 198 mg/kg/d barium as barium chloride and observed a 30% mortality.

Schroeder and Mitchener (1975a, b) exposed rats and mice to 5 mg barium/L in drinking water for their lifetime. There was a slight but significant reduction in longevity of treated male mice when measured as the mean age at death of the last surviving 10% of animals. The overall average life span of the group, however, was about the same as the control group. In another study, Perry et al. (1983) exposed rats to 0, 1, 10, or 100 ppm barium for up to 16 months. A significant increase in average blood pressure was observed in the highest dose group; a slight but statistically significant increase was seen in the 10 ppm dose group. Information on developmental and reproductive toxicity of barium to mammals is not available.

The LD_{50} of barium to chickens is 623 mg/kg (Johnson et al. 1960). Johnson et al. (1960) report that while chickens will tolerate 1000 ppm barium in their diet without adverse effects, 2000 ppm reduces growth, 8000 ppm produces 50% mortality in 4 weeks, and diets containing 16,000 or 32,000 ppm barium are 100% lethal.

Cadmium. While there is little information to indicate that this relatively rare metal is biologically essential or beneficial, Cd has been suggested as the cause of various deleterious effects to wildlife (Eisler 1985a). Mammals and birds are comparatively resistant to the biocidal properties of Cd, which include growth retardation, anemia, and testicular damage. Cd tends to bioaccumulate in the liver and kidney, eventually acting as a cumulative toxin. Cd residues of 2 ppm whole body fresh weight are evidence of Cd contamination, and residues >5 ppm whole animal fresh weight may be life-threatening (Eisler 1985a).

The lowest oral dose resulting in death for rats was 250 mg Cd/kg body weight (EPA 1980c). Weigel et al. (1987) fed rats 0.24, 0.85, or 2.25 ug/g Cd in diet for 8 weeks. Concentrations ≥ 0.85 ug/g resulted in reduced food intake, reduced body weights, and reduced enzyme activity, but no hematological effects were noted. Ma et al. (1991) determined that an average cadmium intake of 15 ug/g/day corresponded with critical renal metal loads of 120 ug/g, a level indicative of adverse health effects. Rats on a diet with 5 ppm Cd suffered shortened lifespans (Schroeder et al. 1965). Cd at 50 ppm in the diet depleted iron from rat livers (Whanger 1973). Rats eating diets with 7.15 ppm Cd (as CdO) exhibited growth reductions, but those consuming a diet with 2.80 ppm Cd did not (Weigel et al. 1984). In a 3 generation reproductive study, the population of mice exposed to 1 ppm $CdCl_2$ in their drinking water died out after the second generation (Schroeder and Mitchner 1971). Rats receiving >6 mg Cd/kg body weight daily during pregnancy gave birth to malformed fetuses (Ferm and Layton 1981).

No mortality was observed among adult mallard ducks fed diets containing 0, 2, 20, and 200 ppm Cd, however egg production was significantly reduced in the group consuming 200 ppm Cd (White and Finley 1978). In addition, the testes of males in the 200 ppm Cd group

atrophied and the spermatogenic process was disrupted (White et al. 1978). Among mallard ducklings, 20 ppm Cd in the diet produces mild to severe kidney lesions, reduces packed cell volume and hemoglobin concentrations in the blood (Cain et al. 1983). Avoidance behavior of black ducklings is impaired by diets containing 40 ppm Cd (Heinz and Haseltine 1983).

Chromium. Chromium occurs as either chromium (III) or chromium (VI). Trivalent chromium is an essential metal in man and wildlife, playing an important role in insulin metabolism (Langard and Norseth 1979). Hexavalent chromium is more toxic than chromium (III) because of its high oxidation potential and the ease with which it penetrates biological membranes (Steven et al. 1976; Taylor and Parr 1978). However, it is unlikely that all chromium in soil would be chromium (VI) because it is a highly oxidizing chemical species which is usually reduced by soil organic matter to chromium (III). Chromium (III) solubility decreases with increasing pH, and it is completely precipitated at pH above 5.5. In most soils, chromium is primarily present as precipitated chromium (III) and is not bioavailable. Most chromium in soil and sediments is unavailable to living organisms, and there is little evidence of chromium biomagnifying through food chains in its inorganic form (Eisler 1986a). Concentrations of total chromium >4.0 mg/kg dry weight should be viewed as presumptive evidence of chromium contamination (Eisler 1986a).

At high concentrations, chromium is a mutagen, teratogen and carcinogen (Eisler 1986a). The LD₅₀ for chromium (III) in mice is 260 mg/kg bw and 5 mg/kg bw for chromium (VI) (Steven et al. 1976). Rats fed chromium (VI) reached a toxic threshold at 1000 ppm (Steven et al., 1976). Pregnant hamsters injected with 5 to 15 mg CrO₃ [chromium (VI)]/kg bw displayed a dose-dependent increase in the number of resorbed and malformed fetuses (Gale 1978). Guinea pigs fed 50 ppm chromium (III) for 21 weeks showed no adverse effects (Preston et al. 1976). Similar results were observed among rats consuming water containing 25 ppm chromium (VI) for 1 year (Mackenzie et al. 1958).

Injection of 0.002 to 0.05 mg CrO₃ [chromium (VI)]/chicken egg produced a dose-dependent decrease in egg viability and increased frequency of malformed embryos (Gilani and Marano 1979). In contrast, adult black ducks fed a diet containing 0, 10, or 50 ppm chromium (III) for 10 months displayed normal growth and reproduction (Haseltine et al., unpublished manuscript). While no malformations were observed among ducklings from treated birds, growth and survivorship was reduced. Heinz and Haseltine (1981) observed no effects on avoidance behavior of black ducklings fed a diet containing 20 or 200 ppm chromium (III).

Di-n-butyl phthalate. Di-n-butyl phthalate is a colorless oily liquid that is extensively used as a plasticizer in a wide variety of industrial, domestic and medical products. The wide-spread uses of di-n-butyl phthalate have made the compound, along with other phthalic acid esters, ubiquitous in the environment. Di-n-butyl phthalate is taken up and accumulated by a variety of organisms; bioconcentration factors ranging from 12 to 6,600 have been reported for plants and aquatic biota (ATSDR 1990b).

Acute toxicity of di-n-butyl phthalate is low; acute oral LD₅₀ values in excess of 20,000 mg/kg have been listed for rats and mice (Hardin et al. 1987, White et al. 1983). Oral LD₅₀ values for birds have not been reported.

To evaluate effects of di-n-butyl phthalate on mammalian reproduction, Lamb et al. (1987) fed mice 0.03%, 0.3% and 1% di-n-butyl phthalate in their diet for 105 days. Significant

reproductive effects (decreased fertility, increased pup mortality) were observed among mice on the diet containing 1% di-n-butyl phthalate; no adverse effects were observed among the 0.03% or 0.3% dose groups.

In the only study to evaluate effects on birds, eggshell thickness was reduced and water permeability of the shell was increased among ring doves (*Streptopelia risoria*) fed diets containing 10 ppm di-n-butyl phthalate for 4 weeks (Peakall 1974). No other adverse effects were reported.

Lead. Lead is a comparatively rare metal, averaging 16 ppm in the earth's crust, that is neither essential nor beneficial in living organisms (Eisler 1988). Lead has adverse effects on survival, growth, reproduction, development, behavior, learning, and metabolism. In general, organic lead compounds are more toxic than inorganic compounds, biomagnification of lead is minimal, and younger organisms are more susceptible to lead toxicity (Eisler 1988).

Acute oral doses of 5–108 mg lead/kg bw reduced rat survival (Eisler 1988), and rats fed diets with 5 ppm lead had shortened life spans (Schroeder et al. 1965). An acute LD₅₀ based on a single oral dose of 12 mg tetraethyllead/kg body weight was reported by Branica and Konrad (1980). Rats fed 0.5, 5, 25, or 250 ppm inorganic lead in diets over two generations exhibited no substantial developmental effects (Kimmel et al. 1980). In another study, Azar et al. (1973) fed rats a diet containing 0, 10, 50, 100, 1000, or 2000 ppm lead acetate for three generations. While the number of litters and young/litter was not affected by any dose level, growth was reduced and kidney histopathologies were observed among offspring in the 1000 and 2000 ppm treatments. Frequency of pregnancy was reduced in mice ingesting 3 mg/kg body weight tetraethyllead daily, and daily ingestion of 1.5 mg/kg tetraethyllead chloride resulted in a reduction in the success of implanted ova (Clark 1979).

Anemia and other hematological effects were induced among pigeons orally dosed with 6.25 mg lead/kg bw/day (Anders et al. 1982). Kendall and Scanlon (1981) exposed ring doves to drinking water containing 0 or 100 ppm lead and observed no effects on time to produce eggs, egg production, or fertility. However, testes weight and sperm count was decreased among lead-exposed males. Grandjean (1976) correlated eggshell thickness and eggshell lead levels in European kestrels (*Falco tinnunculus*), suggesting that lead may cause eggshell thinning. Among American kestrels (*Falco sparverius*) fed diets containing 0, 10, or 50 ppm lead, no adverse effects on survival, egg-laying, initiation of incubation, egg fertility, or eggshell thickness were observed (Pattee 1984).

Manganese. Manganese makes up about 0.10% of the earth's crust and is the 12th most abundant element (NAS 1980). It can exist in oxidation states from -3 to +7, the most common being +4 in the chemical form of manganese dioxide. The oxides and peroxides are used in industry as oxidizers, and the metal is used for manufacturing metal alloys to increase hardness and corrosion resistance. In living systems, manganese is an essential element that is found most often in the +2 valence state.

Normal nutritional requirements of manganese are satisfied through the diet, which is the normal source of the element, with minor contributions from water and air. Manganese is absorbed throughout the intestinal tract. It can elicit a variety of serious toxic responses upon prolonged exposure to elevated concentrations either orally or by inhalation. The central nervous system is the primary target. Manganese and iron are mutually antagonistic; therefore, animals with low iron intake are more sensitive to manganese toxicity (NAS 1980).

Effects on reproduction (decreased fertility, impotence) have been observed in humans with inhalation exposure and in animals with oral exposure at the same or similar doses that initiate the central nervous system effects.

In a 120-day study, Grummer et al. (1955) suggested that the critical level of manganese required by growing pigs was approximately 12–20 ppm. There were no significant differences in reproductive performance among sows fed a diet supplemented with 40, 80, or 160 ppm manganese (Grummer et al. 1955), but addition of 500 ppm manganese to the diet slowed growth and caused stiffness of limbs. Swine may be somewhat more sensitive than other mammals; ingesting excess manganese at levels as high as 1000 ppm resulted in metabolic deviations but almost no effects on growth or other indicators of toxicosis in most experiments were reported in National Academy of Sciences (1980). Cunningham et al. (1966) suggested that the minimum toxic level of manganese was between 820 and 2460 ppm based on 84-day experiments with calves, but they noted the influence of decreased food intake at higher levels of manganese. In a second study controlling daily feed intake, no significant differences in average daily weight gain were observed in calves on diets containing up to 3000 ppm manganese (Cunningham et al. 1966). Adverse effects are more commonly observed at levels >2000 ppm (NAS 1980). When pregnant rats were fed a diet with 3550 ppm manganese beginning at day 2 of gestation, their offspring, fed the same diet to age 225 days, exhibited decreased fertility (Laskey et al. 1982).

Diets containing 1000 mg/kg of manganese as manganese carbonate fed to chicks for 20 weeks caused no adverse effects (Gallup and Norris 1939). Assuming a body weight of 0.556 kg (Opresko et al. 1994) and a daily ingestion rate of 0.04 kg [from the allometric relationship described by Nagy (1987)], the dietary concentration would be equivalent to a dose of 72 mg/kg-day. Turkey poults tolerated manganese levels of 3600 ppm in starter diets for 21 days with no deleterious effects, but growth depression was observed at 4800 ppm (Vohra and Kratzer 1968). Gallup and Norris (1939) concluded that a minimum of 30–50 ppm manganese in the diet would be necessary to prevent perosis, a disease involving manganese deficiency, depending on the breed of chicken studied.

Mercury. Mercury has no known biological function and is potentially toxic to fish and wildlife. Mercury is a mutagen, teratogen, and carcinogen that adversely affects the central nervous, renal, and reproductive systems of wildlife (Eisler 1987). Inorganic mercury compounds in aquatic systems are readily converted to organomercury by microbial action (Berlin 1979), with organomercury compounds being more toxic than inorganic mercury compounds. Biota bioconcentrate mercury compounds which can be further biomagnified through food chains (Wren 1986).

Daily doses of 0.1–0.5 mg/kg bw/day and dietary concentrations of 1.0–5.0 ppm are lethal to sensitive mammals (Eisler 1987). Central nervous system toxicity, weight loss, and mortality were observed among rats fed a diet containing 250 ppm methyl mercury (MeHg) for 2 weeks (Verschuuren et al. 1976a). Rats consuming 2.5 ppm MeHg in the diet for 2 years displayed reduced growth, increased kidney weight, and altered kidney histochemistry (Verschuuren et al. 1976b). To study effects on reproduction, Verschuuren et al. (1976c) fed rats a diet containing 0, 0.1, 0.5, and 2.5 ppm MeHg for three generations. While no effects were observed among rats fed 0.1 or 0.5 ppm MeHg, offspring viability was reduced among rats in the 2.5 ppm treatment. Among mink, 93-day consumption of diets containing 1.8 to 15.0 ppm MeHg produced mortality, ataxia, anorexia, and paralysis (Wobeser et al. 1976), with the highest exposures showing the greatest effects.

The LD₅₀ for MeHg for *Coturnix* quail ranges from 14.4 to 33.7 mg/kg bw (Eisler 1987). Growth was decreased and mortality increased among leghorn cockerels fed diets containing 6 to 18 ppm MeHg (Fimreite 1970). Ring-necked pheasants fed diets of MeHg-treated grains displayed reduced egg production and hatchability and laid more shell-less eggs than controls (Fimreite 1971). Heinz (1979) fed mallard ducks a diet containing 0.5 ppm MeHg for three generations. While MeHg consumption did not affect adult weights or weight change during the reproductive season, MeHg-exposed females laid fewer eggs (with more eggs outside the nest box), produced fewer young, and displayed slightly thinner eggshells. Young of MeHg-treated adults were less responsive to maternal calls and hyper-responsive to fright stimuli.

PCBs. PCBs are a family of man-made chemicals consisting of 209 individual compounds with varying toxicity (ATSDR 1989b). Aroclor is the trade name for PCBs made by Monsanto. Because of their insulating and nonflammable properties, PCBs were widely used in industrial applications such as coolants and lubricants in transformers, capacitors, and electrical equipment (ATSDR 1989b). The United States stopped manufacturing PCBs in 1977 due to evidence that they accumulate in the environment. PCBs have become widespread environmental contaminants.

Most exposures to PCBs are oral. Absorption of PCBs following oral exposure is often >90% (ATSDR 1989b). PCBs are preferentially stored in adipose tissues in animals. They may cross the placenta or be transferred to offspring through milk. PCBs with higher chlorine content (the last 2 digits of the Aroclor designation indicate the percent Cl content of the compound) tend to persist in the environment longer than those with lower Cl content, and PCBs are known to bioaccumulate and biomagnify to toxic concentrations in animals (Eisler 1986b, ATSDR 1989b). Chronic exposures are of particular concern. PCBs with high K_{ow} values and high numbers of chlorines in adjacent positions are generally the most toxic. Although relatively insoluble in water, PCBs are generally freely soluble in nonpolar organic solvents and in biological lipids (EPA 1980c).

Sixty percent of mice fed diets containing 1,000 ppm Aroclor 1254 for 14 days died within 15 days, but none of the mice fed diets with only 250 ppm Aroclor for 14 days died (Sanders et al. 1974). These diets translate to doses of 130 and 32.5 mg/kg/day, respectively (ATSDR 1989b). White-footed mice fed 10 ppm Aroclor 1254 for 18 months had fewer offspring produced and a longer time between litters than control mice (Linzey 1987).

Feeding studies suggest a total intake of 500-2,000 mg/kg of Aroclor 1254 obtained through the diet over 1 to 7 weeks is lethal in rats (Hudson et al. 1984). Male rats consuming diets containing 0-100 ppm Aroclor 1254 for 104 weeks suffered dose-related reduced survival (NCI 1978); however, there was no effect on similarly treated female rats. Dietary concentrations of ≥ 20 ppm Aroclor 1254 reduced litter sizes in one- and two-generation reproduction studies with rats; concentrations <5 ppm had no effect (Linder et al. 1974).

Mink are one of the most susceptible mammals; dietary levels as low as 0.1 ppm fresh weight have caused death and reproductive toxicity (Eisler 1986b). Diets containing 20 ppm Aroclor 1242 were lethal to mink in a 247-day experiment. The LC₅₀ for chronic exposures is 6.65 ppm Aroclor 1254 for mink over a 8 month period (Ringer et al. 1981). Diets containing 5 ppm Aroclor 1242 caused complete reproductive failure (Bleavins et al. 1980). Exposure for 160 days to 3.57 ppm Aroclor 1254 resulted in 100% mortality of adult mink (Platonow and Karstad 1973).

A chronic study was conducted over 4.5 months exposing mink to 1, 5 and 15 ppm Aroclor 1254 in the diet. There was a significant reduction in the number of offspring born alive at the 5 and 15 mg/kg exposures (Aulerich and Ringer 1977). Mink fed carp containing 1.5 ppm Aroclor 1254 for 6 months produced no offspring that survived to 24 hours (Hornshaw et al. 1983). No effects were observed in mink fed 0.64 ppm Aroclor 1254 for 160 days (Platonow and Karstad 1973). Exposure of mink for 6 months to 1 ppm Aroclor 1254 resulted in no significant difference from controls in number of offspring, or offspring mortality (Wren et al. 1987). Therefore, the 1 ppm dose was considered to be a chronic NOAEL.

A dietary dose of 25 ppm Aroclor 1254 fed for at least a month before egg-laying in mallard ducks had no detrimental effect on reproductive success (Custer and Heinz 1980). Dietary exposure of 5 ppm Aroclor 1254 for 39 weeks to laying hens and roosters resulted in reduced egg production, although hatchability of fertile eggs was not affected (Platonow and Reinhart 1973). Screech owls fed 3 ppm Aroclor 1248 through two breeding seasons did not have significantly different reproductive success, relative to controls (McLane and Hughes 1980). Exposure of pheasants to 12.5 mg/bird/week (1.8 mg/kg/d) of Aroclor 1254 for 17 weeks resulted in significantly reduced egg hatchability (Dahlgren et al. 1972). Because this study considered exposure throughout a critical lifestage (reproduction), the 12.5 mg/bird/week dose was considered to be a chronic LOAEL.

Selenium. While selenium is an essential nutrient that interacts with Vitamin E and maintains muscle integrity, it has a very narrow tolerance range; in humans, while 0.04-0.1 ppm is required in diet, 4 ppm may produce toxic effects (Eisler 1985b). In mammals, chronic selenium poisoning is induced by diets containing 1-44 ppm selenium (Harr 1978). Symptoms include liver cirrhosis, lameness, loss of hair, emaciation, reduced conception, and increased fetal resorption. Plants convert inorganic selenium to organic selenium compounds, thereby increasing their biological availability (Lo and Sandi 1980).

To evaluate the effects of selenium on reproduction, Schroeder and Mitchner (1971) exposed mice to 3 ppm selenate in drinking water for three generations. This dosage level increased juvenile mortality, number of runts, and resulted in reproductive failure by the third generation. In another study, exposure to 3 ppm selenate or selenite in water for a lifetime had no effect on mouse longevity and no tumorigenicity was observed (Schroeder and Mitchner 1972).

Selenium is both embryotoxic and teratogenic to birds, with organic selenium (selenomethionine) being more toxic than inorganic selenium (Hoffman and Heinz 1988). Mallard ducks were fed diets containing 1, 5, 10, 25, or 100 ppm selenite (Heinz et al. 1987) or 1, 2, 4, 8, or 16 ppm selenomethionine (Heinz et al. 1989) for about 10 weeks. Exposure to 1, 5, or 10 ppm selenite or 1, 2, or 4 ppm selenomethionine in the diet had no effect on survival, growth, or reproductive success of adults. The diet containing 100 ppm selenite killed 11 of 12 adults. While only one adult receiving the 25 ppm diet died, time to laying, interval between eggs was increased, and duckling survivorship was reduced in this treatment (Heinz et al. 1987). Diets containing 8 and 16 ppm selenomethionine resulted in 6.8% and 67.9% malformed embryos, respectively. In addition, duckling survival was significantly reduced (Heinz et al. 1989).

The most visible incident of environmental selenium toxicity occurred at the Kesterson National Wildlife Refuge in California. Agricultural wastewater containing approximately

0.3 ppm selenium was used for marsh management at the refuge (Ohlendorf et al. 1986). Mean selenium concentrations in plants, invertebrates, and fish at the site were 22–175 ppm (dry weight). As a result, reproductive success among water birds was poor, and the incidence of embryo mortality and developmental abnormalities was dramatically increased. Raccoons on the refuge were found to bioaccumulate selenium (Clark et al. 1989). While peak births at the refuge was 2 months later than reported at other locations, no adverse effects on raccoon reproduction were observed.

Metabolism of selenium may be significantly modified through interactions with heavy metals, and selenium may provide some protection from adverse effects associated with various metals, including cadmium and mercury (Eisler 1985b). Arsenite inhibits methylation of selenium but increases fecal excretion of selenite (Venugopal and Luckey 1978).

Thallium. Thallium is a widely distributed metal, occurring at concentrations of approximately 1 ppm in the earth's crust (Kazantzis 1979). Principal systems affected by Tl exposure include nervous and digestive; renal damage and hair loss have also been observed. Thallium sulfate, which has been widely used as a rodenticide, has an acute oral LD_{50} of 16 mg/kg (Ware 1978). In chronic studies, rats tolerated a dose of 10 mg Tl acetate/kg, while 30 mg/kg was lethal to males by 15 weeks. All rats fed a daily dose of 0.45 mg Tl/kg died after 4 months (Kazantzis 1979). Rats exposed to 10 ppm Tl in drinking water for 2 months accumulated Tl in testis and exhibited signs of testicular toxicity including reduced sperm motility (Formigli et al. 1986).

Bean and Hudson (1976) orally dosed three golden eagles with 60 and 120 mg Tl_2SO_4 /kg bw; the bird receiving 60 mg Tl_2SO_4 /kg survived while the two dosed with 120 mg Tl_2SO_4 /kg died, suggesting an LD_{50} between the doses. Oral LD_{50} s for quail, geese, and ducks are 12, 15, and 30 mg/kg respectively (Shaw 1933). No long-term studies of thallium toxicity to birds are currently available.

Zinc. Zinc makes up about 0.002% of the earth's crust (NAS 1980). Zinc is an essential trace element in all living organisms; it assures the stability of biological molecules and structures such as DNA, membranes, and ribosomes (Eisler 1993). It is used commercially primarily in galvanized metals and metal alloys, but zinc compounds also have wide applications as chemical intermediates, catalysts, pigments, vulcanization activators and accelerators in the rubber industry, UV stabilizers, and supplements in animal feeds and fertilizers. Zinc compounds are also used in rayon manufacture, smoke bombs, soldering fluxes, mordants for printing and dyeing, wood preservatives, mildew inhibitors, deodorants, antiseptics, and astringents (Lloyd 1984; ATSDR 1989a). In addition, zinc phosphide is used as a rodenticide.

Zinc occurs in nature as a sulfide, oxide, or carbonate (Eisler 1993). It is divalent in solution. In freshwater with pH >4 and <7 it exists almost exclusively as the aquo ion $(Zn(H_2O)_6)^{2+}$ (Campbell and Stokes 1985). Zinc interacts with many chemicals, and it may diminish the toxic effects of cadmium and protect against lead toxicosis in terrestrial animals (Eisler 1993). Background concentrations seldom exceed 40 μ g/L in water or 200 mg/kg in soil or sediment (Eisler 1993).

Although it is essential for normal growth and reproduction (Prasad 1979; Stahl et al. 1989) and important to central nervous system function (Eisler 1993), the primary toxic effect of zinc is on zinc-dependent enzymes that regulate RNA and DNA. It is most harmful to

aquatic life in conditions of low pH, low alkalinity, low dissolved oxygen, and elevated temperature. Zinc is relatively nontoxic in mammals, but excessive intake can cause a variety of effects. It is not known to be carcinogenic by normal exposure routes (Eisler 1993).

Gastrointestinal absorption of zinc is variable (20–80%) and depends on the chemical compound as well as on zinc levels in the body and on dietary concentrations of other nutrients (EPA 1984a). Information on pulmonary absorption is limited and complicated by the potential for gastrointestinal absorption due to mucociliary clearance from the respiratory tract and subsequent swallowing. Pulmonary inflammation and changes in lung function have been observed in inhalation studies on animals (Amur et al. 1982; Lam et al. 1985; Drinker and Drinker 1928). Zinc is present in all tissues with the highest concentrations in the prostate, kidney, liver, heart, and pancreas. Zinc is a vital component of many metalloenzymes such as carbonic anhydrase, which regulates CO₂ exchange (Stokinger 1981a).

In animals, gastrointestinal and hepatic lesions (Allen et al. 1983; Brink et al. 1959), pancreatic lesions (Maita et al. 1981; Drinker et al. 1927), anemia (ATSDR 1989a; Fox and Jacobs 1986; Maita et al. 1981), and diffuse nephrosis (Maita et al. 1981; Allen et al. 1983) have been observed following subchronic oral exposures. Anemia and pancreatitis were the major adverse effects observed in chronic animal studies (Aughey et al. 1977; Drinker et al. 1927; Walters and Roe 1965; Sutton and Nelson 1937). Teratogenic effects have not been seen in animals exposed to zinc; however, high oral doses can affect reproduction and fetal growth (Ketcheson et al. 1969; Schlicker and Cox 1967, 1968; Sutton and Nelson 1937).

Livestock and small mammals are tolerant of extended dietary loadings >100 times the minimum recommended daily zinc requirement (Eisler 1993). No adverse effects on general health or reproduction were observed in dairy cows fed 1310 mg zinc/kg food (Miller et al. 1989). A diet of 4000–5000 mg zinc/kg food for 18 days resulted in fetotoxicity and poor reproduction in rats (NAS 1979). Acute oral LD₅₀ doses of 350–800 mg zinc/kg body weight have been reported for rats (Eisler 1993). Wlostowski et al. (1988) recommended 30 mg zinc/kg in the diet of bank voles.

Dogs on diets with up to 1000 mg zinc/kg of food for up to one year showed no measurable signs of damage (NAS 1979). Horses ingesting >90 mg zinc/kg body weight daily in the vicinity of a lead-zinc smelter exhibited decreased growth and death (NAS 1979). No effects were observed in mice fed <682 mg zinc/kg food (<109 mg zinc/kg body weight daily) for 13 weeks, but at 6820 mg zinc/kg food adverse effects on growth and survival were documented (Maita et al. 1981). In a 37-day study involving rats, doses of 97 mg/kg-day administered as zinc carbonate in the diet had no adverse effects on the reproductivity of rats (Kinnamon 1963). European ferrets (*Mustela putorius furo*) fed up to 500 mg zinc/kg for up to 197 days all survived with no significant histopathologies, but those fed 1500 or 3000 mg/kg diet died within 21 days (Straube et al. 1980; Reece et al. 1986). Reproduction ceased entirely in female rats ingesting a diet with 500 mg zinc/kg/day (Sutton and Nelson 1937), possibly a result of zinc-induced anemia.

Mallards (*Anas platyrhynchos*) fed diets containing >3000 mg zinc/kg for 30 or 60 days suffered leg paralysis, decreased food consumption, and high mortality (Gasaway and Buss 1972; NAS 1979). Egg production in Japanese quail (*Coturnix coturnix japonica*) hens fed 15,000 mg zinc (as ZnO)/kg feed for 7 days decreased to near zero within 3 days (Hussein et al. 1988). Seven percent of 14-day old quail fed 600 mg zinc (as zinc phosphide)/kg feed over 5 days died, 53% of those fed 990 mg/kg died, and 93% of those fed 1634 mg/kg died

(Hill and Camardese 1986). Domestic chicken pullets and hens on a diet with 20,000 mg zinc/kg feed for 5 days were lighter weight by day 5 and produced significantly fewer eggs for 4 weeks following treatment (Palafox and Ho-A 1980). Eggs collected 14–28 days post-treatment had reduced fertility and hatchability. However, normal growth, egg production, fertility, and hatchability was observed 4–12 weeks post-treatment. Acute oral LD₅₀ values for zinc phosphide, a rodenticide, were between 16 and 47 mg/kg body weight in ring-necked pheasants (*Phasianus colchicus*), golden eagles (*Aquila chrysaetos*), mallards, and horned larks (*Eremophila alpestris*) (Hudson et al. 1984), but much of the biocidal action is attributed to the phosphide rather than the zinc (Eisler 1993).

Diets containing 28, 48, 228, or 2028 mg zinc/kg for 12–44 weeks had no effect on overall egg production by domestic chickens although zinc levels were elevated in hens on the highest zinc diet (Stahl et al. 1990). All day-old chicks fed diets containing 16,000 mg zinc/kg feed for 5 weeks and 80% of those fed 8000 mg/kg died; those on a 4000 mg zinc/kg diet showed no significant reductions in growth or survival (Oh et al. 1979). In a 60-day study, doses of 170 mg/kg-day administered as zinc carbonate in the diet caused increased mortality and altered blood chemistry in mallards (Gasaway and Buss 1972).

In chickens, adverse effects associated with zinc deficiency have been observed at <38 mg zinc/kg dry weight feed (Blamberg et al. 1960; Westmoreland and Hoekstra 1969; Stahl et al. 1989), but concentrations of 93–120 mg/kg are suggested as adequate in the diet (Blamberg et al. 1960; Westmoreland and Hoekstra 1969). Greater than 178 mg/kg dry weight feed is considered excessive (Stahl et al. 1989), and dietary concentrations >2000 mg/kg dry weight feed are considered toxic (NAS 1979; Oh et al. 1979; Stahl et al. 1990). Turkey poults tolerated zinc levels up to 2000 ppm in starter diets for 21 days with no deleterious effects, but levels $\geq$ 4000 ppm resulted in marked growth depression (Vohra and Kratzer 1968). No mortality was observed in poults on a diet containing 10,000 ppm zinc (Vohra and Kratzer 1968), but increased mortality has been observed for chickens on diets with 3000 ppm zinc (Roberson and Schaible 1960).

C2.3.1.2.5 Radiological effects data for terrestrial biota

Acute and chronic effects of ionizing radiation on terrestrial organisms has been reviewed by the International Atomic Energy Agency (IAEA 1992). The following section is a summary of this document. Terrestrial populations considered in this summary include mammals, birds, reptiles, amphibians and invertebrates.

Acute effects. Mortality (as measured by LD₅₀) and reproduction of terrestrial organisms are predominantly affected by acute doses of ionizing radiation. Reproductive effects appear to be the most limiting endpoint in terms of survival of the population. However, acute doses of 0.1 Gy or less are very unlikely to produce persistent, measurable deleterious changes in populations or communities of terrestrial plants or animals.

Acute effects on mammals are related to lethality and natality. Direct mortality has been observed in individuals at acute whole body doses as low as 2 Gy. Acute doses ranging from 0.25–0.50 Gy did not appear to affect reproduction of cattle or sheep. Mice, however, are among the most sensitive species and displayed impaired reproduction in females at doses as low as 0.2 Gy. Permanent sterility of female mice was produced by 1 Gy.

Birds of many varieties appear to exhibit LD₅₀ values ranging 4.6-30 Gy. Doses of 7 Gy showed a significant decrease in the growth rate of 2-day-old broiler chicks. Growth of tree swallow (*Tachycineta*) and house wren (*Troglodytes*) nestlings were also slightly depressed at doses greater than 2.6 Gy. Acute exposure to 4 Gy may also reduce egg production of leghorn chickens. Although, a reduction in dose rate to 10 mGy min⁻¹, total dose 8 Gy, eliminated any effects on subsequent egg production. Total doses up to 3.2 Gy did not affect hatching or fledgling success of swallows, but incubation times were slightly increased and growth was slightly depressed after total doses of >1.6 Gy.

Reptiles and amphibians are somewhat less sensitive than birds and mammals to acute radiation in regard to lethality. However, it is likely the response for reproductive effects is similar to that of mammals. Insects, in general, are considerably less sensitive to radiation than vertebrates. Lethality in adult insects requires approximately 100 times the dose required for vertebrates. However, juvenile insects are much more sensitive to lethal doses of radiation due to the rapid cell turnover.

Chronic effects. Reproduction is the population attribute most sensitive to damage from chronic irradiation and is the most significant parameter having ecological relevance. Mammalian studies indicated that a dose rate of 0.42 mGy/h represented an approximate threshold at which effects became apparent in irradiated populations. Tentative conclusions also suggest annual doses of several grays would be required to bring about the extinction of the most sensitive populations. Mammals inhabiting a hardwood forest detected no effects on survival at dose rates of 0.83 mGy/h. However, pigs and donkeys exposed to a dose rate of 0.004 mGy/h showed deterioration in a few weeks and died following a few months of continuous exposure.

Chronic exposure rates of 0.0083 mGy/h to birds have caused embryonic mortality. In contrast, the breeding success of swallows and wrens exposed to 0.029-0.25 mGy/h appeared normal. However, large dose rates, approximately 41.7 mGy/h, reduced hatching success.

Invertebrates are chronically affected by radiation indirectly. Impact primarily occurs due to alteration of the vegetative habitat. Decrease or death of vegetation due to radiation exposure results in reduced litter production, reduced litter decomposition, and depletion of carbon and nitrogen, thereby altering the entire ecosystem, including invertebrates.

The recommended chronic dose rate for terrestrial biota is 0.042 mGy/h (100 mrad/d). This level of exposure to the maximally exposed individual appears to be protective of the population (IAEA 1992). If conservative screening results in a dose rate above 0.01 mGy/h, a more detailed evaluation of the ecological effects to natural population should be made.

C2.3.1.2.6 Fish

Aluminum. Aluminum can be highly toxic to aquatic biota under some circumstances, but its toxicity is strongly dependent on pH, hardness, and organic matter content. Aluminum is amphoteric, i.e., it is more soluble in both acidic and basic solutions than in approximately neutral solutions. EPA's water quality criteria for aluminum (EPA 1988) assume a pH range of 6.5 to 9.0 within which aluminum occurs primarily in the form of monomeric, dimeric, and polymeric hydroxides. Toxicities of aluminum in the field may be substantially lower than indicated by total aluminum analysis values because of complexation with humic and fulvic acids. At pH values below 6.5, however, aluminum may be substantially more toxic than

indicated by the EPA criteria because low pH favors the formation and solubilization of cationic aluminum (Al^{3+}).

Between pH 6.5 and 9.0, acute toxicities of aluminum reported by EPA range between 1900 $\mu\text{g/L}$ (*Ceriodaphnia dubia*) and > 79,900 $\mu\text{g/L}$ (midge larvac, *Tanytarsus dissimilis*). Acute toxicities for fish ranged from 3,600 $\mu\text{g/L}$ (juvenile brook trout, *Salvelinus fontinalis*) to >50,000 $\mu\text{g/L}$ (juvenile green sunfish, *Lepomis cyanellus*). Chronic toxicities reported by EPA ranged from 742 $\mu\text{g/L}$ (*Daphnia magna*) to 3,288 $\mu\text{g/L}$ (fathead minnow, *Pimephales promelas*).

Toxicities to aquatic plants fall within roughly the same ranges: 6480 $\mu\text{g/L}$ caused mortality of the diatom *Cyclotella meneghiniana*, and concentrations from 400 to 900 $\mu\text{g/L}$ were chronically toxic to *Cyclotella meneghiniana* and the green algae *Selenastrum capricornutum*.

Bioconcentration factors from 50 to 231 were obtained in tests with young brook trout. Toxicities of body burdens were not determined. The acute and chronic National Ambient Water Quality Criteria (NAWQC) for the protection of aquatic organisms for aluminum are 750 and 87 $\mu\text{g/L}$, respectively.

Barium. There is relatively little information of the aquatic toxicity of barium, and none has been found for fish. Barium sulfate and chloride were lethal to yellow crabs (*Cancer anthonyi*) in 7-d exposures at 1,000,000 and 100,000 $\mu\text{g/L}$, respectively (MacDonald et al. 1988). Barium inhibited growth of duckweed by 50% at 102,000 to 400,000 $\mu\text{g/L}$ in various ambient waters (Wang 1988). Barium inhibited calcification of the freshwater green alga *Goeotaenium* at 50,000 $\mu\text{g/L}$ (Prasad 1984). The state of Illinois has a water quality standard for indigenous aquatic life of 5,000 $\mu\text{g/L}$ (Wang 1988). Barium is bioconcentrated from water by algae and vascular plants, but is not bioaccumulated through food chains (Moore 1991).

Calcium. Calcium is an essential nutrient and occurs in surface waters primarily as calcium carbonate. Although calcium is not known to be toxic in ambient waters, acute and chronic toxicity values for *Daphnia magna* were determined in laboratory tests by Biesinger and Christensen (1972). The 48-hr LC50s were 464,000 and 52,000 $\mu\text{g/L}$ with and without food added, respectively. Chronic (3 week) exposure to 116,00 $\mu\text{g/L}$ with food added caused a 16% decrease in reproduction. The test concentrations were made with calcium chloride, which is likely to result in a higher rate of dissociation than calcium carbonate. Therefore, measured concentrations of calcium carbonate in ambient waters are likely to over estimate the Ca(II) fraction.

Plant toxicity values and bioconcentration factors were not found. There are no NAWQC for calcium.

Cobalt. Comparatively little is known about the toxicity of cobalt. Acute and chronic toxicity tests using fathead minnows (*Pimephales promelas*) and *Daphnia magna* were conducted in relatively hard water. Acute toxicity values for cobalt ranged from 3,610 $\mu\text{g/L}$ for fathead minnows to 6,680 $\mu\text{g/L}$ for *D. magna*. Chronic toxicity values ranged from 1.1 $\mu\text{g/L}$ for fathead minnows to 5.1 $\mu\text{g/L}$ for *D. magna*. Cobalt toxicity was decreased by the presence of food during the *D. magna* acute toxicity tests.

Fluoride. Fluorides occur naturally in water and are usually found in areas that have been subject to recent volcanic activity (Fieser, et al. 1986). In natural waters, concentrations of 100 ug/L are common, but concentrations that exceed 1,000 ug/L are not unusual. Microorganisms, aquatic invertebrates, and fish have received only minor attention, and very little information is available on the chronic effect of fluorides on aquatic organisms.

The 48-hour LC50 for measured fluoride concentrations to *Daphnia magna* were 350,000 ug/L, 247,000 ug/L, and 180,000 ug/L for temperatures 15, 20, and 25°C, respectively (Fieser et al. 1986). These results confirm that the toxicity of fluorides to aquatic organisms may increase with temperature. Dave (1984a) reported a 48-hr EC50 for immobilization of *Daphnia magna* of 98,000 ug/L. In these tests median survival times were reduced at concentrations above 8,900 ug/L.

Chronic effects were observed in 3-week exposures studies of daphnids to fluoride (Fieser et al. 1986). Impairment in reproduction was observed in measured fluoride concentrations greater than 26,000 ug/L. A concentration of 35,000 ug/L of fluoride reduced the neonate production to 44% of the control. The average number of live young dropped by more than 98% at 49,000 ug/L and daphnids exposed to 84,000 ug/L and 142,000 ug/L did not produce any live neonates. In a 21 day study with *Daphnia magna*, growth and reproduction were significantly reduced at concentrations above 4,400 ug/L (Dave 1984a). However, in this same study reproduction was stimulated at between 600 and 4,400 ug/L.

Toxicity of fluoride to aquatic plants was not reported. Bioconcentration factors and toxicities of body burdens were also not determined for fluoride. There are no federal ambient water quality criteria for fluorides.

Iron. Iron is the fourth most abundant element in the earth's crust and its concentration in water is dependent upon redox conditions and pH. The most common dissolved inorganic form of iron is $\text{Fe}(\text{OH})_2^+$ (Dave 1984b). Toxicity of iron to aquatic organisms has received little attention.

Iron is acutely toxic to freshwater fish and invertebrates at concentrations ranging from 300 µg/L to 2000 µg/L (Train 1979). Reproduction of *Daphnia magna* was stimulated at concentrations up to 1 µg/L, and reproduction and survival were inhibited by iron at 158 µg/L and 256 µg/L, respectively (Dave 1984). This is considerably lower than the 4,380 µg/L concentration causing 16% reproductive decrement in another test with *Daphnia magna* (Biesinger and Christensen 1972). Dave argued that his result was more applicable to a situation in which "an acidic iron-containing waste water is discharged into a lake or a river" where it is neutralized, but Biesinger and Christensen's (1972) result "is probably more close to the steady-state situation in natural freshwater without any point source of iron." Survival of brown trout alevin (swim-up fry) and eyed-eggs was reduced at an average iron concentration of 5170 µg/L (Geertz-Hansen and Mortensen 1983).

Toxicity of iron to aquatic plants was not reported. Bioconcentration factors and toxicities of body burdens were also not determined for iron. The chronic NAWQC for freshwater aquatic life is 1000 µg/L.

Manganese. There is evidence that manganese occurs in surface waters both in suspension in the quadrivalent state and in the trivalent state in a relatively stable, soluble

complex (APHA 1989). Comparatively little is known about the toxicity of manganese (Kimball, n.d.).

Acute and chronic toxicity tests using fathead minnows and *Daphnia magna* were conducted in relatively hard water. Acute toxicity values for manganese ranged from 17,480 µg/L for *D. magna* to 33,800 µg/L for fathead minnow (*Pimephales promelas*). Manganese toxicity was increased by the presence of food during the *D. magna* acute toxicity tests. Chronic toxicity values ranged from <1,100 µg/L for *D. magna* to 1770 µg/L for fathead minnows.

Toxicity of manganese to aquatic plants was not reported. Bioconcentration factors and toxicities of body burdens were also not found for manganese. There are no NAWQC for manganese.

Nickel. Nickel is one of the most common metals in surface water (EPA 1986b). Although nickel can exist in several oxidation states. The divalent cation state predominates and is generally considered the most toxic form. As with many metals the toxicity of nickel increases as hardness decreases. Fish and invertebrates have approximately the same range of sensitivity.

Acute values are available for 18 genera and range from 1,100 µg/L for *Daphnia magna* to 43,250 µg/L for a banded killifish, *Fundulus diaphanis*. Chronic toxicity data are available for two invertebrates (*D. magna* and caddisfly, *Clistoronia magnifica*) and two fishes (fathead minnow, *Pimephales promelas* and rainbow trout, *Salmo gairdneri*): chronic values ranged from 14.7 µg/L with *D. magna* in soft water to 526 µg/L with fathead minnows in hard water.

Concentrations as low as 50 µg/L produce significant inhibition (40-60% reduction in growth) in green algae, *Scenedesmus acuminatz*. Nickel bioconcentration factors range from 0.8 for fish muscle to 193 for a cladoceran. The acute and chronic NAWQC for the protection of aquatic organisms for nickel are 1,400 and 160 µg/L, respectively.

Selenium. Selenium has a combination of attributes which make it an unusual pollutant (EPA 1987). These attributes include, but are not limited to, the following: it is an essential trace nutrient; it can occur in three oxidation states and be reduced or oxidized by various organisms; it is a metalloid with physicochemical properties similar to sulfur, which may reduce the toxicity of selenium or be replaced by selenium in biologically important compounds; it can reduce the toxicity of several heavy metals and have varying effects on cadmium and mercury toxicity; both water and food are important exposure pathways for aquatic biota; and there are substantial natural and anthropogenic releases to water. The two oxidation states [Se(IV) and Se(VI)] for which the most toxicity data exist are discussed separately.

Acute toxicity values for Se(IV) are available for 23 freshwater fish and invertebrate species in 22 genera and range from 340 µg/L for the amphipod *Hyalella azteca* to 203,000 µg/L for the leech *Nepheleopsis obscura*. Both the two most sensitive and resistant species were invertebrates. The lowest acute toxicity value observed for fish was 620 µg/L for the fathead minnow. The species mean acute values were (855.5 µg/L) for *Daphnia magna* and (1,601 µg/L) for the fathead minnow. Chronic values for Se(IV) ranged from > 47 µg/L for the rainbow trout *Salmo gairdneri* to 692.8 µg/L for *Daphnia pulex*. The fathead minnow and *Daphnia magna* had chronic values of 112.7 and 91.65 µg/L, respectively.

Toxicity values for nine species of freshwater algae ranged from 500 to 30,000 µg/L. Uptake of Se(IV) by fish takes about 100 days to reach steady-state and bioconcentration factors from 2 to 452 have been reported.

Acute toxicity values for Se(VI) are available for 12 freshwater animal species and range from 75 µg/L for the amphipod *Gammarus pseudolimnaeus* to 442,000 µg/L for the leech *Nepheleopsis obscura*. The lowest acute toxicity value observed for fish was 2,300 µg/L for juvenile fathead minnows. The species mean acute values were (1,450 µg/L) for *Daphnia magna* and (5,500 µg/L) for the fathead minnow. Chronic values for Se(VI) ranged from 565.5 µg/L for the fathead minnow to 2,891 µg/L for the rainbow trout *Salmo gairdneri*. *Daphnia magna* had a chronic value of 1,999 µg/L.

Toxicity values for nine species of freshwater algae ranged from 10 to 39,000 µg/L. Se(VI) bioaccumulation factors for the fathead minnow ranged from 21 to 52.

The species of selenium are not differentiated in the water quality criteria. The acute and chronic NAWQC for the protection of aquatic organisms are 260 and 35 µg/L, respectively.

1,2-Dichloroethene. Dichloroethylenes are clear, colorless liquids and consist of three isomers: 1,1-dichloroethylene (1,1-DCE), cis-1,2-DCE, and trans 1,2-DCE (EPA 1980d). 1,1-DCE is the isomer most widely used in industry and, consequently, in aquatic toxicity tests. 1,1-DCE is used in the production of copolymers, such as Saran, which are used in the packaging industry and as coatings for steel pipes, and the interior of fuel storage tanks. 1,1-DCE is not known to occur in nature and is expected to be short-lived in water because of its volatilization to the atmosphere. Of the available data, only one test was performed with 1,2-DCE.

Acute toxicity values for 1,1-DCE are available for 3 freshwater animal species and range from 11,600 µg/L for the cladoceran *Daphnia magna* to 169,000 µg/L for the fathead minnow. The species mean acute values, based on two tests for each species, were (30,300 µg/L) for *Daphnia magna* and (108,000 µg/L) for the fathead minnow. For fish, the lowest acute toxicity value observed for 1,1-DCE was 73,900 µg/L for the bluegill *Lepomis macrochirus*. This is also the only test in which 1,2-DCE was used. The acute value for 1,2-DCE (135,000 µg/L) was only twice the 1,1-DCE value and did not demonstrate a wide variability in acute toxicity among DCEs. In the one available chronic test 1,1-DCE had a chronic value for the fathead minnow of >2,800 µg/L.

In the one available toxicity test using freshwater algae *Selenastrum capricornutum* had a 96-hr EC50 of >798,000 µg/L. Bioconcentration factors were not available for either isomer. However, the K_{ow} for 1,1-DCE (5.37) indicates that it should not accumulate significantly. There are no NAWQC for the DCE isomers.

Bis(2-ethylhexyl)phthalate. Phthalate esters are a family of chemicals used as plasticizers. As a group the esters are colorless liquids, have low volatility, and are poorly soluble in water. Bis(2-ethylhexyl)phthalate, also known as di-2-ethylhexyl phthalate or DEHP, is the most widely used phthalate ester (EPA 1980c).

Of the available acute toxicity tests only the *Daphnia magna* data resulted in an acute range (1,000–5,000 µg/L). Calculated LC₅₀ values exceeded the highest test concentrations for the midge, scud, and bluegill and were >18,000 µg/L, >32,000 µg/L, and >0.770 µg/L,

respectively. Data are available from two chronic studies of bis(2-ethylhexyl)phthalate: rainbow trout and *Daphnia magna* had chronic values of 8.4 ug/L and < 3 ug/L, respectively. Representative toxicity data are presented in Table 6.

Although toxicity tests with plants were not conducted using bis(2-ethylhexyl)phthalate, the lowest values for three other phthalate esters were 110 ug/L, 39,800 ug/L, and 85,600 ug/L for butylbenzyl phthalate, dimethyl phthalate, and diethyl phthalate, respectively. Bioconcentration factors for bis(2-ethylhexyl)phthalate in fish and invertebrate species ranged from 14 to 2,680. Toxicities of body burdens were not determined for phthalate esters. There are no federal ambient water quality criteria for phthalate esters.

Radiological effects data

Acute and chronic effects of ionizing radiation on aquatic organisms have been reviewed by the National Council on Radiation Protection and Measurements (NCRP 1991). The following section is a summary of this document.

Acute effects. Effects of acute exposures to ionizing radiations of aquatic organisms gives information in three areas: (1) the relative sensitivities of species, (2) relative sensitivities of different life stages of the same species, and (3) interactions between radiation and other environmental factors that affect radiation response. Effects of ionizing radiation may include mortality, physiological and pathological changes, developmental effects, and reproductive effects of the organism.

The upper limit of radiation sensitivity of aquatic organisms to acute radiation exposure is measure by the LD₅₀. Lethal effects occur at various radiation doses for vertebrates and invertebrates (ranging from 10 - 100 Gy and 100 - 1000 Gy for fish/crustaceans and molluscs, respectively). Developing aquatic animals are most radiosensitive during the early stages of the life cycle. For example, fish at the one-cell stage are sensitive to < 0.1 Gy compared to 1-5 Gy for the 32-cell stage to late embryo. Physiological and pathological changes, occurring at the cellular and biochemical levels, effect blood forming tissues of fish and osmoregulatory abilities of fish and crustaceans. Additionally, radiation exposure affects the reproductive potential of the organism. Acute exposures may cause a decrease in mating success, increase in infertile/unfertilized eggs, reduce fecundity and fertility, and may result in sterility.

Radiation responses of aquatic organisms can be modified by alterations of their environment before, during and after irradiation. Environmental factors including temperature, salinity, water chemistry and quality, and contaminant load, must be considered when determining potential impacts of ionizing radiation on aquatic organisms. Additionally, any factor that affects metabolic rate will alter the rate and intensity of the radiation response of the organism.

Chronic effects. Chronic effects from low levels of irradiation are more difficult to detect in aquatic organisms. Environmental factors and changes in population dynamics may mask subtle effects of radiation. Chronic effects of ionizing radiation include: mortality, physiological, developmental, and reproductive effects of the organism and natural populations.

Deleterious effects of chronic irradiation do not appear to occur in natural populations at dose rates ≤ 0.42 mGy/h. However, effects on aquatic organisms, not necessarily

detrimental in the context of population dynamics, have been detected at dose rates in the range .04-0.42 mGy/h effects on the immune system and spermatogenesis appear to have been detected at dose rates approximately 0.42 mGy/h. Specifically, several physiological effects include reduction in primary spermatogonia (fish: 0.42 mGy/h tritiated water and 1.17 mGy/h gamma radiation) and testicular atrophy (*Gambusia*: 14.3-54.2 mGy/h for 47 days).

Effects on fertility of aquatic invertebrates and fish have been observed at dose rates $<100 \text{ mGy d}^{-1}$. Increase in sterility, increase in number of unfertilized eggs (*Oryzias*: $\geq 2.7 \text{ mGy/h}$ for 60 d), reduction of egg production (*Physa*: 10-50 mGy/h for 98 d), and retarded gonadal development (salmon smolts: $\geq 3.9 \text{ mGy/h}$ for 80 d) are several reproductive effects from various chronic doses of radiation. Additionally, juvenile clams (*Mercenaria mercenaria*) showed reduced growth and survival only at extremely high dose rates (158.3-370.8 mGy/h). Chronic effects on growth and development are somewhat inconsistent for aquatic vertebrates. Studies have shown lower rates of growth (salmon, *Oncorhynchus* sp. (smolts): $\geq 3.9 \text{ mGy/h}$), increased weights (salmon, *Oncorhynchus* (smolts): 0.2 mGy/h for 61-69 d), and no consistent patterns of effects on growth and development (guppy, *Poecilia* sp. (juvenile): 41.7-87.5 mGy/h for 21-30 d).

C2.3.1.2.7 Benthic macroinvertebrates

Acetone. The log organic carbon-water partition coefficient ($\log K_{oc}$) for acetone is 0.24. The sediment quality benchmark (SQB) of 0.064 mg/kg is derived using the equilibrium partitioning approach, based on 1% organic carbon. The Tier II secondary chronic value (Suter and Mabrey 1994) of 11.2 mg/L is used as the water quality benchmark. For comparison, substitution of the lowest chronic value for daphnids results in a SQB of 17.9 mg/kg. No sediment toxicity information is available regarding effects of acetone on benthic macroinvertebrates.

Aroclor 1260. The $\log K_{oc}$ for Aroclor 1260 is 7.02. The SQB of 1099 mg/kg is derived using the equilibrium partitioning approach based on 1% organic carbon. The Tier II secondary chronic value (Suter and Mabrey 1994) of 0.0105 mg/L is used as the water quality benchmark. The Tier II value implies a greater than 20% chance that the NAWQC, if their value were known, would be exceeded. For comparison, substitution of the lowest chronic value for daphnids results in a SQB of 220 mg/kg for Aroclor 1254.

ER-L and effects range-medium (ER-M) values are 0.0227 mg/kg and 0.180 mg/kg, respectively (Long et al 1994). Relatively poor relationships were observed between the incidence of effects and the concentrations of total PCBs. For example, there is a relatively low (51%) incidence of biological effects at concentrations greater than the ER-M (probable-effects range) (Long et al 1994). Cooccurrence analyses and apparent effects thresholds are highly variable and are predominantly for marine and estuarine systems. Co-occurrence analyses indicated that concentrations of PCBs ranging from 0.038 mg/kg to 0.276 mg/kg were highly toxic (43-79% mortality) to the amphipod *Rhepoxynius abronius*. Amphipod bioassays also resulted in LC_{50} and/or EC_{50} at PCB concentrations of 0.26 mg/kg (studies cited in Long and Morgan 1991). Apparent effects thresholds, approximately 1 mg/kg, resulted in reduction of the benthic community composition in Puget Sound. Freshwater data indicated little or no concordance between toxicity and PCB concentrations.

Arsenic. Sediments of Waukegan Harbor, Wisconsin, which had more than 47 mg/kg arsenic caused 34% mortality in *Hyalella azteca*. Sediment from the Sheboygan River,

Wisconsin, which had 2.7 mg/kg arsenic caused significant mortality to the freshwater prawn, *Macrobrachium rosenbergii*. However, this sediment also was contaminated with metals and PCBs. At 2 rivers in Illinois, a low number of benthic macroinvertebrate taxa was associated with arsenic concentrations of 7.4 and 3.7 mg/kg. However, a high number of taxa were associated with 5.9 and 5.0 mg/kg arsenic in the same two rivers (studies cited in Long and Morgan 1991).

ER-L and ER-M values are 8.2 mg/kg and 70 mg/kg, respectively. Only 11% of the documented studies in Long et al (1994) indicated biological effects at concentrations between the ER-L and ER-M, while 63% of the studies at concentrations above the ER-M indicated biological effects.

Barium. The benchmarks used for barium are based on background because sediment toxicity data were not found (Hull and Suter 1994). The EPA Region V Sediment Classifications of Nonpolluted (less than 20 mg/kg), Moderately Polluted (between 20 and 60 mg/kg), and Heavily Polluted (greater than 60 mg/kg) are poorly founded scientifically and considered adequate only for determining the suitability of dredged material for open water disposal. The Wisconsin Department of Natural Resources value of 500 mg/kg is also suitable only for evaluating dredge disposal options.

1,1-Dichloroethane. The log K_{oc} for 1,1-dichloroethane is 1.77. The SQB of 0.027 mg/kg is derived using the equilibrium partitioning approach based on 1% organic carbon. The Tier II secondary chronic value (Suter and Mabrey 1994) of 0.0466 mg/L is used as the water quality benchmark. No sediment toxicity information is available regarding effects of 1,1-dichloroethane on benthic macroinvertebrates.

1,2-Dichloroethene. The log K_{oc} for 1,2-dichloroethene is 1.87. The SQB of 0.023 mg/kg is derived using the equilibrium partitioning approach based on 1% organic carbon. The Tier II secondary chronic value (Suter and Mabrey 1994) of 0.0312 mg/L is used as the water quality benchmark. No sediment toxicity information is available regarding effects of 1,2-dichloroethene on benthic macroinvertebrates.

Iron. There is minimal information on the toxicity of iron in sediment to benthic invertebrates. However, Hull and Suter (1994) describe sediment criteria which are utilized as screening benchmarks. The Ontario Ministry of the Environment has prepared provincial sediment quality guidelines (SQGs). These values are based on Ontario sediments and benthic species from a wide range of geographical areas within the province. The lowest effect level (low) is the level at which actual ecotoxic effects become apparent. The severe effects level (severe) represents contaminant levels that could potentially eliminate most of the benthic organisms. These "low" and "severe" effects levels are 3% (30,000 mg/kg) and 4% (40,000 mg/kg), respectively (Hull and Suter 1994).

Beak Consultants in Canada also developed potential SQGs for Ontario Ministry of the Environment using the background approach. A SQG of 5.9% (59,000 mg/kg) represents a background level to which the site contaminant concentration should be compared. This sediment guideline is not based on/or related to biological effects (Hull and Suter 1994).

The EPA Region V Sediment Classification guidelines are for sediments of Great Lakes Harbors. The "polluted" values ranging from 17,000-25,000 mg/kg are qualified as being "moderately polluted" in the guidelines. The Region V values are poorly founded

scientifically and are considered adequate only for determining the suitability of dredged material for open water disposal (Hull and Suter 1994).

Mercury. Spiked sediment toxicity tests were conducted using sediment from Steele's Run (organic carbon content of 2.3%), a stream in the Kentucky River drainage system. Treatment was of early-life-stage rainbow trout. The test was initiated at the early eyed-egg stage and continued through 10 days posthatching, giving an exposure period of 20 days. Sediment concentrations of between 1 and 12 mg/kg resulted in between 55 and 77% mortality relative to controls. A concentration of 107 mg/kg resulted in 100% mortality (Birge et al. 1979).

Sediments from the Little Grizzly Creek system in California, which had 0.8 to 3.5 (mean 1.5) mg/kg mercury and an organic carbon content of approximately 1%, caused greater than 90% mortality in *Daphnia magna* and *Hexagenia limbata* (mayfly larva) (Maleug et al. 1984). A Michigan lake sediment in the same study, with an organic carbon content of 2.2% and mercury concentration of 0.29 mg/kg, caused 100% mortality in *D. magna* and 40% mortality in *H. limbata*. However, sediments from the Phillips Chain of Lakes in Wisconsin, with mercury concentrations from 0.8 to 9.4 mg/kg, resulted in less than 20% mortality in both species. These sediments had a high organic carbon content of approximately 15% (studies cited in Long and Morgan 1991).

Sediments from Waukegan Harbor, Illinois, with a mercury concentration of 0.1 mg/kg resulted in 34% mortality to *Hyalella azteca*. A study of benthic macroinvertebrate communities in Illinois rivers conducted by the Illinois Environmental Protection Agency found that the lowest number of benthic macroinvertebrate taxa occurred at a site with 1.6 mg/kg mercury, while the highest number of taxa occurred at a site with 0.3 mg/kg mercury (studies cited in Long and Morgan 1991).

ER-L and ER-M values are 0.15 mg/kg and 0.71 mg/kg, respectively. Biological effects were observed in 42% of the documented studies with concentrations greater than the ER-M (Long et al 1994).

Nickel. No information is available from spiked sediment toxicity tests for nickel; data are only from field studies (Long and Morgan 1991). In sediments of Lake Union, Washington, 88 mg/kg resulted in 95% mortality of *Hyalella azteca* (Long and Morgan 1991). Sediments with between 22 and 63 (mean of 40) mg/kg nickel from the Little Grizzly Creek system in California caused greater than 90% mortality in *Daphnia magna* and *Hexagenia limbata* (Maleug et al. 1984). This lake had an organic carbon content of 1%. A Michigan lake sediment in the same study, with an organic carbon content of 2.2% and a nickel concentration of 150 mg/kg, caused 100% mortality in *D. magna* and 40% mortality in *H. limbata*. However, sediments from the Phillips Chain of Lakes in Wisconsin, with a high organic carbon content of approximately 15% and nickel concentrations from 140 to 350 mg/kg, resulted in less than 20% mortality in both species (studies cited in Long and Morgan 1991).

ER-L and ER-M values are 20.9 mg/kg and 51.6 mg/kg, respectively. A relatively low percentage (17%) of the documented studies in Long et al (1994) indicated an incidence of biological effects at concentrations greater than the ER-M.

Silver. Effects were not observed in association with silver concentrations less than approximately 0.6 mg/kg (Long and Morgan 1991). No data were available for freshwater

systems. At concentrations of 2.1 to 2.6 mg/kg in marine systems, there was an absence of feral *Macoma balthica* in Fraser River sediments, low arthropod abundance and low species richness in southern California benthos, and increased burrowing time of *M. balthica* exposed to Strait of Georgia sediments (studies cited in Long and Morgan 1991).

ER-L and ER-M values are 1.0 mg/kg and 3.7 mg/kg, respectively. A high percentage (92.8%) of the documented studies in Long et al (1994) indicated an incidence of biological effects at concentrations greater than the ER-M.

Vinyl chloride. The log K_{oc} for vinyl chloride is 1.38. The SQB of 0.021 mg/kg is derived using the equilibrium partitioning approach based on 1% organic carbon. The Tier II secondary chronic value (Suter and Mabrey 1994) of 0.0878 mg/L is used as the water quality benchmark. No sediment toxicity information is available regarding effects of vinyl chloride on benthic macroinvertebrates.

C2.3.2 Media Toxicity Data

C2.3.2.1 Plant toxicity tests

Materials and methods. The cabbage seedling test was performed on three soil samples from WAG 5 on October 8–22, 1993. Sample sites were located along the border of WAG 5: sample one was on the southern end of the eastern border near well #970, sample two was on the southern border near well #973, and sample three was on the southern border near well #976. Soil from these areas was radiologically too contaminated to be tested in the toxicology laboratory. To reduce contamination to a safer level, each sample was diluted with an undetermined volume of 'clean' soil obtained from within WAG 5. Because the volume and source of soil used to dilute the original soil samples was not recorded, interpretation of the test results is problematic.

Prior to initiation of the test, the moisture fraction, organic matter content, and water holding capacity of each sample was determined. The control soil used was a standard potting soil (Promix®). Table C2.27 summarizes soil characteristics.

A batch of each treatment soil was hydrated to 75% of its water holding capacity. The soil was then used to fill 15 plastic 30 ml beakers within one cm of the beaker lip. The beakers were then placed into a polystyrene tray with holes the same size as the beakers. Each beaker was labeled and arranged alternately, across a row, in the following order, Promix®, sample one sample two, sample three. The tray held sixty beakers in six rows by ten columns. At each beaker, two cabbage seeds were dropped onto the soil surface (Ferry-Morse seeds, var. Ferry's Round Dutch, lot J-1). Approximately one-half tablespoon of silica sand, saturated with distilled water was then added to each beaker, covering the seeds to a depth of about 0.5 cm. The entire tray was then encased in a transparent plastic garbage bag, supported from within by four wooden pencils stuck into the tray. The bag was sealed with tape, and the entire apparatus was placed into an environmental chamber on a 16 h day at about $350 \mu\text{mol}/\text{m}^2\text{sec}^{-1}$ PAR and $20^\circ \pm 2^\circ\text{C}$. The test was monitored daily, and the appearance of condensate on the plastic enclosure was taken as an indication of adequate moisture levels. Each beaker was watered with distilled water 10 and 12 days after test initiation (about 2 ml/beaker).

On the seventh day after initiation, seed germination was recorded for each beaker. Any plant matter breaking the soil surface was counted. If two seeds had germinated, a pair of forceps was used to remove that plant further from the center of the beaker. If the two plants were equally distant from the center, a coin was flipped to determine which plant to remove. Late germinating plants were noted on subsequent checks and then removed.

Fourteen days after test initiation, the test apparatus was removed from the environmental chamber and the garbage bag was also removed. The seedling height was determined for each plant by means of a ruler attached to a dissecting probe. Height was considered as the distance from the soil surface to the highest point on the seedling (whether it was a curve in the stem or an upturned leaf). Each plant was rated for morphological appearance. Any plant with brown (dead) leaf parts, shriveled leaves, or chlorotic leaves received a 1 (unhealthy), while upright plants having green leaves with purple margins received a 0 (healthy). A razor was used to remove the above-ground tissue from each beaker. The plant matter was placed into separate envelopes and dried at $65 \pm 5^\circ\text{C}$ in an oven for >60 h. then removed, allowed to cool to room temperature, and weighed on a Mettler AE 163 balance (accurate to 0.1 mg). Data was analyzed using procedures mentioned in the results section using SAS software.

Results. Results of plant growth measurements are summarized in Table C2.28. Contingency tables used to analyze seed germination and morphological appearance are given in Tables C2.29 and C2.30. To analyze seedling height data, a one-way analysis of variance (ANOVA) was performed, followed by a one-tailed Dunnett's test for multiple comparisons of treatments against a single control. The ANOVA revealed significant differences among treatments ($F=10.38$, $p<0.0001$). The one-tailed Dunnett's test revealed that each treatment was significantly different from the control soil (with 95% confidence intervals). To analyze above ground biomass, a one-way ANOVA followed by a one-tailed Dunnett's was also performed. The ANOVA revealed significant differences among treatments ($F=16.77$, $p<0.0001$). Dunnett's test revealed that mean above-ground biomass in each treatment was significantly different from the control soil (with 95% confidence intervals).

Frequency tables of seed germination and morphology were used to perform chi-square analyses. For germination data, a chi-square value of 9.488 was determined, indicating significant differences among treatments ($p<0.023$). Next 2X2 frequency tables were created to analyze each treatment separately against the control using a one-tailed Fisher's exact test. Significant differences occurred for each treatment against the control (sample one, $p<0.0106$; sample two, $p<0.00238$; sample three, $p<0.021$). The chi-square value for morphology data was 7.851, indicating significant differences among treatments ($p<0.049$). As for seed germination, a Fisher's exact test of 2X2 tables for each treatment against the control was performed. Worm one and worm two were not significantly different from the control (for both soils $p<0.212$), however worm three soil did reveal a significant difference ($p<0.00729$).

Discussion. Seed germination, seedling height, and above-ground biomass data all indicate a significant negative response of cabbage to all of the WAG 5 soils. While appearance scores only indicate toxicity at the sample three site, it is possible that greater replication would reveal toxicity at the sample one and sample two sites as well. While the results of this test are useful as they stand, an analysis of these soils for nutrients and cation exchange capacity would be helpful in validating apparent toxic effects by examining possible soil nutrient deficiencies.

C2.3.2.2 Earthworm toxicity tests

Materials and Methods. The 14-d Earthworm survival test is an adaptation of the method described by Goats and Edwards (1982). Earthworms used in the test are laboratory cultured clitellate adults of the species, *Eisenia foetida*. Soils tested from WAG 5 were the same samples described in the Cabbage seedling toxicity test above. Consequently, the results of the earthworm tests are subject to the same limitations as the cabbage seedling tests. The control soil was an artificial soil prescribed for the earthworm test, its composition (by mass) is 70% silica sand, 20% kaolinite clay, and 10% sphagnum peat moss supplemented with CaCO_3 for pH regulation. The test was performed March 12-26, 1993.

Earthworms were harvested from cultures and placed on wet filter paper, one day prior to test initiation in order to purge their gut contents. To initiate the test, batches of each soil sample were hydrated to 75% of their water holding capacity with distilled water, then four glass canning jars (one pint capacity) were filled from the hydrated batch soil for each sample, including the control. Ten worms were placed onto the soil surface in each jar. Metal lids, each with one 2 mm diameter hole, were screwed onto the jars. All of jars were incubated at 20°C under continuous light for 14-d. At the end of the test, the soil in each jar was handsorted to remove surviving earthworms. Survivors were placed in scintillation vials and their fresh mass was determined on a Mettler AE 163 balance. The vials were next dried at 100° ± 2°C for >48-h, cooled in a desiccator, and weighed. Finally, the vials were ashed in a furnace at 200°C for >48-h, cooled in a desiccator, and weighed.

SAS software was used to analyze data. Survival fractions were arcsine square-root transformed and ANOVA was performed on the transformed data. ANOVAs were also performed on mass raw data.

Results. Results are given in Table C2.31. One worm mortality was recorded among all replicates (in sample three). The ANOVA of transformed survival fractions determined no significant differences among treatments ($F=1.00$, $p<0.43$). Analysis of the final fresh mass means by ANOVA also determined no significant differences among treatments ($F=1.17$, $p<0.36$). Due to problems in removing WAG 5 soil from survivors, measurements of dried mass typically included substantial portions of non-earthworm matter. In order to obtain an accurate indication of biomass, the mass lost upon ignition at 200°C was used as a data point. Since the WAG 5 soils had low organic matter contents, using this data resulted in less interference from dirty worms. The ANOVA of mass lost on ignition determined no significant differences among soil treatments ($F=0.60$, $p<0.6262$).

Conclusion. The results of the 14-d earthworm test show no indication of soil toxicity to *Eisenia foetida*.

C2.3.2.3 *Ceriodaphnia* toxicity tests

In this study, tests with a freshwater microcrustacean, *Ceriodaphnia dubia*, were used to assess the quality of water samples collected from various locations in WAG 5. Studies have shown that this test method can be used reliably to (1) quantify toxicity in ambient waters (cf. Burton et al. 1987, Stewart et al. 1990), (2) identify point- or area-source contributors to ambient toxicity (Nimmo et al. 1990), and (3) identify constituents in ambient and effluent waters that contributed to toxicity (cf. Norberg-King et al. 1991; Kszos et al. 1992).

Ceriodaphnia tests provide an estimate of toxicity by measuring the survival and reproduction of the animals.

Materials and Methods. Ten sites to be evaluated for toxicity initially were identified in the *Ecological Assessment Plan for Waste Area Grouping 5* (Ashwood 1992, Fig. C2.3 and Table C2.32). Preliminary investigation showed that two of the sites (the OHF pond - site 5; and the process waste sludge basin - site 10) were radiologically too contaminated to be tested in the aquatic toxicology laboratory. A grab sample of water from a seepage site on the border of SWSA 5 South (site 6) also proved to be too contaminated for toxicity testing, even after the water had been filtered to remove suspended sediment. Water from site 1, a seepage site on the bank of White Oak Creek, was not accessible to toxicology laboratory personnel during the first two test periods. Thus, during the first two toxicity test periods (December 12-19, 1991, and February 27-March 5, 1992), water samples from each of six locations (sites 2, 3, 4, 7, 8 and 9) were evaluated. A 3-L grab sample of water from site 6 was collected on April 29, and tested for toxicity during April 30-May 7, 1992, during the third test period. Information regarding the collection of the samples for first two toxicity testing periods can be found in ORNL registered technical notebook A-103384 (on pages 273-277 for the December 17-19, 1991 test, and on pages 293-299 for the February 27-March 5, 1992 test). Information about the collection of water from site 6 (White Oak Creek 225 seep) can be found on Aquatic Toxicology Laboratory chain of custody record 00277.

Toxicity assessments and chemical water quality analyses of the water samples were made following standard operating procedures provided in the Environmental Sciences Divisions Toxicology Laboratory Quality Assurance Program (QAP-X-89-ES-002). The toxicity assessments were made using 7-d static-renewal tests based on the survival and fecundity of *Ceriodaphnia dubia* (SOP 10); these procedures are similar to those described by Weber et al. (1989). The chemical water quality measurements, including assessments of pH, conductivity, alkalinity, hardness and dissolved oxygen used procedures described in SOP 11; these methods follow procedures approved by the Environmental Protection Agency (EPA).

Results and discussion. The results of the *Ceriodaphnia* tests conducted during the first two test periods are summarized in Table C2.33. In each of these tests, the control was acceptable and survival of the daphnids was consistently greater than 60%. However, statistically significant reductions in *Ceriodaphnia* reproduction were detectable (based on Tukey's test) in at least one of the WAG 5 sites in each test period, suggesting the presence of chronic toxicity. Water from sites 4 and 9 are considered to show good evidence for chronic toxicity.

The results of the third toxicity test, which was used to assess water from WAG 5 site 6, are summarized in Table C2.34. In this test, the animals had relatively low survival (50%), but the daphnids that survived had moderately high reproduction (21.2 ± 1.5 offspring per female). In ambient testing situations, such as that used for assessing the surface water and seepage water samples from WAG 5, the probability of getting a *Ceriodaphnia* survival value less than or equal to 60% is only about 1.5% in tests where survival in the control is 80% to 100% (Stewart and Kszos 1991). Thus, the results of the site 6 test could be considered to be equivocal. However, ambient tests conducted concurrently with the site 6 test (including tests of filtered and nonfiltered water from the outfall of Lake Reality, a settling basin at the Oak Ridge Y-12 Plant) had high survival and very high reproduction (cf. Table C2.34). Thus, in comparison to the test results for the two Lake Reality samples, the water from site 6

(WAG 5) might be considered to be toxicologically problematic. The results of a confirmatory test probably would reduce uncertainty about this possibility.

Data for the chemical water quality factors measured during the three toxicity test periods are summarized in Tables C2.35, C2.36 and C2.37. Rain events occurred between the second and third sampling days during the first test period. A temporary dilution of conservative water quality factors (such as conductivity, alkalinity and hardness) was caused by the rainfall; this situation resulted in greater variation of these factors during the February test than during the December test (Table C2.35 versus C2.36). With each site-date sample considered individually, none of the sites had pH, conductivity, alkalinity or hardness levels that would be expected to adversely affect *Ceriodaphnia* survival or reproduction, based on much experience in ambient and effluent testing with this organism. Additionally, the concentrations of dissolved oxygen in the water samples was, in every instance, over 7 mg/L. A concentration of oxygen of 7 mg/L is high enough to be non-limiting to *Ceriodaphnia*. Thus, none of the measured water quality factors, singly or in combination, appeared to be sufficient to importantly lower either the survival or reproduction of *Ceriodaphnia*. This consideration suggests that reductions in either survival or reproduction in these tests could provide reliable evidence for acute or chronic toxicity, respectively.

C2.3.3 Biological Survey Data

C2.3.3.1 Earthworm bioaccumulation survey

Earthworms were collected from several areas within and around WAG 5 to determine if contaminants in the soil were bioavailable and to establish site-specific contaminant uptake factors. These contaminant uptake factors will be used to estimate contaminant body burdens in earthworms from each of the six areas being assessed. Estimated earthworm contaminant body burdens will then be used to estimate contaminant exposure experienced by vermivorous wildlife in each of the six areas.

Materials and methods. Earthworms were collected from six locations, three contaminated (05.SB008, 05.SB046, and 05.SB049) and three uncontaminated (05.SB057, 05.SB062 and 05.SB063), as determined by USRADS radiological data. Five locations were within the WAG 5 boundary and one just outside the fenced area (Fig C2.4).

Earthworms and soil were collected at each location. Earthworms were collected using a mustard-water solution as an expellant, similar to the method described by Gunn (1992). The expellant solution consisted of 1 teaspoon dry mustard (Colman's English Mustard) per L deionized water. At each of the six locations, a 25 m² area was delineated into 10 by 10 sample grid. Earthworms were collected from multiple 0.25 m² sites within the sample grid. A stainless steel frame (50 X 50 X 10 cm) was inserted into the ground to demarcate the sample area and to contain the expellent. Percent vegetation or litter cover was estimated then removed. Approximately three liters (3 L) of mustard-water expellent were then slowly applied with a watering can. The application rate was approximately equal to the infiltration rate to prevent puddling of the expellent. As they emerged from the soil, earthworms were collected using stainless steel entomological forceps. Collection continued for twenty minutes; The number of individuals expelled per minute was recorded.

Soil sampling followed earthworm sampling and consisted of composite samples collected with 2 inch hand augers to a depth of 6 inches at the lower left corner of and adjacent to

each earthworm sample site. Physical and chemical properties of soil, including cation exchange capacity, total organic carbon, soil temperature, texture, soil moisture (tension) and soil pH, were measured at each location.

Upon collection, each earthworm was rinsed in the field with DI water to remove soil and expellent, placed in a clean plastic petri dish, and set in a cooler with ice. To identify each earthworm, petri dishes were marked with sample location as a soil boring (05.SB0XX), grid number (1-100), collection date and a unique accession number. Information was recorded in controlled field and laboratory field logbooks. Earthworms were transported under a custody seal to the laboratory where they were weighed, moistened, and placed in an incubator ($20^{\circ}\text{C} \pm 2^{\circ}\text{C}$) for a 4 day gut depuration period. Depurate was harvested on the first and fourth day after collection (day 1 and 4). Earthworms which expired before three full days of depuration, were not used in tissue samples. However, earthworms that lived for three days of depuration but found dead on the fourth day, were used in the composite tissue sample. Earthworms are considered dead if they do not respond to a gentle mechanical stimulus to the front end. On day four, earthworms were weighed and composited in designated sample containers. Before shipping and analysis, all tissue samples were fully homogenized in a clean stainless steel blender. The composited soil, tissue and depurate samples were frozen until analysis.

Composite samples of soil and earthworm tissues were analyzed for concentrations of gamma-emitting radio-isotopes (K-40, Co-60, and Cs-137), gross Beta, radioactive strontium, trace metals, and PCBs and pesticides. Similar analyses were performed on the composite depurate samples, except radiological analysis was omitted due to insufficient depurate volume.

Results. Physical and chemical soil properties and juvenile-adult ratios for each sampling location are presented in Table C2.38. Results of earthworm tissue, soil, and depurate analyses are listed in Attachment A. In all analyses, observations with laboratory qualifiers of B, J, P, or JP were used as reported. Observations with the laboratory qualifier of U were excluded from all analyses.

To determine if locations where earthworms were collected were truly contaminated or uncontaminated, soil contaminant concentrations from each location were compared to the 2 x mean background concentrations (Table C2.39). A total of 11 contaminants (Aroclor 1254, Aroclor 1260, Cd, Co-60, Cs-137, Cu, Hg, Mg, Mn, Se, and Radioactive strontium) found in soil samples from WAG 5 exceeded twice background concentrations. At four locations (05.SB008, 05.SB046, 05.SB049, and 05.SB063) from 2 to 7 contaminants were more than twice background concentrations. At location 05.SB057, while cadmium concentrations exceeded background, the concentration was substantially below, soil benchmarks (Will et al. 1994a and b). Only at one location (05.SB062) was contaminant below 2 x background levels for all contaminants. These results indicate that at least four of the six sampling locations should be considered contaminated.

Earthworms accumulated concentrations of Ag, Aroclor 1260, Be, Cd, Hg, K, Na, Se, and Zn to levels greater than that found in soil (Table C2.40). Aroclor 1254, Co-60, Ni, Tl, and

V were not detected in earthworms in WAG 5, despite detection of these contaminants in the soil.

Soil-earthworm uptake factors were determined in two ways. First, simple linear regressions of earthworm tissue contaminant concentrations on soil concentrations were performed using data from all six locations. Significant linear relationships were observed for only three analytes: copper, lead and manganese. Results of these regressions are listed in Table C2.41. Using this information, contaminant concentrations in earthworm tissue may be predicted using the following equation:

$$C_{\text{worm}} = m (C_{\text{soil}}) + b$$

where:

C_{worm} = contaminant concentration in earthworm tissue

m = slope

C_{soil} = contaminant concentration in soil

b = intercept

Soil-earthworm uptake factors for all other contaminants were determined by dividing the concentration in earthworm tissue by the concentration in soil. Mean soil-earthworm uptake factors using data from all six locations are presented in Table C2.42.

C2.3.3.2 Fish

Existing data (i.e., fish community structure, bioaccumulation, and bioindicators) for fish communities inhabiting White Oak Creek and Melton Branch, reported in this section, were derived from the *Biological Monitoring and Abatement Program 1994 Annual Report* (Ashwood 1994).

C2.3.3.2.1 Fish community surveys

Fish community data for the exposed communities provide evidence concerning the effects of contaminants. Fish community data were obtained in White Oak Creek and Melton Branch by electrofishing techniques. Surveys were conducted by Biological Monitoring and Abatement Program personnel in spring and fall from 1985 through 1993 (Ryon 1989, 1992a, 1992b; Ryon and Schilling 1990, 1991; Schilling and Ryon 1992; Schilling 1993a; and Schilling 1994). A detailed discussion of the methods and results from 1993 surveys are found in Ashwood (1994). Sampling sites in this assessment included White Oak Creek and Melton Branch only.

The assessment endpoints for fish communities are species richness and production. Overall species richness in White Oak Creek is less than that found in other area streams (Ryon and Loar 1988). The families Catostomidae and Percidae, in addition to the genera *Lythrurus*, *Luxilus*, *Notropis*, *Noturus*, and *Phoxinus* are missing from White Oak Creek (with the exception of the single collection of a striped shiner in spring 1992 at WCK 2.3). Historic records of White Oak Creek indicate the presence of these families and genera

(Krumholz 1954). The disappearance of these fish may be a result of not only poor water quality, but also the construction of White Oak Dam, which is a barrier to immigration from the remainder of the Clinch River basin. The presence of weirs and dams in the White Oak Creek system may prevent upstream migration and access for fish recolonization following toxic episodes. Slightly higher species richness was found at WCK 2.3 which may be a result of its proximity to White Oak Lake.

Fish community production is indicated by density, biomass and annual production estimates of fish. Estimated fish densities have exhibited natural variation from spring to fall at most sites in White Oak Creek watershed. Typically, density in the fall tends to be higher due to fish reproduction. Density was higher at all sites in the fall, except MEK 1.4 and WCK 2.9 in spring of 1992 and MEK 2.1 in fall 1993 (MEK 2.1 due to low water flow conditions).

WCK 3.9 has experienced substantial increases in estimated fish densities throughout the 7-year sampling time period. The total estimated fish densities (9.70 and 27.55 individuals/m²) and biomass (27.97 and 46.31 g/m²) were highest at WCK 3.9 in spring and fall of 1993. Estimated densities have increased substantially from 1989 (when no fish were found) to high densities in 1993 (Fig. C2.5). The increase in fish population densities and biomass, may be attributed to continued improvements in water quality from pollution abatement projects (i.e., decrease in chlorine concentrations through elimination of point source discharge; and/or contaminant dilution, and nutrient enrichment due to Non-Radiological Waste Treatment Facility (Schilling 1993b). The central stoneroller is responsible for the increased density and biomass at this site. Blacknose dace (fall only) and the central stoneroller exhibited the expected length-frequency distribution of normal populations in 1992 (Schilling 1993a) and 1993 (Schilling 1994).

Total fish densities at WCKs 2.3, 2.9 and 3.4 have displayed similar trends since 1985. All three sites have shown a slight increase in density since fall 1991 and an increase in seasonal variability (Fig. C2.6).

Total density (0.3 and 1.7 individuals/m²) and biomass (10.49 and 17.06 g/m²) increased at WCK 2.3 from spring to fall 1993 demonstrating similar seasonal variability since spring 1991. Density decreased at WCK 2.3 from spring 1992 to spring 1993, but the 1993 values were within the ranges from previous years (Fig. C2.6). The dominant fish species in terms of density at WCK 2.3 in 1993 were the central stoneroller, western mosquitofish, redbreast sunfish, and bluegill. The central stoneroller comprised 70% of the total fish density in fall 1993 at WCK 2.3 as compared to 42% in fall 1992 and 4% in fall 1991. The central stoneroller did not exhibit the expected length-frequency distribution of a normal population but normal populations of redbreast sunfish, bluegill and western mosquitofish were present at WCK 2.3 in 1993.

Total density (0.77 and 1.36 individuals/m²) and biomass (10.8 and 13.34 g/m²) at WCK 2.9, during spring and fall 1993, were similar to values since fall 1991 (Fig. C2.6). The central stoneroller was not collected at WCK 2.9 in fall 1990 but represented 16% and 65% of the fall fish community density in 1991 and 1992, respectively. In fall 1993, the central stoneroller represented 64% of the fish community density. It appears that the central stoneroller

population may be stable as the density has remained fairly constant and an expected length-frequency distribution of a normal population of the central stoneroller was present in 1993 (Schilling 1994) and 1992 (Schilling 1993b). The redbreast sunfish was also a dominant species in terms of density but did not have the expected length-frequency distribution of a normal population.

Total density (2.18 individuals/m²) at WCK 3.4 in fall of 1993 is similar to densities obtained since fall 1992. Biomass decreased slightly (17.16 g/m² to 14.3 g/m²) from spring to fall 1993. Densities since fall 1992 were greater than previous years (excluding fall 1986) (Fig. C2.6). The increase in the numbers of central stonerollers at WCK 3.4 accounts for the increases in density and biomass. The central stoneroller and the western mosquitofish were the dominant species in terms of density and exhibited the expected length-frequency distributions of normal populations.

