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White Oak Creek Watershed: Melton Valley Area Remedial Investigation Report, Oak Ridge National Laboratory, Oak Ridge, Tennessee

Volume 3. Appendix C

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APPENDIX C

BASELINE ECOLOGICAL RISK ASSESSMENT FOR THE WHITE OAK CREEK WATERSHED: MELTON VALLEY AREA

CONTENTS

TABLES vii

FIGURES xiii

ACRONYMS xv

1. INTRODUCTION 1-1

2. ECOLOGICAL PROBLEM FORMULATION 2-1
2.1 ENVIRONMENTAL DESCRIPTION 2-1
2.2 SOURCES 2-2
2.3 ECOLOGICAL ENDPOINTS 2-2
2.3.1 Assessment Endpoints 2-2
2.3.2 Measurement Endpoints 2-3
2.4 CONCEPTUAL MODELS 2-6
2.5 ORGANIZATION OF THE ECOLOGICAL RISK ASSESSMENT 2-6

3. RISKS TO FISH 3-1
3.1 EXPOSURE ASSESSMENT 3-1
3.1.1 Aqueous Chemical Exposures 3-1
3.1.2 Fish Chemical Body Burdens 3-1
3.1.3 Toxicity Test Exposures 3-2
3.2 EFFECTS ASSESSMENT 3-2
3.2.1 Single-Chemical Aqueous Toxicity 3-2
3.2.2 Fish Body Burdens 3-2
3.2.3 Ambient Water Toxicity 3-3
3.2.4 Fish Community Survey 3-3
3.2.5 Indicators of Fish Reproduction 3-3
3.3 RISK CHARACTERIZATION 3-4
3.3.1 Single-Chemical Aqueous Toxicity 3-4
3.3.2 Single-Chemical Internal Toxicity 3-6
3.3.3 Ambient Water Toxicity 3-7
3.3.4 Biological Indicators 3-7
3.3.5 Biological Surveys 3-7
3.3.6 Weight of Evidence for Fish 3-7
3.4 UNCERTAINTIES CONCERNING RISKS TO FISH 3-10

4. RISKS TO BENTHIC INVERTEBRATES 4-1
4.1 RIFFLE COMMUNITIES 4-1
4.1.1 Exposure Assessment 4-1
4.1.2 Effects Assessment 4-1
4.1.3 Risk Characterization 4-1
4.2 SEDIMENT COMMUNITIES 4-4
4.2.1 Exposure Assessment 4-4
4.2.2 Effects Assessment 4-4

4.3 UNCERTAINTIES CONCERNING RISKS TO BENTHIC INVERTEBRATES 4-10

5. RISKS TO SOIL INVERTEBRATES 5-1
5.1 EXPOSURE ASSESSMENT FOR SOIL INVERTEBRATES 5-1
5.2 EFFECTS ASSESSMENT FOR SOIL INVERTEBRATES 5-1
5.3 RISK CHARACTERIZATION FOR SOIL INVERTEBRATES 5-2
5.3.1 Single Chemical Soil Toxicity 5-2
5.3.2 Summary of Risk Characterization for Soil Invertebrates 5-9
5.4 UNCERTAINTIES CONCERNING RISKS TO SOIL INVERTEBRATES 5-9

6. RISKS TO PLANTS 6-1
6.1 EXPOSURE ASSESSMENT FOR PLANTS 6-1
6.1.1 Soil Exposures 6-1
6.1.2 Soil Solution Exposures 6-1
6.2 EFFECTS ASSESSMENT FOR THE PLANT COMMUNITY 6-2
6.3 RISK CHARACTERIZATION FOR THE PLANT COMMUNITY 6-2
6.3.1 Single chemical soil and solution toxicity 6-2
6.4 SUMMARY OF POTENTIAL RISKS TO PLANTS 6-24
6.5 UNCERTAINTIES CONCERNING RISKS TO PLANTS 6-24

7. RISKS TO TERRESTRIAL WILDLIFE 7-1
7.1 EXPOSURE ASSESSMENT 7-1
7.1.1 Oral Ingestion 7-1
7.1.2 Uptake Factors 7-2
7.1.3 Contaminant Concentrations in Media 7-3
7.1.4 Exposure Modeling using Point-Estimates 7-3
7.1.5 Exposure Modeling using Monte Carlo Simulations 7-4
7.2 CHEMICAL EFFECTS ASSESSMENT FOR WILDLIFE 7-5
7.2.1 Single Chemical Toxicity Data 7-5
7.2.2 Biological Surveys 7-6
7.3 CHARACTERIZATION OF CHEMICAL RISKS TO WILDLIFE 7-7
7.3.1 Single Chemical Toxicity Data 7-7
7.3.2 Effects of Retained Contaminants 7-15
7.3.3 Biological Surveys 7-16
7.3.4 Weight of Evidence 7-16
7.3.5 Summary of Risks to Terrestrial Wildlife 7-18
7.4 UNCERTAINTIES CONCERNING RISKS TO WILDLIFE 7-19
7.4.1 Bioavailability of Contaminants 7-19
7.4.2 Extrapolation from Published Toxicity Data 7-19
7.4.3 Variable Food Consumption 7-19
7.4.4 Single Contaminant Tests vs Exposure to Multiple Contaminants in the Field 7-19
7.4.5 Inorganic Forms or Species Present in the Environment 7-19
7.4.6 Uptake Factors 7-20
7.4.7 Contaminant Concentrations in Unanalyzed Food Types 7-20

8. ASSESSMENT OF RISKS TO PISCIVORES ON THE WHITE OAK CREEK WATERSHED 8-1
8.1 EXPOSURE ASSESSMENT 8-2
8.1.1 Exposure Through Oral Ingestion of Fish 8-2
8.2 EFFECTS ASSESSMENT FOR PISCIVOROUS WILDLIFE 8-6
8.2.1 Single Chemical Toxicity Data 8-6
8.2.2 Effects of Contaminants on the Reproductive Performance of Mink .. 8-6
8.2.3 Biological Surveys 8-7
8.3 RISK CHARACTERIZATION FOR PISCIVOROUS WILDLIFE 8-9
8.3.1 Single Chemical Toxicity Data 8-9
8.3.2 Mink Toxicity Tests 8-14
8.3.3 Biological Surveys 8-16
8.3.4 Weight of Evidence 8-17
8.3.5 Uncertainties Concerning Risks to Piscivorous Wildlife 8-20

9. RISKS TO ECOLOGICAL RECEPTORS FROM EXPOSURE TO RADIONUCLIDES .. 9-1
9.1 EXPOSURE ASSESSMENT 9-1
9.1.1 Exposure models 9-2
9.2 EFFECTS LEVELS FOR RADIONUCLIDES 9-7
9.3 RISK CHARACTERIZATION FOR BIOTA EXPOSED TO RADIONUCLIDES 9-8
9.3.1 HFIR Basin 9-8
9.3.2 HRE Basin 9-9
9.3.3 SWSA5 Seep A Basin 9-9
9.3.4 SWSA5 Seep B Basin 9-9
9.3.5 SWSA 5 Drainage D-2 Basin 9-10
9.3.6 SWSA5 Seep C Basin 9-10
9.3.7 MWOC/East Basin 9-10
9.3.8 MWOC/West Basin 9-11
9.3.9 West Seep Basin 9-12
9.3.10 SWSA6 Basin 9-12
9.3.11 WOL, Creek, and Floodplain Basin 9-12
9.3.12 NHF Basin 9-13
9.3.13 East Seep Basin 9-13
9.3.14 WCTrib1 & ^{60}Co Basin 9-14
9.4 SUMMARY OF RISKS TO BIOTA FROM EXPOSURE TO RADIONUCLIDES 9-14
9.4.1 Risks to terrestrial biota from exposure to radionuclides 9-14
9.4.2 Risks to piscivorous wildlife from exposure to radionuclides 9-14
9.4.3 Risks to aquatic biota from exposure to radionuclides 9-14
9.5 UNCERTAINTIES IN THE RADIOLOGICAL RISK ASSESSMENT 9-15

10. SUMMARY OF ECOLOGICAL RISKS WITHIN THE WHITE OAK CREEK WATERSHED 10-1
10.1 SOIL EXPOSURES 10-1
10.2 SURFACE WATER EXPOSURES 10-2
10.3 SEDIMENT EXPOSURES 10-3

11. REFERENCES 11-1

ATTACHMENT A TOXICITY PROFILES FOR CONTAMINANTS OF CONCERN A-1

TABLES

2.1 Subbasins within the White Oak Creek watershed. 2-1

3.1 Descriptions of ecotoxicological screening benchmarks for aquatic biota. 3-11

3.2 Surface water COPECs, risk scores, and resulting characterization of risks to benthic invertebrates based on surface water contamination. 3-12

3.3 Individual and sum of hazard quotients (HQs) for COPECs in unfiltered water from seeps and ephemeral tributaries, by subbasin. 3-13

3.4 Individual and sum of average hazard quotients (HQs) for surface water COPECs. . 3-21

3.5 Rules for assigning and interpreting risk scores for aqueous COPECs. 3-22

3.6 Comparison of maximum detected concentration of COPECs in unfiltered surface water to NAWQ criteria. 3-23

3.7 Exposure concentrations, benchmarks, and the resulting hazard quotients (HQs) for surface water COPECs. 3-24

3.8 Summary of data availability for aquatic assessment endpoints. 3-46

4.1 Descriptions of ecotoxicological screening benchmarks for benthic biota exposed to contaminated sediments. 4-11

4.2 Sediment COPECs, risk scores, and resulting characterization of risk to benthic invertebrates based on sediment contamination. 4-13

4.3 Individual and sum of average hazard quotients (HQs) for sediment COPECs. 4-17

4.4 Rules for assigning and interpreting risk scores for sediment COPECs. 4-21

4.5 Calculation of final confidence scores for sediment COPEC risk scores. 4-22

4.6 Exposure concentrations, benchmarks, and resulting hazard quotients (HQs) for sediment COPECs. 4-23

5.1 Summary of potential risks to invertebrates exposed to soils in the White Oak Creek watershed. 5-11

5.2 Risk results for soil invertebrates and terrestrial plants exposed to contaminants in White Oak Creek watershed soil. 5-12

6.1 Results of single contaminant screening for plants exposed to surface water seeps in the White Oak Creek watershed. 6-26

6.2 Summary of potential risks to plants exposed to contaminants in soil in the White Oak Creek watershed. 6-46

6.3 Summary of risks to plants from contaminants in seeps in White Oak Creek subbasins. 6-47

7.1 Contaminant biotransfer factors for selected ecological receptors in the White Oak Creek watershed. 7-21

7.2 Life history parameters for the short-tailed shrew (*Blarina brevicauda*) 7-27

7.3 Life history parameters for the white-footed mouse (*Peromyscus leucopus*). 7-29

7.4 Life history parameters for red fox (*Vulpes fulva*). 7-30

7.5 Life history parameters for white-tailed deer (*Odocoileus virginianus*). 7-32

7.6 Life history parameters for red-tailed hawks (*Buteo jamaicensis*). 7-34

7.7 Life history parameters for the Wild Turkey (Meleagris gallopavo). 7-36

7.8 Life history parameters for mink. 7-38

7.9 Exposure (mg/kg/d) and risk estimates for short-tailed shrews exposed to contaminants in surface water subbasins in the White Oak Creek watershed. ... 7-39

7.10 Exposure (mg/kg/d) and risk estimates for white-footed mice exposed to contaminants in surface soil at subbasins in the White Oak Creek watershed. ... 7-42

7.11 Exposure (mg/kg/d) and risk estimates for red fox exposed to contaminants in surface soils at subbasins in the White Oak Creek watershed. 7-43

7.12 Exposure (mg/kg/d) and risk estimates for white-tailed deer exposed to contaminants in surface soil at subbasins in the White Oak Creek watershed. ... 7-44

7.13 Exposure (mg/kg/d) and risk estimates for red-tailed hawks exposed to contaminants in surface soil at subbasins in the White Oak Creek watershed. ... 7-45

7.14 Exposure (mg/kg/d) and risk estimates for wild turkeys exposed to contaminants in surface soil at subbasins in the White Oak Creek watershed. ... 7-46

7.15 Exposure (mg/kg/d) and risk estimates for mink exposed to contaminants in surface soil at subbasins in the White Oak Creek watershed. 7-47

7.16 Metal concentrations in hair of mink from the ORR and from offsite reference samples. 7-48

7.17 Summary of potential risks (HQs > 1) from soils to the short-tailed shrew in the White Oak Creek watershed. 7-49

7.18 Summary of potential risks (HQs > 1) from soils to the white-footed mouse in the White Oak Creek watershed. 7-50

7.19 Summary of potential risk (HQs > 1) from soils to the red fox in the White Oak Creek watershed. 7-51

7.20 Summary of potential risk (HQs > 1) from soils to the white-tailed deer in the White Oak Creek watershed. 7-52

7.21 Summary of potential risk (HQs > 1) from soils to the red-tailed hawk in the White Oak Creek watershed. 7-53

7.22 Summary of potential risk (HQs > 1) from soils to the wild turkey in the White Oak Creek watershed. 7-54

7.23 Summary of potential risk (HQs > 1) from soils to the mink in the White Oak Creek watershed. 7-55

7.24 Interpretation of effects level/exposure distribution comparisons. 7-56

7.25 Estimated size of wildlife populations in the White Oak Creek watershed. 7-57

7.26 Summary of the number of individuals of terrestrial wildlife endpoints estimated to be experiencing adverse effects in the White Oak Creek watershed. .. 7-58

7.27 Summary of Monte Carlo results estimating population-level risk for white-footed mice and short-tailed shrews exposed to contaminants in soil within subbasins. 7-60

8.1 Life history parameters for river otter. 8-23

8.2 Life history parameters for belted kingfisher. 8-24

8.3 Life history parameters for great blue heron. 8-25

8.4 Life history parameters for osprey. 8-27

8.5 Summary statistics for fish data from the White Oak Creek watershed. 8-28

8.6 Estimated exposure of mink on the WOCW to mercury and PCBs. 8-29

8.7 Estimated exposure of river otter on the WOCW to mercury and PCBs. 8-30

8.8 Estimated exposure of belted kingfisher on the WOCW to mercury and PCBs. 8-31

8.9 Estimated exposure of great blue heron on the WOCW to mercury and PCBs. 8-32

8.10 Estimated exposure of osprey on the WOCW to mercury and PCBs. 8-33

8.11 Total biomass of fish observed at sampling locations in the WOCW. 8-34

8.12 Results of Monte Carlo simulation of exposure for piscivores on the WOCW. 8-35

8.13 Estimated NOAELs and LOAELs for mink and river otter. 8-36

8.14 Estimated NOAELs and LOAELs for belted kingfisher, great blue heron, and osprey. 8-37

8.15 Comparison of mainstem water concentrations (mg/L) in White Oak Creek watershed subbasins to piscivore water benchmarks. 8-38

8.16 Contaminant concentrations (mg/kg) found in kingfisher egg shells on the ORR. .. 8-51

8.17 Contaminant concentrations in tissues of the three kingfishers found on the ORR. . 8-52

8.18 Summary of number of locations where HQs > 1 were observed. 8-53

8.19 Summary of number of individuals of piscivore endpoints species estimated to be experiencing adverse effects by watershed and for the ORR. 8-55

8.20 Simulation of exposure of mink to mercury and PCBs in toxicity test diets. 8-57

9.1 Species-specific exposure parameters used in estimating wildlife exposures to radionuclides. 9-17

9.2 Average energy of decay and absorbed fractions for radionuclides detected in soil in the WOCW. 9-18

9.3a Average energy of decay and absorbed fractions for radionuclides detected in surface water used to evaluate exposures for aquatic organisms in the WOCW. . 9-20

9.3b Average energy of decay and absorbed fractions for radionuclides detected in surface water used to evaluate piscivore exposure in the WOCW. 9-23

9.4 Soil-to-tissue and food-to-tissue radionuclide uptake factors used in food chain models. 9-25

9.5 Equations for estimation of internal and external dose rates for aquatic organisms. . 9-27

9.6a Estimated radiation doses (mrad/d) from surface soil for soil invertebrates, plants, and short-tailed at WOC. 9-28

9.6b Estimated radiation doses (mrad/d) from surface soil for white-footed mouse, red fox, and white-tailed deer at WOC. 9-45

9.6c Estimated radiation doses (mrad/d) from surface soil for red-tailed hawk, wild turkey, and mink at WOC. 9-62

9.7 Estimated radiation doses (mrad/d) to piscivorous wildlife exposed to radionuclides in surface water at WOC. 9-79

9.8 Estimated radiation doses (mrad/d) to aquatic organisms exposed to radionuclides in surface water at WOC. 9-84

9.9 Estimated radiation doses (mrad/d) to aquatic organisms exposed to radionuclides in sediment at WOC. 9-92

9.10 Summary of risk to terrestrial biota from exposure to radionuclides in White Oak Creek watershed soil. 9-96

9.11 Summary of estimated risks to piscivorous wildlife from food chain exposures to radionuclides in White Oak Creek watershed surface water. 9-99

9.12 Summary of estimated risks to aquatic biota from exposures to radionuclides in White Oak Creek watershed surface water and sediment. 9-99

FIGURES

8.1 Conceptual model of the mechanisms by witch piscivorous wildlife are exposed to contaminants in the White Oak Creek watershed. 8-58

8.2 Fish sampling locations within the White Oak Creek watershed. 8-59

8.3 Summary of LOAEL-based toxic units for piscivorous wildlife in the White Oak Creek watershed. 8-60

ACRONYMS

COEC	contaminants of ecological concern
COPECs	contaminants of potential ecological concern
CVs	Chronic Values
DOE	U.S. Department of Energy
EPA	U. S. Environmental Protection Agency
EPT	Ephemeroptera, Plecoptera, and Trichoptera
HI	hazard index
HQ	hazard quotient
LCV	lowest chronic value
LOAELs	lowest observed adverse effects levels
LTV	lowest test value
NAWQC	National Ambient Water Quality Criteria
NOAELs	no observed adverse effects levels
NPDES	National Pollutant Discharge Elimination System
ORNL	Oak Ridge National Laboratory
ORR	Oak Ridge Operations
OU	operable unit
PCB	polychlorinated biphenyl
RI	Remedial Investigation
SAV	secondary acute value
SCV	secondary chronic value
SWMUs	solid waste management units
T&E	threatened and endangered
UCL	upper confidence limit
WAGs	waste area groupings (WAGs
WOCW	White Oak Creek watershed
WOCE	White Oak Creek Embayment
WOC	White Oak Creek

1. INTRODUCTION

This report provides details on the baseline ecological risk assessment conducted in support of the Remedial Investigation (RI) Report for the Melton Valley area of the White Oak Creek watershed (WOCW). The RI presents an analysis meant to enable the U.S. Department of Energy (DOE) to pursue a series of remedial actions resulting in site cleanup and stabilization. The ecological risk assessment builds off of the WOCW screening ecological risk assessment (Efroymson et al. 1996a). All information available for contaminated sites under the jurisdiction of the U.S. Department of Energy's Comprehensive Environmental Response, Compensation, and Liability Act Federal Facilities Agreement within the White Oak Creek (WOC) RI area has been used to identify areas of potential concern with respect to the presence of contamination posing a potential risk to ecological receptors within the Melton Valley area of the White Oak Creek watershed. The risk assessment report evaluates potential risks to receptors within each subbasin of the watershed as well as at a watershed-wide scale.

The Melton Valley area of the WOCW consists of WOC and its tributaries downstream of the Oak Ridge National Laboratory (ORNL) Main Plant area, White Oak Lake, the White Oak Creek Embayment (WOCE) of the Clinch River and the associated flood plains, and Melton Branch and its tributaries (Fig. 2.1 of Chapter 2 in this RI). The WOC RI area encompasses 1062 acres in Melton Valley. Approximately 160 acres of the area lie within designated solid waste management units (SWMUs) or contain secondary contamination. The WOC system has been exposed to contaminants released from ORNL and associated operations since 1943 and continues to receive contaminants from adjacent waste area groupings (WAGs).

2. ECOLOGICAL PROBLEM FORMULATION

The problem formulation consists of the identification of ecological endpoints, description of the relevant features of the environment, description of the sources of contamination, and summarization of that information in terms of a conceptual model of the hazard posed by the contaminants to the endpoint biota.

2.1 ENVIRONMENTAL DESCRIPTION

The environment considered in this assessment is the Melton Valley area of the WOCW. The Melton Valley area of the WOCW consists of WOC and its tributaries downstream of the ORNL Main Plant area, White Oak Lake, the WOCE of the Clinch River and the associated flood plains, and Melton Branch and its tributaries (Fig. 2.1 of the RI report).

While hazardous waste sites at ORNL have traditionally been organized into WAGs based on drainage area and similar waste characteristics, this report focuses on individual subbasins that make up the overall WOCW (Fig. 2.2 of the RI report). The subbasin organization is meant better refine linkages between source areas and potential effects within defined geographic areas of the watershed. The watershed has been divided into 33 subbasins. These are identified in Table 2.1 and portrayed in Fig. 2.2 of the RI report. Further description of basins and subbasins is provided in Sect. 2 and Sect. 3 of the WOCW RI report.

Table 2.1. Subbasins within the White Oak Creek watershed

Basin	Subbasin
Melton Branch	HFIR, HFIR East, HFIR South, MB-15, HF-2, HRE, SWSA 5 Seep A, SWSA 5 Seep B West, SWSA 5 Drainage D-2, and SWSA 5 Seep C
Middle White Oak Creek East	Melton Valley Drive (MVDrive), SWSA 5 WOC, SWSA 5 N WOC, and SWSA 5 Trib 1
Middle White Oak Creek West	Haw Ridge, Intermediate Pond, SWSA 4 East, SWSA 4 Main, WAG 7 WOC, and WOC
Lower White Oak Creek Tributary Basins	West Seep, East Seep, WCTRIB-1, ^{60}Co Seep, W6MS1, and W6MS3
White Oak Lake, White Oak Creek, and White Oak Creek Floodplain	Lower WOC, Pit 4 South, SWSA 6 East, SWSA 6 South, Trench 5 south, and WOCE

Surface water and sediment data from the watershed have been categorized as mainstem or seep. Mainstem (MS) reaches are those on WOC including White Oak Lake and tributaries, Melton Branch, and other streams that feed WOC and are not ephemeral. Seep data include springs, seeps, and ephemeral tributaries. Seep sites are associated with the subbasins in which they are located so that sources of chemicals can be identified, but seep data are not averaged with the mainstem data for evaluation of risks to aquatic biota.