Total density (1.21 and 1.71 individuals/m²) and biomass (3.01 and 2.58 g/m²) at WCK 6.8 (reference site) were similar from spring to fall in 1993. These values were similar to previous years, although decreased slightly from 1992 to 1993. The blacknose dace (the most abundant fish species at WCK 6.8) exhibited the expected length-frequency distribution of a normal population. This site appears to sustain a relatively stable community of fish, demonstrating a small degree of natural variability. Fish density has not changed substantially since 1985 (Fig. C2.5).

Density was higher at MEK 0.6 (3.99 individuals/m²) during fall 1993 than any sample since the fall 1987 (Fig. C2.7). Biomass decreased slightly at MEK 0.6 (10.52 to 9.60 g/m²) from spring to fall 1993. The length-frequency distribution of the most abundant fish species at MEK 0.6 (blacknose dace) did not reflect that of a balanced population. Redbreast sunfish and creek chub exhibited the length-frequency distribution of a balanced population.

Density at MEK 1.4 (3.63 individuals/m²) in fall 1993 was higher than densities obtained in previous years. Biomass at MEK 1.4 (4.8 to 3.09 g/m²) decreased from spring to fall 1993. At MEK 1.4 neither the blacknose dace nor the creek chub exhibited the length-frequency distribution of a balanced population.

Density (1.68 to 0.01 individuals/m²) and biomass (2.13 to 0.03 g/m²) at MEK 2.1 (reference site) decreased from spring to fall 1993. The density and biomass at MEK 2.1 was the lowest of all sites during fall 1993. This decrease in density at MEK 2.1 can be associated with low water flow conditions. The expected length-frequency distributions of a normal populations of fish were observed for both blacknose dace and creek chub in 1993.

Total annual production rates ranged from 22.66 to 2.02 g wet wt/m²/year (WCK 3.9 and MEK 2.1, respectively). Annual production rates decreased downstream for White Oak Creek and Melton Branch (Table C2.43).

Although fish community data provides evidence concerning the effects of contaminants, many other factors can influence community structure. Habitat, food availability (i.e.,

periphyton biomass), presence of riparian vegetation, weir barriers, and temperature may be other factors influencing species composition, density, and biomass.

C2.3.3.2.2 Fish bioaccumulation data

Results reported in previous annual reports (Loar 1989, 1990, 1991, 1992a,b; Sect. 4 in Ashwood 1993) indicated that the ORNL complex was a source of mercury and PCB contamination to fish in White Oak Creek. No other organic contaminants, including polycyclic aromatic hydrocarbons (PAHs), other pesticides, and acid/base neutral semivolatiles, were detected at substantial concentrations in fish from White Oak Creek. Despite evidence of past (Loar 1992b, Sect. 4.1.1) and current discharges of copper and zinc to White Oak Creek (Table 3.17 in Loar 1992b; Table 2.5 in Ashwood 1994), concentrations of metals (other than mercury) in fish from seven sites in the White Oak Creek watershed were similar to concentrations in fish from an uncontaminated reference stream.

Mercury concentrations in fish from most White Oak Creek sites were elevated over the concentrations found in fish from reference streams in winter 1992/1993. Mercury contamination in White Oak Creek sunfish has remained relatively stable since 1986. Sources of mercury to the White Oak Creek system have been identified, but they are not associated with WAG 5 (Rogers et al. 1989).

Concentrations of PCBs in White Oak Creek sunfish appear to have decreased since monitoring began in 1987. However, in more recent years PCB concentrations in sunfish appear to have stabilized. The continued presence of PCBs in sunfish throughout White Oak Creek suggest that White Oak Creek continues to receive PCB inputs from sediments or discharges somewhere in upper White Oak Creek downstream of the main facility.

C2.3.3.2.3 Biological indicators of contaminant-related stress in fish

Assessment of overall health of the redbreast sunfish (*Lepomis auritus*) population provides an indication of the health of the White Oak Creek system. Sampling was conducted in White Oak Creek between WCKs 2.2 and 2.7 and in three reference streams, Brushy Fork, Hinds Creek, and Paint Rock Creek. Assessing the overall health of the redbreast sunfish population in White Oak Creek involved analysis of functional bioindicator response groups (i.e., detoxification enzyme induction, organ dysfunction, histopathology) for fish sampled in 1992, comparison of integrated bioindicator responses between 1989 and 1992, evaluation of reproductive and developmental competence in fish, and population-level analyses. Serum chemical, histopathological, detoxification enzyme, reproductive and developmental, and population analyses were conducted on redbreast sunfish. Fish embryo-larval toxicity tests were evaluated using medaka (*Oryzias latipes*). A detailed discussion of methods employed and results of each bioindicator analysis are described in Ashwood 1994.

Summary and synthesis. Individual bioindicator responses and the results of the integrated site analysis continue to suggest that the fish populations in White Oak Creek are being affected by stressors in that system. Based on the integrated site analysis, however, there is convincing evidence to suggest that environmental conditions in White Oak Creek

have improved over the period of the last 4 years (1989–1992). The integrated responses of White Oak Creek fish have progressively and consistently moved closer to the integrated responses reference site responses indicating an improvement in the health of the redbreast sunfish population over this period.

It appears that the overall reproductive condition of redbreast sunfish in White Oak Creek shifted between 1989 and 1993 towards a condition more typical of redbreast sunfish populations in the reference streams. The incidences of oocyte atresia in the prespawning ovaries of redbreast sunfish in White Oak Creek also dropped steadily from 1989 through 1993. Taken together, these results are suggestive of improving water quality in White Oak Creek during the course of this study period.

Results of the population-level studies showed that growth of the three major age classes of redbreast sunfish in White Oak Creek exceeded that of sunfish in each of the three reference streams. The higher growth could be due to a variety of interacting factors, such as greater food availability, lower population density, favorable temperature regimes, or greater overall system productivity. A similar growth pattern was observed in a redbreast sunfish population in the Pigeon River, where decreased recruitment due to reproductive impairment caused a reduction in population size and resulted in decreased competition and increased resource availability (Adams et al. 1992a). With increased food and habitat availability, more energy was available for growth of survivors in the Pigeon River.

The cumulative results of a series of medaka embryo-larval tests conducted since 1991 on water from various sites in the White Oak Creek watershed are shown in Fig. C2.9. It is clear from these results that a significant source of toxicity to medaka embryos exists between WCKs 5.1 and 4.4 (see Fig. C2.8 for approximate sampling locations), and that the toxic effect persists and appears to be amplified throughout the remainder of White Oak Creek and White Oak Lake. Previous studies have suggested that the initial source of this embryotoxic effect lies in a stretch of stream near the Holyfield Heavy Ion facility. Included in this reach of the stream are a number of outfalls, although only one of these (outfall 313) is significant in terms of flow. Outfall 313 has been identified previously as a major source of total recoverable chlorine to White Oak Creek (Ashwood 1994).

C2.3.3.3 Benthic macroinvertebrates

The benthic macroinvertebrate communities in White Oak Creek watershed were evaluated quarterly by Biological Monitoring and Abatement Program personnel since 1988. Benthic macroinvertebrates were collected at 15 stream sites in White Oak Creek watershed including White Oak Creek, Melton Branch, First Creek, Fifth Creek, and Northwest Tributary. The uppermost site on each stream served as a reference site. Density, taxonomic richness, and combined richness of Ephemeroptera, Plecoptera, and Tricoptera taxa (EPT richness) were assessed to determine adverse impacts in the White Oak Creek watershed. Methods employed, results, and conclusions are discussed in detail in Ashwood (1994).

Adverse changes in benthic invertebrate community structure are evident at all sites in the White Oak Creek system that are downstream from ORNL discharges. In general, impacts

are manifest primarily as a loss of numbers of sensitive (EPT) taxa and low densities of the representatives of that group which are present. Total density of benthic invertebrates shows little response to ORNL discharges. The most severe impact appears to be at WCK 3.9, where sensitive fauna (mayflies, stoneflies, and caddisflies) are virtually absent, and total taxonomic richness is approximately 1/2 that typically observed in unimpacted streams. The invertebrate fauna at that site is dominated by midges (Chironomidae).

The remaining sites in White Oak Creek were clearly less impacted than WCK 3.9, primarily reflected in a higher number of EPT taxa. This index nevertheless remained well below the pooled reference site values, ranging from 5.0 to 5.3 at WCKs 5.1, 3.4, 2.9, and 2.3 versus 11.3 to 17.0 in the 5 upstream reference sites. Mean total taxonomic richness at these White Oak Creek sites ranged from 16.3 to 18.7 (WCKs 3.4 to 2.3, respectively), an improvement of 1 to 4 taxa over WCK 3.9.

Mean total taxonomic richness and EPT richness in Melton Branch (MEKs 1.2 and 0.6) were lower than reference site means, but were higher than at impacted sites in White Oak Creek, Fifth Creek, and First Creek. The downstream increase in Chironomidae dominance and total density in Melton Branch suggests nutrient enrichment as a possible factor affecting benthic communities in this stream.

The ecological impacts apparent in benthic invertebrate communities in the White Oak Creek system could arise from a number of causes, including thermal discharges, nutrient enrichment, residual chlorine and perhaps other toxicants, increased sediment loading, and changes in major ion chemistry. The most severely impacted site (White Oak Creek 3.9) is downstream from sources of chlorine associated with process water discharges. The lowermost sites in Melton Branch and White Oak Creek exhibited high densities of benthic invertebrates and very high measures of Chironomidae dominance, suggesting effects of nutrient enrichment.

C2.4 RISK CHARACTERIZATION

Risk characterization integrates the results of the exposure assessment (Sect. C2.2) and effects assessment (Sect. C2.3) to estimate risks (the likelihood of effects given the exposure) based on each line of evidence, and then applies a weight of evidence inference logic to determine the best estimate of risk to each assessment endpoint. The principal lines of evidence concerning effects are biological survey data that indicate the actual state of the receiving environment, media toxicity data which indicate whether the contaminated media are toxic under controlled conditions, and single chemical toxicity data which indicate the toxic effects of the concentrations measured in site media. Procedurally, the risk characterization is performed for each assessment endpoint by (1) screening all measured contaminants against toxicological benchmarks and background concentrations, (2) estimating the effects of the contaminants retained by the screening analysis, (3) estimating the toxicity of the ambient media based on the media toxicity test results, (4) estimating the effects of exposure on the endpoint biota based on the results of the biological survey data, (5) logically integrating the lines of evidence to characterize risks to the endpoint, and (6) listing and discussing the uncertainties in the assessment.

C2.4.1 Risk Characterization for Contaminant Screening

Risk characterization must begin with a screening of contaminants to identify those that require more detailed assessment. This is done in two steps: screening against background and screening against benchmarks.

In the screening against the benchmarks portion of risk characterization, the chemical concentrations measured in soil, surface water, sediment, and earthworms (Sect. C2.2) are compared to ecotoxicological benchmarks (Sect. C2.3.1.) to derive hazard quotients by the formula

$$\text{Hazard quotient} = \text{media concentration} / \text{toxicological benchmark}.$$

Hazard quotients (HQs) greater than 1 suggest that the chemical is hazardous to the endpoint biota and therefore worthy of further assessment, and HQs less than 1 suggest that the chemical is nonhazardous and need not be considered further. The ecotoxicological benchmarks are described in Sect. C2.3.1.1.

In the screening against the background portion of risk characterization, the contaminant concentrations are compared to concentrations at uncontaminated reference sites. Many of the contaminants commonly found during a remedial investigation (RI) also occur naturally in the environment. The concentrations of these chemicals found at the reference sites are assumed to be nonhazardous. To ensure that risk management decisions are based on the risks posed by site contaminants, the reference constituents must be differentiated from the site-associated contaminants. The maximum detected contaminant concentration, or the upper 95% confidence limit, was used for detected analytes at WAG 5. These were compared to the twice-mean (mean value $\times$ 2) for the analyte from the background sites. If the analyte concentration from WAG 5 was greater than the twice-mean background value, this analyte was retained as a potential contaminant.

The contaminant screening is performed for each endpoint population or community. Some endpoints have multiple routes of exposure (e.g., surface water, soil, food) and have more than one set of applicable benchmarks (e.g., both water and sediment benchmarks are applicable to benthic invertebrates). With the exception of the wildlife benchmarks, each source medium in each reach was screened separately against the appropriate benchmarks. For wildlife, the potential routes of exposure were integrated in the benchmark screening procedure.

C2.4.1.1 Risk characterization from contaminant toxicity

The contaminants are screened to determine which contaminants are potentially toxic to the endpoint biota, but this approach does not indicate what effects would be expected to occur. Therefore, the next step in the assessment is a comparison of the distributions in space or time of concentrations in the medium being considered to the distributions of effects with increasing concentration derived from the literature. Depending on the endpoint, the exposure is expressed variously as a range, a sample mean, and a 95% upper confidence limit on the population mean. For each contaminant, the effects are expressed as increasing intensity of effects and increasing numbers of species or processes affected as exposure increases. Integration of these two distributions results in a distribution of possible types and levels of effects which will be expressed as a most likely effect and a reasonable maximum effect on the endpoint. This characterization must also consider the form and speciation of the contaminants in the toxicity studies and in the media on the site to ensure that the most appropriate toxicity data are used.

C2.4.1.2 Risk characterization from media toxicity tests

Risk characterization for the media toxicity tests involves interpretation of the test results in terms of the exposures experienced by the endpoint biota in the field. That is, the durations of the tests relative to the duration of field exposures, the level of contamination at the times and locations sampled relative to the ranges of contamination found in the media analyses, and the influence of sample preparation on the exposure are used to help interpret the effects seen in the tests as indicators of toxic effects in the field. In some cases, there are validation studies for the media toxicity tests that can be used to help interpret the test results in terms of field effects.

C2.4.1.3 Risk characterization from biological surveys

Risk characterization for the biological survey data involves interpretation of the survey results in terms of the exposures experienced by the surveyed biota. For example, if the exposure levels and the surveyed community characteristics change over time, do the survey results include the period of maximum effects, and, if not, what might those maximum effects be? It also involves interpretation of the survey data in terms of the endpoint definitions. That is, are the survey data consistent with types and levels of effects prescribed in the definition of the assessment endpoints?

C2.4.1.4 Weight of evidence

Risk characterization requires that all of the available evidence be weighed to estimate risks. Three distinct lines of evidence are potentially available for assessing risks of contaminants to the ecological assessment endpoints. They are single chemical toxicity data,

media toxicity data, and biological survey data. The weighing of alternative lines of scientific evidence is always a matter of professional judgment. However, some general concepts and concerns are always applicable, and use of a common format for presenting the weight of evidence provides clarity and consistency. This section explains how the different lines of evidence are weighed to estimate ecological risks first by discussing the considerations that may lend weight to or diminish weight for a particular line of evidence and then by discussing inference logic.

Biological surveys

Biological survey data indicate the true state of the receiving environment. That is, they indicate how the actual organisms, populations, and communities of the site have responded to the actual spatial and temporal patterns of exposure to contaminants and other environmental variables. Ideally, biological survey data would be sufficient to determine whether the endpoint effects have or have not occurred, and the other lines of evidence would be used to determine causation. However, the following considerations may limit the interpretation of biological survey data.

1. The survey data may not be sufficiently detailed to determine whether the endpoint has been exceeded. For example, a vegetation survey may only indicate that a particular vegetation type occurs on the site and not whether species are missing or whether production has been diminished.
2. The survey may not be replicated in time and therefore may be biased by temporally variable factors such as drought or a chlorine release that caused a fish kill.
3. Biological surveys depend on comparison of the exposed community to reference communities. Reference communities may differ from the waste-exposed community for any of a variety of reasons. A regional reference based on surveys of multiple undisturbed communities provides a more reliable basis for inference, but variance within the reference community set may mask real effects.
4. Biological surveys measure the responses of populations and communities to all of the characteristics of the environment, not just contaminants. Because the investigator has no control over exposures, it is not possible to distinguish the influences of various factors and infer causation from these data.

For these reasons, biological surveys may not serve to accurately estimate effects on the endpoint populations and communities.

Media toxicity

Toxicity tests conducted with ambient media serve to indicate whether the water, sediment, or soil in question are toxic to particular organisms in particular exposures. They have the considerable advantage of indicating the combined toxicity of all contaminants in a medium and of incorporating the effects of the physical-chemical properties of the receiving medium as it occurs at the site. However, certain limitations must be considered when interpreting medium toxicity data.

1. The toxicity of media varies over time due to various factors including changes in the

flux rate of contaminants from sources, the relative proportions of contaminants, and the dilution volume of the receiving medium. Therefore, the tests may miss episodic toxicity, or may, by chance, represent episodic nontoxicity. This is clearly a greater concern for water than for sediments or soils.

2. The toxicity of a medium may be modified by the manner in which it is collected and handled. Volatile contaminants may be lost, highly soluble contaminants may be lost from sediments by drainage and replacement of water, and pH and oxidation states may change.
3. The test may not be sufficiently sensitive. That is, species at the site may be more sensitive than test species, life stages not included in the test may be more sensitive, responses not measured in the tests may be both more sensitive and critical to population or community performance, or responses may require more time to appear than is allowed by the test. Validation studies for the standard 7-d aqueous toxicity tests confirm that, in general, statistically significant community level effects are detected in biological surveys when test results are positive and are not detected when test results are negative, but the correspondence of test thresholds to thresholds for field effects is unclear at best (Dickson et al. 1992). Comparable validation studies are unavailable for toxicity tests with other media.
4. The test may not be of adequate quality. Protocols, including quality standards, are well defined for the standard aqueous toxicity tests, so the quality of the resulting data are well specified. However, the protocols and quality standards for other tests are not as well defined. In general, low test quality will tend to obscure toxic effects rather than causing false toxic responses.

For these reasons, it is more likely that toxicity will be undetected by the tests than that apparent toxicity in the tests will be either false or irrelevant. Therefore, a positive result from a medium toxicity test (i.e., detection of toxicity) is more conclusive than a negative result. If test organisms exhibit significant reductions in survival, growth, or reproduction in the tests, it is likely that toxic effects occur in the field. However, the conditions of the tests, the numeric results, and the comments of the test performers should be carefully considered for signs of unreliable positive or negative results.

Single chemical toxicity (media analyses)

Comparison of ambient contaminant concentrations to concentrations of contaminants causing toxic effects is the traditional method of risk characterization. However, it is fundamentally less reliable than biological survey data for determining responses in the receiving environment and is less reliable than media toxicity tests for determining the toxicity of media. However, traditional toxicity data are useful for suggesting what contaminants are responsible for effects detected in biological surveys or for toxicity observed in media toxicity tests. When biological surveys and media toxicity data are unavailable or unreliable, risk characterization must be based on this line of evidence alone. Certain limitations must be considered when interpreting chemical toxicity data.

1. Combined toxic effects of contaminants are not considered.
2. The test medium may have very different physical and chemical properties from those in the receiving environment.
3. The form of the contaminant in the test may have been very different from that in the receiving environment. Chemicals in the environment may differ in their speciation, ionization, or sorption from their state in the test.
4. The species and life stages in the tests may not be as sensitive as those at the site, and important toxic responses may not have been measured.
5. The durations of the tests may not have been sufficient to reveal effects of chronic exposures.
6. These test results are applied to exposure estimates based on analyses of ambient media. These analyses may miss periods of high concentration in temporally variable media or locally high concentrations in spatially variable media. Additionally, they may have limits of detection that are above toxic concentrations.
7. For wildlife, exposure estimation requires modeling contaminant consumption in food, soil, and water. These models may have significant inaccuracies.

These factors may tend to induce either false positive or false negative results.

Single chemical toxicity data (body burdens)

Contaminant concentrations in earthworms and other organisms are measured primarily for the purpose of estimating risks to organisms that consume them. However, if data are available concerning the toxicity of body burdens, they can be used to estimate risks to the analyzed organisms. This approach is potentially more reliable than the use of media concentrations, because analysis of body burdens bypasses assumptions about sources of exposure, rates of intake, and uptake efficiency. The chief restriction on this approach is the lack of good exposure-response relationships for exposures expressed as body burdens.

1. If significant toxic effects are occurring, the organisms that are available in sufficient abundance to be sampled and analyzed are not likely to be those that have the highest body burdens because the highly exposed species will be absent or have reduced abundance.
2. The organisms sampled may have been chosen for reasons other than their level of exposure (e.g., species likely to be consumed by humans, abundant species), so they may not represent the most exposed species or trophic group.
3. The tissues analyzed may not be those analyzed in the toxicity studies.
4. Treatments of the organisms or tissues prior to analysis may make the test data less relevant. Examples include washing and depuration.

Inference procedure

The first step in inference by weight of evidence is to summarize the evidence. We use a simple table that lists in the first column the lines of evidence; in the second column, the table presents a symbol to indicate whether the evidence is consistent with occurrence of the endpoint effect (+), is inconsistent with occurrence of the endpoint effect (-), or is too ambiguous to interpret ($\pm$). The third column provides a brief narrative summary of the results that justify the scoring. A table is prepared for each ecological assessment endpoint.

The second step is to determine whether the weight of evidence is consistent with the occurrence of the effect specified in the definition of the assessment endpoint (i.e., is there a significant risk that a real effect is occurring or will occur?). If there are no inconsistencies in the scores of the lines of evidence or if there is only one line of evidence, no weighing is required. If there are inconsistencies, we use a variation on Chapman's (1990) sediment quality triad to resolve them (Table C2.44). The conclusions presented in that table are appropriate if all data are of high quality (e.g., procedures are well specified, validated, and carried out; replication and distribution in space and time are adequate; tests have adequate sensitivity; and control media and reference sites are appropriate for comparison). Therefore, alternative conclusions are considered based on the relative strengths and weaknesses of the studies based on the factors discussed previously. In addition, Table C2.44 is based on the assumption that all three lines of evidence are available. If there are two lines of evidence, the inference process is analogous.

The third step is to describe the nature and magnitude of effects that are believed to occur as a result of weighing the evidence. That is, the risk characterization must indicate what types and magnitudes of effects are estimated to occur for those endpoints and locations where effects in excess of the endpoint level are determined to occur and the possible range of effects given uncertainties.

The final step is determination of causation. To a large extent, the inference concerning the occurrence of real effects also addresses the issue of causation. However, it is necessary to consider which of the sources is responsible for the estimated effects. These may be ongoing releases from an identifiable source or in situ contaminants from historic releases. These inferences may be based on known sources of individual contaminants or on the spatial distribution of effects relative to sources and pathways. In addition, when effects have been inferred primarily from biological survey results, causes other than contaminants may be credible such as low flows, poor substrate quality, or other habitat features.

C2.4.1.5 Uncertainties

Following the characterization of risks to each of the ecological assessment endpoints, uncertainties that may affect the conclusions of the assessment are listed and, as far as possible, quantified.

C2.4.1.6 Threatened and endangered species

No T&E plant or animal species are currently known to occur on WAG 5 (see Sect. B1.7.3); therefore, WAG 5 is not believed to present a risk to T&E species. Special studies

may need to be performed to evaluate risks to T&E species, should they become established on or use WAG 5 in the future.

C2.4.2. Risk Characterization for Current Conditions

C2.4.2.1. Plants

C2.4.2.1.1. Terrestrial Plants

The evidence concerning risks to terrestrial plants consists of soil toxicity test data and analyses of chemicals in soil. These lines of evidence are summarized in the following text.

Single Chemical Toxicity

Contaminants of potential concern (COPCs) in soils of WAG 5 were identified by comparing maximum site concentrations to the concentrations in appropriate ORR reference (background) soils. (Background values used were the same as those considered in the Human Health Risk Assessment, see Table 2a in Section C1). Chemicals were rejected from further consideration if maximum concentrations were not above twice the mean of the background (TMBG) levels.

As discussed in Section C2.2.2., plants are exposed to the full range of contaminants in the soil over their life span. To be protective of plants in highly contaminated locations, the maximum reported detected concentrations of the COPCs in each area of WAG 5 were compared to the available phytotoxicity benchmarks. Hazard quotients were calculated by dividing the maximum concentration in soil by the toxicity benchmark concentration. Benchmarks, maximum concentrations of analytes in soils exceeding background for which benchmarks are available, and hazard quotients for these contaminants are given in Table C2.45. Maximum concentrations of analytes in soils for which no benchmarks are available, and background concentrations for these contaminants are given in Table C2.46. Risk characterization for current conditions will be discussed below by area within WAG 5. Toxicological profiles for contaminants are given in Section C2.3.1.2.

SWSA 5 South. The maximum detected manganese, mercury and selenium concentrations were 9, 10, and 2 times the benchmarks, i.e. concentrations causing toxic effects when added to surface soil (Wallace et al. 1977b, Kloke 1979, Carlson et al. 1991). The maximum concentration of antimony slightly exceeded the benchmark concentration.

The mean concentration Mn in the soil samples, 1380 ppm, was over twice the 500 ppm concentration causing toxic effects but less than the TMBG concentration (2,400 ppm). The mean and maximum Mn concentrations were within the reported range of <2 to 7000 ppm Mn in unpolluted soils of the eastern United States (Shacklette and Boerngen, 1984). Although the maximum concentration of Hg (4.3 ppm) exceeded the 0.3 ppm concentration causing toxic effects and the TMBG concentration (0.59 ppm), the mean value for Hg, 0.07 ppm, did not. This mean is within the range of Hg concentrations reported in unpolluted soils of the eastern U.S. (<0.01-3.4 ppm). Although the maximum concentration of Sb (6.2 ppm) exceeded the benchmark, the mean value for Sb, 4.4 ppm, did not. The maximum and mean Sb concentrations exceeded the TMBG concentration (0.44 ppm), however, they are within the range of Sb concentrations reported in unpolluted soils of the eastern U.S. (<1 - 8.8 ppm)

(Shacklette and Boerngen 1984). Although the maximum concentration of Se (2 ppm) exceeded the 1 ppm concentration causing toxic effects, the mean value for Se, 0.53 ppm, did not exceed the benchmark or the TMBG concentration (1.3). Both the maximum and mean concentrations are within the range of Se concentrations reported in unpolluted soils of the eastern U.S. (<0.1-3.9 ppm) (Shacklette and Boerngen 1984). Risk to plant growth posed by these contaminants is probably low due to their low bioavailability in soil and the fact that concentrations are generally within those reported for unpolluted surface soils in the eastern U.S.

Radioactivity from many radionuclides was greater than measured in background soils. Concentrations of many organic contaminants were greater than measured in background soils. We have no data with which to assess the risk posed by radioactivity and these organic compounds to plant growth.

OHF. The maximum detected cobalt, manganese, and silver concentrations were 3, 8, and 3 times the benchmarks, i.e. concentrations causing toxic effects when added to surface soil (Wallace et al. 1977a, Wallace et al. 1977b, Linzon 1978). The mean concentration Co in the soil samples from OHF (23 ppm) was less than the TMBG concentration (37 ppm) and over twice the mean of 9.2 ppm reported in unpolluted soils of the eastern U.S. (Shacklette and Boerngen 1984). The mean concentration Mn in the soil samples (1210 ppm) was less than the TMBG concentration (2400 ppm) and twice the mean of 640 ppm Mn reported in unpolluted soils of the eastern U.S. (Shacklette and Boerngen, 1984). Both maximum (4000 ppm) and mean Mn concentrations at OHF were within the range reported in these soils (<2 - 7000 ppm) (Shacklette and Boerngen 1984). The mean concentration of silver in soil of OHF, 0.74 ppm, did not exceed the concentration reported to cause toxic effects in plants or the TMBG concentration (4 ppm). No values for Ag were reported in Shacklette and Boerngen (1984).

Risk to plant growth posed by these contaminants is probably low due to their low bioavailability in soil and the fact that concentrations are generally within those reported for unpolluted surface soils in the eastern U.S.

Radioactivity from many radionuclides and concentrations of cyanide and acetone were greater than measured in background soils. However, data to assess their effects on plants are not available.

TRU. There were no contaminants at concentrations exceeding concentrations causing toxicity. Radioactivity from Th-228, Th-232, and tritium was greater than measured in background soils.

PWSB. There were no contaminants at concentrations exceeding concentrations causing toxicity. Radioactivity from many radionuclides was greater than measured in background soils.

NHF. There were no contaminants at concentrations exceeding concentrations causing toxicity. Radioactivity from many radionuclides was greater than measured in background soils.

WAG 5 Wide. The maximum detected mercury and zinc concentrations were 10 and 6 times the benchmarks, i.e. concentrations causing toxic effects when added to surface soil (Kloke 1979; Lata and Veer 1990). The mean value for Hg at WAG 5 Wide, 0.24 ppm, did not exceed concentrations causing toxicity in soil or the TMBG concentration (0.59 ppm).

This mean is within the range of Hg concentrations reported in unpolluted soils of the eastern U.S. (<0.01-3.4 ppm) but above the mean for these data of 0.12 ppm (Shacklette and Boerngen 1984). Both the maximum detected concentration and the mean (186 ppm) are above the TMBG concentration (120 ppm) but within the range of Zn concentrations reported in unpolluted soils of the eastern U.S. (<9 - 2900 ppm)(Shacklette and Boerngen, 1984). The maximum Zn concentration was measured in a landfill area which represents a very small portion of the WAG 5 Wide area. Zn was not measured above background at the other WAG 5 Wide soil sampling site. Risk to plant growth posed by these contaminants is probably low due to their low bioavailability in soil and the fact that concentrations are generally within those reported for unpolluted surface soils in the eastern U.S.

Radioactivity from many radionuclides was greater than measured in background soils. The source of these contaminants may be the wastes buried at SWSA 5 South and TRU.

Medium Toxicity Data

To evaluate the toxicity of WAG 5 soils to plants, a laboratory toxicity test was performed using cabbage grown from seed for 14 d in soil from SWSA 5 South. The results of the test must be considered inconclusive because no information is available concerning the contaminant concentrations in the media actually tested. The field samples emitted radioactivity at levels too high for available laboratory facilities, therefore, the samples were diluted with an unreported amount of undefined soil material for the toxicity tests. This resulted in unusable data. The reported characteristics of the test and reference media (Section C2.3.2.1) suggest the possibility that physical characteristics, such as bulk density and water holding capacity, may have influenced the results of the seedling test (height and biomass). We have no confidence that the tests evaluated the effects of contaminants in site soils at site-specific concentrations on seedling growth.

Biosurvey Data

While qualitative observations indicate that WAG 5 is vegetated in grass or deciduous forest, no quantitative survey or chemical analyses of vegetation were performed to assess possible negative effects on the terrestrial plant population resulting from exposure to soil contaminants. A winter survey of the vegetation associated with potentially impacted seeps indicated no noticeably reduced plant growth other than that expected due to the season.

Weight of Evidence

A summary of the weight of evidence for risk to wetland plants posed by contaminated seeps in WAG 5 is given in Table C2.47. Due to the low availability to plants of the contaminants in WAG 5 soils, risk to plant growth posed by these chemicals is probably low. However, because benchmark concentrations of the contaminants are associated with

significant reductions in plant production in controlled tests, site concentrations exceeding those benchmarks cannot be dismissed without further investigation as to contaminant bioavailability. There are also many organic chemicals and radionuclides for which there are no benchmarks. We have no confidence that the soil toxicity tests evaluated the effects of contaminants in site soils at site-specific concentrations on seedling growth. Because there was no quantitative survey or chemical analyses of vegetation done, media toxicity test data is inconclusive, and there are no benchmarks for many of the contaminants, we cannot fully assess the effect of the mix of chemicals in soils of WAG 5 on plant growth. The fact that WAG 5 is vegetated, except where roads and other facilities occur, and that the vegetation does not have a conspicuously different composition from other woodlands and lawns on the ORR suggests that any phytotoxic effects are not catastrophic. Therefore, we can state that plant production has been reduced by less than 100%, but because the plant toxicity tests could not be completed due to safety concerns, we cannot be certain that effects are less than 20%.

C2.4.2.1.2 Wetland plants

Contaminant Screening of Seep Discharge

Contaminants of potential ecological concern in seeps of WAG 5 were identified by comparing maximum site concentrations to the concentrations in reference seeps. (Background values were the same as those used in the Human Health Risk Assessment. See Table 2d in Sect. C1.) Chemicals were rejected from further consideration if maximum concentrations were not above twice the mean of the background levels.

Wetland plants are exposed to the full range of contaminants in the soil pore water and surface water over their lifespan. To evaluate the toxicity to wetland plants of contaminants in seeps, the maximum concentrations in each seep of WAG 5 were compared against phytotoxicity benchmarks for plants grown in solution culture. Sample preparation for metals analysis includes acidification to pH 2. In unfiltered water samples (i.e., containing soil and organic particles), acidification will bring into solution metals strongly bound to this particulate matter. These metals, especially Al, Fe, and Mn, are not readily available to plants growing in wetlands. The total exposure of plants to metals in the seep discharge is thus overestimated by using chemical concentration values from acidified, unfiltered seep water samples. The benchmarks, on the other hand, are derived from experiments in which chemicals are in dissolved form. Interpretation of comparison to benchmarks must be made carefully. There are no background values for comparison to seep drainage chemical concentrations. To further place the seep contaminant concentrations in perspective they are also compared to the calculated median of the effects data (ER-M) for the specific contaminant.

Hazard quotients were calculated by dividing the maximum concentration in seep water by the toxicity benchmark concentration. Benchmarks for plants growing in solution, maximum concentrations of analytes in seeps exceeding background for which benchmarks are available, and HQs for these contaminants are given in Table C2.48. Maximum concentrations of analytes in seeps for which no benchmarks are available, and background concentrations for these contaminants are given in Table C2.49. Risk characterization for current conditions will be discussed below by individual seep. Toxicological profiles for contaminants are given in Sect. C2.3.1.2.

Seep 1. The maximum detected aluminum in unfiltered seep drainage was five times

the concentration of 0.2 ppm causing toxicity in solution culture (Wheeler and Follett 1991). Maximum concentration of Al in filtered Seep 1 drainage did not exceed this concentration. Based on the low bioavailability of particle-bound Al, there is little likelihood that the plants are at risk from Al. Radioactivity from beta particles, Th-232, and tritium were greater than measured in background seeps. As with upland plants (Sect. C2.4.2.1.1), there are no data that allow assessment of effects of radiation in the rooting medium on plants.

Seep 2. The maximum detected aluminum in unfiltered seep drainage was twice the concentration of 0.2 ppm causing toxicity in solution culture (Wheeler and Follett 1991). Maximum concentration of Al in filtered Seep 2 drainage did not exceed this concentration. Based on the low bioavailability of particle-bound Al, there is little likelihood that the plants are at risk from Al. Radioactivity from alpha and beta particles were greater than measured in background seeps.

Seep 3. The maximum detected aluminum in unfiltered seep drainage was 20 times the concentration of 0.2 ppm causing toxicity in solution culture (Wheeler and Follett 1991). Maximum concentration of Al in filtered Seep 3 drainage did not exceed this concentration. Based on the low bioavailability of particle-bound Al, there is little likelihood that the plants are at risk from Al. Radioactivity from the following were greater than measured in background seeps: Alpha and beta particles, tritium, U-233/234, and U-238.

Seep 4. There were no contaminants at concentrations exceeding those found to be toxic to plants growing in solution. Radioactivity from beta particles, tritium and Ra-228 were greater than measured in background seeps. Maximum concentrations of barium, 1,2-dichloroethene, and trichloroethene were greater than background, but there are no phytotoxicity data for these chemicals.

Seep 5. The maximum detected aluminum in unfiltered seep drainage was 12 times the concentration of 0.2 ppm causing toxicity in solution culture (Wheeler and Follett 1991). Maximum concentration of Al in filtered Seep 5 drainage did not exceed this concentration. Based on the low bioavailability of particle-bound Al, there is little likelihood that the plants are at risk from Al. Radioactivity from beta particles and tritium were greater than measured in background seeps. Maximum concentrations of barium, sodium, 1,2-dichloroethene, and trichloroethene were greater than background.

Seep 6. There were no contaminants at concentrations exceeding those found to be toxic to plants growing in solution. Radioactivity from alpha and beta particles, and tritium were greater than measured in background seeps. Maximum concentrations of barium and sodium were greater than background.

Seep 7. The maximum detected aluminum and iron in unfiltered seep drainage were 30 and 2 times the concentrations of 0.2 and 10 ppm causing toxicity in solution culture (Wheeler and Follett 1991; Wallihan 1966). The maximum detected manganese concentration in unfiltered drainage was slightly over the toxic concentration of 4 ppm. Maximum concentration of Al in filtered Seep 7 drainage (0.6 ppm) was lower than in the unfiltered sample (5.8 ppm) but still exceeded toxic concentrations. The maximum concentration of Al in filtered seep drainage is lower than the concentration of 3.6 ppm representing the median of the effects data for Al in solution. Maximum concentrations of Fe and Mn in filtered Seep 7 drainage did not exceed concentrations known to be toxic to plants grown in solution. Based on the low bioavailability of particle-bound Fe and Mn, there is little likelihood that

the plants are at risk from these elements. Based on the low availability of particle-bound Fe and Mn and comparison of the maximum concentration of Al in filtered drainage with the ER-M for Al in solution, we conclude that the plants affected by Seep 7 are not likely to be at risk from contaminants in that seep.

Radioactivity from alpha and beta particles, and tritium were greater than measured in background seeps. Maximum concentrations of barium, sodium, and 1,2-dichloroethene were greater than background.

Seep 8. There were no contaminants at concentrations exceeding those found to be toxic to plants growing in solution. Radioactivity from alpha and beta particles, U-233/234, and tritium were greater than measured in background seeps. Maximum concentration of sodium was greater than background.

Seep 9. The maximum detected aluminum and manganese concentrations in unfiltered seep drainage were seven and two times the concentrations of 0.2 and 4 ppm causing toxicity in solution culture (Wheeler and Follett 1991; Wong and Bradshaw 1982). Maximum concentration of Mn in filtered drainage did not exceed this concentration. Maximum concentration of Al in filtered Seep 9 drainage (0.3 ppm) was lower than in the unfiltered sample (1.4 ppm) and still exceeded benchmark. However, it was lower than the concentration of 3.6 ppm representing the median of the effects data for Al in solution. Based on the low availability of particle-bound Mn and comparison of the maximum concentration of Al in filtered drainage with the ER-M for Al in solution, we conclude that the plants affected by Seep 9 are not likely to be at risk from contaminants in that seep. Radioactivity from beta particles and tritium were greater than measured in background seeps. Maximum concentrations of barium, sodium, and 1,2-dichloroethene were greater than background.

Seep 11. There were no contaminants at concentrations exceeding those found to be toxic to plants growing in solution. Radioactivity from beta particles, Ra-228, and tritium were greater than measured in background seeps. Maximum concentrations of barium, sodium, and alpha- and delta-BHC were greater than background.

Seep 12. The maximum detected aluminum concentration in unfiltered seep drainage was four times the concentrations of 0.2 ppm causing toxicity in solution culture (Wheeler and Follett 1991). Maximum concentration of Al in filtered Seep 12 drainage did not exceed this concentration. Based on the low availability of particle-bound Al we conclude that the plants affected by Seep 12 are not likely to be at risk from Al in that seep. Radioactivity from beta particles and tritium were greater than measured in background seeps. Maximum concentrations of barium, sodium, and 1,2-dichloroethene were greater than background.

Seep 14. The maximum detected aluminum concentration in unfiltered seep drainage was ten times the concentrations of 0.2 ppm causing toxicity in solution culture (Wheeler and Follett 1991). Maximum concentration of Al in filtered drainage did not exceed this concentration. Based on the low availability of particle-bound Al we conclude that the plants affected by Seep 14 are not likely to be at risk from Al in that seep. Radioactivity from beta particles and tritium were greater than measured in background seeps. Maximum concentrations of barium, sodium, 1,2-dichloroethene, trichloroethene, and tetrachloroethene, vinyl chloride were greater than background.

Seep 15. The maximum detected cobalt and manganese concentrations in unfiltered

seep drainage were five and two times the concentrations of 0.06 and 4 ppm causing toxicity in solution culture (Wallace et al. 1977a; Wong and Bradshaw 1982). Maximum concentrations of Mn and Co in filtered Seep 15 drainage (5.8 and 0.2 ppm) were lower than in the unfiltered sample (7.9 and 0.3 ppm). This Mn concentration was lower than the ER-M concentration of 37 ppm for this element. The concentration of nickel was essentially the same between the two samples (0.3 ppm), almost equal the benchmark concentration but lower than the 2 ppm ER-M concentration. Because there was very little experimental data on which to base a conclusion about the potential toxic effects of Co, this metal must remain one of concern. Based on comparisons of Mn and Ni seep drainage concentrations with concentrations representing the median of the effects data for those elements, we conclude that the vegetation affected by drainage from Seep 15 is not likely to be at risk from these metals in the seep.

Radioactivity from alpha and beta particles, Ra-228, Th-234, U-233/234, U-238, and tritium were greater than measured in background seeps. Maximum concentration of sodium was greater than background.

Seep 16. The maximum detected aluminum concentration in unfiltered seep drainage was 60 times the concentration of 0.2 ppm causing toxicity in solution culture (Wheeler and Follett 1991). The maximum detected iron concentration in unfiltered seep drainage slightly exceeded the concentration of 10 ppm causing toxicity to plants grown in solution (Wallihan 1966). Maximum concentrations of Al and Fe in filtered drainage did not exceed toxic concentrations, therefore, we conclude that the vegetation affected by Seep 16 are not likely to be at risk from Al and Fe in the drainage. Radioactivity from alpha and beta particles and tritium were greater than measured in background seeps. Maximum concentration of barium was greater than background.

Seep 17. The maximum detected aluminum, iron, and manganese concentrations in unfiltered seep drainage were all twice the concentrations of 0.2, 10, and 4 ppm causing toxicity in solution culture (Wheeler and Follett 1991; Wallihan 1966; Wong and Bradshaw 1982). Maximum concentration of Al in filtered Seep 17 drainage did not exceed, and that of Fe was about the same as, their respective benchmark concentrations. Maximum concentration of Mn (10 ppm) in filtered drainage exceeded its benchmark but not the ER-M concentration of 28 for the literature toxicity data. Based on the low availability of particle-bound Al and Fe and comparison of the maximum concentration of Mn in filtered drainage with the ER-M for Mn in solution, we conclude that the plants affected by Seep 17 are not likely to be at risk from contaminants in that seep. Radioactivity from beta particles and tritium were greater than measured in background seeps. Maximum concentration of barium and sodium were greater than background.

Media toxicity data

There were no media toxicity tests performed to assess the effects of water-borne contaminants on wetland plants.

Biosurvey data

A wetland vegetation survey was performed to identify and list plants rather than to assess possible negative effects on the wetland plant population resulting from exposure to contaminants in WAG 5 seeps. A comparison of the plant communities in the seep areas of

WAG 5 to reference (i.e., unpolluted) may indicate reduced growth or absence of sensitive species at WAG 5.

Weight of evidence

A summary of the weight of evidence for risk to wetland plants posed by contaminated seeps in WAG 5 is given in Table C2.50. The contaminants found in Seeps 1 and 2 may originate in the TRU burial grounds. Contaminants in the remainder of the seeps may originate in the SWSA 5 South burial grounds.

Although the maximum concentrations of several elements in filtered seep drainage of exceed the calculated benchmark concentrations for plants grown in solution culture, comparisons of seep concentrations with the ER-M values from the literature data indicate a general lack of risk to the wetland vegetation. Cobalt in Seep 15 may be at high enough concentrations to negatively impact vegetation and there are chemicals for which we have no benchmarks. The seriousness of any negative effects of seep-derived elements may be mediated by the fact that the seeps are small and intermittently wet during the year. The plants are may be receiving part of their water from soil water not fully impacted by the seep drainage. A winter survey of the potentially impacted seeps turned up no evidence of negative impacts on the vegetation. Therefore, we conclude that, except possibly in the case of Co in Seep 15, we see no evidence that the seep vegetation of WAG 5 is at risk from contaminants in the seeps.

C2.4.2.2 Soil invertebrates

The evidence concerning risks to earthworms consists of soil toxicity test data, analyses of chemicals in soil, and biosurvey data (numbers of earthworms retrieved and body burdens). These lines of evidence are summarized in the following text.

Single chemical toxicity

Contaminants of potential concern (COPCs) in soils of WAG 5 were identified by comparing maximum site concentrations to the concentrations in appropriate ORR reference (background) soils identified in the ORR Background Soils Characterization Project. Chemicals were rejected from further consideration if maximum concentrations were not above twice the mean of the background levels.

As discussed in Sect. C2.2.2, soil invertebrates are exposed to the full range of contaminants in the soil over their entire lifespan. To be protective of soil invertebrates in highly contaminated locations, the maximum reported detected concentration of the COPCs in each area of WAG 5 were compared to the available benchmarks for toxicity of soil-borne contaminants to earthworms. Hazard quotients were calculated by dividing the maximum concentration in soil by the toxicity benchmark concentration. Benchmarks for earthworms, maximum concentrations of analytes in soils exceeding background for which benchmarks are available, and HQs for these contaminants are given in Table C2.45. Maximum concentrations of analytes in soils for which no benchmarks are available, and background concentrations for these contaminants are given in Table C2.46. Risk characterization for current conditions will be discussed below by area within WAG 5. The bioavailability in soil of contaminants over benchmarks is discussed in Sect. C2.4.1.1.1.

SWSA 5 South. The maximum detected mercury concentration (4.3 ppm) was 40 times

the concentration of inorganic mercury likely to cause reduced survival and cocoon production in earthworms (Abbasi and Soni 1983) but below the 6.5 ppm concentration representing the ER-M for the toxicity data. Based on these data, Hg in soils of SWSA 5 South may be at levels that place the soil invertebrate populations at risk.

Concentrations of many organic contaminants were greater than measured in background soils. Radioactivity from many radionuclides was greater than measured in background soils. Total exposure to alpha, gamma, and beta external and internal radiation exceeded the IAEA general terrestrial biota threshold level of 42 $\mu\text{Gy/h}$ in SWSA 5 South only (Sect. C2.2.2.1.2). This value is not specifically for exposure earthworms but refers to a dose of radiation at which reproduction in a generic terrestrial animal is not negatively affected. There is no experimental data on effects of radiation on earthworm reproduction, growth, and survival from which to derive a benchmark or confirm this threshold for earthworms.

OHF. There were no contaminants at concentrations exceeding concentrations toxic to earthworms in soil. Radioactivity from many radionuclides was greater than measured in background soils. The estimated radiation dose did not exceed the IAEA recommended value. Concentrations of cyanide and acetone were greater than measured in background soils.

TRU. There were no contaminants at concentrations exceeding concentrations toxic to earthworms in soil. Radioactivity from Th-228, Th-232, and tritium was greater than measured in background soils. The estimated radiation dose did not exceed the IAEA recommended value.

PWSB. There were no contaminants at concentrations exceeding concentrations toxic to earthworms in soil. Radioactivity from many radionuclides was greater than measured in background soils. The estimated radiation dose did not exceed the IAEA recommended value.

NHF. There were no contaminants at concentrations exceeding concentrations toxic to earthworms in soil. Radioactivity from many radionuclides was greater than measured in background soils. The estimated radiation dose did not exceed the IAEA recommended value.

WAG 5 Wide. The maximum detected concentrations of mercury (4.3 ppm) and zinc (321 ppm) were 40 and 1.5 times the concentrations of inorganic mercury (0.1 ppm) and zinc (200 ppm) likely to cause reduced survival and cocoon production in earthworms (Abbasi and Soni 1983; Spurgeon et al. 1994). The mean value for Hg at WAG 5 Wide, 0.24 ppm, still exceeded concentrations causing toxicity in soil, but is below the 6.5 ppm concentration representing the ER-M for the toxicity data and within the range of Hg concentrations (<0.01–3.4 ppm) reported in unpolluted soils of the eastern United States (Shacklette and Boerngen 1984). Both the maximum detected concentration at WAG 5 Wide and the mean (186 ppm) are below the 1100 ppm concentration representing the ER-M for the toxicity data and within the range Zn concentrations (<9–2900 ppm) reported in unpolluted soils of the eastern United States (Shacklette and Boerngen 1984). The maximum Zn concentration was measured in a landfill area which represents a very small portion of the WAG 5 Wide area. Zn was not measured above background at the other WAG 5 Wide soil sampling site. Risk to soil invertebrate survival and reproduction posed by Zn is probably low due to the low bioavailability in soil and the foregoing comparisons. Mercury in soils of WAG 5 Wide may be at levels that place the soil invertebrate populations at risk.

Radioactivity from many radionuclides was greater than measured in background soils. The estimated radiation dose did not exceed the IAEA recommended value. The concentration of Aroclor 1260 was greater than measured in background soils.

Media toxicity data

To evaluate the toxicity of soil to soil-dwelling invertebrates, a laboratory toxicity test was performed using *Eisenia foetida*. The results of the test must be considered inconclusive because no information is available concerning the contaminant concentrations in the media actually tested. The field samples emitted radioactivity at levels too high for available laboratory facilities; therefore, the samples were diluted with an unreported amount of undefined material for the toxicity tests. This resulted in unusable data. Although the tests found no effect on earthworm growth and survival, we have no confidence that the tests evaluated the effects of contaminants in site soils at site-specific concentrations on earthworms.

Biosurvey data

No rigorous biological survey was performed to assess possible negative effects on the soil invertebrates resulting from exposure to contaminants in WAG 5 soils. However, earthworms in the vicinity of SWASA 5 South and WAG 5 Wide were sampled for chemical analysis as described in Sect. C2.3.3.1. A comparison of the numbers of earthworms retrieved during a defined sampling period at the contaminated and reference sites gives an indication of the effects of contaminants on earthworm populations in these portions of WAG 5. Results of this sampling (Table C2.36) showed average earthworm densities in SWSA 5 South and WAG 5 Wide sampling locations (22 and 42 earthworms per 0.25 m²) to be approximately 40 and 70% the average density in reference sites (60 earthworms per 0.25 m²).

Concentrations of contaminants in earthworms collected from WAG 5 were measured. A limited amount of information is available relating chemical body burdens to toxic effects in earthworms. Mean chemical concentrations in earthworms in soils of SWSA 5 South and WAG 5 Wide for contaminants with concentration factors greater than 1 were (in ppm dry weight earthworm): Aroclor 1260, 1.6; Ag, 13.8; Be, 1.25; Cd, 3.5; Hg, 0.87; Se, 7.8; and Zn, 371.8. No information was available for silver or beryllium.

Van Hook (1974) measured concentrations of Cd in depurated earthworms collected in six unpolluted soils on the ORR. The mean concentration of Cd in the earthworms was approximately 6 ppm (dry weight depurated), and the range was 3.1 to 9.3 ppm. The mean concentration of Cd in earthworms from contaminated sampling locations was less than this mean and at the low end of the range. Furthermore, reproduction and growth of *E. foetida* in OECD artificial soil was not affected at 115 ppm Cd (dry weight basis) in the depurated earthworm (van Gestel et al. 1993).

Zinc uptake by earthworms is extremely variable. Van Hook (1974) measured a mean Zn concentration of about 317 ppm (range 93 to 502 ppm) in earthworms from unpolluted soils of the ORR. The average earthworm concentration at contaminated sampling sites of SWSA 5 South and WAG 5 Wide was slightly higher than this mean but well within the range of concentrations. However, van Gestel et al. (1993) found inhibition of reproduction (cocoon production) of *E. foetida* associated with a body concentration of 150 ppm Zn (van Gestel et al. 1993).

Beyer et al. (1987) and Beyer and Cromartie (1987) report depurated earthworm concentrations of 16, and a trace to 2.5 ppm (dry weight basis) in natural soils. The mean of 0.87 ppm Hg found in the contaminated SWSA 5 South and WAG 5 Wide soils is within this range. Little information is available on the relationship between earthworm Hg concentration and toxicity. Segment regeneration was severely reduced by a depurated body concentration of approximately 500 ppm Hg (dry weight basis) as methyl mercury (Beyer et al. 1985). The WAG 5 earthworm Hg body burdens are much lower than this toxic concentration.

Concentrations reported in earthworms from contaminated soils of SWSA 5 South and WAG 5 Wide do not appear to be excessive compared to concentrations in unpolluted soils reported in the literature or compared to those generally reported to be associated with toxic effects. However, concentrations of Zn in earthworms lower than those found in SWSA 5 South and WAG 5 Wide are associated with reduced reproduction (van Gestel et al. 1993).

Weight of evidence

A summary of the weight of evidence for risk to soil invertebrates posed by contaminated soils in WAG 5 is given in Table C2.51. The isolated occurrence of high soil Zn concentration in the area of an old landfill lead to the conclusion that the Zn concentrations of WAG 5 soils do not generally pose a threat to invertebrate populations. Single chemical toxicity data indicates that mercury exists in soils of SWSA 5 South and WAG 5 Wide areas to pose a risk to soil invertebrate populations in those areas. Mercury may be the cause of reduced earthworm densities at sampling sites in these two areas. Many organic chemicals and radionuclides for which there are no benchmarks occur at concentrations greater than background in the WAG 5 Wide and SWSA 5 South areas. Total radioactivity exceeded IAEA recommended dose for terrestrial biota in the SWSA 5 South area. There is high uncertainty, but the weight of evidence indicates significant risk to soil invertebrate populations in SWSA 5 South and WAG 5 Wide soils. There are no biosurvey data for the other areas, however, calculated radiation dose was below the IAEA threshold and single chemical toxicity data did not indicate toxicity.

C2.4.2.3. Soil microorganisms and microbial processes

Contaminant screening of soil

Contaminants of potential concern (COPCs) in soils of WAG 5 were identified by comparing maximum site concentrations to the concentrations in appropriate ORR reference (background) soils identified in the ORR Background Soils Characterization Project. Chemicals were rejected from further consideration if maximum concentrations were not above twice the mean of the background levels.

As discussed in Sect. C2.2.2, soil microbes are exposed to the full range of contaminants in the soil over their entire lifespan. To be protective of soil microorganisms in highly contaminated locations, the maximum reported detected concentrations of the COPCs in each area of WAG 5 were compared to the available toxicity benchmarks for microorganisms and microbial processes in soil. Hazard quotients were calculated by dividing the maximum concentration in soil by the toxicity benchmark concentration. Benchmarks for microbes in soils, maximum concentrations of analytes in soils exceeding background for which benchmarks are available, and HQs for these contaminants are given in Table C2.45. Maximum concentrations of analytes in soils for which no benchmarks are available, and

background concentrations for these contaminants are given in Table C2.46. Risk characterization for current conditions will be discussed below by area within WAG 5. The bioavailability in soil of contaminants over benchmarks is discussed in Sect. C2.4.1.1.1.

SWSA 5 South. The maximum detected manganese concentration was 50 times the concentration of 100 ppm causing reduced nitrogen transformations in soil (Premi and Cornfield 1969) and over three times the highest reported concentration reported as inhibiting enzymatic activity (Juma and Tabatabai 1977). There is no information available on the toxic effects of Mn in soils at concentrations approaching the maximum measured in SWSA 5 South soil (4700 ppm). The mean concentration Mn in the soil samples from SWSA 5 South was 1380 ppm, still over twice the 100 ppm concentration causing toxic effects, and exceeding the mean of 640 ppm Mn reported in unpolluted soils of the eastern United States. However, the SWSA 5 mean and maximum Mn concentrations were within the reported range of <2 to 7000 ppm (Shacklette and Boerngen 1984). Radioactivity from many radionuclides and concentrations of many organic contaminants were greater than measured in background soils.

OHF. The maximum detected manganese concentration was 40 times the concentration of 100 ppm causing reduced nitrogen transformations in soil (Premi and Cornfield 1969) and about three times the highest reported concentration reported as inhibiting enzymatic activity (Juma and Tabatabai 1977). There is no information available on the toxic effects of Mn in soils at concentrations approaching the maximum measured in OHF soil (4000 ppm). The mean concentration Mn in the soil samples from OHF, 1570 ppm, exceeded the mean of 640 ppm Mn reported in unpolluted soils of the eastern United States; however, the OHF mean and maximum Mn concentrations were within the reported range of <2 to 7000 ppm (Shacklette and Boerngen 1984). Radioactivity from many radionuclides was greater than measured in background soils. Concentrations of cyanide and acetone were greater than measured in background soils. Based on the low bioavailability of Mn in soil and comparisons to background concentrations in the eastern United States, we conclude that the soil microbial community is probably not at risk from Mn in these soils.

TRU. There were no contaminants at concentrations causing reduced microbial activity in soil. Radioactivity from Th-228, Th-232, and tritium was greater than measured in background soils.

PWSB. There were no contaminants at concentrations causing reduced microbial activity in soil. Radioactivity from many radionuclides was greater than measured in background soils.

NHF. There were no contaminants at concentrations causing reduced microbial activity in soil. Radioactivity from many radionuclides was greater than measured in background soils.

WAG 5 Wide. The maximum detected zinc concentration was three times the concentration of 100 ppm causing reduced enzyme activity in soil (Doelman and Haanstra 1986). Both the maximum detected concentration at WAG 5 Wide and the mean (186 ppm) are below the 1000 ppm concentration representing the median of the toxic effects data and within the range Zn concentrations (<9-2900 ppm) reported in unpolluted soils of the eastern United States (Shacklette and Boerngen 1984). The maximum Zn concentration was measured in a landfill area which represents a very small portion of the WAG 5 Wide area.

Zn was not measured above background at the other WAG 5 Wide soil sampling site. Risk to soil microbial activity posed by Zn is probably low due to the low bioavailability in soil and the fact that concentrations are generally within those reported for unpolluted surface soils in the eastern United States.

Radioactivity from many radionuclides was greater than measured in background soils. The concentration of Aroclor 1260 was greater than measured in background soils.

Media toxicity data

There were no media toxicity tests performed to assess the effects of soil-borne contaminants on microorganisms or microbial processes.

Biosurvey data

No biological survey was performed to assess possible negative effects on the soil microorganisms resulting from exposure to contaminants in WAG 5 soils.

Weight of evidence

The maximum manganese concentrations in soils of SWSA 5 South (4700 ppm) and OHF (4000 ppm) areas of WAG 5 exceed those at which significant inhibition of critical enzyme activities has been recorded in experiments with salts of the metals added to soil. The concentrations are, however, well within the range of those occurring in unpolluted soils of the eastern United States and cannot, therefore, be considered as likely to be toxic to microbial activity. The maximum zinc concentrations in soil of WAG 5 Wide (321 ppm) is within the range shown experimentally to inhibit several critical enzyme systems. Because this high concentration is not representative of the entire WAG 5 Wide area and is within the range of concentrations occurring in unpolluted soils of the eastern United States, it cannot be considered as likely to be toxic to microbial activity. Furthermore, the effects measured concentrations of Mn and Zn will be mediated by low bioavailability in soil. There are many chemicals and radionuclides for which there are no benchmarks, and we cannot assess the effect of the mix of chemicals in soils of WAG 5 on soil microorganisms. There is uncertainty, but from the above considerations, we conclude that contaminants in soils of WAG 5 are not likely to pose a threat to microbial populations or processes.

C2.4.2.4 Vermivorous wildlife

Screening of contaminants against benchmarks

Estimates of contaminant exposure under the current case scenario are available only for the WAG 5 Wide area of WAG 5 (see Sect. C2.2.2.1.4). To determine if the contaminant exposures experienced by American woodcock and short-tailed shrew in the WAG 5 Wide area of WAG 5 are potentially hazardous, the total contaminant exposure estimates (Tables C2.4 and C2.5) were compared to estimated NOAELs for these species (Tables C2.21 and C2.22). To quantify the magnitude of hazard, a hazard quotient (HQ) was calculated where $HQ = \text{exposure}/\text{NOAEL}$. Hazard quotients greater than 1 indicate that individuals may be experiencing exposures that are in excess of NOAELs and suggest that adverse effects may be occurring. Hazard quotients for American woodcock and short-tailed shrew in the WAG 5 Wide area of WAG 5 are presented along with the exposure estimates in Tables C2.4 and C2.5. To determine if the total radionuclide dose is potentially hazardous, dose estimates from

Sect. C2.2.2.1.4.4 were compared to the maximum value recommended by IAEA (1992), 42 $\mu\text{Gy/h}$.

American woodcock. Exposure estimates for six contaminants—barium, chromium, lead, mercury, zinc, and di-*n*-butyl phthalate—were both greater than background and produced HQs >1 for American woodcock in the WAG 5 Wide area of WAG 5 (Table C2.4). The estimated radiation dose did not exceed the IAEA recommended value.

Short-tailed shrew. Exposure estimates for four contaminants—barium, mercury, zinc, and Aroclor 1254—were both greater than background and produced HQs >1 for short-tailed shrews in the WAG 5 Wide area of WAG 5 (Table C2.5). The estimated radiation dose did not exceed the IAEA recommended value.

Estimated effects from retained contaminants

Exposure models and toxicological benchmarks used in this assessment focus on exposure and effects experienced by individual organisms, but except for threatened and endangered species, all of the wildlife endpoints for the ORR are for populations (Suter et al. 1994). The use of organism-level exposures and effects is appropriate because of the need to integrate exposure estimates with exposure-response information which is expressed as organism-level responses. However, the conversion of individual exposure to population effects must occur in the risk characterization.

Conceptually, the conversion of organism level exposures to the population level can be made as follows. It may be assumed that there is a distinct population on the site so that the exposure of the population is the exposure of all of the individuals. This assumption is appropriate for small organisms on large sites, particularly if the site constitutes a distinct habitat that is surrounded by inappropriate habitat. For example, a grassy site surrounded by forest or industrial development might support a distinct population of voles. The risks to that population can be estimated directly from the exposures of the individual organisms. Because the WAG 5 Wide area contains appropriate habitat and is large (approximately 12 ha) in relation to the home range of shrews (0.39 ha), a distinct population may exist in the area, and exposure and effects experienced by individuals may be assumed to be representative of that experienced by the population. In the case of woodcock, because they have larger home ranges and are more mobile, it is unlikely that a distinct WAG 5 Wide or even WAG 5 population exists. Population effects for woodcock must be assessed on an ORR-wide scale. Information from WAG 5 can only be used to identify the exposure and effects that may be experienced by individual woodcocks that use WAG 5.

Barium. Barium exposure experienced by shrews in the WAG 5 Wide area is 1.7 times greater than the estimated NOAEL and 4.8 times greater than an estimated LOAEL (for LOAELs, see Table C2.64). The NOAEL is based on a 16-month laboratory study considering growth and cardiovascular effects among rats (Perry et al. 1983). The LOAEL is based upon short-term study in which a 30% increase in mortality was observed among rats fed barium chloride for 10 d (Borzelleca et al. 1988). Because the study was subchronic in duration, the LOAEL was multiplied by a subchronic-chronic correction factor of 0.1 to estimate a chronic LOAEL.

Barium exposure experienced by woodcock in the WAG 5 Wide area is 1.5 times

greater than the estimated NOAEL but only 77.3 % of the estimated LOAEL. Both the NOAEL and the LOAEL are based upon a short-term study in which mortality was observed among chickens fed barium hydroxide for 4 weeks (Johnson et al. 1960). Because the study was subchronic in duration, both the NOAEL and LOAEL were multiplied by a subchronic-chronic correction factor of 0.1 to estimate the chronic NOAEL and LOAEL.

Estimated Ba exposure for shrews exceeded both the estimated LOAEL and NOAEL. Therefore, increased mortality may be observed among the population of shrews in the WAG 5 Wide area. While estimated Ba exposure for woodcock exceeded the estimated NOAEL, it did not exceed the estimated LOAEL. Therefore, adverse effects from Ba are not expected among woodcock in the WAG 5 Wide area.

Chromium. Chromium exposure experienced by woodcock in the WAG 5 Wide area is 5.8 and 1.16 times greater than the estimated NOAEL and LOAEL, respectively (for LOAELs, see Table C2.64). Both the NOAEL and the LOAEL are based upon a study in which reproductive success and offspring survival was observed among black ducks fed $\text{CrK}(\text{SO}_4)_2$ for 10 months (Haseltine et al., unpubl. MS). The study was considered to represent chronic exposure; therefore, a subchronic-chronic correction factor was not employed.

Estimated Cr exposure for woodcock exceeded both the estimated LOAEL and NOAEL. Therefore reduced reproductive success and offspring survival may be observed among individual woodcock in the WAG 5 Wide area.

Lead. Lead exposure experienced by woodcock in the WAG 5 Wide area is 2.6 times greater than the estimated NOAEL but only 86% of the estimated LOAEL (for LOAELs, see Table C2.64). The NOAEL based upon a 7-month laboratory study considering effects of lead on reproduction in American kestrels (Pattee 1984). The LOAEL is based upon a study in which a reduced egg hatchability was observed among Japanese quail fed lead acetate for 12 weeks (Edens et al. 1976). The study was considered to represent chronic exposure; therefore, a subchronic-chronic correction factor was not employed.

While estimated Pb exposure for woodcock exceeded the estimated NOAEL, it did not exceed the estimated LOAEL. Therefore, adverse effects from Pb are not expected among woodcock in the WAG 5 Wide area.

Mercury. Mercury exposure experienced by shrews in the WAG 5 Wide area is 9.1 and 1.8 times greater than the estimated NOAEL and LOAEL, respectively (for LOAELs, see Table C2.64). Both the NOAEL and the LOAEL are based upon a study in which reproductive success and offspring survival was observed among rats fed methyl mercury for three generations (Verschuuren et al. 1976a, 1976b, 1976c). The study was considered to represent chronic exposure; therefore, a subchronic-chronic correction factor was not employed.

Mercury exposure experienced by woodcock in the WAG 5 Wide area is 92 and 9.2 times greater than the estimated NOAEL and LOAEL, respectively. Both the NOAEL and the LOAEL are based upon a study in which reproductive success and offspring survival was observed among mallard ducks fed methyl mercury for three generations (Heinz 1979). The study was considered to represent chronic exposure; therefore, a subchronic-chronic correction factor was not employed.

Estimated Hg exposure for shrews and woodcock exceeded both the estimated LOAEL and NOAEL. Therefore, reduced reproductive success and offspring survival may be observed among the shrew population and individual woodcock in the WAG 5 Wide area as a result of Hg exposure.

Zinc. Zinc exposure experienced by shrews in the WAG 5 Wide area is 1.36 times greater than the estimated NOAEL but only 68% of the estimated LOAEL (for LOAELs, see Table C2.64). Both the NOAEL and the LOAEL are based upon a study in which reproductive success, fetal resorption, and fetal growth was observed among rats fed zinc oxide through the gestation period (Schlicker and Cox 1968). Because the study considered exposure through a critical lifestage (reproduction), it was considered to represent chronic exposure, and a subchronic-chronic correction factor was not employed.

Zinc exposure experienced by woodcock in the WAG 5 Wide area is 147.7 and 14.7 times greater than the estimated NOAEL and LOAEL, respectively. Both the NOAEL and the LOAEL are based upon a study in mortality that observed mallard ducks fed zinc carbonate for 60 d (Gasaway and Buss 1972). Because the study was subchronic in duration, both the NOAEL and LOAEL were multiplied by a subchronic-chronic correction factor of 0.1 to estimate the chronic NOAEL and LOAEL.

While estimated Zn exposure for shrews exceeded the estimated NOAEL, it did not exceed the estimated LOAEL. Therefore, adverse effects from Zn are not expected among shrews in the WAG 5 Wide area. Estimated Zn exposure for woodcock exceeded both the estimated LOAEL and NOAEL. Therefore, increased mortality may be observed among individual woodcock in the WAG 5 Wide area as a result of Zn exposure.

PCB (Aroclor 1254). Aroclor 1254 exposure experienced by shrews in the WAG 5 Wide area is 1.22 times greater than the estimated NOAEL but only 12% of the estimated LOAEL (for LOAELs, see Table C2.64). Both the NOAEL and the LOAEL are based upon a study in which reproductive success and litter size was observed among white-footed mice fed Aroclor 1254 for 18 months (Linzey 1987). The study was considered to represent chronic exposure; therefore, a subchronic-chronic correction factor was not employed.

While estimated Aroclor 1254 exposure for shrews exceeded the estimated NOAEL, it did not exceed the estimated LOAEL. Therefore, adverse effects from Aroclor 1254 are not expected among shrews in the WAG 5 Wide area.

Di-*n*-butyl phthalate. Di-*n*-butyl phthalate exposure experienced by woodcock in the WAG 5 Wide area is 1.18 times greater than the estimated NOAEL but only 11.5% of the estimated LOAEL (for LOAELs, see Table C2.64). Both the NOAEL and the LOAEL are based upon a study in which eggshell thickness and permeability was observed among ringed doves fed di-*n*-butyl phthalate for 4 weeks (Peakall 1974). Because the study considered exposure through a critical lifestage (reproduction), it was considered to represent chronic exposure, and a subchronic-chronic correction factor was not employed.

While estimated di-*n*-butyl phthalate exposure for woodcock exceeded the estimated NOAEL, it did not exceed the estimated LOAEL. Therefore, adverse effects from di-*n*-butyl phthalate are not expected among woodcock in the WAG 5 Wide area.

Media toxicity tests

No media toxicity tests were performed for vermivorous wildlife. Therefore, this line of evidence is unavailable.

Biological survey data

No biological surveys were performed for vermivorous wildlife. Therefore, this line of evidence is unavailable.

Weight of evidence

Only one line of evidence, literature toxicity data, was available to evaluate ecological risk to vermivorous wildlife. Using only comparisons to benchmarks, the data suggest that reproduction and abundance of the shrew population in the WAG 5 Wide area may be being adversely affected by barium and mercury. Reproduction and survival of individual woodcock in the WAG 5-wide area may be adversely affected by chromium, mercury, and zinc. Population effects, however, must be addressed at the ORR level. WAG 5 alone is unlikely to significantly impact the ORR-wide woodcock population. To evaluate effects to the ORR-wide population, exposure from multiple OUs must be considered.

C2.4.2.5. Fish

The evidence concerning risks to fish communities at WAG 5 consists of acute toxicity tests using *Ceriodaphnia dubia* and chemical analyses of water from drainages D1 (SW001) and D2 (SW002). There are no fish survey data for WAG 5 because there is no permanent fish habitat on the site. However, fish are believed to make use of drainages D1 and D2 during periods of high flow. The evidence concerning risks to fish is summarized below.

Media toxicity data

Survival of *Ceriodaphnia* during the standard 7-d toxicity tests of water from drainages D1 and D2 were not substantially different from controls. Both sites were tested twice, and survival was not reduced more than 20% for either site. Reproduction in water from D1 and D2 during the first test period was not significantly reduced relative to the corresponding control. During the second test period reproduction was significantly lower for D1. Reproduction in water from D2 was reduced, but not significantly relative to controls. Survival in the controls was 100% and controls for both test periods were characterized as acceptable. These results are presented in Table C2.33. Evaluation of mean reproduction values did not indicate that water from D1 or D2 adversely affected *Ceriodaphnia* during both test periods (Sect. C2.3.2.3).

Samples were collected daily for renewal and were not filtered prior to testing. As tested, the water should sufficiently represent the field exposures at the time of sampling. The tests were replicated but within the same season (December 1991 and February 1992) and without regard for storm events. Therefore, these results are reflective of conditions during high base flow and give no indication of exposures during storm or low base flow conditions. These results give no indication of lethality at drainages D1 or D2 during high base flow conditions. Given that reproduction was significantly reduced during only one test period at D1, these results provide some evidence for chronic toxicity at drainage D1 and no evidence for chronic toxicity at D2.

Contaminant screening of surface water

Contaminants of potential concern for risk to fish communities were identified by comparing contaminant concentrations in water to toxicological benchmarks (Sect. C2.3.1.1.5). At each site the four flow regimes (high base, low base, high base storm, and low base storm) were screened separately. For naturally occurring analytes the maximum detected concentration/activity was compared to twice the average concentration/activity at the reference site. The maximum detected value was used because only one result was available for most analytes. Contaminants that exceeded background, were not analyzed at the reference site, or are not naturally occurring were compared to benchmarks. Benchmarks which were less than mean background levels were not used. Hazard quotients were calculated for each contaminant. The numerator is the maximum detected concentration or activity in the water. The denominators are a set of toxicological benchmarks that reflect the variety of estimators of a toxicological threshold for aquatic ecological effects (Sect. C2.3.1.1.5). Only acute NAWQC values and secondary acute values are relevant for evaluating storm flow. That is, chronic effects from exposure during storms are unlikely because of the relatively short exposure duration. For each flow regime the absorbed radiation dose from all detected radionuclides was summed and compared to the recommended criterion. Quotients greater than 1 are indicative of a hazard that requires further assessment. Chemical and radiological screening results for these sites are presented in Tables C2.52 and C2.7, respectively.

Only total recoverable concentrations were determined for the background samples. Therefore, total recoverable concentrations were used for all sites so that metal and naturally occurring analytes could be screened against background. Total concentrations are more conservative because the bioavailable fraction is generally less than the total recoverable concentration. Metals, for example, typically include 30–95% particle-bound material (HECD 1992). Also, conventional toxicity data are based on laboratory studies using contaminants dissolved in filtered water. If the total recoverable concentration of a metal exceeded background, and at least one benchmark—the dissolved concentration—was also compared to benchmarks as a more realistic estimate of exposure. The results of these comparisons are presented in Table C2.53.

At drainage D1 total concentrations of three chemicals (aluminum, iron, and manganese) exceeded at least one benchmark during at least one flow regime. During high base flow conditions all three exceeded benchmarks, with aluminum and iron exceeding acute and chronic NAWQC, respectively. Dissolved phase concentrations of aluminum and iron did not exceed any benchmarks, including the NAWQCs. No analytes exceeded benchmarks during low base flow. During both the high and low base storm flow conditions at D1, only total aluminum exceeded benchmarks and only chronic non-NAWQC benchmarks were exceeded. The dissolved phase concentrations were below detection limits during high base storm flow, but were estimated at concentrations far exceeding the total concentrations during low base storm flow. The radiological HQ from the combined doses of all nuclides at D1 was less than 0.1 for all flow regimes.

At drainage D2 five chemicals (aluminum, barium, calcium, iron, and manganese) exceeded at least one benchmark during at least one flow regime. During high base flow conditions all except calcium exceeded benchmarks with aluminum and iron exceeding acute and chronic NAWQC, respectively. Dissolved phase concentrations of aluminum did not exceed any benchmarks, including the NAWQCs. Dissolved concentrations of iron were also

greater than the chronic NAWQC. Three analytes (barium, iron, and manganese) exceeded non-NAWQC benchmarks during low base flow. During high base storm flow no HQs were greater than 1. Three analytes (barium, calcium, and manganese) exceeded benchmarks during low base storm flow. Total concentrations of barium and manganese were higher than secondary acute values by factors of 1.58 and 2.05, respectively. The dissolved concentrations also exceeded the secondary acute values. The radiological HQ from the combined doses of all detected isotopes at D2 was less than 0.1 for all flow regimes.

Only one chemical, phosphate, was detected in surface water at either D1 or D2 that could not be screened because no aquatic toxicity data were found. Phosphate is a macronutrient and is not known to be toxic under ambient conditions.

Contaminants of potential concern: drainages D1 and D2

Aluminum. Total concentrations at D1 and D2 exceeded the acute NAWQC during high base flow conditions by factors of 1.05 and 1.30, respectively. The chronic NAWQC was less than background levels and was not used. Two of the five other benchmarks were also exceeded at both sites during high base flow (Table C2.52). Both concentrations were lower than the lowest acute toxicity values for invertebrates (1900 µg/L for *Ceriodaphnia dubia*) and fish (3600 µg/L for juvenile brook trout, *Salvelinus fontinalis*) but greater than the lowest chronic value for daphnids (742 µg/L for *Daphnia magna*). Only one sample was analyzed from each site at high base flow, and the reported concentrations are total aluminum, which is likely to significantly overestimate the bioavailable concentration. The dissolved concentration was less than the detection limit of 23.5 µg/L for both sites. Also, total aluminum values at both sites were below all benchmarks during low base flow. Given that, there is only weak evidence that acute or chronic toxicity is occurring.

During storm flow sampling the total aluminum concentrations at D1 were less than the acute NAWQC. Total concentrations at D2 were less than background. All concentrations at D1 were lower than the lowest acute toxicity values for invertebrates (1900 µg/L for *C. dubia*) and fish (3600 µg/L for juvenile brook trout, *S. fontinalis*). Dissolved concentrations of aluminum at D1 were below detection limits (24.7 µg/L) during the high base storm flow. However, during the low base storm dissolved concentrations were estimated at six times the total concentration, which is impossible. These results provide no evidence of acute toxicity from aluminum during storm events.

Barium. Total concentrations at D1 were less than background for all flow regimes. Total concentrations at D2 exceeded the secondary acute value during the high and low base flow conditions by factors of 1.34 and 1.77, respectively. The secondary chronic value was less than background and was not used. The observed concentrations were more than an order of magnitude higher than the one other benchmark (Table C2.52). As discussed in Sect. C2.3.1.1.5, the secondary acute value is extremely conservative and concentrations that exceed it should be evaluated against the toxicity values used in its derivation. At approximately 100 µg/L the maximum total concentrations at base flow are three orders of magnitude less than the acute value for *D. magna* (410,000 µg/L) and three times less than the lowest acute value (330 µg/L for a gastropod snail) used to calculate the secondary acute value (Appendix A in Suter and Mabrey 1994). Only one sample was analyzed from each base flow sampling. Although total barium concentrations may significantly overestimate the bioavailable concentration, the dissolved concentrations were not appreciably different. These results provide only weak evidence that acute or chronic toxicity is occurring.

During storm flow sampling the total barium concentrations at D2 exceeded the secondary acute value by a factor of 1.58. Although three samples were collected the mean and maximum concentrations were approximately the same as the maximums during high and low base flow. These results imply that total barium concentrations are unlikely to increase during storms. Dissolved concentrations were in the same range as total concentrations. These results provide weak evidence of acute toxicity during storms.

Calcium. The only benchmark used for screening calcium in this assessment was the lowest chronic value for daphnids (116,000 µg/L). The secondary acute value and secondary chronic value were less than background levels and were not used. Total calcium concentrations did not exceed the benchmark during either high or low base flow conditions.

During low base storm flow conditions total calcium was detected above background in all three samples from D2. An acute benchmark was not available because the secondary acute value was less than background. However, the maximum total concentration (123,000 µg/L) was less than the 48-h LC50 with food added (464,000 µg/L) for *D. magna* (Biesinger and Christensen 1972). Calcium was not above background during storms at D1. Given that, there is no evidence that calcium is acutely toxic during storms at either site.

Iron. Total concentrations at D1 and D2 exceeded the chronic NAWQC during high base flow conditions by factors of 1.01 and 3.19, respectively. Total iron exceeded the chronic NAWQC at D2 during low base flow conditions by a factor of 4.74. There is no acute NAWQC.

Two other benchmarks were less than background and were not used. The concentrations at high and low base for D1 and high base for D2 were below the concentration (4380 µg/L) that caused chronic toxicity to daphnids. Total iron during low base conditions at D2 (4740 µg/L) was higher than the chronic toxicity value for daphnids. Total concentrations at all sites were less than the 48-h LC50 for *D. magna* (9600 µg/L). Only one sample was analyzed from each site for each base flow condition. Although total concentrations are likely to significantly overestimate the bioavailable concentration, only the dissolved concentration at D1 was lower (estimated at 10.9 µg/L) than the NAWQC. Some highly sensitive invertebrates may be affected by chronic exposure to water from D1 and D2, but acute toxicity is unlikely.

During storm flow conditions the total iron concentration at D2 did not exceed background. Iron at D1 (868 µg/L) was above background during high base storm flow but below the 48-h LC50 for *D. magna* (9600 µg/L). These results provide no evidence of acute toxicity from iron during storm events.

Manganese. Total concentrations at D1 and D2 exceeded one or more benchmarks during the high and low base flow conditions (Table C2.52). The secondary chronic value was less than background levels and was not used. D1 exceeded only the EC20 for fish populations. This benchmark is an order of magnitude lower than the other benchmarks because of the assumptions of combined effects to all life stages. Base flow concentrations at D2 exceeded the secondary acute value. However, the acute values used to derive that benchmark (19,400 µg/L for *D. magna* and 33,800 µg/L for fathead minnow) were an order of magnitude above the D2 base flow concentrations. Fish growth and invertebrate reproduction in laboratory tests were reduced by concentrations similar to those observed in D2 (Sect C2.3.1.2.6). Only one sample was analyzed from each site, and total concentrations

may overestimate the bioavailable concentration. However, dissolved concentrations were approximately the same as total concentrations. These results provide only weak evidence for significant toxicity at D1. The evidence is weak for significant acute toxicity, but there is strong evidence of chronic effects at D2.

During storm flow sampling the total manganese concentrations at D1 did not exceed background. During low base storm flow the mean (2450 µg/L) and maximum (3020 µg/L) concentrations from D2 were comparable to the base flow values. Dissolved concentrations were not different from totals. As with base flow, these results provide only weak evidence of significant acute toxicity.

Weight of evidence

The weight of evidence indicates that fish are likely to be impacted by chronic exposure to water from drainages D1 and D2. Acute effects are not expected during base flow or storm flow conditions. However, these drainages do not support distinct fish communities, and effects on the White Oak Creek and Melton Branch communities require evaluation at the integrator (WAG 2) level of resolution. The evidence concerning risks to fish in WAG 5 drainages D1 (SW001) and D2 (SW002) are presented in Table C2.54.

Of the two lines of evidence available, the toxicity tests provide the most realistic indication of the effects of water from these drainages on the fish community. These tests indicated that chronic impacts may be occurring in D1. No impacts were indicated at D2. Although water was tested only during high base flow conditions, the samples were collected every day during both test periods and were not filtered. The second line of evidence indicates that iron and manganese concentrations during base flow may reach chronically toxic levels at D2 but not at D1. Acutely toxic concentrations are not expected during storms at either site.

Several factors may be responsible for the differences between these lines of evidence. Only one sample for chemical analysis was collected during each base flow regime. The sample for chemical analysis may not be representative of the chronic exposures received by fish at D1. Unmeasured contaminants or other stressors may have caused the decrease in reproduction observed in the toxicity tests. The samples for chemical analysis from D2 may also be unrepresentative of the chronic exposures received by fish. The concentrations in samples for toxicity testing may have been higher than the measured concentrations. The samples for toxicity testing were collected on several consecutive days and are likely to be more representative of the actual exposure during high base flow conditions than the single sample for chemical analysis.

C2.4.2.6 Benthic macroinvertebrates

The evidence concerning risks to the benthic macroinvertebrate communities of drainages D1 and D2 consists of analyses of contaminants in sediment and water. This evidence is summarized in the following text.

Screening of contaminants in sediments

Contaminants of potential concern for risk to benthic macroinvertebrates were identified by comparing contaminant concentrations in sediment to toxicological benchmarks

and EPA Region IV Screening Values (Sect. C2.3.1.1.6).

Four sediment samples were collected at each drainage. The maximum detected chemical concentration for each drainage was used as the estimate of exposure. For naturally occurring analytes the maximum detected concentration was compared to twice the average concentration at the reference site. Contaminants that exceeded background, were not analyzed at the reference site (e.g., mercury), or are not naturally occurring were compared to benchmarks and EPA Region IV screening values. Benchmarks which were less than mean background levels were not used.

Hazard quotients were calculated for each contaminant. The numerator is the maximum detected concentration in sediment or absorbed radiation dose. The denominators are the toxicological benchmarks, the Region IV screening values, and the recommended radiation exposure criterion (Sect. C2.3.1.1.6). For each sediment sample the absorbed radiation dose from all detected radionuclides was summed and compared to the recommended criterion. The eight sediment sampling sites were evaluated separately because the nuclides detected varied between sites. The absorbed radiation dose for both large and small benthic invertebrates was calculated. Only the dose to large invertebrates is presented because it was either equal to or greater than the dose to small invertebrates. Quotients greater than 1 are indicative of a hazard that requires further assessment. Chemical and radiological screening results for these sites are presented in Tables C2.55 and C2.56, respectively.

Drainage D1

Four contaminants (mercury, nickel, silver, and Aroclor 1260) exceeded the EPA Region IV screening value (Table C2.55). Nickel and silver also exceeded the ER-L sediment benchmark. Silver had HQs greater than 1.0 at two sites (SD001 and SD002), whereas nickel and mercury exceeded 1.0 at only one site each. Aroclor 1260 was highest at SD003, but all four sites exceeded the Region IV values. The radiological HQ from the combined doses of all detected isotopes was less than 0.01 for all four samples at D1.

Three chemicals (cobalt, manganese, and 4-methyl-2-pentanone) were detected in sediment from D1 but could not be screened because appropriate toxicity data were not found. The benchmarks for manganese, including the Ontario MOE severe value of 1110 mg/kg (Hull and Suter 1995), were not used because they were less than the mean background level of 1500 mg/kg.

Drainage D2

Ten contaminants [arsenic, barium, iron, mercury, silver, 1,1-dichloroethene, 1,2-dichloroethene (total), acetone, Aroclor 1260, and vinyl chloride] exceeded the EPA Region IV screening value and/or the sediment benchmark (Table C2.55). Hazard quotients for the inorganics ranged from 1.7 to 7.3, whereas the HQs for organics were as high as 21.21 for 1,2-dichloroethene (total) at SD008. Most of the inorganics exceeded benchmarks in the two downstream sites, SD005 and SD006. Only mercury exceeded benchmarks in SD007 or SD008. In contrast to that, most of the organic chemicals were detected at the two upstream sites, SD007 and SD008. The radiological HQ from the combined doses of all detected isotopes was less than 0.1 for all four samples at D2.