No threatened or endangered species are known to occur in the watershed, but some state listed species (e.g., river otter) and federally listed species (e.g., bald eagle) are undergoing range expansions and may use the watershed in the future. Threatened or endangered species that are believed to occur on the Oak Ridge Reservation are listed by Suter et al. (1995).

2.2 SOURCES

The proximate sources considered in this assessment are the contaminated media in surface water, sediment, and surface soil. The ultimate sources of contaminants are the NPDES permitted point discharges at ORNL and releases from wastes in WAGs 1, 3-9, and 17. DOE's operations in the WOC watershed have included waste disposal, spills, and use of chemicals such as pesticides in the environment. A more detailed description of sources within the watershed is provided in Sec. 3 and Appendix A of the RI.

2.3 ECOLOGICAL ENDPOINTS

The problem formulation 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.

2.3.1 Assessment Endpoints

The following assessment endpoints for aquatic and terrestrial risks have been selected for this assessment.

- Reduction in species richness or abundance or increased frequency of gross pathologies in fish communities resulting from toxicity.
- Reduced species richness or abundance of benthic macroinvertebrate communities resulting from toxicity.
- Reduction in abundance or production of earthworms
- Reduction in abundance or production of piscivorous wildlife populations resulting from toxicity.
- Reduction in production of terrestrial plant communities resulting from toxicity.
- Reduction in abundance or production of terrestrial wildlife populations resulting from toxicity.

The ecological assessment endpoints have been selected based on DQO meetings that included representatives of the DOE, EPA Region IV, and TDEC and the strategy for ecological risk assessment on the ORR which was also a product of a DQO process (Suter et al. 1995). The selected endpoints are explained below.

1. The fish community is considered to be an appropriate endpoint community because it is ecologically and societally important, susceptible, and has a scale appropriate to the site. The societal importance is due to recreational fisheries; the ecological significance comes from the fact that much of the energy flow in temperate streams passes through fishes, and fishes are a major nutrient reservoir in those systems. In addition, the fish species in the watershed tend to move within an area smaller than the OU, and their movement is restricted by weirs and dams, so the scale is appropriate.

2. The benthic invertebrate community is considered to be an appropriate endpoint community because benthic invertebrates are highly susceptible and have a scale appropriate to the site. The high susceptibility is due to the association of these organisms with the sediment, which is the repository of most of the COPECs. In addition, the insects and crustaceans that dominate this community are sensitive to a variety of contaminants. Because these organisms are sedentary for all or most of their lives, their scale is highly appropriate to the scale of the site.

3. Soil invertebrates are considered to be an appropriate endpoint assemblage because they are susceptible, ecologically important, and have an appropriate scale. The susceptibility results from their intimate exposure to contaminated soils including, in the case of earthworms, ingestion. The ecological importance is due to their role in litter degradation, nutrient cycling, and maintaining soil structure. The appropriate scale results from their low mobility; biological populations could occupy an area as small as the subbasins defined for this assessment.

4. 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 floodplain. Finally, the scale is appropriate because plants are immobile and because a distinct plant community occurs on the floodplain.

5. Piscivorous and terrestrial wildlife species are considered to be appropriate because individuals are potentially sensitive due to food-web magnification of chemicals and because of the known sensitivity of some species (e.g., mink). Two of the contaminants of potential concern, PCBs and mercury, biomagnify in aquatic food webs leading to high levels of exposure in piscivorous wildlife. Mink have been shown to be highly sensitive to the toxic effects of PCBs and mercury in toxicity tests. Reproduction of piscivorous birds has been shown to be highly sensitive to PCBs. Prior screening assessments have shown that there is a potential for toxic exposures of wildlife to contaminants in WAG 2 (Blaylock et al. 1992, Sample et al. 1995). The chosen wildlife endpoint populations are mink, river otter, great blue heron, osprey, and belted kingfisher for piscivores and short-tailed shrew, white footed mouse, red fox, white-tailed deer, red-tailed hawk, and wild turkey for terrestrial wildlife. Although wildlife are not as clearly associated with the site as fish and plants, the watershed is considered to be an appropriate scale for assessing effects on wildlife populations.

T&E species are not directly addressed in this assessment. This is because the other endpoint species are judged to be as sensitive or more sensitive than the endangered species that may come to use the site.

Wetlands are assumed to be protected by assessing the risks to plants in the small wetland areas associated with seeps. These wetlands should be more highly exposed than those associated with the streams.

2.3.2 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, and toxicity test endpoints for chemicals found in the CR OU. Measurement endpoints are presented below for each assessment endpoint.

2.3.2.1 Fish

- **Biological Survey Data**—No fish survey data were collected by the WOC RI program. However, results of BMAP surveys will be cited as supporting evidence. The BMAP measurement endpoints are assumed to be direct estimates of that assessment endpoint.

- **Biological Indicators Data**—No fish bioindicators data were collected by the WOC RI program. However, published results of the BMAP biological indicators task will be cited as supporting evidence. Frequencies of gross pathologies are a direct measure of one aspect of the assessment endpoint. Measures of fish fecundity in largemouth bass and bluegill provide an indication of the potential contribution of reproductive toxicity to community effects. Measures of the levels of physiological and histological condition in redbreast sunfish help to confirm that exposures have occurred and may suggest mechanistic connections between exposure and effects on the fish community.

- **Media Toxicity Data**—No fish aqueous toxicity tests were conducted by the WOC RI program. However, published results of the BMAP tests will be cited as supporting evidence. Test endpoints include reductions in growth and survivorship of larval fathead minnows and in fecundity and survivorship of *Ceriodaphnia dubia (C. dubia)* in 7 day tests of ambient water, and reductions in hatching and larval survival and increases in terata in Japanese medaka (*Oryzias latipes*) eggs and larvae exposed to ambient water from shortly after fertilization to 48 hours post-hatch. Responses that are statistically significantly different or are inhibited by 20% or greater relative to control or reference waters are assumed to be indicative of waters that are toxic to fish.

- **Single Chemical Toxicity Data**—Chronic toxicity thresholds for freshwater fish are expressed as chronic EC20s or Chronic Values (CVs). 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 WOCW species, and exceedence of the CVs and EC20s are assumed to correspond to 20% or greater reductions in abundance, with some uncertainty.

2.3.2.2 Benthic invertebrates

- **Biological Survey Data**—Benthic invertebrate survey data were collected by the WOC RI program from areas in which fine sediments had been deposited. In addition, results of BMAP surveys of benthic invertebrates in riffles will be cited as supporting evidence. The measurement endpoints for both surveys are assumed to be direct estimates of that assessment endpoint.

- **Media Toxicity Data**—Planned sediment toxicity tests could not be performed because of concerns for worker safety.

- **Single Chemical Toxicity Data**—Chronic toxicity thresholds for freshwater invertebrates are expressed as chronic EC20s or CVs. 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 WOCW species, and exceedence of the CVs and EC20s are assumed to correspond to 20% or greater reductions in abundance, with some uncertainty. Two types of values were extracted from data on toxic concentrations in ambient sediment reported by the state of Florida: (1) thresholds for modification of benthic invertebrate community properties based on co-occurrence analyses, which are assumed to correspond to

the assessment endpoint, (2) thresholds for lethality in toxicity tests of contaminated sediments, which are also assumed to correspond to the assessment endpoint effect, but with greater uncertainty due to the extrapolation to the field.

2.3.2.3 Soil invertebrates

- **Biological Survey Data**—Earthworms were collected by the WAG 2 program, but no quantitative survey data are available.

- **Media Toxicity Data**—Planned earthworm toxicity tests could not be performed because of concerns for worker safety.

- **Single Chemical Toxicity Data**—Chronic toxicity thresholds for earthworms have been obtained from the literature. These test endpoints vary in their relevance but they are assumed to correspond to the assessment endpoint for this assemblage if they include sublethal responses.

2.3.2.4 Terrestrial plants

- **Biological Survey Data**—No quantitative vegetation surveys were performed. However, qualitative observations indicate that large portions of the watershed are vegetated.

- **Media Toxicity Data**—No media toxicity data are available.

- **Single Chemical Toxicity Data**—This includes 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 species within the WOCW. Exceeding the test endpoints is assumed to correspond to 20% reductions in abundance or productivity with some uncertainty.

2.3.2.5 Terrestrial wildlife

- **Biological Survey Data**—No quantitative surveys were performed for this assessment.

- **Media Toxicity Data**—No media toxicity data are available.

- **Single Chemical Toxicity Data**—These include 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. After allometric scaling for the endpoint species, these test endpoints are assumed to correspond to effects on individuals that could result in exceeding the population-level assessment endpoint. An extrapolation must be made to populations if effects on individuals are estimated to occur.

2.3.2.6 Piscivorous wildlife

- **Biological Survey Data**—Kingfisher reproduction was surveyed in WAG 2 and reference areas. Assuming that the kingfishers in the watershed constitute a population, this is a direct measure of the assessment endpoint for avian piscivores. Limited data concerning

presence/absence, movements, and bioaccumulation of contaminants are available for mink on the ORR, including the WOCW.

- **Media Toxicity Data**—Results of reproductive toxicity tests are available for ranch mink fed fish obtained from the Clinch River and Poplar Creek embayment.

- **Single Chemical Toxicity Data**—These include 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. After allometric scaling for the endpoint species, these test endpoints are assumed to correspond to effects on individuals that could result in exceeding the population-level assessment endpoint. An extrapolation must be made to populations if effects on individuals are estimated to occur. In addition, body burdens of a kingfisher were compared to concentrations associated with toxic effects on birds.

2.4 CONCEPTUAL MODELS

Conceptual models are graphical representations of the relationships among sources of contaminants, ambient media, and the endpoint biota. Figure 2.15 of the RI report shows a conceptual model for the streams and floodplains of the WOC watershed. Figure 2.16 of the RI report shows a conceptual model for wide-ranging wildlife that utilize the streams and floodplains as well as upland areas and nearby aquatic habitat. The exposure pathways shown are those that are included in the assessment. Note that different benthic invertebrate assemblages are exposed to water and sediments. That is, the invertebrates inhabiting soft sediments in depositional areas are assumed to be exposed to chemicals in those sediments and their pore water with negligible exposure to free water, and invertebrates inhabiting the rocky substrates of riffles are assumed to be primarily exposed to chemicals in water. These conceptual models are derived from the generic models developed for the ORR and are discussed in detail in the strategy document for ecological risk assessment on the ORR (Suter et al. 1995).

2.5 ORGANIZATION OF THE ECOLOGICAL RISK ASSESSMENT

The risks of chemicals to each of the ecological risk assessment endpoints in the current baseline case are assessed separately (Sect. 3.8). Each includes an exposure assessment, effects assessment, risk characterization, and characterization of uncertainty. Risks from exposure to radionuclides are discussed for all receptors in Sect. 9. Finally, ecological risks are summarized (Sect. 10). The components of the assessment are explained in the following text.

Exposure assessment characterizes the distribution in space and time of the concentrations of contaminants to which organisms are exposed. Risk from undetected chemicals are not assessed, as instructed by the FFA parties. Exposure calculations are performed for each subbasin.

Effects assessment characterizes the evidence concerning effects of contaminant exposure. The principle 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, bioindicator data which are biochemical and histological indications of the potential mechanisms and causes of effects, and single chemical toxicity data which indicate the toxic effects of the concentrations measured in site media.

Risk characterization is the phase of risk assessment in which the information concerning exposure and the information concerning the potential effects of exposure are integrated to estimate risks (the likelihood of effects given the exposure). Procedurally, the risk characterization is performed for each assessment endpoint by (1) screening all measured contaminants against toxicological benchmarks and background concentrations, if available, (2) considering the implications of other types of data for the hypothesis that a hazard exists that requires further assessment, (3) logically integrating the screening results with the other evidence to determine whether a credible hazard exists to the endpoint, and (4) listing and discussing the major uncertainties in the assessment.

3. RISKS TO FISH

Risks to fish communities were evaluated in mainstem surface waters and major tributaries. Seeps and small ephemeral tributaries do not support fish communities and are not assessed for risks to this endpoint. However, they are evaluated to determine which of these sources is contributing to risks in the streams and whether the seep waters exceed water quality standards.

3.1 EXPOSURE ASSESSMENT

3.1.1 Aqueous Chemical Exposures

Fish are exposed primarily to contaminants in water. Contaminants in water may come from upstream aqueous sources including the permitted outfalls, runoff, and the numerous seeps sampled and analyzed by the WAG 2 RI program. They may also come from internal cycling including exchange of materials between the surface water and contaminated sediments and exchange of contaminants between the biota and the water column. The consensus of the scientific community and of the EPA Office of Water is that aquatic biota should be assumed to be exposed to the dissolved fraction of the chemicals in water, because that is the bioavailable form (Prothro 1993). The EPA Region IV has previously expressed a preference for the use of total metals concentrations as conservative estimates of the exposure concentration. Only total concentrations were available and used in the exposure assessment for fish.

Because water is likely to be more variable in time than space, due to the rapid replacement of water, the mean water concentration within a subreach is an appropriate estimate of the chronic exposure experienced by fishes. The upper 95% confidence bound on the mean is an appropriately conservative estimate of this exposure for use in the contaminant screening. However, the distribution of observed concentrations is used to estimate risks.

Many of the chemical concentrations in water were below analytical detection limits. Chemicals that were not detected in any sample in a reach were eliminated. If a subbasin contained some detects and some nondetects for a chemical, nondetects were included at half the detection limit.

3.1.2 Fish Chemical Body Burdens

Although nearly all toxicity data for fishes is expressed in terms of aqueous concentrations, fish body burdens potentially provide an exposure metric that is more strongly correlated with effects (McCarty and Mackay 1993). This is particularly likely to be the case for chemicals that bioaccumulate in fish and other biota to concentrations greater than in water. For such chemicals, dietary exposure may be more important than direct aqueous exposures and concentrations that are not detectable in water may result in high body burdens in fish. Sufficient toxicological data are available for three potential WOC watershed contaminants that bioaccumulate in that manner: mercury, PCBs, and selenium. Only mercury and PCBs are considered in this assessment, because selenium was not found to be significantly elevated in fish from the WOC watershed (Ashwood 1994). Since the individual body burden measurements correspond to an exposure level for an individual fish, the maximum value is used for screening purposes, and the risk estimate is based on the distribution of individual observations. Measurements were performed on the muscle (fillet) of

largemouth bass (*Micropterus salmoides*), bluegill (*Lepomis macrochirus*), and redbreast sunfish (*Lepomis auritus*).

3.1.3 Toxicity Test Exposures

The water toxicity tests include direct exposure of *Ceriodaphnia dubia*, fathead minnow (*Pimephales promelas*) larvae, and Japanese medaka (*Oryzias latipes*) eggs and larvae to whole water. It is assumed that the form and bioavailability of chemicals is not altered by water collection and handling, so these tests represent exposures in the field.

3.2 EFFECTS ASSESSMENT

3.2.1 Single-Chemical Aqueous Toxicity

The sets of screening benchmarks for aquatic biota (described in Table 3.1) are taken from Suter and Tsao (1996). Ecotox Threshold values were issued by the EPA Office of Solid Waste and Emergency Response (OSWER 1996). They are not included as separate benchmarks in this assessment because the OSWER values were either from, or consistent with, the Suter and Tsao (1996) benchmarks. The benchmarks used in this assessment also are consistent with the EPA Region IV surface water screening values (EPA Region IV 1995). The Region IV BTAG Coordinator has indicated that on the ORR the Region IV screening values need not be used in addition to the more extensive set of benchmarks presented in Suter and Tsao (1996). The benchmark preferred by the regulatory agencies is the chronic national ambient water quality criteria (NAWQC), but they are available for relatively few industrial chemicals. Secondary chronic values, which are conservative estimates of chronic NAWQC, were calculated for chemicals that do not have NAWQC. Other benchmarks are included to provide greater assurance of detecting all COPECs.

NAWQC that are functions of water hardness are corrected for site-specific conditions. For purposes of screening, conditions were selected that would constitute reasonable maximum toxicity, defined as conditions that would persist for seven days. This was a hardness of approximately 100 mg/L (Blaylock et al. 1992).

Toxicity profiles are presented for COPECs in the attachment of this appendix. The toxicity profiles summarize the existing toxicity information for each chemical, including concentrations causing acute lethality and chronic lethal and sublethal effects, and physical-chemical conditions that modify toxicity. For chemicals with hardness-dependent criteria, test endpoints were corrected to 100 mg/L hardness using EPA's formula.

3.2.2 Fish Body Burdens

There are no standard benchmarks for effects on fish from internal chemical exposures. The body burdens associated with effects in toxicity tests and field studies and body burdens found at other sites are discussed in the following text. To be consistent with EPA practices, thresholds for toxic effects are expressed as geometric means of body burdens measured at the no observed effect concentration and lowest observed effect concentration. Only mercury and PCBs were considered because they are the COPECs known to significantly bioaccumulate in fish through dietary exposure.

3.2.2.1 Mercury

Estimates of body burdens of mercury that constitute a threshold for toxic effects on fish range from 0.66 mg/kg to 5.6 mg/kg wet wt. The lower figure is the geometric mean of body burdens in fathead minnows showing significant reproductive effects and those of fish showing no significant effects in a chronic test of mercuric chloride that included dietary exposures (Snarski and Olson 1982). The higher figure is the geometric mean of body burdens associated with reproductive effects and no significant effects in exposures of brook trout (*Salvelinus fontinalis*) to methyl mercury (McKim et al. 1976). Mercury concentrations in sunfish from streams in the vicinity of the ORR that were not mercury contaminated ranged from 0.06 to 0.11 mg/kg wet wt (Southworth et al. 1994).

3.2.2.2 Polychlorinated biphenyls

Estimates of body burdens of PCBs that constitute thresholds for toxic effects in fish are presented in the attachment of this appendix. They are presented on a whole-body basis, and, when possible, on a lipid-normalized basis. A very large range of values has been reported to constitute thresholds for toxic effects in toxicity tests, including one incredibly low value for lake trout.

3.2.3 Ambient Water Toxicity

Toxicity tests of WAG 2 water are performed by the ORNL BMAP and presented in their annual reports. The tests include (1) the standard 7-d tests of growth and survival, for fathead minnow larvae; (2) the standard 7-d tests of fecundity and survival, for *C. dubia*; and (3) an early life stage test with Japanese medaka eggs and larvae. The standard tests did not indicate aqueous toxicity in the last two years reported, 1992 and 1993. However, the more sensitive medaka embryo-larval test consistently indicated toxicity in water collected adjacent to or downstream of ORNL relative to upstream and control waters (Ashwood 1994). Attempts to identify the causal agent determined that medaka mortality was not affected by filtration with a 0.1 micron filter to eliminate suspended particles and pathogens, or by treatment with sodium thiosulfate to detoxify total residual chlorine. However, toxicity was completely eliminated by filtration with activated charcoal, a non specific treatment for aqueous contaminants.

3.2.4 Fish Community Survey

Analysis of fish population and community survey data provides a direct measure of impacts of human activities on aquatic ecosystems. The following results are taken from the most recent ORNL BMAP report (Ashwood 1993). The species composition of the fish community in the WOC watershed is stable at 13 species, which is less than other local streams. It is missing two families (Catastomidae and Percidae) and five genera (*Lythruras, Luxilus, Notropis, Noturus, and Phoxinus*) that historically occurred in the stream. The fish community in upper Melton Branch is somewhat less species rich than that of a similar reference site (two species versus three or four species in WOC above ORNL), but it is more dense than the reference. Species richness in lower Melton Branch is comparable to the references.

3.2.5 Indicators of Fish Reproduction

Reproduction and indicators of reproduction have been monitored in redbreast sunfish from 1989 to 1993. Indicators of reproductive condition of female redbreast sunfish improved over the period monitored until they nearly equal background values. However, reproductive success was highly variable with apparent reproductive failure occurring in lower WOC during the last reported year

of monitoring. Since this failure was not associated with poor reproductive condition of the female fish prior to spawning, effects on the embryos or larvae were said to be the likely cause (Ashwood 1994).

3.3 RISK CHARACTERIZATION

3.3.1 Single-Chemical Aqueous Toxicity

3.3.1.1 Screening of aqueous exposures against chemical benchmarks

Measured concentrations of inorganic chemicals were compared to twice the background concentration. This screening criterion is recommended by EPA Region IV. It should be noted that this practice in combination with the practice of using total metal concentrations, which is preferred by EPA Region IV, is potentially anticonservative because the concentration of particulate metal is being doubled along with the bioavailable dissolved fraction. If contamination doubled the bioavailable metal over the background concentration of bioavailable metal, that would not necessarily double the total metal concentration. Inorganics that exceeded the background criterion and all detected organic chemicals were screened against benchmarks and evaluated as COPECs. This was done by dividing the UCL95 concentration by each of the aqueous screening benchmarks (Table 3.1). Chemicals that exceeded any benchmark (i.e., the quotient of UCL95/aqueous screening benchmark was >1) were identified as COPECs (Table 3.2).

In addition to stream waters, the WAG 2 program sampled waters from seeps and small, ephemeral tributaries (Hicks 1996). Because these sites do not support fish communities, they are not assessed for risks to this endpoint. However, it is important to know which of these sources is contributing to risks in the streams. In addition, the State of Tennessee is concerned with whether the seep waters exceed water quality standards. Therefore, the UCL95 or maximum concentration for each chemical detected in each seep is compared to that chemicals chronic NAWQC, if one is available, or to the SCV (Table 3.3). Use of the regulatory standard (NAWQC) or a conservative estimate of the standard addresses the regulatory concern and provides a means of highlighting those seeps that have high concentrations relative to toxicity without suggesting the seeps support communities of fish and macroinvertebrates like the streams.

A second step in the screening process involved determining the relative contribution of the COPECs to the distribution of toxicity in the WOC watershed. This was done by calculating each COPEC's average screening hazard quotient (HQs based on UCL95) for the mainstem and large tributary surface water in a subbasin and adding these together to get the sum of the average HQs (Table3.4). Use of the average HQs, rather than the maximum HQs, reduces the influence of highly conservative screening benchmarks (e.g., SCVs). It is important to note that average HQs are heuristic only, providing an indication of the relative toxicity of sites and the relative contributions of chemicals to that toxicity. That is, these values are not used to identify COECs. Seeps were evaluated by summing the HQs for each COPEC (Table3.3), because only one HQ (based on NAWQC or SCV) was calculated.

3.3.1.2 Exposure–effects profiles for aqueous exposures

Risks were estimated by subbasin for each COPEC by comparing the distribution of observed concentrations to each aquatic benchmark. These comparisons were performed mathematically, rather than graphically, in order to ensure consistency and facilitate the evaluation of large data sets.

This was done by (1) identifying and then estimating points that define key segments of the exposure distributions; (2) classifying the available benchmarks with regard to the conservatism with which they estimate effects; (3) comparing each segment of the distribution to each benchmark; and (4) assigning a basin-specific risk score to each COPEC.

The distribution of aqueous concentrations represents the variation in exposure over time. Hence, the 80th percentile represents the concentration that is exceeded approximately 20 percent of the time. The key segments of the distribution are defined by four points: the 100th, 80th, 50th, and 0 percentiles. The benchmarks were classified as either possible-effects or probable-effects benchmarks. Possible-effects benchmarks are conservative estimates of concentrations at which toxicity may occur. Probable-effects benchmarks are concentrations at which toxicity is likely. Of the available benchmarks, only the secondary acute and chronic values (SAVs and SCVs) are considered to be conservative estimates of toxic concentrations. The NAWQC, lowest chronic values (LCVs), and lowest test values (LTVs) are probable-effects benchmarks (i.e., concentrations at which toxicity is more likely than not). Each segment of the distribution was compared to the benchmarks and a risk score of 0 to 8 was assigned. The rules and interpretations of this scoring process are presented in Table 3.5. The default score of zero indicates that the conservative point estimate of exposure (i.e., the UCL95) exceeded at least one benchmark, but that the observed concentrations were less than all benchmarks.

It should be noted that nondetects were included in the distribution at 0.5 times the detection limit. Hence, it is possible that the maximum value (100th percentile) is not a detected concentration. The conservatism this introduces was countered by specifying that the maximum detected concentration must exceed at least one probable-effects benchmark in order for a chemical to receive a score of 5 or higher. That is, a chemical can not be a COEC unless it was detected at least once at a concentration that is expected to be toxic. Furthermore, exclusion of the nondetects at the low end of the distribution would bias the estimations of exposure high. It also should be noted that the 80th percentile was set equal to the 100th percentile if the data set was too small (generally less than 5 observations) to estimate an 80th percentile.

Each risk score also was given a confidence score. Confidence in the risk score is a function of the quality of the benchmark that was exceeded and the magnitude of the exceedence. Confidence scores consist of a set of plus (+) or minus (-) signs. The default is a moderate to high degree of confidence, which is given a score of zero (indicated by the absence of a plus or minus sign). Unlike the benchmarks for sediment-associated biota (Section 4.3), all of the aqueous benchmarks are considered to be of moderate to high quality. The magnitude of the exceedence is determined by the largest hazard quotient (HQ) calculated for the final risk score. An HQ of 1-10 is indicated by the default score of zero, an HQ of 10-100 is indicated by a single plus (+), and an HQ of more than 100 is indicated by a double plus (++). Therefore, the confidence scores for aqueous COPECs range from zero to double plus (i.e., " ", "+", "++"). As an example, a final score of "7++" indicates that the 50th percentile of the exposure distribution was at least 100 times higher than one or more probable-effects benchmark. This suggests that toxicity is likely most of the time.

The final risk scores were then used to characterize the risks to fish as negligible (0 to 2++), marginal (3 to 5++), or significant (6 to 8++). That is, chemicals are considered to present a significant risk and to be of concern (CEOCs) if at least 20% of the concentrations exceeded probable-effects benchmarks. COPECs are considered to present a marginal risk if at least 50% of the concentrations exceeded possible-effects benchmarks or the maximum detected concentration exceeded probable-effects benchmarks. All other COPECs are considered to present negligible risks, including those for which only the UCL95 exceeded benchmarks.

Table 3.2 presents, for each COPEC, the characterization of risks to fish and the final risk score by subbasin. Table 3.6 presents the hazard quotients of the maximum detected concentration for chemicals with NAWQC. Table 3.7 details the exposure estimates (UCL95) for each location, benchmark values, and the corresponding HQs. Therefore, this section addresses only that information that aids in characterizing the risks associated with the COECs. NAWQC are included in the screening against benchmarks, but are not the sole factor in characterizing risks and are not evaluated as ARARs in this section.

Fourteen of the nineteen inorganic COPECs are COECs, nine of which (ammonia, aluminum, copper, iron, lead, silver, thallium, tin, and zinc) appear to present a significant risk to fish in every subbasin in which they were detected at concentrations greater than background. Only two of the nine organic COPECs are COECs, bis(2-ethylhexyl)phthalate and polychlorinated biphenyl (Total PCBs). Five of these chemicals (cadmium, lead, nickel, silver, and Total PCBs) could be disregarded as COECs in at least one subbasin, because they were detected in less than five percent of the samples (Table 3.2).

Risks to aquatic biota may be overestimated for all of the inorganic COECs and Total PCBs. The available data are from unfiltered water samples, which are likely to overestimate bioavailability. This may be particularly true for Total PCBs, which are strongly particle reactive and rarely detected in filtered water samples.

The toxicological data for aluminum and ammonia require further consideration. Aluminum is very insoluble in circum neutral water and the fraction that is bioavailable in the WOC watershed is unlikely to be toxic to aquatic biota. The available toxicological data, including that used to derive the NAWQC, are from tests in which aluminum was dissolved in an acidic solution which was then neutralized. This is appropriate for evaluating situations such as neutralized acid mine drainage. Given that such conditions are not known to exist in the WOC watershed, remediation to reduce aluminum in water is not warranted. Ammonia is identified as a COEC in the two subbasins where it was detected above background, WOC and Lower WOC. However, caution should be exercised in deciding to remediate for this chemical because the lowest chronic value for fish (0.0017 mg/l) was the only benchmark exceeded. That benchmark is more than 250 times lower than the other available benchmarks. None of the detected concentrations exceeded these other benchmarks.

Bis(2-ethylhexyl)phthalate was detected in two subbasins (W6MS1 and W6MS3). However, detection of this chemical is often an artifact of the sampling and analytical processes.

3.3.2 Single-Chemical Internal Toxicity

3.3.2.1 Mercury

Mercury concentrations in largemouth bass, but not sunfish, increased from a mean of 0.11 to 0.57 mg/kg wet weight during the period 1988-1992 for unknown reasons (Ashwood 1994). The maximum concentrations in largemouth bass in the last two reported years (0.70 and 0.71 mg/kg in 1991 and 1992) exceeded the 0.66 mg/kg concentration that corresponded to a CV for fathead minnows but was well below the value for brook trout (5.6 mg/kg). The median concentration for largemouth bass and all concentrations for bluegill and redbreast sunfish were below 0.66 mg/kg.

3.3.2.2 Polychlorinated biphenyls

PCBs have been detected in sunfish, largemouth bass, and channel catfish in WOC with the highest concentrations found in channel catfish from the embayment (Ashwood 1994). However, both mean and maximum concentrations in catfish in 1993 were below the concentration of PCB-1242 that reduced growth and caused liver hypertrophy in channel catfish at a body burden of 14.3 mg/kg (Hansen et al. 1976).

3.3.3 Ambient Water Toxicity

Water from the watershed was lethal to Medaka embryos and larvae. Medaka toxicity was tested in WOC but not its tributaries (Ashwood 1993). Toxicity was not observed above ORNL, but consistently occurred downstream (Ashwood 1994). During 1991-1993 Medaka survival averaged less than 20% in water from the subbasins below ORNL (i.e., intermediate Pond, WOC, Lower WOC), whereas survival in reference and control water averaged approximately 90%. The lowest mean survival rate (<10%) was in water from the White Oak Lake dam. This pattern is consistent with an accretion of contaminants in the creek. Since water was not chemically analyzed in conjunction with the toxicity tests and the toxicity identification and evaluation (TIE) was not completed, it is not possible to determine which contaminants may be responsible for the toxicity. However, preliminary TIE results indicate that a chemical other than chlorine was responsible.

In contrast , WOC water was not toxic, based on the results of the 7-day fathead minnow and *C. dubia* tests. This lack of response relative to the snail test was attributed to the insensitivity of the standard static renewal test to total residual chlorine (Ashwood 1993). The lack of response relative to Medaka may be attributed to the inherent sensitivity of Medaka or the longer duration of the Medaka test and the inclusion of two life stages.

3.3.4 Biological Indicators

Results of the studies of histological, physiological, and reproductive indicators are presented by Ashwood (1994). Although these indicators show improvement, reproductive indicators for redbreast sunfish can not be interpreted as indicative of effects on the fish community endpoint. Rather, they are suggestive of inhibited reproduction in individuals of one species.

3.3.5 Biological Surveys

Surveys of the fish community in WOC indicate a significant loss of species compared to surveys conducted in the 1950s. Although it seems likely that the original loss was due to contaminants, it is not clear that the current contaminant levels would cause the same effect. The dam and numerous weirs inhibit movement of fish and may be preventing recovery of the community. However, the fish community in Melton Branch does not appear to be significantly degraded relative to references.

3.3.6 Weight of Evidence for Fish

The weighing of evidence is performed by asking the following questions concerning each subbasin in the watershed:

1. Is the fish community less species-rich or abundant than would be expected?

2. Do individual fish display injuries that are indicative of significant toxic effects?

3. Is the water toxic to aquatic organisms?

4. Does that water contain chemicals in toxic amounts?

5. Do the fish contain chemicals in toxic amounts?

6. What factors account for apparent discrepancies in the results?

7. What is the likelihood that the fish community is at least 20% less species rich or abundant than it would be in the absence of contamination?

Subbasins for which at least surface water chemistry data are available (Table 3.8) are discussed below. Water chemistry and biological data are available for the following seven subbasins.

3.3.6.1 Intermediate pond

The weight-of-evidence suggests that water in this subbasin poses a significant risk to fish. The fish community is less species rich relative to the community observed here in the 1950s and the water has been lethal to Medaka embryos and larvae. Copper, iron, silver, and thallium concentrations appear to present significant risks. However, aluminum concentrations are probably not toxic in this system.

3.3.6.2 WOC

The weight-of-evidence suggests that water in this subbasin poses a significant risk to fish. The fish community is less species rich relative to the community observed here in the 1950s, redbreast sunfish have experienced reproductive failures, and the water has been lethal to Medaka embryos and larvae. Of the eight COECs, copper, iron, and thallium concentrations appear to be the most likely contributors to toxicity. Ammonia concentrations exceeded only the lowest benchmark, suggesting that they may be toxic to sensitive species. Lead and nickel concentrations may be toxic, but these metals were detected in less than 5% of the samples. Total PCBs were detected in only 7% of the samples and are likely to be bound to particulate matter and not bioavailable. Aluminum concentrations are not expected to be toxic in this system.

3.3.6.3 MB-15

The weight-of-evidence suggests that water in this subbasin does not pose a significant risk to fish. Although the fish community is somewhat less species rich than a similar reference stream (two species versus three or four species), it is more dense than the reference, the water has not been toxic in the standard toxicity tests, and none of the detected chemicals exceeded any benchmarks (i.e., there are no COPECs).

3.3.6.4 Seep B East

The weight-of-evidence suggests that water in this subbasin does not pose a significant risk to fish. Species richness is comparable to that of the reference streams, though this reach is somewhat larger than the references, which may account in part for number of species present. However, the

water has not been toxic in the standard toxicity tests and none of the detected chemicals exceeded any benchmarks (i.e., there are no COPECs).

3.3.6.5 Seep C

Although the weight-of-evidence is not strong, it suggests that water in this subbasin does not pose a significant risk to fish. Copper and nickel are COECs, but the concentrations measured may over estimate the fraction that is bioavailable. Furthermore, the water has not been toxic in the standard toxicity tests. However, the medaka toxicity data and fish community surveys that made the single chemical toxicity data credible in other subbasins are not available here.

3.3.6.6 Lower WOC

The weight-of-evidence suggests that water in this subbasin poses a significant risk to fish. The fish community is less species rich relative to the community observed here in the 1950s, redbreast sunfish have experienced reproductive failures, and the water has been lethal to Medaka embryos and larvae. Of the eleven COECs, cobalt, copper, iron, nickel, thallium and zinc concentrations appear to be the most likely contributors to toxicity. Ammonia concentrations exceeded only the lowest benchmark, suggesting that it may be toxic to sensitive species. Cadmium, silver and Total PCB concentrations may be toxic, but these chemicals were detected in less than 5% of the samples. Aluminum concentrations are not expected to be toxic in this system.

3.3.6.7 WOCE

Although the weight-of-evidence is not strong, it suggests that water in this subbasin poses a significant risk to fish. Cadmium is the only COEC and the concentrations measured may over estimate the fraction that is bioavailable. Body burdens measurements suggest that mercury and PCBs are not significantly toxic, but provide no evidence for the effects of cadmium. Although water from within the embayment was not tested, water entering the embayment reduced Medaka embryo and larvae survival by 90%. Hence, there is no strong evidence to indicate that cadmium does not pose a risk in this subbasin.

Chemical concentrations in surface water is the only line of evidence available for eleven subbasins. Significant risks are not indicated in three of these subbasin (SWSA 5 N WOC, HRE, and Seep B west), because none of the detected chemicals exceeded benchmarks (i.e., there are no COPECs). Even if the benchmarks for aluminum are set aside as inappropriate to this site, there is at least one COEC in each of the remaining subbasins (Table 3.8). That is, significant risks are indicated in eight subbasins.

In summary, the toxicity to Medaka embryos and larvae provides important supporting evidence that waters in WOC are toxic to fish. The low species richness of WOC is consistent with effects but could have physical causes. Although all of these lines of evidence are consistent with a hazard to fish in WOC, the evidence is not conclusive. The high metal concentrations could be non bioavailable, the Medaka could be much more sensitive than any of the fish species native to the stream, and the low species richness could be due to physical barriers to recovery. In particular, it should be noted that three years have passed since the collection of the most recent biological data that were available for this assessment. At that time, the bioindicators data suggested that the condition of fish in WOC was improving and was approaching that of fish in reference streams. It is possible that the fish community has largely recovered and that toxicity would no longer be observed in WOC at this time.

3.4 UNCERTAINTIES CONCERNING RISKS TO FISH

The following issues constitute the major sources of uncertainty in the risk assessment for the fish community.

- The bioavailable concentrations of chemicals in water are unknown. In assessments that included analyses of filtered as well as unfiltered water, concentrations of aluminum and some other metals that were above criteria in the unfiltered water were shown to be associated with particles (i.e., not bioavailable).

- The toxicity of water in 13 subbasins is unknown.

- The high observed mortality in Medaka embryos and larvae are believed to constitute toxic effects that would result in significant effects on the fish community. However, this test is sensitive and has not been validated against biological survey data at sites where clear toxic effects are occurring and fish community properties are clearly related to toxic effects, as has been done with the standard 7-day tests.

Table 3.1. Descriptions of the ecotoxicological screening benchmarks for aquatic biota[a]

Benchmark	Abbreviation	Description
Acute National Ambient Water Quality Criteria	NAWQC_ACU	Current national criteria for protection of aquatic life from lethal effects in episodic exposures. Adjusted for hardness of 100 mg/L $CaCO_3$ for hardness-dependent metals.
Chronic National Ambient Water Quality Criteria	NAWQC_CHR	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. Adjusted for hardness of 100 mg/L CaCO3 for hardness-dependent metals.
Secondary Acute Value	S_ACU_V	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	S_CHR_V	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_DAPH	The lowest value, from acceptable daphnid chronic toxicity tests, of the geometric mean of the LOEC and the NOEC.
Lowest Chronic Value for non-daphnid invertebrates	LCV_NDI	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_AQPL	The lowest value from an acceptable aquatic plant 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_DAPH	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 and fecundity.

[a]More details are presented by Suter and Tsao (1996).

Table 3.2. Surface water COPECs, risk scores, and the resulting characterization of risks to benthic invertebrates based on surface water contamination

Analyte	SWSA 5 WOC	SWSA 5 Trib 1	Intermediate Pond	WOC	HF-2	HFIR/ south	Seep A	Seep C	West Seep	W6MS1	W6MS3	SWSA 6 East	Lower WOC	WOCE
Ammonia				S (8)									S (8)	
Aluminum	S (7)		S (6)	S (7)	S (7)				S (6)	S (7+)	S (7)	S (7)	S (7)	
Barium					M (4)					M (3+)	M (3+)		M (4)	
Beryllium			N (1)	N (1)	N (1)		N (1)	N (1)	N (2)		N (2)		N (1)	
Boron			M (4)	M (4)	M (4)		M (4)	M (4+)		M (4+)	M (4)		M (4)	
Cadmium				N (0)^					S (8)	S (8)	S (8)		S (7+)^	S (8)
Cobalt					S (6)		N (0)			S (7)	S (7)		S (6)	
Copper	S (8)		S (8)	S (8)	S (8)		S (8)	S (8)	S (8+)	S (8+)	S (8+)		S (8)	
Iron			S (7)	S (7)		S (8+)			S (8)	S (7+)	S (7+)	S (8+)	S (7+)	
Lead				S (7)^						S (7)	S (7)			
Lithium	M (4+)												N (0)	
Manganese				N (1)						M (5)	S (6)		M (5)	
Mercury				M (5)	M (5++)					S (6)	S (6)	S (6)	M (5)	
Nickel	N (0)	S (6)		S (7)^				S (6)		S (7)	S (7)		S (7)	
Selenium	N (0)									N (0)			N (0)^	
Silver			S (8+)								S (8)		S (8)^	
Thallium			S (6)	S (6)	S (6)		S (6)						S (6)	
Tin											S (6)			
Zinc					S (7)								S (6)	
Benzene	N (0)	N (0)									N (0)			
Bis(2-Ethylhexyl)Phthalate	N (0)									S (8)	S (7)			
Carbon Disulfide			M (4)	M (3+)	M (4+)		M (4)		M (4)	M (3)	M (3)		M (4)	
Carbon Tetrachloride	N (2)	N (2)												
Ethylbenzene	N (2)	N (2)												
Naphthalene	N (0)	N (0)								N (0)				
Polychlorinated Biphenyl				S (7)									S (7)^	
Toluene	N (2)	N (2)							N (0)	N (0)	N (0)			
Xylene (Total)	N (0)	N (0)												

S = Significant Risks (Risk Score is 6, 7, or 8), Chemical is COEC
M = Marginal Risks (Risk Score is 3, 4, or 5), Chemical is COPEC
N = Negligible Risks (Risk Score is 0, 1 or 2), Chemical is COPEC
Confidence scores indicate magnitude of benchmark exceedence (+ = Hazard Quotient (HQ) of 10 to 100, ++ = HQ of more than 100)
BOLD indicates COEC
None of the chemicals in the following five subbasins were COPECs: SWSA 5 N WOC, MB-15, HRE, Seep B East, and Seep B West.
^Detected in less than 5%of the samples.