Several other organic chemicals (e.g., benzene and toluene) were detected in drainage D2 but were less than the sediment benchmarks. Four chemicals (calcium, manganese, selenium, and 2-butanone) were detected in sediment from D2 but could not be screened because appropriate toxicity data were not found. The benchmarks for manganese, including the Ontario MOE severe value of 1110 mg/kg (Hull and Suter 1995), were not used because they were less than the mean background level of 1500 mg/kg. Calcium is a macronutrient and is unlikely to be toxic under ambient conditions.

Contaminants of Potential Concern

Drainage D1

Mercury. Mercury exceeded the EPA Region IV screening value, based on the no observed effects level for marine and estuarine sediments (MacDonald 1993), of 0.1 mg/kg at SD003 (0.14 mg/kg) only. At all four sites, mercury was less than the benchmark of 0.15 mg/kg, which corresponds to the ER-L from Long et al. (1994). Toxicity data for similar sediment concentrations vary considerably. Since mercury concentrations exceed the ER-L (the tenth percentile of mercury concentrations observed to cause toxic effects) effects are possible in D1 if it is a sensitive site. For example, a Michigan lake sediment with an organic carbon content of 2.2% and mercury concentration of 0.29 mg/kg caused 100% mortality in *D. magna* and 40% mortality in *H. limbata*, and sediments from Waukegan Harbor, Illinois, with a mercury concentration of 0.1 mg/kg resulted in only 34% mortality to *Hyaella azteca*. However, since the ER-M (the 50th percentile) is not five times the maximum concentration in D1, effects are not likely.

Nickel. The nickel concentration at SD002 (70.6 mg/kg) exceeded the ER-M (51.6 mg/kg) by a factor of 1.4. The ER-L (21 mg/kg) was not used as the benchmark because the average background concentration (26 mg/kg) exceeded this benchmark. SD002 also exceeded the EPA Region IV screening value. Nickel was less than twice the mean background at the other three sites in D1 and was not compared to benchmarks or the EPA screening value. No information is available from spiked sediment toxicity tests for nickel (Long and Morgan 1991). However, lake sediments with a similar organic carbon content (approximately 1%) and lower nickel concentrations (from 22 to 63 with a mean of 40 mg/kg) caused >90% mortality in *D. magna* and *H. limbata* (Maleug et al. 1984). Acute and chronic effects are likely at SD002, but are not indicated at the other three sites in D1.

Silver. Concentrations at SD001 and SD002 exceeded the ER-L benchmark (1.0 mg/kg) and the EPA Region IV screening value (2 mg/kg). Silver was not detected, or was below background, at the two upstream sites. Silver at SD001 (2.2 mg/kg) and SD002 (2.3 mg/kg) did not exceed the ER-M of 3.7 mg/kg. No data were available for freshwater systems. At concentrations of 2.1 to 2.6 mg/kg in marine systems, there was an absence of feral *Macoma balthica* in Fraser River sediments, as well as low arthropod abundance and low species richness in southern California benthos (studies cited in Long and Morgan 1991). Acute effects are not expected at drainage D1. Silver may be chronically toxic to sensitive species at SD001 and SD002, but this is weak evidence given the lack of appropriate toxicological data.

Aroclor 1260. Aroclor 1260 was detected at all four sediment sampling sites in drainage D1, but a consistent downstream gradient was not evident. None of the sites exceeded the screening benchmark for drainage D1 (1319 mg/kg), which was derived using

the EqP Approach (see Sect. C2.3.1.1.6), the drainage-specific total organic carbon concentration (1.2%), and the conservative Tier II secondary chronic value (Suter and Mabrey 1994) of 0.0105 mg/L. Aroclor 1260 exceeded the EPA Region IV screening value (0.033 mg/kg) at all four sites. The screening value equals the Contract Laboratory Program Practical Quantitation Limit (CLP PQL). Region IV did not use the ER-L of 0.0227 mg/kg from Long et al. (1994) because it was less than the CLP PQL. One site, SD003 (0.83 mg/kg), exceeded the ER-M of 0.180 mg/kg from Long et al. (1994). However, relatively poor relationships were observed between the incidence of effects and the concentrations of total PCBs. For example, there is a relatively low (51%) incidence of biological effects at concentrations greater than the ER-M (probable-effects range) (Long et al 1994). Given that, toxic effects are possible at SD003, but unlikely at the other sites in drainage D1.

Drainage D2

Arsenic. Concentrations at SD005 and SD006 exceeded the ER-L benchmark of 8.2 mg/kg and the EPA Region IV screening value of 8 mg/kg. Arsenic was below the twice mean background level of 12.0 mg/kg at the two upstream sites. Arsenic at SD005 (12.5 mg/kg) and SD006 (14.0 mg/kg) did not exceed the ER-M of 70 mg/kg. Limited data are available from tests of freshwater sediments, and results were inconsistent at levels comparable to those found in drainage D2 (see Sect. C2.3.1.2.7). Overall, only 11% of the studies documented in Long et al. (1994) indicated biological effects at concentrations between the ER-L and ER-M, while 63% of the studies at concentrations above the ER-M indicated biological effects. Acute effects are not expected at drainage D2. Chronic effects at SD005 and SD006 are possible but highly unlikely.

Barium. Concentrations at the two upstream sites (SD007 and SD008) were less than the screening value using local background. Barium at SD005 and SD006 was higher than the Wisconsin Department of Natural Resources criteria of 500 mg/kg. However, this value is based on background concentrations and was developed for evaluating the suitability of dredged material for open water disposal. Sediment toxicity data were not found (Hull and Suter 1994). Therefore, it can only be said that toxic effects are possible, but that the probability and magnitude of these effects are unknown.

Iron. The concentration at SD006 (93,800 mg/kg) exceeded the screening value based on local background levels (91,000 mg/kg) and the Beak SQG of 59,000 mg/kg. The three other sites in drainage D2 were less than the local background level. Toxicity data for iron in sediment to benthic invertebrates are very limited. The only sediment guidelines based on effects data, the Ontario Ministry of the Environment low (30,000 mg/kg) and severe (40,000 mg/kg) effects levels, were not used because they are less than the average local background level of 45,000 mg/kg. The EPA Region V sediment classification guidelines for dredge material disposal, which are 17,000 and 25,000 mg/kg, were also less than local background. The Beak SQG is based on background concentrations in Ontario, Canada. Although it is higher than the mean local background, it is considerably less than twice the mean background (91,000 mg/kg), which is used for comparison of site data to background levels. This sediment guideline is not based on or related to biological effects (Hull and Suter 1994). Therefore, it can only be said that toxic effects are possible, but that the probability and magnitude of these effects are unknown.

Mercury. Mercury was detected at the four upstream locations and ranged from 0.17 mg/kg at SD006 to 0.38 mg/kg at SD008. Since a local background screening value was

not determined, the detected concentrations were compared to the benchmarks. Mercury at all three sites exceeded the EPA Region IV screening value (0.1 mg/kg) and the benchmark of 0.15 mg/kg, which corresponds to the ER-L from Long et al. (1994). Toxicity data for similar sediment concentrations vary considerably. A Michigan lake sediment with an organic carbon content of 2.2% and mercury concentration of 0.29 mg/kg caused 100% mortality in *D. magna* and 40% mortality in *H. limbata*, and sediments from Waukegan Harbor, Illinois, with a mercury concentration of 0.1 mg/kg resulted in only 34% mortality to *Hyalella azteca*. The highest concentration at drainage D2 results in an HQ of 0.52 when compared to the ER-M of 0.71 mg/kg from Long et al. (1994). Given that, toxic effects of mercury in Drainage D2 are possible but unlikely.

Silver. Concentrations at SD005 and SD006 exceeded the ER-L benchmark (1.0 mg/kg) and the EPA Region IV screening value (2 mg/kg). Silver was not detected at the two upstream sites. Silver at both SD005 (7.3 mg/kg) and SD006 (6.9 mg/kg) exceeded the ER-M of 3.7 mg/kg. No toxicity data were found for freshwater systems. At concentrations of 2.1 to 2.6 mg/kg in marine systems, there was an absence of feral *Macoma balthica* in Fraser River sediments, as well as low arthropod abundance and low species richness in southern California benthos (studies cited in Long and Morgan 1991). A high percentage (92.8%) of the studies documented in Long et al. (1994) indicated biological effects at concentrations greater than the ER-M. Given that, silver concentrations in sediment at SD005 and SD006 are likely to be toxic to benthic invertebrates.

1,1-Dichloroethane. Concentrations were below detection limits at SD005 and did not indicate a consistent downstream gradient at the three other sites: SD007 (0.14 mg/kg) was twice as high as the upstream site, SD008 (0.067 mg/kg), and an order of magnitude higher than the next downstream site, SD006 (0.014 mg/kg). No sediment toxicity information is available regarding effects of 1,1-dichloroethane on benthic macroinvertebrates. The screening benchmark (0.12 mg/kg) was derived using the EqP Approach (see Sect. C2.3.1.1.6) and the conservative Tier II secondary chronic value (Suter and Mabrey 1994) of 0.0466 mg/L. The Tier II value implies a greater than 20% chance that the NAWQC, if their value were known, would be exceeded. Substituting the lowest chronic value for all aquatic organisms (14.68 mg/l for fish) results in a sediment benchmark of 37.2 mg/kg. Given that the highest concentration in drainage D2 is more than two orders of magnitude less than this value, 1,1-dichloroethane in sediments is not expected to be toxic to benthic invertebrates.

1,2-Dichloroethene. Concentrations were below detection limits at SD005, but did indicate a consistent downstream gradient at the three other sites: SD008, SD007, and SD006 had concentrations of 2.1, 0.98, and 0.08 mg/kg, respectively. No sediment toxicity information is available regarding effects of 1,1-dichloroethene on benthic macroinvertebrates. The screening benchmark (0.0603 mg/kg) was derived using the EqP Approach (see Sect. C2.3.1.1.6) and the conservative Tier II secondary chronic value (Suter and Mabrey 1994) of 0.0312 mg/L. The Tier II value implies a greater than 20% chance that the NAWQC, if their value were known, would be exceeded. Substituting the lowest chronic value for all aquatic organisms (9.54 mg/l for fish) results in a sediment benchmark of 30.4 mg/kg. Using this benchmark, HQs for the three detected concentrations in drainage D2 range from 0.0026 to 0.069. Given that, it is unlikely that 1,2-dichloroethene in the sediments of drainage D2 is toxic to benthic invertebrates.

Acetone. Concentrations were below detection limits at all sites in drainage D2 except SD007 (0.64 mg/kg). No sediment toxicity information is available regarding effects of acetone

on benthic macroinvertebrates. The screening benchmark (0.28 mg/kg) was derived using the EqP Approach (see Sect. C2.3.1.1.6) and the conservative Tier II secondary chronic value (Suter and Mabrey 1994) of 11.2 mg/L. Substituting the lowest chronic value for daphnids (3115 mg/l for fish) results in a sediment benchmark of 77.1 mg/kg. Given that the only detected concentration in drainage D2 is more than two orders of magnitude less than this value, acetone in sediments is not expected to be toxic to benthic invertebrates.

Aroclor 1260. Aroclor 1260 was detected at SD005 and SD006, but not at the two upstream sites. Neither site exceeded the screening benchmark for drainage D2 (4728 mg/kg), which was derived using the EqP Approach (see Sect. C2.3.1.1.6), the drainage-specific total organic carbon concentration (4.3%), and the conservative Tier II secondary chronic value (Suter and Mabrey 1994) of 0.0105 mg/L. Aroclor 1260 did exceed the EPA Region IV screening value (0.033 mg/kg) at both downstream sites. This screening value equals the Contract Laboratory Program Practical Quantitation Limit (CLP PQL). Region IV did not use the ER-L of 0.0227 mg/kg from Long et al. (1994) because it was less than the CLP PQL. Both SD005 (0.039 mg/kg) and SD006 (0.085 mg/kg) were less than the ER-M of 0.180 mg/kg (Long et al. 1994). Given the low concordance between the incidence of effects and the concentrations of PCBs (see Sect. C2.3.1.2.7), toxic effects from Aroclor 1260 are unlikely in drainage D2.

Vinyl chloride. Concentrations were below detection limits at the two downstream sites but exceeded the sediment screening benchmark at SD007 (0.57 mg/kg) and SD008 1.1 mg/kg). No sediment toxicity information is available regarding effects of vinyl chloride on benthic macroinvertebrates. The screening benchmark (0.09 mg/kg) was derived using the EqP Approach (see Sect. C2.3.1.1.6) and the conservative Tier II secondary chronic value (Suter and Mabrey 1994) of 0.0878 mg/L. Substituting the lowest chronic value for all aquatic organisms (28.88 mg/l for fish) results in a sediment benchmark of 29.8 mg/kg. Using this benchmark, HQs for SD007 and SD008 are 0.019 and 0.037, respectively. Given that, it is unlikely that vinyl chloride in the sediments of drainage D2 is toxic to benthic invertebrates.

Weight of Evidence

The evidence indicates that benthic macroinvertebrates may be impacted by chronic exposure to sediments in drainages D1 and D2. However, these communities are ephemeral, the toxic reaches occupy only 150 m of channel, and only one line of evidence is available.

In drainage D1 toxic effects are possible from exposure to contaminants at SD002 and SD003. Toxic effects are possible but unlikely at the other sites in drainage D1. That is, of the four contaminants that exceeded benchmarks in drainage D1, only two exceeded the ER-M: nickel at SD002 and Aroclor 1260 at SD003. Toxic effects from exposure to mercury and silver in drainage D1 are possible but unlikely. Adverse effects are not expected from exposure of benthic invertebrates to the sediment-associated radionuclides in drainage D1.

In drainage D2 toxic effects are possible from exposure to silver at SD005 and SD006. Toxic effects are possible but unlikely at the other sites in drainage D2. That is, of the ten contaminants that exceeded benchmarks in drainage D2, only silver exceeded the ER-M. Toxic effects from exposure to arsenic, mercury, 1,1-dichloroethane, 1,2-dichloroethene, acetone, Aroclor 1260, and vinyl chloride in drainage D1 are possible but unlikely. There is insufficient toxicological information to confidently evaluate the possible effects of barium and iron. However, it is highly unlikely that these elements pose a significant and immediate risk

to the benthic invertebrates of drainage D2. The five organic chemicals that were detected in drainage D2 at concentrations less than the screening benchmarks are not expected increase the risks to benthic invertebrates. Adverse effects are not expected from exposure of benthic invertebrates to the sediment-associated radionuclides in drainage D2.

Because there were no sediment toxicity tests or benthic field surveys conducted for WAG 5, the comparison of contaminant concentrations to benchmarks is the only line of evidence for the risk characterization of drainages D1 and D2. These benchmarks were based on either studies of marine and estuarine sediments or water quality benchmarks adjusted using the equilibrium partitioning methodology. Therefore, the physico-chemical characteristics of the sediments and the sensitivities of the organisms in the drainages of WAG 5 may be considerably different from those used to derive the benchmarks. Furthermore, these drainages provide habitat for only those species that are tolerant of no-flow periods of several months.

C2.4.3. Risk Characterization for Future Conditions

C2.4.3.1. Plants

Terrestrial plants. Risk characterization for future conditions must be conducted if there are foreseeable changes in contaminant inputs or in receptors being exposed to them. Under conditions of no institutional controls, natural succession of the vegetation would produce mixed deciduous woodland, similar to the cover of WAG 5 Wide, over areas of WAG 5 not covered by water or buildings. Trees having deeper roots than the present grass on SWSA 5 South and TRU may be exposed to higher concentrations of contaminants buried beneath. Direct exposure to wastes is possible but effects are not predictable. There are no known rare plants likely to occupy the changing habitat of the WAG.

Wetland plants. Exposure of wetland plants to contaminants in the seeps may remain unchanged or decrease if the volume of seepage is reduced by the increased evapotranspiration resulting from reforestation.

C2.4.3.2. Soil invertebrates

Although there will probably be no major changes in contaminant inputs to WAG 5, under hypothetical future vegetation (mixed deciduous forest), earthworms and other soil and litter dwelling arthropods may be exposed to higher concentrations of contaminants in the surface soil and litter layer. This follows from the possibility that deep-rooted trees may accumulate more chemicals in above-ground vegetation. The contaminants may become available to soil invertebrates through leaf litter. Direct exposure to wastes is possible, but effects are not predictable.

C2.4.3.3. Soil microorganisms and microbial processes

Under the hypothetical future scenario (mixed deciduous forest), soil and litter microorganisms may be exposed to higher concentrations of contaminants in the surface soil and litter layer. This follows from the possibility that in deep-rooted trees may accumulate more chemicals in above-ground vegetation. The contaminants may become available to soil

microbes through leaf litter. Direct exposure to wastes is possible, but effects are not predictable.

C2.4.3.4. Vermivorous wildlife

Screening of contaminants against benchmarks

Estimates of contaminant exposure under the future case scenario were derived for the OHF, NHF, PWSB, SWSA 5, and TRU areas of WAG 5 (see Sect. C2.2.2.2.4). Exposure and risk in the WAG 5-wide area are assumed to be similar in both the current and future case scenarios because this area is already forested. To determine if the contaminant exposures experienced by American woodcock and short-tailed shrew in the OHF, NHF, PWSB, SWSA 5, and TRU areas of WAG 5 are potentially hazardous, the total contaminant exposure estimates (Tables C2.11 through C2.20) were compared to estimated NOAELs for these species (Tables C2.21 and C2.22). To quantify the magnitude of hazard, an HQ (HQ) was calculated where $HQ = \text{exposure}/\text{NOAEL}$. HQs greater than 1 indicate that individuals may be experiencing exposures that are in excess of NOAELs and suggest that adverse effects may be occurring. HQs for American woodcock and short-tailed shrew in the OHF, NHF, PWSB, SWSA 5, and TRU areas of WAG 5 are presented along with the exposure estimates in Tables C2.11 through C2.20. To determine if the total radionuclide dose is potentially hazardous, dose estimates from Sect. C2.2.2.2.4 were compared to the maximum value recommended by IAEA (1992), 42 $\mu\text{Gy/h}$. Risks are characterized below for contaminants that exceed these screening criteria.

The exposure estimate for short-tailed shrews to cadmium was both greater than background and produced HQs > 1 in the OHF area of WAG 5 (Table C2.12).

In the NHF area, estimated barium exposure was both greater than background and produced an HQ > 1 for American woodcock (Table C2.13). For short-tailed shrews, exposure estimates for barium and manganese were both greater than background and produced HQs > 1 (Table C2.14).

While no contaminant for which estimated exposure to American woodcock at the SWSA 5 area of WAG 5 exceeded background, produced an HQ > 1 (Table C2.17), exposure estimates for short-tailed shrews to antimony and selenium were both greater than background and produced HQs > 1 (Table C2.18). The estimated radiation doses for woodcock (5731 $\mu\text{Gy/h}$) and shrews (5750 $\mu\text{Gy/h}$) exceeded the IAEA recommended value (42 $\mu\text{Gy/h}$). Approximately 95% of the total radiation exposure in the SWSA 5 area is attributable to alpha radiation emitted from Cm-243/244. The combined alpha, beta, and gamma radiation from the other 14 radionuclides observed in the SWSA 5 area contribute only 5% to the total exposure.

In the TRU area, estimated selenium exposure was both greater than background and produced an HQ > 1 for American woodcock (Table C2.19) and short-tailed shrews (Table C2.20).

Estimated effects from retained contaminants

Antimony. Antimony exposure experienced by shrews in the SWSA 5 area is 7.8 times

greater than the estimated NOAEL but only 80% of the estimated LOAEL (for LOAELs, see Table C2.64). Both the NOAEL and the LOAEL are based upon a long-term study in which longevity was observed among mice given antimony potassium tartrate in drinking water for an entire lifetime (Schroeder et al. 1968b). The study was considered to represent chronic exposure; therefore, a subchronic-chronic correction factor was not employed.

While estimated Sb exposure for shrews exceeded the estimated NOAEL, it did not exceed the estimated LOAEL. Therefore, adverse effects from Sb are not expected among shrews in the SWSA 5 area.

Barium. Barium exposure experienced by shrews in the NHF area is 2.23 times greater than the estimated NOAEL and 6.12 times greater than an estimated LOAEL (for LOAELs, see Table C2.64). The NOAEL based upon a 16-month laboratory study considering growth and cardiocascular effects among rats (Perry et al. 1983). The LOAEL is based upon short-term study in which a 30% increase in mortality was observed among rats fed barium chloride for 10 d (Borzelleca et al. 1988). Because the study was subchronic in duration, the LOAEL was multiplied by a subchronic-chronic correction factor of 0.1 to estimate a chronic LOAEL

Barium exposure experienced by woodcock in the NHF area is 1.99 times greater than the estimated NOAEL and 99% of the estimated LOAEL. Both the NOAEL and the LOAEL are based upon a short-term study in which mortality was observed among chickens fed barium hydroxide for 4 weeks (Johnson et al. 1960). Because the study was subchronic in duration, both the NOAEL and LOAEL were multiplied by a subchronic-chronic correction factor of 0.1 to estimate the chronic NOAEL and LOAEL.

Estimated Ba exposure for shrews exceeded both the estimated LOAEL and NOAEL. Therefore, increased mortality may be observed among the population of shrews in the NHF area. While estimated Ba exposure for woodcock exceeded the estimated NOAEL, it did not exceed the estimated LOAEL. Therefore, adverse effects from Ba are not expected among woodcock in the NHF area.

Cadmium. Cadmium exposure experienced by shrews in the OHF area is 1.37 times greater than the estimated NOAEL but only 10% of the estimated LOAEL (for LOAELs, see Table C2.64). Both the NOAEL and the LOAEL are based upon a study in which reproductive success and offspring survival was observed among mice fed Cd in drinking water for two generations (Schroeder and Mitchner 1971). The study was considered to represent chronic exposure; therefore, a subchronic-chronic correction factor was not employed.

While estimated Cd exposure for shrews exceeded the estimated NOAEL, it did not exceed the estimated LOAEL. Therefore, adverse effects from Cd are not expected among shrews in the OHF area.

Manganese. Manganese exposure experienced by shrews in the NHF area is 1.007 times greater than the estimated NOAEL but only 31% of the an estimated LOAEL (for LOAELs, see Table C2.64). Both the NOAEL and the LOAEL are based upon a study in which reproductive success and offspring survival was observed among rats fed manganese oxide through (Laskey et al. 1982). Brcause the study considered exposure during a critical lifestage (reproduction), it was considered to represent chronic exposure, and a subchronic-chronic correction factor was not employed.

While estimated Mn exposure for shrews exceeded the estimated NOAEL, it did not exceed the estimated LOAEL. Therefore, adverse effects from Mn are not expected among shrews in the NHF area.

Selenium. Selenium exposure experienced by shrews in the SWSA 5 area is 13.9 and 1.4 times greater than the estimated NOAEL and LOAEL, respectively (for LOAELs, see Table C2.64). In the TRU area, Se exposure is 26.05 and 2.6 times greater than the estimated NOAEL and LOAEL, respectively. Both the NOAEL and the LOAEL are based upon a study in which reproductive success and offspring survival was observed among mice fed Se in drinking water for three generations (Schroeder and Mitchner 1971). The study was considered to represent chronic exposure; therefore, a subchronic-chronic correction factor was not employed.

Selenium exposure experienced by woodcock in the TRU area is 3.6 and 1.8 times greater than the estimated NOAEL and LOAEL, respectively. Both the NOAEL and the LOAEL are based upon a study in which reproductive success and offspring survival was observed among mallard ducks fed selenium for 78 d (Heinz et al. 1987). The study was considered to represent chronic exposure; therefore, a subchronic-chronic correction factor was not employed.

Estimated Se exposure for shrews and woodcock exceeded both the estimated LOAEL and NOAEL. Therefore, reduced reproductive success and offspring survival may be observed among the shrew populations in the SWSA 5 and TRU areas and among individual woodcock in the TRU area as a result of Se exposure.

Radionuclides. Radiation doses received by shrews and woodcock in the SWSA 5 area are more than 100 times greater than the "safe" dose recommended by IAEA (1992). While exceeding the recommended dose may result in impaired reproductive function, data specific to shrews and woodcock are unavailable. In the absence of species-specific data, it must be assumed that reduced reproductive success and offspring survival may be observed among the shrew populations and among individual woodcock in the SWSA 5 area as a result of radiation exposure.

Media toxicity tests

No media toxicity tests were performed for vermivorous wildlife in any area of WAG 5. Therefore, this line of evidence is unavailable.

Biological survey data

No biological surveys were performed for vermivorous wildlife in any area of WAG 5. Therefore, this line of evidence is unavailable.

Weight of evidence

Only one line of evidence, literature toxicity data, was available to evaluate ecological risk to vermivorous wildlife. Using only comparisons to benchmarks, the data suggest reproduction and abundance of the shrews would be adversely affected by barium in the NHF area, selenium in the TRU area, and selenium and radiation in the SWSA 5 area. Because the NHF area is only 1 ha in size and represents only 3% of the total area within WAG 5,

barium exposure within this area is not likely to significantly affect the WAG 5-wide shrew population. In contrast, because the TRU and SWSA 5 areas are sufficiently large (representing 12.5% and 45% of the total area in WAG 5, respectively) to contain a substantial portion of the WAG 5-wide shrew population, selenium and radiation (from SWSA 5 only) exposure in these areas may adversely affect the WAG 5-wide shrew population.

Among woodcock, reproduction and survival of individuals may be adversely affected by selenium in the TRU area and radiation in the SWSA 5 area. Population effects, however, must be addressed at the ORR level. WAG 5 alone is unlikely to significantly impact the ORR-wide woodcock population. To evaluate effects to the ORR-wide population, exposure from multiple OUs must be considered.

C2.4.3.5. Fish

The future case for this assessment is succession of WAG 5 to mixed deciduous forest. Except for decreased aqueous flow due to greater transpiration, this would not substantially alter the exposures for fish. Therefore, the characterization of future risks for fish in WAG 5 is the same as for current conditions.

C2.4.3.6. Benthic macroinvertebrates

Risk characterization for future conditions must be evaluated if it is expected that there will be changes in contaminant inputs or in receptors present. No change in receptor community is expected. Future risks are expected to be identical to current risks, or to decrease as contaminants are bound, degraded, or the sediment is scoured downstream.

C2.4.4. Contribution to WAG 2 Risk

One of the outputs of an RI for any source OU is the characterization of contributions to "downstream" OUs (Suter et al. 1994). In the case of WAG 5, this consists of describing the contribution of contaminated surface and ground waters and eroded soils from the site to Melton Branch and White Oak Creek and their floodplains (i.e., WAG 2). This information serves to identify the primary sources responsible for contamination observed in integrator OUs and aids in the prioritization of remedial actions.

Characterization of contributions to off-site risk is performed in a manner similar to that for evaluating on-site risks, i.e., using multiple lines of evidence. These lines of evidence include biomonitoring data, toxicological tests of ambient media, and single-chemical toxicity data. To quantify the contribution of a source OU to an integrator OU, data from the reference sites are compared to data from the integrator "downstream" from the source. The difference between the reference and "downstream" data provides an estimate of the contribution of the source OU to the integrator OU.

The approach described above assumes that data from within the integrator OU are available. In the absence of data from the integrator OU, potential contribution to off-site risk may be evaluated by considering both the media and contaminants present in the source OU in concentrations that exceed toxicological benchmarks. The magnitude with which these contaminants exceed toxicological benchmarks is a measure of the degree of dilution needed in the integrator OU to reduce contaminant concentrations to below toxic levels. For

example, contaminants that marginally exceed benchmarks would require minimal dilution and therefore are unlikely to contribute significantly to off-site risk. In contrast, contaminants whose concentrations are orders of magnitude larger than benchmark values are very likely to present off-site risks.

One limitation of using data solely from the source OU is that it focuses only on contaminants that exceed benchmarks in the source. It is possible that contaminant input from multiple source OUs into a single integrator, with each contaminant input being below benchmark values, may produce a total contaminant input that exceeds benchmarks. Use of biomonitoring and contaminants data from within the integrator permits the detection of such events.

C2.4.4.1. Plants

Terrestrial plants. Two lines of evidence were available to characterize the contribution to off-site risk: single chemical toxicity data describing toxicity to plants growing in soil and the fact that the WAG 2 floodplain is vegetated with a plant community qualitative similar to those on similar floodplains. The contribution to off-site risk of contaminated soil in each of the areas will be described in terms of the dilution required to bring the contaminant level in the soil to below the phytotoxicity benchmark. It was assumed that contaminants with dilution factors (i.e., HQs) of 10 or less were unlikely to contribute significantly to off-site risk. No data for soil concentrations in WAG 2 were available for this assessment.

Only one contaminant (Hg) from one area (SWSA 5) was observed to have an HQ > 10. In all other areas, either no benchmarks were exceeded (i.e., TRU, PWSB, and NHF) or all HQs < 10 (i.e., OHF and WAG 5 Wide). While SWSA 5 may contribute to off-site risk, the maintained grass cover at the site minimizes the likelihood of off-site erosion of contaminated soil.

Wetland plants. Two lines of evidence were available to characterize the contribution to off-site risk: single chemical toxicity data describing toxicity to plants growing in solution, and the fact that the seep areas of WAG 5 are vegetated. The contribution to off-site risk of contaminated seep drainage in each of the seeps will be described in terms of the dilution required to bring the contaminant level to below the phytotoxicity benchmark. It was assumed that contaminants with dilution factors (i.e., HQs) of 10 or less were unlikely to contribute significantly to off-site risk.

In three seeps (5, 7, and 14), one analyte (Al) produced HQs > 10. In all other seeps, either no benchmarks were exceeded or all HQs < 10. Because dissolved Al did not exceed benchmarks at seeps 5, 7, or 14, off-site phytotoxic effects are highly unlikely.

C2.4.4.2. Soil invertebrates

Only one line of evidence was available to characterize the contribution to off-site risk: single chemical toxicity data for earthworms. The contribution to off-site risk of contaminated soil in each of the areas will be described in terms of the dilution required to bring the contaminant level to below the toxicity benchmark. It was assumed that contaminants with dilution factors (i.e., HQs) of 10 or less were unlikely to contribute significantly to off-site risk. No data for soil concentrations in WAG 2 were available for this

assessment.

Only one contaminant (Hg) from two areas (SWSA 5 and WAG 5 Wide) was observed to have an HQ > 10. In all other areas, either no benchmarks were exceeded or all HQs < 10. While SWSA 5 and WAG 5 Wide may contribute to off-site risk, the maintained grass cover and vegetation at these sites minimizes the likelihood of off-site erosion of contaminated soil.

C2.4.4.3. Soil microorganisms and microbial processes

Only one line of evidence was available to characterize the contribution to off-site risk: single chemical toxicity data describing toxicity to soil microorganisms and microbial processes. The contribution to off-site risk of contaminated soil in each of the areas will be described in terms of the dilution required to bring the contaminant level to below the toxicity benchmark. It was assumed that contaminants with dilution factors (i.e., HQs) of 10 or less were unlikely to contribute significantly to off-site risk. No data for soil concentrations in WAG 2 were available for this assessment.

Only one contaminant (Mn) from two areas (SWSA 5 and OHF) was observed to have an HQ > 10. In all other areas, either no benchmarks were exceeded or all HQs < 10. While SWSA 5 and OHF may contribute to off-site risk, the maintained grass cover and pavement at these sites minimizes the likelihood of off-site erosion of contaminated soil.

C2.4.4.4. Vermivorous wildlife

No data from WAG 2 concerning terrestrial contamination were available with which to evaluate the contribution of WAG 5 to WAG 2. Therefore, the contribution of contaminants from WAG 5 to WAG 2 is based solely on data from WAG 5.

To determine the contribution of contaminants in WAG 5 to risks to vermivorous wildlife in WAG 2, exposure estimates were calculated as described in Sect. C2.2.2.1.4, except exposure through water consumption was excluded. Water was excluded because the water pathway generally contributed little to total contaminant exposure (see Sect. C2.2.2.1.4), impoundments that do not release to off-site areas were included in the on-site evaluation, and contribution of WAG 5 to WAG 2 water contamination is best described in relation to aquatic endpoints (see Sects. C2.4.4.5 and C2.4.4.6, below).

Exposure through soil and food ingestion was estimated for all contaminants with HQs > 1 (see Sects. C2.4.2.4 and C2.4.3.4). These exposure estimates were then compared to estimated NOAELs (Tables C2.21 and C2.22) and HQs were calculated. Estimated off-site exposures and HQs are presented in Table C2.57.

As described above, the magnitude with which these contaminants exceed toxicological benchmarks is a measure of the degree of dilution needed in the integrator OU to reduce contaminant concentrations to below toxic levels. For shrews, the maximum dilution needed ranges from approximately eightfold to ninefold; all other contaminants would require a dilution factor (i.e., HQ) of 2.5 or less (Table C2.57). In contrast, the maximum dilution needed to bring contaminant concentrations below benchmarks for American woodcock is 147 (for Zn in the WAG 5 Wide area). If it is assumed that contaminants with dilution factors (i.e., HQs) of 10 or less are unlikely to contribute significantly to off-site risk, then only one

area and two contaminants may contribute to risk in WAG 2; Hg and Zn from the WAG 5 Wide area.

Identification the WAG 5 Wide area as potentially contributing Hg and Zn to WAG 2 should be viewed with caution. Exposure estimates for the WAG 5 Wide area are based on the 95% UCL for contaminants in soil. Because the UCLs are based on a very small sample (only two samples), the 95% UCL is biased and exceeds the maximum values observed at the site (see Table C2.65). If exposure estimates for Hg and Zn are recalculated using the maximum value and compared to LOAELs (the lowest exposure at which effects are actually observed), HQs < 10 result (Table C2.65). It is therefore unlikely that WAG 5 Wide area contributes significantly to risk in WAG 2.

C2.4.4.5. Fish

The weight-of-evidence approach was used to assess the contribution of WAG 5 to risks for fish communities in the aquatic integrator. Three sets of evidence are available: fish community surveys of White Oak Creek and Melton Branch; chemical analyses of water from Melton Branch and its tributaries; and acute toxicity tests of 5 seeps and chemical analyses of water from 15 seeps in and around WAG 5. There are no fish survey data for drainage D3 because there is no permanent fish habitat on the site. However, fish are believed to make use of this drainage during periods of high flow. The evidence of risks to fish is presented separately for the streams and seeps. This evidence is summarized in Table C2.60 (drainage D3, White Oak Creek, and Melton Branch) and Table C2.63 (Seeps).

C2.4.4.5.1 Risks in White Oak Creek and Melton Branch

Fish community surveys

Surveys of White Oak Creek and Melton Branch were conducted in the spring and fall since 1985. Surveys relevant to this assessment were conducted at three locations on Melton Branch [one adjacent to WAG 5 at Melton Branch kilometer (MEK) 0.6 and two above WAG 5 at MEK 1.4 and MEK 2.1] and at four locations on White Oak Creek [one below WAG 5 (WCK 2.3), one adjacent to WAG 5 (WCK 2.9), one just above WAG 5 (WCK 3.4), and one reference site (WCK 6.8) above all known inputs] (Fig. C2.8). Other locations in White Oak Creek and Melton Branch were surveyed but are not specifically addressed herein. The assessment endpoints for the fish community are species richness and abundance. Bioaccumulation and biological indicators of contaminant-related stress are measured by the ORNL Biological Monitoring and Abatement Program and provide supplemental evidence of risk. Each stream is discussed separately below.

Fish community surveys: White Oak Creek

Species richness does not indicate that WAG 5 increases the impacts on the fish communities of White Oak Creek. That is, species richness did not decline in the stretch adjacent to WAG 5. If impacts of WAG 5 are occurring they may not be severe enough to detect above the noise of the system. Contribution to risks in White Oak Creek from WAG 5 may become evident as the effects of severe stressors (e.g., chlorine discharges) are ameliorated. However, the low number of fish species in White Oak Creek is due in part to the construction of weirs in White Oak Creek and White Oak Dam. These structures inhibit immigration from downstream reaches of White Oak Creek and the Clinch River basin. These

physical limitations may continue to obscure any impacts of WAG 5 as White Oak Creek-wide recovery continues.

Fish density does not provide a clear indication that WAG 5 increases the impacts on the fish communities of White Oak Creek. The most recent density results appear to indicate that WAG 5 is impacting the fish community of White Oak Creek. However, the higher densities adjacent to and above WAG 5 are attributable, at least in part, to differences in habitat. Pollution abatement projects in upper White Oak Creek have improved the overall water quality, resulting in increased density at all three sites around WAG 5 since 1989 (Fig. C2.6). This increase is primarily due to stonerollers, which prefer the habitat at the two upstream sites. Also, densities over the last eight years do not exhibit a consistent downstream gradient along the WAG 5 boundary. Although the increased seasonal and inter-site variability observed in White Oak Creek is consistent with a recovering community, it precludes a definitive evaluation of the contribution to risks from WAG 5.

There is some evidence that WAG 5 contributes to the contaminant body burdens in fish from White Oak Creek. Mercury and PCBs were elevated in fish from sites along WAG 5. Although consistent downstream gradients in White Oak Creek fish were not evident, both mercury and PCB 1260 were identified as COCs in the sediments of drainage D1. However, WAG 5 does not appear to be the sole source of these contaminants and the impact of these body burdens on the White Oak Creek fish community is not clear.

Biological indicators of contaminant-related stress do not provide a clear indication that WAG 5 increases the impacts on the White Oak Creek fish communities. The overall evaluation of biological indicators suggests that fish populations in White Oak Creek are still being affected by stressors in the system. However, significant improvement has occurred since 1989. This is consistent with the increases observed in fish densities due to water quality improvements in upper White Oak Creek. Also, impacts due to WAG 5 were not specifically evident.

Fish community surveys: Melton Branch

Species richness does not indicate that WAG 5 increases the impacts on the fish communities of Melton Branch. That is, species richness adjacent to WAG 5 was at least as high as at the two upstream locations and the reference station in White Oak Creek. As in White Oak Creek, there are a limited number of fish species in Melton Branch, in part because of the construction of weirs in Melton Branch and White Oak Dam. These structures inhibit immigration from downstream reaches of White Oak Creek and the Clinch River basin.

Fish density does not indicate that WAG 5 increases the impacts on the fish communities of Melton Branch. In 1993 the density adjacent to WAG 5 was greater than or equal to the two upstream sites and all three were greater than the reference in White Oak Creek. Densities over the last eight years did not exhibit an apparent or consistent downstream gradient (Fig. C2.7), but have remained comparable to the reference site. Melton Branch is a small stream and can only support a low density fish community. This significantly limits the ability to discern changes in density that are due to only moderate stresses. These communities are also more sensitive to natural stressors, such as drought.

There is some evidence that WAG 5 contributes to the contaminant body burdens in fish from Melton Branch. PCBs were elevated in fish from around MEK 0.2. PCB 1260 was identified as a contaminant of concern in the sediments of drainage D2. However, measurements were not taken upstream of WAG 5, and the impact of these body burdens on the Melton Branch fish community is not clear.

Medium toxicity tests: White Oak Creek

Medaka embryo-larval toxicity tests do not provide a clear indication that WAG 5 increases the impacts on the fish communities of White Oak Creek. A biologically and statistically significant reduction in survival did occur upstream of WAG 5. Although the reductions were not statistically significant, survival in water from the site adjacent to WAG 5 was considerably less than in the water from above WAG 5 (Table C2.9). Drainage D1 could be the source of this toxicity. This would be consistent with the results of aquatic toxicity tests conducted in that drainage (see Sect C2.4.2.5). However, drainage D1 is ephemeral, and the Medaka toxicity tests were conducted during the summer. The tributary from WAG 4 could also be the source of toxicity. That tributary discharges in the same general area and usually has some flow during the summer.

Contaminant screening of surface water

Contaminants of potential concern for risk to fish communities were identified by comparing contaminant concentrations in water from Melton Branch to toxicological benchmarks (Sect. C2.3.1.1.5). Four sites were sampled: just downstream of WAG 5 (SW006, which is approximately MEK 0.2), below seep SP016 in drainage D3 (SW003), above drainage D3 in the tributary that flows along the eastern boundary of WAG 5 (SW004), and above WAG 5 but below the tributary from HFIR (SW005, which is approximately MEK 1.1) (Fig. A2.15). At each site the four flow regimes (high base, high base storm, low base, low base storm) were screened separately. Contaminants were screened and HQs were calculated following the same procedure and assumptions used for on-site surface water (Sect. C2.4.2.5). Quotients greater than 1 are indicative of a hazard that requires further assessment. Screening results for total and dissolved phase chemical concentrations for these sites are presented in Tables C2.58 and C2.59, respectively. Radiological screening results are presented in Table C2.7.

Downstream of WAG 5 (SW006/MEK 0.2) only one contaminant, fluoride, exceeded any benchmarks during any flow regime. During high base flow conditions fluoride exceeded the secondary chronic value by a factor 1.18 and the population EC20 by a factor of 1.25. Fluoride was not measured in the filtered water samples. No analytes exceeded benchmarks during low base, high base storm, or low base storm flow conditions. The radiological HQ from the combined doses of all nuclides at SW006/MEK 0.2 was less than 0.01 for all flow regimes.

Samples from SW003 (drainage D3 downstream of SP016) and SW005/MEK 1.1 (upstream of WAG 5) had concentrations of three contaminants (aluminum, fluoride, and manganese) that exceeded at least one benchmark during at least one flow regime. At the other upstream location (SW004) no analytes exceeded any benchmarks during any flow regimes.

During high base flow conditions manganese in drainage D3 (SW003) exceeded the population EC20. During high base flow fluoride at SW005/MEK 1.1 exceeded the secondary chronic value and population EC20 by factors of 1.58 and 1.67, respectively. The concentration of dissolved manganese at SW003 also exceeded the benchmark. No analytes exceeded any benchmarks during low base flow.

During high base storm flow aluminum in drainage D3 (SW003) had HQs greater than 1. However, dissolved aluminum was less than the detection limit and all benchmarks. No analytes exceeded any benchmarks during high base storm flow at SW005/MEK 1.1. During low base storm flow aluminum exceeded benchmarks at both sites and manganese exceeded benchmarks at SW003. Dissolved concentrations of aluminum and manganese also exceeded benchmarks at these sites. At each of the three upstream sites the radiological HQ from the combined doses of all detected isotopes was less than 0.1 for all flow regimes.

Four chemicals (chloride, nitrate, phosphate, and sulfate) were detected in surface water from Melton Branch that could not be screened because no aquatic toxicity data were found. Phosphate is a macronutrient and is not known to be toxic under ambient conditions. The internal dose rate for one radionuclide, Sn-119m, could not be estimated because a bioconcentration factor was not found. This nuclide was detected only once, in drainage D3 (SW003) during high base flow conditions.

Contaminants of potential concern

Aluminum. Downstream of WAG 5 (SW006/MEK 0.2) total aluminum concentrations were below detection limits or background during all flow conditions. During high and low base flow conditions aluminum did not exceed benchmarks at either location SW003 or SW005/MEK 1.1.

During storm flow sampling the total aluminum concentrations at SW003 and SW005/MEK 1.1 exceeded the acute NAWQC by factors of 1.13 and 4.24, respectively (Table C2.58). At low base storm flow aluminum concentrations at SW003 were less than the NAWQC. The maximum concentrations during high and low base storms were lower than the lowest acute toxicity values for both invertebrates (1900 µg/L for *Ceriodaphnia dubia*) and fish (3600 µg/L for juvenile brook trout, *Salvelinus fontinalis*).

At SW005/MEK 1.1 aluminum was detected above background during low base storm flow but not during high base storm conditions. The maximum detected total aluminum concentration (3180 µg/L) was 4.24 times higher than the acute NAWQC. The maximum was lower than the lowest acute toxicity value for fish (3600 µg/L for juvenile brook trout, *S. fontinalis*), but higher than the lowest acute toxicity value for invertebrates (1900 µg/L for *C. dubia*). Total aluminum, however, was detected in only two of the four samples analyzed, and the mean concentration (350 µg/L) did not exceed any benchmarks or acute toxicity values.

Particle load during storms is likely to be increased and total aluminum concentrations may overestimate the bioavailable concentration. However, dissolved concentrations were also above benchmarks during low base storm flow. It should be noted that the estimated dissolved aluminum concentrations (8900 µg/L at SW003 and 40,400 µg/L at SW005/MEK 1.1) are inordinately high, relative to total recoverable concentrations. For this assesment it was assumed that dissolved aluminum was approximately the same as total recoverable aluminum. These results provide some evidence of acute toxicity during storm events at SW003 and

SW005/MEK 1.1.

Fluoride. During high base flow conditions fluoride was detected downstream of WAG 5 (SW006/MEK 0.2) and at two locations (SW004 and SW005/MEK 1.1) upstream of WAG 5.

The concentrations downstream (1350 $\mu\text{g/L}$) and upstream (1800 $\mu\text{g/L}$ at SW005/MEK 1.1) of WAG 5 were greater than the secondary chronic value (1140 $\mu\text{g/L}$) and the population EC20 (1080 $\mu\text{g/L}$) for fluoride but less than four other chronic benchmarks (Table C2.58). Total fluoride concentrations at both sites were an order of magnitude less than the lowest fluoride ion concentration (26,000 $\mu\text{g/L}$) producing chronic effects in daphnids. The concentration at SW004 (528 $\mu\text{g/L}$) did not exceed any benchmarks but does indicate a second source of fluoride upstream of WAG 5. Also, a background value for fluoride was not available. The secondary chronic value and population EC20 are for fluoride ion, which is likely to be overestimated by the available measurements of total fluoride. These results are at best weak evidence of chronic toxicity due to fluoride and indicate that if these levels are above background the source of fluoride is likely to be upstream of WAG 5.

Manganese. Total concentrations downstream of WAG 5 (SW006/MEK 0.2) did not exceed any benchmarks during any flow regime. Upstream of WAG 5 only SW003 had concentrations in excess of at least one benchmark (Table C2.58). The concentrations during high base flow (244 $\mu\text{g/L}$) and low base storm flow conditions (355 $\mu\text{g/L}$) were higher than the population EC20 (112 $\mu\text{g/L}$). The EC20 for fish populations is an order of magnitude lower than the other benchmarks because of the assumptions of combined effects to all life stages. These results provide weak evidence of chronic effects above WAG 5. However, these results provide no evidence of increased toxicity in Melton Branch due to manganese released from WAG 5 during base flow or storm flow conditions.

Weight of evidence

The weight of evidence indicates that fish may be impacted by chronic exposure to water from drainage D3 (Table C2.60). Acute effects are not expected during base flow but may occur during storm flow conditions. However, this ephemeral drainage does not support a distinct fish community and comparison to benchmarks was the only available line of evidence. Aluminum exceeded the acute NAWQC during a low base storm event, but there is considerable uncertainty in these measurements: dissolved aluminum was an order of magnitude higher than total aluminum.

The weight of evidence is too ambiguous to determine whether fish in White Oak Creek are impacted by WAG 5 (Table C2.60). Fish community surveys and Medaka toxicity tests indicate impacts are occurring in White Oak Creek. However, if WAG 5 contributes to these impacts, its contribution cannot be distinguished from the impacts of other sources and habitat quality.

The weight of evidence indicates that fish in Melton Branch are not impacted by WAG 5 (Table C2.60). One contaminant, fluoride, exceeded chronic benchmarks during base flow conditions. However, the source appears to be upstream of WAG 5, concentrations in the stream may be comparable to background levels, and the fish community does not appear to be impacted. During storm flow conditions aluminum exceeded the acute NAWQC at one site. Dissolved aluminum was an order of magnitude higher than total aluminum, the source

is upstream of WAG 5, and the fish community does not appear to be impacted.

C2.4.4.5.2 Risks from seeps in and around WAG 5

Media toxicity data

The standard *Ceriodaphnia* 7-d toxicity tests indicate that acute and chronic toxicity to fish may occur from exposure to undiluted seep SP006 water. Toxicity to fish may occur from chronic exposure to undiluted water from seeps SP004 and SP009. There is no evidence of toxicity from exposure to water from seeps SP003 and SP008. Toxicity to aquatic communities in White Oak Creek and Melton Branch is not expected because exposure to undiluted seep water is not possible at these seeps: they are isolated from the main channels, too small to support significant aquatic communities, and dry part of the year.

As tested, the water should sufficiently represent the field exposures at the time of sampling. The test results are reflective of conditions during high base flow and give no indication of exposures during storm or low base flow conditions. That is, the tests were replicated but within the same season (December 1991 and February 1992) and without regard for storm events. The single test of SP006 water may not adequately represent the field exposures at the time of sampling. Toxicity may have been increased by sampling the seep only once and storing the water during testing. However, filtering and then refrigerating the sample should have prevented significant release of particle-bound contaminants or changes in the chemical form of the contaminants.

Contaminant screening of seeps

Contaminants of potential concern for risk to fish communities were identified by comparing contaminant concentrations in seep water to toxicological benchmarks (Sect. C2.3.1.1.5). For naturally occurring analytes the maximum detected concentration/activity was compared to twice the average concentration/activity at the reference site. The maximum detected value was used because only one result was available. Contaminants that exceeded background, were not analyzed at the reference site, or are not naturally occurring were compared to benchmarks. Benchmarks which were less than mean background levels were not used. Hazard quotients were calculated for each contaminant. The numerator is the maximum detected concentration or activity in the water. The denominators are a set of toxicological benchmarks that reflect the variety of estimators of a toxicological threshold for aquatic ecological effects (Sect. C2.3.1.1.5). For each seep the absorbed radiation dose from all detected radionuclides was summed and compared to the recommended criterion. Quotients greater than 1 are indicative of a hazard that requires further assessment.

For seeps, the HQ is equivalent to the dilution factor. This is the amount of water needed to reduce the HQ to 1. That is, 1 L of water that contains 400 µg/L of a chemical and has an HQ of 4 would need to be diluted to a total volume of 4 liters in order to be equal to the benchmark of 100 µg/L. For a seep discharging at a rate of 1 L/min the receiving stream would need a final downstream discharge rate of 4 L/min. This assumes that the water for dilution does not contribute significantly to the final concentration. The purpose of the dilution factor is to provide a general point of reference for evaluating seep discharges, rather than an absolute exposure rate. Therefore, if the total and dissolved concentrations of an analyte results in an HQ greater than 1, seep flow rates at the time of sample collection were compared to the minimum flow rates for the year at either White Oak Creek or Melton

Branch weir. Chemical and radiological screening results for these seeps are presented in Tables C2.61 and C2.8, respectively.

Only total recoverable concentrations were determined for the background samples. Therefore, total recoverable concentrations were used for all sites such that metal and naturally occurring analytes could be screened against background. Total concentrations are more conservative because the bioavailable fraction is generally less than the total recoverable concentration. Metals, for example, typically include 30–95% particle-bound material (HECD 1992). Also, conventional toxicity data are based on laboratory studies using contaminants dissolved in filtered water. If the total recoverable concentration of a metal exceeded background and at least one benchmark, the dissolved concentration was also compared to benchmarks as a more realistic estimate of exposure. The results of these comparisons are presented in Table C2.62.

Total concentrations of nine contaminants (aluminum, barium, calcium, cobalt, iron, manganese, nickel, selenium, and 1,2-dichloroethene) exceeded at least one benchmark at one or more seeps. Aluminum, barium, iron, and manganese were the analytes that exceeded benchmarks in the most seeps. Cobalt, nickel, and selenium were each observed only once. All seeps, except SP002, had at least one contaminant for which total concentrations exceeded at least one benchmark. Two seeps (SP006 and SP008) had radiological HQs greater than 1.0. All other seeps had radiological HQs less than 0.25. Concentrations of contaminants that exceeded at least one benchmark are discussed separately for each seep in the following section.

Six chemicals (chloride, nitrate, phosphate, silicon, sulfate, and 1,2,4-trichlorobenzene) were detected in seep water but could not be screened against benchmarks because no aquatic toxicity data were found. Phosphate is a macronutrient and is not known to be toxic under ambient conditions.

Contaminants of potential concern

SP001

Aluminum. Total concentrations at SP001 in May 1993 exceeded the acute NAWQC by a factor of 1.31. The chronic NAWQC was also exceeded but was less than background levels. Two of the five other benchmarks were also exceeded (Table C2.61). The maximum concentration of total aluminum (980 µg/L) was lower than the lowest acute toxicity values for invertebrates (1900 µg/L for *Ceriodaphnia dubia*) and fish (3600 µg/L for juvenile brook trout, *Salvelinus fontinalis*) but greater than the lowest chronic value for daphnids (742 µg/L for *Daphnia magna*). However, only one sample was analyzed, and the total aluminum concentration is likely to significantly overestimate the bioavailable concentration. The dissolved phase concentration was only 91 µg/L, which does not exceed any benchmarks. Based on these results it is unlikely that WAG 5 increases risks to fish in White Oak Creek through the release of aluminum from seep SP001.

Iron. Total concentrations at SP001 exceeded the chronic NAWQC by a factor of 1.20. There is no acute NAWQC. The only other benchmarks, the lowest chronic value and the lowest test EC20 for daphnids, were less than background and were not used. The total concentration (1200 µg/L) was below the concentration (4380 µg/L) that caused a 16% reproductive decrement and the 48-h LC50 for *D. magna* (9600 µg/L). Only one sample was

analyzed, and the total iron concentration is likely to significantly overestimate the bioavailable concentration. The dissolved phase concentration was (306 µg/L), which does not exceed the chronic NAWQC or the chronic toxicity value for *D. magna* (4380 µg/L). Based on these results it is unlikely that WAG 5 increases risks to fish in White Oak Creek through the release of iron from seep SP001.

Manganese. Total manganese was 1.28 to 2.06 times greater than the four chronic benchmarks and 20.27 times the EC20 for fish populations (Table C2.61). The population benchmark is an order of magnitude lower than the other benchmarks because of the assumptions of combined effects to all life stages. The secondary acute value was also exceeded but the acute values used to derive that benchmark (19,400 µg/L for *D. magna* and 33,800 µg/L for fathead minnow) were an order of magnitude above the total concentration at SP001. Only one sample was analyzed, but the dissolved phase concentration (2300 µg/L) was comparable to the total concentration (2270 µg/L). At the time the samples were collected SP001 had a flow rate of 0.8 L/min. The minimum daily flow at White Oak Creek weir in 1993 was 6840 L/min (4.03 cfs) and the flow rate when SP001 was sampled was 12,970 L/min. The minimum White Oak Creek flow divided by the contribution from SP001 gives a dilution rate of 8550. Based on these results it is unlikely that manganese released from SP001 is toxicologically problematic for fish in White Oak Creek. These results do, however, provide strong evidence of chronic toxicity from exposure to undiluted water from seep SP001.

Radionuclides. Two radionuclides, tritium and Th-232, were detected in the unfiltered sample from SP001. The radiological HQ from the combined doses of these isotopes was 0.001. Based on these results it is unlikely that WAG 5 increases risks to fish in White Oak Creek through the release of radionuclides from seep SP001.

SP003

Aluminum. Total concentrations at SP003 in May 1993 exceeded the acute NAWQC by a factor of 4.83. The chronic NAWQC was less than background levels and was not used. Total aluminum was 1.10 to 7.87 time higher than four of the five chronic benchmarks (Table C2.61). The concentration of total aluminum (3620 µg/L) was higher than the lowest acute toxicity values for invertebrates (1900 µg/L for *C. dubia*) and fish (3600 µg/L for juvenile brook trout, *S. fontinalis*) and the lowest chronic value for daphnids (742 µg/L for *D. magna*). However, only one sample was analyzed, and the total aluminum concentration is likely to significantly overestimate the bioavailable concentration. The dissolved phase concentration was less than detection limits but was estimated at only 23.5 µg/L, which does not exceed any benchmarks or the toxicity values mentioned above. Based on these results it is unlikely that WAG 5 increases risks to fish in White Oak Creek through the release of aluminum from seep SP001.

Barium. The total concentration at SP003 exceeded the secondary acute value by a factor of 2.69. The secondary chronic value was less than background and was not used. Only one other benchmark was available, and it was not exceeded (Table C2.61). As discussed in Sect. C2.3.1.1.5, the secondary acute value is extremely conservative and concentrations that exceed it should be evaluated against the toxicity values used in its derivation. At 185 µg/L the concentration of total barium is three orders of magnitude less than the acute value for *D. magna* (410,000 µg/L) and approximately half the lowest acute value (330 µg/L for a gastropod snail) used to derive the secondary acute value (Appendix A in Suter and Mabrey

1994). Only one sample was analyzed, and total barium is likely to significantly overestimate the bioavailable concentration. The estimated dissolved phase value (96.3 µg/L) was 1.4 times the secondary acute value. At the time the samples were collected, SP003 had a flow rate of 1.6 L/min. The minimum daily flow at White Oak Creek weir in 1993 was 6840 L/min (4.03 cfs), and the flow rate when SP003 was sampled was 12,970 L/min. The minimum White Oak Creek flow divided by the contribution from SP003 gives a dilution rate of 4275. Based on these results it is unlikely that barium released from SP003 is toxicologically problematic for fish in White Oak Creek. These results provide weak evidence at best of acute and chronic toxicity from exposure to undiluted water from seep SP003.

Iron. Total concentrations at SP003 exceeded the chronic NAWQC by a factor of 7.46. There is no acute NAWQC. The only other benchmarks—the lowest chronic value and the lowest test EC20 for daphnids—were less than background and were not used. The total concentration (7460 µg/L) was higher than the concentration (4380 µg/L) that caused a 16% reproductive decrement in a test with *D. magna*, but lower than the 48-h LC50 for *D. magna* (9600 µg/L). Only one sample was analyzed, and the total iron concentration is likely to significantly overestimate the bioavailable concentration. The dissolved phase concentration was 208 µg/L, which does not exceed the chronic NAWQC or the chronic toxicity value for *D. magna* (4380 µg/L). Based on these results, it is unlikely that WAG 5 increases risks to fish in White Oak Creek through the release of iron from seep SP003.

Manganese. Total manganese was 1.70 to 2.74 times greater than the four chronic benchmarks and 26.88 times the EC20 for fish populations (Table C2.61). The population benchmark is an order of magnitude lower than the other benchmarks because of the assumptions of combined effects to all life stages. The secondary acute value was also exceeded, but the acute values used to derive that benchmark (19,400 µg/L for *D. magna* and 33,800 µg/L for fathead minnow) were an order of magnitude above the total concentration at SP003. Only one sample was analyzed, and the total manganese concentration (3010 µg/L) is likely to significantly overestimate the bioavailable concentration. The dissolved phase concentration was 900 µg/L, which does not exceed the secondary chronic value or the chronic toxicity values for daphnids and fathead minnows. The dissolved concentration was eight times the population EC20. The minimum White Oak Creek flow divided by the contribution from SP003 gives a dilution rate of 4275. Based on these results it is unlikely that manganese released from SP003 is toxicologically problematic for fish in White Oak Creek. These results provide only weak evidence of chronic toxicity from exposure to undiluted water from seep SP003.

Radionuclides. Five radionuclides were detected in the unfiltered sample from SP003. The radiological HQ from the combined doses of these isotopes was 0.001. Based on these results it is unlikely that WAG 5 increases risks to fish in White Oak Creek through the release of radionuclides from seep SP003.

SP004

Aluminum. Total concentrations at SP004 in May 1993 exceeded the acute NAWQC by a factor of 1.60. The chronic NAWQC was less than background levels and was not used. Two of the five other chronic benchmarks were also exceeded (Table C2.61). The concentration of total aluminum (1200 µg/L) was less than the lowest acute toxicity values for invertebrates (1900 µg/L for *C. dubia*) and fish (3600 µg/L for juvenile brook trout, *S. fontinalis*) but higher than the lowest chronic value for daphnids (742 µg/L for *D. magna*).

However, only one sample was analyzed for total aluminum. The dissolved phase concentration was less than detection limits but was estimated at only 23.5 µg/L, which does not exceed any benchmarks or the toxicity values mentioned above. Based on these results it is unlikely that WAG 5 increases risks to fish in White Oak Creek through the release of aluminum from seep SP004.

Barium. At 86.2 µg/L the total concentration at SP004 exceeded the secondary acute value by a factor of 1.25. The secondary chronic value was less than background and was not used. Only one other benchmark was available and it was not exceeded (Table C2.61). The secondary acute value is extremely conservative, and concentrations that exceed it should be evaluated against the toxicity values used in its derivation (see Sect. C2.3.1.1.5). Total barium was four orders of magnitude less than the acute value for *D. magna* (410,000 µg/L) and three times lower than the lowest acute value (330 µg/L for a gastropod snail) used to derive the secondary acute value (Suter and Mabrey 1994, Appendix A). Total barium is likely to significantly overestimate the bioavailable concentration. The estimated dissolved phase value (74.7 µg/L) was 1.09 times the secondary acute value. At the time the samples were collected SP004 had a flow rate of 1.7 L/min. The minimum daily flow at White Oak Creek weir in 1993 was 6840 L/min (4.03 cfs), and the flow rate when SP003 was sampled was 12,970 L/min. The minimum White Oak Creek flow divided by the contribution from SP004 gives a dilution rate of 3811. Based on these results it is unlikely that barium released from SP004 is toxicologically problematic for fish in White Oak Creek. These results provide weak evidence at best of acute or chronic toxicity from exposure to undiluted water from seep SP004.

Iron. Total concentrations at SP004 exceeded the chronic NAWQC by a factor of 1.49. There is no acute NAWQC. The lowest chronic value and the lowest test EC20 for daphnids were less than background and were not used. The total concentration (1490 µg/L) was less than the concentration (4380 µg/L) that caused a 16% reproductive decrement in a test with *D. magna* and the 48-h LC50 for *D. magna* (9600 µg/L). Only one sample was analyzed, and the total iron concentration is likely to significantly overestimate the bioavailable concentration. The dissolved phase concentration was estimated at 28.3 µg/L, which does not exceed the chronic NAWQC or the chronic toxicity value for *D. magna* (4380 µg/L). Based on these results it is unlikely that WAG 5 increases risks to fish in White Oak Creek through the release of iron from seep SP004.

1,2-Dichloroethene. At 180 µg/L the concentration at SP004 exceeded the secondary chronic value by a factor of 5.77. The observed concentration was less than the secondary acute value and the two other benchmarks (Table C2.61). Chronic toxicity values were not found for 1,2-dichloroethene. The concentration at SP004 was three orders of magnitude less than the acute value (135,000 µg/L for the bluegill *Lepomis macrochirus*) used to estimate the chronic values for fish. It is also less than the chronic value for fish (>2000 µg/L) for a similar analyte, 1,1-dichloroethene. The minimum White Oak Creek flow divided by the contribution from SP004 gives a dilution rate of 3811. Based on these results it is unlikely that 1,2-dichloroethene released from SP004 is toxicologically problematic for fish in White Oak Creek. These results do provide some evidence of chronic toxicity from exposure to undiluted water from seep SP004.

Radionuclides. Six radionuclides were detected in the unfiltered sample from SP004. The radiological HQ from the combined doses of these isotopes was 0.001. Based on these results it is unlikely that WAG 5 increases risks to fish in White Oak Creek through the release of radionuclides from seep SP004.

SP005

Aluminum. Total concentrations at SP005 in May 1993 exceeded the acute NAWQC by a factor of 3.07. The chronic NAWQC was less than background levels and was not used. Total aluminum was 1.21 to 5.00 times higher than three of the five chronic benchmarks (Table C2.61). The concentration of total aluminum (2300 µg/L) was less than the lowest acute toxicity value for fish (3600 µg/L for juvenile brook trout, *S. fontinalis*) but higher than the lowest acute toxicity value for invertebrates (1900 µg/L for *C. dubia*) and the lowest chronic value for daphnids (742 µg/L for *D. magna*). However, only one sample was analyzed, and the total aluminum concentration is likely to significantly overestimate the bioavailable concentration. The dissolved phase concentration was less than detection limits but was estimated at only 64.8 µg/L, which does not exceed any benchmarks or the toxicity values mentioned above. Based on these results it is unlikely that WAG 5 increases risks to fish in Melton Branch through the release of aluminum from seep SP005.

Barium. The total concentration at SP005 exceeded the secondary acute value by a factor of 2.31. The secondary chronic value was less than background and was not used. Only one other benchmark was available, and it was not exceeded (Table C2.61). At 159 µg/L the concentration of total barium is three orders of magnitude less than the acute value for *D. magna* (410,000 µg/L) and approximately half the lowest acute value (330 µg/L for a gastropod snail) used to derive the secondary acute value (Suter and Mabrey 1994, Appendix A). Only one sample was analyzed. Although total barium is likely to significantly overestimate the bioavailable concentration, the dissolved phase value (143 µg/L) was not appreciably lower. At the time the samples were collected SP005 had a flow rate of 0.5 L/min. The minimum daily flow at Melton Branch weir in 1993 was 255 L/min (0.15 cfs), and the flow rate when SP005 was sampled was 1698 L/min. The minimum Melton Branch flow divided by the contribution from SP005 gives a dilution rate of 510. Based on these results it is unlikely that barium released from SP005 is toxicologically problematic for fish in Melton Branch. These results provide weak evidence of acute and chronic toxicity from exposure to undiluted water from seep SP005.

Iron. Total concentrations at SP005 exceeded the chronic NAWQC by a factor of 2.58. There is no acute NAWQC. The only other benchmarks, the lowest chronic value and the lowest test EC20 for daphnids, were less than background and were not used. The total concentration (2580 µg/L) was less than the concentration (4380 µg/L) that caused a 16% reproductive decrement in a test with *D. magna* and the 48-h LC50 for *D. magna* (9600 µg/L). Only one sample was analyzed, and the total iron concentration is likely to significantly overestimate the bioavailable concentration. The dissolved phase concentration was 228 µg/L, which does not exceed the chronic NAWQC or the chronic toxicity value for *D. magna*. Based on these results it is unlikely that WAG 5 increases risks to fish in Melton Branch through the release of iron from seep SP005.

Manganese. Total manganese at SP005 in May 1993 was 2.05 times the EC20 for fish populations. It did not exceed the four chronic benchmarks or the secondary acute value (Table C2.61). The population benchmark is an order of magnitude lower than the other benchmarks because of the assumptions of combined effects to all life stages. Only one sample was analyzed from SP005. Although total manganese (230 µg/L) is likely to significantly overestimate the bioavailable concentration, the dissolved phase value (233 µg/L) was not appreciably different. The minimum Melton Branch flow divided by the contribution

from SP005 gives a dilution rate of 510. Based on these results it is unlikely that manganese released from SP005 is toxicologically problematic for fish in Melton Branch. These results do provide some evidence of chronic toxicity, but no evidence of acute toxicity, from exposure to undiluted water from seep SP005.

Radionuclides. Six radionuclides were detected in the unfiltered sample from SP005. The radiological HQ from the combined doses of these isotopes was 0.050. Based on these results it is unlikely that WAG 5 increases risks to fish in Melton Branch through the release of radionuclides from seep SP005.

SP006

Barium. The total concentration at SP006 exceeded the secondary acute value by a factor of 1.37. The secondary chronic value was less than background and was not used. Only one other benchmark was available and it was not exceeded (Table C2.61). The secondary acute value is extremely conservative and concentrations that exceed it should be evaluated against the toxicity values used in its derivation (see Sect. C2.3.1.1.5). The concentration of total barium (94.3 $\mu\text{g/L}$) is more than three orders of magnitude less than the acute value for *D. magna* (410,000 $\mu\text{g/L}$) and less than half the lowest acute value (330 $\mu\text{g/L}$ for a gastropod snail) used to derive the secondary acute value (Suter and Mabrey 1994, Appendix A). Only one sample was analyzed. Although total barium is likely to significantly overestimate the bioavailable concentration, the dissolved phase value (90 $\mu\text{g/L}$) was not appreciably lower. At the time the samples were collected SP006 had a flow rate of 1.4 L/min. The minimum daily flow at Melton Branch weir in 1993 was 255 L/min (0.15 cfs) and the flow rate when SP006 was sampled was 1698 L/min. The minimum Melton Branch flow divided by the contribution from SP006 gives a dilution rate of 182. Based on these results it is unlikely that barium released from SP006 is toxicologically problematic for fish in Melton Branch. These results provide weak evidence of acute and chronic toxicity from exposure to undiluted water from seep SP005.

Iron. Total concentrations at SP006 exceeded the chronic NAWQC by a factor of 1.34. There is no acute NAWQC. The only other benchmarks, the lowest chronic value and the lowest test EC20 for daphnids, were less than background and were not used. The total concentration (1340 $\mu\text{g/L}$) was less than the concentration (4380 $\mu\text{g/L}$) that caused a 16% reproductive decrement in a test with *D. magna* and the 48-h LC50 for *D. magna* (9600 $\mu\text{g/L}$). Only one sample was analyzed, and the total iron concentration is likely to significantly overestimate the bioavailable concentration. The dissolved phase concentration was (120 $\mu\text{g/L}$), which does not exceed the chronic NAWQC or the chronic toxicity value for *D. magna*. Based on these results it is unlikely that WAG 5 increases risks to fish in Melton Branch through the release of iron from seep SP006.

Manganese. Total manganese at SP006 in May 1993 was 5.01 times the EC20 for fish populations. It did not exceed the four chronic benchmarks or the secondary acute value (Table C2.61). The population benchmark is an order of magnitude lower than the other benchmarks because of the assumptions of combined effects to all life stages. Only one sample was analyzed from SP006. Although total manganese (561 $\mu\text{g/L}$) is likely to significantly overestimate the bioavailable concentration, the dissolved phase value (356 $\mu\text{g/L}$) was not less than the population EC20. The minimum Melton Branch flow divided by the contribution from SP006 gives a dilution rate of 182. Based on these results it is unlikely that manganese released from SP006 is toxicologically problematic for fish in Melton Branch.

These results do provide weak evidence of chronic toxicity, but no evidence of acute toxicity, from exposure to undiluted water from seep SP006.

Radionuclides. Five radionuclides (tritium, C-14, Ca-45, Sr-89/90, and Tc-99) were detected in the unfiltered sample from SP006. The radiological HQ from the combined doses of these isotopes was 1.084. Most of the estimated dose (HQ of 1.080) is from internal exposure from Sr-89/90. Only one sample was analyzed, and the unfiltered activity is likely to overestimate the bioavailable fraction and the resulting internal dose rate. The minimum Melton Branch flow divided by the contribution from SP006 gives a dilution rate of 182. Based on these results it is unlikely that WAG 5 increases risks to fish in White Oak Creek through the release of radionuclides from seep SP006. These results do provide significant evidence of risk from exposure to undiluted water from seep SP006.

SP007

Aluminum. Total concentrations at SP007 in May 1993 exceeded the acute NAWQC by a factor of 7.73. The chronic NAWQC was less than background levels and was not used. Total aluminum was 1.23 to 12.61 times higher than the five chronic benchmarks (Table C2.61). The concentration of total aluminum (5800 $\mu\text{g/L}$) was higher than the lowest acute toxicity values for invertebrates (1900 $\mu\text{g/L}$ for *C. dubia*) and fish (3600 $\mu\text{g/L}$ for juvenile brook trout, *S. fontinalis*) and the lowest chronic value for daphnids (742 $\mu\text{g/L}$ for *D. magna*). Only one sample was analyzed, and the total aluminum concentration is likely to significantly overestimate the bioavailable concentration. However, the dissolved phase concentration was 598 $\mu\text{g/L}$, which exceeds the lowest chronic values for plants and the lowest EC20 for daphnids. At the time the samples were collected SP007 had a flow rate of 0.5 L/min. The minimum daily flow at Melton Branch weir in 1993 was 255 L/min (0.15 cfs) and the flow rate when SP007 was sampled was 1460 L/min. The minimum Melton Branch flow divided by the contribution from SP007 gives a dilution rate of 2920. Based on these results it is unlikely that aluminum released from SP007 is toxicologically problematic for fish in Melton Branch. These results do provide evidence of chronic toxicity, but no evidence of acute toxicity, from exposure to undiluted water from seep SP007.

Barium. The total concentration at SP007 exceeded the secondary acute value by a factor of 3.02. The secondary chronic value was less than background and was not used. Only one other benchmark was available and it was not exceeded (Table C2.61). The total barium concentration (208 $\mu\text{g/L}$) is three orders of magnitude less than the acute value for *D. magna* (410,000 $\mu\text{g/L}$) and about 70% of the lowest acute value (330 $\mu\text{g/L}$ for a gastropod snail) used to derive the secondary acute value (Suter and Mabrey 1994, Appendix A). Only one sample was analyzed, and the total barium concentration is likely to significantly overestimate the bioavailable concentration. The dissolved phase value (120 $\mu\text{g/L}$) was lower, but not less than the secondary acute value. The minimum Melton Branch flow divided by the contribution from SP007 gives a dilution rate of 2,920. Based on these results it is unlikely that barium released from SP007 is toxicologically problematic for fish in Melton Branch. These results provide weak evidence of acute and chronic toxicity from exposure to undiluted water from seep SP007.

Iron. Total concentrations at SP007 exceeded the chronic NAWQC by a factor of 16.80. There is no acute NAWQC. The only other benchmarks, the lowest chronic value and the lowest test EC20 for daphnids, were less than background and were not used. The total concentration (16,800 $\mu\text{g/L}$) was higher than the concentration (4380 $\mu\text{g/L}$) that caused a

16% reproductive decrement in a test with *D. magna* and the 48-h LC50 for *D. magna* (9600 µg/L). Only one sample was analyzed, and the total iron concentration is likely to significantly overestimate the bioavailable concentration. However, the dissolved phase concentration was 8280 µg/L, which exceeds the chronic NAWQC and the chronic toxicity value for *D. magna*. The minimum Melton Branch flow divided by the contribution from SP007 gives a dilution rate of 2920. Based on these results it is unlikely that iron released from SP007 is toxicologically problematic for fish in Melton Branch. These results provide strong evidence of chronic toxicity, and weak evidence of acute toxicity, from exposure to undiluted water from seep SP007.

Manganese. Total manganese was 2.54 to 4.08 times greater than the four chronic benchmarks and 40.09 times the EC20 for fish populations (Table C2.61). The population benchmark is an order of magnitude lower than the other benchmarks because of the assumptions of combined effects to all life stages. The secondary acute value was also exceeded, but the acute values used to derive that benchmark (19,400 µg/L for *D. magna* and 33,800 µg/L for fathead minnow) were not. Only one sample was analyzed, and the total manganese concentration (4490 µg/L) is likely to significantly overestimate the bioavailable concentration. However, the dissolved phase value (4340 µg/L) was not appreciably lower. The minimum Melton Branch flow divided by the contribution from SP007 gives a dilution rate of 2920. Based on these results it is unlikely that manganese released from SP007 is toxicologically problematic for fish in Melton Branch. These results provide strong evidence of chronic toxicity, and weak evidence of acute toxicity, from exposure to undiluted water from seep SP007.

Radionuclides. Four radionuclides were detected in the unfiltered sample from SP007. The radiological HQ from the combined doses of these isotopes was 0.004. Based on these results it is unlikely that WAG 5 increases risks to fish in Melton Branch through the release of radionuclides from seep SP007.

SP008

Manganese. Total manganese at SP008 in May 1993 was 4.16 times the EC20 for fish populations. It did not exceed the four chronic benchmarks or the secondary acute value (Table C2.61). The population benchmark is an order of magnitude lower than the other benchmarks because of the assumptions of combined effects to all life stages. Only one sample was analyzed from SP006. Although total manganese (466 µg/L) is likely to significantly overestimate the bioavailable concentration, the dissolved phase value (442 µg/L) was not less than the population EC20. A flow rate was not determined at the time the samples were collected. Seep SP008 was dry from August to November 1993. Water was present in December and March but the flow was not measured. Although the flow was not measured, it is unlikely that seep SP008 contributes over 25% of the flow at Melton Branch weir. Therefore, it is unlikely that manganese released from SP008 is toxicologically problematic for fish in Melton Branch. These results do provide weak evidence of chronic toxicity, but no evidence of acute toxicity, from exposure to undiluted water from seep SP008.

Radionuclides. Six radionuclides (tritium, C-14, Ca-45, Sr-89/90, Tc-99, and U-233/234) were detected in the unfiltered sample from SP008. The radiological HQ from the combined doses of these isotopes was 3.217. Most of the estimated dose (HQ of 3.189) is from internal exposure from Sr-89/90. Only one sample was analyzed, and the unfiltered activity is likely to

overestimate the bioavailable fraction and the resulting internal dose rate. Although the flow was not measured, it is unlikely that seep SP008 contributes over 25% of the flow at Melton Branch weir. Based on these results it is unlikely that WAG 5 increases risks to fish in Melton Branch through the release of radionuclides from seep SP008. These results do provide significant evidence of risk from exposure to undiluted water from seep SP008.

SP009

Aluminum. Total concentrations at SP009 in May 1993 exceeded the acute NAWQC by a factor of 1.80. The chronic NAWQC was less than background levels and was not used. Two of the five other chronic benchmarks were also exceeded (Table C2.61). The concentration of total aluminum (1350 µg/L) was less than the lowest acute toxicity value for fish (3600 µg/L for juvenile brook trout, *S. fontinalis*) and the lowest acute toxicity value for invertebrates (1900 µg/L for *C. dubia*) but higher than lowest chronic value for daphnids (742 µg/L for *D. magna*). However, only one sample was analyzed, and the total aluminum concentration is likely to significantly overestimate the bioavailable concentration. The dissolved phase concentration (317 µg/L) did not exceed any benchmarks or the toxicity values mentioned above. Based on these results it is unlikely that WAG 5 increases risks to fish in Melton Branch through the release of aluminum from seep SP009.

Barium. The total concentration at SP009 exceeded the secondary acute value by a factor of 3.17. The secondary chronic value was less than background and was not used. Only one other benchmark was available, and it was not exceeded (Table C2.61). At 218 µg/L the concentration of total barium is three orders of magnitude less than the acute value for *D. magna* (410,000 µg/L) and approximately half the lowest acute value (330 µg/L for a gastropod snail) used to derive the secondary acute value (Suter and Mabrey 1994, Appendix A). Only one sample was analyzed. Although total barium is likely to significantly overestimate the bioavailable concentration, the dissolved phase value (230 µg/L) was not appreciably different. At the time the samples were collected, SP009 had a flow rate of 3.4 L/min. The minimum daily flow at Melton Branch weir in 1993 was 255 L/min (0.15 cfs), and the flow rate when SP009 was sampled was 1410 L/min. The minimum Melton Branch flow divided by the contribution from SP009 gives a dilution rate of 75. Based on these results it is unlikely that barium released from SP009 is toxicologically problematic for fish in Melton Branch. These results provide weak evidence of acute and chronic toxicity from exposure to undiluted water from seep SP009.

Calcium. The only benchmark used for screening calcium in this assessment was the lowest chronic value for daphnids (116,000 µg/L). The secondary acute value and secondary chronic value were less than background levels and were not used. Total calcium at SP009 exceeded the lowest chronic value for daphnids by a factor of 1.09. Although total calcium is likely to significantly overestimate the bioavailable concentration, the dissolved phase value was not appreciably different. The minimum Melton Branch flow divided by the contribution from SP009 gives a dilution rate of 75. Based on these results it is unlikely that calcium released from SP009 is toxicologically problematic for fish in Melton Branch. These results provide weak evidence of chronic toxicity, and no evidence of acute toxicity, from exposure to undiluted water from seep SP009.

Iron. Total concentrations at SP009 exceeded the chronic NAWQC by a factor of 6.58. There is no acute NAWQC. The only other benchmarks, the lowest chronic value and the lowest test EC20 for daphnids, were less than background and were not used. The total

concentration (6,580 µg/L) was higher than the concentration (4,380 µg/L) that caused a 16% reproductive decrement in a test with *D. magna* but less than the 48-h LC50 for *D. magna* (9,600 µg/L). Only one sample was analyzed, and the total iron concentration is likely to significantly overestimate the bioavailable concentration. However, the dissolved phase concentration (4,710 µg/L) exceeded the chronic NAWQC and the chronic toxicity value for *D. magna*. The minimum Melton Branch flow divided by the contribution from SP009 gives a dilution rate of 75. Based on these results it is unlikely that iron released from SP009 is toxicologically problematic for fish in Melton Branch. These results provide significant evidence of chronic toxicity, but no evidence of acute toxicity, from exposure to undiluted water from seep SP009.

Manganese. Total manganese was 4.59 to 7.39 times greater than the four chronic benchmarks and 72.59 times the EC20 for fish populations (Table C2.61). The population benchmark is an order of magnitude lower than the other benchmarks because of the assumptions of combined effects to all life stages. The secondary acute value was also exceeded; but the acute values used to derive that benchmark (19,400 µg/L for *D. magna* and 33,800 µg/L for fathead minnow) were not. Only one sample was analyzed, and the total manganese concentration (8,130 µg/L) is likely to significantly overestimate the bioavailable concentration. However, the dissolved phase value (8,750 µg/L) was not appreciably different. The minimum Melton Branch flow divided by the contribution from SP009 gives a dilution rate of 75. Based on these results it is possible that manganese released from SP009 is toxicologically problematic for fish communities in Melton Branch. These results provide significant evidence of chronic toxicity, but no evidence of acute toxicity, from exposure to undiluted water from seep SP009.

1,2-Dichloroethene. At 33 µg/L the concentration at SP009 exceeded the secondary chronic value by a factor of 1.06. The observed concentration was less than the secondary acute value and the two other benchmarks (Table C2.61). Chronic toxicity values were not found for 1,2-Dichloroethene. The concentration at SP009 was four orders of magnitude less than the acute value (135,000 µg/L for the Bluegill *Lepomis macrochirus*) used to estimate the chronic values for fish. It is also less than the chronic value for fish (>2,000 µg/L) for a similar analyte, 1,1-dichloroethene. The minimum Melton Branch flow divided by the contribution from SP009 gives a dilution rate of 75. Based on these results it is unlikely that 1,2-dichloroethene released from SP009 is toxicologically problematic for fish in White Oak Creek. These results provide weak evidence of chronic toxicity, and no evidence of acute toxicity, from exposure to undiluted water from seep SP009.

Radionuclides. Four radionuclides were detected in the unfiltered sample from SP009. The radiological HQ from the combined doses of these isotopes was 0.097. Based on these results it is unlikely that WAG 5 increases risks to fish in Melton Branch through the release of radionuclides from seep SP009.

SP011

Barium. The total concentration at SP009 exceeded the secondary acute value by a factor of 2.03. The secondary chronic value was less than background and was not used. Only one other benchmark was available and it was not exceeded (Table C2.61). At 140 µg/L the concentration of total barium is three orders of magnitude less than the acute value for *D. magna* (410,000 µg/L) and approximately half the lowest acute value (330 µg/L for a

gastropod snail) used to derive the secondary acute value (Suter and Mabrey 1994, Appendix A). Only one sample was analyzed. Although total barium is likely to significantly overestimate the bioavailable concentration, the dissolved phase value (125 µg/L) was not appreciably lower. At the time the samples were collected SP011 had a flow rate of 1.3 L/min. The minimum daily flow at Melton Branch weir in 1993 was 255 L/min (0.15 cfs) and the flow rate when SP011 was sampled was 1,700 L/min. The minimum Melton Branch flow divided by the contribution from SP011 gives a dilution rate of 715. Based on these results it is unlikely that barium released from SP011 is toxicologically problematic for fish in Melton Branch. These results provide weak evidence of acute and chronic toxicity from exposure to undiluted water from seep SP011.

Iron. Total concentrations at SP011 exceeded the chronic NAWQC by a factor of 4.36. There is no acute NAWQC. The only other benchmarks, the lowest chronic value and the lowest test EC20 for daphnids, were less than background and were not used. The total concentration (4,360 µg/L) was just lower than the concentration (4,380 µg/L) that caused a 16% reproductive decrement in a test with *D. magna* but considerably less than the 48-h LC50 for *D. magna* (9,600 µg/L). Only one sample was analyzed, and the total iron concentration is likely to significantly overestimate the bioavailable concentration. The dissolved phase concentration (3,000 µg/L) did exceed the chronic NAWQC but not the chronic toxicity value for *D. magna*. The minimum Melton Branch flow divided by the contribution from SP011 gives a dilution rate of 715. Based on these results it is unlikely that iron released from SP011 is toxicologically problematic for fish in Melton Branch. These results provide weak evidence of acute toxicity and chronic toxicity from exposure to undiluted water from seep SP011.

Manganese. Total manganese was 1.06 to 1.70 times greater than the four chronic benchmarks and 16.70 times the EC20 for fish populations (Table C2.61). The population benchmark is an order of magnitude lower than the other benchmarks because of the assumptions of combined effects to all life stages. The secondary acute value was also exceeded, but the acute values used to derive that benchmark (19,400 µg/L for *D. magna* and 33,800 µg/L for fathead minnow) were not. Only one sample was analyzed, and the total manganese concentration (1,870 µg/L) is likely to significantly overestimate the bioavailable concentration. However, the dissolved phase value (1,600 µg/L) was not appreciably different. The minimum Melton Branch flow divided by the contribution from SP011 gives a dilution rate of 715. Based on these results it is unlikely that manganese released from SP011 is toxicologically problematic for fish in Melton Branch. These results provide weak evidence of acute toxicity and significant evidence of chronic toxicity from exposure to undiluted water from seep SP011.

Radionuclides. Six radionuclides were detected in the unfiltered sample from SP011. The radiological HQ from the combined doses of these isotopes was 0.008. Based on these results it is unlikely that WAG 5 increases risks to fish in Melton Branch through the release of radionuclides from seep SP011.