Table 3.3. Individual and sum of hazard quotients (HQs) for COPECs in unfiltered water from seeps and ephemeral tributaries, by subbasin

		MVDrive	SWSA 5 WOC		SWSA5 N WOC			SWSA 5 Trib 1			
Analyte	Benchmark	5NNT	05.SP004	SW5-2	05.SP002	5NW-1	5NW-2	05.SP003	05.SP015	05.SW001	SW5-1
Sum of HQs		**227**	**93**	**167**	**26**	**63**	**166**	**363**	**161**	**37**	**323**
Aluminum	NAWQ_CHR	23	50	18	18	18	10	152		13	35
Antimony	S_CHR_V	< 1									
Barium	S_CHR_V	31	29	23				105			43
Beryllium	S_CHR_V	2		1		2	1				2
Boron	S_CHR_V			118		13	111				50
Cadmium	NAWQ_CHR	3									
Cobalt	S_CHR_V	< 1					< 1	< 1	19		< 1
Copper	NAWQ_CHR	< 1	2	< 1						< 1	
Iron	NAWQ_CHR	2	5	2			1	27	11	< 1	6
Lead	NAWQ_CHR										
Lithium	S_CHR_V	< 1								14	
Manganese	S_CHR_V	3				25	35	72	113	1	61
Mercury	S_CHR_V	< 1							< 1		
Nickel	NAWQ_CHR	< 1							2	< 1	
Selenium	NAWQ_CHR	< 1							11	< 1	
Silver	S_CHR_V										
Thallium	S_CHR_V	7									124
Tin	S_CHR_V	< 1									
Vanadium	S_CHR_V	1		2		5	1	1			1
Zinc	NAWQ_CHR										
Zirconium	S_CHR_V										
1,1,1-Trichloroethane	S_CHR_V										
Bis(2-Ethylhexyl)Phthalate	S_CHR_V							< 1		2	< 1
Carbon Disulfide	S_CHR_V	152					1				
Carbon Tetrachloride	S_CHR_V		1		2		1	1	1	< 1	
Cis-1,3-Dichloropropene	S_CHR_V										
Ethylbenzene	S_CHR_V									1	
Naphthalene	S_CHR_V		1		2		1	1	1	< 1	
Tetrachloroethene	S_CHR_V		< 1		< 1		< 1	< 1	< 1	< 1	
Toluene	S_CHR_V		1		2		1	1	1	< 1	
Total-1,2-Dichloroethene	S_CHR_V		< 1	< 1				< 1	< 1		< 1
Trans-1,3-Dichloropropene	S_CHR_V										
Trichloroethene	S_CHR_V		2	2				< 1	< 1		< 1
Xylene (Total)	S_CHR_V		1		< 1		< 1	1	< 1	< 1	

Table 3.3. (continued)

Analyte	Benchmark	SWSA 4 main							
		BTT	SCS1B	SW4-1	SW4-2	W4TRIB-11	W4TRIB-5	W4TRIB-7	WAG4 MS1
Sum of HQs		**136**	**167**	**325**	**308**	**172**	**132**	**325**	**195**
Aluminum	NAWQ_CHR						21		2
Antimony	S_CHR_V		2	1					
Barium	S_CHR_V	78	48	133	109	67	22	38	46
Beryllium	S_CHR_V	< 1	2	2	< 1	< 1			2
Boron	S_CHR_V	54	63	108	119	71	87	256	113
Cadmium	NAWQ_CHR	2	5		2	2			< 1
Cobalt	S_CHR_V	< 1	< 1	< 1	1	< 1			< 1
Copper	NAWQ_CHR	< 1	< 1		< 1	2			< 1
Iron	NAWQ_CHR			26	4	2	2	< 1	< 1
Lead	NAWQ_CHR		16						
Lithium	S_CHR_V		2		8				
Manganese	S_CHR_V		5	31	9	19		31	8
Mercury	S_CHR_V				< 1				< 1
Nickel	NAWQ_CHR	< 1	< 1		53	< 1	< 1		< 1
Selenium	NAWQ_CHR		10						
Silver	S_CHR_V		14			8			
Thallium	S_CHR_V			23					22
Tin	S_CHR_V		< 1						
Vanadium	S_CHR_V	< 1	< 1	< 1	< 1				< 1
Zinc	NAWQ_CHR								
Zirconium	S_CHR_V		1						
1,1,1-Trichloroethane	S_CHR_V								
Bis(2-Ethylhexyl)Phthalate	S_CHR_V								
Carbon Disulfide	S_CHR_V	< 1							
Carbon Tetrachloride	S_CHR_V								
Cis-1,3-Dichloropropene	S_CHR_V								
Ethylbenzene	S_CHR_V								
Naphthalene	S_CHR_V								
Tetrachloroethene	S_CHR_V			< 1	< 1				
Toluene	S_CHR_V				1				
Total-1,2-Dichloroethene	S_CHR_V								
Trans-1,3-Dichloropropene	S_CHR_V								
Trichloroethene	S_CHR_V			< 1	< 1		< 1		
Xylene (Total)	S_CHR_V				< 1				

Table 3.3. (continued)

Analyte	Benchmark	Intermediate Pond				WOC		
		SW2-2	WAG4 T2A	WCTRIB-3	WCTRIB-4	5NST	SW2-3	SW2-4
Sum of HQs		**98**	**148**	**147**	**310**	**71**	**83**	**318**
Aluminum	NAWQ_CHR		7					
Antimony	S_CHR_V							
Barium	S_CHR_V	37	26		48			52
Beryllium	S_CHR_V	1	< 1	1	2	2	< 1	
Boron	S_CHR_V	42	108	128	155	27		47
Cadmium	NAWQ_CHR		2					
Cobalt	S_CHR_V	< 1						
Copper	NAWQ_CHR		< 1					
Iron	NAWQ_CHR		1					1
Lead	NAWQ_CHR							
Lithium	S_CHR_V							
Manganese	S_CHR_V	12	2	14	20			112
Mercury	S_CHR_V							< 1
Nickel	NAWQ_CHR		< 1	< 1				
Selenium	NAWQ_CHR							
Silver	S_CHR_V							16
Thallium	S_CHR_V				36	36		45
Tin	S_CHR_V							
Vanadium	S_CHR_V	5	1	5	2	2	4	
Zinc	NAWQ_CHR							
Zirconium	S_CHR_V							
1,1,1-Trichloroethane	S_CHR_V						< 1	
Bis(2-Ethylhexyl)Phthalate	S_CHR_V							
Carbon Disulfide	S_CHR_V				47	4	78	45
Carbon Tetrachloride	S_CHR_V							
Cis-1,3-Dichloropropene	S_CHR_V							
Ethylbenzene	S_CHR_V							
Naphthalene	S_CHR_V							
Tetrachloroethene	S_CHR_V		< 1					
Toluene	S_CHR_V							
Total-1,2-Dichloroethene	S_CHR_V							
Trans-1,3-Dichloropropene	S_CHR_V							
Trichloroethene	S_CHR_V		< 1					
Xylene (Total)	S_CHR_V							

Table 3.3. (continued)

Analyte	Benchmark	WAG7/WOC	HF-2	MB-15	HRE		
		WCTRIB-2	05.SW005	MBTRIB-2A	05.SW004	SW9-1	SW9-2
Sum of HQs		**6**	**160**	**1**	**74**	**143**	**128**
Aluminum	NAWQ_CHR		70		16		21
Antimony	S_CHR_V						
Barium	S_CHR_V		31		25	38	72
Beryllium	S_CHR_V	< 1	1				
Boron	S_CHR_V						
Cadmium	NAWQ_CHR		2				
Cobalt	S_CHR_V		< 1		< 1		
Copper	NAWQ_CHR		1	1		< 1	1
Iron	NAWQ_CHR		4		2		4
Lead	NAWQ_CHR		6		3		
Lithium	S_CHR_V		14		14		
Manganese	S_CHR_V		6		7	2	23
Mercury	S_CHR_V						
Nickel	NAWQ_CHR		< 1		< 1		
Selenium	NAWQ_CHR				< 1		
Silver	S_CHR_V						
Thallium	S_CHR_V						
Tin	S_CHR_V						
Vanadium	S_CHR_V	4	1		< 1		
Zinc	NAWQ_CHR		2				3
Zirconium	S_CHR_V						
1,1,1-Trichloroethane	S_CHR_V						
Bis(2-Ethylhexyl)Phthalate	S_CHR_V		15				
Carbon Disulfide	S_CHR_V	< 1				102	3
Carbon Tetrachloride	S_CHR_V		1		< 1		
Cis-1,3-Dichloropropene	S_CHR_V						
Ethylbenzene	S_CHR_V		1		1		
Naphthalene	S_CHR_V		< 1		< 1		
Tetrachloroethene	S_CHR_V		< 1		< 1		
Toluene	S_CHR_V		< 1		< 1		
Total-1,2-Dichloroethene	S_CHR_V						
Trans-1,3-Dichloropropene	S_CHR_V						
Trichloroethene	S_CHR_V						< 1
Xylene (Total)	S_CHR_V		< 1		< 1		

Table 3.3. (continued)

Analyte	Benchmark	SEEP A									SEEP B West
		05.SP009	05.SP010	05.SP016	05.SP017	05.SW003	SW5-6	SW5-7	SW5-8	SW5-9	SW5-11
Sum of HQs		**216**	**4**	**730**	**209**	**63**	**673**	**583**	**546**	**1007**	**129**
Aluminum	NAWQ_CHR	47		515	15	20	13			6	
Antimony	S_CHR_V				3						
Barium	S_CHR_V	65		132	60	16	73	86	57	56	
Beryllium	S_CHR_V					< 1	2	4		2	2
Boron	S_CHR_V						340	395	406	847	46
Cadmium	NAWQ_CHR										
Cobalt	S_CHR_V			1		< 1		< 1		< 1	
Copper	NAWQ_CHR			1							
Iron	NAWQ_CHR	12		50	33	< 1	9	8	4	6	
Lead	NAWQ_CHR										
Lithium	S_CHR_V					14					
Manganese	S_CHR_V	87		23	91	4	85	86	38	36	4
Mercury	S_CHR_V				< 1						
Nickel	NAWQ_CHR			< 1	< 1	< 1	< 1		< 1	< 1	
Selenium	NAWQ_CHR					< 1					
Silver	S_CHR_V										69
Thallium	S_CHR_V						149		34	47	
Tin	S_CHR_V										
Vanadium	S_CHR_V			3	< 1	< 1	< 1	3	< 1	< 1	< 1
Zinc	NAWQ_CHR										
Zirconium	S_CHR_V										
1,1,1-Trichloroethane	S_CHR_V										
Bis(2-Ethylhexyl)Phthalate	S_CHR_V					2					
Carbon Disulfide	S_CHR_V										
Carbon Tetrachloride	S_CHR_V	1	1	1	2	< 1			1	1	2
Cis-1,3-Dichloropropene	S_CHR_V										
Ethylbenzene	S_CHR_V					1					
Naphthalene	S_CHR_V	1	< 1	1	2	< 1			1	1	2
Tetrachloroethene	S_CHR_V	< 1	< 1	< 1	< 1	< 1			< 1	< 1	< 1
Toluene	S_CHR_V	1	1	1	1	< 1	1		1	1	1
Total-1,2-Dichloroethene	S_CHR_V	< 1			< 1		< 1			< 1	< 1
Trans-1,3-Dichloropropene	S_CHR_V										
Trichloroethene	S_CHR_V	< 1					< 1			< 1	< 1
Xylene (Total)	S_CHR_V	1	< 1	< 1	< 1	< 1			1	< 1	< 1

Table 3.3. (continued)

Analyte	Benchmark	SEEP C				WCTRIB-1	SWSA 5 Drainage D-2				
		05.SP005	05.SP018	SW5-3	SW5-4	SW7-6	05.SP007	05.SP014	05.SP019	05.SW002	SW5-5
Sum of HQs		**166**	**19**	**209**	**185**	**141**	**392**	**214**	**19**	**89**	**612**
Aluminum	NAWQ_CHR	96		96		11	226	96		6	243
Antimony	S_CHR_V				< 1						
Barium	S_CHR_V	50		49	33		78	68		30	140
Beryllium	S_CHR_V			2	< 1	< 1	2				2
Boron	S_CHR_V			50	95						109
Cadmium	NAWQ_CHR				2						
Cobalt	S_CHR_V						< 1	< 1			< 1
Copper	NAWQ_CHR									< 1	
Iron	NAWQ_CHR	9		4	2		39	24		6	50
Lead	NAWQ_CHR										
Lithium	S_CHR_V		14		23				14	14	
Manganese	S_CHR_V	2		4	23		41	17		25	65
Mercury	S_CHR_V				< 1						
Nickel	NAWQ_CHR				< 1			< 1		< 1	
Selenium	NAWQ_CHR									< 1	
Silver	S_CHR_V										
Thallium	S_CHR_V										
Tin	S_CHR_V										
Vanadium	S_CHR_V			3	< 1	2		< 1			2
Zinc	NAWQ_CHR										
Zirconium	S_CHR_V										
1,1,1-Trichloroethane	S_CHR_V	< 1		< 1				< 1			
Bis(2-Ethylhexyl)Phthalate	S_CHR_V									2	
Carbon Disulfide	S_CHR_V					127					
Carbon Tetrachloride	S_CHR_V	2	1		1		1	1	1	1	
Cis-1,3-Dichloropropene	S_CHR_V										
Ethylbenzene	S_CHR_V		1		2				1	1	
Naphthalene	S_CHR_V	2	< 1		< 1		1	1	< 1	< 1	
Tetrachloroethene	S_CHR_V	< 1	< 1		< 1		< 1	< 1	< 1	< 1	
Toluene	S_CHR_V	2	1		1		1	1	1	< 1	
Total-1,2-Dichloroethene	S_CHR_V	< 1		< 1			< 1	1		< 1	< 1
Trans-1,3-Dichloropropene	S_CHR_V										
Trichloroethene	S_CHR_V	< 1		< 1			< 1	2		< 1	< 1
Xylene (Total)	S_CHR_V	2	< 1		< 1		1	1	< 1	< 1	

Table 3.3. (continued)

Analyte	Benchmark	EAST SEEP				West Seep						
		SW7-3	SW7-4	SW7-7	SW7-8	RS-1	RS-3	RS-3A	RS-3B	SW6-2	SW7-1	SW7-2
Sum of HQs		**79**	**490**	**365**	**9**	**172**	**654**	**281**	**396**	**127**	**535**	**202**
Aluminum	NAWQ_CHR	5			6		61	146	21			5
Antimony	S_CHR_V						1			< 1		
Barium	S_CHR_V							15		34		
Beryllium	S_CHR_V	< 1	4	2	< 1	1	4	2			1	1
Boron	S_CHR_V	69	228	292		70	580	69	81	39		116
Cadmium	NAWQ_CHR	2						2				
Cobalt	S_CHR_V	< 1					< 1	1				7
Copper	NAWQ_CHR	< 1					< 1	2				1
Iron	NAWQ_CHR					1		10	1	2	8	
Lead	NAWQ_CHR											
Lithium	S_CHR_V											
Manganese	S_CHR_V		223	8		53		3		15	55	2
Mercury	S_CHR_V	< 1					1	< 1				
Nickel	NAWQ_CHR	< 1	< 1	< 1		< 1	< 1	< 1				
Selenium	NAWQ_CHR	< 1						11				
Silver	S_CHR_V							15				
Thallium	S_CHR_V		31	13		18				26		
Tin	S_CHR_V							2				
Vanadium	S_CHR_V	< 1	4	< 1	2	< 1	4	1			2	1
Zinc	NAWQ_CHR											
Zirconium	S_CHR_V											
1,1,1-Trichloroethane	S_CHR_V											
Bis(2-Ethylhexyl)Phthalate	S_CHR_V											
Carbon Disulfide	S_CHR_V			49	< 1	27		1	292	11	469	70
Carbon Tetrachloride	S_CHR_V											
Cis-1,3-Dichloropropene	S_CHR_V											
Ethylbenzene	S_CHR_V											
Naphthalene	S_CHR_V											
Tetrachloroethene	S_CHR_V											
Toluene	S_CHR_V											
Total-1,2-Dichloroethene	S_CHR_V											
Trans-1,3-Dichloropropene	S_CHR_V											
Trichloroethene	S_CHR_V											
Xylene (Total)	S_CHR_V											

Table 3.3. (continued)

Notes:

NAWQ_CHR = chronic National Ambient Water Quality Criterion, S_CHR_V = secondary chronic value.
HQs less than 1.0 are indicated by "<1"; HQs greater than 1.0 are rounded to nearest integer.
Missing HQs indicate that the chemical was not detected if it is an organic chemical or not detected above background if it is an inorganic chemical. None of the chemicals in seep water from subbasins HFIR East and Seep B East exceeded benchmarks.

Table 3.4. Individual and sum of average Hazard Quotients (HQs) for surface water COPECs

Analyte	SWSA 5 WOC	SWSA 5 Trib 1	Intermediate Pond	WOC	HF-2	HFIR South	SEEP A	SEEP C	West Seep	W6MS1	W6MS3	SWSA 6 East	Lower WOC	WOCE
Sum of Average HQs	**126**	**4**	**61**	**43**	**373**	**15**	**54**	**20**	**29**	**125**	**168**	**370**	**171**	**12**
Aluminum	56.79		0.47	0.68	0.77				1.34	9.10	9.10	48.29	2.30	
Ammonia				6.97									8.80	
Barium					6.42					5.37	8.36		5.36	
Beryllium			0.17	0.16	0.15		0.18	0.18	0.27		0.36		0.17	
Boron			8.23	9.30	20.67		8.29	12.06		19.73	17.37		11.89	
Cadmium				3.13					3.61	6.28	4.58		2.88	12.08
Cobalt					0.36		0.33			1.11	0.86		0.29	
Copper	58.02		10.82	6.86	24.05		3.75	7.29	12.63	19.94	31.17		8.51	
Iron			3.95	5.71		14.68			10.65	58.33	69.59	320.57	17.76	
Lead				1.56						0.72	0.75			
Lithium	7.53												0.27	
Manganese				0.08						0.50	1.07		0.39	
Mercury				0.10	236.97					0.53	0.35	1.08	0.12	
Nickel	0.66	0.87		0.53				0.48		0.74	1.26		0.41	
Selenium	0.40									0.08			1.05	
Silver			8.09								18.07		6.72	
Thallium			28.41	1.35	78.84		40.51						0.17	
Tin											2.93			
Zinc					2.46								0.73	
Benzene	0.26	0.26									0.03			
Bis(2-Ethylhexyl)Phthalate	0.14									1.33	0.90			
Carbon Disulfide			1.15	3.34	2.53		1.15		0.73	1.42	0.75		3.76	
Carbon Tetrachloride	0.58	0.58												
Ethylbenzene	0.68	0.68												
Naphthalene	0.32	0.32								0.08				
Polychlorinated Biphenyl				3.10									99.45	
Toluene	0.58	0.58							0.14	0.07	0.08			
Xylene (Total)	0.48	0.26												

Hazard Quotients = UCL95/benchmark value.
Average HQ = sum of HQs/number of HQs; calculated for each COPEC and subbasin combination
Sum of Average HQs is indicative of relative toxicity of surface waters that may support aquatic communities in each basin.

Table 3.5. Rules for assigning and interpreting risk scores for aqueous COPECs

Estimated Exposure Concentration [a]	Class of Benchmark Exceeded	Interpretation	Risk Score
UCL95	Any	The conservative point estimate of exposure exceeded at least one benchmark, but the observed concentrations were less than all benchmarks.	0
100th percentile	Possible-Effects	Toxicity is possible at least 1% of the time.	1
80th percentile	Possible-Effects	Toxicity is possible at least 20% of the time.	2
50th percentile	Possible-Effects	Toxicity is possible at least 50% of the time.	3
Zero percentile	Possible-Effects	Toxicity is possible 100% of the time.	4
100th percentile	Probable-Effects	Toxicity is likely at least 1% of the time.	5
80th percentile	Probable-Effects	Toxicity is likely at least 20% of the time	6
50th percentile	Probable-Effects	Toxicity is likely at least 50% of the time	7
Zero percentile	Probable-Effects	Toxicity is likely 100% of the time	8

[a] UCL95 is the upper 95% confidence limit on the mean concentration in a subbasin. Percentiles indicate the concentration below which the specified percentage of concentrations measured in a subbasin occur (i.e., 80% of the concentrations were less than the 80th percentile concentration).

Table 3.6 Comparison of maximum detected concentration of COPECs in unfiltered surface water to NAWQ Criteria

Analyte	Bmk Name	Bmk Value (mg/l)	SWSA 5 WOC	SWSA 5 Trib 1	Intermediate Pond	WOC	HF-2	HFIR South	SWSA 5 SEEP A	SWSA 5 SEEP C	West Seep	W6MS1	W6MS3	SWSA 6 East	Lower WOC	WOCE
Aluminum	NAWQ_ACU	0.75	**8.12**		**1.31**	**4.13**	**0.60**				**1.32**	**29.33**	**54.27**	**6.96**	**11.20**	
	NAWQ_CHR	0.087	**70.00**		**11.33**	**35.63**	**5.14**				**11.39**	**252.87**	**467.82**	**60.00**	**96.55**	
Ammonia	NAWQ_ACU	2.4				0.08									0.08	
	NAWQ_CHR	0.45				0.42									0.44	
Cadmium	NAWQ_ACU	0.0039				0.01					0.72	**6.31**	**1.72**		0.26	0.62
	NAWQ_CHR	0.0011				0.05					**2.55**	**22.36**	**6.09**		0.91	**2.18**
Copper	NAWQ_ACU	0.018	0.70		0.93	0.98	**1.66**		0.12	0.27	0.56	**2.22**	**4.91**		**4.39**	
	NAWQ_CHR	0.012	**1.05**		**1.39**	**1.47**	**2.48**		0.18	0.41	0.83	**3.33**	**7.36**		**6.58**	
Iron	NAWQ_CHR	1			**1.13**	**3.70**		0.83			**1.08**	**26.70**	**57.90**	**5.45**	**11.00**	
Lead	NAWQ_ACU	0.082				0.71						0.22	**4.34**			
	NAWQ_CHR	0.0032				**18.13**						**5.59**	**111.29**			
Mercury	NAWQ_ACU	0.0024				0.15	**55.83**					**1.96**	0.30	0.13	0.35	
	S_CHR_V	0.0013				0.28	**103.08**					**3.62**	0.56	0.23	0.65	
Nickel	NAWQ_ACU	1.4	0.00	0.00		0.05				0.00		0.02	0.04		0.01	
	NAWQ_CHR	0.16	0.03	0.03		0.45				0.04		0.14	0.31		0.13	
Selenium	NAWQ_ACU	0.02	0.16									0.13			0.05	
	NAWQ_CHR	0.005	0.62									0.52			0.20	
Silver	NAWQ_ACU	0.0041			0.93								**4.34**		**2.78**	
Zinc	NAWQ_ACU	0.12					**2.38**								**2.00**	
	NAWQ_CHR	0.11					**2.59**								**2.18**	
Polychlorinated Biphenyl	NAWQ_ACU	0.002				0.50									0.50	
	S_CHR_V	0.00014				**7.14**									**7.14**	

Values for subbasins are the hazard quotients (HQs) calculated as the maximum detected concentration in unfiltered water divided by the benchmark value.

NAWQ_CHR = chronic National Ambient Water Quality Criterion; NAWQ_ACU = acute National Ambient Water Quality Criterion; and S_CHR_V = secondary chronic value.

S_CHR_V are used for mercury and PCBs because the NAWQC are based on the body burden in fish that is protective of fish-eating wildlife

BOLD indicates HQ > 1

Table 3.7 Exposure concentrations, benchmarks, and the resulting hazard quotients (HQs) for surface water COPECs

Analyte	Subbasin	Dets.	Obs.	Min Det.	Median	Max Det.	UCL95	Bmk Value	Bmk Name	HQ
Aluminum	**HF-2**	**6**	**11**	**0.0355**	**1.44E-01**	**0.447**	**3.02E-01**	**0.087**	**NAWQ_CHR**	**3.48**
Aluminum	HF-2	6	11	0.0355	1.44E-01	0.447	3.02E-01	0.46	LCV_AQPL	0.66
Aluminum	HF-2	6	11	0.0355	1.44E-01	0.447	3.02E-01	0.54	LTV_DAPH	0.56
Aluminum	HF-2	6	11	0.0355	1.44E-01	0.447	3.02E-01	0.75	NAWQ_ACU	0.40
Aluminum	HF-2	6	11	0.0355	1.44E-01	0.447	3.02E-01	1.9	LCV_DAPH	0.16
Aluminum	HF-2	6	11	0.0355	1.44E-01	0.447	3.02E-01	3.288	LCV_FISH	0.09
Aluminum	HF-2	6	11	0.0355	1.44E-01	0.447	3.02E-01	4.7	LTV_FISH	0.06
Aluminum	**Intermediate Pond**	**9**	**15**	**0.0398**	**7.01E-02**	**0.986**	**1.83E-01**	**0.087**	**NAWQ_CHR**	**2.10**
Aluminum	Intermediate Pond	9	15	0.0398	7.01E-02	0.986	1.83E-01	0.46	LCV_AQPL	0.40
Aluminum	Intermediate Pond	9	15	0.0398	7.01E-02	0.986	1.83E-01	0.54	LTV_DAPH	0.34
Aluminum	Intermediate Pond	9	15	0.0398	7.01E-02	0.986	1.83E-01	0.75	NAWQ_ACU	0.24
Aluminum	Intermediate Pond	9	15	0.0398	7.01E-02	0.986	1.83E-01	1.9	LCV_DAPH	0.10
Aluminum	Intermediate Pond	9	15	0.0398	7.01E-02	0.986	1.83E-01	3.288	LCV_FISH	0.06
Aluminum	Intermediate Pond	9	15	0.0398	7.01E-02	0.986	1.83E-01	4.7	LTV_FISH	0.04
Aluminum	**Lower WOC**	**120**	**149**	**0.0285**	**4.33E-01**	**8.4**	**9.00E-01**	**0.087**	**NAWQ_CHR**	**10.34**
Aluminum	**Lower WOC**	**120**	**149**	**0.0285**	**4.33E-01**	**8.4**	**9.00E-01**	**0.46**	**LCV_AQPL**	**1.96**
Aluminum	**Lower WOC**	**120**	**149**	**0.0285**	**4.33E-01**	**8.4**	**9.00E-01**	**0.54**	**LTV_DAPH**	**1.67**
Aluminum	**Lower WOC**	**120**	**149**	**0.0285**	**4.33E-01**	**8.4**	**9.00E-01**	**0.75**	**NAWQ_ACU**	**1.20**
Aluminum	Lower WOC	120	149	0.0285	4.33E-01	8.4	9.00E-01	1.9	LCV_DAPH	0.47
Aluminum	Lower WOC	120	149	0.0285	4.33E-01	8.4	9.00E-01	3.288	LCV_FISH	0.27
Aluminum	Lower WOC	120	149	0.0285	4.33E-01	8.4	9.00E-01	4.7	LTV_FISH	0.19
Aluminum	**SWSA 5 WOC**	**1**	**2**	**6.09**	**3.62E-01**	**6.09**	**2.22E+01**	**0.087**	**NAWQ_CHR**	**255.32**
Aluminum	**SWSA 5 WOC**	**1**	**2**	**6.09**	**3.62E-01**	**6.09**	**2.22E+01**	**0.46**	**LCV_AQPL**	**48.29**
Aluminum	**SWSA 5 WOC**	**1**	**2**	**6.09**	**3.62E-01**	**6.09**	**2.22E+01**	**0.54**	**LTV_DAPH**	**41.14**
Aluminum	**SWSA 5 WOC**	**1**	**2**	**6.09**	**3.62E-01**	**6.09**	**2.22E+01**	**0.75**	**NAWQ_ACU**	**29.62**
Aluminum	**SWSA 5 WOC**	**1**	**2**	**6.09**	**3.62E-01**	**6.09**	**2.22E+01**	**1.9**	**LCV_DAPH**	**11.69**
Aluminum	**SWSA 5 WOC**	**1**	**2**	**6.09**	**3.62E-01**	**6.09**	**2.22E+01**	**3.288**	**LCV_FISH**	**6.76**
Aluminum	**SWSA 5 WOC**	**1**	**2**	**6.09**	**3.62E-01**	**6.09**	**2.22E+01**	**4.7**	**LTV_FISH**	**4.73**
Aluminum	**SWSA 6 East**	**2**	**2**	**0.0749**	**6.25E-01**	**5.22**	**1.89E+01**	**0.087**	**NAWQ_CHR**	**217.13**
Aluminum	**SWSA 6 East**	**2**	**2**	**0.0749**	**6.25E-01**	**5.22**	**1.89E+01**	**0.46**	**LCV_AQPL**	**41.06**
Aluminum	**SWSA 6 East**	**2**	**2**	**0.0749**	**6.25E-01**	**5.22**	**1.89E+01**	**0.54**	**LTV_DAPH**	**34.98**
Aluminum	**SWSA 6 East**	**2**	**2**	**0.0749**	**6.25E-01**	**5.22**	**1.89E+01**	**0.75**	**NAWQ_ACU**	**25.19**
Aluminum	**SWSA 6 East**	**2**	**2**	**0.0749**	**6.25E-01**	**5.22**	**1.89E+01**	**1.9**	**LCV_DAPH**	**9.94**
Aluminum	**SWSA 6 East**	**2**	**2**	**0.0749**	**6.25E-01**	**5.22**	**1.89E+01**	**3.288**	**LCV_FISH**	**5.75**
Aluminum	**SWSA 6 East**	**2**	**2**	**0.0749**	**6.25E-01**	**5.22**	**1.89E+01**	**4.7**	**LTV_FISH**	**4.02**
Aluminum	**W6MS3**	**66**	**80**	**0.023**	**6.74E-01**	**40.7**	**3.56E+00**	**0.087**	**NAWQ_CHR**	**40.90**

Table 3.7 (Continued)

Analyte	Subbasin	Dets.	Obs.	Min Det.	Median	Max Det.	UCL95	Bmk Value	Bmk Name	HQ
Aluminum	**W6MS3**	**66**	**80**	**0.023**	**6.74E-01**	**40.7**	**3.56E+00**	**0.46**	**LCV_AQPL**	**7.74**
Aluminum	**W6MS3**	**66**	**80**	**0.023**	**6.74E-01**	**40.7**	**3.56E+00**	**0.54**	**LTV_DAPH**	**6.59**
Aluminum	**W6MS3**	**66**	**80**	**0.023**	**6.74E-01**	**40.7**	**3.56E+00**	**0.75**	**NAWQ_ACU**	**4.74**
Aluminum	**W6MS3**	**66**	**80**	**0.023**	**6.74E-01**	**40.7**	**3.56E+00**	**1.9**	**LCV_DAPH**	**1.87**
Aluminum	**W6MS3**	**66**	**80**	**0.023**	**6.74E-01**	**40.7**	**3.56E+00**	**3.288**	**LCV_FISH**	**1.08**
Aluminum	W6MS3	66	80	0.023	6.74E-01	40.7	3.56E+00	4.7	LTV_FISH	0.76
Aluminum	**W6MS1**	**44**	**45**	**0.042**	**1.05E+00**	**22**	**3.56E+00**	**0.087**	**NAWQ_CHR**	**40.92**
Aluminum	**W6MS1**	**44**	**45**	**0.042**	**1.05E+00**	**22**	**3.56E+00**	**0.46**	**LCV_AQPL**	**7.74**
Aluminum	**W6MS1**	**44**	**45**	**0.042**	**1.05E+00**	**22**	**3.56E+00**	**0.54**	**LTV_DAPH**	**6.59**
Aluminum	**W6MS1**	**44**	**45**	**0.042**	**1.05E+00**	**22**	**3.56E+00**	**0.75**	**NAWQ_ACU**	**4.75**
Aluminum	**W6MS1**	**44**	**45**	**0.042**	**1.05E+00**	**22**	**3.56E+00**	**1.9**	**LCV_DAPH**	**1.87**
Aluminum	**W6MS1**	**44**	**45**	**0.042**	**1.05E+00**	**22**	**3.56E+00**	**3.288**	**LCV_FISH**	**1.08**
Aluminum	W6MS1	44	45	0.042	1.05E+00	22	3.56E+00	4.7	LTV_FISH	0.76
Aluminum	**West Seep**	**4**	**6**	**0.036**	**4.87E-02**	**0.991**	**5.22E-01**	**0.087**	**NAWQ_CHR**	**6.00**
Aluminum	**West Seep**	**4**	**6**	**0.036**	**4.87E-02**	**0.991**	**5.22E-01**	**0.46**	**LCV_AQPL**	**1.14**
Aluminum	West Seep	4	6	0.036	4.87E-02	0.991	5.22E-01	0.54	LTV_DAPH	0.97
Aluminum	West Seep	4	6	0.036	4.87E-02	0.991	5.22E-01	0.75	NAWQ_ACU	0.70
Aluminum	West Seep	4	6	0.036	4.87E-02	0.991	5.22E-01	1.9	LCV_DAPH	0.27
Aluminum	West Seep	4	6	0.036	4.87E-02	0.991	5.22E-01	3.288	LCV_FISH	0.16
Aluminum	West Seep	4	6	0.036	4.87E-02	0.991	5.22E-01	4.7	LTV_FISH	0.11
Aluminum	**WOC**	**60**	**69**	**0.011**	**9.65E-02**	**3.1**	**2.64E-01**	**0.087**	**NAWQ_CHR**	**3.04**
Aluminum	WOC	60	69	0.011	9.65E-02	3.1	2.64E-01	0.46	LCV_AQPL	0.57
Aluminum	WOC	60	69	0.011	9.65E-02	3.1	2.64E-01	0.54	LTV_DAPH	0.49
Aluminum	WOC	60	69	0.011	9.65E-02	3.1	2.64E-01	0.75	NAWQ_ACU	0.35
Aluminum	WOC	60	69	0.011	9.65E-02	3.1	2.64E-01	1.9	LCV_DAPH	0.14
Aluminum	WOC	60	69	0.011	9.65E-02	3.1	2.64E-01	3.288	LCV_FISH	0.08
Aluminum	WOC	60	69	0.011	9.65E-02	3.1	2.64E-01	4.7	LTV_FISH	0.06
Ammonia	**Lower WOC**	**77**	**85**	**0.02**	**4.90E-02**	**0.2**	**7.42E-02**	**0.0017**	**LCV_FISH**	**43.67**
Ammonia	Lower WOC	77	85	0.02	4.90E-02	0.2	7.42E-02	0.45	NAWQ_CHR	0.16
Ammonia	Lower WOC	77	85	0.02	4.90E-02	0.2	7.42E-02	0.63	LCV_DAPH	0.12
Ammonia	Lower WOC	77	85	0.02	4.90E-02	0.2	7.42E-02	2.4	LCV_AQPL	0.03
Ammonia	Lower WOC	77	85	0.02	4.90E-02	0.2	7.42E-02	2.4	NAWQ_ACU	0.03
Ammonia	**WOC**	**39**	**43**	**0.02**	**4.00E-02**	**0.187**	**5.88E-02**	**0.0017**	**LCV_FISH**	**34.57**
Ammonia	WOC	39	43	0.02	4.00E-02	0.187	5.88E-02	0.45	NAWQ_CHR	0.13
Ammonia	WOC	39	43	0.02	4.00E-02	0.187	5.88E-02	0.63	LCV_DAPH	0.09
Ammonia	WOC	39	43	0.02	4.00E-02	0.187	5.88E-02	2.4	LCV_AQPL	0.02

Table 3.7 (Continued)

Analyte	Subbasin	Dets.	Obs.	Min Det.	Median	Max Det.	UCL95	Bmk Value	Bmk Name	HQ
Ammonia	WOC	39	43	0.02	4.00E-02	0.187	5.88E-02	2.4	NAWQ_ACU	0.02
Barium	**HF-2**	**11**	**11**	**0.0322**	**5.62E-02**	**0.1**	**7.43E-02**	**0.004**	**S_CHR_V**	**18.58**
Barium	HF-2	11	11	0.0322	5.62E-02	0.1	7.43E-02	0.11	S_ACU_V	0.68
Barium	HF-2	11	11	0.0322	5.62E-02	0.1	7.43E-02	5.8	LCV_DAPH	0.01
Barium	**Lower WOC**	**60**	**62**	**0.033**	**4.58E-02**	**0.108**	**6.21E-02**	**0.004**	**S_CHR_V**	**15.52**
Barium	Lower WOC	60	62	0.033	4.58E-02	0.108	6.21E-02	0.11	S_ACU_V	0.56
Barium	Lower WOC	60	62	0.033	4.58E-02	0.108	6.21E-02	5.8	LCV_DAPH	0.01
Barium	**W6MS3**	**79**	**84**	**0.0029**	**6.11E-02**	**0.315**	**9.67E-02**	**0.004**	**S_CHR_V**	**24.17**
Barium	W6MS3	79	84	0.0029	6.11E-02	0.315	9.67E-02	0.11	S_ACU_V	0.88
Barium	W6MS3	79	84	0.0029	6.11E-02	0.315	9.67E-02	5.8	LCV_DAPH	0.02
Barium	**W6MS1**	**43**	**44**	**0.0162**	**4.29E-02**	**0.161**	**6.22E-02**	**0.004**	**S_CHR_V**	**15.54**
Barium	W6MS1	43	44	0.0162	4.29E-02	0.161	6.22E-02	0.11	S_ACU_V	0.57
Barium	W6MS1	43	44	0.0162	4.29E-02	0.161	6.22E-02	5.8	LCV_DAPH	0.01
Beryllium	HF-2	2	11	0.00018	5.00E-04	0.0004	5.25E-04	0.00066	S_CHR_V	0.80
Beryllium	HF-2	2	11	0.00018	5.00E-04	0.0004	5.25E-04	0.0038	LTV_DAPH	0.14
Beryllium	HF-2	2	11	0.00018	5.00E-04	0.0004	5.25E-04	0.0053	LCV_DAPH	0.10
Beryllium	HF-2	2	11	0.00018	5.00E-04	0.0004	5.25E-04	0.035	S_ACU_V	0.02
Beryllium	HF-2	2	11	0.00018	5.00E-04	0.0004	5.25E-04	0.057	LCV_FISH	0.01
Beryllium	HF-2	2	11	0.00018	5.00E-04	0.0004	5.25E-04	0.148	LTV_FISH	0.00
Beryllium	HF-2	2	11	0.00018	5.00E-04	0.0004	5.25E-04	100	LCV_AQPL	0.00
Beryllium	Intermediate Pond	2	13	0.00014	5.00E-04	0.0005	5.99E-04	0.00066	S_CHR_V	0.91
Beryllium	Intermediate Pond	2	13	0.00014	5.00E-04	0.0005	5.99E-04	0.0038	LTV_DAPH	0.16
Beryllium	Intermediate Pond	2	13	0.00014	5.00E-04	0.0005	5.99E-04	0.0053	LCV_DAPH	0.11
Beryllium	Intermediate Pond	2	13	0.00014	5.00E-04	0.0005	5.99E-04	0.035	S_ACU_V	0.02
Beryllium	Intermediate Pond	2	13	0.00014	5.00E-04	0.0005	5.99E-04	0.057	LCV_FISH	0.01
Beryllium	Intermediate Pond	2	13	0.00014	5.00E-04	0.0005	5.99E-04	0.148	LTV_FISH	0.00
Beryllium	Intermediate Pond	2	13	0.00014	5.00E-04	0.0005	5.99E-04	100	LCV_AQPL	0.00
Beryllium	Lower WOC	10	53	0.00016	5.00E-04	0.0015	5.94E-04	0.00066	S_CHR_V	0.90
Beryllium	Lower WOC	10	53	0.00016	5.00E-04	0.0015	5.94E-04	0.0038	LTV_DAPH	0.16
Beryllium	Lower WOC	10	53	0.00016	5.00E-04	0.0015	5.94E-04	0.0053	LCV_DAPH	0.11
Beryllium	Lower WOC	10	53	0.00016	5.00E-04	0.0015	5.94E-04	0.035	S_ACU_V	0.02
Beryllium	Lower WOC	10	53	0.00016	5.00E-04	0.0015	5.94E-04	0.057	LCV_FISH	0.01
Beryllium	Lower WOC	10	53	0.00016	5.00E-04	0.0015	5.94E-04	0.148	LTV_FISH	0.00
Beryllium	Lower WOC	10	53	0.00016	5.00E-04	0.0015	5.94E-04	100	LCV_AQPL	0.00
Beryllium	SWSA 5 SEEP A	1	10	0.00028	5.00E-04	0.00028	6.19E-04	0.00066	S_CHR_V	0.94
Beryllium	SWSA 5 SEEP A	1	10	0.00028	5.00E-04	0.00028	6.19E-04	0.0038	LTV_DAPH	0.16

Table 3.7 (Continued)

Analyte	Subbasin	Dets.	Obs.	Min Det.	Median	Max Det.	UCL95	Bmk Value	Bmk Name	HQ
Beryllium	SWSA 5 SEEP A	1	10	0.00028	5.00E-04	0.00028	6.19E-04	0.0053	LCV_DAPH	0.12
Beryllium	SWSA 5 SEEP A	1	10	0.00028	5.00E-04	0.00028	6.19E-04	0.035	S_ACU_V	0.02
Beryllium	SWSA 5 SEEP A	1	10	0.00028	5.00E-04	0.00028	6.19E-04	0.057	LCV_FISH	0.01
Beryllium	SWSA 5 SEEP A	1	10	0.00028	5.00E-04	0.00028	6.19E-04	0.148	LTV_FISH	0.00
Beryllium	SWSA 5 SEEP A	1	10	0.00028	5.00E-04	0.00028	6.19E-04	100	LCV_AQPL	0.00
Beryllium	SWSA 5 SEEP C	2	3	0.00011	1.90E-04	0.00019	6.14E-04	0.00066	S_CHR_V	0.93
Beryllium	SWSA 5 SEEP C	2	3	0.00011	1.90E-04	0.00019	6.14E-04	0.0038	LTV_DAPH	0.16
Beryllium	SWSA 5 SEEP C	2	3	0.00011	1.90E-04	0.00019	6.14E-04	0.0053	LCV_DAPH	0.12
Beryllium	SWSA 5 SEEP C	2	3	0.00011	1.90E-04	0.00019	6.14E-04	0.035	S_ACU_V	0.02
Beryllium	SWSA 5 SEEP C	2	3	0.00011	1.90E-04	0.00019	6.14E-04	0.057	LCV_FISH	0.01
Beryllium	SWSA 5 SEEP C	2	3	0.00011	1.90E-04	0.00019	6.14E-04	0.148	LTV_FISH	0.00
Beryllium	SWSA 5 SEEP C	2	3	0.00011	1.90E-04	0.00019	6.14E-04	100	LCV_AQPL	0.00
Beryllium	**W6MS3**	**16**	**47**	**0.001**	**5.00E-04**	**0.0027**	**1.25E-03**	**0.00066**	**S_CHR_V**	**1.89**
Beryllium	W6MS3	16	47	0.001	5.00E-04	0.0027	1.25E-03	0.0038	LTV_DAPH	0.33
Beryllium	W6MS3	16	47	0.001	5.00E-04	0.0027	1.25E-03	0.0053	LCV_DAPH	0.24
Beryllium	W6MS3	16	47	0.001	5.00E-04	0.0027	1.25E-03	0.035	S_ACU_V	0.04
Beryllium	W6MS3	16	47	0.001	5.00E-04	0.0027	1.25E-03	0.057	LCV_FISH	0.02
Beryllium	W6MS3	16	47	0.001	5.00E-04	0.0027	1.25E-03	0.148	LTV_FISH	0.01
Beryllium	W6MS3	16	47	0.001	5.00E-04	0.0027	1.25E-03	100	LCV_AQPL	0.00
Beryllium	**West Seep**	**1**	**4**	**0.001**	**5.00E-04**	**0.001**	**9.19E-04**	**0.00066**	**S_CHR_V**	**1.39**
Beryllium	West Seep	1	4	0.001	5.00E-04	0.001	9.19E-04	0.0038	LTV_DAPH	0.24
Beryllium	West Seep	1	4	0.001	5.00E-04	0.001	9.19E-04	0.0053	LCV_DAPH	0.17
Beryllium	West Seep	1	4	0.001	5.00E-04	0.001	9.19E-04	0.035	S_ACU_V	0.03
Beryllium	West Seep	1	4	0.001	5.00E-04	0.001	9.19E-04	0.057	LCV_FISH	0.02
Beryllium	West Seep	1	4	0.001	5.00E-04	0.001	9.19E-04	0.148	LTV_FISH	0.01
Beryllium	West Seep	1	4	0.001	5.00E-04	0.001	9.19E-04	100	LCV_AQPL	0.00
Beryllium	WOC	5	20	0.00017	5.00E-04	0.0005	5.41E-04	0.00066	S_CHR_V	0.82
Beryllium	WOC	5	20	0.00017	5.00E-04	0.0005	5.41E-04	0.0038	LTV_DAPH	0.14
Beryllium	WOC	5	20	0.00017	5.00E-04	0.0005	5.41E-04	0.0053	LCV_DAPH	0.10
Beryllium	WOC	5	20	0.00017	5.00E-04	0.0005	5.41E-04	0.035	S_ACU_V	0.02
Beryllium	WOC	5	20	0.00017	5.00E-04	0.0005	5.41E-04	0.057	LCV_FISH	0.01
Beryllium	WOC	5	20	0.00017	5.00E-04	0.0005	5.41E-04	0.148	LTV_FISH	0.00
Beryllium	WOC	5	20	0.00017	5.00E-04	0.0005	5.41E-04	100	LCV_AQPL	0.00
Boron	**HF-2**	**4**	**10**	**0.033**	**2.95E-02**	**0.487**	**1.26E-01**	**0.0016**	**S_CHR_V**	**78.46**
Boron	**HF-2**	**4**	**10**	**0.033**	**2.95E-02**	**0.487**	**1.26E-01**	**0.03**	**S_ACU_V**	**4.18**
Boron	HF-2	4	10	0.033	2.95E-02	0.487	1.26E-01	7	LTV_DAPH	0.02