SP012

Aluminum. Total concentrations at SP012 in May 1993 did not exceed the acute NAWQC. The chronic NAWQC was less than background levels and was not used. Two of the five other chronic benchmarks were also exceeded (Table C2.61). The concentration of total aluminum (709 µg/L) was less than the lowest acute toxicity value for fish (3,600 µg/L

for juvenile brook trout, *S. fontinalis*), the lowest acute toxicity value for invertebrates (1900 µg/L for *C. dubia*), and the lowest chronic value for daphnids (742 µg/L for *D. magna*). However, only one sample was analyzed, and the total aluminum concentration is likely to significantly overestimate the bioavailable concentration. The dissolved phase concentration was less than or equal to the sample detection limit of 260 µg/L, which did not exceed any benchmarks or toxicity values. Based on these results it is unlikely that WAG 5 increases risks to fish in Melton Branch through the release of aluminum from seep SP012.

Barium. The total concentration at SP009 exceeded the secondary acute value by a factor of 2.14. The secondary chronic value was less than background and was not used. Only one other benchmark was available and it was not exceeded (Table C2.61). At 147 µg/L the concentration of total barium is three orders of magnitude less than the acute value for *D. magna* (410,000 µg/L) and approximately half the lowest acute value (330 µg/L for a gastropod snail) used to derive the secondary acute value (Suter and Mabrey 1994, Appendix A). Only one sample was analyzed. Although total barium is likely to significantly overestimate the bioavailable concentration, the dissolved phase value (160 µg/L) was not appreciably different. At the time the samples were collected SP012 had a flow rate of 1.6 L/min. The minimum daily flow at Melton Branch weir in 1993 was 255 L/min (0.15 cfs) and the flow rate when SP012 was sampled was 1,410 L/min. The minimum Melton Branch flow divided by the contribution from SP012 gives a dilution rate of 160. Based on these results it is unlikely that barium released from SP012 is toxicologically problematic for fish in Melton Branch. These results provide weak evidence of acute and chronic toxicity from exposure to undiluted water from seep SP012.

Calcium. The only benchmark used for screening calcium in this assessment was the lowest chronic value for daphnids (116,000 µg/L). The secondary acute value and secondary chronic value were less than background levels and were not used. Total calcium at SP012 exceeded the lowest chronic value for daphnids by a factor of 1.08. Although total calcium is likely to significantly overestimate the bioavailable concentration, the dissolved phase value was not appreciably different. The minimum Melton Branch flow divided by the contribution from SP012 gives a dilution rate of 160. Based on these results it is unlikely that calcium released from SP012 is toxicologically problematic for fish in Melton Branch. These results provide weak evidence of chronic toxicity, and no evidence of acute toxicity, from exposure to undiluted water from seep SP012.

Iron. Total concentrations at SP012 exceeded the chronic NAWQC by a factor of 2.46. There is no acute NAWQC. The only other benchmarks, the lowest chronic value and the lowest test EC20 for daphnids, were less than background and were not used. The total concentration (2,460 µg/L) was less than the concentration (4,380 µg/L) that caused a 16% reproductive decrement in a test with *D. magna* and the 48-h LC50 for *D. magna* (9,600 µg/L). Only one sample was analyzed, and the total iron concentration is likely to significantly overestimate the bioavailable concentration. However, the dissolved phase concentration (1,520 µg/L) exceeded the chronic NAWQC. The minimum Melton Branch flow divided by the contribution from SP012 gives a dilution rate of 160. Based on these results it is unlikely that iron released from SP012 is toxicologically problematic for fish in Melton Branch. These results provide evidence of chronic toxicity, but no evidence of acute toxicity, from exposure to undiluted water from seep SP012.

Manganese. Total manganese was 1.71 to 2.75 times greater than the four chronic benchmarks and 27.05 times the EC20 for fish populations (Table C2.61). The population

benchmark is an order of magnitude lower than the other benchmarks because of the assumptions of combined effects to all life stages. The secondary acute value was also exceeded, but the acute values used to derive that benchmark (19,400 µg/L for *D. magna* and 33,800 µg/L for fathead minnow) were not. Only one sample was analyzed, and the total manganese concentration (3,030 µg/L) is likely to significantly overestimate the bioavailable concentration. However, the dissolved phase value (3,330 µg/L) was not appreciably different. The minimum Melton Branch flow divided by the contribution from SP012 gives a dilution rate of 160. Based on these results it is unlikely that manganese released from SP012 is toxicologically problematic for fish in Melton Branch. These results provide strong evidence of chronic toxicity, but no evidence of acute toxicity, from exposure to undiluted water from seep SP012.

Radionuclides. Four radionuclides were detected in the unfiltered sample from SP012. The radiological HQ from the combined doses of these isotopes was 0.014. Based on these results it is unlikely that WAG 5 increases risks to fish in Melton Branch through the release of radionuclides from seep SP012.

SP014

Aluminum. Total concentrations at SP014 in May 1993 exceeded the acute NAWQC by a factor of 3.05. The chronic NAWQC was less than background levels and was not used. Total aluminum was 1.21 to 4.98 times higher than three of the five chronic benchmarks (Table C2.61). The concentration of total aluminum (2,290 µg/L) was less than the lowest acute toxicity value for fish (3,600 µg/L for juvenile brook trout, *S. fontinalis*), but higher than the lowest acute toxicity value for invertebrates (1900 µg/L for *Ceriodaphnia dubia*) and the lowest chronic value for daphnids (742 µg/L for *D. magna*). Only one sample was analyzed, and the total aluminum concentration is likely to significantly overestimate the bioavailable concentration. The dissolved phase concentration was estimated 32.5 µg/L, which is less than all the benchmarks and toxicity values mentioned above. Based on these results it is unlikely that WAG 5 increases risks to fish in Melton Branch through the release of aluminum from seep SP014.

Barium. The total concentration at SP014 exceeded the secondary acute value by a factor of 2.69. The secondary chronic value was less than background and was not used. Only one other benchmark was available and it was not exceeded (Table C2.61). The concentration of total barium (185 µg/L) is three orders of magnitude less than the acute value for *D. magna* (410,000 µg/L) and almost half the lowest acute value (330 µg/L for a gastropod snail) used to derive the secondary acute value (Suter and Mabrey 1994, Appendix A). Only one sample was analyzed. Although total barium is likely to significantly overestimate the bioavailable concentration, the dissolved phase value (152 µg/L) was not appreciably different. At the time the samples were collected SP014 had a flow rate of 1 L/min. The minimum daily flow at Melton Branch weir in 1993 was 255 L/min (0.15 cfs) and the flow rate when SP014 was sampled was 1,700 L/min. The minimum Melton Branch flow divided by the contribution from SP014 gives a dilution rate of 255. Based on these results it is unlikely that barium released from SP014 is toxicologically problematic for fish in Melton Branch. These results provide weak evidence of acute and chronic toxicity from exposure to undiluted water from seep SP014.

Calcium. The only benchmark used for screening calcium in this assessment was the lowest chronic value for daphnids (116,000 µg/L). The secondary acute value and secondary

chronic value were less than background levels and were not used. Total calcium at SP014 exceeded the lowest chronic value for daphnids by a factor of 1.11. The dissolved phase value was not appreciably different from the total concentration. The minimum Melton Branch flow divided by the contribution from SP014 gives a dilution rate of 255. Based on these results it is unlikely that calcium released from SP014 is toxicologically problematic for fish in Melton Branch. These results provide no evidence of acute toxicity, but some evidence of chronic toxicity, from exposure to undiluted water from seep SP014.

Iron. Total concentrations at SP014 exceeded the chronic NAWQC by a factor of 8.21. There is no acute NAWQC. The only other benchmarks, the lowest chronic value and the lowest test EC20 for daphnids, were less than background and were not used. The total concentration (8,210 $\mu\text{g/L}$) was higher than the concentration (4,380 $\mu\text{g/L}$) that caused a 16% reproductive decrement in a test with *D. magna* but less than the 48-h LC50 for *D. magna* (9,600 $\mu\text{g/L}$). Only one sample was analyzed, and the total iron concentration is likely to significantly overestimate the bioavailable concentration. The dissolved phase concentration (2,390 $\mu\text{g/L}$) exceeded the chronic NAWQC, but was less than the acute and chronic toxicity values for *D. magna*. The minimum Melton Branch flow divided by the contribution from SP014 gives a dilution rate of 255. Based on these results it is unlikely that iron from SP014 is toxicologically problematic for fish in Melton Branch. These results provide no evidence of acute toxicity, but some evidence of chronic toxicity, from exposure to undiluted water from seep SP014.

Manganese. Total manganese was 1.05 times greater than the lowest chronic value and lowest test EC20 for daphnids. It was also 10.27 times the EC20 for fish populations. The population benchmark is an order of magnitude lower than the other benchmarks because of the assumptions of combined effects to all life stages. The secondary acute value was not exceeded. Only one sample was analyzed, and the total manganese concentration (1,150 $\mu\text{g/L}$) is likely to significantly overestimate the bioavailable concentration. The dissolved phase value (812 $\mu\text{g/L}$) was less than the lowest chronic value and lowest test EC20 for daphnids, but greater than the EC20 for fish populations. The minimum Melton Branch flow divided by the contribution from SP014 gives a dilution rate of 255. Based on these results it is unlikely that manganese from SP014 is toxicologically problematic for fish in Melton Branch. These results provide no evidence of acute toxicity, but some evidence of chronic toxicity, from exposure to undiluted water from seep SP014.

1,2-Dichloroethene. At 850 $\mu\text{g/L}$ the concentration at SP014 exceeded the secondary acute and chronic values by factors of 1.52 and 27.24, respectively. The observed concentration was less than the estimated lowest chronic value and lowest test EC20 for fish. Chronic toxicity values were not found for 1,2-dichloroethene. The concentration at SP014 was three orders of magnitude less than the acute value (135,000 $\mu\text{g/L}$ for the Bluegill *Lepomis macrochirus*) used to estimate the chronic values for fish. It is also less than the chronic value for fish (>2,000 $\mu\text{g/L}$) for a similar analyte, 1,1-dichloroethene. The minimum Melton Branch flow divided by the contribution from SP014 gives a dilution rate of 255. Based on these results it is unlikely that 1,2-dichloroethene from SP014 is toxicologically problematic for fish in Melton Branch. These results provide weak evidence of acute and chronic toxicity from exposure to undiluted water from seep SP014.

Radionuclides. Four radionuclides were detected in the unfiltered sample from SP014. The radiological HQ from the combined doses of these isotopes was 0.003. Based on these results it is unlikely that WAG 5 increases risks to fish in Melton Branch through the release

of radionuclides from seep SP014.

SP015

Calcium. The only benchmark used for screening calcium in this assessment was the lowest chronic value for daphnids (116,000 µg/L). The secondary acute value and secondary chronic value were less than background levels and were not used. Total calcium at SP015 exceeded the lowest CV for daphnids by a factor of 1.08. Although total calcium is likely to significantly overestimate the bioavailable concentration, the dissolved phase value was not appreciably different. At the time the samples were collected SP015 had a flow rate of 2 L/min. The minimum daily flow at White Oak Creek weir in 1993 was 6,840 L/min (4.03 cfs) and the flow rate when SP015 was sampled was 21,225 L/min. The minimum White Oak Creek flow divided by the contribution from SP015 gives a dilution rate of 342. Based on these results it is unlikely that calcium released from SP015 is toxicologically problematic for fish in White Oak Creek. These results provide weak evidence of chronic toxicity, and no evidence of acute toxicity, from exposure to undiluted water from seep SP015.

Cobalt. Total concentrations at SP015 exceeded the secondary acute value and the lowest chronic value for fish by factors of 2.79 and 1.01, respectively. The secondary chronic value, the lowest chronic value for daphnids, and the lowest EC20 for daphnids were less than background levels. The lowest EC20 for fish was not exceeded. The concentration of total cobalt (293 µg/L) was less than the acute toxicity values for fathead minnows (3,610 µg/L) and *D. magna* (6,680 µg/L), but higher than the chronic toxicity values (1.1 µg/L for fathead minnows and 5.1 µg/L for *D. magna*). Only one sample was analyzed, and the total concentration is likely to overestimate the bioavailable concentration. The dissolved phase concentration was 237 µg/L, which is less than the lowest CV for fish but still greater than the secondary acute value. The minimum White Oak Creek flow divided by the contribution from SP015 gives a dilution rate of 342. Based on these results it is unlikely that WAG 5 increases risks to fish in White Oak Creek through the release of cobalt from seep SP015. These results provide weak evidence of acute toxicity, and some evidence of chronic toxicity, from exposure to undiluted water from seep SP015.

Iron. Total concentrations at SP015 exceeded the chronic NAWQC by a factor of 4.88. There is no acute NAWQC. The only other benchmarks, the lowest chronic value and the lowest test EC20 for daphnids, were less than background and were not used. The total concentration (4,880 µg/L) was higher than the concentration (4,380 µg/L) that caused a 16% reproductive decrement in a test with *D. magna* but less than the 48-h LC50 for *D. magna* (9,600 µg/L). Only one sample was analyzed, and the total iron concentration is likely to significantly overestimate the bioavailable concentration. The dissolved phase concentration (2,550 µg/L) exceeded the chronic NAWQC but not the chronic toxicity value for *D. magna*. The minimum White Oak Creek flow divided by the contribution from SP015 gives a dilution rate of 342. Based on these results it is unlikely that WAG 5 increases risks to fish in White Oak Creek through the release of iron from seep SP015. These results provide weak evidence of chronic toxicity, and no evidence of acute toxicity, from exposure to undiluted water from seep SP015.

Manganese. Total manganese was 4.46 to 7.18 times greater than the four chronic benchmarks and 70.54 times the EC20 for fish populations (Table C2.61). The population benchmark is an order of magnitude lower than the other benchmarks because of the

assumptions of combined effects to all life stages. The secondary acute value was also exceeded, but the acute values used to derive that benchmark (19,400 $\mu\text{g/L}$ for *D. magna* and 33,800 $\mu\text{g/L}$ for fathead minnow) were not. Only one sample was analyzed, and the total manganese concentration (7,900 $\mu\text{g/L}$) is likely to significantly overestimate the bioavailable concentration. However, the dissolved phase value (5,780 $\mu\text{g/L}$) was not appreciably different. The minimum White Oak Creek flow divided by the contribution from SP015 gives a dilution rate of 342. Based on these results it is unlikely that WAG 5 increases risks to fish in White Oak Creek through the release of manganese from seep SP015. These results provide weak evidence of chronic toxicity, and no evidence of acute toxicity, from exposure to undiluted water from seep SP015. The minimum White Oak Creek flow divided by the contribution from SP009 gives a dilution rate of 75. These results provide significant evidence of chronic toxicity, but only weak evidence of acute toxicity, from exposure to undiluted water from seep SP015.

Nickel. Total concentrations at SP015 exceeded the chronic NAWQC by a factor of 2.05. The acute NAWQC was not exceeded. Total nickel was 2.55 to 9.37 times greater than the four chronic benchmarks and 1.53 times the EC20 for fish populations (Table C2.61). The lowest chronic values for daphnids and the EC20 for sensitive species were less than background and were not used. The observed concentration was less than the acute values for *D. magna* (1,100 $\mu\text{g/L}$) the banded killifish, *Fundulus diaphanis* (43,250 $\mu\text{g/L}$). Only one sample was analyzed. Although total nickel (328 $\mu\text{g/L}$) may overestimate the bioavailable concentration, the dissolved phase value (310 $\mu\text{g/L}$) was not appreciably lower. The minimum White Oak Creek flow divided by the contribution from SP015 gives a dilution rate of 342. Based on these results it is unlikely that WAG 5 increases risks to fish in White Oak Creek through the release of nickel from seep SP015. These results provide significant evidence of chronic toxicity, but no evidence of acute toxicity, from exposure to undiluted water from seep SP015.

Selenium. Total concentrations at SP015 exceeded the chronic NAWQC by a factor of 1.02. The acute NAWQC was not exceeded. Total nickel was 1.42 times greater than the lowest test EC20 for daphnids. The EC20 for sensitive species, which was exceeded by a factor of 13.69, is the EC20 adjusted to estimate the fifth percentile of the species sensitivity distribution. The four other chronic benchmarks were not exceeded (Table C2.61). The observed concentration (35.6 $\mu\text{g/L}$) was considerably less than the species mean acute values for *D. magna* (855.5 $\mu\text{g/L}$) and the fathead minnow (1,601 $\mu\text{g/L}$). The lowest acute toxicity value observed for fish was 620 $\mu\text{g/L}$ for the fathead minnow. Only one sample was analyzed. Although total selenium may overestimate the bioavailable concentration, the dissolved phase value was estimated at 50.8 $\mu\text{g/L}$. The minimum White Oak Creek flow divided by the contribution from SP015 gives a dilution rate of 342. Based on these results it is unlikely that WAG 5 increases risks to fish in White Oak Creek through the release of selenium from seep SP015. These results provide significant evidence of chronic toxicity, but no evidence of acute toxicity, from exposure to undiluted water from seep SP015.

Radionuclides. Nine radionuclides were detected in the unfiltered sample from SP015. However, the radiological HQ from the combined doses of these isotopes was only 0.009. Based on these results it is unlikely that WAG 5 increases risks to fish in White Oak Creek through the release of radionuclides from seep SP015.

SP016

Aluminum. Total concentrations at SP016 exceeded the acute NAWQC by a factor of 16.40. The chronic NAWQC was less than background levels and was not used. Total aluminum was 2.62 to 26.74 times higher than the five chronic benchmarks (Table C2.61). The concentration of total aluminum (12,300 µg/L) was higher than the lowest acute toxicity values for invertebrates (1900 µg/L for *C. dubia*) and fish (3,600 µg/L for juvenile brook trout, *S. fontinalis*) and the lowest chronic value for daphnids (742 µg/L for *D. magna*). Only one sample was analyzed, and the total aluminum concentration is likely to significantly overestimate the bioavailable concentration. The dissolved phase concentration, which was below the sample detection limit of 150 µg/L, does not exceed any of the benchmarks or toxicity values mentioned above. Based on these results it is unlikely that aluminum released from SP016 is toxicologically problematic for fish in Melton Branch. These results do not provide evidence of acute or chronic toxicity from exposure to undiluted water from seep SP016.

Barium. The total concentration at SP016 exceeded the secondary acute value by a factor of 2.66. The secondary chronic value was less than background and was not used. Only one other benchmark was available and it was not exceeded (Table C2.61). The total barium concentration (183 µg/L) is three orders of magnitude less than the acute value for *D. magna* (410,000 µg/L) and about 70% of the lowest acute value (330 µg/L for a gastropod snail) used to derive the secondary acute value (Suter and Mabrey 1994, Appendix A). Only one sample was analyzed, and the total barium concentration is likely to significantly overestimate the bioavailable concentration. The dissolved phase value (53.2 µg/L) was less than the secondary acute value. Based on these results it is unlikely that barium released from SP016 is toxicologically problematic for fish in Melton Branch. These results do not provide evidence of acute or chronic toxicity from exposure to undiluted water from seep SP016.

Iron. Total concentrations exceeded the chronic NAWQC by a factor of 13.80. There is no acute NAWQC. The only other benchmarks, the lowest chronic value and the lowest test EC20 for daphnids, were less than background and were not used. The total concentration (13,800 µg/L) was higher than the concentration (4,380 µg/L) that caused a 16% reproductive decrement in a test with *D. magna* and the 48-h LC50 for *D. magna* (9,600 µg/L). Only one sample was analyzed, and the total iron concentration is likely to significantly overestimate the bioavailable concentration. The dissolved phase concentration, which was 220 µg/L, did not exceed the chronic NAWQC or the above mentioned toxicity values for *D. magna*. Based on these results it is unlikely that iron released from SP016 is toxicologically problematic for fish in Melton Branch. These results do not provide evidence of acute or chronic toxicity from exposure to undiluted water from seep SP016.

Manganese. Total manganese at SP016 was 9.11 times the EC20 for fish populations. It did not exceed the four chronic benchmarks or the secondary acute value (Table C2.61). The population benchmark is an order of magnitude lower than the other benchmarks because of the assumptions of combined effects to all life stages. Only one sample was analyzed, from SP016. Although total manganese (1,020 µg/L) is likely to significantly overestimate the bioavailable concentration, the dissolved phase value (364 µg/L) was not less than the population EC20. A flow rate was not determined at the time the samples were collected. Flow from seep SP016 was observed, but not always measured, each time it was visited in 1993. The flow rates on 9/27/93 and 11/2/93 were 15.1 L/min and 3.8 L/min, respectively. The corresponding discharge rates at Melton Branch weir were 2,105 and 628 L/min. On these dates SP016 contributed approximately 0.7% and 0.6% the flow at Melton Branch weir. Therefore, it is unlikely that manganese released from SP016 is toxicologically

problematic for fish in Melton Branch. These results do provide weak evidence of chronic toxicity, but no evidence of acute toxicity, from exposure to undiluted water from seep SP016.

Radionuclides. One radionuclide, Sr-89/90, was detected in the unfiltered sample from SP016. The radiological HQ from the combined doses of this isotope was <0.001 . Based on these results it is unlikely that WAG 5 increases risks to fish in Melton Branch through the release of radionuclides from seep SP016.

SP017

Barium. The total concentration at SP017 exceeded the secondary acute value by a factor of 2.99. The secondary chronic value was less than background and was not used. Only one other benchmark was available and it was not exceeded (Table C2.61). At $206 \mu\text{g/L}$ the concentration of total barium is three orders of magnitude less than the acute value for *D. magna* ($410,000 \mu\text{g/L}$) and approximately 70% of the lowest acute value ($330 \mu\text{g/L}$ for a gastropod snail) used to derive the secondary acute value (Suter and Mabrey 1994, Appendix A). Only one sample was analyzed. Although total barium is likely to significantly overestimate the bioavailable concentration, the dissolved phase value ($193 \mu\text{g/L}$) was not appreciably different. A flow rate was not determined at the time the samples were collected. Seep SP017 was dry in September 1993. Water was present in August, November, and December but the flow was not measured. Although the discharge rate was not measured it is unlikely that seep SP017 contributes over 25% of the flow at Melton Branch weir. Therefore, it is unlikely that manganese released from SP017 is toxicologically problematic for fish in Melton Branch. These results do provide weak evidence of chronic toxicity, but no evidence of acute toxicity, from exposure to undiluted water from seep SP017.

Iron. Total concentrations at exceeded the chronic NAWQC by a factor of 17.20. There is no acute NAWQC. The only other benchmarks, the lowest chronic value and the lowest test EC20 for daphnids, were less than background and were not used. The total concentration ($17,200 \mu\text{g/L}$) was higher than the concentration ($4,380 \mu\text{g/L}$) that caused a 16% reproductive decrement in a test with *D. magna* and than the 48-h LC50 for *D. magna* ($9,600 \mu\text{g/L}$). Only one sample was analyzed, and the total iron concentration is likely to significantly overestimate the bioavailable concentration. However, the dissolved phase concentration ($11,300 \mu\text{g/L}$) also exceeded the chronic NAWQC and the above mentioned toxicity values for *D. magna*. The discharge rate was not measured. Given that, and the high dissolved phase concentration, it is possible that iron released from SP017 is toxicologically problematic for fish in Melton Branch. These results provide strong evidence of acute and chronic toxicity from exposure to undiluted water from seep SP017.

Manganese. Total manganese was 5.61 to 6.03 times greater than the four chronic benchmarks and 88.66 times the EC20 for fish populations (Table C2.61). The population benchmark is an order of magnitude lower than the other benchmarks because of the assumptions of combined effects to all life stages. The secondary acute value was also exceeded, but the acute values used to derive that benchmark ($19,400 \mu\text{g/L}$ for *D. magna* and $33,800 \mu\text{g/L}$ for fathead minnow) were not. Only one sample was analyzed, and the total manganese concentration ($9,930 \mu\text{g/L}$) is likely to significantly overestimate the bioavailable concentration. However, the dissolved phase value ($10,200 \mu\text{g/L}$) was not appreciably different. The discharge rate for SP017 was not measured. Given that, and the high dissolved

phase concentration, it is possible that manganese released from SP017 is toxicologically problematic for fish in Melton Branch. These results provide weak evidence of acute toxicity, but strong evidence of chronic toxicity, from exposure to undiluted water from seep SP017.

Radionuclides. Four radionuclides were detected in the unfiltered sample from SP017. The radiological HQ from the combined doses of these isotopes was 0.011. Based on these results it is unlikely that WAG 5 increases risks to fish in Melton Branch through the release of radionuclides from seep SP017.

Weight of evidence

The weight of evidence indicates that toxic effects at the seep are possible for all seeps except SP002. This, however, is based on the assumption that these seeps support aquatic communities. This assumption is highly conservative, given that many seeps are dry part of the year or are too small to support a significant aquatic community. Only one seep (SP009) had the potential to contribute to risks in Melton Branch. Weighing the two available lines of evidence for SP009, it is unlikely that risk to the fish community in Melton Branch is actually increased by this seep. The evidence concerning risks to fish from exposure to seep water is presented in Table C2.63.

Risk was assessed at each seep and in either White Oak Creek or Melton Branch. The available lines of evidence for risks at the seeps include medium toxicity tests at five seeps and chemical concentrations in undiluted seep water from 15 seeps. Two lines of evidence are available for assessing the contribution of seeps to off-site risk: surveys of the fish communities in White Oak Creek and Melton Branch; and dilution factors based on the flow rate of each seep and the minimum flow rate for 1993 at either White Oak Creek or Melton Branch weir.

Of the two lines of evidence available at the seeps, the toxicity tests provide the most realistic indication of the effects of undiluted water on fish. These tests indicate that effects could occur if fish were chronically exposed to undiluted water from seeps SP004 and SP009. Acute effects could occur from exposure to seep SP006. In general, the single contaminant toxicity data provided supporting evidence of these effects. Concentrations of one or more contaminants at seeps SP004 and SP009 exceeded at least one chronic benchmark. 1,2-dichloroethylene exceeded the secondary chronic value at both seeps. SP009 also had high levels of dissolved iron and manganese. Acutely toxic contaminant levels were not found in water from SP006. Dissolved manganese exceeded the population EC20, but that is at best weak evidence of chronic toxicity. The estimated radiation dose rate to small fish from Sr-89/90 was marginally higher than the recommended criterion for protection of aquatic life. This criterion is for chronic effects, including reproduction. The toxicity test indicated that acute effects were occurring, but the daphnids that did survive had relatively high rates of reproduction. Also, the exposure rate was conservatively based on activities in unfiltered water, which may overestimate the internal dose rate. Given the conservative exposure assumptions and the inherent conservatism of the criterion, it is unlikely that the observed activities are acutely toxic. Furthermore, the Sr-89/90 activities in Seep SP008 were higher than in SP006, but neither acute nor chronic effects were observed in the two toxicity tests. The estimated dose rate from exposure to undiluted water from seep SP008 was 3.189 times higher than the chronic criterion. As with SP006, dissolved manganese at SP008 exceeded the population EC20 but no other chronic benchmarks. The measured concentrations in SP008 and SP006 may not be representative of the actual exposures received during the toxicity

tests, since confirmatory analyses were not performed on the water for toxicity testing. Dissolved manganese was the only contaminant that exceeded a benchmark (population EC20) at SP003. The lack of chronic toxicity in water from this seep and SP008 provides some evidence that the population EC20 may be overly conservative.

Contaminant concentrations was the only line of evidence of risk to fish from undiluted water for the ten other seeps. Of these all except for SP002 had at least one contaminant above benchmarks. There was only weak evidence (manganese exceeded the population EC20 only) of chronic toxicity for seeps SP005 and SP016. Manganese was the only contaminant of concern at SP001, but the dissolved concentration exceeded multiple chronic benchmarks. Dissolved iron exceeded the chronic NAWQC at all other seeps (SP007, SP011, SP012, SP014, SP015, and SP017). Of these SP015 had the most contaminants in excess of benchmarks: dissolved concentrations of cobalt, iron, nickel and selenium all exceeded chronic NAWQC, and manganese exceeded multiple chronic benchmarks. Besides the two seeps exhibiting chronic toxicity to daphnids (SP004 and SP009), SP014 was the only seep with a concentration of 1,2-dichloroethylene higher than benchmarks (secondary acute value and secondary chronic value). The weight of evidence indicates that chronic effects are unlikely at one site (SP002), possible at two sites (SP005 and SP016), and likely at the remaining seven sites. Acute effects are not likely at any seeps but are possible at seep SP014. However, these conclusions are based on the least realistic line of evidence, only one sample for each seep, and the conservative assumption that chronic exposure of fish populations to undiluted seep water is possible.

Characterization of risk in White Oak Creek and Melton Branch from seep discharges is based on two lines of evidence. Of these, surveys of fish communities in the receiving streams is the most realistic line of evidence. As discussed in Sect. C2.4.4.5.1., these surveys provide no convincing evidence that WAG 5 increases the impacts on the fish communities. The second line of evidence is the estimated contribution of each seep to the contaminant load in the main channel. A semi-quantitative dilution rate was calculated for each seep. If this dilution rate was approximately the same as the most conservative dilution factor for any contaminant in a seep, it was assumed that the seep contributed to risk in the main channel. Only one seep (SP009) had a dilution rate sufficient to indicate any risk in the main channel. However, this only applied to the population EC20 for manganese, which is a highly conservative benchmark. That benchmark (112 ug/L) was only marginally higher than the mean background concentration (100 ug/L) of manganese. Given the apparent lack of effects in Melton Branch, it is unlikely that manganese from SP009 is actually toxic in the main channel.

C2.4.4.6. Benthic macroinvertebrates

The weight-of-evidence approach was used to assess the contribution to off-site risks in drainage D3, White Oak Creek, and Melton Branch. Sediment Contaminant concentrations was the only line of evidence available for drainage D3. Benthic community surveys was the only substantial line of evidence available for White Oak Creek, and Melton Branch. One sample (SD016) for radiochemical analysis was collected in Melton Branch. Ambient concentrations of contaminants in water were measured also. These data are used to supplement the evaluation of impacts based on the community data.

Benthic Macroinvertebrate Community Surveys

As part of the ORNL Biological Monitoring and Abatement Program, total density and community structure of the benthic macroinvertebrates of Melton Branch and White Oak Creek were determined. Locations around WAG 5 include Melton Branch kilometer (MEK) 1.2 which is upstream of WAG 5, and MEK 0.16 which is alongside WAG 5. In White Oak Creek, sites include White Oak Creek kilometer (WCK) 3.9 and 3.4 upstream of WAG 5, WCK 2.9 which is alongside WAG 5 and WCK 2.3 which is below the confluence of Melton Branch with White Oak Creek. Each of these sites will be discussed below.

Melton Branch

Mean density of benthic macroinvertebrates was less at the upstream location on Melton Branch, MEK 1.2, than at the site alongside WAG 5, MEK 0.6. Mean density at MEK 0.6 did not differ from the mean density of the pooled reference sites.

Total richness of benthic macroinvertebrates was not significantly different between MEK 1.2 and MEK 0.6, or the pooled reference sites. Total EPT richness did not differ between the two sites on Melton Branch, but was less than that observed at the combined reference sites. There was a downstream increase in Chironomidae dominance in Melton Branch.

White Oak Creek

There was no statistically significant difference in the mean density of benthic macroinvertebrates at the four White Oak Creek sites (two upstream, one alongside WAG 5 and one below the confluence with Melton Branch). There also was no difference in the total richness of benthic macroinvertebrates, although all four sites had a lower mean density than the pooled reference sites. There was no difference in EPT richness at WCK 3.4, 2.9 and 2.3, although the richness at these sites was greater than at the higher upstream site WCK 3.9. All four sites had lower EPT richness than the pooled reference sites.

Screening of contaminants in sediments

Contaminants of potential concern for risk to benthic macroinvertebrates were identified by comparing contaminant concentrations in sediment to toxicological benchmarks and EPA Region IV screening values (Sect. C2.3.1.1.5).

One sediment sample (SD009) was collected at drainage D3 and analyzed for inorganics, organics, and radionuclides. One sediment sample (SD016) was collected from Melton Branch and analyzed for radionuclides. The detected concentration of each chemical was used as the estimate of exposure. These concentrations were compared to background and benchmarks following the procedures detailed in Sect. C2.4.2.6. Chemical and radiological screening results for these sites are presented in Tables C2.55 and C2.56, respectively.

Drainage D3

Four contaminants (mercury, carbon disulfide, chloroform, and toluene) were detected

at SD009. None of these contaminants exceeded either screening benchmark or the EPA Region IV screening value (Table C2.55). The radiological HQ from the combined doses of all detected isotopes was less than 0.01.

Two chemicals (selenium and 2-butanone) were detected in sediment from D3 but could not be screened because appropriate toxicity data were not found.

Melton Branch

The sediment sample from SD016 was analyzed for gross alpha, gross beta, tritium, and cesium-137. Only gross beta (13.8 pCi/g) and Cesium-137 (0.05 pCi/g) were detected. To calculate an absorbed dose to benthic invertebrates the gross beta measurement was assumed to represent strontium-90. The HQ resulting from exposure to both radionuclides was less than 0.0005.

Contaminant Concentrations in Water

Contaminants were analyzed in surface water samples taken from drainage D3 (SW003), Melton Branch upstream of WAG 5 (SW005), and from above the confluence of White Oak Creek (SW006). Surface water (SW001) was collected from the drainage entering White Oak Creek above WCK 2.9.

Drainage D3

During storm flow sampling the total aluminum concentration at SW003 exceeded the acute NAWQC by a factor of 1.13. No radionuclides exceeded benchmarks.

Melton Branch

Analyses of contaminants in the SW006 show that, although fluoride and sodium levels exceed benchmarks, levels were less than those found at SW005 which is upstream of WAG 5. No radionuclides exceeded benchmarks. Also, during storm flow sampling the total aluminum concentration at SW005 exceeded the acute NAWQC by a factor and 4.24.

White Oak Creek

Analyses of contaminants in the SW001 surface water sample above WCK 2.9 suggest that aluminum and manganese levels exceed aquatic benchmarks during certain flow conditions during the year. There is no sediment benchmark for aluminum. The only aquatic benchmark exceeded for manganese was the largemouth bass population EC₂₀. None of the aquatic invertebrate benchmarks were surpassed. No radionuclides exceeded benchmarks.

Weight of Evidence

The principle line of evidence for risks to benthic invertebrates in drainage D3 is sediment contaminant concentrations. Water contaminant concentrations were also evaluated. The principle lines of evidence for risks to benthos of White Oak Creek and Melton Branch are benthic community surveys and one sediment sample in Melton Branch. Water contaminant concentrations were also evaluated.

The four contaminants detected in drainage D3 did not exceed the screening benchmarks and are not expected increase the risks to benthic invertebrates. Adverse effects are not expected from exposure of benthic invertebrates to the sediment-associated radionuclides in drainage D3. Acute toxicity from aluminum in the water column during storm events is possible, but the quality of the measurements is highly questionable (see Sect. C2.4.4.5.1).

There does not appear to be an impact resulting from releases from WAG 5 in either Melton Branch or White Oak Creek, based on comparisons with the benthic communities upstream in both of these creeks. Adverse effects are not expected from exposure of benthic invertebrates to the sediment-associated radionuclides in Melton Branch at SD016. Acute toxicity from aluminum in the water column of Melton Branch during storm events is possible, but the quality of the measurements is highly questionable (see Sect. C2.4.4.5.1). During base flow conditions there does not appear to be any WAG 5-associated contaminants in Melton Branch or White Oak Creek water which may cause impacts to the benthic community.

C2.4.5. Uncertainties

C2.4.5.1. Terrestrial and wetland plants

The following factors create uncertainty in assessing the risk posed by the contaminants of potential concern in the WAG 5 soils:

"Bioavailability" of elements. The extraction methods used may remove from the soil quantities of elements and compounds greater than are available to plants. The double-acid extraction removes the exchangeable fraction of metals thereby giving a concentration that reflects the total potential pool of contaminants, not that to which the plant is exposed at any one time. Under field conditions these contaminants will be in the soil solution and available for uptake in concentrations reflecting a dynamic equilibrium between the solid and liquid phase. Therefore, it is difficult to assess the types of interactions between contaminants and between contaminants and plant roots that may occur under field conditions at the site from the reported soil metal concentrations. This is confounded by the concentration- and species-dependent synergistic and antagonistic interactions between metals during uptake by roots and inside plants. The analytical techniques also fail to differentiate between species of chemicals present in the soil (particularly As, Cr, and Hg) which have variable toxicity to plants and other life forms. Without specific analyses for these forms, or soil chemical and physical data sufficient to evaluate the probable occurrence of the species, it is not possible to accurately assess the risk posed by these contaminants at the site.

There are also uncertainties in assessing the risk posed by water-borne contaminants in seep discharge to wetland plant communities. No background data was available for comparison to filtered seep discharge data. Differences between maximum contaminant concentrations in filtered and unfiltered seep water indicates that the bioavailability of chemicals in the two samples is probably quite different.

Variable response to toxicants. There is a considerable amount of variability between plant species and plant growth stages in tolerance to specific, and combinations of, contaminants. The literature from which benchmarks were derived is not based on experiments using plants found in ecosystems representative of the WAG 5 units. It is difficult

to extrapolate from largely agricultural crops in early growth stages used in most of the published literature to trees and the varied ground vegetation found at WAG 5.

Multiple contaminant exposure. Because of our lack of understanding of the complex interactions between contaminants, benchmark levels are necessarily derived from experiments in which plants are exposed to single contaminants. The reality in soils is one of multiple contaminant exposure which may not be adequately assessed on the basis of literature-derived benchmarks.

Lack of benchmarks for some metals and most organic compounds and radionuclides. Little research has been conducted on the phytotoxic effects of the radionuclides and organic compounds. Thus, it is not possible to assess the risk to plant growth posed by some of the analytes found in the WAG 5 soils.

Sufficiency of media toxicity test data. A complete and accurate risk assessment requires input from as many lines of evidence as possible. The results of the laboratory media toxicity test (cabbage seedling test) must be considered inconclusive because no information is available concerning the contaminant concentrations in the media actually tested. The reported characteristics of the test and reference media suggest the possibility that physical characteristics, such as bulk density and water holding capacity, may have influenced the results of the seedling test (height and biomass). We have little confidence that the tests evaluated the effects of contaminants in site soils at site-specific concentrations on seedling growth.

Sufficiency of biosurvey data. Survey information is required to understand how the populations in the area of concern have or have not adapted to exposure in a longer time frame than is seen in short-term soil toxicity tests. This can only be accomplished through vegetation survey of the contaminated site and comparison with reference sites.

Representativeness of soil samples. The number and distribution of soil samples taken to characterize the soil contamination in each of the areas was uneven. In particular, only two soil samples were taken in WAG 5 Wide which contains approximately 12 ha, while 12 samples were extracted to characterize OHF containing 0.57 ha, part of which is covered by a water impoundment. It is difficult to assess the distribution of contaminants at the site without adequate sampling.

C2.4.5.2. Soil invertebrates

The following factors create uncertainty in assessing the risk posed by the potential contaminants of concern in soils:

"Bioavailability" of elements. This factor is discussed in the previous section focusing on the uncertainty associated with evaluating the risk to plants. The extraction methods used may remove from the soil quantities of elements and compounds greater than are effective on earthworms externally, or greater than will be extracted from soil as it passes through the gut.

Variable response to contaminants. There is variability between earthworm species and growth stages in terms of tolerance to specific, and combinations of, contaminants. The literature from which benchmarks were derived is not necessarily based on experiments using

earthworm species known to be representative of those occurring in the soils of the WAG 5 units.

Multiple contaminant exposure. Toxicity benchmark concentrations are derived from experiments in which earthworms are exposed to single contaminants. The reality of soils is one of multiple contaminant exposure which may not be adequately assessed on the basis of literature-derived benchmarks.

Lack of benchmarks for some metals and most organic compounds and radionuclides. Little research has been conducted on the toxic effects of the radionuclides and organic compounds, other than pesticides. Thus, it is not possible to assess the risk to earthworm populations posed by many of the analytes found in the soils.

Sufficiency of biosurvey data. As discussed in the section on uncertainty in the assessment of risk to plants, a complete and accurate risk assessment requires input from as many lines of evidence as possible. An assessment for which there is no data from medium toxicity experiments conducted with earthworms representative of those of WAG 5 cannot be validated with site-specific data. Survey information is also required to understand how the populations in the area of concern have or have not adapted to exposure in a longer time frame than is seen in chemical analyses and short-term soil toxicity tests. The limited information available on the number of earthworms in the soils of WAG 5 comes from a task with the objective of collecting earthworms for chemical analysis, not for quantifying and describing earthworm populations. The sampling locations were concentrated in one area (SWSA 5 South) and do not give an indication of the distribution and nature of the earthworm populations at WAG 5.

Representativeness of soil samples. The number and distribution of soil samples taken to characterize the soil contamination in each of the areas was uneven. In particular, only two soil samples were taken in WAG 5 Wide which contains approximately 12 ha, while 12 samples were extracted to characterize OHF containing 0.57 ha, part of which is covered by a water impoundment. It is difficult to assess the distribution of contaminants at the site without adequate sampling.

Radionuclide reference dose. The IAEA value used as a threshold for exposure to radioactivity is not specifically for exposure of earthworms but refers to a dose of radiation at which reproduction in a generic terrestrial animal is not negatively affected. There are no experimental data on effects of radiation on earthworm reproduction, growth, and survival from which to derive a benchmark or to confirm this threshold for earthworms.

Radionuclide body burdens. Due to the lack of data, radionuclide body burdens in biota were assumed to be equivalent to that observed in the soil. Because some radionuclides have a high tendency to bioaccumulate while others are poorly taken up by biota, this assumption may produce either over- or underestimates of radionuclide exposure, depending on the accumulative potential of the radionuclide.

Radionuclide distribution in the body. To estimate radionuclide exposure, it was assumed that all radionuclides are equally distributed throughout the body and therefore all tissues are equally exposed. Radionuclides display affinities for different body tissues (e.g. Cs-

137 and muscle; Sr-90 and bone). As a result, this assumption underestimates the dose to receptor organs (muscle) while overestimating exposure for susceptible organs such as the genitals.

C2.4.5.3. Soil microorganisms and microbial processes

The factors creating uncertainty in assessing the risk posed by the potential contaminants of concern in soils to microbes are the same as discussed for earthworms (Sect. C2.4.5.2). They include: bioavailability of elements, variable response to contaminants by different species, multiple contaminant exposure, lack of benchmarks for some metals and most organic compounds and radionuclides, representativeness of soil samples, and sufficiency of biosurvey data.

C2.4.5.4. Vermivorous wildlife

The following uncertainties are associated with the assessment of the risks to vermivorous wildlife using WAG 5.

"Bioavailability" of contaminants. It was assumed that 100% of the contaminant concentration reported in the various media (water, soil, earthworms, etc.) was bioavailable. Much of the contaminant burden in biotic media (earthworms) is likely to be bioavailable; however, it is very unlikely that 100% of the contaminants in abiotic media (soil or water) are bioavailable. While contaminants in biotic media may be bioavailable, the uptake efficiencies for wildlife may not be 100%. Therefore, exposure estimates based upon the contaminant concentrations in media are conservative and are likely to overestimate the actual contaminant exposure experienced.

Species/form of metal present in the environment. Toxicity of metals varies dramatically depending upon the valence state or form (organic or inorganic) of the metal. For example, As^{+3} , Cr^{+6} , and methyl Hg are more toxic than As^{+5} , Cr^{+3} , and inorganic Hg, respectively. The available data on the contaminant concentrations in media do not report which species or form of contaminant was observed. While species may be predicted for some metals (e.g., due to the high oxidizing potential of Cr^{+6} , most Cr in soil is likely to be Cr^{+3} ; Eisler 1986), this was not possible for all metals. Because benchmarks used for comparison represented the more toxic species/forms of the metals (particularly for As, Cr, and Hg), if the less toxic species/form of the metal was actually present at WAG 5, potential toxicity at these sites may be overestimated.

Interactions between contaminants. Animal studies have shown that some of the metals observed on WAG 5 interact antagonistically such that the exposure to one reduces effects of the other. For example, Se protects mammals and birds from toxic effects of As, Cd, Hg, and Tl (Levander and Argrett 1969; Eisler 1985b). In contrast, while inorganic As reduces the toxicity of inorganic Se compounds, inorganic As enhances the toxicity of organic Se compounds (Eisler 1988a). The interactive effects of the metals to which wildlife on WAG 5 are exposed cannot be predicted and are wholly unknown. Therefore, risks may be either over- or underestimated.

Single contaminant tests vs exposure to multiple contaminants in the field. While

wildlife resident on WAG 5 are exposed to multiple contaminants concurrently, published toxicological values only consider effects experienced by exposures to single contaminants. Because some contaminants to which wildlife are exposed can interact antagonistically, single contaminant studies may overestimate their toxic potential. Similarly, for those contaminants that interact synergistically, single contaminant studies may underestimate their toxic potential.

Extrapolation from published toxicity data. No published NOAELs were found for wildlife species present on WAG 5. To estimate the toxicity of contaminants at the site, it was necessary to extrapolate from NOAELs observed for test species (frequently mice, rats, or mallard ducks) to NOAELs for short-tailed shrews and American woodcock. While it was assumed that toxicity could be estimated as a function of body size (Sect. C2.3.1.1.4), the accuracy of the estimates is not known. For example, a wildlife species may be either more or less sensitive to a contaminant than would be predicted.

Additional extrapolation uncertainty exists for those contaminants for which data consisted of either LOAELs or was subchronic in duration. For either case, a uncertainty factor of 10 was employed to estimate NOAELs or chronic data. The uncertainty factor of 10 may either over- or underestimate the actual LOAEL-NOAEL or subchronic-chronic relationship.

Variable food and water consumption. While food consumption by wildlife was assumed to be similar to that reported for the same or related species in other locations, the validity of this assumption cannot be determined. Food consumption by wildlife on WAG 5 could be greater or less than that reported in the literature, resulting in either an increase or decrease in contaminant exposure. Similarly, water consumption for all species was estimated according to the allometric equations of Calder and Braun (1983). The accuracy with which the estimated water consumption represents actual water consumption is unknown.

For all estimates of contaminant exposure through food and water consumption, it was assumed that 100% of water or food of a given type (for species with diverse diets) was obtained from a contaminated source and that the level of contamination was constant. Because wildlife are mobile, they may travel off the site to drink or forage, thereby reducing their exposure. Additionally, contaminant concentrations in media at the site may vary both spatially and temporally. Therefore, the assumption that 100% of food and water consumed is contaminated is likely to overestimate actual contaminant exposure.

Radionuclide body burdens. Due to the lack of data, radionuclide body burdens in biota were assumed to be equivalent to that observed in the soil. Because some radionuclides have a high tendency to bioaccumulate while others are poorly taken up by biota, this assumption may produce either over- or underestimates of radionuclide exposure, depending on the accumulative potential of the radionuclide.

Radionuclide distribution in the body. To estimate radionuclide exposure, it was assumed that all radionuclides are equally distributed throughout the body and therefore all tissues are equally exposed. Radionuclides display affinities for different body tissues (e.g. Cs-137 and muscle; Sr-90 and bone). As a result, this assumption underestimates the dose to receptor organs (muscle and bone) while overestimating exposure for susceptible organs such as the genitals.

Radionuclide reference dose. While radiation exposure experienced by shrews and

woodcock in the SWSA 5 area exceeds the recommended exposure value for terrestrial animals, it is unknown how or if this general value corresponds to effects thresholds specific for shrews and woodcock. Among mammals, reproductive impairment by radiation is likely to be greatest among long-lived species (IAEA 1992). Because shrews generally do not live longer than one year (George et al. 1986), effects of radiation on this species is likely to be less than that observed in longer lived species. Among birds, not only have few chronic studies been performed, the minimum chronic levels at which reproductive effects or mortality become manifest are poorly defined (IAEA 1992). Because the appropriateness of the recommended radiation exposure value for terrestrial biota to shrews and woodcock is unknown, risks to these species may be either over or underestimated.

C2.4.5.5. Fish

The following uncertainties are associated with the assessment of risks to fish communities.

Multiple lines of evidence. Risk characterizations based on contaminant analyses provide evidence concerning which contaminants may be responsible for any apparent effects or observed toxicity and concerning whether toxic effects may be occurring that were not detected by the surveys or the media toxicity tests. However, community surveys and media toxicity tests were not available for all locations or flow regimes.

Temporal variability. Contaminant concentrations in surface water and seeps is likely to vary. Although surface water sites were sampled during four flow regimes, only one concentration was available for each base flow regime and all seep locations. Also, samples for chemical analysis were not collected coincident with samples for toxicity testing.

Contaminant screening. The comparison of laboratory toxicity data for individual contaminants to measured concentrations of individual contaminants in the environment does not address the potential for combined effects of multiple contaminants, the effects of site-specific conditions on contaminant availability and toxicity, or the range of responses of individual species or different life stages.

Multiple benchmarks. Water toxicity data are much more standardized than soil or sediment toxicity data and water composition is less variable than soil or sediments. However, alternative methods for calculating thresholds for aquatic toxic effects from laboratory tests produce benchmarks that vary over a range greater than two orders of magnitude (Suter et al. 1992b).

Missing benchmarks. Benchmarks and toxicity data were not available for all the detected contaminants. Benchmarks were not available for several inorganic and organic contaminants.

Insufficient background characterization. Dissolved phase concentrations were not available for the background samples. Background for fluoride, which screened out above benchmarks in Melton Branch, was not determined.

C2.4.5.6. Benthic macroinvertebrates

The EqP methodology has several uncertainties. It relies on an empirical model to

compute the pore water concentration from the solid phase measurements. Thus, there is an uncertainty associated with the use of the model. Also, there is uncertainty with respect to the K_{ow} associated with the specific chemical because it is an experimentally determined quantity (EPA 1989).

The assumption that benthic organisms have similar sensitivities to water column species has a level of uncertainty (EPA 1989). This may be of particular concern for tube-dwelling amphipods. The tubes tend to isolate them from the interstitial water, causing speculation that their exposure is at the sediment/water interface. Also, the amphipod tubes are matrices of organics and inorganics; the tube walls could sorb appreciable amounts of organic contaminants, which could alter the availability of sediment-associated contaminants to those organisms (Lee and Jones-Lee 1993).

The NOAA ER-L and ER-M values have several limitations. Primarily, all of the data used in their derivation were based on marine and estuarine systems. These values are being applied to the freshwater system at the ORR. Differences include physico-chemical characteristics of the system as well as possible differences in sensitivity of biota. NOAA values were derived for single chemicals, although sediments containing chemical mixtures were used for their derivation.

Several contaminants (e.g., calcium, cobalt, magnesium, selenium, thallium, 2-butanone) have no benchmarks. In addition, background levels of manganese exceeded benchmarks. Specifically, there is a lack of spiked sediment bioassays to evaluate the effects of single contaminants on benthic species.

Because there are no bioaccumulation factors for benthic invertebrates, calculation of internal radiation doses assumed that the concentration of nuclides inside the invertebrate was identical to that in the sediment. Due to the uptake of nutrients from the sediment by the invertebrate, the concentration of nuclides is likely higher in the organism than in the surrounding sediment. However, because the largest HQ for nuclides was 0.07, this uncertainty should not affect the results of the risk characterization.

The calculation of radiation doses to benthic invertebrates assumed that the organisms were buried in the sediment 100% of the time. Exposure from sediment would be less if the organism was at the sediment/water interface.

No sediment toxicity tests or benthic macroinvertebrate surveys were conducted at WAG 5. The weight of evidence approach to characterize risks is optimal when two or three lines of evidence are available. Therefore, it is not known if contaminants present at WAG 5 are actually exerting an adverse effect on the benthic community.

C2.5 RISK-BASED REMEDIAL ACTION OBJECTIVES

Because ecological risk assessments may be based on a weighing of multiple lines of evidence, the procedure for developing risk-based remedial action objectives (RBRAOs) must also be based on weight of evidence. The procedure is depicted diagrammatically in Fig. C2.10.

The procedure begins with input from the ecological risk characterization. RBRAOs must be developed for each endpoint for which risks have been characterized as significant. The first step is to determine what means are available for determining what areas or concentrations in media may require remediation. These alternative means are the lines of evidence used to characterize ecological risks: biological surveys, media toxicity tests, and single chemical toxicities. The manner of weighing them is as follows:

- If biological surveys have been performed and are judged to be sufficiently conclusive to be used for this purpose, the areas within which the surveys reveal a significant degradation are the areas requiring remediation.
- If the biological survey results are inconclusive or absent, media toxicity tests are potentially the most conclusive line of evidence because they indicate the toxicity of the media which are subject to remediation. Areas requiring remediation are those in which media toxicity was observed that exceed the levels specified in the assessment endpoint.
- If the biological surveys and the media toxicity tests are inconclusive or absent, the comparisons of ambient chemical concentrations to single chemical toxicity data must be used to derive RBRAOs. Areas requiring remediation are those in which ambient concentrations are estimated to cause effects that exceed the levels specified in the ecological assessment endpoint. The concentrations that are estimated to cause unacceptable effects should be compared to estimates of background concentration to ensure that the RBRAO does not propose remediating to below background.

The output of this weighing of evidence will be a set of areas that are candidates for remediation based on risks to a particular ecological assessment endpoint. For this assessment, the areas are the WAG 5 Wide, OHF, NHF, PWSB, SWSA 5, and TRU areas of WAG 5. If it is possible that the remediation would consist of treatment of a source or of contaminated media within the defined areas, rather than simply removing or isolating the contaminated media (e.g., dredging or capping), then the RBRAOs should be defined as concentrations that should be achieved within those areas. This should be done by referring to the characterization of risk based on ambient chemical concentrations and single chemical toxicity. The RBRAOs should be to eliminate all concentrations of contaminants that are estimated to cause significant risks to the endpoint.

C2.5.1 Risk-based Remedial Action Objectives for Soil

Risk-based remedial action objectives for soil are based on an evaluation of the soil exposed endpoints, e.g., terrestrial plants, soil invertebrates, soil microbes, microbial processes, and vermivorous wildlife. After evaluating each endpoint, all data are combined to recommend RBRAOs that are protective of all endpoints exposed to soil contamination.

C2.5.1.1 Terrestrial plants

Based on the available lines of evidence, risk posed to terrestrial plants at WAG 5 appears to be minimal (Sect. C2.4.2.1.1). Contaminants in soils of SWSA 5 South, OHF, and WAG 5 Wide that exist in concentrations shown to cause toxicity in experiments with soluble salts added to soil are likely to be of low bioavailability in WAG 5. Based on available information, no RBRAOs for plants are necessary.

C2.5.1.2 Soil invertebrates

Soils from SWSA 5 South and WAG 5 Wide contain mercury at concentrations causing reduced survival and reproduction of earthworms in laboratory experiments (Sect. C2.4.2.2). They also have lower densities of earthworms than the reference sites. However, concentrations of Hg in earthworms from these areas are within the range measured for earthworms from unpolluted sites and are below a concentration reported as being toxic. This leads to the conclusion that bioavailability of Hg is low. While radiation exposure experienced by earthworms in SWSA 5 South exceeded the recommended exposure value for terrestrial animals, it is not known whether this general value corresponds to effects thresholds specific for earthworms (Sect. C2.4.2.2). Based on available information, no RBRAOs for soil invertebrates are necessary.

C2.5.1.3 Soil microorganisms and microbial processes

Based on the available lines of evidence, risk posed to soil microorganisms and microbial processes at WAG 5 appears to be minimal (Sect. C2.4.2.3). Contaminants in soils of SWSA 5 South, OHF, and WAG 5 Wide that exist in concentrations shown to cause toxicity in experiments with soluble salts added to soil are likely to be of low bioavailability in WAG 5. Based on available information, no RBRAOs for microbes are necessary.

C2.5.1.4 Vermivorous wildlife

Non-radionuclide contamination

The procedure for developing RBRAOs outlined in this section was employed for vermivorous wildlife. Because biological surveys and media toxicity tests were not performed for these endpoints, RBRAOs were developed using the only remaining line of evidence, literature toxicity data. RBRAOs for vermivorous wildlife were developed in the following manner. Published toxicological literature was evaluated to find data concerning LOAELs for those contaminants where HQs > 1 were observed (see to Sects. C2.4.2.4. and C2.4.3.4.). LOAELs for shrews and woodcock were estimated from published LOAELs using body mass correction factors in a manner similar to that used for NOAELs (see Sect. C2.3.1.1.4.). Estimated LOAELs were then compared to the estimated contaminant exposures for those species and contaminants where HQs > 1 were observed (Table C2.64). If the estimated exposure was less than the estimated LOAEL, the exposure was assumed to be sufficiently low such that adverse effects are unlikely. Remediation is therefore not warranted. If the exposure estimate from a WAG 5 site exceeded the LOAEL, it was assumed that contamination at the site is sufficient to produce adverse effects in the endpoint species and remediation to reduce exposure to below the level of the LOAEL may be warranted.

Shrews and woodcock in the WAG 5 Wide area are, in the other areas will be,

experiencing exposures in excess of estimated LOAELs. Contaminants exceeded LOAELs in the following areas:

WAG 5 Wide	barium and mercury for shrews; chromium, mercury, zinc, and di- <i>n</i> -butyl phthalate for woodcock.
NHF	barium for shrews
SWSA 5	selenium for shrews
TRU	selenium for both shrews and woodcock

Because wildlife are mobile and integrate contamination spatially, the mean concentration is the appropriate expression of exposure. To assure protection, the upper 95% control limit (UCL) is used as the estimate of the mean throughout this assessment. Because only a small number of samples was used to derive the 95% UCL for media in some areas (e.g., only two soil samples were collected from within the WAG 5 Wide area), in some instances the 95% UCL is larger than the maximum value observed at a site, and therefore may not accurately represent the actual magnitude of contamination. To better determine if contamination observed at a site warrants remediation, exposure estimates were recalculated for those areas and contaminants where exposure exceeded LOAELs (Table C2.65). Substitution of maximum detected values for the 95% UCL, in cases where the 95% UCL exceeds the maximum value, resulted in fewer contaminants and locations exceeding LOAELs. For shrews, only barium exceeds LOAELs in the WAG 5 Wide and NHF areas. For woodcock, mercury and zinc exceed LOAELs in the WAG 5 Wide area.

Identification of the NHF and WAG 5 Wide areas for remediation must still be viewed with caution. First, because woodcock are wide-ranging, only effects to individuals may be assessed at the WAG 5 level; effects to the population must be addressed at the ORR-level. Potential effects to individuals identified in this assessment can not be used to drive remediation.

Second, because the NHF area is both small in size (approximately 1 ha) and consists primarily of buildings and gravel surfaces, it provides minimal habitat for shrews. As a result of its industrial nature, habitat at the site is not likely to increase substantially in the future. Because use of a site by wildlife (and therefore exposure to contaminants) is dependant upon the availability of habitat (which for shrews is minimal at the NHF), contamination at the NHF is unlikely to present a significant risk to shrews. Therefore actions to remediate barium in soils at the NHF site cannot be recommended.

Third, because the soil contaminant characterization for the WAG 5 Wide area is based on only two soil samples, these data may not accurately represent the actual magnitude present throughout the area.

Estimation of RBRAOs

While evaluation of the available data do not suggest the need for remediation of soil, RBRAOs were calculated for consideration. By back calculating from the estimated LOAEL

values using exposure parameters (e.g., soil or food consumption) for each species, contaminant concentrations in soil that are not hazardous to these species was determined. These values may be used as RBRAOs. The general equation to calculate the RBRAO is

$$\text{RBRAO} = (\text{LOAEL} \times \text{bw})/\text{IR} ,$$

where

RBRAO	= risk based remedial action objective (mg contaminant/kg medium)
LOAEL	= lowest observed adverse effects level (mg contaminant/kg body weight/day)
bw	= body weight (kg)
IR	= medium consumption rate (kg medium/day).

The contaminant concentrations in (and exposure from) earthworms is estimated from soil contaminant concentrations, therefore the RBRAO for soil must account for exposure through both soil and food consumption. Because the fraction of total contaminant exposure attributable to soil and food consumption is dependant upon the soil-earthworm uptake factor, to estimate a RBRAO for soil that would be protective for both soil and food consumption, the above equation was modified as follows:

$$\begin{aligned} \text{RBRAO}_s &= \text{FE}_s(\text{LOAEL} \times \text{bw})/\text{IR}_s \\ \text{or} \\ \text{RBRAO}_s &= ([\text{FE}_w(\text{LOAEL} \times \text{bw})/\text{IR}_w]/\text{UF})/\text{P}_{\text{dry}} , \end{aligned}$$

where

RBRAO _s	= risk-based remedial action objective for soil (mg contaminant/ kg soil - dry weight)
IR _s	= soil consumption rate (kg soil/day - dry weight)
FE _s	= exposure fraction attributable to soil
IR _w	= earthworm consumption rate (kg earthworm/day - wet weight)
FE _w	= exposure fraction attributable to earthworm
UF	= contaminant-specific soil-earthworm uptake factor
P _{dry}	= proportion of dry worm content (0.16, see Sect. C2.2.2.1.4).

Solving either equation produces the same result. Assuming that shrews weigh 0.015 kg, consume 0.009 kg earthworms/day and 0.00117 kg soil/day, and woodcock weigh 0.198 kg, consume 0.15 kg earthworms/day and 0.0156 kg soil/day, the RBRAOs for these species and contaminants are as follows:

Risk-based remedial action objectives for soil (mg/kg)

<i>Short-tailed Shrew</i>				
Contaminant	UF	FE _s	FE _w	RBRAO
Barium	0.0777	0.90	0.086	65
<i>American Woodcock</i>				
Mercury	5.7669	0.101	0.899	0.14
Zinc	5.5897	0.104	0.896	68

Comparison of the concentrations of barium, mercury and zinc at the two soil sampling locations in the WAG 5 Wide area to the RBRAOs (Table C2.66.) shows that all three contaminants at sample location 4113 are below the RBRAOs, indicating that remediation is not warranted at this location. At the other sampling location (SB044), while concentrations of all three contaminants exceeded the RBRAOs (Table C2.66.), barium was less than mean background (both local and eastern United States) and proposed RCRA action levels. Mercury and zinc exceeded both local and eastern United States mean background, but were less than the maximum values observed in the eastern United States (Table C2.66.); in addition, the mercury concentration was less than the RCRA action level.

Sample location SB044 is located in the old landfill (SWMU 5.14; see Table A1.1). Therefore, contaminants observed in this sample may be attributable to wastes buried in this landfill. Because contaminant concentrations from only one of two soil samples from the WAG 5 Wide area exceeded RBRAOs and that site may be related to an identifiable source, contamination in the WAG 5 Wide area likely to be localized and not widespread. If remediation is determined to be appropriate, efforts should focus on the old landfill location (SWMU 5.14).

Radionuclide Contamination

Approximately 95% of the total radiation exposure experienced by shrews and woodcock in the SWSA 5 area is attributable to Cm-243/244. Radionuclide RBRAOs for vermivores were developed by back-calculating the radiation exposure estimate to identify the concentration of Cm-243/244 in the soil that results in an exposure equivalent to the IAEA recommended level (42 μ Gy/h). The lowest value (15 pCi Cm-243/244 /g) was obtained for shrews. This value may be used as the RBRAO.

C2.5.1.5. Summary

Because RBRAOs for terrestrial plants, soil invertebrates, or soil microbes, or microbial processes were not necessary, final RBRAOs for protection of soil-exposed endpoints are based only on vermivorous wildlife. While barium concentrations in soils in the NHF area were determined to be potentially hazardous to shrews, the small size of the NHF area and the minimal availability of habitat, suggest that the site is unlikely to present a realistic hazard to shrew populations. Remediation is therefore not recommended.

Risks identified in the WAG 5 Wide area can be attributed solely to a single sampling site located in the old landfill (SWMU 5.14). If remediation is determined to be appropriate, it should be focused on this area. Potential soil remediation levels are presented in Table C2.66.

To protect shrews and woodcock from excessive radiation exposure in the SWSA 5 area, the concentration of Cm-243/244 in the soil should not exceed 15 pCi Cm-243/244 /g.

C2.5.2 Risk-based Remedial Action Objectives for Surface Water

Risk-based remedial action objectives for surface water are based on an evaluation of the surface water exposed endpoints, e.g., fish and aquatic plants. After evaluating each endpoint, all data are combined to recommend RBRAOs that are protective of all endpoints exposed to surface water contamination.

C2.5.2.1 Fish

On-site surface water

The weight of evidence for drainage D1 suggests a need for remedial actions, but specific RBRAOs could not be identified. Remediation will not be necessary if (1) *Ceriodaphnia* toxicity tests show less than 20% reduction in survival or reproduction or (2) surveys of the fish community show that species richness and abundance in White Oak Creek are not reduced more than 20% (relative to reference sites) by impacts at this site.

Biological surveys were not available, but the medium toxicity tests indicated a need for remediation of drainage D1. Although chronic toxicity during high base flow was evinced by the laboratory tests, contaminant concentrations did not identify any likely causes of acute or chronic toxicity. High base flow concentrations were only measured once and may not represent the true exposure at the site. Since removal or isolation of surface water from D1 are not viable options, it is necessary to identify the sources of toxicity in order to set specific RBRAOs. The spatial distribution of toxicity could be clarified by collecting samples for toxicity testing and concurrent chemical analysis at several locations along drainage D1. Also, in situ toxicity tests could be used to identify possible source areas and to better integrate exposure over time. Since D1 does not support a distinct fish community, effects on the White Oak Creek community as a result of impacts on this portion of the White Oak Creek habitat could be estimated.

The weight of evidence for drainage D2 suggests a need for remedial actions. Biological surveys were not available and the medium toxicity tests did not provide evidence of acute or chronic toxicity. However, two contaminants exceeded benchmarks during base flow conditions. Dissolved manganese exceeded multiple chronic benchmarks and dissolved iron exceeded the chronic NAWQC. The appropriate RBRAO for manganese is the lowest chronic value for daphnids (<1,100 µg/L). Because it is an ARAR, the appropriate RBRAO for iron is the chronic NAWQC (1,000 µg/L). To meet these preliminary objectives the dissolved concentrations of iron and manganese should not exceed the RBRAOs over a four day averaging period. Remediation for manganese will not be necessary if (1) fathead minnow and daphnid toxicity tests show less than 20% reduction in survival or reproduction or (2) surveys of the fish community show that species richness and abundance in Melton Branch are not reduced more than 20%, relative to reference sites, by impacts at this site.

However, remedial actions to meet ARARs are not necessarily subject these alternate evaluations.

Contribution to off-site surface water

The weight of evidence for off-site impacts includes the off-site surface water locations (Table C2.60) and the contribution of each seep to risk in White Oak Creek (White Oak Creek) or Melton Branch (Melton Branch) (Table C2.63). Three off-site areas (White Oak Creek, Melton Branch, and drainage D3) potentially impacted by WAG 5 are discussed below.

The weight of evidence for White Oak Creek does not suggest a need for remedial actions in WAG 5 at this time. The fish community in White Oak Creek appears to be impacted, relative to other area streams, but the evidence neither supports nor refutes the contribution of WAG 5 to these impacts. Contaminant concentrations were not available for White Oak Creek and the seeps that ultimately drain into White Oak Creek are not expected to contribute significantly to the contaminant load in the main channel.

The weight of evidence for Melton Branch does not suggest a need for remedial actions in WAG 5 at this time. The fish community in Melton Branch does not appear to be impacted, relative to the reference and upstream sites, and provides no evidence that WAG 5 contributes to risks in Melton Branch. Although fluoride exceeded the secondary chronic value and the population EC20 there were no background values for fluoride. Concentrations at SW004 and SW005 provide good evidence that the source(s) of fluoride are upstream of WAG 5. Also, the concentrations at both SW005 and SW006 were below the lowest chronic values for fish and daphnids, which are the most appropriate toxicity values for RBRAOs. Dissolved manganese from SP009 has the potential to reach concentrations in Melton Branch that exceed the population EC20. However, the potential concentrations in Melton Branch do not exceed the lowest chronic values for fish and daphnids, which are the most appropriate toxicity values for RBRAOs. At this time there is insufficient information to justify a need for remedial actions.

The weight of evidence for drainage D3 suggests a potential need for remedial actions. Biological surveys and medium toxicity tests were not available for drainage D3 (SW003), but total aluminum exceeded the acute NAWQC during storm flow conditions. Total aluminum may not be representative of the bioavailable concentration. However, the dissolved concentration was more than an order of magnitude higher than the total recoverable concentration. Although this indicates that the dissolved analysis is not reliable it does not refute the evidence for toxicity based on the total aluminum concentration. Because it is an ARAR, the appropriate RBRAO for aluminum is the acute NAWQC (750 µg/L). To meet this preliminary objective the dissolved concentration of aluminum in D3 should not exceed the RBRAOs during storm events. Without further information it is not possible to identify the source of aluminum for remediation.

C2.5.2.2 Wetland plants

Based on the available lines of evidence, risk posed to wetland plants at WAG 5 appears to be minimal (Sect. C2.4.2.1.2). While Co in Seep 15 may be at high enough

concentrations to negatively impact vegetation, a winter survey turned up no evidence of negative impacts on the vegetation. Based on available information, no RBRAOs for wetland plants are necessary.

C2.5.2.3 Summary

Because RBRAOs for wetland plants were not necessary, final RBRAOs for protection of surface water-exposed endpoints are based only on fish. Available information suggests that remediation may be indicated for drainages D1, D2, and D3.

While medium toxicity tests for drainage D1 indicate toxicity, comparisons to benchmarks do not identify the contaminant(s) responsible. To identify the contaminant(s) responsible, water data, collected under different flow regimes, are needed. These data will serve to identify the sources of toxicity so that RBRAOs may be established.

Comparisons to benchmarks suggests the need for remediation of drainage D2. Dissolved manganese exceeded multiple chronic benchmarks and dissolved iron exceeded the chronic NAWQC. The appropriate RBRAO for manganese is $<1,100 \mu\text{g/L}$. Because it is an ARAR, the appropriate RBRAO for iron is the chronic NAWQC ($1000 \mu\text{g/L}$).

Comparisons to benchmarks suggests the need for remediation of drainage D3. Total aluminum exceeded the acute NAWQC during storm flow conditions. Because it is an ARAR, the appropriate RBRAO for aluminum is the acute NAWQC ($750 \mu\text{g/L}$).

Remediation for manganese in D2 will not be necessary if *Ceriodaphnia* toxicity tests show less than 20% reduction in survival or reproduction. However, remedial actions to meet ARARs, such as those for iron and aluminum, are not necessarily subject these alternate evaluations.

C2.5.3 Risk-based Remedial Action Objectives for Sediment

Risk-based remedial action objectives for sediment are based on an evaluation of the sediment exposed endpoints, e.g., benthic macroinvertebrates. The preliminary remedial actions goals were based solely on the maximum sediment contaminant concentrations at each sampling location. Remediation should be performed only in those locations where contaminant concentrations are likely to produce effects. For As, Hg, Ni, Ag, and Aroclor 1260, sediment RBRAOs are equivalent to the ER-Ms reported in Long et al. (1994); for acetone, 1,1-dichloroethane, 1,2-dichloroethene, and vinyl chloride, the RBRAO is based on sediment concentrations derived using the EqP method (see Hull and Suter 1994) and lowest chronic values for fish or daphnids (see Suter and Mabrey 1994).

Insufficient information is available to establish sediment RBRAOs for Ba and Fe. While concentrations of these contaminants were below twice-mean background levels (360 mg/kg and 91000 mg/kg for Ba and Fe, respectively) at all sampling locations in the D-1 and D-3 drainages and two locations in the D-2 drainage, Ba exceeded twice-mean background at SD005 and SD006 and Fe exceeded twice-mean background at SD006 (see Table C2.69). Screening benchmarks for these contaminants are derived from background concentrations in Wisconsin and Canada, respectively (Hull and Suter 1994). Because there are no toxicity-based data with which to assess these analytes, and there is no evidence to

suggest the concentrations observed in the D-2 drainage are toxic (see *Ceriodaphnia* toxicity test results for sample location 7; Sect. C2.3.2.3.), remediation of Ba and Fe in sediments cannot be recommended.

RBRAOs and contaminant concentrations in sediment from each sampling location were compared to identify locations where remediation may be warranted. No remediation is warranted at 5 of 9 sampling locations (Table C2.67). Concentrations of nickel, silver, or Aroclor 1260 exceeded RBRAOs at four locations, suggesting a potential need for remediation (Table C2.67). Remediation of these sites would not be necessary if sediment was collected from each site and provided to a laboratory for chronic sediment toxicity testing using either *Chironomus tentans* (a midge) or *Hyaella azteca* (an amphipod). If toxicity of sediments from these locations was not significantly different from toxicity in control sediments, then remediation would not be required.

C2.6. SUMMARY AND RECOMMENDATIONS

Ecological risks posed by contaminants in WAG 5 were assessed using the weight-of-evidence approach outlined in Suter et al. (1994). Endpoints considered included terrestrial and wetland plants, soil invertebrates, soil microorganisms and microbial processes, vermivorous wildlife, fish, and benthic macroinvertebrates. Onsite risks were assessed for the site in its current state and for a hypothetical future case where institutional controls are not maintained, succession occurs, and the site reverts to deciduous forest. Potential contribution of WAG 5 to ecological risks in the "downstream" integrator OU (WAG 2) were also evaluated.

Evaluation of risks to terrestrial endpoints (e.g., terrestrial plants, soil invertebrates, microorganisms and microbial processes, and vermivorous wildlife) was performed for each of six areas within WAG 5. Risks to aquatic endpoints (e.g., wetland plants, fish, and benthic macroinvertebrates) were addressed separately for each seep or drainage.

The definition of areas assessed in the ecological risk assessment differed from that employed elsewhere in this RI. While study areas for the human health risk assessment and other tasks in this RI were defined primarily by hydrology (surface water drainage and ground water divides; see Vol. 1, Sect. 3.1), areas assessed in the ecological risk assessment are defined according to available habitat and area history. WAG 5 was separated into six areas (see Fig. B1.27). Habitat on five of these six areas (SWSA 5, TRU, OHF, NHF, and PWSB) consists primarily of lawns, pavement, or industrial structures. At each of these locations, wastes were disposed of or stored or other waste management-related activities occurred. In contrast, the sixth area (WW), which represents the remaining area within the WAG 5 boundary but not within the other five areas, is essentially undisturbed (waste-related activities were minimal). As a result, the habitat is primarily deciduous forest. Because both surface contamination and the presence of biota in an area (and therefore exposure to and risks from contaminants) are dependent on past use of a site and available habitat, this approach was determined to be most appropriate for the ecological endpoints.

Tables C2.68, C2.69, C2.70, and C2.71. summarize risks identified for each endpoint under the current and future scenarios, in addition to the projected contribution of each area to risks in WAG 2. For clarity, onsite risks (both current and future case) were ranked into four categories:

- (1) **Likely impact:** Available evidence suggests there is a high probability that contaminant concentrations observed at the site are sufficiently high to result in adverse effects to endpoint populations or communities. For a site to receive a "likely impact" rank, (1) site media are clearly and consistently toxic, and contaminants are detected in toxic amounts; (2) biological surveys show clear and consistent degradation of endpoint population or community and contaminants detected in toxic amounts; or (3) contaminants are detected in clearly and consistently toxic amounts, taking into consideration speciation and bioavailability. For WAG 5, no site or endpoint received a "Likely Impact" rank.
- (2) **Possible impact:** Available evidence suggests there is a possibility that contaminant concentrations observed at the site are sufficiently high to result in adverse effects to endpoint

populations or communities. A "possible impact" rank is assigned to sites when evidence suggests an impact but evidence is incomplete or contradictory, or confidence in applicability of evidence is limited.

Impact possible

but unlikely: Available evidence suggests there is a possibility that contaminant concentrations observed at the site are sufficiently high to result in adverse effects to endpoint populations or communities, but there is considerable uncertainty about the validity of the evidence. An "impact possible but unlikely" rank is similar to the "possible impact" rank except that confidence in the data is very low or supporting data indicate that adverse effects are unlikely. For example, an "impact possible but unlikely" rank was assigned to the future risk that contaminants in the NHF area present to shrews (Table C2.68). While benchmarks were exceeded, the size of the site and the potential availability of habitat suggest there would be minimal use of the site by shrews, therefore adverse impacts are unlikely.

- (3) **No impact:** There is no evidence to suggest that contaminant concentrations observed at the site are sufficiently high to result in adverse effects to endpoint populations or communities. A "no impact" rank is assigned to sites when toxicity tests are negative, biomonitoring data indicate that site populations are not reduced relative to reference locations, and comparisons of exposures to toxicological benchmarks result in HQs < 1. For a site or endpoint to receive a "no impact" rank, no available data can suggest an adverse impact.

The contribution of a site to risks in the integrator OU (WAG 2) were ranked into four categories (contribution likely, possible contribution, contribution possible but unlikely, and no contribution) in a manner similar to that employed for onsite risks. Definitions of these categories are also comparable to those outlined for onsite impacts (above).

C2.6.1 Current Case

Terrestrial plant. Soil contamination does not present a risk to terrestrial plants in the TRU, PWSB, or NHF areas (Table C2.68, see also Sect. C2.4.2.1.1). Antimony, manganese, mercury, and selenium in SWSA 5 South, Co, manganese, and Ag in the OHF, and mercury and zinc WAG 5 Wide, were present in soil at concentrations exceeding benchmarks (Sect. C2.4.2.1.1, Table C2.45). Because the bioavailability of these elements to plants is generally low and WAG 5 concentrations are generally within the range of those reported for unpolluted surface soils in the eastern United States, risk to plant growth posed by these chemicals is probably low. Laboratory toxicity tests to evaluate the effects of contaminants in WAG 5 soils on seedling growth are inconclusive. No vegetation survey was done to quantify possible reductions in plant growth; however, the plant communities are not obviously different from others on the ORR. Overall, the evidence suggests possible impacts to plants growing in SWSA 5 South, OHF, and WAG 5-Wide soils.

Soil invertebrates. Soil contamination does not present a risk to soil invertebrates in the OHF, TRU, PWSB, or NHF areas (Table C2.68, see also Sect. C2.4.2.2). Mercury in

SWSA 5 South and mercury and zinc WAG 5-Wide were present in soil at concentrations exceeding benchmarks (Sect. C2.4.2.2, Table C2.45). In addition, SWSA 5 South has a lower density of worms than the reference site, the total radioactivity exceeded International Atomic Energy Agency recommended dose for terrestrial biota, and there is indication of toxic body burdens of some chemicals. Overall, the evidence suggests possible impacts to soil invertebrates in SWSA 5 South and WAG 5-Wide soils.

Soil microorganisms and microbial processes. Soil contamination does not present a risk to soil microorganisms and microbial processes in the TRU, PWSB, or NHF areas (Table C2.68, see also Sect. C2.4.2.3). The maximum manganese concentrations in soils of SWSA 5 South and OHF exceed those at which significant inhibition of nitrogen transformations occurs. The maximum zinc concentrations in soil WAG 5-Wide is within the range shown to inhibit several critical enzyme systems. However, because bioavailability of manganese and zinc is likely to be low and concentrations observed are within the range of those observed in uncontaminated soil in the eastern United States, the weight of evidence indicates that adverse impacts on microbial functioning in SWSA 5 South, OHF, and WAG 5-Wide soils are possible but unlikely.

Vermivorous wildlife. In the current scenario, risks were assessed only for the WAG 5-Wide area. Only one line of evidence, literature toxicity data, was available to evaluate ecological risk to vermivorous wildlife. Initial exposure evaluations for American woodcock and short-tailed shrews, based upon 95% UCLs, indicated that shrew exposure to barium and mercury and woodcock exposure to chromium, mercury, and zinc exceeded LOAELs (see Sect. C2.4.2.4). Because exposure estimates were based on data from only two soil samples, and the 95% UCLs exceeded the maximum values observed at the site, exposure estimates were recalculated using the maximum values. While these data indicate that shrew exposure to barium and woodcock exposure to mercury and zinc exceeded LOAELs (see Sect. C2.5.1.4), risks are attributable solely to a single sampling location.

Overall, the evidence suggests possible impacts to shrews in the WAG 5-Wide area (Table C2.68). While potential effects to individual woodcock are identified in the WAG 5-Wide area, population effects must be addressed at the ORR -level. WAG 5 alone is unlikely to significantly impact the ORR-wide woodcock population. To evaluate effects to the ORR-wide population, exposure from multiple OUs must be considered.

Wetland plants. Contaminants in Seeps 4, 6, 8, and 11 do not present a hazard to wetland plants (Table C2.69, see also Sect. C2.4.2.1.2). In Seeps 1, 2, 3, 5, 12, 14, and 16, Al in unfiltered samples exceeded the benchmark, but not in filtered samples, indicating possible but unlikely adverse impacts.

In Seeps 7, 9, and 17, iron, manganese, or nickel exceeded benchmarks, suggesting possible impacts to plants growing in wetland areas affected by these seeps. However, because of low bioavailability, adverse impacts are unlikely. Cobalt in Seep 15 may be at high enough concentrations to negatively impact vegetation.

Fish. Fish in Drainages D1 and D2 do not experience any adverse impacts during periods of storm flow (Table C2.70, Sect. C2.4.2.5). Aquatic toxicity tests and chemical analyses, however, indicate that fish may be affected by chronic exposure to water from drainages D1 and D2 during base flow. Acute effects are not expected at either location.

During base flow at D2, dissolved manganese exceeded multiple chronic benchmarks and dissolved iron exceeded the chronic NAWQC. While benchmarks were not exceeded at D1, toxicity tests indicate toxicity from an unidentified agent (Sect. C2.4.2.5). These drainages do not support distinct fish communities, and data are not conclusive; the evidence suggests possible impacts.

Benthic macroinvertebrates. In the D1 drainage, nickel and Aroclor 1260 exceeded ER-Ms (Sect. C2.4.2.6). In the D2 drainage, Ag exceeded the ER-M. Adverse impacts on the benthic macroinvertebrate community in these drainages are therefore possible (Table C2.71).

Radionuclides were not present at levels sufficient to cause adverse impacts to the benthic macroinvertebrate community at any site.

C2.6.2 Future Case

Terrestrial plants, soil invertebrates, soil microbes, and microbial processes. Exposure and risks experienced by these terrestrial endpoints are not likely to increase in the future scenario (for additional discussion see Sects. C2.4.3.1, C2.4.3.2, and C2.4.3.3). Therefore, risks identified in the current case are believed to be representative of those expected in the future (Table C2.68).

Vermivorous wildlife. Contamination is not expected to present a risk to woodcock in the OHF, TRU, PWSB, or NHF areas or to shrews in the OHF, TRU, or PWSB areas (Table C2.68, see also Sects. C2.4.3.4 and C2.5.1.4). Radiation exposure among shrews and woodcock in the SWSA5 area exceeded the International Atomic Energy Agency recommended value. Exposure of shrews to barium in the NHF area exceeded LOAELs, but because of the small size of the area and the likely unavailability of habitat, adverse impacts are considered to be unlikely (Sect. C2.5.1.4). Impacts in the WAG 5-Wide area are not expected to increase. Therefore, risks identified in the current case (see above) are believed to represent those expected in the future.

Wetland plants. Exposure of wetland plants to contaminants in the seeps may remain unchanged or decrease if the volume of seepage is reduced by the increased evapotranspiration resulting from reforestation. Therefore, risks identified in the current case (see above) are believed to represent those expected in the future (Table C2.69, see also Sect. C2.4.3.1.2).

Fish and benthic macroinvertebrates. In the absence of any changes to contaminant inputs to the aquatic systems at WAG 5, future onsite risks should be identical to current onsite risks.

C2.6.3 Contributions to WAG 2 Risk

The contribution of WAG 5 to off-site risks to terrestrial and wetland plants, soil invertebrates, soil microbes, and vermivorous wildlife was evaluated by considering the magnitude by which contaminants exceeded toxicological benchmarks. This was assumed to be a measure of the degree of dilution needed in the integrator OU to reduce contaminant concentrations to below toxic levels. For example, contaminants that marginally exceed benchmarks would require minimal dilution; therefore, they are unlikely to contribute

significantly to off-site risk. In contrast, contaminants whose concentrations are orders of magnitude larger than benchmark values are likely to present off-site risks. For WAG 5, it was assumed that contaminants with dilution factors (i.e., HQs) of 10 or less were unlikely to contribute significantly to off-site risk to terrestrial endpoints.

Terrestrial plants and soil invertebrates. There is no evidence to suggest that the OHF, TRU, PWSB, or NHF areas contribute to off-site risks to terrestrial plants or soil invertebrates (Table C2.68, Sects. C2.4.4.1.1 and C2.4.4.2). Because HQs >10 were observed for mercury in the SWSA 5 and WAG 5-Wide areas for both plants and soil invertebrates, off-site risks are possible. However, because both areas are vegetated, there is little likelihood that erosion and transport of WAG 5 soil will significantly contaminate off-site soils.

Soil microorganisms and microbial processes. There is no evidence to suggest that the TRU, PWSB, or NHF areas contribute to off-site risks to soil microorganisms or microbial processes (Table C2.68, Sect. C2.4.4.3). Because HQs >10 were observed for manganese in the SWSA 5 and OHF areas and for zinc in the WAG 5-Wide area, contributions to off-site risks are possible. However, because all areas are vegetated or paved, there is little likelihood that erosion and transport of WAG 5 soil will significantly contaminate off-site soils.