Table 3.7 (Continued)

Analyte	Subbasin	Dets.	Obs.	Min Det.	Median	Max Det.	UCL95	Bmk Value	Bmk Name	HQ
Boron	HF-2	4	10	0.033	2.95E-02	0.487	1.26E-01	8.83	LCV_DAPH	0.01
Boron	**Intermediate Pond**	**5**	**15**	**0.0255**	**2.78E-02**	**0.0661**	**5.00E-02**	**0.0016**	**S_CHR_V**	**31.24**
Boron	**Intermediate Pond**	**5**	**15**	**0.0255**	**2.78E-02**	**0.0661**	**5.00E-02**	**0.03**	**S_ACU_V**	**1.67**
Boron	Intermediate Pond	5	15	0.0255	2.78E-02	0.0661	5.00E-02	7	LTV_DAPH	0.01
Boron	Intermediate Pond	5	15	0.0255	2.78E-02	0.0661	5.00E-02	8.83	LCV_DAPH	0.01
Boron	**Lower WOC**	**25**	**60**	**0.0292**	**3.55E-02**	**0.747**	**7.22E-02**	**0.0016**	**S_CHR_V**	**45.12**
Boron	**Lower WOC**	**25**	**60**	**0.0292**	**3.55E-02**	**0.747**	**7.22E-02**	**0.03**	**S_ACU_V**	**2.41**
Boron	Lower WOC	25	60	0.0292	3.55E-02	0.747	7.22E-02	7	LTV_DAPH	0.01
Boron	Lower WOC	25	60	0.0292	3.55E-02	0.747	7.22E-02	8.83	LCV_DAPH	0.01
Boron	**SWSA 5 SEEP A**	**4**	**10**	**0.0259**	**2.60E-02**	**0.06**	**5.04E-02**	**0.0016**	**S_CHR_V**	**31.47**
Boron	**SWSA 5 SEEP A**	**4**	**10**	**0.0259**	**2.60E-02**	**0.06**	**5.04E-02**	**0.03**	**S_ACU_V**	**1.68**
Boron	SWSA 5 SEEP A	4	10	0.0259	2.60E-02	0.06	5.04E-02	7	LTV_DAPH	0.01
Boron	SWSA 5 SEEP A	4	10	0.0259	2.60E-02	0.06	5.04E-02	8.83	LCV_DAPH	0.01
Boron	**SWSA 5 SEEP C**	**5**	**5**	**0.0417**	**4.62E-02**	**0.0864**	**7.33E-02**	**0.0016**	**S_CHR_V**	**45.79**
Boron	**SWSA 5 SEEP C**	**5**	**5**	**0.0417**	**4.62E-02**	**0.0864**	**7.33E-02**	**0.03**	**S_ACU_V**	**2.44**
Boron	SWSA 5 SEEP C	5	5	0.0417	4.62E-02	0.0864	7.33E-02	7	LTV_DAPH	0.01
Boron	SWSA 5 SEEP C	5	5	0.0417	4.62E-02	0.0864	7.33E-02	8.83	LCV_DAPH	0.01
Boron	**W6MS3**	**1**	**3**	**0.0394**	**3.94E-02**	**0.0394**	**1.06E-01**	**0.0016**	**S_CHR_V**	**65.95**
Boron	**W6MS3**	**1**	**3**	**0.0394**	**3.94E-02**	**0.0394**	**1.06E-01**	**0.03**	**S_ACU_V**	**3.52**
Boron	W6MS3	1	3	0.0394	3.94E-02	0.0394	1.06E-01	7	LTV_DAPH	0.02
Boron	W6MS3	1	3	0.0394	3.94E-02	0.0394	1.06E-01	8.83	LCV_DAPH	0.01
Boron	**W6MS1**	**2**	**3**	**0.0699**	**6.99E-02**	**0.0933**	**1.20E-01**	**0.0016**	**S_CHR_V**	**74.90**
Boron	**W6MS1**	**2**	**3**	**0.0699**	**6.99E-02**	**0.0933**	**1.20E-01**	**0.03**	**S_ACU_V**	**3.99**
Boron	W6MS1	2	3	0.0699	6.99E-02	0.0933	1.20E-01	7	LTV_DAPH	0.02
Boron	W6MS1	2	3	0.0699	6.99E-02	0.0933	1.20E-01	8.83	LCV_DAPH	0.01
Boron	**WOC**	**14**	**27**	**0.0204**	**2.63E-02**	**0.08**	**5.65E-02**	**0.0016**	**S_CHR_V**	**35.29**
Boron	**WOC**	**14**	**27**	**0.0204**	**2.63E-02**	**0.08**	**5.65E-02**	**0.03**	**S_ACU_V**	**1.88**
Boron	WOC	14	27	0.0204	2.63E-02	0.08	5.65E-02	7	LTV_DAPH	0.01
Boron	WOC	14	27	0.0204	2.63E-02	0.08	5.65E-02	8.83	LCV_DAPH	0.01
Cadmium	**Lower WOC**	**3**	**127**	**0.00006**	**2.50E-03**	**0.001**	**1.87E-03**	**0.00015**	**LCV_DAPH**	**12.44**
Cadmium	**Lower WOC**	**3**	**127**	**0.00006**	**2.50E-03**	**0.001**	**1.87E-03**	**0.00075**	**LTV_DAPH**	**2.49**
Cadmium	**Lower WOC**	**3**	**127**	**0.00006**	**2.50E-03**	**0.001**	**1.87E-03**	**0.0011**	**NAWQ_CHR**	**1.70**
Cadmium	**Lower WOC**	**3**	**127**	**0.00006**	**2.50E-03**	**0.001**	**1.87E-03**	**0.0017**	**LCV_FISH**	**1.10**
Cadmium	**Lower WOC**	**3**	**127**	**0.00006**	**2.50E-03**	**0.001**	**1.87E-03**	**0.0018**	**LTV_FISH**	**1.04**
Cadmium	Lower WOC	3	127	0.00006	2.50E-03	0.001	1.87E-03	0.002	LCV_AQPL	0.93
Cadmium	Lower WOC	3	127	0.00006	2.50E-03	0.001	1.87E-03	0.0039	NAWQ_ACU	0.48

Table 3.7 (Continued)

Analyte	Subbasin	Dets.	Obs.	Min Det.	Median	Max Det.	UCL95	Bmk Value	Bmk Name	HQ
Cadmium	W6MS3	18	45	0.002	2.50E-03	0.0067	2.97E-03	0.00015	LCV_DAPH	19.77
Cadmium	W6MS3	18	45	0.002	2.50E-03	0.0067	2.97E-03	0.00075	LTV_DAPH	3.95
Cadmium	W6MS3	18	45	0.002	2.50E-03	0.0067	2.97E-03	0.0011	NAWQ_CHR	2.70
Cadmium	W6MS3	18	45	0.002	2.50E-03	0.0067	2.97E-03	0.0017	LCV_FISH	1.74
Cadmium	W6MS3	18	45	0.002	2.50E-03	0.0067	2.97E-03	0.0018	LTV_FISH	1.65
Cadmium	W6MS3	18	45	0.002	2.50E-03	0.0067	2.97E-03	0.002	LCV_AQPL	1.48
Cadmium	W6MS3	18	45	0.002	2.50E-03	0.0067	2.97E-03	0.0039	NAWQ_ACU	0.76
Cadmium	W6MS1	5	18	0.002	2.40E-03	0.0246	4.07E-03	0.00015	LCV_DAPH	27.10
Cadmium	W6MS1	5	18	0.002	2.40E-03	0.0246	4.07E-03	0.00075	LTV_DAPH	5.42
Cadmium	W6MS1	5	18	0.002	2.40E-03	0.0246	4.07E-03	0.0011	NAWQ_CHR	3.70
Cadmium	W6MS1	5	18	0.002	2.40E-03	0.0246	4.07E-03	0.0017	LCV_FISH	2.39
Cadmium	W6MS1	5	18	0.002	2.40E-03	0.0246	4.07E-03	0.0018	LTV_FISH	2.26
Cadmium	W6MS1	5	18	0.002	2.40E-03	0.0246	4.07E-03	0.002	LCV_AQPL	2.03
Cadmium	W6MS1	5	18	0.002	2.40E-03	0.0246	4.07E-03	0.0039	NAWQ_ACU	1.04
Cadmium	West Seep	2	5	0.002	1.00E-03	0.0028	2.34E-03	0.00015	LCV_DAPH	15.59
Cadmium	West Seep	2	5	0.002	1.00E-03	0.0028	2.34E-03	0.00075	LTV_DAPH	3.12
Cadmium	West Seep	2	5	0.002	1.00E-03	0.0028	2.34E-03	0.0011	NAWQ_CHR	2.13
Cadmium	West Seep	2	5	0.002	1.00E-03	0.0028	2.34E-03	0.0017	LCV_FISH	1.38
Cadmium	West Seep	2	5	0.002	1.00E-03	0.0028	2.34E-03	0.0018	LTV_FISH	1.30
Cadmium	West Seep	2	5	0.002	1.00E-03	0.0028	2.34E-03	0.002	LCV_AQPL	1.17
Cadmium	West Seep	2	5	0.002	1.00E-03	0.0028	2.34E-03	0.0039	NAWQ_ACU	0.60
Cadmium	WOC	1	57	0.00005	2.50E-03	0.00005	2.02E-03	0.00015	LCV_DAPH	13.50
Cadmium	WOC	1	57	0.00005	2.50E-03	0.00005	2.02E-03	0.00075	LTV_DAPH	2.70
Cadmium	WOC	1	57	0.00005	2.50E-03	0.00005	2.02E-03	0.0011	NAWQ_CHR	1.84
Cadmium	WOC	1	57	0.00005	2.50E-03	0.00005	2.02E-03	0.0017	LCV_FISH	1.19
Cadmium	WOC	1	57	0.00005	2.50E-03	0.00005	2.02E-03	0.0018	LTV_FISH	1.12
Cadmium	WOC	1	57	0.00005	2.50E-03	0.00005	2.02E-03	0.002	LCV_AQPL	1.01
Cadmium	WOC	1	57	0.00005	2.50E-03	0.00005	2.02E-03	0.0039	NAWQ_ACU	0.52
Cadmium	WOCE	2	2	0.00036	9.30E-04	0.0024	7.82E-03	0.00015	LCV_DAPH	52.13
Cadmium	WOCE	2	2	0.00036	9.30E-04	0.0024	7.82E-03	0.00075	LTV_DAPH	10.43
Cadmium	WOCE	2	2	0.00036	9.30E-04	0.0024	7.82E-03	0.0011	NAWQ_CHR	7.11
Cadmium	WOCE	2	2	0.00036	9.30E-04	0.0024	7.82E-03	0.0017	LCV_FISH	4.60
Cadmium	WOCE	2	2	0.00036	9.30E-04	0.0024	7.82E-03	0.0018	LTV_FISH	4.34
Cadmium	WOCE	2	2	0.00036	9.30E-04	0.0024	7.82E-03	0.002	LCV_AQPL	3.91
Cadmium	WOCE	2	2	0.00036	9.30E-04	0.0024	7.82E-03	0.0039	NAWQ_ACU	2.01
Cobalt	HF-2	1	11	0.0053	4.00E-03	0.0053	4.53E-03	0.0044	LTV_DAPH	1.03

Table 3.7 (Continued)

Analyte	Subbasin	Dets.	Obs.	Min Det.	Median	Max Det.	UCL95	Bmk Value	Bmk Name	HQ
Cobalt	HF-2	1	11	0.0053	4.00E-03	0.0053	4.53E-03	0.0051	LCV_DAPH	0.89
Cobalt	HF-2	1	11	0.0053	4.00E-03	0.0053	4.53E-03	0.023	S_CHR_V	0.20
Cobalt	HF-2	1	11	0.0053	4.00E-03	0.0053	4.53E-03	0.29	LCV_FISH	0.02
Cobalt	HF-2	1	11	0.0053	4.00E-03	0.0053	4.53E-03	0.81	LTV_FISH	0.01
Cobalt	HF-2	1	11	0.0053	4.00E-03	0.0053	4.53E-03	1.5	S_ACU_V	0.00
Cobalt	Lower WOC	3	55	0.0022	3.50E-03	0.0114	3.72E-03	0.0044	LTV_DAPH	0.85
Cobalt	Lower WOC	3	55	0.0022	3.50E-03	0.0114	3.72E-03	0.0051	LCV_DAPH	0.73
Cobalt	Lower WOC	3	55	0.0022	3.50E-03	0.0114	3.72E-03	0.023	S_CHR_V	0.16
Cobalt	Lower WOC	3	55	0.0022	3.50E-03	0.0114	3.72E-03	0.29	LCV_FISH	0.01
Cobalt	Lower WOC	3	55	0.0022	3.50E-03	0.0114	3.72E-03	0.81	LTV_FISH	0.00
Cobalt	Lower WOC	3	55	0.0022	3.50E-03	0.0114	3.72E-03	1.5	S_ACU_V	0.00
Cobalt	SWSA 5 SEEP A	1	10	0.0019	3.24E-03	0.0019	4.15E-03	0.0044	LTV_DAPH	0.94
Cobalt	SWSA 5 SEEP A	1	10	0.0019	3.24E-03	0.0019	4.15E-03	0.0051	LCV_DAPH	0.81
Cobalt	SWSA 5 SEEP A	1	10	0.0019	3.24E-03	0.0019	4.15E-03	0.023	S_CHR_V	0.18
Cobalt	SWSA 5 SEEP A	1	10	0.0019	3.24E-03	0.0019	4.15E-03	0.29	LCV_FISH	0.01
Cobalt	SWSA 5 SEEP A	1	10	0.0019	3.24E-03	0.0019	4.15E-03	0.81	LTV_FISH	0.01
Cobalt	SWSA 5 SEEP A	1	10	0.0019	3.24E-03	0.0019	4.15E-03	1.5	S_ACU_V	0.00
Cobalt	**W6MS3**	**4**	**36**	**0.0104**	**5.00E-03**	**0.037**	**1.09E-02**	**0.0044**	**LTV_DAPH**	**2.48**
Cobalt	**W6MS3**	**4**	**36**	**0.0104**	**5.00E-03**	**0.037**	**1.09E-02**	**0.0051**	**LCV_DAPH**	**2.14**
Cobalt	W6MS3	4	36	0.0104	5.00E-03	0.037	1.09E-02	0.023	S_CHR_V	0.47
Cobalt	W6MS3	4	36	0.0104	5.00E-03	0.037	1.09E-02	0.29	LCV_FISH	0.04
Cobalt	W6MS3	4	36	0.0104	5.00E-03	0.037	1.09E-02	0.81	LTV_FISH	0.01
Cobalt	W6MS3	4	36	0.0104	5.00E-03	0.037	1.09E-02	1.5	S_ACU_V	0.01
Cobalt	**W6MS1**	**3**	**16**	**0.00793**	**8.91E-03**	**0.025**	**1.42E-02**	**0.0044**	**LTV_DAPH**	**3.22**
Cobalt	**W6MS1**	**3**	**16**	**0.00793**	**8.91E-03**	**0.025**	**1.42E-02**	**0.0051**	**LCV_DAPH**	**2.78**
Cobalt	W6MS1	3	16	0.00793	8.91E-03	0.025	1.42E-02	0.023	S_CHR_V	0.62
Cobalt	W6MS1	3	16	0.00793	8.91E-03	0.025	1.42E-02	0.29	LCV_FISH	0.05
Cobalt	W6MS1	3	16	0.00793	8.91E-03	0.025	1.42E-02	0.81	LTV_FISH	0.02
Cobalt	W6MS1	3	16	0.00793	8.91E-03	0.025	1.42E-02	1.5	S_ACU_V	0.01
Copper	**HF-2**	**7**	**11**	**0.0021**	**5.00E-03**	**0.0298**	**1.75E-02**	**0.000205**	**LTV_DAPH**	**85.39**
Copper	**HF-2**	**7**	**11**	**0.0021**	**5.00E-03**	**0.0298**	**1.75E-02**	**0.00023**	**LCV_DAPH**	**76.11**
Copper	**HF-2**	**7**	**11**	**0.0021**	**5.00E-03**	**0.0298**	**1.75E-02**	**0.001**	**LCV_AQPL**	**17.51**
Copper	**HF-2**	**7**	**11**	**0.0021**	**5.00E-03**	**0.0298**	**1.75E-02**	**0.0038**	**LCV_FISH**	**4.61**
Copper	**HF-2**	**7**	**11**	**0.0021**	**5.00E-03**	**0.0298**	**1.75E-02**	**0.005**	**LTV_FISH**	**3.50**
Copper	**HF-2**	**7**	**11**	**0.0021**	**5.00E-03**	**0.0298**	**1.75E-02**	**0.006066**	**LCV_NDI**	**2.89**
Copper	**HF-2**	**7**	**11**	**0.0021**	**5.00E-03**	**0.0298**	**1.75E-02**	**0.012**	**NAWQ_CHR**	**1.46**

Table 3.7 (Continued)

Analyte	Subbasin	Dets.	Obs.	Min Det.	Median	Max Det.	UCL95	Bmk Value	Bmk Name	HQ
Copper	HF-2	7	11	0.0021	5.00E-03	0.0298	1.75E-02	0.018	NAWQ_ACU	0.97
Copper	Intermediate Pond	7	14	0.004	4.20E-03	0.0167	7.87E-03	0.000205	LTV_DAPH	38.41
Copper	Intermediate Pond	7	14	0.004	4.20E-03	0.0167	7.87E-03	0.00023	LCV_DAPH	34.24
Copper	Intermediate Pond	7	14	0.004	4.20E-03	0.0167	7.87E-03	0.001	LCV_AQPL	7.87
Copper	Intermediate Pond	7	14	0.004	4.20E-03	0.0167	7.87E-03	0.0038	LCV_FISH	2.07
Copper	Intermediate Pond	7	14	0.004	4.20E-03	0.0167	7.87E-03	0.005	LTV_FISH	1.57
Copper	Intermediate Pond	7	14	0.004	4.20E-03	0.0167	7.87E-03	0.006066	LCV_NDI	1.30
Copper	Intermediate Pond	7	14	0.004	4.20E-03	0.0167	7.87E-03	0.012	NAWQ_CHR	0.66
Copper	Intermediate Pond	7	14	0.004	4.20E-03	0.0167	7.87E-03	0.018	NAWQ_ACU	0.44
Copper	Lower WOC	58	147	0.002	3.50E-03	0.079	6.19E-03	0.000205	LTV_DAPH	30.21
Copper	Lower WOC	58	147	0.002	3.50E-03	0.079	6.19E-03	0.00023	LCV_DAPH	26.92
Copper	Lower WOC	58	147	0.002	3.50E-03	0.079	6.19E-03	0.001	LCV_AQPL	6.19
Copper	Lower WOC	58	147	0.002	3.50E-03	0.079	6.19E-03	0.0038	LCV_FISH	1.63
Copper	Lower WOC	58	147	0.002	3.50E-03	0.079	6.19E-03	0.005	LTV_FISH	1.24
Copper	Lower WOC	58	147	0.002	3.50E-03	0.079	6.19E-03	0.006066	LCV_NDI	1.02
Copper	Lower WOC	58	147	0.002	3.50E-03	0.079	6.19E-03	0.012	NAWQ_CHR	0.52
Copper	Lower WOC	58	147	0.002	3.50E-03	0.079	6.19E-03	0.018	NAWQ_ACU	0.34
Copper	SWSA 5 SEEP A	1	10	0.0022	2.00E-03	0.0022	2.73E-03	0.000205	LTV_DAPH	13.33
Copper	SWSA 5 SEEP A	1	10	0.0022	2.00E-03	0.0022	2.73E-03	0.00023	LCV_DAPH	11.88
Copper	SWSA 5 SEEP A	1	10	0.0022	2.00E-03	0.0022	2.73E-03	0.001	LCV_AQPL	2.73
Copper	SWSA 5 SEEP A	1	10	0.0022	2.00E-03	0.0022	2.73E-03	0.0038	LCV_FISH	0.72
Copper	SWSA 5 SEEP A	1	10	0.0022	2.00E-03	0.0022	2.73E-03	0.005	LTV_FISH	0.55
Copper	SWSA 5 SEEP A	1	10	0.0022	2.00E-03	0.0022	2.73E-03	0.006066	LCV_NDI	0.45
Copper	SWSA 5 SEEP A	1	10	0.0022	2.00E-03	0.0022	2.73E-03	0.012	NAWQ_CHR	0.23
Copper	SWSA 5 SEEP A	1	10	0.0022	2.00E-03	0.0022	2.73E-03	0.018	NAWQ_ACU	0.15
Copper	SWSA 5 SEEP C	3	4	0.0036	3.75E-03	0.0049	5.31E-03	0.000205	LTV_DAPH	25.88
Copper	SWSA 5 SEEP C	3	4	0.0036	3.75E-03	0.0049	5.31E-03	0.00023	LCV_DAPH	23.07
Copper	SWSA 5 SEEP C	3	4	0.0036	3.75E-03	0.0049	5.31E-03	0.001	LCV_AQPL	5.31
Copper	SWSA 5 SEEP C	3	4	0.0036	3.75E-03	0.0049	5.31E-03	0.0038	LCV_FISH	1.40
Copper	SWSA 5 SEEP C	3	4	0.0036	3.75E-03	0.0049	5.31E-03	0.005	LTV_FISH	1.06
Copper	SWSA 5 SEEP C	3	4	0.0036	3.75E-03	0.0049	5.31E-03	0.006066	LCV_NDI	0.87
Copper	SWSA 5 SEEP C	3	4	0.0036	3.75E-03	0.0049	5.31E-03	0.012	NAWQ_CHR	0.44
Copper	SWSA 5 SEEP C	3	4	0.0036	3.75E-03	0.0049	5.31E-03	0.018	NAWQ_ACU	0.29
Copper	SWSA 5 WOC	1	2	0.0126	4.27E-03	0.0126	4.22E-02	0.000205	LTV_DAPH	205.97
Copper	SWSA 5 WOC	1	2	0.0126	4.27E-03	0.0126	4.22E-02	0.00023	LCV_DAPH	183.58
Copper	SWSA 5 WOC	1	2	0.0126	4.27E-03	0.0126	4.22E-02	0.001	LCV_AQPL	42.22

Table 3.7 (Continued)

Analyte	Subbasin	Dets.	Obs.	Min Det.	Median	Max Det.	UCL95	Bmk Value	Bmk Name	HQ
Copper	SWSA 5 WOC	1	2	0.0126	4.27E-03	0.0126	4.22E-02	0.0038	LCV_FISH	11.11
Copper	SWSA 5 WOC	1	2	0.0126	4.27E-03	0.0126	4.22E-02	0.005	LTV_FISH	8.44
Copper	SWSA 5 WOC	1	2	0.0126	4.27E-03	0.0126	4.22E-02	0.006066	LCV_NDI	6.96
Copper	SWSA 5 WOC	1	2	0.0126	4.27E-03	0.0126	4.22E-02	0.012	NAWQ_CHR	3.52
Copper	SWSA 5 WOC	1	2	0.0126	4.27E-03	0.0126	4.22E-02	0.018	NAWQ_ACU	2.35
Copper	W6MS3	41	63	0.0033	1.18E-02	0.0883	2.27E-02	0.000205	LTV_DAPH	110.64
Copper	W6MS3	41	63	0.0033	1.18E-02	0.0883	2.27E-02	0.00023	LCV_DAPH	98.62
Copper	W6MS3	41	63	0.0033	1.18E-02	0.0883	2.27E-02	0.001	LCV_AQPL	22.68
Copper	W6MS3	41	63	0.0033	1.18E-02	0.0883	2.27E-02	0.0038	LCV_FISH	5.97
Copper	W6MS3	41	63	0.0033	1.18E-02	0.0883	2.27E-02	0.005	LTV_FISH	4.54
Copper	W6MS3	41	63	0.0033	1.18E-02	0.0883	2.27E-02	0.006066	LCV_NDI	3.74
Copper	W6MS3	41	63	0.0033	1.18E-02	0.0883	2.27E-02	0.012	NAWQ_CHR	1.89
Copper	W6MS3	41	63	0.0033	1.18E-02	0.0883	2.27E-02	0.018	NAWQ_ACU	1.26
Copper	W6MS1	10	21	0.0033	5.00E-03	0.04	1.45E-02	0.000205	LTV_DAPH	70.77
Copper	W6MS1	10	21	0.0033	5.00E-03	0.04	1.45E-02	0.00023	LCV_DAPH	63.08
Copper	W6MS1	10	21	0.0033	5.00E-03	0.04	1.45E-02	0.001	LCV_AQPL	14.51
Copper	W6MS1	10	21	0.0033	5.00E-03	0.04	1.45E-02	0.0038	LCV_FISH	3.82
Copper	W6MS1	10	21	0.0033	5.00E-03	0.04	1.45E-02	0.005	LTV_FISH	2.90
Copper	W6MS1	10	21	0.0033	5.00E-03	0.04	1.45E-02	0.006066	LCV_NDI	2.39
Copper	W6MS1	10	21	0.0033	5.00E-03	0.04	1.45E-02	0.012	NAWQ_CHR	1.21
Copper	W6MS1	10	21	0.0033	5.00E-03	0.04	1.45E-02	0.018	NAWQ_ACU	0.81
Copper	West Seep	1	4	0.01	5.00E-03	0.01	9.19E-03	0.000205	LTV_DAPH	44.84
Copper	West Seep	1	4	0.01	5.00E-03	0.01	9.19E-03	0.00023	LCV_DAPH	39.96
Copper	West Seep	1	4	0.01	5.00E-03	0.01	9.19E-03	0.001	LCV_AQPL	9.19
Copper	West Seep	1	4	0.01	5.00E-03	0.01	9.19E-03	0.0038	LCV_FISH	2.42
Copper	West Seep	1	4	0.01	5.00E-03	0.01	9.19E-03	0.005	LTV_FISH	1.84
Copper	West Seep	1	4	0.01	5.00E-03	0.01	9.19E-03	0.006066	LCV_NDI	1.52
Copper	West Seep	1	4	0.01	5.00E-03	0.01	9.19E-03	0.012	NAWQ_CHR	0.77
Copper	West Seep	1	4	0.01	5.00E-03	0.01	9.19E-03	0.018	NAWQ_ACU	0.51
Copper	WOC	18	66	0.0029	3.50E-03	0.0176	4.99E-03	0.000205	LTV_DAPH	24.36
Copper	WOC	18	66	0.0029	3.50E-03	0.0176	4.99E-03	0.00023	LCV_DAPH	21.72
Copper	WOC	18	66	0.0029	3.50E-03	0.0176	4.99E-03	0.001	LCV_AQPL	4.99
Copper	WOC	18	66	0.0029	3.50E-03	0.0176	4.99E-03	0.0038	LCV_FISH	1.31
Copper	WOC	18	66	0.0029	3.50E-03	0.0176	4.99E-03	0.005	LTV_FISH	1.00
Copper	WOC	18	66	0.0029	3.50E-03	0.0176	4.99E-03	0.006066	LCV_NDI	0.82
Copper	WOC	18	66	0.0029	3.50E-03	0.0176	4.99E-03	0.012	NAWQ_CHR	0.42

Table 3.7 (Continued)

Analyte	Subbasin	Dets.	Obs.	Min Det.	Median	Max Det.	UCL95	Bmk Value	Bmk Name	HQ
Copper	WOC	18	66	0.0029	3.50E-03	0.0176	4.99E-03	0.018	NAWQ_ACU	0.28
Iron	HFIR South	1	1	0.832	.	0.832	8.32E-01	0.016	LTV_DAPH	52.00
Iron	HFIR South	1	1	0.832	.	0.832	8.32E-01	0.158	LCV_DAPH	5.27
Iron	HFIR South	1	1	0.832	.	0.832	8.32E-01	1	NAWQ_CHR	0.83
Iron	HFIR South	1	1	0.832	.	0.832	8.32E-01	1.3	LCV_FISH	0.64
Iron	Intermediate Pond	8	15	0.0995	9.95E-02	1.13	2.24E-01	0.016	LTV_DAPH	13.97
Iron	Intermediate Pond	8	15	0.0995	9.95E-02	1.13	2.24E-01	0.158	LCV_DAPH	1.42
Iron	Intermediate Pond	8	15	0.0995	9.95E-02	1.13	2.24E-01	1	NAWQ_CHR	0.22
Iron	Intermediate Pond	8	15	0.0995	9.95E-02	1.13	2.24E-01	1.3	LCV_FISH	0.17
Iron	Lower WOC	139	148	0.0112	4.33E-01	11	1.01E+00	0.016	LTV_DAPH	62.89
Iron	Lower WOC	139	148	0.0112	4.33E-01	11	1.01E+00	0.158	LCV_DAPH	6.37
Iron	Lower WOC	139	148	0.0112	4.33E-01	11	1.01E+00	1	NAWQ_CHR	1.01
Iron	Lower WOC	139	148	0.0112	4.33E-01	11	1.01E+00	1.3	LCV_FISH	0.77
Iron	SWSA 6 East	2	2	0.665	1.90E+00	5.45	1.82E+01	0.016	LTV_DAPH	1135.20
Iron	SWSA 6 East	2	2	0.665	1.90E+00	5.45	1.82E+01	0.158	LCV_DAPH	114.96
Iron	SWSA 6 East	2	2	0.665	1.90E+00	5.45	1.82E+01	1	NAWQ_CHR	18.16
Iron	SWSA 6 East	2	2	0.665	1.90E+00	5.45	1.82E+01	1.3	LCV_FISH	13.97
Iron	W6MS3	74	82	0.01	6.15E-01	57.9	3.94E+00	0.016	LTV_DAPH	246.44
Iron	W6MS3	74	82	0.01	6.15E-01	57.9	3.94E+00	0.158	LCV_DAPH	24.96
Iron	W6MS3	74	82	0.01	6.15E-01	57.9	3.94E+00	1	NAWQ_CHR	3.94
Iron	W6MS3	74	82	0.01	6.15E-01	57.9	3.94E+00	1.3	LCV_FISH	3.03
Iron	W6MS1	43	44	0.0285	9.01E-01	26.7	3.30E+00	0.016	LTV_DAPH	206.56
Iron	W6MS1	43	44	0.0285	9.01E-01	26.7	3.30E+00	0.158	LCV_DAPH	20.92
Iron	W6MS1	43	44	0.0285	9.01E-01	26.7	3.30E+00	1	NAWQ_CHR	3.30
Iron	W6MS1	43	44	0.0285	9.01E-01	26.7	3.30E+00	1.3	LCV_FISH	2.54
Iron	West Seep	6	6	0.023	4.91E-02	1.08	6.03E-01	0.016	LTV_DAPH	37.70
Iron	West Seep	6	6	0.023	4.91E-02	1.08	6.03E-01	0.158	LCV_DAPH	3.82
Iron	West Seep	6	6	0.023	4.91E-02	1.08	6.03E-01	1	NAWQ_CHR	0.60
Iron	West Seep	6	6	0.023	4.91E-02	1.08	6.03E-01	1.3	LCV_FISH	0.46
Iron	WOC	58	67	0.069	1.40E-01	3.7	3.24E-01	0.016	LTV_DAPH	20.23
Iron	WOC	58	67	0.069	1.40E-01	3.7	3.24E-01	0.158	LCV_DAPH	2.05
Iron	WOC	58	67	0.069	1.40E-01	3.7	3.24E-01	1	NAWQ_CHR	0.32
Iron	WOC	58	67	0.069	1.40E-01	3.7	3.24E-01	1.3	LCV_FISH	0.25
Lead	W6MS3	45	69	0.002	3.20E-03	0.35612	9.63E-03	0.0032	NAWQ_CHR	3.01
Lead	W6MS3	45	69	0.002	3.20E-03	0.35612	9.63E-03	0.01226	LCV_DAPH	0.79
Lead	W6MS3	45	69	0.002	3.20E-03	0.35612	9.63E-03	0.01888	LCV_FISH	0.51

Table 3.7 (Continued)

Analyte	Subbasin	Dets.	Obs.	Min Det.	Median	Max Det.	UCL95	Bmk Value	Bmk Name	HQ
Lead	W6MS3	45	69	0.002	3.20E-03	0.35612	9.63E-03	0.022	LTV_FISH	0.44
Lead	W6MS3	45	69	0.002	3.20E-03	0.35612	9.63E-03	0.02546	LCV_NDI	0.38
Lead	W6MS3	45	69	0.002	3.20E-03	0.35612	9.63E-03	0.082	NAWQ_ACU	0.12
Lead	W6MS3	45	69	0.002	3.20E-03	0.35612	9.63E-03	0.5	LCV_AQPL	0.02
Lead	**W6MS1**	**24**	**32**	**0.0021**	**3.43E-03**	**0.0179**	**9.23E-03**	**0.0032**	**NAWQ_CHR**	**2.89**
Lead	W6MS1	24	32	0.0021	3.43E-03	0.0179	9.23E-03	0.01226	LCV_DAPH	0.75
Lead	W6MS1	24	32	0.0021	3.43E-03	0.0179	9.23E-03	0.01888	LCV_FISH	0.49
Lead	W6MS1	24	32	0.0021	3.43E-03	0.0179	9.23E-03	0.022	LTV_FISH	0.42
Lead	W6MS1	24	32	0.0021	3.43E-03	0.0179	9.23E-03	0.02546	LCV_NDI	0.36
Lead	W6MS1	24	32	0.0021	3.43E-03	0.0179	9.23E-03	0.082	NAWQ_ACU	0.11
Lead	W6MS1	24	32	0.0021	3.43E-03	0.0179	9.23E-03	0.5	LCV_AQPL	0.02
Lead	**WOC**	**1**	**57**	**0.058**	**2.50E-02**	**0.058**	**2.00E-02**	**0.0032**	**NAWQ_CHR**	**6.24**
Lead	**WOC**	**1**	**57**	**0.058**	**2.50E-02**	**0.058**	**2.00E-02**	**0.01226**	**LCV_DAPH**	**1.63**
Lead	**WOC**	**1**	**57**	**0.058**	**2.50E-02**	**0.058**	**2.00E-02**	**0.01888**	**LCV_FISH**	**1.06**
Lead	WOC	1	57	0.058	2.50E-02	0.058	2.00E-02	0.022	LTV_FISH	0.91
Lead	WOC	1	57	0.058	2.50E-02	0.058	2.00E-02	0.02546	LCV_NDI	0.78
Lead	WOC	1	57	0.058	2.50E-02	0.058	2.00E-02	0.082	NAWQ_ACU	0.24
Lead	WOC	1	57	0.058	2.50E-02	0.058	2.00E-02	0.5	LCV_AQPL	0.04
Lithium	Lower WOC	2	2	0.0032	3.71E-03	0.0043	7.22E-03	0.014	S_CHR_V	0.52
Lithium	Lower WOC	2	2	0.0032	3.71E-03	0.0043	7.22E-03	0.26	S_ACU_V	0.03
Lithium	**SWSA 5 WOC**	**1**	**1**	**0.2**	**.**	**0.2**	**2.00E-01**	**0.014**	**S_CHR_V**	**14.29**
Lithium	SWSA 5 WOC	1	1	0.2	.	0.2	2.00E-01	0.26	S_ACU_V	0.77
Manganese	**Lower WOC**	**141**	**142**	**0.017**	**1.10E-01**	**8.82**	**1.96E-01**	**0.12**	**S_CHR_V**	**1.63**
Manganese	Lower WOC	141	142	0.017	1.10E-01	8.82	1.96E-01	1.1	LCV_DAPH	0.18
Manganese	Lower WOC	141	142	0.017	1.10E-01	8.82	1.96E-01	1.1	LTV_DAPH	0.18
Manganese	Lower WOC	141	142	0.017	1.10E-01	8.82	1.96E-01	1.27	LTV_FISH	0.15
Manganese	Lower WOC	141	142	0.017	1.10E-01	8.82	1.96E-01	1.78	LCV_FISH	0.11
Manganese	Lower WOC	141	142	0.017	1.10E-01	8.82	1.96E-01	2.3	S_ACU_V	0.09
Manganese	**W6MS3**	**71**	**81**	**0.002**	**1.73E-01**	**6.34**	**5.38E-01**	**0.12**	**S_CHR_V**	**4.48**
Manganese	W6MS3	71	81	0.002	1.73E-01	6.34	5.38E-01	1.1	LCV_DAPH	0.49
Manganese	W6MS3	71	81	0.002	1.73E-01	6.34	5.38E-01	1.1	LTV_DAPH	0.49
Manganese	W6MS3	71	81	0.002	1.73E-01	6.34	5.38E-01	1.27	LTV_FISH	0.42
Manganese	W6MS3	71	81	0.002	1.73E-01	6.34	5.38E-01	1.78	LCV_FISH	0.30
Manganese	W6MS3	71	81	0.002	1.73E-01	6.34	5.38E-01	2.3	S_ACU_V	0.23
Manganese	**W6MS1**	**43**	**44**	**0.0035**	**8.98E-02**	**2.76**	**2.53E-01**	**0.12**	**S_CHR_V**	**2.11**
Manganese	W6MS1	43	44	0.0035	8.98E-02	2.76	2.53E-01	1.1	LCV_DAPH	0.23

Table 3.7 (Continued)

Analyte	Subbasin	Dets.	Obs.	Min Det.	Median	Max Det.	UCL95	Bmk Value	Bmk Name	HQ
Manganese	W6MS1	43	44	0.0035	8.98E-02	2.76	2.53E-01	1.1	LTV_DAPH	0.23
Manganese	W6MS1	43	44	0.0035	8.98E-02	2.76	2.53E-01	1.27	LTV_FISH	0.20
Manganese	W6MS1	43	44	0.0035	8.98E-02	2.76	2.53E-01	1.78	LCV_FISH	0.14
Manganese	W6MS1	43	44	0.0035	8.98E-02	2.76	2.53E-01	2.3	S_ACU_V	0.11
Manganese	WOC	66	68	0.0015	2.79E-02	0.29	4.24E-02	0.12	S_CHR_V	0.35
Manganese	WOC	66	68	0.0015	2.79E-02	0.29	4.24E-02	1.1	LCV_DAPH	0.04
Manganese	WOC	66	68	0.0015	2.79E-02	0.29	4.24E-02	1.1	LTV_DAPH	0.04
Manganese	WOC	66	68	0.0015	2.79E-02	0.29	4.24E-02	1.27	LTV_FISH	0.03
Manganese	WOC	66	68	0.0015	2.79E-02	0.29	4.24E-02	1.78	LCV_FISH	0.02
Manganese	WOC	66	68	0.0015	2.79E-02	0.29	4.24E-02	2.3	S_ACU_V	0.02
Mercury	**HF-2**	**1**	**8**	**0.134**	**1.00E-04**	**0.134**	**1.83E-01**	**0.00023**	**LCV_FISH**	**794.79**
Mercury	**HF-2**	**1**	**8**	**0.134**	**1.00E-04**	**0.134**	**1.83E-01**	**0.00087**	**LTV_DAPH**	**210.12**
Mercury	**HF-2**	**1**	**8**	**0.134**	**1.00E-04**	**0.134**	**1.83E-01**	**0.00087**	**LTV_FISH**	**210.12**
Mercury	**HF-2**	**1**	**8**	**0.134**	**1.00E-04**	**0.134**	**1.83E-01**	**0.00096**	**LCV_DAPH**	**190.42**
Mercury	**HF-2**	**1**	**8**	**0.134**	**1.00E-04**	**0.134**	**1.83E-01**	**0.0013**	**S_CHR_V**	**140.62**
Mercury	**HF-2**	**1**	**8**	**0.134**	**1.00E-04**	**0.134**	**1.83E-01**	**0.0024**	**NAWQ_ACU**	**76.17**
Mercury	**HF-2**	**1**	**8**	**0.134**	**1.00E-04**	**0.134**	**1.83E-01**	**0.005**	**LCV_AQPL**	**36.56**
Mercury	Lower WOC	33	120	0.00005	6.35E-05	0.00084	9.40E-05	0.00023	LCV_FISH	0.41
Mercury	Lower WOC	33	120	0.00005	6.35E-05	0.00084	9.40E-05	0.00087	LTV_DAPH	0.11
Mercury	Lower WOC	33	120	0.00005	6.35E-05	0.00084	9.40E-05	0.00087	LTV_FISH	0.11
Mercury	Lower WOC	33	120	0.00005	6.35E-05	0.00084	9.40E-05	0.00096	LCV_DAPH	0.10
Mercury	Lower WOC	33	120	0.00005	6.35E-05	0.00084	9.40E-05	0.0013	S_CHR_V	0.07
Mercury	Lower WOC	33	120	0.00005	6.35E-05	0.00084	9.40E-05	0.0024	NAWQ_ACU	0.04
Mercury	Lower WOC	33	120	0.00005	6.35E-05	0.00084	9.40E-05	0.005	LCV_AQPL	0.02
Mercury	**SWSA 6 East**	**1**	**2**	**0.0003**	**1.73E-04**	**0.0003**	**8.31E-04**	**0.00023**	**LCV_FISH**	**3.61**
Mercury	SWSA 6 East	1	2	0.0003	1.73E-04	0.0003	8.31E-04	0.00087	LTV_DAPH	0.96
Mercury	SWSA 6 East	1	2	0.0003	1.73E-04	0.0003	8.31E-04	0.00087	LTV_FISH	0.96
Mercury	SWSA 6 East	1	2	0.0003	1.73E-04	0.0003	8.31E-04	0.00096	LCV_DAPH	0.87
Mercury	SWSA 6 East	1	2	0.0003	1.73E-04	0.0003	8.31E-04	0.0013	S_CHR_V	0.64
Mercury	SWSA 6 East	1	2	0.0003	1.73E-04	0.0003	8.31E-04	0.0024	NAWQ_ACU	0.35
Mercury	SWSA 6 East	1	2	0.0003	1.73E-04	0.0003	8.31E-04	0.005	LCV_AQPL	0.17
Mercury	**W6MS3**	**9**	**35**	**0.00023**	**1.00E-04**	**0.00073**	**2.69E-04**	**0.00023**	**LCV_FISH**	**1.17**
Mercury	W6MS3	9	35	0.00023	1.00E-04	0.00073	2.69E-04	0.00087	LTV_DAPH	0.31
Mercury	W6MS3	9	35	0.00023	1.00E-04	0.00073	2.69E-04	0.00087	LTV_FISH	0.31
Mercury	W6MS3	9	35	0.00023	1.00E-04	0.00073	2.69E-04	0.00096	LCV_DAPH	0.28
Mercury	W6MS3	9	35	0.00023	1.00E-04	0.00073	2.69E-04	0.0013	S_CHR_V	0.21

Table 3.7 (Continued)