Vermivorous wildlife. To evaluate contribution of WAG 5 to risks to vermivorous wildlife in WAG 2, exposure estimates were recalculated excluding exposure from water. (Water was excluded because the water pathway generally contributed little to total contaminant exposure, impoundments that do not release to off-site areas were included in the on-site evaluation, and contribution of WAG 5 to WAG 2 water contamination is best described in relation to aquatic endpoints.) These new exposure estimates were compared with toxicological benchmarks and HQs were calculated (Sect. C2.4.4.4).

If it is assumed that contaminants with dilution factors (i.e., HQs) of 10 or less are unlikely to contribute significantly to off-site risk, then only one area and two contaminants may possibly contribute to risk to only one endpoint species (woodcock) in WAG 2: mercury and zinc from the WAG 5-Wide area; HQs for shrews were all less than 10 (Table C2.68, Sect. C2.4.4.4). Recalculation of woodcock exposure estimates using maximum observed values from the WAG 5-Wide area in place of 95% UCLs suggests that there is no contribution to WAG 2 contamination (Sect. C2.4.4.4). For this reason, contribution of the WAG 5-Wide area to risks to woodcock in WAG 2 was determined to be possible but unlikely (Table C2.68).

Wetland plants. Because seeps 1, 2, 4, 6, 8, 9, 11, 12, 15, and 17 displayed HQs <10 for all contaminants, they were determined not to contribute to off-site risk (Table C2.69, Sect. C2.4.4.1.2). All other seeps are listed as possible but unlikely contributors to WAG 2. This is due to AI exceeding benchmarks for unfiltered samples but not for filtered samples.

Fish. Three off-site areas (White Oak Creek, Melton Branch, and drainage D3) were evaluated for increased risks from WAG 5 (Table C2.70, Sect. C2.4.4.5.1). The evidence neither supports nor refutes an increase in risks to the fish communities of White Oak Creek by WAG 5. The available evidence indicates that WAG 5 does not increase the risks to the fish communities of Melton Branch. Based solely on chemical analyses, fish may be affected by chronic exposure to water from drainage D3. Acute effects are not expected during base flow but may occur at D3 during storm flow conditions. Manganese exceeded the population EC20 during base flow and total AI exceeded the acute NAWQC during storm flow

conditions. This drainage does not support a distinct fish community and effects on the MB community require evaluation at the integrator (WAG 2) level of resolution.

Based on aquatic toxicity tests and contaminant concentrations toxic effects of undiluted water are possible for all seeps except SP002 (Sect. C2.4.4.5.2). This, however, assumes that these seeps support aquatic communities. This is highly conservative, given that many seeps are dry part of the year or are too small to support a significant aquatic community. Only one seep (SP009) had the potential to contribute to risks in MB. Weighing the two available lines of evidence for SP009, it is unlikely that risk to the fish community in MB is actually increased by this seep.

Benthic macroinvertebrates. Based solely on the evaluation of upstream and downstream benthic macroinvertebrate communities in Melton Branch and White Oak Creek near WAG 5, and contaminant concentrations in these waters, there does not appear to be an impact resulting from releases from WAG 5 in either Melton Branch or White Oak Creek (Table C2.71, Sect. C2.4.4.6).

C2.6.4 Remedial Recommendations

Based upon the conclusions of the ecological risk assessment, recommendations for remediation may be made for soil, water, and sediments associated with WAG 5. These are discussed in detail in Sect. C2.5 and are summarized below.

Soil. Insufficient information was available to establish RBRAOs for terrestrial plants, soil invertebrates, soil microbes, or microbial processes. Therefore, final RBRAOs for protection of soil-exposed endpoints are based only on vermivorous wildlife. Soil contamination in the OHF, TRU, PWSB, and NHF areas was not found to be sufficiently high to warrant remediation.

While risks were identified in the WAG 5-Wide area, they can be attributed solely to a single sampling site located in the old landfill (SWMU 5.14). If remediation is determined to be appropriate, it should be focused on this area. Potential soil remediation levels are presented in Table C2.66.

Radionuclides (primarily Cm 243/244) were identified as presenting a hazard to shrews and woodcock in the SWSA 5 area. To prevent radiation exposure from exceeding the IAEA recommended value, Cm 243/244 in soil should not exceed 15 pCi/g.

Water. Insufficient information was available to establish RBRAOs for aquatic plants; therefore, final RBRAOs were based only on fish. Available information suggests that remediation may be indicated for drainages D1, D2, and D3.

While medium toxicity tests for drainage D1 indicate toxicity, comparisons with benchmarks do not identify the contaminant(s) responsible. To identify the contaminant(s) responsible, water data collected under different flow regimens are needed. These data will serve to identify the sources of toxicity so that RBRAOs may be established.

Comparisons with benchmarks suggest the need for remediation of drainage D2. Dissolved manganese exceeded multiple chronic benchmarks and dissolved iron exceeded the

chronic NAWQC. The appropriate RBRAO for manganese is $<1,100$ ug/L. Because it is an ARAR, the appropriate RBRAO for iron is the chronic NAWQC (1,000 ug/L).

Comparisons with benchmarks suggest the need for remediation of drainage D3. Total Al exceeded the acute NAWQC during storm flow conditions. Because exposure is brief and intermittent, the appropriate RBRAO for Al is the acute NAWQC (750 ug/L).

Remediation for manganese will not be necessary if *Ceriodaphnia* toxicity tests shows less than 20% reduction in survival or reproduction. However, remedial actions to meet ARARs, such as those for iron and aluminum, are not necessarily subject to these alternate evaluations.

Sediment. No remediation is warranted at five of nine sampling locations (Table C2.67). Concentrations of nickel, silver, or Aroclor 1260 exceeded RBRAOs at four locations, suggesting a potential need for remediation (Table C2.67). Remediation of these sites might not be necessary if sediment were collected from each site and provided to a laboratory for chronic sediment toxicity testing using either *Chironomus tentans* (a midge) or *Hyalella azteca* (an amphipod). If toxicity of sediments from these locations was not significantly different from toxicity in control sediments, then remediation would not be required.

REFERENCES

- Abbasi, S.A., and R. Soni. 1983. "Stress-induced enhancement of reproduction in earthworm *Octochaetus pattoni* exposed to chromium (VI) and mercury (II) - Implications in environmental management." *Intern. J. Environ. Stud.* 22:43-47.
- Adams, S. M. 1990a. Status and use of biological indicators for evaluating the effects of stress on fish. IN S. M. Adams (ed.), *Biological Indicators of stress in fish*. Amer. Fish. Soc. 8:1-8.
- Adams, S. M. 1990b. *Biological indicators of stress in fish*. Amer. Fish. Soc. Sym. No. 8, Amer. Fish. Soc., Bethesda, MD.
- Adams, S. M., and M. S. Greeley, Jr. 1991. Assessment and evaluation of the ecological health of fish populations exposed to PCBs in Hartwell Reservoir. Tennessee Valley Authority Publisher, TVA/WR/AB-91/14, Chattanooga, Tenn.
- Adams, S. M., and M. S. Greeley, Jr. 1992. Biological indicators of contaminant-related stress. IN R.L. Hinzman (ed.), *Second Report on the Oak Ridge Y-12 Plant Biological Monitoring and Abatement Program for East Fork Poplar Creek*. Draft ORNL/TM-12016. Oak Ridge National Laboratory, Oak Ridge, Tenn.
- Adams, S.M., and R.B. McLean. 1985. Estimation of largemouth bass, *Micropterus salmoides* Lacepede, growth using the liver somatic index and physiological variables. *J. Fish Biol.* 26: 111-126.
- Adams, S.M., J.E. Breck, and R.B. McLean. 1985. Cumulative stress-induced mortality of gizzard shad in a southeastern U.S. reservoir. *Environmental Biology of Fishes* 13:103-112.
- Adams, S. M., K. L. Shepard, M. S. Greeley, Jr., B. D. Jimenez, M. G. Ryon, L. R. Shugart, J. F. McCarthy, and D. E. Hinton. 1989. The use of bioindicators for assessing the effects of pollutant stress on fish. *Mar. Environ. Res.* 28:459-464.
- Adams, S. M., W. D. Crumby, and M. S. Greeley, Jr. 1991. Biological indicators of contaminant-related stress. 398 pp. IN J. M. Loar (ed.), *Fifth Annual Report on the ORNL Biological Monitoring and Abatement Program*. Draft ORNL/TM Report. Oak Ridge National Laboratory, Oak Ridge, Tenn.
- Adams, S.M., W.D. Crumby, M.S. Greeley, and L.R. Shugart. 1992a. Responses of fish populations and communities to pulp mill effluents: a holistic assessment. *Ecotoxicol. Environ. Saf.* 24:347-360.
- Adams, S. M., W.D. Crumby, M.S. Greeley, M. G. Ryon, and E. M. Schilling. 1992b. Relationships between physiological and fish population responses in a contaminated stream. *Environ. Toxicol. Chem.* 11:1549-1557.
- Adams, S.M., A.M. Brown, and R.W. Goede. 1993. A quantitative health assessment index for rapid evaluation of fish condition in the field. *Trans. Amer. Fish. Soc.* 122: 63-73.

Adams, S.M., M.S. Greeley, Jr., and W.D. Crumby. 1994. Biological Indicators of Contaminant-Related Stress. IN T.L. Ashwood (ed.) , Eighth Annual Report On the ORNL Biological Monitoring and Abatement Program. Draft ORNL/TM-12767. Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Addison, R.F. 1984. Hepatic mixed function oxidase (MFO) induction in fish as a possible biological monitoring system. pp. 51-60. IN: V.W. Cairns, P.V. Hodson, and J.O. Nriagu, (eds.), Contaminant Effects on Fisheries. John Wiley & Sons, New York.

Aery, N.C. and S. Sakar. 1991. "Studies on the effect of heavy metal stress on growth parameters of soybean." *J. Environ. Biol.* 12(1):15-24.

Aho, J.M., C.S. Anderson, and J.W. Terrell. 1986. Habitat suitability index models and instream flow suitability curves:redbreast sunfish. U.S. Fish Wildl. Serv. Biol. Rep. 82(10.119). 23pp.

Ahokas, J. T.; Kärki N. T.; Oikari, A. and Soivio A., 1976. Mixed function monooxygenase of fish as an indicator of pollution of Aquatic Environment by industrial effluent. *Bull. Environ. Contam. Toxicol.* 16: 270-274.

Al-Khafaji, A.A., and M.A. Tabatabai. 1979. "Effects of trace elements on arylsulfatase activity in soils." *Soil. Sci.* 127(3):129-133.

Allain, C.C., L.S. Poon, C.S.G. Chan, W.Richmond, and P.C. Fu. 1974. Enzymatic determination of total serum cholesterol. *Clin. Chem.* 20:470-475.

Allen, J.G., H.G. Masters, R.L. Peet, K.R. Mullins, R.D. Lewis, S.Z. Skirrow, and J. Fry. 1983. "Zinc toxicity in ruminants." *J. Comp. Pathol.* 93:363-377.

Aller, A.J., J.L. Bernal, M.J. del Nozal, and L. Deban. 1990. "Effects of selected trace elements on plant growth." *J. Sci. Food Agric.* 51:447-479.

Alumot, E. (Olomucki), E. Nachtomi, E. Mandel, and P. Holstein. 1976a. "Tolerance and acceptable daily intake of chlorinated fumigants in the rat diet." *Fd. Cosmet. Toxicol.* 14: 105-110.

Alumot, E., M. Meidler, and P. Holstein. 1976b. "Tolerance and acceptable daily intake of ethylene dichloride in the chicken diet." *Fd. Cosmet. Toxicol.* 14: 111-114.

Ambrose, A.M., P.S. Larson, J.F. Borzelleca, and G.R. Hennigar, Jr. 1976. "Long-term toxicologic assessment of nickel in rats and dogs." *J. Food Sci. Tech.* 13: 181-187.

Amur, M., J. McCarthy, M. Gill. 1982. "Respiratory response of guinea pigs to zinc oxide fume." *Am. Ind. Hyg. Assoc. J.* 43:887-889.

Anders, E. D.D. Dietz, C.R. Bagnell, Jr. J. Gaynor, M.R. Krigman, D.W. Ross, J.D. Leander, and P. Mushak. 1982. "Morphological, pharmacokinetic, and hematological studies of lead exposed pigeons." *Environ. Res.* 28: 344-363.

Anderson, R. O., and S. J. Gutreuter. 1983. Length, weight, and associated structural indices.

468 pp. IN L. A. Nielsen and D. L. Johnson (eds.), *Fisheries Techniques*. American Fisheries Society, Bethesda, Maryland.

Anderson, S.L., and T.J. Norberg-King. 1991. "Precision of short-term chronic toxicity tests in the real world." *Environ. Toxicol. Chem.* 10: 143-145.

Anderson, D.W., R.W. Risebrough, L.A. Woods, Jr., L.R. DeWeese, and W.G. Edgecomb. 1975. "Brown pelicans: improved reproduction off the southern California coast." *Science* 190: 806-808.

APHA, AWWA and WPCF. 1989. *Standard methods for the examination of water and wastewater*. American Public Health Assoc., Washington, D.C.

Ashwood, T.L. 1992. *Ecological assessment plan for Waste Area Grouping 5*. ORNL/M-1871. Oak Ridge National Laboratory, Oak Ridge, TN.

Ashwood, T.L., G.W. Suter II, and A.J. Stewart. 1992. *Preliminary Report on the Ecological Assessment of Waste Area Grouping 5 Oak Ridge National Laboratory, Oak Ridge, Tennessee*, ORNL/ER-137, Martin Marietta Energy Systems, Inc., Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Ashwood, T. L. (ed.) 1993. Draft seventh annual report on the ORNL Biological Monitoring and Abatement Program. ORNL/TM-000000. Oak Ridge National Laboratory, Oak Ridge, Tenn.

Ashwood, T. L., G. W. Suter, II, B. E. Sample, and R. N. Hull. 1993. *Remedial Investigation Plan for ORNL Waste Area Grouping 5, Vol. 3, Ecological Assessment Plan*, DOE/OR-1032/V3&D2, Oak Ridge National Laboratory, Oak Ridge, Tenn.

Ashwood, T.L., B.E. Sample, G.W. Suter II, H. Offerman, M.G. Turner, J.M. Loar, and L.W. Barnthouse. 1994. *Oak Ridge Reservation Ecological Monitoring and Assessment Program: Work Plan*. DOE/OR/01-1298&D1, Martin Marietta Energy Systems, Inc., Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Ashwood, T.L. (ed.). 1994. Eighth Annual Report On the ORNL Biological Monitoring and Abatement Program. Draft ORNL/TM-12767. Oak Ridge National Laboratory, Oak Ridge, Tennessee.

ATSDR (Agency for Toxic Substances and Disease Registry). 1989a. *Toxicological Profile for Zinc*. Agency for Toxic Substances and Disease Registry, U.S. Public Health Service, Atlanta, GA. 121 pp. ATSDR/TP-89-25.

ATSDR (Agency for Toxic Substances and Disease Registry). 1989b. *Toxicological profile for selected PCBs (Aroclor-1260, -1254, -1248, -1242, -1232, -1221, and -1016)*. Syracuse Research Corporation for ATSDR, U.S. Public Health Serv. ATSDR/TP-88/21. 135pp.

ATSDR (Agency for Toxic Substances and Disease Registry). 1990a. *Antimony*. ATSDR/U.S. Public Health Service, DRAFT.

ATSDR (Agency for Toxic Substances and Disease Registry) 1990b. *Toxicological profile for*

Di-n-Butylphthalate. ATSDR/TP_DI_n_B_90/11 (Draft).

Aughey, E., L. Grant, B.L. Furman, and W.F. Dryden. 1977. "The effects of oral zinc supplementation in the mouse." *J. Comp. Pathol.* 87:1-14.

Aulerich, R.J. and R.K. Ringer. 1977. "Current status of PCB toxicity, including reproduction in mink." *Arch. Environ. Contam. Toxicol.* 6: 279.

Aulerich, R.J., R.K. Ringer, M.R. Bleavins, et al. 1982. "Effects of supplemental dietary copper on growth, reproductive performance and kit survival of standard dark mink and the acute toxicity of copper to mink." *J. Animal Sci.* 55: 337-343.

Aulerich, R.J., A.C. Napolitano, S.J. Bursian, B.A. Olson, and J.R. Hochstein. 1987. "Chronic toxicity of dietary fluorine in mink." *J. Anim. Sci.* 65: 1759-1767.

Azar, A., H.J. Trochimowicz, and M.E. Maxwell. 1973. "Review of lead studies in animals carried out at Haskell Laboratory: two-year feeding study and response to hemorrhage study." In: *Environmental Health Aspects of Lead: Proceedings, International Symposium*, D. Barth et al., eds. Commission of European Communities. pp. 199-210.

Barclay, L.A. (U.S. Fish and Wildlife Service, Cookeville, TN). June 13, 1990. Letter to R.L. Kroodsma (ORNL).

Barnthouse, L.W., G.W. Suter II, and A. E. Rosen. 1990. Risks of toxic contaminants to exploited fish populations: influence of life history, data uncertainty and exploitation intensity. *Environ. Toxicol. Chem.* 9:297-311.

Barton, B. A., and C.B. Schreck. 1987. Metabolic cost of acute physical stress in juvenile steelhead. *Trans. Amer. Fish. Soc.* 116:257-263.

Bay, R.T. (U.S. Fish and Wildlife Service, Cookeville, TN). March 7, 1991. Letter to R.L. Kroodsma (ORNL).

Bean, J.R., and R.H. Hudson. 1976. Acute oral toxicity and tissue residues of thallium sulfate in golden eagles, *Aquila chrysaetos*. *Bull. Environ. Contam. Toxicol.* 15: 118-121.

Bechtel National Inc., 1988. *Remedial Investigation Plan for ORNL Waste Area Grouping 5*, ORNL/RAP/Sub-87/99053/88.V2, Oak Ridge, Tennessee.

Bechtel National Inc., 1992. *Remedial Investigation Plan for Waste Area Grouping 5 at Oak Ridge National Laboratory, Oak Ridge, Tennessee. Volume 2: Appendixes and Addendum 1 to Appendix A*. DOE/OR-1032/V2&D1, Oak Ridge, Tennessee.

Bechtel National Inc., 1993. *Measurement and Sampling of Storm Water Runoff at WAG 5: May and June 1993 Technical Bulletin 05-TB-027*. Oak Ridge National Laboratory.

Beliles, R. P. 1979. The lesser metals. In Oehme, F. W., Ed., *Toxicity of heavy metals in the environment*, Marcel Dekker, New York, pp. 547-615.

Belyaeva, A. P. 1967. The effect of antimony on reproduction. *Gig. Truda. Prof. Zabol.* 11:32.

- Bergmeyer, H.Y., Scheibe, P., and A.W. Wahlefeld. 1978. Clin. Chem. 24:1.
- Berlin, M. 1979. Mercury. pp. 503-530. in L. Friberg (ed). Handbook on the toxicology of metals. Elsevier Press, NY. 709 pp.
- Beyer, W.N., and E.J. Cromartie. 1987. "A survey of Pb, Cu, Zn, Cd, Cr, As, and Se in earthworms and soil from diverse sites." *Environ. Monit. Assess.* 8:27-36.
- Beyer, W.N., E. Conner, and S. Gerould. 1994. Estimates of soil ingestion by wildlife. J. Wildl. Mgmt. 58: 375-382.
- Beyer, N.W., G. Hensler, and J. Moore. 1987. "Relation of pH and other soil variables to concentrations of Pb, Cu, Zn, Cd, and Se in earthworms." *Pedobiologia* 30:167-172.
- Beyer, W.N., E. Cromartie, and G.B. Moment. 1985. "Accumulation of methylmercury in the earthworm *Eisenia foetida*, and its effect on regeneration." *Bull. Environ. Contam. Toxicol.* 35:157-162.
- Biesinger, K. E. and G. M. Christensen. 1972. "Effects of various metals on survival, growth, reproduction and metabolism of the *Daphnia magna*." *J. Fish. Res. Bd. Canada.* 29:1691-1700.
- Birge, W.J., J.A. Black, J.E. Hudson and D.M. Bruser. 1979. Embryo-larval toxicity tests with organic compounds. In *Aquatic Toxicology*. ASTM STP 667, L.L. Marking and R.A. Kimerle, eds. American Society for Testing and Materials, Philadelphia, PA. pp. 131-147.
- Blamberg, D.L., U.B. Blackwood, W.C. Supplee, and G.F. Combs. 1960. Effect of zinc deficiency in hens on hatchability and embryonic development. *Proc. Soc. Exp. Biol. Med.* 104:217-220.
- Blaylock, B.G., M.L. Frank, and B.R. O'Neal. 1993. Methodology for estimating radiation dose rates to freshwater biota exposed to radionuclides in the environment. ES/ER/TM-78. Oak Ridge National Laboratory, Oak Ridge, Tenn.
- Bleavins, M. R., R. J. Aulerich, and R. K. Ringer. 1980. Polychlorinated biphenyls (Aroclors 1016 and 1242): effects on survival and reproduction in mink and ferrets. *Arch. Environ. Contam. Toxicol.* 9(5):627-635.
- Bleavins, M.R., R.J. Aulerich, and R.K. Ringer. 1984. Effects of chronic dietary hexachlorobenzene exposure on the reproductive performance and survivability of mink and European ferrets. *Arch. Environ. Contam. Toxicol.* 13: 357-365.
- Bollag, J.-M., and W. Barabasz. 1979. "Effect of heavy metals on the denitrification process in soil." *J. Environ. Qual.* 8(2):196-201.
- Borzelleca, J.F., L.W. Condie, Jr., and J.L. Egle, Jr. 1988. "Short-term toxicity (one- and ten-day gavage) of barium chloride in male and female rats." *J. American College of Toxicology.* 7:675-685.
- Bradford, M. M., 1976. A rapid and sensitive method for the quantitation of protein utilizing the principle of protein-dye binding. *Anal. Biochem.* 72: 248-254.

Bradley, W.R. and W. G. Frederick. 1941. The toxicity of antimony - animal studies. *Ind. Med.* 10:15-22.

Branica, M., and Z. Konrad (eds). 1980. Lead in the marine environment. Pergamon Press, Oxford, England. 353pp.

Bremner, J.M., and L.A. Douglas. 1971. "Inhibition of urease activity in soils." *Soil Biol. Biochem.* 3:297-307.

Brink, M.F., D.E. Becker, S.W. Terril., and A.H. Jensen. 1959. Zinc toxicity in the weanling pig. *J. Anim. Sci.* 18:836-842.

Breiger, H., C. W. Semisch, J. Stasney and D.A. Piatnek. 1954. Industrial antimony poisoning. *Indust. Med. Health* 23:521-523.

Brown, C. 1993. Letter to W. Nelson Lingle RE: Invocation of Informal Dispute Resolution on the draft final Ecological Assessment Plan for Waste Area Grouping 5.

Brown D. A., R. W. Gossett, G. P. Hershelman, C. F. Ward, A. M. Westcott, and J. N. Cross, 1986. Municipal wastewater contamination in the Southern California Bight: Part I-Metal and organic contaminants in sediments and organisms. *Mar. Environ. Res.* 18:291-310.

Brown, J.A., P.H. Johansen, P.W. Colgan, and R.A. Mathers. 1987. Impairment of early feeding behavior of largemouth bass by pentachlorophenol exposure: a preliminary assessment. *Trans. Amer. Fish. Soc.* 116:71-78.

Buben, J.A. and E.J. O'Flaherty. 1985. Delineation of the role of metabolism in the hepatotoxicity of trichloroethylene and perchloroethylene:a dose-effect study. *Toxicol. Appl. Pharmacol.* 78: 105-122.

Buckner, C.H. 1964. Metabolism, food capacity, and feeding behavior in four species of shrews. *Can. J. Zool.* 42: 259-279.

Buckner, C.H. 1966. Populations and ecological relationships of shrews in Tamarack bogs of southeastern Manitoba. *J. Mammalogy* 47:181-194.

Bucolo, G, and H. David. 1973. Quantitative determination of serum triglycerides by the use of enzymes. *Clin. Chem.* 19:476-482.

Budavari, S. ed. 1989. The Merck Index. An Encyclopedia of Chemicals, Drugs, and Biologicals. 11th Ed. Merck and Co., Rahway, NJ. p. 110.

Burke, M.D., and R.T. Mayer. 1974. Ethoxyresorufin: Direct fluorimetric assay of a microsomal O-dealkylation which is preferentially inducible by 3-methylcholanthrene. *Drug. Metab. Dispos.* 2: 583-588.

Burton, G.A., D. Nimmo, D. Murphey and F. Payne. 1987. Stream profile determinations using microbial activity assays and *Ceriodaphnia*. *Environ. Toxicol. Chem.* 6:505-513.

Cain, B.W. and E.A. Pafford. 1981. Effects of dietary nickel on survival and growth of Mallard

ducklings. Arch. Environm. Contam. Toxicol. 10: 737-745.

Cain, B.W., L. Sileo, J. C. Franson, and J. Moore. 1983. Effects of dietary cadmium on mallard ducklings. Environ. Res. 32: 286-297.

Calder, W.A. and E.J. Braun. 1983. Scaling of osmotic regulation in mammals and birds. Am. J. Physiol. 224: R601-R606.

Cameron, I. L., W. C. Lawrence, and J. B. Lum. 1985. Medaka eggs as a model system for screening potential teratogens. pp. 239-243. IN Prevention of Physical and Mental Congenital Defects, Part C: Basic and Medical Science, Education and Future Strategies. Alan R. Liss, Inc.

Camner, P. and K. Philipson. Arch. Environ. Health. In: Handbook on the Toxicology of metals. Elsevier/North-Holland Biomedical Press, New York.

Campbell, P.G.C., and P.M. Stokes. 1985. Acidification and toxicity of metals to aquatic biota. Can. J. Fish. Aquatic Sci. 42:2034-2049.

Capuzzo, J.M. 1985. Biological effects of petroleum hydrocarbons on marine organisms: integration of experimental results and predictions of impacts. Marine Environmental Research 17: 272-276.

Carlander, K.D. 1982. Standard intercepts for calculating lengths from scale measurements for some centrarchid and percoid fishes. Trans. Amer. Fish. Soc. 111:332-336.

Carle, F. L., and M. R. Strub. 1978. A new method for estimating population size from removal data. Biometrics 34:621-630.

Carlson, C. L., D. C. Adriano, and P. M. Dixon. 1991. "Effects of soil-applied selenium on the growth and selenium content of forage species." J. Environ. Qual. 20:363-68.

Carriere, D., K. Fischer, D. Peakall, and P. Angehrn. 1986. Effects of dietary aluminum in combination with reduced calcium and phosphorus on the ring dove (*Streptopelia risoria*). Water, Air, and Soil Poll. 30: 757-764.

Chapman, H.D. (ed.). 1966. "Zinc." In Diagnostic Criteria for Plants and Soils. H.D. Chapman (ed.). Univ. of California, Div. Agric. Sci., Riverside.

Chapman, H.D. 1990. The environmental quality triad approach to determining pollution-induced degradation. *Sci. Total Environ.* 97/98, 815-825.

Chaudhry, F. M., A. Wallace, and R. T. Mueller. 1977. "Barium toxicity in plants." Commun. Soil Sci. Plant Anal. 8(9):795-97.

Chew, R.M. 1951. The water exchanges of some small mammals. Ecol. Monogr. 21(3): 215-224.

Clark, D. R. 1979. Lead concentrations: bats vs. terrestrial mammals collected near a major highway. Environ. Sci. Technol. 3:338-341.

- Clark, D.R., Jr., P.A. Ogasawara, G.J. Smith, and H.M. Ohlendorf. 1989. Selenium accumulation by raccoons exposed to irrigation drainwater at Kesterson National Wildlife Refuge, California, 1986. *Arch. Environ. Contam. Toxicol.* 18: 787-794.
- Collins, J.C. 1981. "Zinc." In N.W. Lepp (ed) *Effects of Heavy Metal Pollution on Plants*, Vol. 1. *Effects of Trace Metals on Plant Function*. pp. 145-170.
- Connors, J.I. and P.D. Doerr. 1982. Woodcock use of agricultural fields in coastal North Carolina. In: Dwyer, T.J., Storm, G.W., tech. coords. *Woodcock ecology and management*. U.S. Fish Wildl. Serv., Wildl. Res. Rep. 14:139-147.
- Cook, R. 1992. "WAG 5 Wetland Survey Field Notes," Field notes from Rebecca Cook, Martin Marietta Energy Systems, Environmental Sciences Division, February 6, 1992.
- Coon, R.A., B.K. Williams, J.S. Lindzey, et al. 1982. Examination of woodcock nest sites in central Pennsylvania. U.S. Fish Wildl. Serv., Wildl. Res. Rep. 14:55-62.
- Cooper, C.F., and W.C. Jolly. 1970. "Ecological effects of silver iodide and other weather modification agents: A review." *Water Resour. Res.* 6:88-98.
- Cooper, K. R., H. Liu, P-A. Bergqvist, and C. Rappe. 1991. Evaluation of Baltic herring and Icelandic cod liver oil for embryo toxicity, using the Japanese medaka (*Oryzias latipes*) embryo larval assay. *Environ. Toxicol. and Chem.* 10: 707-714.
- Cunningham, G.N., and M.B. Wise, E.R. Barrick. 1966. Effect of high dietary levels of manganese on the performance and blood constituents of calves. *J. Anim. Sci.* 25: 532-538
- Curl, E.A., P.J. Edwards, C. Elliott, and J.P. Leahey. 1987. "The conjugation and accumulation of metabolites of cypermethrin by earthworms." *Pesticide Sci.* 20:207-222.
- Custer, T.W. and G.H. Heinz. 1980. Reproductive success and nest attentiveness of mallard ducks fed Aroclor 1254. *Environmental Pollution (Series A)* 21: 313-318.
- Dahlgren, R.B., R.L. Linder and C.W. Carlson. 1972. Polychlorinated biphenyls: their effects on penned pheasants. *Environmental Health Perspectives* 1: 89-101.
- Dave, G. 1984a. Effects of fluoride on growth, reproduction, and survival in *Daphnia magna*. *Comp. Biochem. Physiol.* 78C:425-431.
- Dave, G. 1984b. Effects of waterborne iron on growth, reproduction, survival and haemoglobin in *Daphnia magna*. *Comp. Biochem. Physiol.* 78C:433-438.
- DeGraaf, R.M., H.R. Pywell, and J.W. Thomas. 1975. Relationships between nest height, vegetation, and housing density in New England suburbs. *Trans. 32nd Northeast Wildl. Conf.* p. 130-150.
- Deubert, K. H., R.M. Devlin, M.J. Kisiel, and A.S. Kostusiak. 1979. "The influence of benzo(a)pyrene on the growth of wheat and corn." *Environ Intern* 2:91-93.
- Dial, N. 1978. Methylmercury: some effects on embryogenesis in the Japanese medaka, *Oryzias*

latipes. Teratology 17: 83-92.

Dickson et al. 1992.

Diercxsens, P., D. de Weck, N. Borsinger, B. Rosset, and J. Tarradellas. 1985. "Earthworm contamination by PCBs and heavy metals." *Chemosphere* 14(5):511-522.

Di Toro, D. M. 1985. "A Particle Interaction Model of Reversible Organic Chemical Sorption." *Chemosphere* 14(10), 1503-1538.

Doelman, P., and L. Haanstra. 1989. "Short- and long-term effects of heavy metals on phosphatase activity in soils: An ecological dose-response model approach." *Biol. Fertil. Soils* 8:235-241.

Doelman, P., and L. Haanstra. 1986. "Short- and long-term effects of heavy metals on urease activity." *Biol. Fertil. Soils* 2:213-218.

Domingo, J.L., J.L. Paternain, J.M. Llobet, and J. Corbella. 1986. Effects of vanadium on reproduction, gestation, parturition and lactation in rats upon oral administration. *Life Sci.* 39: 819-824.

Doumas, B. T., and H.G. Biggs. 1972. Determination of serum albumin. pp. 175-188. IN G.R. Cooper (ed.), *Standard Methods of Clinical Chemistry*, Vol. 7. Academic Press, New York.

Drinker, K., and P. Drinker. 1928. Metal fume fever: V. Results of the inhalation by animals of zinc and magnesium oxide fumes. *J. Ind. Hyg.* 10:56-70.

Drinker, K.R., P.K. Thompson, and M. Marsh. 1927. An investigation of the effect of long continued ingestion of zinc, in the form of zinc oxide, by cats and dogs, together with observations upon the excretion and storage of zinc. *Am. J. Physiol.* 80:31-64.

Dunning, J.B. 1984. Body weights of 686 species of North American birds. West. Bird Banding Assoc. Monogr. No. 1. Eldon Publ. Co. Cave Crk, AZ. 38 pp.

Edens, F.W., E. Benton, S.J. Bursian, and G.W. Morgan. 1976. "Effect of Dietary Lead on Reproductive Performance in Japanese Quail, Coturnix coturnix japonica." *Toxicol. Appl. Pharmacol.* 38:307-314.

Edwards, C.A. 1992. "Testing the effects of chemicals on earthworms: The advantages and limitations of field tests." In *Ecotoxicology of Earthworms*. P.W. Greig-Smith et al. (eds). Intercept Ltd. pp. 75-84.

Eisler, M. 1968. Heptachlor: toxicology and safety evaluation. *Ind. Med. Surg.*, Nov. 840-844.

Eisler, R. 1985a. Cadmium hazards to fish, wildlife, and invertebrates: a synoptic review. U.S. Fish Wildl. Serv. Biol. Rep. 85(1.2). 46pp.

Eisler, R. 1985b. Selenium hazards to fish, wildlife, and invertebrates: a synoptic review. U.S. Fish Will. Serv. Bill: Rep. 85(1.5). 57pp.

- Eisler, R. 1986a. Chromium hazards to fish, wildlife, and invertebrates: a synoptic review. U.S. Fish Will. Serv. Bill. Rep. 85(1.6). 60pp.
- Eisler, R. 1986b. Polychlorinated biphenyl hazards to fish, wildlife, and invertebrates: a synoptic review. U.S. Fish Will. Serv. Bill. Rep. 85(1.7). 72 pp.
- Eisler, R. 1987. Mercury hazards to fish, wildlife, and invertebrates: a synoptic review. U.S. Fish Will. Serv. Bill. Rep. 85(1.10). 90pp.
- Eisler, R. 1988a. Arsenic hazards to fish, wildlife, and invertebrates: a synoptic review. U.S. Fish Wildl. Serv. Biol. Rep. 85(1.12). 92pp.
- Eisler, R. 1988b. Lead hazards to fish, wildlife, and invertebrates: a synoptic review. U.S. Fish Will. Serv. Bill. Rep. 85(1.14). 134pp.
- Eisler, R. 1993. Zinc hazards to fish, wildlife, and invertebrates: a synoptic review. U.S. Fish Will. Serv. Bill. Rep. 85(1.26). 106pp.
- Elliot, J. M. 1977. Some Methods for the Statistical Analysis of Samples of Benthic Invertebrates. Sci. Pub. No. 25. Freshwater Biological Association, Ambleside, England.
- Energy Systems (Martin Marietta Energy Systems). 1993. *Background Soil Characterization Project for the Oak Ridge Reservation*. DOE/OR/01-1174/V1 and Appendices DOE/OR/01-1175/V2. Oak Ridge, Tennessee.
- Eno, C.F., and P.H. Everett. 1958. "Effects of soil applications of 10 chlorinated hydrocarbon insecticides on soil microorganisms and the growth of Stringless Black Valentine beans." *Soil Sci Soc Am Proc* 22:235-238..
- EPA (U.S. Environmental Protection Agency). 1980a. Guidelines and methodology used in the preparation of health effects assessment chapters of the consent decree water quality criteria documents. *Fed. Regist.* 45(231): 79347-79356.
- EPA (U.S. Environmental Protection Agency). 1980b. Ambient water quality criteria for phthalate esters, EPA 440/5-80-067. U.S. Environmental Protection Agency, Washington, D.C.
- EPA (Environmental Protection Agency). 1980c. Ambient water quality criteria for polychlorinated biphenyls. U.S. Environ. Protection Agency Rep. 440/5-80-068. 211pp.
- EPA (U.S. Environmental Protection Agency). 1980d. Ambient water quality criteria for dichloroethylenes. EPA 440/5-80-041. U.S. Environmental Protection Agency, Washington, D.C.
- EPA (U.S. Environmental Protection Agency). 1980e. Ambient water quality criteria for cadmium. U.S. Environmental Protection Agency Rep. 440/5-80-025. 183 pp.
- EPA (U.S. Environmental Protection Agency). 1984a. Health Effects Assessment for Zinc (and Compounds). U.S. Environmental Protection Agency, Office of Research and Development, Washington, DC. EPA/540/1-86-048.
- EPA (U.S. Environmental Protection Agency). 1984b. Extraction and analysis of priority

pollutants in biological tissue, Method PPB 12/83. Environmental Services Division, Region IV, Analytical Support Branch, U.S. Environmental Protection Agency, Athens, Georgia. Mimeo, 10 pp.

EPA (U. S. Environmental Protection Agency). 1985. Ambient water quality criteria for copper - 1984, EPA 440/5-84-031. Office of Water Regulations and Standards, Washington, D.C.

EPA (U. S. Environmental Protection Agency). 1985a. Technical Support Document for Water Quality-Based Toxic Control. U.S. Environmental Protection Agency, Washington, D.C.

EPA (U. S. Environmental Protection Agency). 1986a. Quality criteria for water - U.S. Environmental Protection Agency, Washington, D.C. 1986, EPA 440/5-86-001.

EPA (U. S. Environmental Protection Agency). 1986b. Ambient water quality criteria for nickel - 1986, EPA 440/5-86-004. U.S. Environmental Protection Agency, Washington, D.C.

EPA (U. S. Environmental Protection Agency). 1986c. 90-day gavage study in albino rats using acetone. Office of Solid Waste, Washington, D.C.

EPA (U. S. Environmental Protection Agency). 1987. Ambient water quality criteria for selenium. EPA 440/5-87-006. U.S. Environmental Protection Agency, Washington, D.C.

EPA (U. S. Environmental Protection Agency). 1988. Ambient water quality criteria for aluminum. EPA 440/5-86-008. U.S. Environmental Protection Agency, Washington, D.C.

EPA (U.S. Environmental Protection Agency). 1989. *Briefing Report to the EPA Science Advisory Board on the Equilibrium Partitioning Approach to Generating Sediment Quality Criteria*. EPA 440/5-89-002. Washington D.C.

EPA (U.S. Environmental Protection Agency). 1990. Toxic Substance Spreadsheet. U.S. Environmental Protection Agency, Region-4, Water Management Division, Atlanta, Georgia. Mimeo. 8 pp.

EPA (U.S. Environmental Protection Agency). 1990b. Corrective action for solid waste management units (SWMUs) at hazardous waste management facilities. Federal Register. 55: 30798-30884.

EPA (U.S. Environmental Protection Agency). 1991. Methods for the Determination of Metals in Environmental Samples. EPA-600/4-91-010. Environmental Monitoring Systems Laboratory, U.S. Environmental Protection Agency, Cincinnati, Ohio.

EPA (U. S. Environmental Protection Agency). 1993a. Wildlife exposure factors handbook. Volume I. Office of Research and Development, Washington, DC. EPA/600/R-93/187a.

EPA (U. S. Environmental Protection Agency). 1993b. Integrated Risk Information System (IRIS). Carcinogenicity Assessment for Zinc and Compounds, and Oral RFD Assessment for Zinc phosphide. Office of Health and Environmental Assessment, Cincinnati, OH.

EPA (U. S. Environmental Protection Agency). 1993c. "Water quality guidance for the Great Lakes System and correction: Proposed rules." *Federal Register*. 58(72):20802-21047.

EPA (U. S. Environmental Protection Agency). 1993d. Wildlife criteria portions of the

proposed water quality guidance for the Great Lakes system. EPA/822/R-93/006. Office of Science and Technology, Washington, D.C.

EPA (U.S. Environmental Protection Agency). 1993a. *Sediment Quality Criteria for the Protection of Benthic Organisms: Acenaphthene*. EPA-822-R-93-013. United States Environmental Protection Agency, Washington D.C.

FDA (Food and Drug Administration). 1984a. Action level for methyl mercury in fish. Federal Register 49(224):45663.

FDA (Food and Drug Administration). 1984b. Polychlorinated biphenyls (PCBs) in fish and shellfish: Reduction of tolerances; Final Decision. Federal Register 49(100):21520.

Felicetti, S. W., R. G. Thomas and R. O. McClellan. 1974. Retention of inhaled antimony-124 in the beagle dog as a function of temperature of aerosol formation. *Health Phys.* 26:525-531.

Ferm, V.H., and W.M. Layton, Jr. 1981. Teratogenic and mutagenic effects of cadmium. Pp 743-756 in J.O. Nriagu (ed) *Cadmium in the environment. Part 2. Health Effects*. John Wiley, New York.

Fieser, A. H., J. L. Sykora, M. S. Kostalos, Y. C. Wu, and D. W. Weyel. 1986. Effects of fluorides on survival and reproduction of *Daphnia magna*. *Journal WPCF*. 58(1):82-86.

Fischer, E., and L. Koszorus. 1992. "Sublethal effects, accumulation capacities and elimination rates of As, Hg and Se in the manure worm, *Eisenia foetida* (Oligochaeta, Lumbricidae)." *Pedobiologia* 36:172-178.

Fitzhugh, O.G. 1948. Use of DDT insecticides on food products. *Ind. Eng. Chem.* 40: 704-705.

Feron, V.J., C.F.M. Hendriksen, A.J. Speek, et al. 1981. Lifespan oral toxicity study of vinyl chloride in rats. *Food Cosmet. Toxicol.* 13: 633-638.

Fimreite, N. 1970. Effects of methyl mercury treated feed on the mortality and growth of leghorn cockerels. *Can. J. Anim. Sci.* 50: 387-389.

Fimreite, N. 1971. Effects of dietary methylmercury on ringnecked pheasants. *Can. Will. Serv. Occ. Paper No. 9*. 37 pp.

Fleming, A. J. 1982. The toxicity of antimony trioxide. Sponsored by E. I. DuPont de Nemours and Co., Wilmington, DE. OTS215027.

Fletcher, G.L, M.J. King, J.W. Kiceniuk, and R.F. Addison. 1982. Liver hypertrophy in winter flounder following exposure to experimentally oiled sediments. *Comp. Biochem. Physiol.* 73C:457-462.

Forlin, L., and T. Andersson, 1985. Storage conditions of rainbow trout liver cytochrome P-450 and conjugating enzymes. *Comp. Biochem. Physiol.* 3: 569-572.

Formigli, L., R. Scelsi, P. Poggi, C. Gregotti, A. DiNucci, E. Sabbioni, L. Gottardi, and L.

- Manzo. 1986. Thallium-induced testicular toxicity in the rat. *Environ. Res.* 40: 531-539.
- Fox, M.R.S., and R.M. Jacobs. 1986. Zinc: essentiality, function, effects of deficiency, and requirements. In: *Metal Ions in Biological Systems*, H. Sigel, ed. Marcel Dekker, Inc., New York. pp. 214-248.
- Foy, C.D., R.L. Chaney, and M.C. White. 1978. "The physiology of metal toxicity in plants." *Ann Review Plant Physiol* 29:511-566.
- Francis, C.W., and O.M. Sealand. 1987. *Concentrations of Radionuclides in ORNL Waste Pond Sediments and Their leaching Characteristics*, ORNL/RAP/LTR-87/70, Oak Ridge National Laboratory.
- Fraser, C.M. 1916. Growth of the spring salmon. *Trans. Pacific Fish. Soc.* 1915:29-39.
- Gale, T.F. 1978. Embryotoxic effects of chromium trioxide in hamsters. *Environ. Res.* 16: 101-109.
- Gallup, W.D., and L.C. Norris. 1939. The amount of manganese required to prevent perosis in the chick. *Poult. Sci.* 18: 76-82.
- Garman, G.C., and T. F. Waters. 1983. Use of the size-frequency (Hynes) method to estimate annual production of a stream fish population. *Can. J. Fish. Aquat. Sci.* 40:2030-2034.
- Gasaway, W.C., and I.O. Buss. 1972. Zinc toxicity in the mallard duck. *J. Will. Manage.* 36: 1107-1117.
- Geertz-hansen, P., and E. Mortensen. 1983. The effect of dissolved and precipitated iron on the reproduction of brown trout (*Salmo trutta*). *Vatten* 39:55-62.
- Geisy, J. P., and R. A. Hoke. 1990. "Freshwater Sediment Quality Criteria: Toxicity Bioassessment." pp. 265-348 in *Sediments: Chemistry and Toxicity of In-Place Pollutants*. Baudo, R., J. Giesy, and H. Muntau (eds.). Lewis Publishers, Inc. Chelsea, Mich.
- George, S.B., J.R. Choate, and H.H. Genoways. 1986. *Blarina brevicauda*. *Mammalian Species*. 261: 1-9.
- Gerber, G. B., J. Maes and B. Eykens. 1982. Transfer of antimony and arsenic to the developing organism. *Arch. Toxicol.* 49:159-168.
- Gerisch, F. M. 1984. "Evaluation of static renewal chronic toxicity test method for *Daphnia magna* Straus using boric acid." *Environ. Toxicol. Chem.* 3:89-94.
- Getz, L.L. 1989. A 14- year study of *Blarina brevicauda* populations in east-central Illinois. *J. Mammalogy*. 70:58-66.
- Gilani, S.H., and M. Marano. 1979. Chromium poisoning and chick embryogenesis. *Environ. Res.* 19: 427-431.
- Goats, G.C. and C.A. Edwards, 1982. Testing the Toxicity of Industrial Chemicals to Earthworms. Rothamsted Exp. Stn. Rep. 1982:104-105.

Goede, R. W., and B. A. Barton. 1990. Organismic indices and an autopsy-based assessment as indicators of health and condition of fish. *American Fisheries Society Symposium* 8:93-108.

Good, E.E., and G.W. Ware. 1969. Effects of insecticides on reproduction in the laboratory mouse, IV. Endrin and Dieldrin. *Toxicol. Appl. Pharmacol.* 14: 201-203.

Graf, W. 1965. "On the natural occurrence and importance of carcinogenic polycyclic aromatic hydrocarbons." *Medizinische Klinik* 60:561. Cited in Sims, R.C., and M.R. Overcash. 1983. Fate of polynuclear aromatic compounds (PNAs) in soil-plant systems. *Residue Reviews* 88:1-68.

Grandjean, P. 1976. Possible effect of lead on eggshell thickness in kestrels 1874-1974. *Bull. Environ. Contam. Toxicol.* 16: 101

Grant, D.L., W.E.J. Phillips, and G.V. Hatina. 1977. Effects of hexachlorobenzene on reproduction in the rat. *Arch. Environ. Contam. Toxicol.* 5: 207-216.

Greeley, M. S., Jr., D. R. Calder, and R. A. Wallace. 1987. Oocyte growth and development in the striped mullet, *Mugil cephalus*, during seasonal ovarian recrudescence: Relationship to fecundity and size at maturity. *Fish. Bull.* 85: 187-200.

Greeley, M. S., Jr., R. MacGregor III, and K. R. Marion. 1988. Changes in the ovary of the Gulf killifish, *Fundulus grandis* (Baird and Girard), during seasonal and semilunar spawning cycles. *J. Fish Biol.* 33: 97-107.

Greeson, P. E., T. A. Ehlke, G. A. Irwin, B. W. Lium, and K. V. Slack. 1977. Methods for collection and analysis of aquatic biological and microbiological samples. Book 5, chapter 4A, pp. 1-322. IN U.S. Geological Survey, *Techniques of Water-Resources Investigations of the United States Geological Survey*. U.S. Government Printing Office, Washington, D.C.

Grummer, R.H., O.G. Bentley, P.H. Phillips, and G. Bohstedt. 1955. The role of manganese in growth, reproduction, and lactation of swine. *J. Anim. Sci.* 19:170-175.

Gunn, A. 1992. The use of mustard to estimate earthworm populations. *Pedobiologia*. 36: 65-67.

Haanstra, L., and P. Doelman. 1991. "An ecological dose-response model approach to short- and long-term effects of heavy metals on arylsulfatase activity." *Biol. Fertil. Soils* 11:18-23.

Hagemeyer, J., D. Lohrmann, and S.-W. Breckle. 1993. "Development of annual xylem rings and shoot growth of young beech (*Fagus sylvatica* L.) grown in soil with various Cd and Zn levels." *Water, Air Soil Pollut.* 69:351-361.

Hara, T., Y. Sonoda, and I. Iwai. 1976. "Growth response of cabbage plants to transition elements under water culture conditions." *Soil Sci. Plant Nutr.* 22(3):307-315.

Hardin, B.D., R.L. Schuler, J.R. Burg, et al. 1987. Evaluation of 60 chemicals in a preliminary developmental toxicity test. *Teratogenesis Carcinogen Mutagen* 7: 29-48

Harr, J.R. 1978. Biological effects of selenium. pp. 393-426. in F.W. Oehme (ed.) *Toxicity of*

heavy metals in the environment. Part I. Marcel Dekker, Inc. New York. 515 pp.

Hart, D.R., J. Fitchko and P.M. McKee. 1988. Development of Sediment Quality Guidelines Phase II -Guideline Development. Final Report to: Ontario Ministry of the Environment, Toronto, Ontario. Beak Consultants Limited, Brampton, Ontario.

Hartenstein, R., E.F. Neuhauser, and A. Narahara. 1981. "Effects of heavy metal and other elemental additives to activated sludge on growth of *Eisenia foetida*." J Environ Qual 10(3):372-376.

Haseltine, S.D., L. Sileo, D.J. Hoffman, and B.D. Mulhern. Effects of Chromium on reproduction and growth in black ducks. Unpubl. MS.

Hatcher, R.M. 1990. Help for Tennessee's rare and endangered wildlife. Tennessee Wildlife Resources Agency, Nashville, Tennessee.

Heath, A.G. 1987. Use of physiological and biochemical measures in pollution biology. Pgs. 221-234, In A.G. Heath, editor. Water pollution and fish physiology. CRC Press, Boca Raton, Florida.

Heale, E.L., and D.P. Ormrod. 1982. "Effects of nickel and copper on *Acer rubrum*, *Cornus stolonifera*, *Lonicera tatarica*, and *Pinus resinosa*." Can. J. Bot. 60:2674-2681.

HECD (Health and Criteria Division). 1992. Interim guidance on interpretation and implementation of aquatic life criteria for metals. U.S. Environmental Protection Agency, Washington, D.C.

Heidinger, R.C., and S.D. Crawford. 1977. Effect of temperature and feeding rate on the liver-somatic index of the largemouth bass, Micropterus salmoides. J. Fish. Res. Bd. Can. 34: 633-638.

Heimbach, F. 1992. "Effects of pesticides on earthworm populations: Comparison of results from laboratory and field tests." In *Ecotoxicology of Earthworms*. P.W. Greig-Smith et al. (eds). Intercept Ltd., U.K. pp. 100-106.

Heimbach, F. 1988. "A comparison of laboratory methods for toxicity testing with earthworms." In *Earthworms in Waste and Environmental Management*. C.A. Edwards and E.F. Neuhauser (eds). SPB Academic Pub., Netherlands. pp. 329-335.

Heinz, G.H., and S.D. Haseltine. 1981. Avoidance behavior of young black ducks treated with chromium. Toxicol. Lett. 8: 307-310..

Heinz, G.H., and S.D. Haseltine. 1983. Altered avoidance behavior of young black ducks fed cadmium. Environ. Toxicol. Chem. 2: 419-421.

Heinz, G.H. 1979. Methyl mercury: reproduction and behavioral effects on three generations of mallard ducks. J. Will. Mgmt. 43: 394-401.

Heinz, G.H. D.J. Hoffman, A.J. Krynitsky, and D.M.G. Weller. 1987. Reproduction in mallards fed selenium. Environ. Toxicol. Chem. 6: 423-433.

- Heinz, G.H., D.J. Hoffman, and L.G. Gold. 1989. Impaired reproduction of mallards fed an organic form of selenium. *J. Will. Mgmt.* 53: 418-428.
- Heisinger, J. F., and W. Green. 1975. Mercuric chloride uptake by eggs of the ricefish and resulting teratogenic effects. *Bull. Environ. Contam. Toxicol.* 14: 655-673.
- Henry, R.J., Cannon, D.C., and J.W. Winkelman. 1974. *Clinical chemistry; principles and technics*, 2nd ed. Harper and Row, Hagerstown, Maryland.
- Hill, E.F., and M.B. Camardese. 1986. Lethal dietary toxicities of environmental contaminants and pesticides to Coturnix. *U.S. Fish Will. Serv. Tech. Rep.* 2. 147pp.
- Hinton, D.E., and J.A. Couch. 1984. Pathological measures of marine pollution effects. pp.7-32. IN: H.H. Harris (ed.), *Concepts in Marine Pollution Measurements*. Maryland Sea Grant College, University of Maryland, College Park, Maryland.
- Hinzman, R.L. 1992. Second report on the Y-12 plant biological monitoring and abatement program for East Fork Poplar Creek. Draft ORNL/TM-12016. Oak Ridge Natl. Laboratory, Oak Ridge, TN.
- Hiraoka, N. 1986. The toxicity and organ-distribution of antimony after chronic administration to rats. *J. Kyoto Prefect. Univ. Med.* 95:997-1017.
- Hiraoka, Y. and H. Okuda. 1983. Characteristics of vertebral abnormalities of medaka as a water pollution indicator. *Hiroshima J. of Med. Sci.* 32: 261-266.
- Hoffman, D.J., and G.H. Heinz. 1988. Embryotoxic and teratogenic effects of selenium in the diet of mallards. *J. Toxicol. Environ. Health.* 24: 477-490.
- Hoffman, F. O., B. G. Blaylock, C. C. Travis, K. L. Daniels, E. L. Etnier, K. E. Cowser, and C. W. Weber. 1984. Preliminary screening of contaminants in sediments. ORNL/TM-9370. Oak Ridge National Laboratory, Oak Ridge, Tenn. 86 pp.
- Hornshaw, T.C., R.J. Aulerich and H.E. Johnson. 1983. Feeding Great Lakes fish to mink: effects on mink and accumulation and elimination of PCBs by mink. *J. Toxicology and Environ. Health* 11: 933-946.
- Huckabee, J.W., and B.G. Blaylock. 1973. "Transfer of mercury and cadmium from terrestrial to aquatic ecosystems." *Adv. Exp. Med. Biol.* 40:125-160.
- Hudgins, J.E., G.L. Storm, and J.S. Wakeley. Local movements and diurnal-habitat selection by male American woodcock in Pennsylvania. *J. Will. Manage.* 49:615-619.
- Hudson, R. H., R. K. Tucker, and M. A. Haegele. 1984. *Handbook of toxicity of pesticides to wildlife*. 2nd ed. U.S. Fish Will. Serv. Resour. Publ. 153. 90pp.
- Hull, C. G. 1993. Japanese medaka (*Oryzias latipes*) embryo assay for developmental toxicity incorporating individual embryo incubations: evaluation of controls, a pure compound (BAP), soil extracts, and stream effluents. Ph.D Dissertation, University of Tennessee, Knoxville.

Hull, R.N. and G.W. Suter II. 1994. Toxicological benchmarks for screening contaminants of potential concern for effects on sediment-associated biota: 1994 revision. ES/ER/TM-95/R1. Oak Ridge National Laboratory, Oak Ridge, Tenn.

Hussein, A.S., A.H. Cantor, and T.H. Johnson. 1988. Use of high levels of dietary aluminum and zinc for inducing pauses in egg production of Japanese quail. Poultry Sci. 67:1157-1165.

Ireland, M.P. 1979. "Metal accumulation by the earthworms *Lumbricus rubellus*, *Dendrobaena veneta*, and *Eiseniella tetraedra* living in heavy metal polluted sites." Environ Pollut 19:201-206.

IAEA. 1982. Generic models and parameters for assessing the environmental transfer of radionuclides from routine releases. Exposures of critical groups. International Atomic Energy Agency Safety Series No. 57. 96pp.

IAEA. 1992. Effects of ionizing radiation on plants and animals at levels implied by current radiation protection standards. International Atomic Energy Agency Technical Reports Series No. 332. 74pp.

ICRP. 1983. "Radionuclide transformations: energy and intensity of emissions." International Commission on Radiological Protection publication No. 38. Pergamon Press, New York.

Ishida, J. 1951. Effects of 2,4-dinitrophenol on oxygen consumption during early development of the teleost, *Oryzias latipes*. Annot. Zool. Jpn. 24: 181-186.

Ishihara, K. 1956. Effect of 2,4-dinitrophenol and sodium azide on the ammonia production in the embryos of *Oryzias latipes*. J. Fac. Sci. Univ. Tokyo. Section IV:Zoology. 7: 525-533.

Ivankovic, S. and R. Preussmann. 1975. Absence of toxic and carcinogenic effects after administration of high doses of chromic oxide pigment in subacute and long-term feeding experiments in rats. Fd. Cosmet. Toxicol. 13: 347-351.

Jearld, A. 1983. Age determination. In L.A. Nielsen and D.L. Johnson (ed.) Fisheries Techniques. Southern Printing Co., Blacksburg, Virginia. pp.301-324.

Johannesen, K. M. and J. W. DePierre, 1978. Measurements of cytochrome P₄₅₀ in the presence of large amounts of contaminating hemoglobin and methemoglobin. Anal. Biochem. 86: 725-32. Johnson et al 1988.

Johnson, D., Jr., A.L. Mehring, Jr., and H.W. Titus. 1960. Tolerance of chickens for barium. Proc. Soc. Exp. Biol. Med. 104: 436-438.

Johnson, L.L., E. Casillas, T.K. Collier, B.B. McCain, and U. Varanasi. 1988. Contaminant effects on ovarian development in English Sole (*Parophrys vetulus*) from Puget Sound, Washington. Can. J. Fish. Aquat. Sci. 45: 2133-2146.

Juma, N.G., and M.A. Tabatabai. 1977. "Effects of trace elements on phosphatase activity in soils." Soil Sci. Soc. Am. J. 41:343-346.

Kabata-Pendias, A., and H. Pendias. 1984. Trace Elements in Soils and Plants. CRC Press, Inc. Boca Raton, Florida.

- Kanisawa, M. and H. A. Schroeder. 1969. Life term studies on the effects of trace elements on spontaneous tumors in mice and rats. *Cancer Res.* 29:892-895.
- Karr, J. R. 1987. Biological monitoring and assessment: A conceptual framework. *Environ. Manage.* 11:249-256.
- Karr, J. R. 1981. Assessment of biotic integrity using fish communities. *Fisheries* 6:21-27.
- Karr, J. R., K. D. Fausch, P. L. Angermeier, P. R. Yant, and I. J. Schlosser. 1986. Assessing biological integrity in running waters: A method and its rationale. Illinois Natural History Survey Special Publication 5. 28 pp.
- Kazantzis, G. 1979. Thallium. pp. 599-612. in L. Friberg (ed). *Handbook on the toxicology of metals*. Elsevier Press, NY. 709 pp.
- Keltjens, W. G. 1990. "Effects of aluminum on growth and nutrient status of Douglas-fir seedlings grown in culture solution." *Tree Physiol.* 6:165-75.
- Kendall, R.J., and P.F. Scanlon. 1981. Effects of chronic lead ingestion on reproductive characteristics of ringed turtle doves *Streptopelia risoria* and on tissue lead concentrations of adults and progeny. *Environ. Poll. Series A*, 26 203-213.
- Ketcheson, M.R., G.P. Barron, and D.H. Cox. 1969. Relationship of maternal dietary zinc during gestation and lactation to development and zinc, iron, and copper content of the postnatal rat. *J. Nutr.* 98:303-311.
- Khalid, B. Y. and J. Tinsley. 1980. Some effects of nickel toxicity on rye grass." *Plant Soil.* 55:139-44.
- Kimball, G. n.d. The effects of lesser known metals and one organic to fathead minnows [*Pimephales promelas*] and *Daphnia magna*. U.S. Environmental Protection Agency, Duluth, MN.
- Kimmel, C.A., L.D. Grant, C.S. Sloan, and B.C. Gladen. 1980. Chronic low-level lead toxicity in the rat. I. Maternal toxicity and perinatal effects. *Toxicol. Appl. Pharmacol.* 56: 28-41.
- Kinnamon, K.E. 1963. Some independent and combined effects of copper, molybdenum, and zinc on the placental transfer of zinc-65 in the rat. *J. Nutr.* 81: 312-320.
- Kirchen, R. V. and W. R. West. 1976. *The Japanese Medaka: Its Care and Development*. Carolina Biological Supply Company, Burlington, North Carolina. 35 pp.
- Klapow, L. A., and R. H. Lewis. 1979. "Analysis of Toxicity Data for California Marine Water Quality Standards." *J. Water Pollut. Control Fed.* 51, 2054-2070.
- Kloke, A. 1979. "Content of arsenic, cadmium, chromium, fluorine, lead, mercury, and nickel in plants grown on contaminated soil." Paper presented at United Nations-ECE Symp. Effects of Air-borne Pollution on Vegetation. Warsaw. Cited in A. Kabata-Pendias and H. Pendias (eds.). 1984. *Trace Elements in Soils and Plants*. CRC Press, Inc. Boca Raton, Florida.

Kokta, C. 1992. "Measuring effects of chemicals in the laboratory: Effect criteria and endpoints." In *Ecotoxicology of Earthworms*. P.W. Greig-Smith et al. (eds). Intercept Ltd., U.K. pp. 55-62.

Krarup, T. 1969. Oocyte destruction and ovarian tumorigenesis after direct application of a chemical carcinogen (9:10-dimethyl-1:2-benzanthracene) to the mouse ovary. *Int. J. Cancer* 4: 61-75.

Krohn, W.B. 1970. Woodcock feeding habits as related to summer field usage in central Maine. *J. Will. Manage.* 34:769-775.

Kroodsma, R.L. 1987. Resource Management Plan for the Oak Ridge Reservation. Volume 24: Threatened and Endangered Animal Species. ORNL/ESH-1/V24, Oak Ridge National Laboratory, Oak Ridge, Tennessee. 24 pgs.

Krumholz, L. A. 1954. An ecological survey of White Oak Creek, 1950-1953. ORO-587, Vol. 1. U.S. Atomic Energy Commission, Division of Technical Information, Oak Ridge, Tenn.

Kszos, L.A., A.J. Stewart, L.F. Wicker, and G.M. Logsdon. 1989. Environmental Sciences Division Toxicology Laboratory Standard Operating Procedures. ORNL/TM-11194. Oak Ridge National Laboratory, Oak Ridge, Tennessee. 134 pp.

Kszos, L.A. , A. J. Stewart and P.A. Taylor. 1992. An evaluation of nickel toxicity to *Ceriodaphniadubia* and *Daphnia magna* in a contaminated stream in laboratory tests. *Environ. Toxicol. Chem.* 11: xxx-xxx(in press).

Labanauskas, C.K. 1966. "Manganese." In *Diagnostic Criteria for Plants and Soils*. Chapman, H.D. (ed.). Univ. of California, Div. Agric. Sci., Riverside.

Lake, J. L., N. I. Rubinstein, H. Lee II, C. A. Lake, J. Heltshe, and S. Pavignano. 1990. "Equilibrium Partitioning and Bioaccumulation of Sediment-Associated Contaminants by Infaunal Organisms." *Environ. Toxicol. Chem.* 9, 1095-1106.

Lam, H.F., M.W. Conner, A.E. Rogers, S. Fitzgerald, and M.O. Amdur. 1985. Functional and morphological changes in the lungs of guinea pigs exposed to freshly generated ultrafine zinc oxide. *Toxicol. Appl. Pharmacol.* 78:29-38.

Lamb, J.C., IV, R.E. Chapin, J. Teague, A.D. Lawton, and J.R. Reel. 1987. Reproductive effects of four phthalic acid esters in the mouse. *Toxicol. Appl. Pharmacol.* 88: 255-269.

Landa, E.R., and S.C. Fang. 1978. "Effect of mercuric chloride on carbon mineralization in soils." *Plant Soil* 49:179-183.

Lane, R. W., B. L. Riddle, and J. F. Borzelleca. 1982. Effects of 1,2-dichloroethane and 1,1,1-trichloroethane in drinking water on reproduction and development in mice. *Toxicol. Appl. Pharmacol.* 63: 409-421.

Larngard, S., and T. Norseth. 1979. Chromium. pp. 383-397. in L. Friberg (ed). *Handbook on the toxicology of metals*. Elsevier Press, NY. 709 pp.

- Larsen, B. F. Pelusio, H. Skejo, and A. Paya-Perez. 1992. "Bioavailability of polychlorinated biphenyl congeners in the soil to earthworm (*L. rubellus*) system." *Intern J Anal Chem* 46:149-162.
- Laskey, J.W., G.L. Rehnberg, J.F. Hein, and S.D. Carter. 1982. Effects of chronic manganese (Mn_3O_4) exposure on selected reproductive parameters in rats. *J. Toxicol. Environ. Health*. 9: 677-687.
- Lata, K. and B. Veer. 1990. "Phytotoxicity of Zn amended soil to *Spinacia* and *Coriandrum*." *Acta Bot. Indica*. 18:194-198.
- Le Bot, J., E. A. Kirkby, and M. L. van Beusichem. 1990. "Manganese toxicity in tomato plants: Effects on cation uptake and distribution." *J. Plant Nutr.* 13(5):513-25.
- Lee, R.M. 1920. A review of the methods of age and growth determination in fishes by means of scales. *Fishery Investigations, Series II, Marine Fisheries Great Britain Ministry of Agriculture and Fisheries and Food*.4(2):1-32.
- Lee, G. F., and A. Jones-Lee. 1993. "Problems in Use of Chemical Concentration-Based Sediment Quality Criteria for Regulating Contaminated Sediment." Preprint of Paper Presented at the *First International Specialized Conference of Contaminated Aquatic Sediments: Historical Records, Environmental Impact, and Remediation*. Milwaukee, Wis., International Association on Water Quality. pp. 439-448.
- Levander, O.A., and L.C. Argrett. 1969. Effects of arsenic, mercury, thallium, and lead on selenium metabolism in rats. *Toxicol. Appl. Pharmacol.* 14: 308-314.
- Lewis, M. A. and L. C. Valentine. 1981. "Acute and chronic toxicities of boric acid to *Daphnia magna* Straus." *Bull. Environ. Contam. Toxicol.* 27:309-315
- Lewis, R.J. and D.V. Sweet, eds. 1984. *Registry of Toxic Effects of Chemical Substances*, Vol. 1. U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, Cincinnati, OH.
- Liang, C.N., and M.A. Tabatabai. 1977. "Effects of trace elements on nitrogen mineralisation in soils." *Environ. Pollut.* 12:141-147.
- Lighthart, B., H. Bond, and M. Ricard. 1977. *Trace Elements Research Using Coniferous Forest Soil/Litter Microcosms*. USEPA-600/3-77-091.
- Lin, Y-W. P., M. S. Greeley, Jr., and Robin A. Wallace. 1989. *Fundulus heteroclitus* gonadotropin(s) 2. Year-round husbandry of animals with active pituitaries and responsive follicles. *Fish Physiol. Biochem.* 6:139-148.
- Linder, R. E., T. B. Gaines, and R. D. Kimbrough. 1974. The effect of PCB on rat reproduction. *Food Cosmet. Toxicol.* 12:63.
- Linzey, A.V. 1987. Effects of chronic polychlorinated biphenyls exposure on reproductive success of white-footed mice (*Peromyscus leucopus*). *Arch. Environ. Contamin. Toxicol.* 16: 455-460.

Linzon, S.N. 1978. Phytotoxically excessive levels for contaminants in soil and vegetation. Report of Ministry of the Environment. Ontario, Canada. Cited in A. Kabata-Pendias and H. Pendias (eds.). 1984. Trace Elements in Soils and Plants. CRC Press, Boca Raton, Florida.

Lloyd, T.B. 1984. Zinc compounds. In: Kirk-Othmer Encyclopedia of Chemical Technology, 3rd ed., H.F. Mark, D.F. Othmer, C.G. Overberger, G.T. Seaborg, eds. John Wiley & Sons, New York. pp. 851-863.

Lo, M.T., and E. Sandi. 1980. Selenium: occurrence in foods and its toxicological significance. A review. J. Environ. Pathol. Toxicol. 4: 193-218.

Loar, J. M. (ed.). 1989. Third annual report on the ORNL Biological Monitoring and Abatement Program, Draft ORNL/TM Report. Oak Ridge National Laboratory, Oak Ridge, Tenn. 436 pp.

Loar, J. M. (ed.). 1990. Fourth annual report on the ORNL Biological Monitoring and Abatement Program, Draft ORNL/TM Report. Oak Ridge National Laboratory, Oak Ridge, Tenn. 371 pp.

Loar J.M. (ed). 1991. Fifth annual report on the ORNL Biological Monitoring and Abatement Program, Draft(ORNL/TM) Report. Oak Ridge National Laboratory, Oak Ridge, Tenn. 398 pp.

Loar, J.M., S.M. Adams, L.J. Allison, B.G. Blaylock, H.L. Boston, M.A. Huston, B.L. Kimmel, J.T. Kitchings, C.R. Olsen, J.G. Smith, G.R. Southworth, A.J. Stewart, and B.T. Walton. 1991. Oak Ridge National Laboratory Biological Monitoring and Abatement Program for White Oak Creek Watershed and the Clinch River. ORNL/TM-10370. Oak Ridge National Laboratory, Oak Ridge, Tenn. 142 pp.

Loar, J. M. (ed.). 1992a. Sixth annual report on the ORNL Biological Monitoring and Abatement Program, Draft ORNL/TM Report. Oak Ridge National Laboratory, Oak Ridge, Tenn.

Loar, J. M. (ed.) 1992b. Second report on the Oak Ridge National Laboratory Biological Monitoring and Abatement Program for White Oak Creek Watershed and the Clinch River. ORNL-TM/10804. Oak Ridge National Laboratory, Oak Ridge, Tenn. 475 pp.

Loar, J. M., S. M. Adams, L. J. Allison, B. G. Blaylock, H. L. Boston, M. A. Huston, B. L. Kimmel, J. T. Kitchings, C. R. Olsen, J. G. Smith, G. R. Southworth, A. J. Stewart, and B. T. Walton. 1991. Oak Ridge National Laboratory Biological Monitoring and Abatement Program for White Oak Creek Watershed and the Clinch River. ORNL/TM-10370. Oak Ridge National Laboratory, Oak Ridge, Tenn. 142 pp.

Long, E. R., and L. G. Morgan. 1991. *The Potential for Biological Effects of Sediment-Sorbed Contaminants Tested in the National Status and Trends Program*. NOAA Technical Memorandum NOS OMA 52. National Oceanic and Atmospheric Administration.

Long, E.R., D.D. MacDonald, S.L. Smith and F.D. Calder. 1994. "Incidence of Adverse Biological Effects within Ranges of Chemical Concentrations in Marine and Estuarine Sediments." *Environmental Management*

- Lowe, T.P., T.W. May, W.G. Brumbaugh, and D.A. Kane. 1985. National Contaminant Biomonitoring Program: Concentrations of seven elements in freshwater fish, 1978-1981. *Arch. Environ. Contam. Toxicol.* 14:363-388.
- Ma, W., W. Denneman, and J. Faber. 1991. Hazardous exposure of ground-living small mammals to cadmium and lead in contaminated terrestrial ecosystems. *Arch. Environ. Contam. Toxicol.* 20: 266-270.
- MacDonald, J. M., J. D. Shields, and R. K. Zimmer-Faust. 1988. Acute toxicities of eleven metals to early life-history stages of the yellow crab (*Cancer anthonyi*). *Mar. Biol.* 98:201-207.
- Mackenzie, R.D., R.U. Byerrum, C.F. Decker, et al. 1958. Chronic toxicity studies, II. Hexavalent and trivalent chromium administered in drinking water to rats. *Am. Med. Assoc. Arch. Ind. Health.* 18:232-234.
- Maita, K., M. Hirano, K. Mitsumori, K. Takahashi, and Y. Shirasu. 1981. Subacute toxicity with zinc sulfate in mice and rats. *J. Pest. Sci.* 6:327-336.
- Maleug, K.W., G.S. Schuytema, J.H. Gakstatter and D.F. Krawczyk. 1984. Toxicity of sediments from three metal-contaminated areas. *Environ. Toxicol. Chem.* 3: 279-291.
- Marks, T.A., T.A. Ledoux, and J.A. Moore. 1982. Teratogenicity of a commercial xylene mixture in the mouse. *J. Toxicol. Environ. Health.* 9: 97-105.
- Marty, G. D., J. M. Núñez, D. J. Lauren, and D. E. Hinton. 1990. Age-dependent changes in toxicity of N-nitros compounds to Japanese medaka (*Oryzias latipes*) embryos. *Aquat. Toxicol.* 17: 45-62.
- Mattison, D. R., K. Shiromizu, and M.S. Nightingale. 1983. Oocyte destruction by polycyclic aromatic hydrocarbons. *Am. J. Ind. Med.* 4: 191-202.
- McCormick, J.H., K.M. Jensen, R.L. Leino, and G.N. Stokes. 1987. Fish blood osmolality, gill histology, and oocyte atresia as early warning acid stress indicators. *Annls. Soc. R. Zool. Belg.* 117 (suppl. 1): 309 - 319.
- McKee, M.J., A.C. Hendricks and R.E. Ebel. 1983. Effects of Naphthalene on Benzo[a]pyrene hydroxylase and cytochrome P-450 in Fundulus heteroclitus. *Aquat. Toxicol.* 3:103-114.
- McLane, M.A.R. and D.L. Hughes. 1980. Reproductive success of screech owls fed Aroclor 1248. *Arch. Environm. Contam. Toxicol.* 9: 661-665.
- McMaster, M.E., G.J. Van Der Kraak, C.B. Portt, K.R. Munkittrick, P.K. Sibley, I.R. Smith, and D.G. Dixon. 1991. Changes in hepatic mixed-function oxygenase (MFO) activity, plasma steroid levels and age at maturity of a white sucker (*Catostomus commersoni*) population exposed to bleached kraft pulp mill effluent. *Aquat. Toxicol.* 21: 199-218.
- Mehring, A.L. Jr., J.H. Brumbaugh, A.J. Sutherland, and H.W. Titus. 1960. The tolerance of growing chickens for dietary copper. *Poult. Sci.* 39: 713-719.

Michibata, H. 1981a. Effect of water hardness on the toxicity of cadmium to the egg of teleost, *Oryzias latipes*. Bull. Environ. Contam. Toxicol. 27: 187-192.

Michibata, H. 1981b. Uptake and distribution of cadmium in the egg of the teleost, *Oryzias latipes*. J. Fish Biol. 19: 691-696.

Michibata, H., Y. Nojima, and M. K. Kojima. 1987. Stage sensitivity of eggs of the teleost *Oryzias latipes* to cadmium exposure. Environ. Res. 42: 321-327.

Michibata, H., S. Sahara, and M. K. Kojima. 1986. Effects of calcium and magnesium ions on the toxicity of cadmium to the egg of the teleost, *Oryzias latipes*. Environ. Res. 40:110-114.

Microbiological Associates. 1986. Subchronic toxicity of methyl isobutyl ketone in Sprague-Dawley rats. Study No. 5221.0. Preliminary report to Research Triangle Institute, Research Triangle Park, NC.

Mid-America Fish Contaminants Group. 1989. Extraction and analysis of acid stable organochlorine pesticides/PCBs in biological tissue. Unpublished mimeo, 6 pp.

Miller, D.E (ed). 1993. *Phase I Remedial Investigation Report of Waste Area Grouping 2 at Oak Ridge National Laboratory, Oak Ridge, Tennessee*. DOE/OR/01-1179&DO; ORNL/ER-176&DO. Oak Ridge National Laboratory.

Miller, D.H. and L.L. Getz. 1977. Factors influencing local distribution and species diversity of forest small mammals in New England. Can. J. Zool. 55:806-814.

Miller, D.L. and M.K. Causey. 1985. Food preferences of American woodcock wintering in Alabama. J. Will. Manage. 49:492-496.

Miller, W.J., H.E. Amos, R.P. Gentry, D.M. Blackman, R.M. Durrance, C.T. Crowe, A.S. Fielding, and M.W. Neathery. 1989. Long-term feeding of high zinc sulfate diets to lactating and gestating dairy cows. J. Dairy Sci. 72:1499-1508.

Missouri Dept. of Conservation. 1989. Fishery Analysis Tools. Conservation Commission of the State of Missouri. Jefferson City, Missouri. 396 pp.

Moore, G.K., 1988. *Concepts of Groundwater Occurrence and Flow Near Oak Ridge National Laboratory, Tennessee*, ORNL/TM-10969, Oak Ridge National Lab.

Moore, J. W. 1991. Inorganic Contaminants of Surface Waters, Research and Monitoring Priorities. Springer-Verlag, NY.

Morrissey, C.M., T.L. Ashwood, D.S. Hicks. 1994. *Active Sites Environmental Monitoring Program FY 1992 Annual Report*. ORNL/M-3183. Oak Ridge National Laboratory.

Mount, D.I. and T.J. Norberg. 1984. A seven-day life cycle cladoceran toxicity test. Environ. Toxicol. Chem. 3:425-435.

Munkittrick, K.R., M.E. McMaster, C.B. Portt, G.J. Van Der Kraak, I.R. Smith, and D.G. Dixon. 1992. Changes in maturity, plasma sex steroid levels, hepatic mixed-function oxygenase

activity, and the presence of external lesions in lake whitefish (*Coregonus clupeaformis*) exposed to bleached kraft mill effluent. Can. J. Fish. Aquat. Sci. 49: 1560-1569.

Nagy, K.A. 1987. Field metabolic rate and food requirement scaling in mammals and birds. Ecol. Monogr. 57: 111-128.

National Academy of Sciences (NAS). 1979. Zinc. U.S. National Acad. Sci., National Res. Council., Subcommittee on Zinc. Univ. Park Press, Baltimore, Md. 471pp.

National Academy of Sciences (NAS). 1980. Mineral Tolerance of Domestic Animals. National Academy Press, Washington, DC.

National Committee for Clinical Laboratory Standards (NCCLS). 1979. NCCLS Approved Standards: ACS-1 Specification for Standard Protein Solution (Bovine Serum Albumin), 2nd ed. National Committee for Clinical Laboratory Standards, Villanova, Pennsylvania.

Nawrot, P.S. and R.E. Staples. 1979. Embryofetal toxicity and teratogenicity of benzene and toluene in the mouse. Teratology. 19: 41A

NCA (National Coffee Association). 1982. 24-month chronic toxicity and oncogenicity study of methylene chloride in rats. Final Report. Hazelton Laboratories, Inc., Vienna VA.

NCI (National Cancer Institute). 1978. Bioassay of Aroclor 1254 for possible carcinogenicity. NCI-GC-TR-38. National Cancer Institute, Bethesda, Md.

NCRP (National Council on Radiation Protection and Measurements). 1991. Effects of ionizing radiation on aquatic organisms. NCRP Report No. 109, National Council on Radiation Protection and Measurements, Bethesda, MD.

Nebeker, A., G. Schuytema, W. Griffis, J. Barbitta, and J. Carey. 1989. "Effect of Sediment Organic Carbon on Survival of *Hyalella Azteca* Exposed to DDT and Endrin." *Environ. Toxicol. Chem.* 8, 705-718.

Neff, J. M. 1978. "Polycyclic Aromatic Hydrocarbons". Applied Science Publisher, Ltd., London, 262.

Neuhauser, E.F., R.C. Loehr, D.L. Milligan, and M.R. Malecki. 1985. "Toxicity of metals to the earthworm *Eisenia fetida*. *Biol. Fertil. Soils* 1:149-152.

Nimmo, D.W., M.H. Dodson, P.H. Davies, J.C. Greene and M.A. Kerr. 1990. Three studies using *Ceriodaphnia* to detect nonpoint sources of metals from mine drainage. Res. J. Water Pollut. Control Fed. 62:7-15.

Norberg-King, T.J., and D.I. Mount. 1986. The validity of effluent and ambient toxicity tests for predicting biological impact, Skeleton Creek, Enid, Oklahoma. U.S. Environmental Protection Agency, Environmental Research Laboratory, Duluth, MN. EPA/600/8-86/002.

Norberg-King, T. J., E. J. Durhan, G. T. Ankley, and E. Robert. 1991. Application of toxicity identification evaluation procedures to the ambient waters of the Colusa basin drain, California. *Environ. Toxicol. Chem.* 10:891-900.

NRC (National Research Council). 1983. Risk Assessment in the Federal Government: Managing the Process. National Academy Press. 191 pp.

Office of Pesticide Programs. 1982. Pesticide assessment guidelines, Subdivision E, Hazard Evaluation: wildlife and aquatic organisms. EPA-540/9-82-024. U.S. Environmental Protection Agency, Washington D.C.

Oh, S.H., H. Nakaue, J.T. Deagen, P.D. Whanger, and G.H. Arscott. 1979. Accumulation and depletion of zinc in chick tissue metallothioneins. *J. Nutr.* 109:1720-1729.

Ohlendorf, H.M., R.L. Hothem, C.M. Bunck, T.W. Aldrich, and J.F. Moore. 1986. Relationships between selenium concentrations and avian reproduction. *Trans. N. Am. Wildl. Nat. Res. Conf.* 51: 330-342.

Ondreicka, R., E. Ginter, and J. Kortus. 1966. Chronic toxicity of aluminum in rats and mice and its effects on phosphorus metabolism. *Brit. J. Indust. Med.* 23: 305-313.

Opresko, D.M., B.E. Sample, and G.W. Suter, III. 1994. Toxicological benchmarks for wildlife. ES/ER/TM-6/R1. Oak Ridge National Laboratory, Oak Ridge, TN.

Overcash, M.R., J.B. Weber, and M.L. Miles. 1982. Behavior of Organic Priority Pollutants in the Terrestrial System: Di-n-butyl Phthalate Ester, Toluene, and 2,4 Dinitrophenol. UNC-WRRI-82-171. Raleigh, NC.

Palafox, A.L., and E. Ho-A. 1980. Effect of zinc toxicity in laying white leghorn pullets and hens. *Poultry Sci.* 59:2024-2028.

Palmer, A.K., A.E. Street, F.J.C. Roe, A.N. Worden, and N.J. Van Abbe. 1979. Safety evaluation of toothpaste containing chloroform, II. Long term studies in rats. *J. Environ. Pathol. Toxicol.* 2: 821-833.

Patel, P. M., and A. Wallace, and R. T. Mueller. 1976. "Some effects of copper, cobalt, cadmium, zinc, nickel, and chromium on growth and mineral element concentration in chrysanthemum." *J. Am. Soc. Hortic. Sci.* 101(5):553-556.

Pattee, O.H. 1984. Eggshell thickness and reproduction in American kestrels exposed to chronic dietary lead. *Arch Environ. Contam. Toxicol.* 13: 29-34.

Pattee, O.H., S.N. Wiemeyer, and D.M. Swineford. 1988. Effects of dietary fluoride on reproduction in eastern Screech-Owls. *Arch. Environ. Contam. Toxicol.* 17:213-218.

Pavlou, S. P. 1987. "The Use of the Equilibrium Partitioning Approach in Determining Safe Levels of Contaminants in Marine Sediments." pp. 388-412 in *Fate and Effects of Sediment-Bound Chemicals in Aquatic Systems*. Proceedings of the Sixth Pellston Workshop, 13-17 August 1984, Florissant, Co. Dickson, K. L., A. W. Maki, and W. A. Brungs (eds.). Pergamon Press. Toronto, Ontario.

Payne J. F. and W. R. Penrose. 1975. Induction of aryl hydrocarbon benzo(a)pyrene hydroxylase in fish by petroleum. *Bull. Environ. Contam. Toxicol.* 14: 112-116.

Peakall, D.B. 1974. Effects of Di-N-butylphthalate and Di-2-ethylhexylphthalate on the eggs of ring doves. *Bull. Environ. Contam. Toxicol.* 12: 698-702.

Perry, H.M., E.F. Perry, M.N. Erlanger, and S.J. Kopp. 1983. Cardiovascular effects of chronic barium ingestion. In: *Proc. 17th Ann. Conf. Trace Substances in Environ. Health*, vol. 17. U. of Missouri Press, Columbia, MO.

Persaud, D., R. Jaagumagi, and A. Hayton. October 1990. *The Provincial Sediment Quality Guidelines*. Ontario Ministry of the Environment.

Peterson, M.J., R.B. Petrie, and G.R. Southworth. 1994. Bioaccumulation Studies. IN Ashwood, T.L. (ed.), *Eighth Annual Report On the ORNL Biological Monitoring and Abatement Program*. Draft ORNL/TM-12767. Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Plafkin, J.L., M.T. Barbour, K.D. Porter, S.K. Gross, and R.M. Hughes. 1989. Rapid bioassessment protocols for use in streams and rivers: benthic macroinvertebrates and fish. EPA/440/4-89/001. U.S. Environmental Protection Agency, Washington, D.C.

Platonow, N.S. and L.H. Karstad. 1973. Dietary effects of polychlorinated biphenyls on mink. *Can. J. Comp. Med.* 37:391-400.

Platonow, N.S. and B.S. Reinhart. 1973. The effects of polychlorinated biphenyls (Aroclor 1254) on chicken egg production, fertility and hatchability. *Can. J. Comp. Med.* 37: 341-346.

Prasad, A.S. 1979. Clinical, biochemical, and pharmacological role of zinc. *Ann. Rev. Pharmacol. Toxicol.* 20:393-426.

Prasad, P.V.D. 1984. Effect of magnesium, strontium, and barium on the calcification of the freshwater green alga *Goeotaenium*. *PHYKOS* 23:202-206.

Premi, P.R., and A.H. Cornfield. 1969. "Effects of addition of copper, manganese, zinc and chromium compounds on ammonification and nitrification during incubation of soil." *Plant Soil* 31(2):345-352.

Premi, P.R., and A.H. Cornfield. 1969/1970. "Effects of copper, zinc and chromium on immobilization and subsequent re-mobilization of nitrogen during incubation of soil treated with sucrose." *Geoderma* 3:233-237.

Preston, A.M., R.P. Dowdy, M.A. Preston, and J.N. Freeman. 1976. Effect of dietary chromium on glucose tolerance and serum cholesterol in guinea pig. *J. Nutr.* 106: 1391-1397.

Railsback, S. F., B. D. Holcomb, and M. G. Ryon. 1989. A computer program for estimating fish population sizes and annual production rates. ORNL/TM-11061. Oak Ridge National Laboratory, Oak Ridge, Tenn. 62 pp.

Reece, R.L., D.B. Dickson, and P.J. Bunowes. 1986. Zinc toxicity (new wire disease) in aviary birds. *Australian Vet. J.* 63:199.

Reinecke, A.J. 1992. "A review of ecotoxicological test methods using earthworms." In *Ecotoxicology of Earthworms*. P.W. Greig-Smith et al. (eds). Intercept Ltd., U.K. pp. 7-19.

Renes, L. E. 1953. Antimony poisoning in industry. *Arch. Ind. Hyg.* 7:99-108.

Ringer, R. K., R. J. Aulerich, and M. R. Bleavins. 1981. Biological effects of PCBs and PBBs on mink and ferrets: a review. In: M.A.Q. Khan, ed. *Halogenated hydrocarbons: health and ecological effects*. Permagon Press, Elmsford, N.Y. pp. 329-343. (Cited in ATSDR 1989)

Risk Assessment Forum. 1992. Framework for ecological risk assessment. EPA/630/R-92/001. U.S. Environmental Protection Agency, Washington, D.C.

Roberson, R.H., and P.J. Schaible. 1960. The tolerance of growing chicks for high levels of different forms of zinc. *Poult. Sci.* 39: 893-896.

Robison, H. W., and T. M. Buchanan. 1988. *Fishes of Arkansas*. The University of Arkansas Press, Fayetteville, Arkansas. 536 pp.

Roche Diagnostic Systems. 1986. Reagent for total protein. Roche Diagnostic Systems Information Package, Item 44903 & 44313. Nutley, New Jersey.

Rogers, J.E., and S.W. Li. 1985. "Effect of metals and other inorganic ions on soil microbial activity: Soil dehydrogenase assay as a simple toxicity test." *Bull. Environ. Contam. Toxicol.* 34:858-865.

Rogers J. G., K. L. Daniels, S. T. Goodpasture, C. W. Kimbrough, and N. L. Prince. 1989. Oak Ridge Reservation environmental report for 1988. ES/ESH-8/V1. Environmental and Safety Activities, Martin Marietta Energy Systems, Inc., Oak Ridge, Tenn. 304 pp.

Rosensteel, B.A. 1992. "Wetland Delineation Flagged Boundary - WAG 5." Internal correspondence from Barbara A. Rosensteel, MMES, Environmental Sciences Division, to Butch Will, MMES, Environmental Restoration Division. April 27, 1992.

Rosensteel, B.A. 1992. "Preliminary Wetlands Investigation - WAG 5 Remedial Investigation". Internal Correspondence from Barbara A. Rosensteel, MMES, Environmental Sciences Division, to Tom L. Ashwood, MMES, Environmental Sciences Division. March 9, 1992.

Ruby, S.M., D.R. Idler, and Y.P. So. 1993. Plasma vitellogenin, 17β -estradiol, T_3 and T_4 levels in sexually maturing rainbow trout *Oncorhynchus mykiss* following sublethal HCN exposure. *Aquat. Toxicol.* 26: 91-102.

Ruby, S.M., P. Jaroslowski and R.N. Hull. 1993. Lead and Cyanide Toxicity in Sexually Maturing Rainbow Trout, *Oncorhynchus mykiss* during Spermatogenesis. *Aquatic Toxicology* 26: 225-238.

Ryon, M. G. 1989. *Fishes*. IN J. M. Loar (ed.), Third Report on the Oak Ridge National Laboratory Biological Monitoring and Abatement Program for White Oak Creek Watershed and the Clinch River. Draft ORNL/TM-11358. Oak Ridge National Laboratory, Oak Ridge, Tenn. 436 pp.

Ryon, M. G. 1992a. Fishes. IN J. M. Loar (ed.), First Annual Report on the Biological Monitoring and Abatement Program at Oak Ridge National Laboratory. ORNL/TM-10399. Oak Ridge National Laboratory, Oak Ridge, Tenn. 354 pp.

Ryon, M. G. 1992b. Fishes. IN J. M. Loar (ed.), Second Report on the Oak Ridge National Laboratory Biological Monitoring and Abatement Program for White Oak Creek Watershed and the Clinch River. ORNL/TM-10804. Oak Ridge National Laboratory, Oak Ridge, Tenn. 475 pp.

Ryon, M. G., and J. M. Loar. 1988. A checklist of fishes on the Department of Energy Oak Ridge Reservation. J. Tenn. Acad. Sci. 58(4):97-102.

Ryon, M. G., and E. M. Schilling. 1990. IN J. M. Loar (ed.), Fourth Report on the Oak Ridge National Laboratory Biological Monitoring and Abatement Program for White Oak Creek Watershed and the Clinch River. Draft ORNL/TM-11544. Oak Ridge National Laboratory, Oak Ridge, Tenn. 371 pp.

Ryon, M. G., and E. M. Schilling. 1991. Fishes. IN J. M. Loar (ed.), Fifth Report on the Oak Ridge National Laboratory Biological Monitoring and Abatement Program for White Oak Creek Watershed and the Clinch River. Draft ORNL/TM-12143. Oak Ridge National Laboratory, Oak Ridge, Tenn. 398 pp.

SAS Institute, Inc. 1985a. SAS User's Guide:Basics, Version 5 Edition. SAS Institute, Inc., Cary, North Carolina. 1290 pp.

SAS Institute, Inc. 1985b. Sas User's Guide:Statistics, Version 5 Edition. SAS Institute, Inc., Cary, North Carolina. 956 pp.

Shacklette, H.T., and J.G. Boerngen. 1984. *Element Concentrations in Soils and Other Surficial Materials of the Coterminous United States*. USGS Prof. Paper 1270. U.S. Govt Printing Office, Washington.

Schilling, E. M. 1993a. IN T. L. Ashwood (ed.), Seventh Report on the Oak Ridge National Laboratory Biological Monitoring and Abatement Program for White Oak Creek Watershed and the Clinch River. Draft ORNL/TM. Oak Ridge National Laboratory, Oak Ridge, Tenn. 417 pp.

Schilling E.M., 1993b. *Fishes - Subtask 4cIn: Biological Monitoring and Abatement Program at Oak Ridge National Laboratory* . Ashwood (ed.) 1993. DRAFT. Environmental Sciences Division. ORNL-TM.

Schilling, E.M. 1994. Fish Community Studies. IN Ashwood,T.L. (ed.) , Eighth Annual Report On theORNL Biological Monitoring and Abatement Program. Draft ORNL/TM-12767. Oak Ridge National Laboratory, OakRidge, Tennessee.

Schilling, E. M., and M. G. Ryon. 1992. IN J. M. Loar (ed.), Sixth Report on the Oak Ridge National Laboratory Biological Monitoring and Abatement Program for White Oak Creek Watershed and the Clinch River. Draft ORNL/TM-12083. Oak Ridge National Laboratory, Oak Ridge, Tenn. 408 pp.

- Schlesinger, W.H. and G.L. Potter. 1974. Lead, copper, and cadmium concentrations in small mammals in the Hubbard Brook experimental forest. *Oikos*. 25: 148-152.
- Schlicker, S.A., and D.H. Cox. 1967. Maternal dietary Zn in excess, fetal development, and Fe and Cu metabolism. (Abstract). *Fed. Amer. Proc.* 26:520.
- Schlicker, S.A. and D.H. Cox. 1968. Maternal dietary zinc, and development and zinc, iron, and copper content of the rat fetus. *J. Nutr.* 95: 287-294.
- Schreiweis, D. O. and G. J. Murray. 1976. Cardiovascular malformations in *Oryzias latipes* embryos treated with 2,4,5-trichlorophenoxyacetic acid (2,4,5-T). *Teratology*. 14:287-290.
- Schroeder, H. A., J. J. Balassa, and W. H. Vinton, Jr. 1965. Chromium, cadmium and lead in rats: effects on life span, tumors and tissue levels. *J. Nutr.* 86:51-66.
- Schroeder, H.A., M. Kanisawa, D.V. Frost, and M. Mitchener. 1968a. Germanium, tin, and arsenic in rats: effects on growth, survival and tissue levels. *J. Nutr.* 96: 37-45.
- Schroeder, H.A., M. Mitchener, J.J. Balassa, M. Kanisawa, and A.P. Nason. 1968b. Zirconium, niobium, antimony, and fluorine in mice: effects on growth, survival and tissue levels. *J. Nutr.* 95: 95-101.
- Schroeder, H.A and M. Mitchener. 1971. Toxic effects of trace elements on the reproduction of mice and rats. *Arch. Environ. Health*. 23: 102-106.
- Schroeder, H. A., and M. Mitchener. 1972. Selenium and Tellurium in mice. *Arch. Environ. Health* 24:66-71.
- Schroeder, H.A and M. Mitchener. 1975a. Life-term studies in rats: effects of aluminum, barium, beryllium, and tungsten. *J. Nutr.* 105: 421-427.
- Schroeder, H. and M. Mitchener. 1975b. Life-term effects of mercury, methyl mercury and nine other trace metals on mice. *J. Nutr.* 105: 452-458.
- Shacklette, H.T., and J.G. Boerngen. 1984. "Element concentrations in soils and other surficial materials of the conterminous United States" U.S. Geological Survey Professional Paper No. 1270. 105 pp.
- Shaw, P.A. 1933. Toxicity and deposition of thallium in certain game birds. *J. Pharmacol. Exp. Ther.* 48: 478-487.
- Sheldon, W.G. 1971. The book of the American woodcock. The University of Massachusetts Press, Amherst, MA. 227 pp.
- Shi, M. and E. M. Faustman. 1989. Development and characterization of a morphological scoring system for medaka (*Oryzias latipes*) embryo culture. *Aquat. Toxicol.* 15: 127-140.
- Shul'man, G.E. 1974. Life cycles of fish. Physiology and biochemistry. John Wiley and Sons, New York. 258 pp.

- Singh, S., and T.P. Singh. 1987. Evaluation of toxicity limit and sex hormone production in response to cythion and BHC in the vitellogenic catfish *Clarias batrachus*. Environ. Res. 42: 482-488.
- Sivarajah, K., C.S. Franklin and P. Williams. 1978. The effects of polychlorinated biphenyls on plasma steroid levels and hepatic microsomal enzymes in fish. J. Fish Biol. 13: 401-409.
- Skadsen, J.M., P.W. Webb, and P.T. Lpstecki. 1980. Measurement of sublethal metabolic stress in rainbow trout (*Salmo gairdneri*) using automated respirometry. J. Environ. Sci. Health, Part B. Pesticides. Food contaminants and agricultural wastes 15:193-206.
- Sleight, S.D. and O.A. Atallah. 1968. Reproduction in the guinea pig as affected by chronic administration of potassium nitrate and potassium nitrite. Toxicol. Appl. Pharmacol. 12: 179-185.
- Slooff, W., and J. H. Canton. 1983. Comparison of the susceptibility of 11 freshwater species to 8 chemical compounds. II:(Semi)chronic toxicity tests. Aquat. Toxicol. 4:271-282.
- Slooff, W., J. H. Canton, and J. L. M. Hermens. 1983. Comparison of the susceptibility of 22 freshwater species to 15 chemical compounds. I:(sub) acute toxicity tests. Aquat. Toxicol. 4:113-128.
- Smith, J. G. 1992. Biological Monitoring and Abatement Program (BMAP) Benthic Macroinvertebrate Monitoring Project Sample Collection and Storage QA Plan. QAP-X-90-ES-068. Oak Ridge National Laboratory, Oak Ridge, Tennessee.
- Smith, S. P.J. Peterson, and K.H.M. Kwan. 1989. "Chromium accumulation, transport and toxicity in plants." Toxicol Environ Chem 24:241-251.
- Smyth, H.F., Jr. and W. L. Thompson. 1945. The single dose and subacute-toxicity of antimony oxide (Sb_2O_3). Mellon Inst. of Indust. Res., Univ. of Pittsburgh. OTS206062.
- Sokal R. R., and F. J. Rohlf. 1981. Biometry. W. H. Freeman and Company, San Francisco, CA.
- Solomon, H. M. 1977a. Teratogenic effects of carbaryl, malathion and parathion on developing medaka eggs. Abstract Only. Bull. N.J. Acad. Sci. 22(2):46-47.
- Solomon, H. M. 1977b. Teratogenic effects of carbaryl, malathion and parathion on developing eggs of medaka (*Oryzias latipes*). Abstract only. Animals as Monitors of Environmental Pollutants: Symposium on Pathobiology of Environmental Pollutants. University of Conn., 1977. Natl. Academy of Sci., Washington, D.C. 393 pp.
- Solomon, F. P. and E. M. Faustman. 1987. Developmental toxicity of four model alkylating agents on Japanese medaka fish (*Oryzias latipes*) embryos. Environ. Toxicol. and Chem. 6: 747-754.
- Solomon, D.K. et al., 1989. *The Transport of Contaminants During Storms in the White Oak Creek and Melton Branch Watersheds*. ORNL/RAP/LTR-89/8, Oak Ridge National Lab.

Soltanpour, P.N., and S.M. Workman. 1980. "Use of NH_4HCO_3 -DTPA soil test to assess availability and toxicity of selenium to alfalfa plants." *Commun. Soil Sci. Plant Anal.* 11(12):1147-1156.

Southworth, J.R., R.L. Hinzman, and J.G. Smith. 1994. Benthic Macroinvertebrates. IN Ashwood, T.L. (ed.) , Eighth Annual Report On the ORNL Biological Monitoring and Abatement Program. Draft ORNL/TM-12767. Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Spann, J.W., G.H. Heinz, and C.S. Hulse. 1986. Reproduction and health in mallards fed endrin. *Environ. Toxicol. Chem.* 5: 755-759.

Sperry, C.C. 1940. Food habits of a group of shorebirds: woodcock, snipe knot, and dowitcher. *Wildlife Research Bulletin* 1. U.S. Government Printing Office, Washington.

Spurgeon, D.J., S.P. Hopkin, and D.T. Jones. 1994. "Effects of cadmium, copper, lead and zinc on growth, reproduction and survival of the earthworm *Eisenia fetida* (Savigny): Assessing the environmental impact of point-source metal contamination in terrestrial ecosystems." *Environ. Pollut.* 84:123-130.

Stahl, J.L., M.E. Cook, M.L. Sunde, and J.L. Greger. 1989. Enhanced humoral immunity in progeny chicks fed practical diets supplemented with zinc. *Appl. Agric. Res.* 4:86-89.

Stahl, J.L., J.L. Greger, and M.E. Cook. 1990. Breeding-hen and progeny performance when hens are fed excessive dietary zinc. *Poultry Sci.* 69:259-263.

Stegeman J. J., Binder R. L. and Orren A. 1979. Hepatic and extrahepatic microsomal electron transport components and mixed function oxygenases in the marine fish Stenotomus versicolor.

Stenersen, J. 1992. "Uptake and metabolism of xenobiotics by earthworms." In . P.W. Greig-Smith et al. (eds). Intercept Ltd., U.K. pp. 129-138.

Steven, J.D., L.J. Davies, E.K. Stanley, R.A. Abbott, M. Ihnat, L. Bidstrup, and J.F. Jaworski. 1976. Effects of chromium in the Canadian environment. NRCC No. 151017. 168 pp.

Stewart, A.J., L.A. Kszos, B.C. Harvey, L.F. Wicker, G.J. Haynes and R.D. Bailey. 1990. Ambient toxicity dynamics: assessments using *Ceriodaphnia dubia* and fathead minnow (*Pimephales promelas*) larvae in short-term tests. *Environ. Toxicol. Chem.* 9: 367-379.

Stewart, A.J. and L.A. Kszos. 1991. In: Loar, J.M. (ed.) Fifth annual report on the ORNL Biological Monitoring and Abatement Program. ORNL/TM-XXXX. Oak Ridge National Laboratory, Oak Ridge, TN.

Stickel, L.F., W.H. Stickel, R.A. Dyrlund, and D.L. Hughes. 1983. Oxychlordan, HCS-3260, and nonachlor in birds: lethal residues and loss rates. *J. Toxicol. Environ. Health.* 12: 611-622.

Stokinger, H.E. 1981a. Zinc. In: Patty's Industrial Hygiene and Toxicology, 3rd rev. ed., vol. 2A. G.D. Clayton and E. Clayton, eds., John Wiley and Sons, New York. pp. 2033-2049.

- Stokinger, H.E. 1981b. Vanadium. In: G.D. Clayton and E. Clayton, eds. *Patty's Industrial Hygiene and Toxicology*, 3rd rev. ed., vol. 2A. John Wiley and Sons, New York. pp. 2013-2033.
- Stoss, F. W. and T. A. Haines. 1979. The effects of toluene on embryos and fry of the Japanese medaka *Oryzias latipes* with a proposal for rapid determination of maximum acceptable concentrations. *Environ. Pollut.* 20: 139-148.
- Straube, E.F., N.H. Schuster, and A.J. Sinclair. 1980. Zinc toxicity in the ferret. *J. Comparative Pathol.* 90:355-361.
- Strek, H.J., and J.B. Weber. 1980. "Absorption and translocation of polychlorinated biphenyls (PCBs) by weeds." *Proc South Weed Sci Soc* 33:226-232.
- Stribling, H.L. and P.D. Doerr. 1985. Nocturnal use of fields by American woodcock. *J. Will. Manage.* 49:485-491.
- Suter, G.W., II, A.E. Rosen, E. Linder, and D.F. Parkhurst. 1987. Endpoints for responses of fish to chronic toxic endpoints. *Environ. Toxicol. Chem.* 6: 793-809.
- Suter, G.W., II. 1989. Ecological endpoints. pp. 2-1 to 2-28. In: Warren-Hicks, W., B.R. Parkhurst, and S.S. Baker, Jr.(eds.). *Ecological assessment of hazardous waste sites: a field and laboratory reference document*. EPA/600/3-89/013. U.S. Environmental Protection Agency, Washington, D.C.
- Suter, G. W. II, A. Redfearn, R. K. White, and R. A. Shaw. 1992a. Approach and strategy for performing ecological risk assessments for the Department of Energy Oak Ridge Field Office Environmental Restoration Program. ES/ER/TM-33. Oak Ridge National Laboratory, Oak Ridge, TN.
- Suter, G. W., II, M. A. Futrell, and G. A. Kerchner. 1992b. *Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Aquatic Biota*. ORNL/ER-139, Oak Ridge National Laboratory, Oak Ridge, Tenn.
- Suter, G. W., II and J. B Mabrey. 1994. *Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Aquatic Biota: 1994 Revision*. ORNL/ER-139/R1, Oak Ridge National Laboratory, Oak Ridge, Tenn.
- Suter, G.W, B.E. Sample, D.S. Jones, and T.L. Ashwood. 1994. Approach and Strategy for Performing Ecological Risk Assessments for the U.S. Department of Energy's Oak Ridge Reservation: 1994 Revision. ES/ER/TM-33/R1. Oak Ridge National Laboratory. Oak Ridge, Tennessee.
- Sutton, W.R., and V.E. Nelson. 1937. Studies on zinc. *Proc. Soc. Exp. Biol. Med.* 36:211-213.
- Sunagawa, S. 1981. Experimental studies on antimony poisoning. *Igaku Kenkyu* 51:129-142.
- Takizawa, K., H. Yagi, D.M. Jerina and D.R. Mattison. 1984. Murine starin differences in ovotoxicity following intraovarian injection with benzo(α)pyrene, (+)-(7R, 8S)-oxide, (-)-(7R,8R)-dihydodiols, or (+)-(7R,8S)-diol-(9S,10R)-epoxide-2. *Canc. Res.* 44: 2571-2576.

- Talmage, S. S., and B. T. Walton. 1991. Small mammals as monitors of environmental contaminants. *Rev. Environ. Contam. Toxicol.* 119:47-145.
- Talmage, S.S. and B.T. Walton. 1993. Food chain transfer and potential renal toxicity to small mammals at a contaminated terrestrial field site. *Ecotoxicol.* 2: 243-256
- Taylor, F.G., Jr., and P.D. Parr. 1978. Distribution of chromium in vegetation and small mammals adjacent to cooling towers. *J. Tenn. Acad. Sci.* 53: 87-91.
- Tewe, O.O. and J.H. Maner. 1981. Long-term and carry-over effect of dietary inorganic cyanide (KCN) in the life cycle performance and metabolism of rats. *Toxicol. Appl. Pharmacol.* 58: 1-7.
- Thomas, P. 1990. Teleost model for studying the effects of chemicals on female reproductive endocrine function. *J. Exp. Zool. Suppl.* 4: 126-128.
- Tietz, N.W. 1986. Textbook of Clinical Chemistry. W.b. Saunders, Co., Philadelphia, Pennsylvania. 1919 pp.
- Tiffany, T.O., Jansen, J.M., Burtis, C.A., Overton, J.B., and Scott, C.D. 1972. *Clin. Chem.* 18:829.
- Train, R. W. 1979. Quality criteria for water. Castle House Publications.
- Travis, C. C., F. O. Hoffman, B. G. Blaylock, K. L. Daniels, C. S. Gist, and C. W. Weber. 1986. Preliminary review of TVA fish sampling and analysis report. Report of Task Group Five to Oak Ridge Task Force. Mimeo. 14 pp.
- Trelease, S.F., A.A. Di Somma, and A.L. Jacobs. 1960. "Seleno-amino acid found in *Astragalus bisulcatus*." *Science* 132:618.
- TVA (Tennessee Valley Authority). 1986. Instream contaminant study, Task 5:Summary Report. Report to U.S. Department of Energy, Oak Ridge Operations Office. Tennessee Valley Authority, Office of Natural Resources and Economic Development, Knoxville, Tennessee. 232 pp.
- TVA (Tennessee Valley Authority). 1985. Instream contaminant study, Task 4:Fish sampling and analysis. Report to U.S. Department of Energy, Oak Ridge Operations Office. Tennessee Valley Authority, Office of Natural Resources and Economic Development, Knoxville, Tennessee.
- TWRC. 1990. Wildlife in need of management, Tennessee Wildlife Resources Commission Proclamation No. 86-29 as amended by Proc. No. 90-2, dated 2-1-90, Nashville, Tennessee.
- Truscott et al 1983.
- U.S. Environmental Research Laboratory. 1991. Methods for Aquatic Toxicology Identification Evaluations. Phase 1. Toxicity Characterization Procedures, 2nd Ed. U.S. Department of Commerce, National Technical Information Service.

U.S. Fish and Wildlife Service. 1964. Pesticide-wildlife studies, 1963:a review of Fish and Wildlife Service investigations during the calendar year. FWS Circular 199.

van Faassen, H.G. 1973. "Effects of mercury compounds on soil microbes." *Plant Soil* 38:485-487.

van Gestel, C.A.M. 1992. "The influence of soil characteristics on the toxicity of chemicals for earthworms: A review." In *Ecotoxicology of Earthworms*. P.W. Greig-Smith et al. (eds). Intercept Ltd. pp 44-54.

van Gestel, C.A.M., E.M. Dirven-van Breemen, and R. Baerselman. 1993. "Accumulation and elimination of cadmium, chromium and zinc and effects on growth and reproduction in *Eisenia andrei* (Oligochaeta, Annelida)." *Sci. Total Environ. Suppl.*: 585-597.

van Hook, R.I. 1974. "Cadmium, lead, and zinc distributions between earthworms and soils: Potentials for biological accumulation." *Bull. Environ. Contam. Toxicol.* 12(4):509-512.

van Velsen, F.L., L.H.J.C. Danse, F.X.R. Van Leeuwen, J.A.M.A. Dormans, and M.J. Van Logten. 1986. "The subchronic oral toxicity of the beta-isomer of hexachlorocyclohexane in rats." *Fund. Appl. Toxicol.* 6: 697-712.

van Zyll de Jong, C.G. 1983. Handbook of Canadian Mammals. National Museums of Canada.

Vaughan, D.S., and W. Van Winkle. 1982. Corrected analysis of the ability to detect reductions in year-class strength of the Hudson River white perch (*Morone americana*) population. *Can. J. Fish Aquat. Sci.* 39: 782-785.

Venugopal, B., and T. D. Luckey. 1978. Metal toxicity in mammals: vol. 2. Chemical toxicity of metals and metalloids. Plenum press, New York. 409pp.

Verschuuren, H.G., R. Kroes, E.M. Den Tonkelaar, J.M. Berkvens, P.W. Helleman, A.G. Rauws, P.L. Schuller, G.J. Van Esch. 1976a. Toxicity of methylmercury in rats I. short-term study. *Toxicology* 6: 85-96.

Verschuuren, H.G., R. Kroes, E.M. Den Tonkelaar, J.M. Berkvens, P.W. Helleman, A.G. Rauws, P.L. Schuller, G.J. Van Esch. 1976b. Toxicity of methylmercury in rats II. long-term toxicity study. *Toxicology* 6: 107-123.

Verschuuren, H.G., R. Kroes, E.M. Den Tonkelaar, J.M. Berkvens, P.W. Helleman, A.G. Rauws, P.L. Schuller, and G.J. Van Esch. 1976. Toxicity of methyl mercury chloride in rats. II. Reproduction study. *Toxicol.* 6: 97-106.

Vohra, P., and F.H. Kratzer. 1968. Zinc, copper and manganese toxicities in turkey poults and their alleviation by EDTA. *Poult. Sci.* 47: 699-704

Vos, J.G., H.L. Van Der Maas, A.Musch, and E. Ram. 1971. Toxicity of hexachlorobenzene in Japanese quail with special reference to porphyria, liver damage, reproduction, and tissue residues. *Toxicol. Appl. Pharmacol.* 18: 944-957.

WADOE (Washington State Department of Ecology). 1991. Summary of Criteria and

Guidelines for Contaminated Freshwater Sediments, Sediment Management Unit. Olympia, Wash. September.

Wagner, K.H., and E. Wagner-Hering. 1971. "The cycle of cancer-causing substances -- polycyclic aromatic hydrocarbons -- in plants and humans." *Protectio Vitae* 6:260. Cited in

Wallace, A. 1979. "Excess trace metal effects on calcium distribution in plants." *Commun. Soil Sci. Plant Anal.* 10:473-79.

Wallace, A., and R.M. Romney. 1971. "Some interactions of Ca, Sr, and Ba in plants." *Agronomy J.* 63:245-248.

Wallace, R. A., and K. Selman. 1981. Cellular and dynamic aspects of oocyte growth in teleosts. *Am. Zool.* 21: 325-344.

Wallace, A., R.T. Mueller, and R.A. Wood. 1980. "Selenate toxicity effects on bush beans grown in solution culture." *J. Plant Nutr.* 2(1&2):107-109.

Wallace, A., G. V. Alexander, and F. M. Chaudhry. 1977a. "Phytotoxicity of cobalt, vanadium, titanium, silver, and chromium." *Commun. Soil Sci. Plant Anal.* 8(9):751-56.

Wallace, A., G. V. Alexander, and F. M. Chaudhry. 1977b. "Phytotoxicity and some interactions of the essential trace metals iron, manganese, molybdenum, zinc, copper, and boron." *Commun. SoilSci. Plant Anal.* 8(9):741-50.

Walters, M., and F.J.C. Roe. 1965. A study of the effects of zinc and tin administered orally to mice over a prolonged period. *Food Cosmet. Toxicol.* 3:271-276.

Walton, B.T., T.A. Anderson, D.J. Deckert, and M.S. Jen. 1992. "Trichloroethylene in soil: plant uptake, toxicity, and biodegradation in the rhizosphere." *Abst. Soc Toxicology* 12(1):336.

Wan H.F., R.L. Mikkelsen, and A.L. Page. 1988. "Selenium uptake by some agricultural crops from central California soils." *J. Environ. Qual.* 17(2):269-272.

Wang, W. 1988. Site-specific barium toxicity to common duckweed, *Lemna minor*. *Aquat. Toxicol.* 12:203-212.

Ware, G.W. 1978. The pesticide book. W.H. Freeman and Co. San Francisco, CA. 197 pp.

Waterman, A. J. 1939. Effects of 2,4-dinitrophenol on the early development of the teleost, *Oryzias latipes*. *Biol. Bull.* 76: 162-170.

Watters, R.L., D.N. Edgington, T.E. Hakonson, W.C. Hanson, M.H. Smith, F.W. Whicker, and R.E. Wildung. 1980. Synthesis of the Research Literature. *In: Transuranic elements in the environment*. U.S. Department of Energy.

Weber, C. I. (ed.). 1973. Biological field and laboratory methods for measuring the quality of surface waters and effluents. EPA 670/4-73-001. National Environmental Research Center, U.S. Environmental Protection Agency, Cincinnati, Ohio.

- Weber, C. I., W. H. Peltier, T. J. Norberg-King, W. B. Horning II, F. A. Kessler, J. R. Menkedick, T. W. Neiheisel, P. A. Lewis, D. J. Klemm, Q. H. Pickering, E. L. Robinson, J. M. Lazorchak, L. J. Wymer and R. W. Freyberg. 1989. Short-term methods for estimating the chronic toxicity of effluents and receiving waters to freshwater organisms, 2nd ed. EPA 600/4-89-001. U.S. Environmental Protection Agency, Cincinnati, Ohio.
- Weigel, H. J., H. J. Jager, and I. Elmadfa. 1984. Cadmium accumulation in rat organs after extended oral administration with low concentrations of cadmium oxide. *Arch. Environ. Contam. Toxicol.* 13:279-287.
- Weigel, H. J., D. Ilge, I. Elmadfa, and H. J. Jaeger. 1987. Availability and toxicological effects of low levels of biologically bound cadmium. *Arch. Environ. Contam. Toxicol.* 16(1):85-93.
- Westmoreland, N., and W.G. Hoekstra. 1969. Pathological defects in the epiphyseal cartilage of zinc-deficient chicks. *J. Nutr.* 98:76-82.
- Whanger, P. D. 1973. Effect of dietary cadmium on intracellular distribution of hepatic iron in rats. *Res. Commun. Chem. Pathol. Pharmacol.* 5:733-740.
- Wheeler, D. M. and J. M. Follet. 1991. "Effect of aluminum on onions, asparagus and squash." *J. Plant Nutr.* 14(9):897-912.
- WHO (World Health Organization). 1984. Chlordane. *Environ. Health Criter.* 34. 82 pp.
- Will, M.E. and G.W. Suter, II. 1994a. *Toxicological benchmarks for screening potential contaminants of concern for effects on terrestrial plants*. ES/ER/TM-85R. Oak Ridge National Laboratory, Environmental Science Division.
- Will, M.E. and G.W. Suter, II. 1994b. *Toxicological benchmarks for screening potential contaminants of concern for effects on soil and litter invertebrates*. ES/ER/TM-? Oak Ridge National Laboratory, Environmental Science Division.
- Whitaker, J.O., Jr. and M.G. Ferraro. 1963. Summer food of 220 short-tailed shrews from Ithaca, New York. *J. Mamm.* 44:419.
- White, D.H., and M.P. Dieter. 1978. Effects of dietary vanadium in mallard ducks. *J. Toxicol. Environ. Health.* 4: 43-50.
- White, D.H., and M.T. Finley. 1978. Uptake and retention of dietary cadmium in mallard ducks. *Environ. Res.* 17: 53-59.
- White, D.H., M.T. Finley, and J.F. Ferrell. 1978. Histopathological effects of dietary cadmium on kidneys and testes of mallard ducks. *J. Toxicol. Environ. Health.*
- White, M. C., R. L. Chaney, and A. M. Decker. 1979. "Differential cultivar tolerance in soybean to phytotoxic levels of soil Zn. II. Range of Zn additions and the uptake and translocation of Zn, Mn, Fe, and P." *Agronomy J.* 71:126-131.
- White, R.D., D.L. Earnest, and D.E. Carter. 1983. The effect of intestinal esterase inhibition on the *in vivo* absorption and toxicity of di-n-butyl phthalate. *Food Chem. Toxicol.* 21: 99-101.

Wlostowski, T., W. Chetnicki, W. Gierlachowska-Baldyga, and B. Chycak. 1988. Zinc, iron, copper, manganese, calcium and magnesium supply status of free-living bank voles. *Acta Theriol.* 33:555-573.

Wobeser, G., N. O. Nielsen, and B. Schiefer. 1976. Mercury and mink. II. Experimental methylmercury intoxication. *Can. J. Comp. Med.* 40:34-45.

Wojtowicz, J. A., and J. G. Smith. 1992. Biological Monitoring and Abatement Program (BMAP) Benthic Macroinvertebrate Monitoring Project Sample Processing QA Plan. QAP-X-91-ES-068. Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Wong, M. H. and A. D. Bradshaw. 1982. "A comparison of the toxicity of heavy metals, using root elongation of rye grass, *Lolium perenne*." *New Phytol.* 92:255-61.

Wren, C.D. 1986. A review of metal accumulation and toxicity in wild mammals: I. Mercury. *Environ. Res.* 40: 210-244.

Wren, C.D., D.B. Hunter, J.F. Leatherland and P.M. Stokes. 1987. The effects of polychlorinated biphenyls and methylmercury, singly and in combination on mink. II: Reproduction and Kit Development. *Arch. Environ. Contam. Toxicol.* 16: 449-454.

Zar, J. H. 1984. Biostatistical analysis. Prentice-Hall, Inc., Englewood Cliffs, New Jersey.

Figures

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Figure C2.1. WAG 5 Ecological Conceptual Model: Current Baseline State

Figure C2.2. WAG 5 Ecological Conceptual Model: Hypothetical Future State

WAG 5 C2-3.DGN
2/21/95

Fig. C2.3. Aquatic toxicity testing locations on WAG 5.

NOTES

1. THE ANGLE OF DECLINATION OF THE ORNL GRID TO TRUE NORTH IS TAKEN FROM THE APPROXIMATE CENTER OF THE WAG.
2. TOPOGRAPHIC AND SITE SPECIFIC INFORMATION PROVIDED BY MARTIN MARETTA ENERGY SYSTEMS, INC.

Fig C2.4. WAG 5 earthworm sampling locations.

Figure C2.5. Fish Community Density (number fish/m²) in White Oak Creek (WCK), Locations 3.9, 5.1, and 6.8. Fall 1985-Fall 1992.

Figure C2.6. Fish Community Density (number fish/m²) in White Oak Creek (WCK), Locations 2.3, 2.9, and 3.4. Fall 1985-Fall 1992.

Figure C2.7. Fish Community Density (number fish/m²) in Melton Branch (MEK), Locations 0.6, 1.4, and 2.1. Fall 1985-Fall 1992.

Figure C2.8. Fish and Benthic Macroinvertebrate Communities Sampling Sites in White Oak Creek and Melton Branch.
WCK = White Oak Creek Kilometer; MEK = Melton Branch Kilometer.

Figure C2.9. Summary of the effects of water from study sites along White Oak Creek on the survival of fish embryos in a series of medaka (*Oryzias latipes*) embryo-larval tests conducted 1991-1993. Numbers of tests conducted for the various sites are provided in parentheses. Laboratory controls were either a medaka rearing medium or millipore filtered water. Water from White Oak Lake outfall (WO Lo) served as a positive control

Estimation of Ecological Risk-Based Remedial Action Objectives

Figure C2.10. Estimation of Risk-based Remedial Action Objectives (RBRAOs)

Tables

Table C2.1. Parameters for estimation of exposure for vermivorous wildlife on WAG5

Parameter	Short-tailed Shrew (<i>Blarina brevicauda</i>)		Reference
	Value ^a	Comments	
Body Weight	0.015 ± 0.00078 kg	New Hampshire (field)	Schlessinger and Potter 1974
Food Consumption Rate	0.01 kg/d	larch sawfly diet (lab)	Buckner 1964
	0.00795 ± 0.00017 kg/d	mealworm diet (lab)	Barrett and Stueck 1976
	mean = 0.009 kg/d		
Water Consumption Rate	0.223 ml/g bw/d		Chew 1951
	0.033 L/d	assuming a 0.015 kg bw	
Soil Consumption Rate	13% of diet		Talmage and Walton 1993
	0.00117 kg/d	assuming diet of 0.009 kg/d	
Diet Composition	earthworms 31.4% slugs/snails 27.1% soil/litter invert 13.2% fungi 8.4% misc. animals 8.1% coleoptera 5.9% vegetation 5.4%	percent volume in diet in summer in New York	Whitaker and Ferraro 1963
Home Range	0.39 ± 0.036 ha	Manitoba bog	Buckner 1966
Habitat Requirements	broad and variable but requires >50% herbaceous cover		Miller and Getz 1977
	forest, wetlands, and grasslands. most abundant in hardwood forests with deep litter and humus.		van Zyll de Jong 1983
Population Density	2.3 /ha - winter 5.2 /ha - spring 9.3 /ha -summer 8.1 /ha - fall	Illinois - alfalfa, tallgrass, and bluegrass; means derived from graph.	Getz 1989

Table C2.1. Parameters for estimation of exposure for vermivorous wildlife on WAG5

Behavior	nocturnal, semifossorial, spends little time above surface		George et al. 1986
	active year-round - does not hibernate		EPA 1993a
Other	appear to be unpalatable to most predators due to lateral gland		van Zyll de Jong 1983
American Woodcock (<i>Scolopax minor</i>)			
Body Weight	0.176 kg (♂) 0.219 kg (♀)		Dunning 1984
	0.198 kg (mean ♂ + ♀)		
Food Consumption Rate	0.15 kg/d		Sheldon 1971
Water Consumption Rate	0.02 L/d	estimated using allometric equation; assuming 0.198 kg bw	Calder and Braun 1983
Soil Consumption Rate	10.4%		Beyer et al. 1994
	0.0156 kg/d	assuming diet of 0.15 kg/d	
Diet Composition	primarily earthworms (58 % - ~ 99 %)		Sperry 1940 Krohn 1970 Miller and Causey 1985 Stribling and Doerr 1985
	plus other ground- dwelling invertebrates		
Home Range	10.5 ha (singing ♂) 73.6 ha (active ♂) 3.1 ha (inactive ♂)	Pennsylvania - mixed forest fields	Hudgins et al. 1985
Habitat Requirements	Breeding: moist early successional woodlands, swamps, river bottoms, alder thickets		DeGraaf et al. 1981
	feeding: moist open pasture, cultivated fields, stream banks		

Table C2.1. Parameters for estimation of exposure for vermivorous wildlife on WAG5

Population Density	3.4 /ha	North Carolina - winter untilled soy stubble untilled corn stubble rebedded corn	Connors and Doerr 1982
	0.2 /ha		
	0.034 /ha		
	0.21 nests/ha	Pennsylvania - mixed pine hardwoods	Coon et al. 1982
Behavior	migrate from northern breeding range to wintering range in south Atlantic and gulf coast states.		Sheldon 1971
	early migrants; leave wintering grounds in February, arrive at northern breeding grounds lat March.		

^a Suggested values for use in exposure assessment are in bold.

Table C2.2. Estimated Contaminant Exposure for American Woodcock at the Background Location

Analyte	Background Media Concentrations (mg /L or kg)			Estimated Exposure (mg/kg/d)			
	Water (Mean x 2)	Soil (Mean x 2)	Estimated in Earthworms ^a (Mean x 2)	Water	Soil	Food	Total
Selenium	0	1.3	1.5424656	0	0.10242	1.16853	1.27095
Silver	0	4	6.582208	0	0.31515	4.98652	5.30167
Sodium	7	0	0	0.70707	0	0	0.70707
Thallium	0	0.87	0	0	0.06855	0	0.06855
Vanadium	0.02	76	0	0.00202	5.98788	0	5.9899
Zinc	0.22	120	107.32224	0.02222	9.45455	81.30473	90.7815
1,1-Dichloroethane	0.01	0.01	0	0.00101	0.00079	0	0.0018
1,1-Dichloroethene	0.01	0.01	0	0.00101	0.00079	0	0.0018
1,1,1-Trichloroethane	0.01	0.01	0	0.00101	0.00079	0	0.0018
1,2-Dichlorobenzene	0.02	0	0	0.00202	0	0	0.00202
1,2-Dichloroethane	0.01	0	0	0.00101	0	0	0.00101
1,2-Dichloroethene (Total)	0.01	0	0	0.00101	0	0	0.00101
1,2-Dichloropropane	0.01	0	0	0.00101	0	0	0.00101
2-Butanone	0.02	0.17	0	0.00202	0.01339	0	0.01541
4-Methyl Phenol	0.02	0	0	0.00202	0	0	0.00202
4-Methyl-2-Pentanone	0.02	0	0	0.00202	0	0	0.00202
4,4'-DDD	0	0.02	0	0	0.00158	0	0.00158
Acetone	0	0.08	0	0	0.0063	0	0.0063
Aroclor 1254	0	0.16	0.1819264	0	0.01261	0.13782	0.15043

5

Table C2.2. Estimated Contaminant Exposure for American Woodcock at the Background Location

Analyte	Background Media Concentrations (mg /L or kg)		Estimated in Earthworms ^a (Mean x 2)	Estimated Exposure (mg/kg/d)			
	Water (Mean x 2)	Soil (Mean x 2)		Water	Soil	Food	Total
Toluene	0.01	0.01	0	0.00101	0.00079	0	0.0018
Trichloroethene	0.01	0.01	0	0.00101	0.00079	0	0.0018
Vinyl Chloride	0.02	0	0	0.00202	0	0	0.00202
Xylene	0.01	0	0	0.00101	0	0	0.00101

^a wet weight

Table C2.3. Estimated Contaminant Exposure for Short-tailed Shrews at the Background Location

Analyte	Background Media Concentrations (mg /L or kg)			Estimated Exposure (mg/kg/d)			
	Water (Mean x 2)	Soil (Mean x 2)	Estimated in Earthworms* (Mean x 2)	Water	Soil	Food	Total
Aluminum	0.34	50000	253.6	0.748	3900	152.16	4052.908
Antimony	0.06	0.44	0	0.132	0.03432	0	0.16632
Arsenic	0	13	1.314976	0	1.014	0.78899	1.80299
Barium	0.08	240	2.98368	0.176	18.72	1.79021	20.68621
Beryllium	0	2.1	0.4385472	0	0.1638	0.26313	0.42693
Cadmium	0.01	0.44	0.33875072	0.022	0.03432	0.20325	0.25957
Calcium	74	2600	470.704	162.8	202.8	282.4224	648.0224
Carbon Disulfide	0.01	0	0	0.022	0	0	0.022
Chromium	0.02	51	2.359872	0.044	3.978	1.41592	5.43792
Cobalt	0.04	37	1.392976	0.088	2.886	0.83579	3.80979
Copper	0.02	38	3.133024	0.044	2.964	1.87981	4.88781
Cyanide	0	0.49	0	0	0.03822	0	0.03822
Iron	0.81	67000	382.704	1.782	5226	229.6224	5457.4044
Lead	0.01	44	0.889856	0.022	3.432	0.53391	3.98791
Magnesium	10	7300	274.3632	22	569.4	164.61792	756.01792
Manganese	0.21		0	0.462	0	0	0.462
Mercury	0	0.59	0.54439536	0	0.04602	0.32664	0.37266
Nickel	0.04	58	0	0.088	4.524	0	4.612
Potassium	2	5700	5079.0192	4.4	444.6	3047.41152	3496.41152
Selenium	0	1.3	1.5424656	0	0.1014	0.92548	1.02688

Table C2.3. Estimated Contaminant Exposure for Short-tailed Shrews at the Background Location

Background Media Concentrations (mg /L or kg)				Estimated Exposure (mg/kg/d)			
Analyte	Estimated in Earthworms*		Water	Soil	Food	Total	
	(Mean x 2)	(Mean x 2)					
Silver	0	4	6.582208	0	0.312	3.94932	4.26132
Sodium	7	0	15.4	0	0	0	15.4
Thallium	0	0.87	0	0	0.06786	0	0.06786
Vanadium	0.02	76	0	0.044	5.928	0	5.972
Zinc	0.22	120	107.32224	0.484	9.36	64.39334	74.23734
1,1-Dichloroethane	0.01	0.01	0	0.022	0.00078	0	0.02278
1,1-Dichloroethene	0.01	0.01	0	0.022	0.00078	0	0.02278
1,1,1-Trichloroethane	0.01	0.01	0	0.022	0.00078	0	0.02278
1,2-Dichlorobenzene	0.02	0	0	0.044	0	0	0.044
1,2-Dichloroethane	0.01	0	0	0.022	0	0	0.022
1,2-Dichloroethene (Total)	0.01	0	0	0.022	0	0	0.022
1,2-Dichloropropane	0.01	0	0	0.022	0	0	0.022
2-Butanone	0.02	0.17	0	0.044	0.01326	0	0.05726
4-Methyl Phenol	0.02	0	0	0.044	0	0	0.044
4-Methyl-2-Pentanone	0.02	0	0	0.044	0	0	0.044
4,4'-DDD	0	0.02	0	0	0.00156	0	0.00156
Acetone	0	0.08	0	0	0.00624	0	0.00624
Aroclor 1254	0	0.16	0.1819264	0	0.01248	0.10916	0.12164
Aroclor 1260	0	0.16	0.1819264	0	0.01248	0.10916	0.12164
Benzene	0.01	0	0	0.022	0	0	0.022

Table C2.3. Estimated Contaminant Exposure for Short-tailed Shrews at the Background Location

Analyte	Background Media Concentrations (mg /L or kg)			Estimated in Earthworms* (Mean x 2)	Estimated Exposure (mg/kg/d)		
	Water (Mean x 2)	Soil (Mean x 2)	Water		Soil	Food	Total
Benzene, 1,2,4-Trichloro-	0.02	0	0	0	0.044	0	0.044
Benzo(k)Fluoranthene	0	0.08	0	0	0.00624	0	0.00624
Bis(2-Ethylhexyl) Phthalate	0.02	0	0.044	0	0	0	0.044
Bromomethane	0.02	0	0.044	0	0	0	0.044
Carbon Tetrachloride	0	0.01	0	0	0.00078	0	0.00078
Chloroform	0.01	0.01	0.022	0	0.00078	0	0.02278
Chloromethane	0	0.02	0	0	0.00156	0	0.00156
Endrin	0	0.02	0	0	0.00156	0	0.00156
Ethylbenzene	0	0.01	0	0	0.00078	0	0.00078
Fluoranthene	0	0.7	0	0	0.0546	0	0.0546
Heptachlor Epoxide	0	0.01	0	0	0.00078	0	0.00078
m-Dichlorobenzene	0.02	0	0.044	0	0	0	0.044
Methylene Chloride	0	0.01	0	0	0.00078	0	0.00078
p-Dichlorobenzene	0.02	0	0.044	0	0	0	0.044
Pyrene	0	1.9	0	0	0.1482	0	0.1482
Styrene	0.01	0.01	0.022	0	0.00078	0	0.02278
Tetrachloroethene	0.01	0.01	0.022	0	0.00078	0	0.02278
Toluene	0.01	0.01	0.022	0	0.00078	0	0.02278
Trichloroethene	0.01	0.01	0.022	0	0.00078	0	0.02278
Vinyl Chloride	0.02	0	0.044	0	0	0	0.044

Table C2.3. Estimated Contaminant Exposure for Short-tailed Shrews at the Background Location

Analyte	Background Media Concentrations (mg /L or kg)			Estimated Exposure (mg/kg/d)		
	Water (Mean x 2)	Soil (Mean x 2)	Estimated in Earthworms* (Mean x 2)	Water	Soil	Food
Xylene	0.01	0	0	0.022	0	0
wet weight						0.022

Table C2.4. Estimated Contaminant Exposure and Hazard Assessment for American Woodcock at the WW area

Analyte	Media Concentrations (mg /L or kg)			Estimated Exposure (mg/kg/d)			Toxicity Benchmark for American Woodcock (mg/kg/d)	Hazard Quotient*	
	Water (95% UCL)	Soil (95% UCL)	Estimated in Earthworms ^a (95% UCL)	Water	Soil	Food			
Aluminum	5.92	20000	101.44	0.59798	1575.758	76.84848	1653.20404	102.75	16.08958
Arsenic	0	4.8	0.4855296	0	0.37818	0.36783	0.74601	8.76	0.08516
Barium	0.14	310	3.85392	0.01414	24.42424	2.91964	27.35802	17.73	1.54304
Calcium	90.92	59000	10681.36	9.18384	4648.485	8091.939	12749.60808		
Chloride	54.36	0	0	5.49091	0	0	5.49091		
Chromium	0.11	94	4.349568	0.01111	7.40606	3.29513	10.7123	1.84	5.8219
Copper	0.01	40	3.29792	0.00101	3.15152	2.49842	5.65095	46.07	0.12266
Fluoride	0.49	0	0	0.04949	0	0	0.04949	7.57	0.00654
Lead	0	94	1.901056	0	7.40606	1.44019	8.84625	3.35	2.64067
Manganese	4.09	1100	15.312	0.41313	86.66667	11.6	98.6798		
Mercury	0	1.3	1.1995152	0	0.10242	0.90872	1.01114	0.011	91.92182
Nickel	0.57	34	0	0.05758	2.67879	0	2.73637	121.78	0.02247
Nitrate	8.92	0	0	0.90101	0	0	0.90101		
Phosphate	0.13	0	0	0.01313	0	0	0.01313		
Selenium	0.24	0	0	0.02424	0	0	0.02424	0.85	0.02852
Sodium	16.53	0	0	1.6697	0	0	1.6697		
Sulfate	110.77	0	0	11.18889	0	0	11.18889		
Vanadium	0.09	34	0	0.00909	2.67879	0	2.68788	20.45	0.13144
Zinc	0.03	1000	894.352	0.00303	78.78788	677.5394	756.3303	5.12	147.72076

Table C2.4. Estimated Contaminant Exposure and Hazard Assessment for American Woodcock at the WW area

Analyte	Media Concentrations (mg /L or kg)			Estimated Exposure (mg/kg/d)			Toxicity Benchmark for American Woodcock (mg/kg/d)	Hazard Quotient ^c
	Water (95% UCL)	Soil (95% UCL)	Estimated in Earthworms ^a (95% UCL)	Water	Soil	Food		
1,2-Dichloroethene (Total)	0.31	0	0	0.03131	0	0	0.03131	
Aroclor 1254	0	0.24	0.2728896	0	0.01891	0.20673	0.31	0.72787
Aroclor 1260	0	0.18	0.2046672	0	0.01418	0.15505	0.31	0.5459
Bis(2-Ethylhexyl) Phthalate	0	1.3	0	0	0.10242	0	1.02	0.10041
Di-n-butyl Phthalate	0	1.5	0	0	0.11818	0	0.1	1.1818
Trichloroethene	0.13	0	0	0.01313	0	0	0.01313	

^a wet weight^b Total exposure values in bold exceed total exposure at the Background.^c Hazard Quotient = total exposure/benchmark; Values shaded and in bold exceed total exposure at the Background and benchmark

Table C2.5 Estimated Contaminant Exposure and Hazard Assessment for Short-tailed Shrews at the WW area

Analyte	Media Concentrations (mg /L or kg)			Estimated Exposure (mg/kg/d)			Toxicity Benchmark for Short-tailed Shrew (mg/kg/d)	Hazard Quotient ^c
	Water (95 % UCL)	Soil (95 % UCL)	Estimated in Earthworm ^a (95 % UCL)	Water	Soil	Food		
1,2-Dichloroethene (Total)	0.31	0	0	0.682	0	0	84.83	0.00804
Aroclor 1254	0	0.24	0.2728896	0	0.01872	0.16373	0.15	1.21633
Aroclor 1260	0	0.18	0.2046672	0	0.01404	0.1228	0.15	0.91227
Bis(2-Ethylhexyl) Phthalate	0	1.3	0	0	0.1014	0	23.04	0.0044
Di-n-butyl Phthalate	0	1.5	0	0	0.117	0	691.35	0.00017
Trichloromethene	0.13	0	0	0.286	0	0	0.88	0.325
wet weight								

^a Total exposure values in bold exceed total exposure at the Background.^c Hazard Quotient = total exposure/benchmark; Values shaded and in bold exceed total exposure at the Background and benchmark

Table C2.6 Parameters used in the calculation of dose to small fish

Radionuclide	Bioconcentration Factor	Absorbed Fraction			Emitted Energies (MeV)		
		Beta	Gamma	Alpha	Average Beta	Maximum Beta ^a	Gamma
Am-241	30	-	-	5.57	-	-	-
C-14	1	1	-	-	0.0495	N/A	-
Cm-45 ^b	60	-	-	0.0772	-	-	-
Cm-243/244 ^c	30	1	0.011	5.88	0.137	0.278	0.134
Co-60	300	0.98	0.009	-	0.0965	1.48	2.5
K-40	10000	0.98	0.011	-	0.523	1.32	0.156
Pb-212	300	1	0.011	-	0.175	N/A	0.148
Pu-238	30	1	1	5.58	0.11	N/A	0.0018
Pu-239/240 ^d	30	1	1	5.24	0.0106	N/A	0.00173
Ra-228 ^e	50	0.93	0.016	-	0.4769	2.145	0.93
Sn-119m ^f	N/A	1	0.8	-	0.0777	N/A	0.0115
Tc-99	20	1	-	-	0.101	0.295	-
Th-228	100	1	1	5.49	0.0205	N/A	0.0033
Th-230	100	1	1	4.74	0.0146	N/A	0.00155
Th-232	100	1	1	4.07	0.0125	N/A	0.00133
Th-234	100	1	1	-	0.0592	N/A	0.00934
Sr-89/90 ^g	60	0.83	-	-	1.13	2.79	-
H-3	1	1	-	-	0.00568	0.018	-
U-233/234 ^h	10	1	1	4.84	0.132	N/A	0.00173
U-235/236 ⁱ	10	1	0.011	4.47	0.048	N/A	0.154
U-238	10	1	1	4.26	0.01	N/A	0.00136

^a Maximum beta energies not found for all beta-emitters.^b Bioconcentration factor for Sr used as estimate for Ca.^c Assumes 100% Cm-244

- ⁴ Assumes 100% Pu-240
- Includes Ac-228 emissions
- ⁵ Bioconcentration factor not found for Sn
- ⁶ Assumes 100% Sr-90
- ⁷ Assumes 100% U-234
- ⁸ Assumes 100% U-235

Table C2.7. Radionuclide activities at on-site and off-site surface water locations, calculated dose to small fish, and resulting Hazard Quotients

Radionuclide	Maximum Detected Activity (pCi/L)	Dose Rate (uGy/h)			HQ ^a
		Internal	External	Total	
SW001 (High Base)					
H-3	5.50e+04	6.66e-03		6.66e-03	0.000
Pu-238	2.90e-01	1.06e-03		1.06e-03	0.000
Sr-89/90	2.40e+01	2.88e-02	9.83e-05	2.89e-02	0.000
U-233/234	2.70e+01	2.86e-02	0.00e+00	2.86e-02	0.000
U-235	1.70e+00	1.64e-03	5.52e-06	1.64e-03	0.000
U-238	4.50e+01	4.10e-02	0.00e+00	4.10e-02	0.000
TOTAL		1.08e-01	1.04e-04	1.08e-01	0.000
SW001 (Low Base)					
H-3	1.17e+05	1.42e-02	0.00e+00	1.42e-02	0.000
Pb-212	2.12e+01	2.39e-02	6.61e-05	2.40e-02	0.000
Sr-89/90	2.99e+01	3.59e-02	1.22e-04	3.60e-02	0.000
U-233/234	1.04e+01	1.10e-02	0.00e+00	1.10e-02	0.000
U-235	8.00e-01	7.71e-04	2.60e-06	7.73e-04	0.000
U-238	1.85e+01	1.68e-02	0.00e+00	1.68e-02	0.000
TOTAL		1.03e-01	1.91e-04	1.03e-01	0.000
SW001 (High Base Storm)					
Am-241	1.11e-01	3.95e-04	0.00e+00	3.95e-04	0.000
H-3	2.50e+04	3.03e-03	0.00e+00	3.03e-03	0.000
Pu-239/240	7.54e-02	2.53e-04	0.00e+00	2.53e-04	0.000
Sr-89/90	1.63e+01	1.95e-02	6.67e-05	1.96e-02	0.000
Th-230	5.32e+00	5.39e-02	0.00e+00	5.39e-02	0.000
U-233/234	5.14e+01	5.45e-02	0.00e+00	5.45e-02	0.000
U-235/236	2.75e+00	2.65e-03	8.93e-06	2.66e-03	0.000
U-238	8.11e+01	7.38e-02	0.00e+00	7.38e-02	0.000
TOTAL		2.08e-01	7.57e-05	2.08e-01	0.001
SW001 (Low Base Storm)					
H-3	2.83e+04	3.43e-03	0.00e+00	3.43e-03	0.000
U-233/234	1.06e+01	1.12e-02	0.00e+00	1.12e-02	0.000
U-235	6.83e-01	6.58e-04	2.22e-06	6.60e-04	0.000
U-238	1.72e+01	1.57e-02	0.00e+00	1.57e-02	0.000
TOTAL		3.10e-02	2.22e-06	3.10e-02	0.000
SW002 (High Base)					

Radionuclide	Maximum Detected Activity (pCi/L)	Dose Rate (uGy/h)			HQ ^a
		Internal	External	Total	
C-14	3.20e+02	3.38e-04	0.00e+00	3.38e-04	0.000
H-3	7.60e+06	9.20e-01	0.00e+00	9.20e-01	0.002
Sr-89/90	2.50e+03	3.00e+00	1.02e-02	3.01e+00	0.008
U-233/234	3.70e+00	3.92e-03	0.00e+00	3.92e-03	0.000
TOTAL		3.92e+00	1.02e-02	3.93e+00	0.010
SW002 (Low Base)					
Am-241	9.30e+00	3.31e-02	0.00e+00	3.31e-02	0.000
C-14	1.80e+02	1.90e-04	0.00e+00	1.90e-04	0.000
H-3	9.60e+05	1.16e-01	0.00e+00	1.16e-01	0.000
Pu-238	1.77e+01	6.44e-02	0.00e+00	6.44e-02	0.000
Ra-228	1.61e+03	7.86e-01	3.25e-02	8.19e-01	0.002
Sr-89/90	1.78e+03	2.13e+00	7.29e-03	2.14e+00	0.005
Tc-99	1.88e+01	2.36e-03	0.00e+00	2.36e-03	0.000
U-233/234	3.20e+00	3.39e-03	0.00e+00	3.39e-03	0.000
TOTAL		3.14e+00	3.98e-02	3.18e+00	0.008
SW002 (High Base Storm)					
Am-241	1.44e-01	5.13e-04	0.00e+00	5.13e-04	0.000
C-14	1.18e+02	1.24e-04	0.00e+00	1.24e-04	0.000
H-3	4.15e+06	5.02e-01	0.00e+00	5.02e-01	0.001
Pu-238	1.40e+01	5.09e-02	0.00e+00	5.09e-02	0.000
Pu-239/240	1.32e-01	4.43e-04	0.00e+00	4.43e-04	0.000
Sr-89/90	1.41e+03	1.69e+00	5.77e-03	1.70e+00	0.004
Tc-99	3.79e+01	4.77e-03	0.00e+00	4.77e-03	0.000
Th-230	1.04e+01	1.05e-01	0.00e+00	1.05e-01	0.000
TOTAL		2.36e+00	5.77e-03	2.36e+00	0.006
SW002 (Low Base Storm)					
Am-241	9.02e-01	3.21e-03	0.00e+00	3.21e-03	0.000
C-14	1.78e+02	1.88e-04	0.00e+00	1.88e-04	0.000
H-3	1.08e+07	1.31e+00	0.00e+00	1.31e+00	0.003
Pu-238	1.91e+01	6.95e-02	0.00e+00	6.95e-02	0.000
Pu-239/240	1.99e-01	6.68e-04	0.00e+00	6.68e-04	0.000
Sr-89/90	2.09e+03	2.51e+00	8.56e-03	2.52e+00	0.006
Tc-99	3.01e+01	3.78e-03	0.00e+00	3.78e-03	0.000
U-233/234	6.20e+00	6.57e-03	0.00e+00	6.57e-03	0.000
TOTAL		3.90e+00	8.56e-03	3.91e+00	0.010

Radionuclide	Maximum Detected Activity (pCi/L)	Dose Rate (uGy/h)			HQ ^a
		Internal	External	Total	
SW003 (High Base)					
H-3	2.40e+03	2.91e-04	0.00e+00	2.91e-04	0.000
Sn-119m ^b	1.90e+01	N/A	9.31e-07	9.31e-07	0.000
TOTAL		2.91e-04	9.31e-07	2.91e-04	0.000
SW003 (Low Base)					
H-3	2.68e+03	3.24e-04	0.00e+00	3.24e-04	0.000
TOTAL		3.24e-04	0.00e+00	3.24e-04	0.000
SW003 (High Base Storm)					
Sr-89/90	5.70e+01	6.84e-02	2.33e-04	6.86e-02	0.000
TOTAL		6.84e-02	2.33e-04	6.86e-02	0.000
SW003 (Low Base Storm)					
Am-241	7.36e-02	2.62e-04	0.00e+00	2.62e-04	0.000
TOTAL		2.62e-04	0.00e+00	2.62e-04	0.000
SW004 (High Base)					
Ca-45	9.90e+02	9.77e-02	0.00e+00	9.77e-02	0.000
Sr-89/90	1.40e+03	1.68e+00	5.73e-03	1.68e+00	0.004
Tc-99	3.80e+00	4.78e-04	0.00e+00	4.78e-04	0.000
TOTAL		1.78e+00	5.73e-03	1.78e+00	0.004
SW004 (Low Base)					
Am-241	5.15e+00	1.83e-02	0.00e+00	1.83e-02	0.000
Sr-89/90	6.13e+02	7.35e-01	2.51e-03	7.38e-01	0.002
Tc-99	1.49e+01	1.87e-03	0.00e+00	1.87e-03	0.000
TOTAL		7.55e-01	2.51e-03	7.58e-01	0.002
SW004 (High Base Storm)					
Am-241	5.24e-02	1.87e-04	0.00e+00	1.87e-04	0.000
Cm-243/244	6.22e-01	2.39e-03	1.76e-06	2.40e-03	0.000
Pu-239/240	7.34e-02	2.46e-04	0.00e+00	2.46e-04	0.000
Sr-89/90	2.08e+02	2.49e-01	8.52e-04	2.50e-01	0.001
Th-230	8.94e+00	9.06e-02	0.00e+00	9.06e-02	0.000
Th-232	3.11e+00	2.71e-02	0.00e+00	2.71e-02	0.000
TOTAL		3.70e-01	8.53e-04	3.71e-01	0.001
SW004 (Low Base Storm)					
Sr-89/90	9.76e+02	1.17e+00	4.00e-03	1.17e+00	0.003
TOTAL		1.17e+00	4.00e-03	1.17e+00	0.003
SW005 (High Base)					

Radionuclide	Maximum Detected Activity (pCi/L)	Dose Rate (uGy/h)			HQ ^a
		Internal	External	Total	
H-3	1.80e+04	2.18e-03	0.00e+00	2.18e-03	0.000
Sr-89/90	3.40e+00	4.08e-03	1.39e-05	4.09e-03	0.000
TOTAL		6.26e-03	1.39e-05	6.27e-03	0.000
SW005 (Low Base)					
H-3	2.23e+04	2.70e-03	0.00e+00	2.70e-03	0.000
TOTAL		2.70e-03	0.00e+00	2.70e-03	0.000
SW005 (High Base Storm)					
Am-241	9.15e-02	3.26e-04	0.00e+00	3.26e-04	0.000
H-3	3.88e+03	4.70e-04	0.00e+00	4.70e-04	0.000
Sr-89/90	3.45e+01	4.14e-02	1.41e-04	4.15e-02	0.000
Th-230	9.59e+00	9.72e-02	0.00e+00	9.72e-02	0.000
Th-232	2.06e+00	1.79e-02	0.00e+00	1.79e-02	0.000
TOTAL		1.57e-01	1.41e-04	1.57e-01	0.000
SW005 (Low Base Storm)					
H-3	1.05e+04	1.27e-03	0.00e+00	1.27e-03	0.000
TOTAL		1.27e-03	0.00e+00	1.27e-03	0.000
SW006 (High Base)					
C-14	1.20e+03	1.27e-03	0.00e+00	1.27e-03	0.000
Ca-45	1.70e+02	1.68e-02	0.00e+00	1.68e-02	0.000
H-3	1.40e+06	1.69e-01	0.00e+00	1.69e-01	0.000
Sr-89/90	5.70e+02	6.84e-01	2.33e-03	6.86e-01	0.002
TOTAL		8.71e-01	2.33e-03	8.73e-01	0.002
SW006 (Low Base)					
Am-241	5.70e+00	2.03e-02	0.00e+00	2.03e-02	0.000
H-3	8.78e+05	1.06e-01	0.00e+00	1.06e-01	0.000
Pu-238	4.18e+00	1.52e-02	0.00e+00	1.52e-02	0.000
Sr-89/90	6.33e+02	7.59e-01	2.59e-03	7.62e-01	0.002
TOTAL		9.01e-01	2.59e-03	9.04e-01	0.002
SW006 (High Base Storm)					
Am-241	1.63e-01	5.80e-04	0.00e+00	5.80e-04	0.000
Cm-243/244	2.91e-01	1.12e-03	8.22e-07	1.12e-03	0.000
H-3	5.74e+05	6.95e-02	0.00e+00	6.95e-02	0.000
Pu-238	3.28e-01	1.19e-03	0.00e+00	1.19e-03	0.000
Sr-89/90	4.31e+02	5.17e-01	1.76e-03	5.19e-01	0.001
TOTAL		5.89e-01	1.77e-03	5.91e-01	0.001

Radionuclide	Maximum Detected Activity (pCi/L)	Dose Rate (uGy/h)			HQ ^a
		Internal	External	Total	
SW006 (Low Base Storm)					
Am-241	7.61e-02	2.71e-04	0.00e+00	2.71e-04	0.000
H-3	5.20e+05	6.29e-02	0.00e+00	6.29e-02	0.000
Pu-238	2.61e+00	9.50e-03	0.00e+00	9.50e-03	0.000
Sr-89/90	4.84e+02	5.80e-01	1.98e-03	5.82e-01	0.001
TOTAL		6.53e-01	1.98e-03	6.55e-01	0.002

^a Hazard Quotient (HQ) = total dose rate (uGy/h) divided by the recommended criterion of 400 uGy/h.

^b A bioconcentration factor for Sn was not found and, therefore, an internal dose rate could not be calculated.

C2-233

Table C2.8 Radionuclide activities in undiluted seep water, calculated dose to small fish, and resulting Hazard Quotients

Radionuclide	Maximum Detected Activity (pCi/L)	Dose Rate (uGy/h)			HQ ^a
		Internal	External	Total	
SP001					
H-3	2.78e+03	3.37e-04		3.37e-04	0.000
Th-232	2.91e+01	2.53e-01		2.53e-01	0.001
TOTAL		2.54e-01		2.54e-01	0.001
SP003					
H-3	1.51e+05	1.83e-02		1.83e-02	0.000
Sr-89/90	4.33e+01	5.19e-02	1.77e-04	5.21e-02	0.000
Tc-99	6.24e+01	2.69e-03		2.69e-03	0.000
U-233/234	4.20e+00	4.45e-03		4.45e-03	0.000
U-238	2.70e+00	2.46e-03		2.46e-03	0.000
TOTAL		7.98e-02	1.77e-04	8.00e-02	0.000
SP004					
C-14	9.80e+01	1.03e-04		1.03e-04	0.000
Co-60	3.38e+01	2.53e-02	1.79e-03	2.71e-02	0.000
H-3	2.86e+04	3.46e-03		3.46e-03	0.000
Ra-228	2.72e+01	1.33e-02	5.50e-04	1.38e-02	0.000
Sr-89/90	2.12e+02	2.54e-01	8.68e-04	2.55e-01	0.001
Tc-99	1.96e+01	8.44e-04		8.44e-04	0.000
TOTAL		2.97e-01	3.20e-03	3.00e-01	0.001
SP005					
C-14	6.30e+02	6.65e-04		6.65e-04	0.000
Ca-45	1.20e+02	1.18e-02		1.18e-02	0.000
H-3	9.80e+06	1.19e+00		1.19e+00	0.003
K-40	1.50e+02	1.64e+01	5.27e-04	1.64e+01	0.041
Sr-89/90	1.93e+03	2.31e+00	7.90e-03	2.32e+00	0.006
Tc-99	2.12e+02	9.13e-03		9.13e-03	0.000
TOTAL		2.00e+01	8.43e-03	2.00e+01	0.050

Radionuclide	Maximum Detected Activity (pCi/L)	Dose Rate (uGy/h)			HQ ^a
		Internal	External	Total	
SP006					
C-14	2.90e+02	3.06e-04		3.06e-04	0.000
Ca-45	8.80e+03	8.69e-01		8.69e-01	0.002
H-3	5.66e+06	6.85e-01		6.85e-01	0.002
Sr-89/90	3.59e+05	4.31e+02	1.47e+00	4.32e+02	1.080
Tc-99	2.12e+03	9.13e-02		9.13e-02	0.000
TOTAL		4.32e+02	1.47e+00	4.34e+02	1.084
SP007					
C-14	4.20e+02	4.43e-04		4.43e-04	0.000
H-3	6.75e+06	8.17e-01		8.17e-01	0.002
Sr-89/90	5.64e+02	6.76e-01	2.31e-03	6.79e-01	0.002
Tc-99	3.95e+01	1.70e-03		1.70e-03	0.000
TOTAL		1.50e+00	2.31e-03	1.50e+00	0.004
SP008					
C-14	5.10e+02	5.38e-04		5.38e-04	0.000
Ca-45	1.50e+04	1.48e+00		1.48e+00	0.004
H-3	7.73e+07	9.36e+00		9.36e+00	0.023
Sr-89/90	1.06e+06	1.27e+03	4.34e+00	1.28e+03	3.189
Tc-99	1.58e+03	6.80e-02		6.80e-02	0.000
U-233/234	3.80e+02	4.03e-01		4.03e-01	0.001
TOTAL		1.28e+03	4.34e+00	1.29e+03	3.217
SP009					
Am-241	3.22e+01	1.15e-01		1.15e-01	0.000
C-14	5.60e+02	5.91e-04		5.91e-04	0.000
H-3	7.62e+06	9.22e-01		9.22e-01	0.002
Sr-89/90	3.15e+04	3.78e+01	1.29e-01	3.79e+01	0.095
TOTAL		3.88e+01	1.29e-01	3.89e+01	0.097

C2-235

Radionuclide	Maximum Detected Activity (pCi/L)	Dose Rate (uGy/h)			HQ ^a
		Internal	External	Total	
SP011					
C-14	1.50e+02	1.58e-04		1.58e-04	0.000
Ca-45	4.60e+01	4.54e-03		4.54e-03	0.000
H-3	2.40e+07	2.91e+00		2.91e+00	0.007
Ra-228	1.50e+01	7.33e-03	3.03e-04	7.63e-03	0.000
Sr-89/90	2.70e+02	3.24e-01	1.11e-03	3.25e-01	0.001
Tc-99	6.60e+00	2.84e-04		2.84e-04	0.000
TOTAL		3.24e+00	1.41e-03	3.24e+00	0.008
SP012					
C-14	2.80e+02	2.95e-04		2.95e-04	0.000
H-3	4.08e+07	4.94e+00		4.94e+00	0.012
Sr-89/90	4.37e+02	5.24e-01	1.79e-03	5.26e-01	0.001
Tc-99	1.41e+01	6.07e-04		6.07e-04	0.000
TOTAL		5.46e+00	1.79e-03	5.47e+00	0.014
SP014					
C-14	9.10e+02	9.60e-04		9.60e-04	0.000
H-3	2.27e+06	2.75e-01		2.75e-01	0.001
Sr-89/90	6.10e+02	7.32e-01	2.50e-03	7.34e-01	0.002
Tc-99	8.83e+01	3.80e-03		3.80e-03	0.000
TOTAL		1.01e+00	2.50e-03	1.01e+00	0.003
SP015					
H-3	3.10e+05	3.75e-02		3.75e-02	0.000
Ra-228	1.10e+02	5.37e-02	2.22e-03	5.60e-02	0.000
Sn-119m ^b	5.50e+01	N/A	2.70e-06	2.70e-06	0.000
Sr-89/90	2.40e+02	2.88e-01	9.83e-04	2.89e-01	0.001
Tc-99	8.50e+00	3.66e-04		3.66e-04	0.000
Th-234	1.10e+03	1.61e-01		1.61e-01	0.000
U-233/234	1.10e+03	1.17e+00		1.17e+00	0.003
U-235	8.10e+01	7.80e-02	2.63e-04	7.83e-02	0.000
U-238	1.90e+03	1.73e+00		1.73e+00	0.004
TOTAL		3.42e+00	1.25e-03	3.42e+00	0.009

Radionuclide	Maximum Detected Activity (pCi/L)	Dose Rate (uGy/h)			HQ ^a
		Internal	External	Total	
SP016					
Sr-89/90	2.90e+00	3.48e-03	1.19e-05	3.49e-03	0.000
TOTAL		3.48e-03	1.19e-05	3.49e-03	0.000
SP017					
C-14	1.40e+02	1.48e-04		1.48e-04	0.000
H-3	5.59e+06	6.77e-01		6.77e-01	0.002
Sr-89/90	3.14e+03	3.77e+00	1.29e-02	3.78e+00	0.009
Tc-99	4.04e+02	1.74e-02		1.74e-02	0.000
TOTAL		4.46e+00	1.29e-02	4.47e+00	0.011

^a Hazard Quotient (HQ) = total dose rate (uGy/h) divided by the recommended criterion of 400 uGy/h.

^b A bioconcentration factor for Sn was not found and, therefore, an internal dose rate could not be calculated.

Table C2.9: Parameters used in the calculation of dose to small invertebrates living 100% of the time within the sediment

Nuclide	Gamma Absorbed Fraction	Beta Absorbed Fraction	Alpha Energy [MeV]	Aver. Beta Energy [MeV]	Max. Beta Energy [MeV]	Gamma Energy [MeV]
Ac-228	0.002	1	-	0.46	-	0.93
Am-241	-	-	5.57	-	-	-
Bi-212	0.002	0.95	2.22	0.469	0.58	0.185
Bi-214	0.002	0.2	-	0.648	3.26	1.46
C-14	-	1	-	0.0495	-	-
Ca-45	-	1	-	0.0772	-	-
Cm-243/244 ^a	0.002	1	5.88	0.137	0.278	0.134
Co-60	0.002	0.48	-	0.0965	1.48	2.5
Cs-137	0.002	0.6	-	0.252	1.17	0.596
Eu-155	0.0014	1	-	0.0626	0.247	0.0626
I-129	0.01	1	-	0.0638	-	0.0246
Pb-210	0.4	1	-	0.038	-	0.00481
Pb-212	0.002	1	-	0.175	-	0.148
Pb-214	0.002	1	-	0.291	0.670	0.248
Pu-238	0.4	1	5.58	0.011	-	0.0018
Pu-239/240 ^b	0.4	1	5.24	0.0106	-	0.00173
Ra-223	0.002	1	5.75	0.0746	-	0.133
Ra-224	-	-	5.78	-	-	-
Ra-226	0.4	1	4.86	0.00359	-	0.00647
Rn-219	0.0014	1	6.88	0.0063	-	0.0558
Total Sr ^c	-	0.25	-	1.13	2.79	-
Sn-126	0.0015	1	-	0.171	-	0.0565
Tc-99	-	1	-	0.101	0.295	-
Th-228	0.4	1	5.49	0.0205	-	0.0033
Th-230	0.4	1	4.74	0.0146	-	0.00155
Th-231	0.01	1	-	0.163	-	0.0255
Th-232	0.4	1	4.07	0.0125	-	0.00133

C2-238

Nuclide	Gamma Absorbed Fraction	Beta Absorbed Fraction	Alpha Energy [MeV]	Aver. Beta Energy [MeV]	Max. Beta Energy [MeV]	Gamma Energy [MeV]
Th-234	0.4	1	-	0.0592	-	0.00934
Tl-208	0.002	0.9	-	0.591	0.647	3.36
Tritium	-	1	-	0.00568	0.018	-
U-232	0.4	1	5.4	0.0174	-	0.00219
U-233/234 ^d	0.4	1	4.84	0.0132	-	0.00173
U-235	0.002	1	4.47	0.048	-	0.154
U-238	0.4	1	4.26	0.01	-	0.00136

^a assumes 100% Cm-244^b assumes 100% Pu-240^c assumes 100% Sr-90^d assumes 100% U-234

Table C2.10: Parameters used in the calculation of dose to molluscs and large benthic macroinvertebrates living 100% of the time within the sediment

Nuclide	Gamma Absorbed Fraction	Beta Absorbed Fraction	Alpha Energy [MeV]	Aver. Beta Energy [MeV]	Max. Beta Energy [MeV]	Gamma Energy [MeV]
Ac-228	0.01	1	-	0.46	-	0.93
Am-241	-	-	5.57	-	-	-
Bi-212	0.01	1	2.22	0.469	0.58	0.185
Bi-214	0.01	0.65	-	0.648	3.26	1.46
C-14	-	1	-	0.0495	-	-
Ca-45	-	1	-	0.0772	-	-
Cm-243/244 ^a	0.01	1	5.88	0.137	0.278	0.134
Co-60	0.008	1	-	0.0965	1.48	2.5
Cs-137	0.01	1	-	0.252	1.17	0.596
Eu-155	0.01	1	-	0.0626	0.247	0.0626
I-129	0.04	1	-	0.0638	-	0.0246
Pb-210	1	1	-	0.038	-	0.00481
Pb-212	0.01	1	-	0.175	-	0.148
Pb-214	0.01	1	-	0.291	0.670	0.248
Pu-238	1	1	5.58	0.011	-	0.0018
Pu-239/240 ^b	1	1	5.24	0.0106	-	0.00173
Ra-223	0.008	1	5.75	0.0746	-	0.133
Ra-224	-	-	5.78	-	-	-
Ra-226	1	1	4.86	0.00359	-	0.00647
Rn-219	0.007	1	6.88	0.0063	-	0.0558
Total Sr ^c	-	0.7	-	1.13	2.79	-
Sn-126	0.01	1	-	0.171	-	0.0565
Tc-99	-	1	-	0.101	0.295	-
Th-228	1	1	5.49	0.0205	-	0.0033
Th-230	1	1	4.74	0.0146	-	0.00155
Th-231	0.03	1	-	0.163	-	0.0255
Th-232	1	1	4.07	0.0125	-	0.00133
Th-234	0.5	1	-	0.0592	-	0.00934

C2-240

Nuclide	Gamma Absorbed Fraction	Beta Absorbed Fraction	Alpha Energy [MeV]	Aver. Beta Energy [MeV]	Max. Beta Energy [MeV]	Gamma Energy [MeV]
Tl-208	0.01	1	-	0.591	0.647	3.36
Tritium	-	1	-	0.00568	0.018	-
U-232	1	1	5.4	0.0174	-	0.00219
U-233/234 ^d	1	1	4.84	0.0132	-	0.00173
U-235	0.01	1	4.47	0.048	-	0.154
U-238	1	1	4.26	0.01	-	0.00136

^a assumes 100% Cm-244^b assumes 100% Pu-240^c assumes 100% Sr-90^d assumes 100% U-234

Table C2.11. Estimated Contaminant Exposure and Hazard Assessment for American Woodcock at the OHF area

Analyte	Media Concentrations (mg /L or kg)				Estimated Exposure (mg/kg/d)			Toxicity Benchmark for Short-tailed Shrew (mg/kg/d)	Hazard Quotient ^c
	Water (95% UCL)	Soil (95% UCL)	Estimated in Earthworms ^a (95% UCL)	Water	Soil	Food	Total ^b		
Aluminum	10.38	29000	147.088	1.04848	2284.848	111.4303	2397.32726	102.75	23.33165
Arsenic	0	4.9	0.4956448	0	0.38606	0.37549	0.76155	8.76	0.08693
Barium	0.24	180	2.33776	0.02424	14.18182	1.69527	15.90133	17.73	0.89686
Cadmium	0	0.61	0.4696317	0	0.04806	0.35578	0.40384	2.59	0.15592
Calcium	137.36	150000	27156	13.87475	11818.18	20572.73	32404.7838		
Chloride	23.82	0	0	2.40606	0	0	2.40606		
Chromium	0	32	1.480704	0	2.52121	1.12175	3.64296	1.84	1.97987
Copper	0.07	21	1.731408	0.00707	1.65455	1.31167	2.97329	46.07	0.06454
Cyanide	0	0.64	0	0	0.05042	0	0.05042		
Fluoride	2.31	0	0	0.23333	0	0	0.23333	7.57	0.03082
Lead	0.02	22	0.444928	0.00202	1.73333	0.33707	2.07242	3.35	0.61863
Magnesium	21.91	11000	413.424	2.21313	866.6667	313.2	1182.0798		
Manganese	0.37	1800	25.056	0.03737	141.8182	18.98182	160.83737		
Mercury	0	0.14	0.1291786	0	0.01103	0.09786	0.10889	0.011	9.89909
Nickel	0	32	0	0	2.52121	0	2.52121	121.78	0.0207
Sodium	18.71	160	1477.5091	1.8899	12.60606	1119.325	1133.82105		
Sulfate	266.26	0	0	26.89495	0	0	26.89495		

Table C2.11. Estimated Contaminant Exposure and Hazard Assessment for American Woodcock at the OHF area

Analyte	Media Concentrations (mg /L or kg)				Estimated Exposure (mg/kg/d)			Toxicity Benchmark for Short-tailed Shrew (mg/kg/d)	Hazard Quotient ^c
	Water (95% UCL)	Soil (95% UCL)	Estimated in Earthworm ^a (95% UCL)	Water	Soil	Food	Total ^b		
Zinc	0.15	68	60.815936	0.01515	5.35758	46.07268	51.44541	5.12	10.04793
Aroclor 1254	0	0.04	0.0454816	0	0.00315	0.03446	0.03761	0.31	0.12132
Aroclor 1260	0	0.04	0.0454816	0	0.00315	0.03446	0.03761	0.31	0.12132
Bis(2-Ethylhexyl) Phthalate	0	0.42	0	0	0.03309	0	0.03309	1.02	0.03244
Butyl Benzyl Phthalate	0	0.43	0	0	0.03388	0	0.03388		
Di-n-butyl Phthalate	0	0.43	0	0	0.03388	0	0.03388	0.1	0.3388
p-Nitrophenol wet weight	0	1	0	0	0.07879	0	0.07879		

^b Total exposure values in bold exceed total exposure at the Background.^c Hazard Quotient = total exposure/benchmark; Values shaded and in bold exceed total exposure at the Background and benchmark

Table C2.12. Estimated Contaminant Exposure and Hazard Assessment for Short-tailed Shrew at the OHF area

Analyte	Media Concentrations (mg /L or kg)			Estimated Exposure (mg/kg/d)				Toxicity Benchmark for Short-tailed Shrew (mg/kg/d)	Hazard Quotient ^c
	Water (95% UCL)	Soil (95% UCL)	Estimated in Earthworms ^a (95% UCL)	Water	Soil	Food	Total ^b		
Aluminum	10.38	29000	147.088	22.836	2262	88.2528	2373.0888	2.46	964.67024
Arsenic	0	4.9	0.4956448	0	0.3822	0.29739	0.67959	0.16	4.24744
Barium	0.24	180	2.23776	0.528	14.04	1.34266	15.91066	15.37	1.03518
Beryllium	0	1.5	0.313248	0	0.117	0.18795	0.30495	1.87	0.16307
Cadmium	0	0.61	0.4696317	0	0.04758	0.28178	0.32936	0.24	1.37233
Calcium	137.36	150000	27156	302.192	11700	16293.6	28295.792		
Chloride	23.82	0	0	52.404	0	0	52.404		
Chromium	0	32	1.480704	0	2.496	0.88842	3.38442	7739	0.00044
Copper	0.07	21	1.731408	0.154	1.638	1.03884	2.83084	46.82	0.06046
Cyanide	0	0.64	0	0	0.04992	0	0.04992	17.9	0.00279
Fluoride	2.31	0	0	5.082	0	0	5.082	125.43	0.04052
Lead	0.02	22	0.444928	0.044	1.716	0.26696	2.02696	22.6	0.08969
Magnesium	21.91	11000	413.424	48.202	858	248.0544	1154.2564		
Manganese	0.37	1800	25.056	0.814	140.4	15.0336	156.2476	248.8	0.628
Mercury	0	0.14	0.1291786	0	0.01092	0.07751	0.08843	0.09	0.98256
Nickel	0	32	0	0	2.496	0	2.496	113.1	0.02207
Sodium	18.71	160	1477.5091	41.162	12.48	886.5055	940.14747		
Sulfate	266.26	0	0	585.772	0	0	585.772		
Vanadium	0	36	0	0	2.808	0	2.808	0.538	5.21933

Table C2.12. Estimated Contaminant Exposure and Hazard Assessment for Short-tailed Shrew at the OHF area

Analyte	Media Concentrations (mg /L or kg)			Estimated Exposure (mg/kg/d)			Toxicity Benchmark for Short-tailed Shrew (mg/kg/d)	Hazard Quotient ^c
	Water (95% UCL)	Soil (95% UCL)	Estimated in Earthworm ^a (95% UCL)	Water	Soil	Food		
Zinc	0.15	68	60.815936	0.33	5.304	36.48956	42.12356	0.09311
Acetone	0	0.03	0	0	0.00234	0	0.00234	0.00008
Aroclor 1254	0	0.04	0.0454816	0	0.00312	0.02729	0.03041	0.20273
Aroclor 1260	0	0.04	0.0454816	0	0.00312	0.02729	0.03041	0.20273
Bis(2-Ethylhexyl) Phthalate	0	0.42	0	0	0.03276	0	0.03276	0.00142
Butyl Benzyl Phthalate	0	0.43	0	0	0.03354	0	0.03354	
Di-n-butyl Phthalate	0	0.43	0	0	0.03354	0	0.03354	0.00005
p-Nitrophenol	0	1	0	0	0.078	0	0.078	
Toluene	0	0.01	0	0	0.00078	0	0.00078	0.00002
wet weight								

^a Total exposure values in bold exceed total exposure at the Background.^c Hazard Quotient = total exposure/benchmark; Values shaded and in bold exceed total exposure at the Background and benchmark

Table C2.13. Estimated Contaminant Exposure and Hazard Assessment for American Woodcock at the NHF area

Analyte	Media Concentrations (mg /L or kg)			Estimated Exposure (mg/kg/d)			Toxicity Benchmark for American Woodcock (mg/kg/d)	Hazard Quotient ^c
	Water (95% UCL)	Soil (95% UCL)	Estimated in Earthworms ^a (95% UCL)	Water	Soil	Food		
Aluminum	0.07	18000	91.296	0.00707	1418.182	69.16364	102.75	14.47545
Arsenic	0	3.4	0.3439168	0	0.26788	0.26054	8.76	0.06032
Barium	0.05	400	4.9728	0.00505	31.51515	3.76727	17.73	1.99027
Calcium	56.93	7400	1339.696	5.75051	583.0303	1014.921		
Chloride	11.4	0	0	1.15152	0	0		
Chromium	0	46	2.128512	0	3.62424	1.61251	1.84	2.84606
Copper	0	31	2.555888	0	2.44242	1.93628	46.07	0.09504
Fluoride	1.35	0	0	0.13636	0	0	7.57	0.01801
Lead	0	8.7	0.1759488	0	0.68545	0.13329	3.35	0.2444
Magnesium	12.1	7900	296.9136	1.22222	622.4242	224.9346		
Manganese	0.07	2900	40.368	0.00707	228.4849	30.58182		
Nickel	0	47	0	0	3.70303	0	121.78	0.03041
Nitrate	0.49	0	0	0.04949	0	0		
Phosphate	0.59	0	0	0.0596	0	0		
Sodium	8.69	96	886.50547	0.87778	7.56364	671.5951		
Sulfate	157	0	0	15.85859	0	0		
Vanadium	0	24	0	0	1.89091	0	20.45	0.09247

Table C2.13. Estimated Contaminant Exposure and Hazard Assessment for American Woodcock at the NHF area

Analyte	Media Concentrations (mg /L or kg)			Estimated Exposure (mg/kg/d)			Toxicity Benchmark for American Woodcock (mg/kg/d)	Hazard Quotient ^c
	Water (95% UCL)	Soil (95% UCL)	Estimated in Earthworms ^a (95% UCL)	Water	Soil	Food	Total ^b	
Zinc	0.02	69	61.710288	0.00202	5.43636	46.75022	52.1886	5.12 10.19309
Di-n-butyl Phthalate	0	0.37	0	0	0.02915	0	0.02915	0.1 0.2915
p-Nitrophenol	0	3.2	0	0	0.25212	0	0.25212	
wet weight								

^a Total exposure values in bold exceed total exposure at the Background.^c Hazard Quotient = total exposure/benchmark; Values shaded and in bold exceed total exposure at the Background and benchmark

Table C2.14. Estimated Contaminant Exposure and Hazard Assessment for Short-tailed Shrew at the NHF area

Analyte	Media Concentrations (mg /L or kg)			Estimated Exposure (mg/kg/d)			Toxicity Benchmark for Short-tailed Shrew (mg/kg/d)	Hazard Quotient ^c
	Water (95% UCL)	Soil (95% UCL)	Estimated in Earthworms ^a (95% UCL)	Water	Soil	Food	Total ^b	
Aluminum	0.07	18000	91.296	0.154	1404	54.7776	1458.9316	593.06163
Arsenic	0	3.4	0.3439168	0	0.2652	0.20635	0.47155	2.94719
Barium	0.05	400	4.9728	0.11	31.2	2.98368	34.29368	2.23121
Beryllium	0	1	0.208832	0	0.078	0.1253	0.2033	1.87
Calcium	56.93	7400	1339.696	125.246	577.2	803.8176	1506.2636	
Chloride	11.4	0	0	25.08	0	0	25.08	
Chromium	0	46	2.128512	0	3.588	1.27711	4.86511	7739
Copper	0	31	2.555888	0	2.418	1.53353	3.95153	46.82
Fluoride	1.35	0	0	2.97	0	0	2.97	125.43
Lead	0	8.7	0.1759488	0	0.6786	0.10357	0.78417	22.6
Magnesium	12.1	7900	296.9136	26.62	616.2	178.1482	820.96816	
Manganese	0.07	2900	40.368	0.154	226.2	24.2208	250.5748	248.8
Nickel	0	47	0	0	3.666	0	3.666	113.1
Nitrate	0.49	0	0	1.078	0	0	1.078	1928
Phosphate	0.59	0	0	1.298	0	0	1.298	
Sodium	8.69	96	886.50547	19.118	7.488	531.9033	558.50928	
Sulfate	157	0	0	345.4	0	0	345.4	
Vanadium	0	24	0	0	1.872	0	1.872	0.538
Zinc	0.02	69	61.710288	0.044	5.382	37.02617	42.45217	452.43

Table C2.14. Estimated Contaminant Exposure and Hazard Assessment for Short-tailed Shrew at the NIIF area

Analyte	Media Concentrations (mg /L or kg)		Estimated Exposure (mg/kg/d)			Toxicity Benchmark for Short-tailed Shrew (mg/kg/d)	Hazard Quotient ^c
	Water (95% UCL)	Soil (95% UCL)	Estimated in Earthworm ^a (95% UCL)	Water	Soil	Food	Total ^b
Di-n-butyl Phthalate	0	0.37	0	0	0.02886	0	0.02886
p-Nitrophenol	0	3.2	0	0	0.2496	0	0.2496
Toluene	0	0.01	0	0	0.00078	0	0.00078
Wet weight							32.66
							0.00002

^a Total exposure values in bold exceed total exposure at the Background.^c Hazard Quotient = total exposure/benchmark; Values shaded and in bold exceed total exposure at the Background and benchmark

Table C2.15. Estimated Contaminant Exposure and Hazard Assessment for American Woodcock at the SB area

Analyte	Media Concentrations (mg /L or kg)			Estimated Exposure (mg/kg/d)			Toxicity Benchmark for American Woodcock (mg/kg/d)	Hazard Quotient ^c	
	Water (95% UCL)	Soil (95% UCL)	Estimated in Earthworms ^a (95% UCL)	Water	Soil	Food			Total ^b
Aluminum	0	27000	136.944	0	2127.273	103.7455	2231.01818	102.75	21.71307
Arsenic	0	2.9	0.2933408	0	0.22848	0.22223	0.45071	8.76	0.05145
Barium	0	190	2.36208	0	14.9697	1.78945	16.75915	17.73	0.94524
Calcium	0	8200	1484.528	0	646.0606	1124.642	1770.70303		
Chromium	0	37	1.712064	0	2.91515	1.29702	4.21217	1.84	2.28922
Copper	0	25	2.0612	0	1.9697	1.56152	3.53122	46.07	0.07665
Lead	0	13	0.262912	0	1.02424	0.19918	1.22342	3.35	0.3652
Magnesium	0	7000	263.088	0	551.5152	199.3091	750.82424		
Manganese	0	1100	15.312	0	86.66667	11.6	98.26667		
Nickel	0	40	0	0	3.15152	0	3.15152	121.78	0.02588
Selenium	0	1	1.186512	0	0.07879	0.89887	0.97766	0.85	1.15019
Sodium	0	85	784.92672	0	6.69697	594.6415	601.33842		
Vanadium	0	30	0	0	2.36364	0	2.36364	20.45	0.11558
Zinc	0	79	70.653808	0	6.22424	53.52561	59.74985	5.12	11.66989
1,2-Benzene-dicarboxylic Acid, Diethyl Ester	0	0.46	0	0	0.03624	0	0.03624		
Aroclor 1260	0	0.05	0.056852	0	0.00394	0.04307	0.04701	0.31	0.15165

Table C2.15. Estimated Contaminant Exposure and Hazard Assessment for American Woodcock at the SB area

Analyte	Media Concentrations (mg /L or kg)			Estimated Exposure (mg/kg/d)			Toxicity Benchmark for American Woodcock (mg/kg/d)	Hazard Quotient ^c
	Water (95 % UCL)	Soil (95 % UCL)	Estimated in Earthworms ^a (95 % UCL)	Water	Soil	Food		
Bis(2-Ethylhexyl) Phthalate	0	0.47	0	0	0.03703	0	0.03703	1.02
Butyl Benzyl Phthalate	0	0.44	0	0	0.03467	0	0.03467	
Di-n-butyl Phthalate	0	0.42	0	0	0.03309	0	0.03309	0.1
wet weight								0.3309

^a Total exposure values in bold exceed total exposure at the Background.^c Hazard Quotient = total exposure/benchmark; Values shaded and in bold exceed total exposure at the Background and benchmark

2

Analyte	Media Concentrations (mg /L or kg)			Estimated Exposure (mg/kg/d)				Toxicity Benchmark for Short-tailed shrew	Hazard Quotient*
	Water (95% UCL)	Soil (95% UCL)	Estimated in Earthworms (95% UCL)*	Water	Soil	Food	Total†		
Aluminum	0	27000	136.944	0	2106	82.1664	2188.1664	2.46	889.49854
Arsenic	0	2.9	0.2933408	0	0.2262	0.176	0.4022	0.16	2.51375
Barium	0	190	2.36208	0	14.82	1.41725	16.23725	15.37	1.05642
Beryllium	0	1.4	0.2923648	0	0.1092	0.17542	0.28462	1.87	0.1522
Calcium	0	8200	1484.528	0	639.6	890.7168	1530.3168		
Chromium	0	37	1.712064	0	2.886	1.02724	3.91324	7739	0.00051
Copper	0	25	2.0612	0	1.95	1.23672	3.18672	46.82	0.06806
Lead	0	13	0.262912	0	1.014	0.15775	1.17175	22.6	0.05185
Manganese	0	1100	15.312	0	85.8	9.1872	94.9872	248.8	0.38178
Nickel	0	40	0	0	3.12	0	3.12	113.1	0.02759
Selenium	0	1	1.186512	0	0.078	0.71191	0.78991	0.094	8.4033
Sodium	0	85	784.92672	0	6.63	470.956	477.58603		
Thallium	0	0.46	0	0	0.03588	0	0.03588	0.021	1.70857
Vanadium	0	30	0	0	2.34	0	2.34	0.538	4.34944
Zinc	0	79	70.653808	0	6.162	42.39228	48.55428	452.43	0.10732
1,2-Benzene-dicarboxylic Acid, Diethyl Ester	0	0.46	0	0	0.03588	0	0.03588		
Aroclor 1260	0	0.05	0.056852	0	0.0039	0.03411	0.03801	0.15	0.2534

Table C2.16. Estimated Contaminant Exposure and Hazard Assessment Short-tailed Shrew at the SB area

Analyte	Media Concentrations (mg /L or kg)			Estimated Exposure (mg/kg/d)			Toxicity Benchmark for Short-tailed shrew	Hazard Quotient ^c
	Water (95% UCL)	Soil (95% UCL)	Estimated in Earthworms (95% UCL) ^a	Water	Soil	Food		
Bis(2-Ethylhexyl) Phthalate	0	0.47	0	0	0.03666	0	23.04	0.00159
Butyl Benzyl Phthalate	0	0.44	0	0	0.03432	0	0.03432	
Chloroform	0	0.01	0	0	0.00078	0	42.41	0.00002
Di-n-butyl Phthalate	0	0.42	0	0	0.03276	0	691.35	0.00005
Toluene	0	0.01	0	0	0.00078	0	32.66	0.00002
wet weight								

^a Total exposure values in bold exceed total exposure at the Background.^c Hazard Quotient = total exposure/benchmark; Values shaded and in bold exceed total exposure at the Background and benchmark

Table C2.17. Estimated Contaminant Exposure and Hazard Assessment for American Woodcock at the S5 area

Analyte	Media Concentrations (mg /L or kg)			Estimated Exposure (mg/kg/d)			Toxicity Benchmark for American Woodcock (mg/kg/d)	Hazard Quotient ^e	
	Water (95% UCL)	Soil (95% UCL)	Estimated in Earthworms ^d (95% UCL)	Water	Soil	Food			Total ^b
Aluminum	4.61	22000	111.584	0.46566	1733.333	84.53333	1818.33232	102.75	17.69666
Antimony	0	16	0	0	1.26061	0	1.26061		
Arsenic	0.01	4.9	0.4956448	0.00101	0.38606	0.37549	0.76256	8.76	0.08705
Barium	0.18	180	2.23776	0.01818	14.18182	1.69527	15.89527	17.73	0.89652
Calcium	110.64	15000	2715.6	11.17576	1181.818	2057.273	3250.26667		
Chloride	37.14	0	0	3.75152	0	0	3.75152		
Chromium	0.03	32	1.480704	0.00303	2.52121	1.12175	3.64599	1.84	1.98152
Copper	0.03	22	1.813856	0.00303	1.73333	1.37413	3.11049	46.07	0.06752
Cyanide	0	0.61	0	0	0.04806	0	0.04806		
Fluoride	0.26	0	0	0.02626	0	0	0.02626	7.57	0.00347
Lead	0.01	25	0.5056	0.00101	1.9697	0.38303	2.35374	3.35	0.70261
Manganese	5.35	1800	25.056	0.5404	141.8182	18.98182	161.3404		
Mercury	0	0.43	0.3967627	0	0.03388	0.30058	0.33446	0.011	30.40545
Nickel	0.2	33	0	0.0202	2.6	0	2.6202	121.78	0.02152
Nitrate	2.34	0	0	0.23636	0	0	0.23636		
Phosphate	0.19	0	0	0.01919	0	0	0.01919		
Selenium	0.24	0.99	1.1746469	0.02424	0.078	0.88988	0.99212	0.85	1.1672

Table C2.17. Estimated Contaminant Exposure and Hazard Assessment for American Woodcock at the S5 area

Analyte	Media Concentrations (mg /L or kg)			Estimated Exposure (mg/kg/d)			Toxicity Benchmark for American Woodcock (mg/kg/d)	Hazard Quotient ^c
	Water (95% UCL)	Soil (95% UCL)	Estimated in Earthworms ^a (95% UCL)	Water	Soil	Food		
Sodium	20.34	110	1015.7875	2.05455	8.66667	769.536	780.25722	
Sulfate	64.49	0	0	6.51414	0	0	6.51414	
Vanadium	0.02	30	0	0.00202	2.36364	0	2.36566	20.45
Zinc	0.02	71	63.498992	0.00202	5.59394	48.1053	53.70126	5.12
1,2-Dichloromethane	0	0.01	0	0	0.00079	0	0.00079	34.27
1,2-Dichloroethene (Total)	0.32	0.01	0	0.03232	0.00079	0	0.03311	0.00002
Amclor 1260	0	0.16	0.1819264	0	0.01261	0.13782	0.15043	0.31
Benzene, 1,2,4-Trichloro-	0.12	0	0	0.01212	0	0	0.01212	
Benzo(k)Fluoranthene	0	0.42	0	0	0.03309	0	0.03309	
Bis(2-Ethylhexyl) Phthalate	0	0.42	0	0	0.03309	0	0.03309	1.02
Ethylbenzene	0	0.01	0	0	0.00079	0	0.00079	
Trichloroethene	0.04	0	0	0.00404	0	0	0.00404	
Vinyl Chloride	0.04	0	0	0.00404	0	0	0.00404	
Xylene	0.05	0	0	0.00505	0	0	0.00505	
wet weight								

^a Total exposure values in bold exceed total exposure at the Background.^c Hazard Quotient = total exposure/benchmark; Values shaded and in bold exceed total exposure at the Background and benchmark

Table C2.18. Estimated Contaminant Exposure and Hazard Assessment for Short-tailed Shrew at the S5 area

Analyte	Media Concentrations (mg /L or kg)			Estimated Exposure (mg/kg/d)			Toxicity Benchmark for Short-tailed Shrew (mg/kg/d)	Hazard Quotient ^c
	Water (95 % UCL)	Soil (95 % UCL)	Estimated in Earthworms ^a (95 % UCL)	Water	Soil	Food	Total ^b	
Aluminum	4.61	22000	111.584	10.142	1716	66.9504	1793.0924	728.89935
Antimony	0	16	0	0	1.248	0	1.248	7.8
Arsenic	0.01	4.9	0.4956448	0.022	0.3822	0.29739	0.70159	4.38494
Barium	0.18	180	2.23776	0.396	14.04	1.34266	15.77866	1.02659
Beryllium	0	1.2	0.2505984	0	0.0936	0.15036	0.24396	0.13046
Calcium	110.64	15000	2715.6	243.408	1170	1629.36	3042.768	
Chloride	37.14	0	0	81.708	0	0	81.708	
Chromium	0.03	32	1.480704	0.066	2.496	0.88842	3.45042	0.00045
Copper	0.03	22	1.813856	0.066	1.716	1.08831	2.87031	0.06131
Cyanide	0	0.61	0	0	0.04758	0	0.04758	0.00266
Fluoride	0.26	0	0	0.572	0	0	0.572	0.00456
Lead	0.01	25	0.5056	0.022	1.95	0.30336	2.27536	0.10068
Manganese	5.35	1800	25.056	11.77	140.4	15.0336	167.2036	0.67204
Mercury	0	0.43	0.3967627	0	0.03354	0.23806	0.2716	3.01778
Nickel	0.2	33	0	0.44	2.574	0	3.014	0.02665
Nitrate	2.34	0	0	5.148	0	0	5.148	0.00267
Phosphate	0.19	0	0	0.418	0	0	0.418	
Selenium	0.24	0.99	1.1746469	0.528	0.07722	0.70479	1.31001	13.93628
Sodium	20.34	110	1015.7875	44.748	8.58	609.4725	662.80051	

Table C2.18. Estimated Contaminant Exposure and Hazard Assessment for Short-tailed Shrew at the S5 area

Analyte	Media Concentrations (mg /L or kg)			Estimated Exposure (mg/kg/d)			Toxicity Benchmark for Short-tailed Shrew (mg/kg/d)	Hazard Quotient ^c
	Water (95 % UCL)	Soil (95 % UCL)	Estimated in Earthworm ^a (95 % UCL)	Water	Soil	Food	Total ^b	
Sulfate	64.49	0	0	141.878	0	0	141.878	
Thallium	0	0.56	0	0	0.04368	0	0.04368	2.08
Vanadium	0.02	30	0	0.044	2.34	0	2.384	4.43123
Zinc	0.02	71	63.498992	0.044	5.538	38.0994	43.6814	0.09655
1,2-Dichloroethane	0	0.01	0	0	0.00078	0	0.00078	0.00001
1,2-Dichloroethene (Total)	0.32	0.01	0	0.704	0.00078	0	0.70478	0.00831
Acetone	0	0.04	0	0	0.00312	0	0.00312	0.00011
Aroclor 1260	0	0.16	0.1819264	0	0.01248	0.10916	0.12164	0.81093
Benzo(k)Fluoranthene	0	0.42	0	0	0.03276	0	0.03276	
Bis(2-Ethylhexyl) Phthalate	0	0.42	0	0	0.03276	0	0.03276	0.00142
Chloroform	0	0.01	0	0	0.00078	0	0.00078	0.00002
Ethylbenzene	0	0.01	0	0	0.00078	0	0.00078	
Tetrachloroethene	0	0.01	0	0	0.00078	0	0.00078	0.00044
Toluene	0	0.01	0	0	0.00078	0	0.00078	0.00002
Trichloroethene	0.04	0	0	0.088	0	0	0.088	0.1
Vinyl Chloride	0.04	0	0	0.088	0	0	0.088	0.18333
Xylene	0.05	0	0	0.11	0	0	0.11	0.42308
wet weight								

^a Total exposure values in bold exceed total exposure at the Background.^c Hazard Quotient = total exposure/benchmark; Values shaded and in bold exceed total exposure at the Background and benchmark

Table C2.19. Estimated Contaminant Exposure and Hazard Assessment for American Woodcock at the TRU area

Analyte	Media Concentrations (mg /L or kg)			Estimated Exposure (mg/kg/d)				Toxicity Benchmark for American Woodcock (mg/kg/d)	Hazard Quotient ^e
	Water (95% UCL)	Soil (95% UCL)	Estimated in Earthworm ^a (95% UCL)	Water	Soil	Food	Total ^b		
Aluminum	4.11	26000	131.872	0.41515	2048.485	99.90303	2148.80303	102.75	20.91292
Arsenic	0	3.5	0.354032	0	0.27576	0.26821	0.54397	8.76	0.0621
Barium	0.15	150	1.8648	0.01515	11.81818	1.41273	13.24606	17.73	0.7471
Calcium	78.53	20000	3620.8	7.93232	1575.758	2743.03	4326.7202		
Chloride	11.84	0	0	1.19596	0	0	1.19596		
Chromium	0	37	1.712064	0	2.91515	1.29702	4.21217	1.84	2.28922
Copper	0	25	2.0612	0	1.9697	1.56152	3.53122	46.07	0.07665
Lead	0.01	16	0.323584	0.00101	1.26061	0.24514	1.50676	3.35	0.44978
Manganese	14.72	840	11.6928	1.48687	66.18182	8.85818	76.52687		
Mercury	0	0.09	0.0830434	0	0.00709	0.06291	0.07	0.011	6.36364
Nickel	0	32	0	0	2.52121	0	2.52121	121.78	0.0207
Selenium	0	3.1	3.6781872	0	0.24424	2.78651	3.03075	0.85	3.56559
Sodium	11.4	0	0	1.15152	0	0	1.15152		
Sulfate	103.52	0	0	10.45657	0	0	10.45657		
Vanadium	0	32	0	0	2.52121	0	2.52121	20.45	0.12329
Zinc	0	64	57.238528	0	5.04242	43.36252	48.40494	5.12	9.45409

Table C2.19. Estimated Contaminant Exposure and Hazard Assessment for American Woodcock at the TRU area

Analyte	Media Concentrations (mg /L or kg)			Estimated Exposure (mg/kg/d)			Toxicity Benchmark for American Woodcock (mg/kg/d)	Hazard Quotient ^c
	Water (95% UCL)	Soil (95% UCL)	Estimated in Earthworms ^a (95% UCL)	Water	Soil	Food	Total ^b	
1,2-Benzene-dicarboxylic Acid, Diethyl Ester	0	0.41	0	0	0.0323	0	0.0323	
Aroclor 1260	0	0.04	0.0454816	0	0.00315	0.03446	0.03761	0.31
Bis(2-Ethylhexyl) Phthalate	0	0.46	0	0	0.03624	0	0.03624	1.02
Di-n-butyl Phthalate	0	0.09	0	0	0.00709	0	0.00709	0.1
Methylene Chloride	0	0.01	0	0	0.00079	0	0.00079	0.0709
wet weight								

^a Total exposure values in bold exceed total exposure at the Background.

^c Hazard Quotient = total exposure/benchmark; Values shaded and in bold exceed total exposure at the Background and benchmark

Table C2.20. Estimated Contaminant Exposure and Hazard Assessment for Short-tailed Shrew at the TRU area

Analyte	Media Concentrations (mg /L or kg)			Estimated Exposure (mg/kg/d)				Toxicity Benchmark for Short-tailed Shrew (mg/kg/d)	Hazard Quotient ^c
	Water (95% UCL)	Soil (95% UCL)	Estimated in Earthworms ^a (95% UCL)	Water	Soil	Food	Total ^b		
Aluminum	4.11	26000	131.872	9.042	2028	79.1232	2116.1652	2.46	860.22976
Arsenic	0	3.5	0.354032	0	0.273	0.21242	0.48542	0.16	3.03388
Barium	0.15	150	1.8648	0.33	11.7	1.11888	13.14888	15.37	0.85549
Beryllium	0	1.4	0.2923648	0	0.1092	0.17542	0.28462	1.87	0.1522
Calcium	78.53	20000	3620.8	172.766	1560	2172.48	3905.246		
Chloride	11.84	0	0	26.048	0	0	26.048		
Chromium	0	37	1.712064	0	2.886	1.02724	3.91324	7739	0.00051
Copper	0	25	2.0612	0	1.95	1.23672	3.18672	46.82	0.06806
Lead	0.01	16	0.323584	0.022	1.248	0.19415	1.46415	22.6	0.06479
Manganese	14.72	840	11.6928	32.384	65.52	7.01568	104.91968	248.8	0.4217
Mercury	0	0.09	0.0830434	0	0.00702	0.04983	0.05685	0.09	0.63167
Nickel	0	32	0	0	2.496	0	2.496	113.1	0.02207
Selenium	0	3.1	3.6781872	0	0.2418	2.20691	2.44871	0.094	26.05011
Sodium	11.4	0	0	25.08	0	0	25.08		
Sulfate	103.52	0	0	227.744	0	0	227.744		
Vanadium	0	32	0	0	2.496	0	2.496	0.538	4.63941
Zinc	0	64	57.238528	0	4.992	34.34312	39.33512	452.43	0.08694
1,2-Benzene-dicarboxylic Acid, Diethyl Ester	0	0.41	0	0	0.03198	0	0.03198		

Table C2.20. Estimated Contaminant Exposure and Hazard Assessment for Short-tailed Shrew at the TRU area

Analyte	Media Concentrations (mg /L or kg)			Estimated Exposure (mg/kg/d)			Toxicity Benchmark for Short-tailed Shrew (mg/kg/d)	Hazard Quotient ^c
	Water (95% UCL)	Soil (95% UCL)	Estimated in Earthworms ^a (95% UCL)	Water	Soil	Food	Total ^b	
Aroclor 1260	0	0.04	0.0454816	0	0.00312	0.02729	0.03041	0.20273
Bis(2-Ethylhexyl) Phthalate	0	0.46	0	0	0.03588	0	0.03588	0.00156
Di-n-butyl Phthalate	0	0.09	0	0	0.00702	0	0.00702	0.00001
Methylene Chloride	0	0.01	0	0	0.00078	0	0.00078	0.00005

wet weight

^a Total exposure values in bold exceed total exposure at the Background.

^c Hazard Quotient = total exposure/benchmark; Values shaded and in bold exceed total exposure at the Background and benchmark

Tables C2.21 Estimated NOAEL's for Short-tailed Shrew in WAG5

Contaminant	Experimental Information				Estimated NOAEL (mg/kg/d)
	Form	Test Species and Duration	Endpoint	Citation	
Aluminum	chloride	mouse	1.93 ² 3 gen. reproduction /growth	Ondreicka et al. 1966	2.4
Antimony	antimony potassium tartrate	mouse	0.125 ² lifetime longevity	Schroeder et al. 1968	0.16
Arsenic	As + 3	mouse	1.26 ² 3 gen. reproduction	Schroeder and Mitchner 1971	0.16
Barium	chloride	rat	0.51 16 mo. growth, cardiovascular.	Perry et al. 1983	15
Beryllium	sulfate	rat	0.66 1126 d longevity/wt. loss	Schroeder and Mitchner 1975	1.9
Cadmium	soluble salt	mouse	0.19 ² 2 gen. reproduction	Schroeder and Mitchner 1971	0.24
Chromium	Cr + 3	rat	2737 2 yr longevity reproduction	Ivankovic and Preussmann 1975	7739
Copper	sulfate	mink	11.71 1 yr reproduction	Aulerich et al. 1982	46.8
Cyanide	potassium cyanide	rat	6.87 ² gestation reproduction	Tewe and Maner 1981	17.9
Fluoride	NaF	mink	31.4 382 d reproduction	Aulerich et al. 1987	125
Lead	acetate	rat	8 3 gen. reproduction	Azar et al. 1973	22.6

Tables C2.21 Estimated NOAEL's for Short-tailed Shrew in WAG5

Contaminant	Experimental Information				Estimated NOAEL (mg/kg/d)
	Form	Test Species and Duration	NOAEL (mg/kg/d)	Endpoint	
Manganese	oxide	rat	88 224 d	reproduction	Laskey et al. 1982 249
Mercury	methyl	rat	0.032 3 gen	reproduction	Verschuuren et al. 1976 0.09
Nickel	sulfate	rat	40 3 gen.	reproduction	Ambrose et al. 1976 113
Nitrate	potassium nitrate	guinea pig	507 204 d	reproduction	Sleight and Atallah 1968 1928
Selenium	Selenate	mouse	0.075 ² 3 gen	reproduction	Schroeder and Mitchner 1971 0.09
Thallium	thallium sulfate	rat	0.0074 ^{1,2} 60 d	reproduction	Formigli et al. 1986 0.021
Vanadium	sodium meta-vanadate	rat	0.95 gestation	reproduction	Domingo et al. 1986 0.5
Zinc	oxide	rat	160 gestation	reproduction	Schlicker and Cox 1968 452
1,1,1-Trichloroethane		mouse	1000 2 gen.	reproduction	Lane et al. 1982 1323
1,2-Dichloroethane		mouse	50 2 gen	reproduction	Lane et al. 1982 66.13
1,2-Dichloroethene		mouse	45.2 ¹ 90 d	blood chemistry	Palmer et al. 1979 84.83

Tables C2.21 Estimated NOAEL's for Short-tailed Shrew in WAG5

Contaminant	Experimental Information				Estimated NOAEL (mg/kg/d)
	Form	Test Species	NOAEL (mg/kg/d) and Duration	Endpoint	
4-Methyl-2-Pentanone		rat	25 ¹ 13 wk	liver/kidney function	70.69
Acetone		rat	10 ¹ 90 d	liver/kidney	28
Benzene		mouse	26.36 ² gestation	reproduction	33.14
Benzene hexachloride (BHC - beta isomer)		rat	0.4 ¹ 13 wks	growth blood chemistry	1.13
Benzene hexachloride (BHC - mixed isomers)		rat mink	1.6 - 4 gen 0.014 ² -331d	reproduction	4.5
bis(2-Ethylhexyl)Phthalate		mouse	18.33 105 d	reproduction	23.04
Carbon Tetrachloride		rat	16 2 yr	reproduction	45.24
Chlordane		mouse	4.6 6 gen.	reproduction	5.8
Chloroform		rat	15 ¹ 13 wks	liver/kidney effects	42.41
DDT and metabolites (DDD, DDE)		rat	0.8 2 yr	reproduction	2.3
Di-n-butyl Phthalate		mouse	550 105 d	reproduction	691.35
Endrin		mouse	0.092 ² 120 d	reproduction	0.12

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Tables C2.21 Estimated NOAEL's for Short-tailed Shrew in WAG5

Contaminant	Experimental Information				Estimated NOAEL (mg/kg/d)
	Form	Test Species and Duration	Endpoint	Citation	
Heptachlor		rat	0.8 reproduction 3 gen.	Eisler 1968	2.3
Methylene Chloride		rat	5.85 liver, 2 yr histology	NCA 1982	16.5
PCB's	Aroclor 1254	white-footed mouse/mink	0.135 ² -18mo. reproduction /0.14-4 mo.	Linzey 1987/ Aulerich and Ringer 1977	0.15
Tetrachloroethene	1,1,2,2 isomer	mouse	30 ¹ hepato 6 wk -toxicity	Buben and O'Flaherty 1985	1.8
Toluene		mouse	26 ² reproduction gestation	Nawrot and Staples 1979	33
Trichloroethene		rat	7 ^{1,2} hepato 6 wk. -toxicity	Buben and O'Flaherty 1985	0.9
Vinyl Chloride		rat	0.17 ² mortality longevity	Feron et al. 1981	0.48
Xylene	mixed isomers	mouse	2.06 reproduction gestation	Marks et al. 1982	2.6

¹ Estimated NOAEL: subchronic to chronic factor applied.

² Estimated NOAEL: LOAEL to NOAEL factor applied.

Tables C2.22. Estimated NOAEL's for American Woodcock in WAG5

Contaminant	Experimental Information					Estimated NOAEL (mg/kg/d)
	Form	Test Species and Duration	NOAEL (mg/kg/d)	Endpoint	Citation	
Aluminum	sulfate	ring dove	111.4 4 mo.	reproduction	Carriere et al. 1986	102.75
Arsenic	arsenite	mallard duck	5.14 128d	mortality	USFWS 1964	8.8
Barium	hydroxide	chicken	20.8 ¹ 4 wk	mortality	Johnson et al. 1960	17.73
Cadmium	chloride	mallard duck	1.45 90 d	reproduction	White and Finley 1978	2.59
Chromium	Cr+3	black duck	1 10 mo	reproduction	Haseltine et al. unpubl. MS	1.84
Copper	oxide	chicken	33.2 10 wk	growth/ mortality	Mehring et al. 1960	46.07
Fluoride	NaF	screech owl	7.8 5-6 mo.	reproduction	Pattee et al. 1988	7.57
Lead	metal	american kestrel	3.9 7 mo.	reproduction	Pattee 1984	3.35
Mercury	methyl	mallard duck	0.0064 ² 3 gen.	reproduction	Heinz 1979	0.011
Nickel	sulfate	mallard duck	77.4 90d	mortality, growth	Cain and Pafford 1981	121.78
Selenium	selenite	mallard duck	0.5 10 wk	reproduction	Heinz et al. 1987	0.85

Tables C2.22. Estimated NOAEL's for American Woodcock in WAGS

Contaminant	Experimental Information				Estimated NOAEL (mg/kg/d)
	Form	Test Species and Duration	Endpoint	Citation	
Vanadium	vanadyl sulfate	mallard duck	11.38 12 wk mortality blood chem.	White and Dieter 1978	20.45
Zinc	zinc carbonate	mallard duck	3 ^{1,2} 60 d mortality blood chem.	Gasaway and Buss 1972	5.12
1,2-Dichloroethane		chicken	17.2 2 yr reproduction	Alumot et al. 1976	34.27
Benzene hexachloride (BHC - mixed isomers)		japanese quail	0.56 90d reproduction	Vos et al. 1971	0.51
bis(2-Ethylhexyl)Phthalate		ring dove	1.11 4 wk reproduction	Peakall 1974	1.02
Chlordane		redwinged blackbird	2.14 84 d mortality	Stickel et al. 1983	1.47
DDT and metabolites (DDD, DDE)		Brown Pelican	0.0028 ¹ > 1 yr reproduction	Anderson et al. 1975	0.0072
Di-n-butyl Phthalate		ringed dove	0.11 ² 4 wk reproduction	Peakall 1974	0.1
Endrin		mallard duck	0.3 > 200d reproduction	Spann et al. 1986	0.54
PCB's	Aroclor 1254	Ring-necked Pheasant	0.18 17 wk reproduction	Dahlgren et al. 1972	0.31

¹ Estimated NOAEL: subchronic to chronic factor applied.

² Estimated NOAEL: LOAEL to NOAEL factor applied.

³ NOAEL as determined in EPA 1993b

Table C2.23. Summary of aquatic toxicological benchmarks* (ug/L) used in this assessment.

Analyte	NAWQC	Secondary Values			Lowest Chronic Values			Lowest EC20			Sensitive Species	Population
		Acute	Chronic	Chronic	Fish	Daphnids	Non-Daphnids	Plants	Fish	Daphnids		
Inorganics												
Aluminum	750				3,288	1,900		460	4,700	540		
Barium		68.8				5,800						
Boron		11,000	547			8,830						
Calcium						116,000						
Cobalt		105			290							
Fluoride		19,200	1140		8,784	4,400			5,336	3,706		1,080
Iron				1,000								
Magnesium						82,000						
Manganese		1,470			1,770	1,100			1,270	1,100		112
Nickel	1,400	160			35		128.4		62	45		215
Potassium						53,000						
Selenium	260	35			88.32	91.65		100	40	25	2.6	
Sodium						680,000						
Organics												
1,1-Dichloroethane		834	46.6		14,680				8,219			1,585
1,1-Dichloroethene		3,520	196		> 2,800	4,720		> 798,000				447
1,2-Dichloroethene (Total)		558	31.2		9,538				5,719			
Benzene		815	45.50		8,250	> 98,000		525,000	21			229
BHC (other than lindane)		43.6	2.44			95						
Bis(2-Ethylhexyl) Phthalate		286	32.2		8.4	3			54	3		50

Analyte ^a	NAWQC			Secondary Values			Lowest Chronic Values				Lowest EC20		EC20	
	Acute	Chronic	Acute ..	Chronic	Fish	Daphnids	Non-Daphnids	Plants	Fish	Daphnids	Sensitive Species	Population		
Carbon disulfide			159	8.89	9538	244			5719			1000		
Chloroform			3360	188	1240	4480			8400			562		
Tetrachloroethene			1,060	71.3	840	750		816,000	500	510		50		
Toluene			3150	176	1296	25229		245,000	<26			200		
Trichloroethene			3,290	354	11,060	7,257			5,758			232		
Vinyl Chloride			1,570	87.8	28,879				14,520					

^a Missing values indicate that a benchmark was not available for that analyte or that the benchmark was not used because it was below the mean background concentration.

^b Includes all detected analytes for which the maximum total recoverable concentration exceeded background and for which at least one benchmark was used. Organic analytes detected in sediments and evaluated for effects on sediment-associated biota using the EqP approach are also included.

Table C.24. Descriptions of the ecotoxicological screening benchmarks for aquatic biota.
More details are presented by Suter and Mabrey (1994).

Benchmark	Abbreviation	Description
Acute National Ambient Water Quality Criteria	NAWQC Acute	Current national criteria for protection of aquatic life from lethal effects in episodic exposures.
Chronic National Ambient Water Quality Criteria	NAWQC Chronic	Current national criteria for protection of aquatic life from lethal and sublethal effects in extended exposures. Criteria for uses of aquatic life (i.e., fish consumption) are not included.
Secondary Acute Value	SAV	Values estimated with 80% confidence to not exceed the unknown acute NAWQC. Used when data are inadequate to calculate the acute criterion.
Secondary Chronic Value	SCV	Values estimated with 80% confidence to not exceed the unknown chronic NAWQC. Used when data are inadequate to calculate the chronic criterion.
Lowest Chronic Value for fish	LCV Fish	The lowest value, from acceptable fish chronic toxicity tests, of the geometric mean of the Lowest Observed Effect Concentration (LOEC) and the No Observed Effect Concentration (NOEC).
Lowest Chronic Value for daphnids	LCV Daphnids	The lowest value, from acceptable daphnid chronic toxicity tests, of the geometric mean of the LOEC and the NOEC.
Lowest Chronic Value for nondaphnid invertebrates	LCV Nondaphnids	The lowest value of the geometric mean of the LOEC and the NOEC from acceptable chronic toxicity tests of nondaphnid invertebrate species.
Lowest Plant Value	LCV Plants	The lowest value from an acceptable daphnid chronic toxicity test of the geometric mean of the LOEC and the NOEC.
Lowest Test EC20 for Fish	LTV Fish	The lowest value, from acceptable fish chronic toxicity tests, of the lowest concentration causing at least a 20% reduction in the weight of young per female or the weight of young per egg.
Lowest Test EC20 for Daphnids	LTV Daphnids	The lowest value from an acceptable daphnid chronic toxicity test of the lowest concentration causing at least a 20% reduction in the product of survivorship, growth, and fecundity.
Sensitive Species EC20	SS EC20	A value analogous to the chronic NAWQC but which uses fish and daphnid EC20s in place of CVs in the calculation.

Table C.24. Descriptions of the ecotoxicological screening benchmarks for aquatic biota.
More details are presented by Suter and Mabrey (1994).

Benchmark	Abbreviation	Description
Population EC20	POP EC20	A concentration estimated to cause a 25% reduction in recruit abundance of a largemouth bass population.

Table C2.25. Toxicological benchmarks for evaluating contaminants of potential concern in sediments for effects on sediment-associated biota (mg/kg dry weight)

Analyte	EPA Region IV Screening Value ^{a,b}	NOAA ^a		Beak SQG ^{a,c}	Ont. MOE ^a Low	Wisconsin DNR ^a SQC ^a	EPA ^a Region V Nonpolluted Classification
		ER-L ^a	ER-M ^a				
Arsenic	8	8.2	70	17‡	6	10	<3
Barium						500	<20
Iron				5.9%*	3%		<17,000
Manganese				1,200*	460		<300
Mercury	0.1	0.15	0.71	0.6*	0.2	0.1	<1
Nickel	20.9	21	51.6	92‡	16	100	<20
Silver	2 ^d	1	3.7				
Total PCBs	0.033 ^d						

^a ER-L = effects range-low; NOAA = National Oceanic and Atmospheric Administration; ER-M = effects range-median; SQG = sediment quality guideline; Ont. MOE=Ontario Ministry of the Environment; Low=lowest effect level; DNR = Department of Natural Resources; SQC = sediment quality criterion; EPA = U.S. Environmental Protection Agency.

^b Draft Region IV Waste Management Division Sediment Screening Values for Hazardous Waste Sites, February 16, 1994.

^c Beak Consultants (Canada) SQGs, from the SLC method, were derived in mg/kg TOC and adjusted to a bulk sediment basis, assuming average 4% TOC (Hart et al. 1988). Method of derivation: * = background; † = SLC; ‡ = toxicity test.

^d Contract Laboratory Program Practical Quantification Limit.

Table C2.26. Descriptions of the ecotoxicological screening benchmarks for benthic biota exposed to contaminated sediments. More details are presented by Hull and Suter (1994), Long et al. (1995) and Region IV (1994). The last three benchmarks are used only when none of the first five are available.

Benchmark	Abbreviation	Description
Effects Range-Low	ER-L	The tenth percentile of estuarine sediment concentrations reported to be associated with some level of toxic effects.
Effects Range-Median	ER-M	The fiftieth percentile of estuarine sediment concentrations reported to be associated with some level of toxic effects.
Region IV Benchmark	Region IV Value	The higher of two values, the EPA Contract Laboratory Program Practical Quantification Limit (CLP PQL) and the Effects Value which is the lower of the ER-L and the Florida NOEL.
National Sediment Quality Criteria	EPA SQC	Sediment quality criteria based on toxicity in water expressed as chronic water quality criteria (recalculated after adding some benthic species) and partitioning of the contaminant between organic matter (1 % of sediment by weight) and pore water.
Equilibrium Partitioning Benchmark	EqP	Benchmarks derived in the same manner as sediment quality criteria except that the expression of aqueous toxicity is the chronic NAWQC or the lowest CV for any species, and location-specific percent organic matter is used.
Ontario Ministry of the Environment Lowest Effect Level	MOE Low	Concentrations determined by the Ontario MOE to constitute thresholds for toxic effects in Ontario sediments.
Region V Benchmark	Region V Value	A concentration determined to constitute background for sediments in Illinois.
Apparent Effect Threshold	AET	A concentration above which toxic effects occurred at all sites in Puget Sound.

Table C2.27 Characteristics of Soil Used in Cabbage Seedling Tests.

soil sample	initial moisture content	water holding capacity (ml H ₂ O/g soil)	pH	organic matter content	mean soil mass/beaker (g)
Promix®	0%	4.95	-	-	19.0
one	26%	0.52	6.48	5.0%	30.2
two	18%	0.66	5.26	3.2%	47.0
three	22%	0.54	7.49	4.0%	37.9

**Table C2.28. Cabbage Seedling Test Growth Results for
WAG-5 Soils**

(standard deviation in parentheses)

* means are significantly different from control by one-tailed Dunnett's test ($p < 0.05$)

soil treatment	N	mean seedling height (mm)	mean above- ground biomass (mg)
control (Promix®)	15	22.3 (4.05)	18.5 (4.74)
sample one	12	16.9 (5.70)*	10.1 (3.11)*
sample two	12	11.5 (4.48)*	6.3 (3.10)*
sample three	14	13.6 (7.11)*	11.2 (6.43)*

Table C2.29. Frequency table for cabbage seed germination

	Promix®	sample one	sample two	sample three
non-germinating seeds	2	10	12	9
germinating seeds	28	20	18	21

Table C2.30. Frequency table for morphological appearance

	Promix®	sample one	sample two	sample three
healthy plants	12	7	7	4
unhealthy plants	3	5	5	10

Table C2.31. Results of 14-d Earthworm Test on WAG-5 Soils

(standard deviation in parentheses)

soil sample	N	mean survival (out of ten)	mean fresh mass per jar (g)	mean combustible mass per jar (g)
artificial soil	4	10.00 (0.00)	3.445 (0.3712)	0.1857 (0.0323)
one	4	10.00 (0.00)	3.6375 (0.1685)	0.1555 (0.0435)
two	4	10.00 (0.00)	3.3272 (0.3858)	0.1444 (0.0532)
three	4	9.75 (0.50)	3.1188 (0.5756)	0.1667 (0.0501)

Table C2.32. Correspondence of Aquatic Toxicity Sampling Sites to WAG 5 Sampling Locations

AQUATIC TOXICITY SAMPLE SITE	WAG 5 SAMPLING LOCATION
1	Seep 001
2	SD003 (Seep on Drainage D-1)
3	SW001 (Mouth of Drainage D-1)
4	Seep 004
5	OHF Impoundment
6	Seep 006
7	SW002 (Mouth of Drainage D-2)
8	Seep 008
9	Seep 009
10	Process Waste Sludge Basin

Table C2.33. Results of *Ceriodaphnia* toxicity tests of WAG 5 water samples during test period 1 (December 12-18, 1991) and test period 2 (February 27 — March 5, 1992).

Site	Test period 1		Test period 2	
	Survival (%)	Reproduction (mean $\pm$ SE)	Survival (%)	Reproduction (mean $\pm$ SE)
Control	100	19.4 $\pm$ 3.5	100	19.2 $\pm$ 1.0
2	80	19.4 $\pm$ 3.4	90	16.8 $\pm$ 1.8
3	80	21.1 $\pm$ 2.5	90	13.1 $\pm$ 1.9*
4	90	10.7 $\pm$ 2.8	70	9.3 $\pm$ 0.7*
7	100	14.5 $\pm$ 2.3	80	15.9 $\pm$ 1.1
8	80	12.9 $\pm$ 1.0	100	14.8 $\pm$ 1.3
9	70	0.9 $\pm$ 0.6*	100	8.2 $\pm$ 0.9*

*Significantly lower than the corresponding test-period control based on Tukey's test ($P < 0.05$).

Table C2.34. Results of *Ceriodaphnia* toxicity test of water from WAG 5 site 6 (April 30 — May 7, 1992).

Site	Survival (%)	Reproduction (mean $\pm$ SE)
LR-o (nonfiltered)	90	47.7 $\pm$ 3.3
LR-o (filtered) ^b	100	47.5 $\pm$ 1.5
WAG 5 Site 6	50	21.2 $\pm$ 1.5

^a The diluted mineral water control for this test was unacceptable. Thus, the results of an ambient toxicity test of filtered and nonfiltered water from the outfall of Lake Reality (LR-o; the Oak Ridge Y-12 Plant settling basin) conducted during the same period are provided for comparative purposes.

^bWater samples was filtered through a 0.5- μ m pore size glass fiber filter to remove particulate matter prior to testing.

Table C2.35. Summary of results of water quality analyses, WAG5 sites, for toxicity tests conducted during December 12-18, 1991. Values are means ($\pm$ SE).

Water quality factor	Site 2	Site 3	Site 4	Site 7	Site 8	Site 9
pH (standard units)	7.78 $\pm$ 0.22	7.75 $\pm$ 0.12	7.72 $\pm$ 0.16	7.82 $\pm$ 0.16	7.74 $\pm$ 0.20	7.68 $\pm$ 0.20
Conductivity (μ S)	375 $\pm$ 81	341 $\pm$ 45	498 $\pm$ 26	480 $\pm$ 28	473 $\pm$ 75	596 $\pm$ 6.0
Alkalinity (mg/L CaCO ₃)	124 $\pm$ 28	127 $\pm$ 29	234 $\pm$ 9	225 $\pm$ 13	213 $\pm$ 35	299 $\pm$ 5
Hardness (mg/L CaCO ₃)	197 $\pm$ 39	170 $\pm$ 15	245 $\pm$ 19	224 $\pm$ 9	216 $\pm$ 19	295 $\pm$ 11
Dissolved oxygen (mg/L)	8.2 $\pm$ 0.1	8.3 $\pm$ 0.1	8.1 $\pm$ 0.1	8.2 $\pm$ 0.1	8.1 $\pm$ 0.1	7.8 $\pm$ 0.2

Table C2.36. Summary of results of water quality analyses, WAG5 sites, for toxicity tests conducted during February 27 – March 5, 1992. Values are means ($\pm$ SE).

Water quality factor	Site 2	Site 3	Site 4	Site 7	Site 8	Site 9
pH (standard units)	7.91 $\pm$ 0.09	8.11 $\pm$ 0.03	8.14 $\pm$ 0.03	8.19 $\pm$ 0.03	7.87 $\pm$ 0.16	8.12 $\pm$ 0.06
Conductivity (μ S)	278 $\pm$ 18	315 $\pm$ 11	522 $\pm$ 11	541 $\pm$ 4	650 $\pm$ 8	605 $\pm$ 5
Alkalinity (mg/L CaCO ₃)	102 $\pm$ 6	114 $\pm$ 5	260 $\pm$ 7	269 $\pm$ 4	354 $\pm$ 24	301 $\pm$ 2
Hardness (mg/L CaCO ₃)	135 $\pm$ 10	159 $\pm$ 7	278 $\pm$ 5	269 $\pm$ 3	294 $\pm$ 4	285 $\pm$ 8
Dissolved oxygen (mg/L)	8.1 $\pm$ 0.2	8.3 $\pm$ 0.1	8.0 $\pm$ 0.2	7.9 $\pm$ 0.2	7.9 $\pm$ 0.2	8.0 $\pm$ 0.2

Table C2.37. Summary of results of water quality analyses, WAG 5 site 6, for the toxicity tests conducted during April 30 — May 7, 1992. Values are for single measurements made from the grab sample on the first day of the test.

Water quality factor	Site 6
pH (standard units)	7.42
Conductivity (μ S)	170
Alkalinity (mg/L CaCO_3)	72
Hardness (mg/L CaCO_3)	96
Dissolved oxygen (mg/L)	8.4

Table C2.38. Summary physical and chemical properties for WAG5 earthworm sampling locations

Location	No. Grids Sampled	Avg. No. Worms m ²	Immature/ AdultWorm Ratio	TOC (mg/kg)	CEC (meq/g)	Soil pH	Soil Temp. (°C)	Soil Moisture (kPa)	Soil Texture	Percent Cover	Habitat
05.SB008	26	25	0.691	26600	21.93	6.82	62.3	3.0	silt clay	32.5	forest
05.SB049	31	13.7		9430	20.62		63.1	11.2	silt sand	70.0	grass
05.SB046	27	27.8	0.828	39300	18.08	7.64	59.9	15.4	silt clay	76.7	grass
05.SB063	22	41.7	0.684	21600	30.09		59.9	10.6	sand silt	54.1	forest
05.SB057	24	61	0.897	27300	23.73		58.5	8.5	silt sand	22.7	forest
05.SB062	13	59.1	0.736	22300	21.44		61.1	7.5	silt clay	15.0	forest

Table C2.39. Comparison of soil from earthworm sampling locations to 2 x background values.

Station	Analyte	Result	Units	Background Soil Concentration (mean x 2)	Exceeds Background?
05.SB008	Alpha	6.77	PCI/G		
	Aluminum	16200	MG/KG	5.00e+04	NO
	Aroclor 1260	0.011	MG/KG	1.60e-01	NO
	Arsenic	3.7	MG/KG	1.30e+01	NO
	Barium	205	MG/KG	2.40e+02	NO
	Beryllium	0.97	MG/KG	2.10e+00	NO
	Beta	840	PCI/G		
	Cadmium	1.2	MG/KG	4.40e-01	YES
	Calcium	3180	MG/KG	2.60e+03	YES
	Chromium	22	MG/KG	5.10e+01	NO
	Cobalt	24.6	MG/KG	3.70e+01	NO
	Copper	16	MG/KG	3.80e+01	NO
	Cs-137	0.954	PCI/G	1.40e+00	NO
	Iron	32600	MG/KG	6.70e+04	NO
	K-40	12	PCI/G	3.20e+01	NO
	Lead	17.6	MG/KG	4.40e+01	NO
	Magnesium	2890	MG/KG	7.30e+03	NO
	Manganese	5540	MG/KG	2.40e+03	YES
	Mercury	0.09	MG/KG	5.90e-01	NO
	Nickel	20.7	MG/KG	5.80e+01	NO
	Potassium	1660	MG/KG	5.70e+03	NO
	Selenium	5.1	MG/KG	1.30e+00	YES
	Silver	1.2	MG/KG	4.00e+00	NO
	Sodium	206	MG/KG		
	Radio Strontium	408	PCI/G	1.90e+00	YES
	Vanadium	25.4	MG/KG	7.60e+01	NO
	Zinc	51.9	MG/KG	1.20e+02	NO
05.SB046	Alpha	22.4	PCI/G		
	Aluminum	10600	MG/KG	5.00e+04	NO

Table C2.39. Comparison of soil from earthworm sampling locations to 2 x background values.

Station	Analyte	Result	Units	Background Soil Concentration (mean x 2)	Exceeds Background?
	Aroclor 1254	0.14	MG/KG	1.60e-01	NO
	Aroclor 1260	0.28	MG/KG	1.60e-01	YES
	Arsenic	5.3	MG/KG	1.30e+01	NO
	Barium	108	MG/KG	2.40e+02	NO
	Beryllium	0.84	MG/KG	2.10e+00	NO
	Beta	1100	PCI/G		
	Cadmium	0.78	MG/KG	4.40e-01	NO
	Calcium	68500	MG/KG	2.60e+03	YES
	Chromium	26	MG/KG	5.10e+01	NO
	Co-60	6.07	PCI/G	1.90e-02	YES
	Cobalt	15	MG/KG	3.70e+01	NO
	Copper	10.9	MG/KG	3.80e+01	NO
	Cs-137	3900	PCI/G	1.40e+00	YES
	Iron	26400	MG/KG	6.70e+04	NO
	K-40	10.1	PCI/G	3.20e+01	NO
	Lead	26.1	MG/KG	4.40e+01	NO
	Magnesium	11900	MG/KG	7.30e+03	YES
	Manganese	1080	MG/KG	2.40e+03	NO
	Mercury	1.7	MG/KG	5.90e-01	YES
	Nickel	13.1	MG/KG	5.80e+01	NO
	Potassium	1290	MG/KG	5.70e+03	NO
	Silver	1	MG/KG	4.00e+00	NO
	Sodium	187	MG/KG		
	Vanadium	24.5	MG/KG	7.60e+01	NO
	Zinc	56.4	MG/KG	1.20e+02	NO
05.SB049	Alpha	12.1	PCI/G		
	Aluminum	18400	MG/KG	5.00e+04	NO
	Aroclor 1260	0.14	MG/KG	1.60e-01	NO
	Arsenic	4.5	MG/KG	1.30e+01	NO

Table C2.39. Comparison of soil from earthworm sampling locations to 2 x background values.

Station	Analyte	Result	Units	Background	Exceeds Background?
				Soil Concentration (mean x 2)	
	Barium	191	MG/KG	2.40e+02	NO
	Beryllium	1.1	MG/KG	2.10e+00	NO
	Beta	844	PCI/G		
	Cadmium	0.29	MG/KG	4.40e-01	NO
	Calcium	5890	MG/KG	2.60e+03	YES
	Chromium	31.5	MG/KG	5.10e+01	NO
	Cobalt	23.2	MG/KG	3.70e+01	NO
	Copper	21.9	MG/KG	3.80e+01	NO
	Cs-137	1160	PCI/G	1.40e+00	YES
	Iron	29900	MG/KG	6.70e+04	NO
	K-40	18.1	PCI/G	3.20e+01	NO
	Lead	14.7	MG/KG	4.40e+01	NO
	Magnesium	6510	MG/KG	7.30e+03	NO
	Manganese	1170	MG/KG	2.40e+03	NO
	Nickel	34.6	MG/KG	5.80e+01	NO
	Potassium	2340	MG/KG	5.70e+03	NO
	Silver	1.6	MG/KG	4.00e+00	NO
	Sodium	78.2	MG/KG		
	Thallium	0.25	MG/KG	8.70e-01	NO
	Vanadium	23.7	MG/KG	7.60e+01	NO
	Zinc	65.2	MG/KG	1.20e+02	NO
05.SB057	Aluminum	17700	MG/KG	5.00e+04	NO
	Aroclor 1260	0.078	MG/KG	1.60e-01	NO
	Arsenic	4.4	MG/KG	1.30e+01	NO
	Barium	117	MG/KG	2.40e+02	NO
	Beryllium	1.1	MG/KG	2.10e+00	NO
	Beta	33	PCI/G		
	Cadmium	0.54	MG/KG	4.40e-01	YES
	Calcium	2320	MG/KG	2.60e+03	NO

Table C2.39. Comparison of soil from earthworm sampling locations to 2 x background values.

Station	Analyte	Result	Units	Background Soil Concentration (mean x 2)	Exceeds Background?
	Chromium	31.1	MG/KG	5.10e+01	NO
	Cobalt	18.9	MG/KG	3.70e+01	NO
	Copper	25.1	MG/KG	3.80e+01	NO
	Cs-137	1.3	PCI/G	1.40e+00	NO
	Iron	35900	MG/KG	6.70e+04	NO
	K-40	18.5	PCI/G	3.20e+01	NO
	Lead	24.5	MG/KG	4.40e+01	NO
	Magnesium	4290	MG/KG	7.30e+03	NO
	Manganese	785	MG/KG	2.40e+03	NO
	Mercury	0.11	MG/KG	5.90e-01	NO
	Nickel	31.6	MG/KG	5.80e+01	NO
	Potassium	2420	MG/KG	5.70e+03	NO
	Silver	2.5	MG/KG	4.00e+00	NO
	Sodium	33.5	MG/KG		
	Radio Strontium	0.62	PCI/G	1.90e+00	NO
	Vanadium	26.9	MG/KG	7.60e+01	NO
	Zinc	73.7	MG/KG	1.20e+02	NO
05.SB062	Aluminum	14800	MG/KG	5.00e+04	NO
	Arsenic	3.2	MG/KG	1.30e+01	NO
	Barium	108	MG/KG	2.40e+02	NO
	Beryllium	0.72	MG/KG	2.10e+00	NO
	Beta	21.1	PCI/G		
	Calcium	2540	MG/KG	2.60e+03	NO
	Chromium	26	MG/KG	5.10e+01	NO
	Cobalt	14.2	MG/KG	3.70e+01	NO
	Copper	16.6	MG/KG	3.80e+01	NO
	Cs-137	0.591	PCI/G	1.40e+00	NO
	Iron	25900	MG/KG	6.70e+04	NO
	K-40	13	PCI/G	3.20e+01	NO

Table C2.39. Comparison of soil from earthworm sampling locations to 2 x background values.

Station	Analyte	Result	Units	Background Soil Concentration (mean x 2)	Exceeds Background?
	Lead	37.9	MG/KG	4.40e+01	NO
	Magnesium	3820	MG/KG	7.30e+03	NO
	Manganese	762	MG/KG	2.40e+03	NO
	Mercury	0.08	MG/KG	5.90e-01	NO
	Nickel	25.1	MG/KG	5.80e+01	NO
	Potassium	1680	MG/KG	5.70e+03	NO
	Silver	1.3	MG/KG	4.00e+00	NO
	Sodium	49.3	MG/KG		
	Radio Strontium	0.328	PCI/G	1.90e+00	NO
	Vanadium	23.1	MG/KG	7.60e+01	NO
	Zinc	57.3	MG/KG	1.20e+02	NO
05.SB063	Aluminum	19000	MG/KG	5.00e+04	NO
	Aroclor 1254	0.46	UG/KG	1.60e-01	YES
	Aroclor 1260	0.42	UG/KG	1.60e-01	YES
	Arsenic	3.3	MG/KG	1.30e+01	NO
	Barium	225	MG/KG	2.40e+02	NO
	Beryllium	1.2	MG/KG	2.10e+00	NO
	Beta	51.5	PCI/G		
	Calcium	7680	MG/KG	2.60e+03	YES
	Chromium	49.8	MG/KG	5.10e+01	NO
	Cobalt	20.5	MG/KG	3.70e+01	NO
	Copper	86.7	MG/KG	3.80e+01	YES
	Cs-137	6.24	PCI/G	1.40e+00	YES
	Iron	33100	MG/KG	6.70e+04	NO
	K-40	18.5	PCI/G	3.20e+01	NO
	Lead	40.3	MG/KG	4.40e+01	NO
	Magnesium	5340	MG/KG	7.30e+03	NO
	Manganese	3710	MG/KG	2.40e+03	YES
	Mercury	0.62	MG/KG	5.90e-01	YES

Table C2.39. Comparison of soil from earthworm sampling locations to 2 x background values.

Station	Analyte	Result	Units	Background Soil Concentration (mean x 2)	Exceeds Background?
	Nickel	33.8	MG/KG	5.80e+01	NO
	Potassium	2540	MG/KG	5.70e+03	NO
	Selenium	0.75	MG/KG	1.30e+00	NO
	Silver	1.7	MG/KG	4.00e+00	NO
	Sodium	85.3	MG/KG		
	Radio Strontium	9.75	PCI/G	1.90e+00	YES
	Vanadium	28.8	MG/KG	7.60e+01	NO
	Zinc	118	MG/KG	1.20e+02	NO

Table C2.40. Mean Soil and Worm Contaminant Concentrations for All Sites from WAG 5.
(Concentration units are mg/kg for inorganics and organics and pCi/g for radionuclides.)

Analyte	Media	Mean	STD	N ^a	Minimum Value	Maximum Value
Alpha	soil	13.8	7.9	3	6.8	22.4
	worm	0.32	*	1	0.32	0.32
Aluminum	soil	16116.7	3105.1	6	10600.0	19000.0
	worm	497.8	270.7	6	155.0	809.0
Aroclor 1254	soil	0.30	0.23	2	0.14	0.46
	worm	*	*	2	*	*
Aroclor 1260	soil	0.19	0.16	5	0.011	0.42
	worm	1.6	2.7	5	0.067	6.3
Arsenic	soil	4.07	0.81	6	3.2	5.3
	worm	2.4	0.56	5	1.8	3.0
Barium	soil	159.0	53.8	6	108.0	225.0
	worm	12.3	7.0	6	5.0	21.5
Beryllium	soil	0.99	0.18	6	0.72	1.2
	worm	1.25	0.07	2	1.2	1.3
Gross Beta	soil	481.6	498.1	6	21.1	1100.0
	worm	12.8	20.9	6	1.69	55.4
Cadmium	soil	0.70	0.39	4	0.29	1.2
	worm	3.5	1.66	6	1.4	5.9
Calcium	soil	15018.3	26285.2	6	2320.0	68500.0
	worm	4953.3	1120.6	6	3160.0	6430.0
Chromium	soil	31.07	9.8	6	22.0	49.8
	worm	8.7	3.3	5	5.9	14.4
Co-60	soil	6.07	*	1	6.07	6.07
	worm	*	*	0	*	*

Table C2.40
cont.

Analyte	Media	Mean	STD	N	Minimum Value	Maximum Value
Cobalt	soil	19.4	4.2	6	14.2	24.6
		3.9	1.7	3	2.2	5.5
Copper	soil	29.5	28.4	6	10.9	86.7
		11.3	4.9	6	7.0	20.7
Cs-137	soil	844.8	1566.7	6	0.59	3900.0
		0.81	0.74	3	0.096	1.6
Iron	soil	30633.3	3963.7	6	25900.0	35900.0
		1083.3	551.2	6	423.0	1760.0
K-40	soil	15.0	3.8	6	10.1	18.5
		2.06	1.5	6	0.67	4.8
Lead	soil	26.9	10.4	6	14.7	40.3
		3.5	0.91	5	2.2	4.7
Magnesium	soil	5791.7	3243.3	6	2890.0	11900.0
		1101.8	180.4	6	820.0	1290.0
Manganese	soil	2174.5	1990.8	6	762.0	5540.0
		255.7	258.9	6	40.2	663.0
Mercury	soil	0.52	0.70	5	0.08	1.7
		0.87	0.50	4	0.40	1.3
Nickel	soil	26.48	8.49	6	13.1	34.6
		*	*	0	*	*
Potassium	soil	1988.3	510.9	6	1290.0	2540.0
		10536.7	1932.1	6	6820.0	12100.0

Table C2.40
cont.

Analyte	Media	Mean	STD	N	Minimum Value	Maximum Value
Selenium	soil	2.9	3.1	2	0.75	5.10
		worm 7.8	2.6	5	4.7	10.3
Silver	soil	1.6	0.53	6	1.0	2.5
		worm 13.8	8.8	4	5.7	23.4
Sodium	soil	106.6	72.4	6	33.5	206.0
		worm 4475.0	1269.8	6	3180.0	6840.0
Thallium	soil	0.25	*	1	0.25	0.25
		worm *	*	0	*	*
Radioactive Strontium	soil	104.7	202.3	4	0.33	408.0
		worm 1.2	0.62	3	0.52	1.7
Vanadium	soil	25.4	2.1	6	23.1	28.8
		worm *	*	0	*	*
Zinc	soil	70.4	24.6	6	51.9	118.0
		worm 371.8	75.9	6	262.0	485.0

^a N = Number of detects.

* Asterisks represent concentrations below detection limit.

Table C2.41. Summary of results of linear regressions of earthworm contaminant concentrations on soil contaminant concentrations

Analyte	N	Slope ($\pm$ Standard Error)	p	Intercept ($\pm$ Standard Error)	R ²
Copper	6	0.157 $\pm$ 0.036	0.01	6.67 $\pm$ 1.41	0.83
Lead	5	0.081 $\pm$ 0.018	0.02	1.15 $\pm$ 0.54	0.87
Manganese	6	0.129 $\pm$ 0.007	0.0001	-55.34 $\pm$ 20.33	0.99

Table C2.42. Soil-earthworm contaminant uptake factors for earthworms from WAG5^a

Analyte	Uptake Factor	STD	N	Minumum Value	Maximum Value
Aluminum	0.0317	0.0161	6	0.0084	0.046
Aroclor 1260	7.1065	8.7613	5	2.1429	22.5
Arsenic	0.6322	0.2168	5	0.434	0.909
Barium	0.0777	0.0319	6	0.0262	0.105
Beryllium	1.3052	0.1745	2	1.1818	1.429
Gross Beta	0.0775	0.0874	6	0.0038	0.24
Cadmium	4.8118	1.9357	4	2.0833	6.41
Calcium	1.1315	0.839	6	0.0939	2.513
Chromium	0.2892	0.1208	5	0.1606	0.457
Cobalt	0.2353	0.0713	3	0.1549	0.291
Cs-137	0.0056	0.0085	3	0.0002	0.015
Iron	0.0357	0.0172	6	0.0141	0.054
K-40	0.1391	0.0979	6	0.0556	0.269
Magnesium	0.2349	0.1206	6	0.095	0.436
Mercury	5.7669	7.194	4	0.2765	16.25
Potassium	5.5691	1.7275	6	4.0551	8.372
Radioactive Strontium	0.2693	0.108	3	0.1692	0.384
Selenium	7.4157	8.9345	2	1.098	13.733
Silver	10.2847	6.8887	4	3.5625	19.5
Sodium	57.7152	35.092	6	22.6738	122.388
Zinc	5.5897	1.477	6	3.2881	7.305

^a Uptake factor expressed as dry weight soil to dry weight earthworm.

Table C2.43. Annual production rates (g wet wt/m²/yr $\pm$ SE^a) in White Oak Creek and Melton Branch for spring 1992 to spring 1993

Species	Site ^b							
	MEK	MEK	MEK	WCK	WCK	WCK	WCK	WCK
Cyprinidae	0.6	1.4	2.1	2.3	2.9	3.4	3.9	5.1
Central stoneroller				1.15 ± 0.05	2.10	7.64 ± 0.19	22.01	11.28
Fathead minnow							-1.54 ± 0.03	0.23 ± 0.03
Blacknose dace	1.98 ± 0.09	2.88 ± 0.28	1.89		0.05 ± 0.02	0.13 ± 0.04	5.57 ± 0.09	3.61
Creek chub	2.25 ± 0.10	0.40 ± 0.04	0.13 ± 0.02				0.08 ± 0.01	2.22 ± 0.11
Poeciliidae								
Western mosquitofish				<0.0 ^c	0.04 ± 0.01	0.02	0.01	
Cottidae								
Banded sculpin							0.79	1.85 ± 0.11
Centrarchidae								
Redbreast sunfish	2.70			0.99	2.86	0.85		
Bluegill				0.62 ± 0.06	0.94	4.19 ± 0.21	-4.26	
Largemouth bass				0.24	-0.05	-0.05		
Total ^d	6.93	3.28	2.02	3.65	5.94	12.78	22.66	17.11
								4.33

^a Standard error could not be calculated for all means because some size classes had only one fish per class.

^b MEK = Melton Branch kilometer; WCK = White Oak Creek kilometer.

^c Value was actually <0.002.

^d Totals for some sites include miscellaneous species (common carp, striped shiner, yellow bullhead, warmouth, redear sunfish, and spotted bass).

Table C2.44. Information provided by differential sediment quality triad responses^a

Situation	Chemicals present	Toxicity	Alteration	Possible conclusions
1	+	+	+	Strong evidence for pollution-induced degradation
2	-	-	-	Strong evidence that there is no pollution-induced degradation
3	+	-	-	Contaminants are not bioavailable or are present at nontoxic levels
4	-	+	-	Unmeasured chemicals or conditions exist with the potential to cause degradation
5	-	-	+	Alteration is not due to toxic chemicals
6	+	+	-	Toxic chemicals are stressing the system
7	-	+	+	Unmeasured toxic chemicals are causing degradation
8	+	-	+	Toxicity tests are insufficiently sensitive or alteration is not due to toxic chemicals

^aResponses are shown as either positive (+) or negative (-), indicating whether or not measurable (e.g., statistically significant) differences from control/reference conditions/measures are determined.
Source: Chapman, P. M. 1990. "The Sediment Quality Triad Approach to Determining Pollution-Induced Degradation." *Sci. Total Environ.* 97/98, 815-825.

Table C2.45. Comparison of soil contaminant concentrations at WAG 5 units to screening benchmarks for toxicity to plants, earthworms, and soil microorganisms in soil

Area	Chemical*	Detect mg/kg	Screening Benchmarks mg/kg				Hazard Quotients		
			Plant	Earthworm	Microbe	Plant	Earthworm	Microbe	
S5	Antimony	6.20	5	--	--	1	--	--	
S5	Manganese	4700	500	--	100	9	--	50	
S5	Mercury	4.30	0.3	0.1	30	10	40	0.1	
S5	Selenium	2.00	1	70	100	2	0.03	0.02	
OHF	Cobalt	53.0	20	--	1000	3	--	0.05	
OHF	Manganese	4000	500	--	100	8	--	40	
OHF	Silver	5.00	2	--	50	3	--	0.1	
TRU	Di-n-butyl phthalate	0.07	200	--	--	0	--	--	
SB	Di-n-butyl phthalate	0.15	200	--	--	0	--	--	
NHF	Di-n-butyl phthalate	0.13	200	--	--	0	--	--	
WW	Mercury	4.3	0.3	0.1	30	10	40	0.1	
WW	Zinc	321	50	200	100	6	2	3	
WW	Di-n-butyl phthalate	0.1	200	--	--	0	--	--	

* Di-n-butyl phthalate is included because, although there were no background values, we have a benchmark for comparison.

Table C2.46. Contaminants measured at concentrations greater than in background soils but for which there are no toxicity benchmarks. Radioactive isotopes are reported in pCi/g

Unit	Chemical	Maximum Detected (mg/kg) or (pCi/g)	Mean of background x 2 (mg/kg) or (pCi/g)
S5	Acetone	0.18	0.08
S5	Am-241	6.8	0.08
S5	Aroclor 1260	1.20	0.16
S5	Benzo(k) fluoranthene	0.05	0.08
S5	2-butanone	0.02	0.17
S5	Chloroform	0.001	0.01
S5	Cm-243/244	36.0	2.8
S5	Co-57	2.3	0.02
S5	Co-60	180	0.02
S5	Cs-137	6800	1.4
S5	Cyanide	0.07	0.49
S5	Ethylbenzene	0.01	0.01
S5	Fluoranthene	0.04	0.7
S5	K-40	33.0	32.0
S5	Pu-238	0.89	0.17
S5	Pu-239/240	0.79	0.06
S5	Pyrene	0.05	1.90
S5	Ra-226	3.6	1.50
S5	Styrene	0.003	0.01
S5	Tetrachloroethene	0.003	0.01
S5	Th-228	2.20	1.5
S5	Th-230	4.40	1.2
S5	Th-232	2.30	1.4
S5	Total radioactive strontium	10,000	1.9
S5	Tritium	1,900	0.08
S5	U-238	7.00	2.30

Unit	Chemical	Maximum Detected (mg/kg) or (pCi/g)	Mean of background x 2 (mg/kg) or (pCi/g)
OHF	Acetone	0.65	0.08
OHF	Am-241	0.47	0.08
OHF	Co-60	0.6	0.02
OHF	Cs-137	1100	1.4
OHF	Cyanide	0.7	0.49
OHF	Pu-238	1.60	0.17
OHF	Pu-239/240	0.06	0.06
OHF	Ra-226	1.80	1.50
OHF	Th-228	1.60	1.5
OHF	Th-230	1.50	1.2
OHF	Th-232	1.50	1.4
OHF	Total radioactive strontium	1,400	1.9
OHF	Tritium	3.10	0.08
TRU	Th-228	2	1.5
TRU	Th-232	2.4	1.4
TRU	Tritium	0.22	0.08
SB	Am-241	0.35	0.08
SB	Cm-243	0.18	1.12
SB	Cs-137	2	1.4
SB	K-40	35	32
SB	Pu-238	4.15	0.17
SB	Ra-226	2.07	1.50
SB	Th-228	1.9	1.5
SB	Th-232	2.04	1.4
SB	Th-234	7.3	3.4
SB	Total radioactive strontium	3.16	1.9
SB	Tritium	4.2	0.08
NHF	Am-241	0.11	0.08
NHF	Pu-238	0.26	0.17

Unit	Chemical	Maximum Detected (mg/kg) or (pCi/g)	Mean of background x 2 (mg/kg) or (pCi/g)
NHF	Th-228	1.67	1.5
NHF	Th-230	1.28	1.2
NHF	Th-232	1.55	1.4
NHF	Tritium	0.74	0.08
WW	Am-241	1.24	0.08
WW	Aroclor 1260	0.18	0.16
WW	Co-60	180	0.02
WW	Cs-137	40	1.4
WW	Pu-238	0.32	0.17
WW	Pu-239/240	1.77	0.06
WW	Ra-226	3.6	1.5
WW	Th-228	1.63	1.5
WW	Th-230	1.65	1.2
WW	Th-232	2.3	1.4
WW	Total radioactive strontium	120	1.9
WW	Tritium	4.41	0.08
WW	U-238	7	2.3

Table C2.47. Summary of risk characterization for terrestrial plants by area

Site	Evidence	Result	Explanation
SWSA 5 S	Literature Toxicity Data	+	Antimony, manganese, mercury, and selenium exceeded concentrations causing reduced plant growth
	Biological Surveys	±	No surveys were performed but the area is vegetated
	Medium Toxicity Tests	±	Toxicity test results not interpretable because of lack of information on contaminant concentrations in soil tested
	Weight of Evidence	+	The terrestrial plant community may be impacted by contaminants at this site
OHF	Literature Toxicity Data	+	Cobalt, manganese, and silver exceeded concentrations causing reduced plant growth
	Biological Surveys	±	No surveys were performed but the area is vegetated
	Medium Toxicity Tests	NA	No tests were performed
	Weight of Evidence	+	The terrestrial plant community may be impacted by contaminants at this site
TRU	Literature Toxicity Data	-	No contaminants for which there were benchmarks exceeded those benchmarks
	Biological Surveys	±	No surveys were performed but the area is vegetated
	Medium Toxicity Tests	NA	No tests were performed
	Weight of Evidence	-	There is no evidence that the soils of TRU are toxic to plants
SB	Literature Toxicity Data	-	No contaminants for which there were benchmarks exceeded those benchmarks
	Biological Surveys	±	No surveys were performed but the area is vegetated
	Medium Toxicity Tests	NA	No tests were performed
	Weight of Evidence	-	There is no evidence that the soils of SB are toxic to plants

Area	Evidence	Result	Explanation
NHF	Literature Toxicity Data	-	No contaminants for which there were benchmarks exceeded those benchmarks
	Biological Surveys	±	No surveys were performed but the area is vegetated
	Medium Toxicity Tests	NA	No tests were performed
	Weight of Evidence	-	There is no evidence that the soils of NHF are toxic to plants
WW	Literature Toxicity Data	+	Mercury and zinc exceeded concentrations causing reduced growth
	Biological Surveys	±	No surveys were performed but the area is vegetated
	Medium Toxicity Tests	NA	No tests were performed
	Weight of Evidence	+	The terrestrial plant community may be impacted by contaminants at this site

+ indicates that the evidence is consistent with the occurrence of the endpoint effect
 - indicates that the evidence is inconsistent with the occurrence of the endpoint effect
 ± indicates that the evidence is too ambiguous to interpret
 NA indicates that the information is not available

Table C2.48. Comparison of seep contaminant concentrations at WAG 5 units to screening benchmarks for toxicity to plants in solution. Included are contaminants for which there are no background values, and for which background values or measurement detection limits are greater than benchmarks

Seep	Chemical	Max Detected Concentration (mg/kg)	Screening Benchmark (mg/kg)	Hazard Quotient
1	Aluminum	0.98	0.2	5
1	Iron	1.2	10	0.1
1	Manganese	2.27	4	0.6
2	Aluminum	0.45	0.2	2
3	Aluminum	3.62	0.2	20
3	Iron	7.46	10	0.7
3	Manganese	3.01	4	0.8
4	Aluminum	1.2	0.2	0.6
4	Iron	1.49	10	0.1
5	Aluminum	2.3	0.2	12
5	Iron	2.58	10	0.3
5	Manganese	0.23	4	0.1
6	Iron	1.34	10	0.1
6	Manganese	0.56	4	0.1
7	Aluminum	5.8	0.2	30
7	Iron	16.8	10	2
7	Manganese	4.49	4	1
8	Manganese	0.47	4	0.1
9	Aluminum	1.35	0.2	7
9	Iron	6.58	10	0.6
9	Manganese	8.13	4	2
11	Iron	4.36	10	0.4
11	Manganese	1.87	4	0.5
12	Aluminum	0.71	0.2	4
12	Iron	2.46	10	0.2
12	Manganese	3.03	4	0.8

Seep	Chemical	Max Detected Concentration (mg/kg)	Screening Benchmark (mg/kg)	Hazard Quotient
14	Aluminum	2.29	0.2	10
14	Iron	8.21	10	0.8
14	Manganese	1.15	4	0.3
15	Cobalt	0.29	0.06	5
15	Iron	4.88	10	0.5
15	Manganese	7.9	4	2
15	Nickel	0.33	0.2	2
15	Selenium	0.04	0.7	0.1
16	Aluminum	12.3	0.2	60
16	Iron	13.8	10	1
16	Manganese	1.02	4	0.3
17	Aluminum	0.34	0.2	2
17	Iron	17.2	10	2
17	Manganese	9.93	4	2

Table C2.49. Contaminants measured at concentrations greater than in background seeps but for which there are no toxicity benchmarks. Radioactive isotopes are reported in pCi/g

Seep	Chemical	Maximum Detected (mg/kg) or (pCi/g)	Mean of background x 2 (mg/kg) or (pCi/g)
1	Beta particle	9.7	8
1	Th-232	29.1	2
1	Tritium	2780	1600
2	Alpha particle	23.4	8.9
2	Beta particle	8.9	8
3	Alpha particle	14.6	8.9
3	Beta particle	167	8
3	Tritium	151,000	1600
3	U-233/234	4.2	2
4	Barium	0.09	0.08
4	1,2-dichloroethene	0.18	0.01
4	Trichloroethene	0.08	0.01
4	Beta particle	665	8
4	Ra-228	27.2	6
4	Tritium	28,600	1600
5	Barium	0.16	0.08
5	Sodium	12.6	7
5	1,2-dichloroethene	0.03	0.01
5	Trichloroethene	0.02	0.01
5	Tritium	9.8 E6	1600
5	Beta particle	4740	8
6	Barium	0.09	0.08
6	Sodium	10.2	7
6	Tritium	5.6 E6	1600
6	Beta particle	790,000	8
6	Alpha particle	15.2	8.9

Seep	Chemical	Maximum Detected (mg/kg) or (pCi/g)	Mean of background x 2 (mg/kg) or (pCi/g)
7	Barium	0.21	0.08
7	Sodium	12.8	7
7	1,2-dichloroethene	0.03	0.01
7	Beta particle	1230	8
7	Alpha particle	39	8.9
7	Tritium	6.8 E6	1600
8	Sodium	31	7
8	Beta particle	1.9 E6	8
8	Alpha particle	409	8.9
8	Tritium	7.7 E7	1600
8	U-233/234	380	2
9	Barium	0.22	0.08
9	Sodium	20	7
9	1,2-dichloroethene	0.03	0.01
9	Beta particle	69,000	8
9	Tritium	7.6 E6	1600
11	Barium	0.14	0.08
11	Sodium	13	7
11	Alpha-BHC	0.0004	0.0001
11	Delta-BHC	0.0003	0.0001
11	Beta particle	550	8
11	Ra-228	15	6
11	Tritium	2.4 E7	1600
12	Barium	0.15	0.08
12	Sodium	18.1	7
12	1,2-dichloroethene	0.01	0.01
12	Beta particle	928	8
12	Tritium	4.1 E7	1600

Seep	Chemical	Maximum Detected (mg/kg) or (pCi/g)	Mean of background x 2 (mg/kg) or (pCi/g)
14	Barium	0.19	0.08
14	Sodium	15.1	7
14	1,2- dichloroethene	0.9	0.01
14	Tetrachloroethene	0.03	0.01
14	Trichloroethene	0.09	0.01
14	Vinyl chloride	0.07	0.02
14	Beta particle	1360	8
14	Tritium	2.3 E6	1600
15	Sodium	33.3	7
15	Alpha particle	7100	8.9
15	Beta particle	4000	8
15	Ra-228	110	6
15	Th-234	1100	530
15	Tritium	310,000	1600
15	U-233/234	1100	2
15	U-238	1900	2
16	Barium	0.18	0.08
16	Alpha particle	15.3	8.9
16	Beta particle	49.8	8
17	Barium	0.21	0.08
17	Sodium	11.1	7
17	Beta particle	26,300	8
17	Tritium	5.6 E6	1600

Table C2.50. Summary of risk characterization for wetland plants by seep

Seep	Evidence	Result	Explanation
1	Literature Toxicity Data	$\pm$	Aluminum in unfiltered samples exceeded benchmark however, Al in filtered seep drainage did not.
	Biological Surveys	NA	No surveys were performed
	Medium Toxicity Tests	NA	No tests were performed
	Weight of Evidence	$\pm$	The wetland plant community may be impacted by aluminum at this site, however, the actual amount of Al available to plants is not clear.
2	Literature Toxicity Data	$\pm$	Aluminum in unfiltered samples exceeded benchmark, however, Al in filtered seep drainage did not.
	Biological Surveys	NA	No surveys were performed
	Medium Toxicity Tests	NA	No tests were performed
	Weight of Evidence	$\pm$	The wetland plant community may be impacted by aluminum at this site, however, the actual amount of Al available to plants is not clear.
3	Literature Toxicity Data	$\pm$	Aluminum in unfiltered samples exceeded benchmark however, Al in filtered seep drainage did not.
	Biological Surveys	NA	No surveys were performed
	Medium Toxicity Tests	NA	No tests were performed
	Weight of Evidence	$\pm$	The wetland plant community may be impacted by aluminum at this site, however, the actual amount of Al available to plants is not clear.
4	Literature Toxicity Data	-	No contaminants for which there were benchmarks exceeded those benchmarks
	Biological Surveys	NA	No surveys were performed
	Medium Toxicity Tests	NA	No tests were performed
	Weight of Evidence	-	There is no evidence of toxicity to wetland plants.

Seep	Evidence	Result	Explanation
5	Literature Toxicity Data	<u>±</u>	Aluminum in unfiltered samples exceeded benchmark, however, Al in filtered seep drainage did not.
	Biological Surveys	NA	No surveys were performed
	Medium Toxicity Tests	NA	No tests were performed
	Weight of Evidence	<u>±</u>	The wetland plant community may be impacted by aluminum at this site, however, the actual amount of Al available to plants is not clear.
6	Literature Toxicity Data	-	No contaminants for which there were benchmarks exceeded those benchmarks
	Biological Surveys	NA	No surveys were performed
	Medium Toxicity Tests	NA	No tests were performed
	Weight of Evidence	-	There is no evidence of toxicity to wetland plants
7	Literature Toxicity Data	+	Aluminum, iron, and manganese in unfiltered samples exceeded benchmarks.
	Biological Surveys	NA	No surveys were performed
	Medium Toxicity Tests	NA	No tests were performed
	Weight of Evidence	+	The wetland plant community may be impacted by aluminum at this site. Al in filtered seep drainage exceeded benchmark.
8	Literature Toxicity Data	-	No contaminants for which there were benchmarks exceeded those benchmarks
	Biological Surveys	NA	No surveys were performed
	Medium Toxicity Tests	NA	No tests were performed
	Weight of Evidence	-	There is no evidence of toxicity to wetland plants

Seep	Evidence	Result	Explanation
9	Literature Toxicity Data	+	Aluminum and manganese in unfiltered samples exceeded benchmarks.
	Biological Surveys	NA	No surveys were performed
	Medium Toxicity Tests	NA	No tests were performed
	Weight of Evidence	+	The wetland plant community may be impacted by aluminum at this site. Al in filtered seep drainage exceeded benchmark. Mn in filtered seep drainage did not exceed benchmark.
11	Literature Toxicity Data	-	No contaminants for which there were benchmarks exceeded those benchmarks
	Biological Surveys	NA	No surveys were performed
	Medium Toxicity Tests	NA	No tests were performed
	Weight of Evidence	-	There is no evidence of toxicity to wetland plants
12	Literature Toxicity Data	<u>±</u>	Aluminum in unfiltered samples exceeded benchmark, however, Al in filtered seep drainage did not.
	Biological Surveys	NA	No surveys were performed
	Medium Toxicity Tests	NA	No tests were performed
	Weight of Evidence	<u>±</u>	The wetland plant community may be impacted by aluminum at this site, however, the actual amount of Al available to plants is not clear.
14	Literature Toxicity Data	<u>±</u>	Aluminum in unfiltered samples exceeded benchmark, however, Al in filtered seep drainage did not.
	Biological Surveys	NA	No surveys were performed
	Medium Toxicity Tests	NA	No tests were performed
	Weight of Evidence	<u>±</u>	The wetland plant community may be impacted by aluminum at this site, however, the actual amount of Al available to plants is not clear.

Seep	Evidence	Result	Explanation
15	Literature Toxicity Data	+	Cobalt, manganese, and nickel in unfiltered samples exceeded benchmarks.
	Biological Surveys	NA	No surveys were performed
	Medium Toxicity Tests	NA	No tests were performed
	Weight of Evidence	+	The wetland plant community may be impacted by contaminants at this site. Co, Mn, and Ni in filtered seep drainage exceeded benchmarks.
16	Literature Toxicity Data	$\pm$	Aluminum and iron in unfiltered samples exceeded benchmarks, however, Al and Fe in filtered seep drainage did not.
	Biological Surveys	NA	No surveys were performed
	Medium Toxicity Tests	NA	No tests were performed
	Weight of Evidence	$\pm$	The wetland plant community may be impacted by contaminants at this site, however, the actual amount of Al and Fe available to plants is not clear.
17	Literature Toxicity Data	+	Aluminum, manganese, and iron in unfiltered samples exceeded benchmarks.
	Biological Surveys	NA	No surveys were performed
	Medium Toxicity Tests	NA	No tests were performed
	Weight of Evidence	+	The wetland plant community may be impacted by contaminants at this site. Mn and Fe in filtered seep drainage exceeded benchmarks. Al did not.

+ indicates that the evidence is consistent with the occurrence of the endpoint effect

- indicates that the evidence is inconsistent with the occurrence of the endpoint effect

$\pm$ indicates that the evidence is too ambiguous to interpret

NA indicates that the information is not available

Table C2.50. Summary of risk characterization for wetland plants by seep

Seep	Evidence	Result	Explanation
1	Literature Toxicity Data	±	Al in unfiltered samples exceeded benchmark. Al in filtered seep drainage did not.
	Biological Surveys	±	No survey was performed but the area supports vegetation
	Medium Toxicity Tests	NA	No tests were performed
	Weight of Evidence	-	Based on the low bioavailability of particulate-bound Al, the seep is not likely to be toxic to the wetland plant community
2	Literature Toxicity Data	±	Al in unfiltered samples exceeded benchmark. Al in filtered seep drainage did not.
	Biological Surveys	±	No survey was performed but the area supports vegetation
	Medium Toxicity Tests	NA	No tests were performed
	Weight of Evidence	-	Based on the low bioavailability of particulate-bound Al, we conclude that the seep is not toxic to the wetland plant community
3	Literature Toxicity Data	±	Aluminum in unfiltered samples exceeded benchmark. Al in filtered seep drainage did not.
	Biological Surveys	±	Visual inspection of the seep vegetation indicates no toxicity
	Medium Toxicity Tests	NA	No tests were performed
	Weight of Evidence	-	Based on the low bioavailability of particulate-bound Al, the seep is not likely to be toxic to the wetland plant community
4	Literature Toxicity Data	-	No contaminants exceeded benchmarks
	Biological Surveys	±	No surveys were performed but the seep area is vegetated
	Medium Toxicity Tests	NA	No tests were performed
	Weight of Evidence	-	There is no evidence of toxicity to wetland plants

Seep	Evidence	Result	Explanation
5	Literature Toxicity Data	±	Aluminum in unfiltered samples exceeded toxic concentrations. Al in filtered drainage did not.
	Biological Surveys	±	No survey was performed but the area is vegetated
	Medium Toxicity Tests	NA	No tests were performed
	Weight of Evidence	-	Based on the low bioavailability of particulate-bound Al, the seep is not likely to be toxic to the wetland plant community
6	Literature Toxicity Data	-	No contaminants exceeded benchmarks
	Biological Survey	±	No survey was performed but the area is vegetated
	Medium Toxicity Tests	NA	No tests were performed
	Weight of Evidence	-	There is no evidence of toxicity to wetland plants
7	Literature Toxicity Data	+	Aluminum, Fe, and Mn in unfiltered samples exceeded concentrations causing reduced plant growth. Only Al did so in filtered samples by a factor of 2
	Biological Surveys	±	Visual inspection yielded no indications of toxicity
	Medium Toxicity Tests	NA	No tests were performed
	Weight of Evidence	-	Al in the seep is not likely to be toxic to the wetland plant community
8	Literature Toxicity Data	-	No contaminants exceeded benchmarks
	Biological Surveys	±	No surveys were performed but the areas is vegetated
	Medium Toxicity Tests	NA	No tests were performed
	Weight of Evidence	-	There is no evidence of toxicity to wetland plants

Seep	Evidence	Result	Explanation
9	Literature Toxicity Data	+	Al and Mn in unfiltered samples exceeded concentrations causing reduced growth. Only Al did so slightly in filtered samples
	Biological Surveys	-	Visual inspection yielded no indications of toxicity
	Medium Toxicity Tests	NA	No tests were performed
	Weight of Evidence	-	The wetland plant community is not likely to be impacted by contaminants
11	Literature Toxicity Data	-	No contaminants exceeded benchmarks
	Biological Surveys	±	No survey was performed but the area is vegetated
	Medium Toxicity Tests	NA	No tests were performed
	Weight of Evidence	-	There is no evidence of toxicity to wetland plants
12	Literature Toxicity Data	±	Al in unfiltered samples exceeded concentrations causing reduced growth. Al in filtered drainage did not.
	Biological Surveys	±	No survey was performed but the area is vegetated
	Medium Toxicity Tests	NA	No tests were performed
	Weight of Evidence	-	Based on the low bioavailability of particulate-bound Al, the seep is not likely to be toxic to the wetland plant community
14	Literature Toxicity Data	±	Al in unfiltered samples exceeded concentrations causing reduced growth. Al in filtered drainage did not.
	Biological Surveys	±	No survey was performed but the area is vegetated
	Medium Toxicity Tests	NA	No tests were performed
	Weight of Evidence	-	Based on the low bioavailability of particulate-bound Al, the seep is not likely to be toxic to the wetland plant community

Seep	Evidence	Result	Explanation
15	Literature Toxicity Data	+	Co, Mn, and Ni in unfiltered and filtered samples exceeded concentrations causing reduced growth
	Biological Surveys	-	Visual inspection yielded no indications of toxicity
	Medium Toxicity Tests	NA	No tests were performed
	Weight of Evidence	+	The wetland plant community may be impacted by Co
16	Literature Toxicity Data	$\pm$	Al and Fe in unfiltered samples exceeded concentrations causing reduced growth. Al and Fe in filtered drainage did not.
	Biological Surveys	$\pm$	No surveys were performed but the area is vegetated
	Medium Toxicity Tests	NA	No tests were performed
	Weight of Evidence	-	Based on the low bioavailability of particulate-bound Al and Fe, the seep is not likely to be toxic to the wetland plant community
17	Literature Toxicity Data	+	Al, Mn, and Fe in unfiltered samples exceeded concentrations causing reduced growth. Mn and Fe in filtered drainage did also but Al did not.
	Biological Surveys	-	Visual inspection yielded no indications of toxicity
	Medium Toxicity Tests	NA	No tests were performed
	Weight of Evidence	+	There is a slight chance that the wetland plant community may be impacted by Mn at this site

+ indicates that the evidence is consistent with the occurrence of the endpoint effect

- indicates that the evidence is inconsistent with the occurrence of the endpoint effect

$\pm$ indicates that the evidence is too ambiguous to interpret

NA indicates that the information is not available

Table C2.51. Summary of risk characterization for soil invertebrates by area

Site	Evidence	Result	Explanation
SWSA 5 S	Literature Toxicity Data	+	Mercury exceeded concentrations causing negative effects on reproduction. Total radioactivity exceeded IAEA recommended dose for terrestrial biota
	Biological Surveys	+	Earthworm density of earthworms is 45% less than in reference sites
	Medium Toxicity Tests	±	Toxicity test results not interpretable because of lack of information on contaminant concentrations in soil tested
	Weight of Evidence	+	The soil invertebrate community may be impacted by Hg. There is no data with which to evaluate applicability of the IAEA threshold value
OHF	Literature Toxicity Data	-	No contaminants exceeded benchmarks
	Biological Surveys	NA	No surveys were performed
	Medium Toxicity Tests	NA	No tests were performed
	Weight of Evidence	-	There is no evidence of toxicity to soil invertebrates
TRU	Literature Toxicity Data	-	No contaminants exceeded benchmarks
	Biological Surveys	NA	No surveys were performed
	Medium Toxicity Tests	NA	No tests were performed
	Weight of Evidence	-	There is no evidence of toxicity to soil invertebrates
SB	Literature Toxicity Data	-	No contaminants exceeded benchmarks
	Biological Surveys	NA	No surveys were performed
	Medium Toxicity Tests	NA	No tests were performed
	Weight of Evidence	-	There is no evidence of toxicity to soil invertebrates

Area	Evidence	Result	Explanation
NHF	Literature Toxicity Data	-	No contaminants exceeded benchmarks
	Biological Surveys	NA	No surveys were performed
	Medium Toxicity Tests	NA	No tests were performed
	Weight of Evidence	-	There is no evidence of toxicity to soil invertebrates
WW	Literature Toxicity Data	+	Hg and Zn exceeded concentrations causing reduced survival or reproduction
	Biological Surveys	-	Earthworm survey indicates number of earthworms present at the one sampling site in this area is not different from reference sites.
	Medium Toxicity Tests	NA	No tests were performed
	Weight of Evidence	+	The soil invertebrate community may be impacted by Hg

+ indicates that the evidence is consistent with the occurrence of the endpoint effect

- indicates that the evidence is inconsistent with the occurrence of the endpoint effect

$\pm$ indicates that the evidence is too ambiguous to interpret

NA indicates that the information is not available

Site (Flow)/ Analyte ^a	Maximum Concentration (ug/L)	Hazard Quotients ^a												
		NAWQS ^a		Secondary Values		Lowest Chronic Values						Lowest EC20		EC20
		Acute	Chronic	Acute	Chronic	Fish	Daphnids	Non- Daphnids	Plants	Fish	Daphnids	Sensitive Species		
Magnesium	13400						0.16							
Manganese	2560			1.74		1.45	2.33			2.02	2.33			22.86
Sodium	13600						0.02							
SW002 (Low Base)														
Barium	122			1.77			0.02							
Calcium	114000						0.98							
Iron	4740		4.74											
Magnesium	15200						0.19							
Manganese	2930			1.99		1.66	2.66			2.31	2.66			26.16
Sodium	17200						0.03							
SW002 (Storm-High Base)														
Magnesium	10700						0.13							
Sodium	11300						0.02							
SW002 (Storm-Low Base)														
Barium	109			1.58			0.02							
Calcium	123000						1.06							
Magnesium	16200						0.20							
Manganese	3020			2.05		1.71	2.75			2.38	2.75			26.96
Potassium	2750						0.05							
Sodium	17700						0.03							

^a Hazard Quotient (HQ) = the maximum total concentration divided by the toxicological benchmark. An HQ > 1 indicates that the observed concentration exceeded that

benchmark. Missing values indicate that a benchmark was not available for that analyte or that the benchmark was not used because it was below the mean background concentration.

• includes all detected analytes for which the maximum total recoverable concentration exceeded background and for which at least one benchmark was used.

Site (Flow)/ Analyte ^a	Maximum ^d Concentration (ug/L)	Hazard Quotients ^c													
		NAWQC		Secondary Values		Lowest Chronic Values								EC20	
		Acute	Chronic	Acute	Chronic	Fish	Daphnids	Non- Daphnids	Plants	Fish	Daphnids	Sensitive Species	Population		
Barium	~ 160			2.33					0.03						
Calcium	~ 116,000								1.00						
SW001 (Storm-Low Base)															
Manganese	~ 4,070			2.77		2.30	3.70			3.20	3.70		36.34		

^a Hazard Quotient (HQ) = the maximum total concentration divided by the toxicological benchmark. An HQ > 1 indicates that the observed concentration exceeded that benchmark. Missing values indicate that a benchmark was not available for that analyte or that the benchmark was not used because it was below the mean background concentration.

^b includes all detected analytes for which the maximum total recoverable concentration exceeded at least one benchmark.

^c ~ indicates that the reported value was estimated; < indicates that the contaminant concentration was below the detection limit, which is the reported value.

^d The dissolved phase concentration was an order of magnitude higher than the total recoverable concentration and should be evaluated with caution.

Table C2.54. On-site surface water summary of risk characterization for fish in drainages D1 and D2

Site	Evidence	Result	Explanation
SW001 (D1) (Base Flow)	Literature Toxicity Data	-	Contaminant concentrations are unlikely to be acutely or chronically toxic.
	Biological Surveys	N/A	No surveys were performed.
	Medium Toxicity Tests	+	Reproduction was significantly reduced during one test period. Acute toxicity was not evident.
	Weight of Evidence	+	The fish community may be impacted through decreased reproduction at this site.
SW001 (D1) (Storm Flow)	Literature Toxicity Data	-	Contaminant concentrations are unlikely to be acutely toxic.
	Biological Surveys	N/A	No surveys were performed.
	Medium Toxicity Tests	N/A	No tests were performed.
	Weight of Evidence	-	Acute impacts on the fish community are not expected during storms.
SW002 (D2) (Base Flow)	Literature Toxicity Data	+	Dissolved Fe exceeded the chronic NAWQC and dissolved Mn exceeded multiple chronic benchmarks.
	Biological Surveys	N/A	No surveys were performed.
	Medium Toxicity Tests	-	Survival and reproduction were not sufficiently reduced to indicate acute or chronic toxicity.
	Weight of Evidence	+	The fish community may be impacted by chronic exposure to Fe and Mn at this site.
SW002 (D2) (Storm Flow)	Literature Toxicity Data	-	Contaminant concentrations are unlikely to be acutely toxic.
	Biological Surveys	N/A	No surveys were performed.
	Medium Toxicity Tests	N/A	No tests were performed.
	Weight of Evidence	-	Acute impacts on the fish community are not expected during storms.

+ indicates that the evidence is consistent with the occurrence of the endpoint effect

- indicates that the evidence is inconsistent with the occurrence of the endpoint effect

$\pm$ indicates that the evidence is too ambiguous to interpret

N/A indicates that the information is not available

Table C2.55. Contaminant concentrations in sediment, benchmarks, screening values, and calculated hazard quotients

Contaminant ^a	Frequency of Detection	Concentration (mg/kg)		Benchmark ^b		EPA-IV Screening Value ^b	
		Mean	Maximum	Value (mg/kg)	Hazard Quotient ^c	Value (mg/kg)	Hazard Quotient
Drainage D1							
Mercury ^d	3/4	0.10	0.14	0.15	0.93	0.10	1.40
Nickel	4/4	49.20	70.60	52	1.36	20.9	3.38
Silver	3/4	1.89	2.30	1.0	2.30	2	1.15
Aroclor 1260	4/4	0.34	0.83	1319	0.00	0.033	25.15
Drainage D2							
Arsenic	4/4	10.7	14	8.2	1.71	8	1.75
Barium	4/4	829	1710	500	3.42		
Iron	4/4	80500	93800	59000	1.59		
Mercury ^d	3/4	0.253	0.38	0.15	2.53	0.1	3.80
Silver	2/4	5.98	7.3	1.0	7.30	2	3.65
1,1-Dichloroethane	3/4	0.0661	0.14	0.12	1.17		
1,1-Dichloroethene	2/4	0.0315	0.028	0.25	0.11		
1,2-Dichloroethane	1/4	0.0423	0.049	1.4	0.04		
1,2-Dichloroethene (Total)	3/4	0.0603	2.1	0.099	21.21		
Acetone	1/4	0.221	0.64	0.28	2.29		
Aroclor 1260	2/4	0.111	0.085	4728	0.00	0.033	2.58
Benzene	2/4	0.0102	0.011	0.225	0.05		
Toluene	2/4	0.00644	0.007	3.38	0.00		
Trichloroethene	2/4	0.00644	0.007	4.58	0.00		
Vinyl Chloride	2/4	0.0438	1.1	0.09	12.22		

Contaminant ^a	Frequency of Detection	Concentration (mg/kg)		Benchmark ^b		EPA-IV Screening Value ^b	
		Mean	Maximum	Value (mg/kg)	Hazard Quotient ^c	Value (mg/kg)	Hazard Quotient
Drainage D3							
Mercury ^d	1/1	0.09	0.09	0.15	0.60	0.1	0.90
Carbon Disulfide	1/1	0.002	0.002	0.019	0.11		
Chloroform	1/1	0.002	0.002	0.256	0.01		
Toluene	1/1	0.003	0.003	1.15	0.00		

^a Contaminants include inorganic chemicals detected above background (see Table 2b), and all detected organic chemicals, that have at least one benchmark or screening value.

^b Benchmarks (see Table C2.24) below background were not used.

^c Hazard Quotients less than 0.005 are reported as 0.00.

^d Background mercury concentrations were not determined.

Table C2.56. Radionuclide activity in sediment (Bq/kg) and calculated dose^a to large benthic macroinvertebrates ($\mu\text{Gy/h}$)

Station	Radionuclide	Maximum Activity	Alpha Internal Dose	Beta Internal Dose	Gamma Internal Dose	Gamma External Dose	Total Dose	HQ ^b
SID001	Drainage DI							
	Am-241	18.13	0.0582	-	-	-	0.0582	0.000
	Co-60	6.29	-	0.00035	-	8.99E-03	0.00934	0.000
	U-233/234	148	0.413	1.12E-03	1.47E-04	0	0.41427	0.001
	U-235	4.44	0.011	1.23E-04	-	3.90E-04	0.01151	0.000
	U-238	199.8	0.490	1.15E-03	1.56E-04	0	0.49131	0.001
	All nuclides						0.975	0.002
SID002	Am-241	24.05	0.077	-	-	-	0.077	0.000
	Co-60	7.4	-	4.11E-04	-	0.0106	0.01101	0.000
	Tc-99	48.1	-	2.80E-04	-	0	0.00028	0.000
	Sr-89/90	55.5	-	0.025	-	0	0.025	0.000
	Tritium	3737	-	0.012	-	0	0.012	0.000
	U-233/234	236.8	0.661	1.80E-03	2.36E-04	0	0.66304	0.002
	U-235	8.88	0.023	2.45E-04	-	7.8E-04	0.02403	0.000
	U-238	377.4	0.925	2.17E-03	2.96E-04	0	0.92747	0.002
	All nuclides						1.74	0.004
SID003	Co-60	6.29	-	3.50E-04	-	8.99E-03	0.00934	0.000
	Tc-99	107.3	-	0.0062	-	-	0.0062	0.000

Station	Radionuclide	Maximum Activity	Alpha Internal Dose	Beta Internal Dose	Gamma Internal Dose	Gamma External Dose	Total Dose	HQ*
	Th-230	129.5	0.354	1.09E-03	1.16E-05	.	0.3551	0.001
	U-233/234	347.8	0.97	0.00264	0.000346	.	0.97299	0.002
	U-235	14.06	0.036	3.88E-04	.	1.23E-03	0.03762	0.000
	U-238	469.9	1.151	2.71E-03	3.68E-04	.	1.15408	0.003
	All nuclides						2.89	0.007
SD004	Ac-228	51.8	.	0.014	.	0.027	0.041	0.000
	Bi-212	55.5	0.071	0.015	.	5.83E-03	0.09183	0.000
	Bi-214	31.82	.	7.73E-03	.	0.027	0.03473	0.000
	Cu-60	13.69	.	7.61E-04	.	0.020	0.02076	0.000
	Eu-155	5.55	.	2.00E-04	.	1.98E-04	0.0004	0.000
	Pb-212	48.1	.	4.86E-03	.	4.06E-03	0.00892	0.000
	Pb-214	34.41	.	5.78E-03	.	4.85E-03	0.01063	0.000
	Ra-223	13.69	0.045	5.89E-04	.	1.04E-03	0.04663	0.000
	Radon 219	17.39	0.069	6.31E-05	.	5.55E-04	0.06962	0.000
	Sn-126	10.36	.	1.02E-03	.	3.34E-04	0.00135	0.000
	Th-231	19.61	.	1.84E-03	.	2.78E-04	0.00212	0.000
	Th-234	407	.	0.014	.	.	0.014	0.000
	Tritium	86580	.	0.283	.	.	0.283	0.001
	U-233/234	218.3	0.609	1.66E-03	2.17E-04	.	0.61088	0.002
	U-235	6.66	0.017	1.84E-04		5.85E-04	0.01777	0.000

Station	Radionuclide	Maximum Activity	Alpha Internal Dose	Beta Internal Dose	Gamma Internal Dose	Gamma External Dose	Total Dose	HQ*
	U-238	370	0.907	2.13E-03	2.90E-04	.	0.90942	0.002
	All nuclides						2.16	0.005
Drainage D2								
SID005	Ac-228	85.1	.	0.023	.	0.045	0.068	0.000
	Bi-212	62.9	0.081	0.017	.	6.60E-03	0.1046	0.000
	C-14	2923	.	0.083	.	.	0.083	0.000
	Ca-45	3367	.	0.150	.	.	0.15	0.000
	Cm-243/244	43.29	0.147	3.42E-03	.	3.31E-03	0.15373	0.000
	Co-60	22.94	.	1.28E-03	.	0.033	0.03428	0.000
	Pb-212	62.9	.	6.35E-03	.	5.31E-03	0.01166	0.000
	Pb-214	44.4	.	7.56E-03	.	6.26E-03	0.01382	0.000
	Pu-238	1158	3.717	7.34E-03	1.20E-03	.	3.72554	0.009
	Ra-223	33.67	0.111	1.45E-03	.	2.56E-03	0.11501	0.000
	Ra-224	144.3	0.481	.	.	.	0.481	0.001
	Radon 219	44.4	0.176	1.61E-04	.	1.42E-03	0.17758	0.000
	Tc-99	444	.	0.026	.	.	0.026	0.000
	Tl 208	48.1	.	0.016	.	0.092	0.108	0.000
	Sr 89/90	30710	.	14.00	.	.	14	0.035
	Tritium	61790	.	0.202	.	.	0.202	0.001

Station	Radionuclide	Maximum Activity	Alpha Internal Dose	Beta Internal Dose	Gamma Internal Dose	Gamma External Dose	Total Dose	HQ*
	U-238	88.8	0.218	5.11E-04	6.95E-05	-	0.21858	0.001
	All nuclides						19.6728	0.049
SI0006	Ac-228	77.7	.	0.021	.	0.041	0.062	0.000
	Am-241	11.91	0.038	.	.	.	0.038	0.000
	Bi-214	44.4	.	0.012	.	0.037	0.049	0.000
	C-14	2738	.	0.078	.	.	0.078	0.000
	Ca-45	3404	.	0.151	.	.	0.151	0.000
	Cm 243/244	204.2	0.692	0.016	.	0.016	0.724	0.002
	Co-60	22.94	.	1.28E-03	.	0.033	0.03428	0.000
	I-129	296	.	0.011	1.68E-04	4.03E-03	0.0152	0.000
	Pb 212	51.8	.	5.23E-03	.	4.37E-03	0.0096	0.000
	Pb-214	40.7	.	6.84E-03	.	5.74E-03	0.01258	0.000
	Pu-238	666	2.14	4.22E-03	6.93E-04	.	2.14491	0.005
	Ra-223	27.38	0.091	1.18E-03	.	2.08E-03	0.09426	0.000
	Ra 224	96.2	0.320	.	.	.	0.32	0.001
	Ra 226	111	0.311	2.30E-04	4.14E-04	.	0.31164	0.001
	Radium 219	34.78	0.138	1.26E-04	.	0.0011	0.13923	0.000

Station	Radionuclide	Maximum Activity	Alpha Internal Dose	Beta Internal Dose	Gamma Internal Dose	Gamma External Dose	Total Dose	HQ*
	Tc-99	207.2	-	0.012	-	-	0.012	0.000
	Tl-208	44.4	-	0.015	-	0.085	0.1	0.000
	Sr-89/90	51800	-	23.62	-	-	23.62	0.059
	Tritium	25308	-	0.083	-	-	0.083	0.000
	U-238	85.1	0.208	4.90E-04	6.66E-05	-	0.20856	0.001
	All nuclides						28.0583	0.070

SI0007

Ac-228	55.5	-	0.015	-	-	0.294	0.309	0.001
Bi-214	26.64	-	6.47E-03	-	-	0.022	0.02847	0.000
C-14	3589	-	0.102	-	-	-	0.102	0.000
Ca-45	629	-	0.028	-	-	-	0.028	0.000
Co-60	16.65	-	9.26E-04	-	-	0.024	0.02493	0.000
I-129	325.6	-	0.012	1.85E-04	-	4.43E-03	0.01662	0.000
Pb-212	55.5	-	5.61E-03	-	-	4.68E-03	0.01029	0.000
Pb-214	25.16	-	4.23E-03	-	-	3.55E-03	0.00778	0.000
Pu-238	129.5	0.416	8.21E-04	1.35E-04	-	-	0.41696	0.001
Pu-239/240	9.62	0.029	5.88E-05	9.58E-06	-	-	0.02907	0.000
Tc-99	85.1	-	4.95E-03	-	-	-	0.00495	0.000
Tl-208	51.8	-	0.018	-	-	0.099	0.117	0.000
Sr-89/90	32930	-	15.02	-	-	-	15.02	0.038

Station	Radionuclide	Maximum Activity	Alpha Internal Dose	Beta Internal Dose	Gamma Internal Dose	Gamma External Dose	Total Dose	HQ*
	Tritium	52170	.	0.171	.	.	0.171	0.000
	U-233/234	592	1.652	4.50E-03	5.90E-04	.	1.65709	0.004
	U-235	15.17	0.039	4.19E-04	.	1.33E-03	0.04075	0.000
	U-238	81.4	0.199	4.69E-04	6.37E-05	.	0.19953	0.000
	All nuclides						17.744	0.044

SID008

Ac-228	85.1	.	0.023	.	0.045	0.068	0.000
Am-241	22.94	0.074	.	.	.	0.074	0.000
Bi-214	28.49	.	6.92E-03	.	0.024	0.03092	0.000
C-14	629	.	0.018	.	.	0.018	0.000
Co-60	23.31	.	1.30E-03	.	0.033	0.0343	0.000
I-129	518	.	0.019	2.94E-04	7.04E-03	0.02633	0.000
Pb-212	59.2	.	5.98E-03	.	5.00E-03	0.01098	0.000
Pb-214	40.7	.	6.84E-03	.	5.74E-03	0.01258	0.000
Ra-224	181.3	0.604	.	.	.	0.604	0.002
Tl-208	40.7	.	0.014	.	0.078	0.092	0.000
Sr-89/90	40700	.	18.56	.	.	18.56	0.046

Station	Radionuclide	Maximum Activity	Alpha Internal Dose	Beta Internal Dose	Gamma Internal Dose	Gamma External Dose	Total Dose	HQ*
	Tritium	54760	.	0.179	.	.	0.179	0.000
	All nuclides						19.71	0.049
				Drainage D3				
SIX009	Ac-228	55.5	.	0.015	.	0.029	0.044	0.000
	Bi-214	33.67	.	8 E-03	.	0.028	0.03618	0.000
	I-129	48.1	.	1.77E-03	2.73E-05	6.54E-04	0.00245	0.000
	Pb-210	99.9	.	2.19E-03	1.33E-04	.	0.00232	0.000
	Pb-212	51.8	.	5.23E-03	.	4.37E-03	0.0096	0.000
	Pb-214	37	.	6.22E-03	.	5.22E-03	0.0144	0.000
	Sn-126	7.03	.	6.92E-04	.	2.26E-04	0.00092	0.000
	Tl-208	40.7	.	0.014	.	0.078	0.092	0.000
	All nuclides						0.19891	0.000
				Melon Branch				
SIX016	Gross Beta	13.8	.	6.28E-03	.	.	0.00628	0.000
	Cs-137	0.05	.	7.76E-06	1.84E-07	1.82E-05	0.00003	0.000
	All nuclides						0.00631	0.000

* Dose calculated using formulas in section C2.2.2.1.6.

† HQ = Hazard Quotient = total dose/toxicological benchmark

‡ Gross Beta assumed to be primarily Sr-90.

Table C2.57. Estimated Contribution of Contaminants to Offsite Exposure of Vermivorous Wildlife

Endpoint Species	Area	Analyte	Media Concentrations (mg /L. or kg)			Estimated Exposure (mg/kg/d)		Toxicity Benchmark (mg/kg/d)	Hazard Quotient
			Soil (95% UCL)	Estimated in Earthworms (95% UCL)	Soil	Food	Total		
Short-tailed Shrew	WW	Barium	310	3.85392	24.18	2.31235	26.49235	15.37	1.72364
		Mercury	1.3	1.1995152	0.1014	0.71971	0.82111	0.09	9.12344
		Zinc	1000	894.352	78	536.6112	614.6112	452.43	1.35847
		Aroclor 1254	0.24	0.2728896	0.01872	0.16373	0.18245	0.15	1.21633
	OHF	Cadmium	0.61	0.4696317	0.04758	0.28178	0.32936	0.24	1.37233
	NHF	Barium	400	4.9728	31.2	2.98368	34.18368	15.37	2.22405
		Manganese	2900	40.368	226.2	24.2208	250.4208	248.8	1.00651
	SS	Antimony	16	0	1.248	0	1.248	0.16	7.8
		Selenium	0.99	1.1746	0.077	0.705	0.782	0.094	8.31
	TRU	Selenium	1	1.186512	0.078	0.71191	0.78991	0.094	8.4033
American Woodcock	WW	Barium	310	3.85392	24.42424	2.91964	27.34388	17.73	1.54224
		Chromium	0.11	0.0050899	0.001472	0.00386	0.00533	1.84	1.84919
		Lead	94	1.901056	7.40606	1.44019	8.84625	3.35	2.64067
		Mercury	1.3	1.1995152	0.10242	0.90872	1.01114	0.011	91.92182
		Zinc	1000	894.352	78.78788	677.5394	756.32727	5.12	147.72017
		Di-n-butyl Phthalate	1.5	0	0.11818	0	0.11818	0.1	1.1818
	NHF	Barium	400	4.9728	31.51515	3.76727	35.28242	17.73	1.98998

Table C2.57. Estimated Contribution of Contaminants to Offsite Exposure of Vermivorous Wildlife

Endpoint Species	Area	Analyte	Media Concentrations (mg /L or kg)		Estimated Exposure (mg/kg/d)			Toxicity Benchmark (mg/kg/d)	Hazard Quotient
			Soil (95 % UCL)	Estimated in Earthworms (95 % UCL)	Soil	Food	Total		
TRU		Selenium	1	1.186512	0.07879	0.89887	0.97766	0.85	1.15019

Table C2.58 Comparison of maximum total contaminant concentrations, from off-site surface water locations, to aquatic benchmarks.

Site (Flow)/ Analyte ^a		Hazard Quotients ^b													
		NAWQC		Secondary Values			Lowest Chronic Values			Lowest EC20		EC20			
		Acute	Chronic	Acute	Chronic	Fish	Daphnids	Non- Daphnids	Plants	Fish	Daphnids		Sensitive Species	Population	
SW003 (High Base)															
Aluminum	442	0.59				0.13	0.23		0.96	0.09	0.82				
Manganese	244		0.17			0.14	0.22			0.19	0.22				2.18
SW003 (Low Base)															
Potassium	2300							0.04							
SW003 (Storm-High Base)															
Aluminum	848	1.13				0.26	0.45		1.84	0.18	1.57				
SW003 (Storm-Low Base)															
Aluminum	475	0.63				0.14	0.25		1.03	0.10	0.88				
Manganese	355		0.24			0.20	0.32			0.28	0.32				3.17
Potassium	5340						0.10								
SW004 (High Base)															
Aluminum	425	0.57				0.13	0.22		0.92	0.09	0.79				
Fluoride	528		0.03	0.46		0.06	0.12			0.10	0.14				0.49
SW004 (Storm-Low Base)															
Potassium	4280							0.08							

Site (Flow)/ Analyte*	Maximum Concentration (ug/L)	Hazard Quotients*											
		NAWQC			Secondary Values			Lowest Chronic Values					
		Acute	Chronic	Acute	Chronic	Fish	Daphnids	Non- Daphnids	Plants	Fish	Daphnids	Sensitive Species	Population
SW005 (High Base)													
Calcium	82600							0.71					
Fluoride	1800			0.09	1.58	0.20		0.41		0.34	0.49		1.67
Magnesium	19500							0.24					
Potassium	3010							0.06					
Sodium	12400							0.02					
SW005 (Low Base)													
Magnesium	10300							0.13					
Potassium	2110							0.04					
Sodium	8460							0.01					
SW005 (Storm-Low Base)													
Aluminum	3180	4.24				0.97	1.67		6.91	0.68	5.89		
Bis(2-Ethylhexyl) Phthalate	36			0.13	1.12	4.29	12.00			0.67	12.00		0.72
Potassium	3000						0.06						
SW006 (High Base)													
Fluoride	1350			0.07	1.18	0.15	0.31			0.25	0.36		1.25
Magnesium	15100						0.18						
Potassium	2250						0.04						
Sodium	9740						0.01						

Site (Flow)/ Analyte ^b	Maximum Concentration (ug/L)	Hazard Quotients ^a									
		NAWQC		Secondary Values			Lowest Chronic Values				EC20
		Acute	Chronic	Acute	Chronic	Fish	Daphnids	Non- Daphnids	Plants	Fish	
SW006 (Low Base)											
Magnesium	10800						0.13				
Potassium	2220						0.04				
Sodium	8560						0.01				
SW006 (Storm-Low Base)											
Magnesium	10400						0.13				
Potassium	3270						0.06				
Sodium	7770						0.01				

^a Hazard Quotient (HQ) = the maximum total concentration divided by the toxicological benchmark. An HQ > 1 indicates that the observed concentration exceeded that benchmark. Missing values indicate that a benchmark was not available for that analyte or that the benchmark was not used because it was below the mean background concentration.

^b includes all detected analytes for which the maximum total recoverable concentration exceeded background and for which at least one benchmark was used.

Table C2.59 Comparison of maximum dissolved metal concentrations, from off-site surface water locations, to aquatic benchmarks.

Hazard Quotients ^a															
Site (Flow)/ Analyte ^b		Maximum ^c Concentration (ug/L)	NAWQC			Secondary Values			Lowest Chronic Values				Lowest EC20		EC20
			Acute	Chronic	Acute	Chronic	Fish	Daphnids	Non- Daphnids	Plants	Fish	Daphnids	Sensitive Species	Population	
SW003 (High Base)															
Manganese		230			0.16		0.13	0.21			0.18	0.21		2.05	
SW003 (Storm-High Base)															
Aluminum		< 36.8	0.05				0.01	0.02		0.08	0.01	0.07			
SW003 (Storm-Low Base)															
Aluminum		~ 8,900 ^d	11.87				2.71	4.68		19.35	1.89	16.48			
Manganese		~ 1,250 ^d			0.85		0.71	1.14			0.98	1.14		11.16	
SW005 (Storm-Low Base)															
Aluminum		~ 40,400 ^d	53.87				12.29	21.26		87.83	8.60	74.81			

^a Hazard Quotient (HQ) = the maximum total concentration divided by the toxicological benchmark. An HQ > 1 indicates that the observed concentration exceeded that benchmark. Missing values indicate that a benchmark was not available for that analyte or that the benchmark was not used because it was below the mean background concentration.

^b includes all detected analytes for which the maximum total recoverable concentration exceeded at least one benchmark.

^c ~ indicates that the reported value was estimated; < indicates that the contaminant concentration was below the detection limit, which is the reported value.

^d The dissolved phase concentration was an order of magnitude higher than the total recoverable concentration and should be evaluated with caution.

Table C2.60 Off-site surface water summary of risk characterization for fish in White Oak Creek (WOC) and Melton Branch (MB)

Site ^a	Evidence	Result	Explanation
White Oak Creek (Base and Storm Flow)	Literature Toxicity Data	N/A	No data were available for this assessment.
	Biological Surveys	±	Surveys indicate impacts, but the contribution of WAG 5 can not be distinguished from other sources and habitat quality.
	Medium Toxicity Tests	±	Survival was reduced, but the contribution of WAG 5 can not be distinguished from other sources.
	Weight of Evidence	±	Impacts of WAG 5 are neither supported nor refuted by the available evidence.
SW003 (D3) (Base Flow)	Literature Toxicity Data	+	Dissolved Mn exceeded the population EC20. This is weak evidence of chronic toxicity.
	Biological Surveys	N/A	No surveys were performed in this tributary.
	Medium Toxicity Tests	N/A	No tests were performed.
	Weight of Evidence	+	The fish community may be impacted by chronic exposure to contaminants at this site, which is downstream of SP016.
SW003 (D3) (Storm Flow)	Literature Toxicity Data	+	Total Al exceeded the acute NAWQC. Estimates of dissolved aluminum are unrealistic. This is weak evidence of acute toxicity.
	Biological Surveys	N/A	No surveys were performed in this tributary.
	Medium Toxicity Tests	N/A	No tests were performed.
	Weight of Evidence	+	Acute impacts on the fish community during storms may occur at this site, which is downstream of SP016.

Site ^a	Evidence	Result	Explanation
SW004 (MB Trib.) (Base Flow)	Literature Toxicity Data	-	Contaminant concentrations are unlikely to be acutely or chronically toxic.
	Biological Surveys	N/A	No surveys were performed in this tributary.
	Medium Toxicity Tests	N/A	No tests were performed.
	Weight of Evidence	-	Acute and chronic impacts on the fish community are unlikely at this site, which is upstream of WAG 5.
SW004 (MB Trib.) (Storm Flow)	Literature Toxicity Data	-	Contaminant concentrations are unlikely to be acutely toxic.
	Biological Surveys	N/A	No surveys were performed in this tributary.
	Medium Toxicity Tests	N/A	No tests were performed.
	Weight of Evidence	-	Acute impacts on the fish community during storms are unlikely at this site, which is upstream of WAG 5.
SW005 (MB) (Base Flow)	Literature Toxicity Data	+	Fluoride exceeded the SCV and population EC20. This is weak evidence of chronic toxicity.
	Biological Surveys	-	The fish communities proximate to this site were not impacted, relative to the reference site.
	Medium Toxicity Tests	N/A	No tests were performed.
	Weight of Evidence	-	Acute and chronic impacts on the fish community are unlikely at this site, which is upstream of WAG 5.

Site*	Evidence	Result	Explanation
SW005 (MB) (Storm Flow)	Literature Toxicity Data	+	Dissolved Al exceeded the acute NAWQC. Estimates of dissolved aluminum are unrealistic. This is weak evidence of acute toxicity.
	Biological Surveys	-	The fish communities proximate to this site were not impacted, relative to the reference site.
	Medium Toxicity Tests	N/A	No tests were performed.
	Weight of Evidence	-	Acute toxicity to fish during storms may occur at this site, which is upstream of WAG 5, but the survey data indicate that any toxic effects are not reflected in the community endpoint.
SW006 (MB) (Base Flow)	Literature Toxicity Data	+	Fluoride exceeded the SCV and population EC20. This is weak evidence of chronic toxicity. There is no evidence of acute toxicity.
	Biological Surveys	-	The fish communities proximate to this site were not impacted, relative to the reference and upstream sites.
	Medium Toxicity Tests	N/A	No tests were performed.
	Weight of Evidence	-	Acute and chronic impacts on the fish community are unlikely at this site, which is downstream of WAG 5.
SW006 (MB) (Storm Flow)	Literature Toxicity Data	-	Contaminant concentrations are unlikely to be acutely toxic.
	Biological Surveys	-	The fish communities proximate to this site were not impacted, relative to the reference and upstream sites.
	Medium Toxicity Tests	N/A	No tests were performed.
	Weight of Evidence	-	Acute impacts on the fish community during storms is unlikely at this site, which is downstream of WAG 5.

+ indicates that the evidence is consistent with the occurrence of the endpoint effect

- indicates that the evidence is inconsistent with the occurrence of the endpoint effect

± indicates that the evidence is too ambiguous to interpret

N/A indicates that the information is not available

* MB Trib. refers to a tributary on Melton Branch. D3 enters this tributary.

Table C2.61. Comparison of total contaminant concentrations in undiluted seep water to aquatic benchmarks.

Hazard Quotients / Dilution Factors*														
Site Analyte ^b	Concentration ^c (ug/L)	NAWQC		Secondary Values			Lowest Chronic Values					Lowest EC20		EC20
		Acute	Chronic	Acute	Chronic	Fish	Daphnids	Non-Daphnids	Plants	Fish	Daphnids	Sensitive Species		
SP001														
Aluminum	980	1.31				0.30	0.52		2.13	0.21	1.81			
Fluoride	52			0.00	0.05	0.01	0.01			0.01	0.01		0.05	
Iron	1200		1.20											
Manganese	2270			1.54		1.28	2.06			1.79	2.06		20.27	
SP002														
Aluminum	446	0.59				0.14	0.23		0.97	0.09	0.83			
SP003														
Aluminum	3620	4.83				1.10	1.91		7.87	0.77	6.70			
Barium	185			2.69			0.03							
Calcium	81200						0.70							
Fluoride	155			0.01	0.14	0.02	0.04			0.03	0.04		0.14	
Iron	7460		7.46											
Manganese	3010			2.05		1.70	2.74			2.37	2.74		26.88	
Potassium	2570						0.05							
1,2-Dichloroethene (Total)	12			0.02	0.38	0.00				0.00				
SP004														
Aluminum	1200	1.60				0.36	0.63		2.61	0.26	2.22			

Hazard Quotients / Dilution Factors*											
Site Analyte ^a	Concentration ^b (ug/L)	NAWQC			Secondary Values			Lowest Chronic Values			
		Acute	Chronic	Acute	Chronic	Fish	Daphnids	Non-Daphnids	Plants	Fish	Daphnids
											EC20
Barium	86.2			1.25			0.01				
Calcium	100000						0.86				
Fluoride	92			0.00	0.08	0.01	0.02			0.02	0.02
Iron	1490		1.49								0.09
Magnesium	16000						0.20				
Potassium	2090						0.04				
1,2-Dichloroethene (Total)	180			0.32	5.77	0.02				0.03	
Trichloroethene	76			0.02	0.21	0.01	0.01			0.01	0.33
SP005											
Aluminum	2300	3.07				0.70	1.21		5.00	0.49	4.26
Barium	159			2.31			0.03				
Calcium	90800						0.78				
Fluoride	70			0.00	0.06	0.01	0.02			0.01	0.02
Iron	2580		2.58								0.06
Magnesium	13700						0.17				
Manganese	230					0.13	0.21			0.18	0.21
Potassium	2310			0.16			0.04				2.05
Sodium	12600						0.02				
1,2-Dichloroethene (Total)	28			0.05	0.90	0.00				0.00	
Trichloroethene	17			0.01	0.05	0.00	0.00			0.00	0.07

Hazard Quotients / Dilution Factors ^a													
Site Analyte ^b	Concentration ^c (ug/L)	NAWQC		Secondary Values			Lowest Chronic Values					Sensitive Species	Population
		Acute	Chronic	Acute	Chronic	Fish	Daphnids	Non-Daphnids	Plants	Fish	Daphnids		
EC20													
SP006													
Barium	94.3			1.37				0.02					
Calcium	86100							0.74					
Fluoride	67			0.00	0.06	0.01	0.02	0.02		0.01	0.02		0.06
Iron	1340		1.34										
Magnesium	16700							0.20					
Manganese	561			0.38		0.32	0.51	0.51		0.44	0.51		5.01
Sodium	10200							0.02					
SP007													
Aluminum	5800	7.73				1.76	3.05		12.61	1.23	10.74		
Barium	208			3.02			0.04						
Fluoride	101			0.01	0.09	0.01	0.02			0.02	0.03		0.09
Iron	16800		16.80										
Magnesium	12900						0.16						
Manganese	4490			3.05		2.54	4.08			3.54	4.08		40.09
Potassium	2230						0.04						
Sodium	12800						0.02						
1,2-Dichloroethene (Total)	31			0.06	0.99	0.00				0.01			
SP008													
Calcium	109000							0.94					

Hazard Quotients / Dilution Factors*														
Site Analyte ^a	Concentration ^b (ug/L)	MAWQC			Secondary Values			Lowest Chronic Values				EC20		
		Acute	Chronic		Acute	Chronic	Fish	Daphnids	Non-Daphnids	Plants	Fish	Daphnids	Sensitive Species	Population
Fluoride	137				0.01	0.12	0.02	0.03			0.03	0.04		0.13
Magnesium	18900							0.23						
Manganese	466				0.32		0.26	0.42			0.37	0.42		4.16
Potassium	2960							0.06						
Sodium	31000							0.05						
SP009														
Aluminum	1350	1.80					0.41	0.71		2.93	0.29	2.50		
Barium	218				3.17			0.04						
Calcium	127000							1.09						
Fluoride	145				0.01	0.13	0.02	0.03			0.03	0.04		0.13
Iron	6580		6.58											
Magnesium	14000							0.17						
Manganese	8130				5.53		4.59	7.39			6.40	7.39		72.59
Sodium	20000							0.03						
1,2-Dichloroethene (Total)	33				0.06	1.06	0.00				0.01			
SP011														
Barium	140				2.03			0.02						
Boron	538				0.05	0.98		0.06						
Calcium	76400							0.66						
Fluoride	70				0.00	0.06	0.01	0.02			0.01	0.02		0.06

Hazard Quotients / Dilution Factors ^a													
Site Analyte ^b	Concentration ^c (ug/L)	NAWQC		Secondary Values			Lowest Chronic Values					Sensitive Species	Population
		Acute	Chronic	Acute	Chronic	Fish	Daphnids	Non-Daphnids	Plants	Fish	Daphnids		
Iron	4360		4.36										
Magnesium	12600						0.15						
Manganese	1870			1.27		1.06		1.70			1.47	1.70	16.70
Sodium	13000							0.02					
Alpha-BHC	0.4			0.01	0.16			0.00					
Delta-BHC	0.32			0.01	0.13			0.00					
SP012													
Aluminum	709	0.95				0.22	0.37		1.54	0.15		1.31	
Barium	147			2.14			0.03						
Calcium	125000						1.08						
Fluoride	87			0.00	0.08	0.01	0.02			0.02	0.02		0.08
Iron	2460		2.46										
Magnesium	13000						0.16						
Manganese	3030			2.06		1.71	2.75			2.39	2.75		27.05
Sodium	18100						0.03						
1,2-Dichloroethene (Total)	13			0.02	0.42	0.00				0.00			
SP014													
Aluminum	2290	3.05				0.70	1.21		4.98	0.49		4.24	
Barium	185			2.69			0.03						
Calcium	129000						1.11						

Hazard Quotients / Dilution Factors*															
Site Analyte	Concentration ¹ (ug/L)	NAWQC			Secondary Values			Lowest Chronic Values					Lowest EC20	Sensitive Species	Population
		Acute	Chronic		Acute	Chronic	Fish	Daphnids	Non-Daphnids	Plants	Fish	Daphnids			
Fluoride	98				0.01	0.09	0.01	0.02			0.02	0.03		0.09	
Iron	8210	8.21													
Magnesium	16700							0.20							
Manganese	1150				0.78		0.65	1.05			0.91	1.05		10.27	
Potassium	2040							0.04							
Sodium	15100							0.02							
1,1-Dichloroethane	14				0.02	0.30	0.00				0.00			0.01	
1,2-Dichloroethene (Total)	850				1.52	27.24	0.09				0.15				
Tetrachloroethene	29				0.03	0.41	0.03	0.04		0.00	0.06	0.06		0.58	
Trichloroethene	89				0.03	0.25	0.01	0.01			0.02			0.38	
Vinyl Chloride	73				0.05	0.83	0.00				0.01				
SP015															
Calcium	125000							1.08							
Cobalt	293				2.79		1.01								
Fluoride	620				0.03	0.54	0.07	0.14			0.12	0.17		0.57	
Iron	4880	4.88													
Magnesium	58900							0.72							
Manganese	7900				5.37		4.46	7.18			6.22	7.18		70.54	
Nickel	328	0.23	2.05				9.37		2.55		5.29	7.29		1.53	
Potassium	4880							0.09							
Selenium	35.6	0.14	1.02				0.40	0.39		0.36	0.89	1.42		13.69	

Site Analyte ^a	Concentration ^a (ug/L)	Hazard Quotients / Dilution Factors ^a										
		NAWQC		Secondary Values			Lowest Chronic Values				Lowest EC20	
		Acute	Chronic	Acute	Chronic	Fish	Daphnids	Non-Daphnids	Plants	Fish	Daphnids	Sensitive Species
Sodium	33300											Population
								0.05				
SP016												
Aluminum	12300	16.40				3.74	6.47		26.74	2.62	22.78	
Barium	183			2.66			0.03					
Fluoride	64			0.00	0.06	0.01	0.01			0.01	0.02	0.06
Iron	13800		13.80									
Manganese	1020			0.69		0.58	0.93			0.80	0.93	9.11
Potassium	4270						0.08					
SP017												
Aluminum	379	0.51				0.12	0.20		0.82	0.08	0.70	
Barium	206			2.99			0.04					
Calcium	81100						0.70					
Fluoride	125			0.01	0.11	0.01	0.03			0.02	0.03	0.12
Iron	17200		17.20									
Magnesium	11700						0.14					
Manganese	9930			6.76		5.61	9.03			7.82	9.03	88.66
Sodium	11100						0.02					

^a Hazard Quotient (HQ) = the maximum total concentration divided by the toxicological benchmark. An HQ > 1 indicates that the observed concentration exceeded that benchmark. The Dilution Factor (DF) is equivalent to the HQ and represents the final discharge rate needed reduce the HQ to 1 in a receiving stream (i.e., an HQ/DF of 4 would be reduced to 1 if the flow rate of the receiving stream is 4 times the seep discharge rate). Missing values indicate that a benchmark was not available for that

- analyte or that the benchmark was not used because it was below the mean background concentration.
- b includes all detected analytes for which the maximum total recoverable concentration exceeded background and for which at least one benchmark was used.
 - c Only one sample was collected at each secp.

Table C2.62. Comparison of dissolved metal concentrations in undiluted seep water to aquatic benchmarks.

Site/ Analyte ^a	Concentration ^c (ug/L)	Hazard Quotients / Dilution Factors ^a											
		NAWQC		Secondary Values		Lowest Chronic Values					EC20		
		Acute	Chronic	Acute	Chronic	Fish	Daphnids	Non- Daphnids	Plants	Fish	Daphnids	Sensitive Species	Population
SP001													
Aluminum	91	0.12				0.03	0.05		0.20	0.02	0.17		
Iron	306		0.31										
Manganese	2300			1.56		1.30	2.09			1.81	2.09		20.54
SP002													
Aluminum	< 19.2	0.03				0.01	0.01		0.04	0.00	0.04		
SP003													
Aluminum	< 23.5	0.03				0.01	0.01		0.05	0.01	0.04		
Barium	~ 96.3			1.40			0.02						
Iron	~ 208		0.21										
Manganese	~ 900			0.61		0.51	0.82			0.71	0.82		8.04
SP004													
Aluminum	< 23.5	0.03				0.01	0.01		0.05	0.01	0.04		
Barium	~ 74.7			1.09			0.01						
Iron	< 28.3		0.03										
SP005													
Aluminum	< 64.8	0.09				0.02	0.03		0.14	0.01	0.12		
Barium	143			2.08			0.02						

Hazard Quotients / Dilution Factors*														
Site/ Analyte ^b	Concentration ^c (ug/L)	NAWQC			Secondary Values			Lowest Chronic Values				EC20		
		Acute	Chronic	0.23	Acute	Chronic	Fish	Daphnids	Non-Daphnids	Plants	Fish	Daphnids	Sensitive Species	Population
Iron	228													
Manganese	233				0.16		0.13	0.21			0.18	0.21		2.08
SP006														
Barium	90				1.31			0.02						
Iron	120			0.12										
Manganese	356				0.24		0.20	0.32			0.28	0.32		3.18
SP007														
Aluminum	598	0.80					0.18	0.31	1.30	0.13	1.11			
Barium	169				2.46			0.03						
Iron	8280		8.28											
Manganese	4340				2.95		2.45	3.95		3.42	3.95			38.75
SP008														
Manganese	442				0.30		0.25	0.40		0.35	0.40			3.95
SP009														
Aluminum	317	0.42					0.10	0.17	0.69	0.07	0.59			
Barium	230				3.34			0.04						
Calcium	140000							1.21						
Iron	4710		4.71											
Manganese	8750				5.95		4.94	7.95		6.89	7.95			78.13

Site/ Analyte ^a	Concentration ^c (ug/L)	Hazard Quotients / Dilution Factors ^a												
		NAWQC		Secondary Values		Lowest Chronic Values						Lowest EC20		EC20
		Acute	Chronic	Acute	Chronic	Fish	Daphnids	Non-Daphnids	Plants	Fish	Daphnids	Sensitive Species		
SP011														
Barium	125			1.82			0.02							
Iron	3000		3.00											
Manganese	1600			1.09		0.90	1.45			1.26	1.45			14.29
SP012														
Aluminum	< 260	0.35				0.08	0.14		0.57	0.06	0.48			
Barium	160			2.33			0.03							
Calcium	134000						1.16							
Iron	1520		1.52											
Manganese	3330			2.27		1.88	3.03			2.62	3.03			29.73
SP014														
Aluminum	32.5	0.04				0.01	0.02		0.07	0.01	0.06			
Barium	152			2.21			0.03							
Calcium	128000						1.10							
Iron	2390		2.39											
Manganese	812			0.55		0.46	0.74			0.64	0.74			7.25
SP015														
Calcium	122000						1.05							
Cobalt	237			2.26		0.82								

Site/ Analyte ^a	Concentration ^c (ug/L)	Hazard Quotients / Dilution Factors ^a											
		NAWQC		Secondary Values		Lowest Chronic Values				Lowest EC20			
		Acute	Chronic	Acute	Chronic	Fish	Daphnids	Non-Daphnids	Plants	Fish	Daphnids	Sensitive Species	Population
Iron	2550		2.55										
Manganese	5780			3.93		3.27	5.25			4.55	5.25		51.61
Nickel	310	0.22	1.94			8.86		2.41		5.00	6.89		1.44
Selenium	~ 50.8	0.20	1.45			0.58	0.55		0.51	1.27	2.03	19.54	
SP016													
Aluminum	< 150	0.20				0.05	0.08		0.33	0.03	0.28		
Barium	183			2.66			0.03						
Iron	220		0.22										
Manganese	364			0.25		0.21	0.33			0.29	0.33		3.25
SP017													
Barium	193			2.81				0.03					
Iron	11300		11.30										
Manganese	10200			6.94		5.76	9.27			8.03	9.27		91.07

^a Hazard Quotient (HQ) = the maximum total concentration divided by the toxicological benchmark. An HQ > 1 indicates that the observed concentration exceeded that benchmark. The Dilution Factor (DF) is equivalent to the HQ and represents the final discharge rate needed reduce the HQ to 1 in a receiving stream (i.e., an HQ/DF of 4 would be reduced to 1 if the flow rate of the receiving stream is 4 times the seep discharge rate). Missing values indicate that a benchmark was not available for that analyte or that the benchmark was not used because it was below the mean background concentration.

^b includes all detected metals for which the maximum total recoverable concentration exceeded at least one benchmark.

^c Only one sample was collected at each seep; ~ indicates that the reported value was estimated; < indicates that the contaminant concentration was below the detection limit, which is the reported value.

Table C2.63 Off-site seep water summary of risk characterization for fish

Site	Evidence	Result	Explanation
SP001 (Undiluted)	Literature Toxicity Data	+	Dissolved Mn exceeded multiple chronic benchmarks. This is strong evidence of chronic toxicity in this seep. Acute toxicity is unlikely.
	Biological Surveys	N/A	No surveys were performed.
	Medium Toxicity Tests	N/A	No tests were performed.
	Weight of Evidence	+	Fish may be impacted by chronic, but not acute, exposure to undiluted seep water.
SP001 (In WOC)	Literature Toxicity Data	-	Contaminant concentrations are unlikely to be toxic when diluted into WOC.
	Biological Surveys	-	Surveys of WOC provide no convincing evidence that impacts on the fish community are increased by WAG 5.
	Medium Toxicity Tests	N/A	No tests were performed.
	Weight of Evidence	-	Acute and chronic impacts in WOC are unlikely.
SP002 (Undiluted)	Literature Toxicity Data	-	Contaminant concentrations are unlikely to be toxic in this seep.
	Biological Surveys	N/A	No surveys were performed.
	Medium Toxicity Tests	N/A	No tests were performed.
	Weight of Evidence	-	Fish are unlikely to be impacted by exposure to undiluted seep water.
SP002 (In WOC)	Literature Toxicity Data	-	Contaminant concentrations are unlikely to be toxic when diluted into WOC.
	Biological Surveys	-	Surveys of WOC provide no convincing evidence that community impacts are increased by WAG 5.
	Medium Toxicity Tests	N/A	No tests were performed.
	Weight of Evidence	-	Acute and chronic impacts in WOC are unlikely.
SP003 (Undiluted)	Literature Toxicity Data	+	Dissolved Mn exceeded the population EC20. This is weak evidence of chronic toxicity. Contaminant concentrations are unlikely to be acutely toxic.
	Biological Surveys	N/A	No surveys were performed.
	Medium Toxicity Tests	-	No evidence of acute or chronic toxicity.
	Weight of Evidence	-	Fish are unlikely to be impacted by exposure to undiluted seep water.

Site	Evidence	Result	Explanation
SP003 (In WOC)	Literature Toxicity Data	-	Contaminant concentrations are unlikely to be toxic when diluted into WOC.
	Biological Surveys	-	Surveys of WOC provide no convincing evidence that community impacts are increased by WAG 5.
	Medium Toxicity Tests	N/A	No tests were performed.
	Weight of Evidence	-	Acute and chronic impacts in WOC are unlikely.
SP004 (Undiluted)	Literature Toxicity Data	+	1,2-dichloroethylene exceeded the SCV. This is weak evidence of chronic toxicity. Contaminant concentrations are unlikely to be acutely toxic.
	Biological Surveys	N/A	No surveys were performed.
	Medium Toxicity Tests	+	Reproduction was significantly reduced. No evidence of acute toxicity.
	Weight of Evidence	+	Fish are likely to be impacted by chronic, but not acute, exposure to undiluted seep water.
SP004 (In WOC)	Literature Toxicity Data	-	Contaminant concentrations are unlikely to be toxic when diluted into WOC.
	Biological Surveys	-	Surveys of WOC provide no convincing evidence that community impacts are increased by WAG 5.
	Medium Toxicity Tests	N/A	No tests were performed.
	Weight of Evidence	-	Acute and chronic impacts in WOC are unlikely.
SP005 (Undiluted)	Literature Toxicity Data	+	Dissolved Mn exceeded the population EC20. This is weak evidence of chronic toxicity. Contaminant concentrations are unlikely to be acutely toxic.
	Biological Surveys	N/A	No surveys were performed.
	Medium Toxicity Tests	N/A	No tests were performed.
	Weight of Evidence	+	Fish may be impacted by chronic, but not acute, exposure to undiluted seep water.
SP005 (In MB)	Literature Toxicity Data	-	Contaminant concentrations are unlikely to be toxic when diluted into MB.
	Biological Surveys	-	Surveys of MB provide no convincing evidence that community impacts are increased by WAG 5.
	Medium Toxicity Tests	N/A	No tests were performed.
	Weight of Evidence	-	Acute and chronic impacts in MB are unlikely.

Site	Evidence	Result	Explanation
SP006 (Undiluted)	Literature Toxicity Data	+	Sr-89/90 exceeded the radiation criterion by a factor of 1.08. Dissolved Mn exceeded the population EC20. This is strong evidence of chronic toxicity.
	Biological Surveys	N/A	No surveys were performed.
	Medium Toxicity Tests	+	Acutely toxic to daphnids. Reproduction was not affected.
	Weight of Evidence	+	Fish may be impacted by acute or chronic exposure to undiluted seep water.
SP006 (In MB)	Literature Toxicity Data	-	Contaminant concentrations are unlikely to be toxic when diluted into MB.
	Biological Surveys	-	Surveys of MB provide no convincing evidence that community impacts are increased by WAG 5.
	Medium Toxicity Tests	N/A	No tests were performed.
	Weight of Evidence	-	Acute and chronic impacts in MB are unlikely.
SP007 (Undiluted)	Literature Toxicity Data	+	Dissolved Al, Fe, and Mn exceeded multiple chronic benchmarks. Dissolved Fe exceeded the chronic NAWQC. This is strong evidence of chronic toxicity. Contaminant concentrations are unlikely to be acutely toxic.
	Biological Surveys	N/A	No surveys were performed.
	Medium Toxicity Tests	N/A	No tests were performed.
	Weight of Evidence	+	Fish may be impacted by chronic, but not acute, exposure to undiluted seep water.
SP007 (In MB)	Literature Toxicity Data	-	Contaminant concentrations are unlikely to be toxic when diluted into MB.
	Biological Surveys	-	Surveys of MB provide no convincing evidence that community impacts are increased by WAG 5.
	Medium Toxicity Tests	N/A	No tests were performed.
	Weight of Evidence	-	Acute and chronic impacts in MB are unlikely.
SP008 (Undiluted)	Literature Toxicity Data	+	Sr-89/90 exceeded the radiation criterion by a factor of 3.189. Dissolved Mn exceeded the population EC20. This is strong evidence of chronic toxicity.
	Biological Surveys	N/A	No surveys were performed.
	Medium Toxicity Tests	-	No evidence of acute or chronic toxicity.
	Weight of Evidence	+	Fish may be impacted by chronic exposure to undiluted seep water.

Site	Evidence	Result	Explanation
SP008 (In MB)	Literature Toxicity Data	-	Contaminant concentrations are unlikely to be toxic when diluted into MB.
	Biological Surveys	-	Surveys of MB provide no convincing evidence that community impacts are increased by WAG 5.
	Medium Toxicity Tests	N/A	No tests were performed.
	Weight of Evidence	-	Acute and chronic impacts in MB are unlikely.
SP009 (Undiluted)	Literature Toxicity Data	+	Dissolved Fe exceeded the chronic NAWQC. 1,2-dichloroethylene exceeded the SCV. Dissolved Mn exceeded multiple benchmarks. This is strong evidence of chronic toxicity. Contaminant concentrations are unlikely to be acutely toxic.
	Biological Surveys	N/A	No surveys were performed.
	Medium Toxicity Tests	+	Reproduction was significantly reduced. No evidence of acute toxicity.
	Weight of Evidence	+	Fish are likely to be impacted by chronic, but not acute, exposure to undiluted seep water.
SP009 (In MB)	Literature Toxicity Data	+	Manganese concentrations may be toxic when diluted into MB. This is based on the dilution factor for the population EC20 and provides only weak evidence of toxicity.
	Biological Surveys	-	Surveys of MB provide no convincing evidence that community impacts are increased by WAG 5.
	Medium Toxicity Tests	N/A	No surveys were performed.
	Weight of Evidence	-	Acute and chronic impacts in MB are unlikely.
SP011 (Undiluted)	Literature Toxicity Data	+	Dissolved Fe exceeded the chronic NAWQC. Dissolved Mn exceeded multiple benchmarks. This is strong evidence of chronic toxicity. Contaminant concentrations are unlikely to be acutely toxic.
	Biological Surveys	N/A	No surveys were performed.
	Medium Toxicity Tests	N/A	No tests were performed.
	Weight of Evidence	+	Fish may be impacted by chronic, but not acute, exposure to undiluted seep water.
SP011 (In MB)	Literature Toxicity Data	-	Contaminant concentrations are unlikely to be toxic when diluted into MB.
	Biological Surveys	-	Surveys of MB provide no convincing evidence that community impacts are increased by WAG 5.
	Medium Toxicity Tests	N/A	No tests were performed.

Site	Evidence	Result	Explanation
	Weight of Evidence	-	Acute and chronic impacts in MB are unlikely.

Site	Evidence	Result	Explanation
SP012 (Undiluted)	Literature Toxicity Data	+	Dissolved Fe exceeded the chronic NAWQC. Dissolved Mn exceeded multiple benchmarks. This is strong evidence of chronic toxicity. Contaminant concentrations are unlikely to be acutely toxic.
	Biological Surveys	N/A	No surveys were performed.
	Medium Toxicity Tests	N/A	No tests were performed.
	Weight of Evidence	+	Fish may be impacted by chronic, but not acute, exposure to undiluted seep water.
SP012 (In MB)	Literature Toxicity Data	-	Contaminant concentrations are unlikely to be toxic when diluted into MB.
	Biological Surveys	-	Surveys of MB provide no convincing evidence that community impacts are increased by WAG 5.
	Medium Toxicity Tests	N/A	No tests were performed.
	Weight of Evidence	-	Acute and chronic impacts in MB are unlikely.
SP014 (Undiluted)	Literature Toxicity Data	+	Dissolved Fe exceeded the chronic NAWQC. 1,2-dichloroethylene exceeded the SAV and SCV. Dissolved Mn exceeded multiple benchmarks. This is strong evidence of chronic toxicity. Contaminant concentrations may be acutely toxic.
	Biological Surveys	N/A	No surveys were performed.
	Medium Toxicity Tests	N/A	No tests were performed.
	Weight of Evidence	+	Fish are likely to be impacted by chronic, and possibly acute, exposure to undiluted seep water.
SP014 (In MB)	Literature Toxicity Data	-	Contaminant concentrations are unlikely to be toxic when diluted into MB.
	Biological Surveys	-	Surveys of MB provide no convincing evidence that community impacts are increased by WAG 5.
	Medium Toxicity Tests	N/A	No tests were performed.
	Weight of Evidence	-	Acute and chronic impacts in MB are unlikely.
SP015 (Undiluted)	Literature Toxicity Data	+	Dissolved Fe, Ni, and Se exceeded chronic NAWQC. Dissolved Co exceeded the SAV and dissolved Mn exceeded multiple benchmarks. This is strong evidence of chronic toxicity. Contaminant concentrations are unlikely to be acutely toxic.
	Biological Surveys	N/A	No surveys were performed.
	Medium Toxicity Tests	N/A	No tests were performed.

Site	Evidence	Result	Explanation
	Weight of Evidence	+	Fish may be impacted by chronic, but not acute, exposure to undiluted seep water.

Site	Evidence	Result	Explanation
SP015 (In WOC)	Literature Toxicity Data	-	Contaminant concentrations are unlikely to be toxic when diluted into MB.
	Biological Surveys	-	Surveys of WOC provide no convincing evidence that community impacts are increased by WAG 5.
	Medium Toxicity Tests	N/A	No tests were performed.
	Weight of Evidence	-	Acute and chronic impacts in WOC are unlikely.
SP016 (Undiluted)	Literature Toxicity Data	+	Dissolved Mn exceeded the population EC20. This is weak evidence of chronic toxicity. Contaminant concentrations are unlikely to be acutely toxic.
	Biological Surveys	N/A	No surveys were performed.
	Medium Toxicity Tests	N/A	No tests were performed.
	Weight of Evidence	+	Fish might be impacted by chronic, but not acute, exposure to undiluted seep water.
SP016 (In MB)	Literature Toxicity Data	-	Contaminant concentrations are unlikely to be toxic when diluted into MB.
	Biological Surveys	-	Surveys of MB provide no convincing evidence that community impacts are increased by WAG 5.
	Medium Toxicity Tests	N/A	No tests were performed.
	Weight of Evidence	-	Acute and chronic impacts in MB are unlikely.
SP017 (Undiluted)	Literature Toxicity Data	+	Dissolved Fe exceeded the chronic NAWQC and acute values for daphnids. Dissolved Mn exceeded multiple benchmarks. This is strong evidence of acute and chronic toxicity.
	Biological Surveys	N/A	No surveys were performed.
	Medium Toxicity Tests	N/A	No tests were performed.
	Weight of Evidence	+	Fish are likely to be impacted by acute or chronic exposure to undiluted seep water.
SP017 (In MB)	Literature Toxicity Data	-	Contaminant concentrations are unlikely to be toxic when diluted into MB.
	Biological Surveys	-	Surveys of MB provide no convincing evidence that community impacts are increased by WAG 5.
	Medium Toxicity Tests	N/A	No tests were performed.
	Weight of Evidence	-	Acute and chronic impacts are unlikely in MB.

+ indicates that the evidence is consistent with the occurrence of the endpoint effect
- indicates that the evidence is inconsistent with the occurrence of the endpoint effect
± indicates that the evidence is too ambiguous to interpret
N/A indicates that the information is not available

Table C2.64. Comparison of Contaminant Exposure Estimates at Sites Where HQ's > 1 to Estimated LOAEL's for Determination of Sites Requiring Remediation

Species	Experimental Information				Endpoint/Effect	Citation	Estimated LOAEL (mg/kg/d)	Estimated Total Exposure (mg/kg/d) where HQ > 1 ¹					
	Analyte	Form	Test Species	LOAEL (mg/kg/d) and Duration				VW	OHF	NHF	SB	S5	TRU
Short-tailed Shrew	Antimony	antimony potassium tartrate	mouse	1.25 lifetime	Reduced longevity	Schroeder et al. 1968b	1.57					1.25	
	Barium	barium chloride	rat	1.98 ² 10 d	mortality	Borzelleca et al. 1988	5.6	26.8		34.29			
	Cadmium	soluble salt	mouse	2.518 2 gen.	Deformities, reduced reproductive success	Schroeder and Mitchner 1971	3.2		0.33				
	Manganese	Mn ₂ O ₃	rat	284 through gestation	Decreased fertility of offspring	Laskey et al. 1982	803			250.42			
	Mercury	methyl	rat	0.16 3 gen	Reduced viability of young	Verschuuren et al. 1976	0.45	0.82					
American Woodcock	Selenium	selenate	mouse	0.75 3 gen	reduced reproductive success	Schroeder and Mitchner 1971	0.94					1.31	2.44
	Zinc	zinc oxide	rat	320 through gestation	inc. fetal resorptions reduce fetal growth	Schlicker and Cox 1968	904.9	614.6					
	PCB	Aroclor 1254	white-footed mouse	1.35 18 mo	Reduced number of young/litter	Linzey 1987	1.5	0.18					
	Barium	barium hydroxide	chicks	41.63 ³ 4 wk	Mortality	Johnson et al. 1960	35.4	27.36		35.28			
	Chromium	CrK(SO ₄) ₂	black duck	5 10 mo.	Reduced survival of offspring	Haselkine et al. unpubl. MS	9.2	10.71					
Lead	acetate	japanese quail	11.26 12 wk	Reduced egg hatchability	Edens et al. 1976	10.3		8.85					

Table C2.64. Comparison of Contaminant Exposure Estimates at Sites Where HQ's > 1 to Estimated LOAEL's for Determination of Sites Requiring Remediation

for Determination of Sites Requiring Remediation													
Species		Experimental Information					Estimated Total Exposure (mg/kg/d) where HQ> 1 ¹						
Analyte	Form	Test Species	LOAEL (mg/kg/d) and Duration	Endpoint/Effect	Citation	Estimated LOAEL (mg/kg/d)	WW	OHF	NHF	SB	SS	TRU	
Mercury	methyl	mallard duck	0.064 3 gen.	Reduced egg production and hatching success	Heinz 1979	0.11	1.01						
Selenium	sodium selenite	mallard duck	1 78 d	inc. freq. of lethally deformed embryos	Heinz et al. 1987	1.7						3.03	
Zinc	zinc carbonate	mallard duck	30 ² 60 d	Mortality	Gasaway and Buss 1972	51.2	756.33						
Di-n-butyl phthalate		ring dove	1.1 4 w/k	reduced eggshell thickness	Peakall 1974	1.02	0.118						
Shaded cells indicate sites and contaminants were exposure estimates exceeded both estimated LOAEL and TRU													

¹ Shaded cells indicate sites and contaminants where exposure estimates exceeded both estimated LOAEL's and background exposure estimates

² Effect severe and study subchronic in duration, therefore a subchronic-chronic uncertainty factor applied.

³ While study was not chronic in duration, the effect was not severe. Therefore a subchronic-chronic uncertainty factor was not applied.

Table C2.65. Comparison of Exposure Estimation Using Upper 95% Confidence Interval and Maximum Detected Values

Endpoint	Area	Analyte	Media Concentrations (mg/L or kg)		Estimated Exposure (mg/kg/d)						LOAEL (mg/kg/d) ^b	Hazard Quotient ^c
			Water	Soil	Estimated in Earthworms ^a	Exposure Estimates Based Upon 95% UCL						
						Water	Soil	Food	Total			
American Woodcock	tru	Selenium	0	3.1	3.6781872	0	0.24424	2.78651	3.03075	1.7	1.78	
	ww	Chromium	0.11	94	4.349568	0.01111	7.40606	3.29513	10.7123	9.2	1.16	
	ww	Mercury	0	1.3	1.1995152	0	0.10242	0.90872	1.01114	0.11	9.19	
	ww	Zinc	0.03	1000	894.352	0.00303	78.78788	677.5394	756.3303	51.2	14.77	
	ww	Di-n-butyl Phthalate	0	1.5	0	0	0.11818	0	0.11818	0.102	1.16	
Exposure Estimates Based Upon Maximum Detected Value ^d												
American Woodcock	tru	Selenium	0	0.75	0.889884	0	0.05909	0.67415	0.73324	1.7	0.43	
	ww	Chromium	0.11	43	1.989696	0.01111	3.38788	1.50735	4.90634	9.2	0.53	
	ww	Mercury	0	0.41	0.3783086	0	0.0323	0.2866	0.3189	0.11	2.89	
	ww	Zinc	0.03	320	286.19264	0.00303	25.21212	216.8126	242.02776	51.2	4.73	
	ww	Di-n-butyl Phthalate	0	0.1	0	0	0.00788	0	0.00788	0.102	0.077	

Table C2.65. Comparison of Exposure Estimation Using Upper 95 % Confidence Interval and Maximum Detected Values

Endpoint	Area	Analyte	Media Concentrations (mg/L or kg)		Estimated Exposure (mg/kg/d)					LOAEL (mg/kg/d) ^b	Hazard Quotient ^c
			Water	Soil	Estimated in Earthworms ^a	Water	Soil	Food	Total		
Exposure Estimate Based Upon 95% UCL											
Short-tailed Shrew	nhf	Barium	0.05	400	4.9728	0.11	31.2	2.98368	34.29368	5.6	6.12387
	ww	Barium	0.14	310	3.85392	0.308	24.18	2.31235	26.80035	5.6	4.78578
	ww	Mercury	0	1.3	1.1995152	0	0.1014	0.71971	0.82111	0.45	1.82469
	s5	Selenium	0.24	0.99	1.1746469	0.528	0.07722	0.70479	1.31001	0.94	1.39363
	tru	Selenium	0	3.1	3.6781872	0	0.2418	2.20691	2.44871	0.94	2.60501
Exposure Estimates Based Upon Maximum Detected Value ^d											
Short-tailed Shrew	nhf	Barium	0.05	220	2.73504	0.11	17.16	1.64102	18.91102	5.6	3.37697
	ww	Barium	0.14	130	1.61616	0.308	10.14	0.9697	11.4177	5.6	2.03888
	ww	Mercury	0	0.41	0.3783086	0	0.03198	0.22699	0.25897	0.45	0.57549
	s5	Selenium	0.0356	0.99	1.1746469	0.07832	0.07722	0.70479	0.86033	0.94	0.91524
	tru	Selenium	0	0.75	0.889884	0	0.0585	0.53393	0.59243	0.94	0.63024
wet weight											

^a wet weight

^b LOAELs obtained from Table 6.4.4.-1.

^c Hazard Quotient = total exposure/LOAEL

^d Substituted maximum detected values in bold.

Table C2.66. Comparison of WW Soils Data to RBRAOS and Background Values
(all values in mg/kg)

Contaminant	WW Area Soil Sampling Locations		RBRAO	Mean Concentration in Background Soils ^a	Mean Concentration in Eastern U.S. Soils ^b	Proposed RCRA Action Levels ^c
	4113	SB044				
Barium	64	132	65	120	290	4000
Mercury	0.06	0.41	0.14	0.295	0.081 (3.4) ^d	20
Zinc	50.7	321	68	60	40 (2900) ^d	nd ^e

^a From Section C1, Table 2a.

^b From Shacklette and Boerngen 1984

^c From EPA 1990b.

^d Values in parenthesis are maximum values

^e nd = No Value Reported

Table C2.67. Comparison of sediment concentrations to RBRAOs for the benthic macroinvertebrates. Sediment concentrations are in mg/kg.
 Bold and highlighted values exceed RBRAOs and may require remediation.

Contaminant	RBRAO	Drainage D-1					Drainage D-2					Drainage D-3	
		SD001	SD002	SD003	SD004	SD005	SD006	SD007	SD008	SD009			
As ^a	70	3.5	3.2	3.4	2.6	12.5	14.0	8.6	7.1	1.7			
Ba ^b		162	269	121	181	959	1710	319	328	151			
Fe ^b		33400	36300	21800	22100	88100	93800	83600	56500	16500			
Hg ^a	0.71	0.09	0.08	0.14	ND	ND	0.17	0.29	0.38	0.09			
Ni ^a	51.6	43.6	70.6	49.1	30.5	21.6	19.0	18.6	20.7	17.2			
Ag ^a	3.7	2.2	2.3	1.1	ND	7.3	6.9	ND	ND	ND			
Acetone ^c	77.1	ND ^e	ND	ND	ND	ND	ND	0.64	ND	ND			
Aroclor 1260 ^a	0.18	0.12	0.15	0.83	0.04	0.039	0.085	ND	ND	ND			
1,1-Dichloroethane ^d	37.2	ND	ND	ND	ND	ND	0.017	0.14	0.067	ND			
1,2-Dichloroethene ^d	30.4	ND	ND	ND	ND	ND	0.08	0.98	2.1	ND			
Vinyl Chloride ^d	29.8	ND	ND	0.02	ND	ND	ND	0.57	1.1	ND			
RBRAO equivalent to ER-M From Long et al. (1994)													

^a RBRAO equivalent to ER-M From Long et al. (1994)

^b RBRAO could not be established

^c RBRAO derived using EqP approach (see Hull and Suter 1994) and LCV for daphnids (see Suter and Mabrey 1994).

^d RBRAO derived using EqP approach (see Hull and Suter 1994) and LCV for fish (see Suter and Mabrey 1994).

^e ND = contaminant not detected.

Table C2.68. Summary of Ecological Risks Identified for Terrestrial Endpoints^a

Location	Terrestrial Plants	Soil Invertebrates	Soil Microbes and Microbial Processes	American Woodcock	Short-tailed Shrew
Current Case					
S5	Possible Impact	Possible Impact	Impact Possible but Unlikely	NA ^b	NA
OHF	Possible Impact	No Impact	Impact Possible but Unlikely	NA	NA
TRU	No Impact	No Impact	No Impact	NA	NA
SB	No Impact	No Impact	No Impact	NA	NA
NHF	No Impact	No Impact	No Impact	NA	NA
WW	Possible Impact	Possible Impact	Impact Possible but Unlikely	Impact Possible but Unlikely	Possible Impact
Future Case					
S5	Possible Impact	Possible Impact	Impact Possible but Unlikely	Possible Impact	Possible Impact
OHF	Possible Impact	No Impact	Impact Possible but Unlikely	No Impact	No Impact
TRU	No Impact	No Impact	No Impact	No Impact	No Impact
SB	No Impact	No Impact	No Impact	No Impact	No Impact
NHF	No Impact	No Impact	No Impact	No Impact	Impact Possible but Unlikely
WW	Possible Impact	Possible Impact	Impact Possible but Unlikely	Impact Possible but Unlikely	Possible Impact
Contribution to Offsite					
S5	Contribution Possible but Unlikely	Contribution Possible but Unlikely	Contribution Possible but Unlikely	No Contribution	No Contribution

Table C2.68. Summary of Ecological Risks Identified for Terrestrial Endpoints^a

Location	Terrestrial Plants	Soil Invertebrates	Soil Microbes and Microbial Processes	American Woodcock	Short-tailed Shrew
OHF	No Contribution	No Contribution	Contribution Possible but Unlikely	No Contribution	No Contribution
TRU	No Contribution	No Contribution	No Contribution	No Contribution	No Contribution
SB	No Contribution	No Contribution	No Contribution	No Contribution	No Contribution
NHF	No Contribution	No Contribution	No Contribution	No Contribution	No Contribution
WW	Contribution Possible but Unlikely	Contribution Possible but Unlikely	Contribution Possible but Unlikely	Contribution Possible but Unlikely	No Contribution

^a For definitions of categories, see Section C2.6.

^b NA = Not Assessed

Table C2.69. Summary of Ecological Risks Identified for Wetland Plants^a

Seep Number	Current and Future Case	Contribution to Offsite
1	Impact Possible but Unlikely	No Contribution
2	Impact Possible but Unlikely	No Contribution
3	Impact Possible but Unlikely	Contribution Possible but Unlikely
4	No Impact	No Contribution
5	Impact Possible but Unlikely	Contribution Possible but Unlikely
6	No Impact	No Contribution
7	Impact Possible but Unlikely	Contribution Possible but Unlikely
8	No Impact	No Contribution
9	Impact Possible but Unlikely	No Contribution
11	No Impact	No Contribution
12	Impact Possible but Unlikely	No Contribution
14	Impact Possible but Unlikely	Contribution Possible but Unlikely
15	Possible Impact	No Contribution
16	Impact Possible but Unlikely	Contribution Possible but Unlikely
17	Impact Possible but Unlikely	No Contribution

^a For definitions of categories, see Section C2.6.

Table C2.70. Summary of Ecological Risks Identified for Fish ^a

Drainage and Flow Regime	Current and Future Case	Contribution to Offsite
D-1 Base Flow	Possible Impact	NA ^b
D-1 Storm Flow	No Impact	NA
D-2 Base Flow	Possible Impact	NA
D-2 Storm Flow	No Impact	NA
D-3 Base Flow	NA	Possible Contribution
D-3 Storm Flow	NA	Possible Contribution
White Oak Creek	NA	No Contribution
Melton Branch	NA	No Contribution

^a For definitions of categories, see Section C2.6.

^b NA = Not Assessed

Table C2.71. Summary of Ecological Risks Identified for Benthic Invertebrates ^a

Drainage	Current and Future Case	Contribution to Offsite
D-1	Possible Impact	NA ^b
D-2	Possible Impact	NA
D-3	NA	No Impact

^a For definitions of categories, see Section C2.6.

^b NA = Not Assessed

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