Analyte	Subbasin	Dets.	Obs.	Min Det.	Median	Max Det.	UCL95	Bmk Value	Bmk Name	HQ
Mercury	W6MS3	9	35	0.00023	1.00E-04	0.00073	2.69E-04	0.0024	NAWQ_ACU	0.11
Mercury	W6MS3	9	35	0.00023	1.00E-04	0.00073	2.69E-04	0.005	LCV_AQPL	0.05
Mercury	**W6MS1**	**6**	**19**	**0.0002**	**1.00E-04**	**0.0047**	**4.06E-04**	**0.00023**	**LCV_FISH**	**1.77**
Mercury	W6MS1	6	19	0.0002	1.00E-04	0.0047	4.06E-04	0.00087	LTV_DAPH	0.47
Mercury	W6MS1	6	19	0.0002	1.00E-04	0.0047	4.06E-04	0.00087	LTV_FISH	0.47
Mercury	W6MS1	6	19	0.0002	1.00E-04	0.0047	4.06E-04	0.00096	LCV_DAPH	0.42
Mercury	W6MS1	6	19	0.0002	1.00E-04	0.0047	4.06E-04	0.0013	S_CHR_V	0.31
Mercury	W6MS1	6	19	0.0002	1.00E-04	0.0047	4.06E-04	0.0024	NAWQ_ACU	0.17
Mercury	W6MS1	6	19	0.0002	1.00E-04	0.0047	4.06E-04	0.005	LCV_AQPL	0.08
Mercury	WOC	15	56	0.000057	5.85E-05	0.00037	7.48E-05	0.00023	LCV_FISH	0.33
Mercury	WOC	15	56	0.000057	5.85E-05	0.00037	7.48E-05	0.00087	LTV_DAPH	0.09
Mercury	WOC	15	56	0.000057	5.85E-05	0.00037	7.48E-05	0.00087	LTV_FISH	0.09
Mercury	WOC	15	56	0.000057	5.85E-05	0.00037	7.48E-05	0.00096	LCV_DAPH	0.08
Mercury	WOC	15	56	0.000057	5.85E-05	0.00037	7.48E-05	0.0013	S_CHR_V	0.06
Mercury	WOC	15	56	0.000057	5.85E-05	0.00037	7.48E-05	0.0024	NAWQ_ACU	0.03
Mercury	WOC	15	56	0.000057	5.85E-05	0.00037	7.48E-05	0.005	LCV_AQPL	0.01
Nickel	**Lower WOC**	**11**	**141**	**0.0062**	**5.00E-03**	**0.0201**	**6.81E-03**	**0.005**	**LCV_AQPL**	**1.36**
Nickel	**Lower WOC**	**11**	**141**	**0.0062**	**5.00E-03**	**0.0201**	**6.81E-03**	**0.005**	**LCV_DAPH**	**1.36**
Nickel	Lower WOC	11	141	0.0062	5.00E-03	0.0201	6.81E-03	0.035	LCV_FISH	0.19
Nickel	Lower WOC	11	141	0.0062	5.00E-03	0.0201	6.81E-03	0.045	LTV_DAPH	0.15
Nickel	Lower WOC	11	141	0.0062	5.00E-03	0.0201	6.81E-03	0.062	LTV_FISH	0.11
Nickel	Lower WOC	11	141	0.0062	5.00E-03	0.0201	6.81E-03	0.1284	LCV_NDI	0.05
Nickel	Lower WOC	11	141	0.0062	5.00E-03	0.0201	6.81E-03	0.16	NAWQ_CHR	0.04
Nickel	Lower WOC	11	141	0.0062	5.00E-03	0.0201	6.81E-03	1.4	NAWQ_ACU	0.00
Nickel	**SWSA 5 SEEP C**	**1**	**3**	**0.0067**	**4.00E-03**	**0.0067**	**8.03E-03**	**0.005**	**LCV_AQPL**	**1.61**
Nickel	**SWSA 5 SEEP C**	**1**	**3**	**0.0067**	**4.00E-03**	**0.0067**	**8.03E-03**	**0.005**	**LCV_DAPH**	**1.61**
Nickel	SWSA 5 SEEP C	1	3	0.0067	4.00E-03	0.0067	8.03E-03	0.035	LCV_FISH	0.23
Nickel	SWSA 5 SEEP C	1	3	0.0067	4.00E-03	0.0067	8.03E-03	0.045	LTV_DAPH	0.18
Nickel	SWSA 5 SEEP C	1	3	0.0067	4.00E-03	0.0067	8.03E-03	0.062	LTV_FISH	0.13
Nickel	SWSA 5 SEEP C	1	3	0.0067	4.00E-03	0.0067	8.03E-03	0.1284	LCV_NDI	0.06
Nickel	SWSA 5 SEEP C	1	3	0.0067	4.00E-03	0.0067	8.03E-03	0.16	NAWQ_CHR	0.05
Nickel	SWSA 5 SEEP C	1	3	0.0067	4.00E-03	0.0067	8.03E-03	1.4	NAWQ_ACU	0.01
Nickel	**SWSA 5 Trib 1**	**1**	**2**	**0.0052**	**2.97E-03**	**0.0052**	**1.45E-02**	**0.005**	**LCV_AQPL**	**2.90**
Nickel	**SWSA 5 Trib 1**	**1**	**2**	**0.0052**	**2.97E-03**	**0.0052**	**1.45E-02**	**0.005**	**LCV_DAPH**	**2.90**
Nickel	SWSA 5 Trib 1	1	2	0.0052	2.97E-03	0.0052	1.45E-02	0.035	LCV_FISH	0.41
Nickel	SWSA 5 Trib 1	1	2	0.0052	2.97E-03	0.0052	1.45E-02	0.045	LTV_DAPH	0.32

Table 3.7 (Continued)

Analyte	Subbasin	Dets.	Obs.	Min Det.	Median	Max Det.	UCL95	Bmk Value	Bmk Name	HQ
Nickel	SWSA 5 Trib 1	1	2	0.0052	2.97E-03	0.0052	1.45E-02	0.062	LTV_FISH	0.23
Nickel	SWSA 5 Trib 1	1	2	0.0052	2.97E-03	0.0052	1.45E-02	0.1284	LCV_NDI	0.11
Nickel	SWSA 5 Trib 1	1	2	0.0052	2.97E-03	0.0052	1.45E-02	0.16	NAWQ_CHR	0.09
Nickel	SWSA 5 Trib 1	1	2	0.0052	2.97E-03	0.0052	1.45E-02	1.4	NAWQ_ACU	0.01
Nickel	**SWSA 5 WOC**	**1**	**2**	**0.0044**	**2.93E-03**	**0.0044**	**1.09E-02**	**0.005**	**LCV_AQPL**	**2.18**
Nickel	**SWSA 5 WOC**	**1**	**2**	**0.0044**	**2.93E-03**	**0.0044**	**1.09E-02**	**0.005**	**LCV_DAPH**	**2.18**
Nickel	SWSA 5 WOC	1	2	0.0044	2.93E-03	0.0044	1.09E-02	0.035	LCV_FISH	0.31
Nickel	SWSA 5 WOC	1	2	0.0044	2.93E-03	0.0044	1.09E-02	0.045	LTV_DAPH	0.24
Nickel	SWSA 5 WOC	1	2	0.0044	2.93E-03	0.0044	1.09E-02	0.062	LTV_FISH	0.18
Nickel	SWSA 5 WOC	1	2	0.0044	2.93E-03	0.0044	1.09E-02	0.1284	LCV_NDI	0.08
Nickel	SWSA 5 WOC	1	2	0.0044	2.93E-03	0.0044	1.09E-02	0.16	NAWQ_CHR	0.07
Nickel	SWSA 5 WOC	1	2	0.0044	2.93E-03	0.0044	1.09E-02	1.4	NAWQ_ACU	0.01
Nickel	**W6MS3**	**10**	**39**	**0.0207**	**1.00E-02**	**0.0497**	**2.10E-02**	**0.005**	**LCV_AQPL**	**4.19**
Nickel	**W6MS3**	**10**	**39**	**0.0207**	**1.00E-02**	**0.0497**	**2.10E-02**	**0.005**	**LCV_DAPH**	**4.19**
Nickel	W6MS3	10	39	0.0207	1.00E-02	0.0497	2.10E-02	0.035	LCV_FISH	0.60
Nickel	W6MS3	10	39	0.0207	1.00E-02	0.0497	2.10E-02	0.045	LTV_DAPH	0.47
Nickel	W6MS3	10	39	0.0207	1.00E-02	0.0497	2.10E-02	0.062	LTV_FISH	0.34
Nickel	W6MS3	10	39	0.0207	1.00E-02	0.0497	2.10E-02	0.1284	LCV_NDI	0.16
Nickel	W6MS3	10	39	0.0207	1.00E-02	0.0497	2.10E-02	0.16	NAWQ_CHR	0.13
Nickel	W6MS3	10	39	0.0207	1.00E-02	0.0497	2.10E-02	1.4	NAWQ_ACU	0.01
Nickel	**W6MS1**	**2**	**16**	**0.0204**	**1.00E-02**	**0.0216**	**1.24E-02**	**0.005**	**LCV_AQPL**	**2.47**
Nickel	**W6MS1**	**2**	**16**	**0.0204**	**1.00E-02**	**0.0216**	**1.24E-02**	**0.005**	**LCV_DAPH**	**2.47**
Nickel	W6MS1	2	16	0.0204	1.00E-02	0.0216	1.24E-02	0.035	LCV_FISH	0.35
Nickel	W6MS1	2	16	0.0204	1.00E-02	0.0216	1.24E-02	0.045	LTV_DAPH	0.27
Nickel	W6MS1	2	16	0.0204	1.00E-02	0.0216	1.24E-02	0.062	LTV_FISH	0.20
Nickel	W6MS1	2	16	0.0204	1.00E-02	0.0216	1.24E-02	0.1284	LCV_NDI	0.10
Nickel	W6MS1	2	16	0.0204	1.00E-02	0.0216	1.24E-02	0.16	NAWQ_CHR	0.08
Nickel	W6MS1	2	16	0.0204	1.00E-02	0.0216	1.24E-02	1.4	NAWQ_ACU	0.01
Nickel	**WOC**	**1**	**61**	**0.072**	**5.00E-03**	**0.072**	**8.79E-03**	**0.005**	**LCV_AQPL**	**1.76**
Nickel	**WOC**	**1**	**61**	**0.072**	**5.00E-03**	**0.072**	**8.79E-03**	**0.005**	**LCV_DAPH**	**1.76**
Nickel	WOC	1	61	0.072	5.00E-03	0.072	8.79E-03	0.035	LCV_FISH	0.25
Nickel	WOC	1	61	0.072	5.00E-03	0.072	8.79E-03	0.045	LTV_DAPH	0.20
Nickel	WOC	1	61	0.072	5.00E-03	0.072	8.79E-03	0.062	LTV_FISH	0.14
Nickel	WOC	1	61	0.072	5.00E-03	0.072	8.79E-03	0.1284	LCV_NDI	0.07
Nickel	WOC	1	61	0.072	5.00E-03	0.072	8.79E-03	0.16	NAWQ_CHR	0.05
Nickel	WOC	1	61	0.072	5.00E-03	0.072	8.79E-03	1.4	NAWQ_ACU	0.01

Table 3.7 (Continued)

Analyte	Subbasin	Dets.	Obs.	Min Det.	Median	Max Det.	UCL95	Bmk Value	Bmk Name	HQ
Selenium	**Lower WOC**	**1**	**42**	**0.001**	**1.00E-03**	**0.001**	**2.12E-02**	**0.005**	**NAWQ_CHR**	**4.24**
Selenium	**Lower WOC**	**1**	**42**	**0.001**	**1.00E-03**	**0.001**	**2.12E-02**	**0.02**	**NAWQ_ACU**	**1.06**
Selenium	Lower WOC	1	42	0.001	1.00E-03	0.001	2.12E-02	0.025	LTV_DAPH	0.85
Selenium	Lower WOC	1	42	0.001	1.00E-03	0.001	2.12E-02	0.04	LTV_FISH	0.53
Selenium	Lower WOC	1	42	0.001	1.00E-03	0.001	2.12E-02	0.08832	LCV_FISH	0.24
Selenium	Lower WOC	1	42	0.001	1.00E-03	0.001	2.12E-02	0.09165	LCV_DAPH	0.23
Selenium	Lower WOC	1	42	0.001	1.00E-03	0.001	2.12E-02	0.1	LCV_AQPL	0.21
Selenium	**SWSA 5 WOC**	**1**	**2**	**0.0031**	**1.93E-03**	**0.0031**	**8.15E-03**	**0.005**	**NAWQ_CHR**	**1.63**
Selenium	SWSA 5 WOC	1	2	0.0031	1.93E-03	0.0031	8.15E-03	0.02	NAWQ_ACU	0.41
Selenium	SWSA 5 WOC	1	2	0.0031	1.93E-03	0.0031	8.15E-03	0.025	LTV_DAPH	0.33
Selenium	SWSA 5 WOC	1	2	0.0031	1.93E-03	0.0031	8.15E-03	0.04	LTV_FISH	0.20
Selenium	SWSA 5 WOC	1	2	0.0031	1.93E-03	0.0031	8.15E-03	0.08832	LCV_FISH	0.09
Selenium	SWSA 5 WOC	1	2	0.0031	1.93E-03	0.0031	8.15E-03	0.09165	LCV_DAPH	0.09
Selenium	SWSA 5 WOC	1	2	0.0031	1.93E-03	0.0031	8.15E-03	0.1	LCV_AQPL	0.08
Selenium	W6MS1	1	14	0.00262	1.00E-03	0.00262	1.69E-03	0.005	NAWQ_CHR	0.34
Selenium	W6MS1	1	14	0.00262	1.00E-03	0.00262	1.69E-03	0.02	NAWQ_ACU	0.08
Selenium	W6MS1	1	14	0.00262	1.00E-03	0.00262	1.69E-03	0.025	LTV_DAPH	0.07
Selenium	W6MS1	1	14	0.00262	1.00E-03	0.00262	1.69E-03	0.04	LTV_FISH	0.04
Selenium	W6MS1	1	14	0.00262	1.00E-03	0.00262	1.69E-03	0.08832	LCV_FISH	0.02
Selenium	W6MS1	1	14	0.00262	1.00E-03	0.00262	1.69E-03	0.09165	LCV_DAPH	0.02
Selenium	W6MS1	1	14	0.00262	1.00E-03	0.00262	1.69E-03	0.1	LCV_AQPL	0.02
Silver	**Intermediate Pond**	**1**	**13**	**0.0038**	**2.00E-03**	**0.0038**	**3.05E-03**	**0.00012**	**LCV_FISH**	**25.42**
Silver	**Intermediate Pond**	**1**	**13**	**0.0038**	**2.00E-03**	**0.0038**	**3.05E-03**	**0.0002**	**LTV_FISH**	**15.25**
Silver	**Intermediate Pond**	**1**	**13**	**0.0038**	**2.00E-03**	**0.0038**	**3.05E-03**	**0.00036**	**S_CHR_V**	**8.47**
Silver	**Intermediate Pond**	**1**	**13**	**0.0038**	**2.00E-03**	**0.0038**	**3.05E-03**	**0.00056**	**LTV_DAPH**	**5.45**
Silver	**Intermediate Pond**	**1**	**13**	**0.0038**	**2.00E-03**	**0.0038**	**3.05E-03**	**0.0026**	**LCV_DAPH**	**1.17**
Silver	Intermediate Pond	1	13	0.0038	2.00E-03	0.0038	3.05E-03	0.0041	NAWQ_ACU	0.74
Silver	Intermediate Pond	1	13	0.0038	2.00E-03	0.0038	3.05E-03	0.03	LCV_AQPL	0.10
Silver	**Lower WOC**	**2**	**139**	**0.0015**	**2.50E-03**	**0.0114**	**2.53E-03**	**0.00012**	**LCV_FISH**	**21.12**
Silver	**Lower WOC**	**2**	**139**	**0.0015**	**2.50E-03**	**0.0114**	**2.53E-03**	**0.0002**	**LTV_FISH**	**12.67**
Silver	**Lower WOC**	**2**	**139**	**0.0015**	**2.50E-03**	**0.0114**	**2.53E-03**	**0.00036**	**S_CHR_V**	**7.04**
Silver	**Lower WOC**	**2**	**139**	**0.0015**	**2.50E-03**	**0.0114**	**2.53E-03**	**0.00056**	**LTV_DAPH**	**4.53**
Silver	Lower WOC	2	139	0.0015	2.50E-03	0.0114	2.53E-03	0.0026	LCV_DAPH	0.97
Silver	Lower WOC	2	139	0.0015	2.50E-03	0.0114	2.53E-03	0.0041	NAWQ_ACU	0.62
Silver	Lower WOC	2	139	0.0015	2.50E-03	0.0114	2.53E-03	0.03	LCV_AQPL	0.08
Silver	**W6MS3**	**12**	**40**	**0.005**	**5.00E-03**	**0.0178**	**6.82E-03**	**0.00012**	**LCV_FISH**	**56.81**

Table 3.7 (Continued)

Analyte	Subbasin	Dets.	Obs.	Min Det.	Median	Max Det.	UCL95	Bmk Value	Bmk Name	HQ
Silver	W6MS3	12	40	0.005	5.00E-03	0.0178	6.82E-03	0.0002	LTV_FISH	34.09
Silver	W6MS3	12	40	0.005	5.00E-03	0.0178	6.82E-03	0.00036	S_CHR_V	18.94
Silver	W6MS3	12	40	0.005	5.00E-03	0.0178	6.82E-03	0.00056	LTV_DAPH	12.17
Silver	W6MS3	12	40	0.005	5.00E-03	0.0178	6.82E-03	0.0026	LCV_DAPH	2.62
Silver	W6MS3	12	40	0.005	5.00E-03	0.0178	6.82E-03	0.0041	NAWQ_ACU	1.66
Silver	W6MS3	12	40	0.005	5.00E-03	0.0178	6.82E-03	0.03	LCV_AQPL	0.23
Thallium	HF-2	1	9	0.41	1.13E-02	0.41	3.55E+00	0.012	S_CHR_V	295.50
Thallium	HF-2	1	9	0.41	1.13E-02	0.41	3.55E+00	0.057	LCV_FISH	62.21
Thallium	HF-2	1	9	0.41	1.13E-02	0.41	3.55E+00	0.064	LTV_DAPH	55.41
Thallium	HF-2	1	9	0.41	1.13E-02	0.41	3.55E+00	0.081	LTV_FISH	43.78
Thallium	HF-2	1	9	0.41	1.13E-02	0.41	3.55E+00	0.1	LCV_AQPL	35.46
Thallium	HF-2	1	9	0.41	1.13E-02	0.41	3.55E+00	0.11	S_ACU_V	32.24
Thallium	HF-2	1	9	0.41	1.13E-02	0.41	3.55E+00	0.13	LCV_DAPH	27.28
Thallium	Intermediate Pond	1	12	0.169	4.74E-03	0.169	1.28E+00	0.012	S_CHR_V	106.49
Thallium	Intermediate Pond	1	12	0.169	4.74E-03	0.169	1.28E+00	0.057	LCV_FISH	22.42
Thallium	Intermediate Pond	1	12	0.169	4.74E-03	0.169	1.28E+00	0.064	LTV_DAPH	19.97
Thallium	Intermediate Pond	1	12	0.169	4.74E-03	0.169	1.28E+00	0.081	LTV_FISH	15.78
Thallium	Intermediate Pond	1	12	0.169	4.74E-03	0.169	1.28E+00	0.1	LCV_AQPL	12.78
Thallium	Intermediate Pond	1	12	0.169	4.74E-03	0.169	1.28E+00	0.11	S_ACU_V	11.62
Thallium	Intermediate Pond	1	12	0.169	4.74E-03	0.169	1.28E+00	0.13	LCV_DAPH	9.83
Thallium	Lower WOC	5	50	0.06	1.13E-02	0.422	7.56E-03	0.012	S_CHR_V	0.63
Thallium	Lower WOC	5	50	0.06	1.13E-02	0.422	7.56E-03	0.057	LCV_FISH	0.13
Thallium	Lower WOC	5	50	0.06	1.13E-02	0.422	7.56E-03	0.064	LTV_DAPH	0.12
Thallium	Lower WOC	5	50	0.06	1.13E-02	0.422	7.56E-03	0.081	LTV_FISH	0.09
Thallium	Lower WOC	5	50	0.06	1.13E-02	0.422	7.56E-03	0.1	LCV_AQPL	0.08
Thallium	Lower WOC	5	50	0.06	1.13E-02	0.422	7.56E-03	0.11	S_ACU_V	0.07
Thallium	Lower WOC	5	50	0.06	1.13E-02	0.422	7.56E-03	0.13	LCV_DAPH	0.06
Thallium	SWSA 5 SEEP A	1	9	0.168	1.13E-02	0.168	1.82E+00	0.012	S_CHR_V	151.84
Thallium	SWSA 5 SEEP A	1	9	0.168	1.13E-02	0.168	1.82E+00	0.057	LCV_FISH	31.97
Thallium	SWSA 5 SEEP A	1	9	0.168	1.13E-02	0.168	1.82E+00	0.064	LTV_DAPH	28.47
Thallium	SWSA 5 SEEP A	1	9	0.168	1.13E-02	0.168	1.82E+00	0.081	LTV_FISH	22.49
Thallium	SWSA 5 SEEP A	1	9	0.168	1.13E-02	0.168	1.82E+00	0.1	LCV_AQPL	18.22
Thallium	SWSA 5 SEEP A	1	9	0.168	1.13E-02	0.168	1.82E+00	0.11	S_ACU_V	16.56
Thallium	SWSA 5 SEEP A	1	9	0.168	1.13E-02	0.168	1.82E+00	0.13	LCV_DAPH	14.02
Thallium	WOC	5	20	0.156	2.00E-02	0.207	6.09E-02	0.012	S_CHR_V	5.07
Thallium	WOC	5	20	0.156	2.00E-02	0.207	6.09E-02	0.057	LCV_FISH	1.07

Table 3.7 (Continued)

Analyte	Subbasin	Dets.	Obs.	Min Det.	Median	Max Det.	UCL95	Bmk Value	Bmk Name	HQ
Thallium	WOC	5	20	0.156	2.00E-02	0.207	6.09E-02	0.064	LTV_DAPH	0.95
Thallium	WOC	5	20	0.156	2.00E-02	0.207	6.09E-02	0.081	LTV_FISH	0.75
Thallium	WOC	5	20	0.156	2.00E-02	0.207	6.09E-02	0.1	LCV_AQPL	0.61
Thallium	WOC	5	20	0.156	2.00E-02	0.207	6.09E-02	0.11	S_ACU_V	0.55
Thallium	WOC	5	20	0.156	2.00E-02	0.207	6.09E-02	0.13	LCV_DAPH	0.47
Tin	**W6MS3**	**3**	**4**	**0.272**	**2.73E-01**	**0.528**	**5.20E-01**	**0.073**	**S_CHR_V**	**7.12**
Tin	**W6MS3**	**3**	**4**	**0.272**	**2.73E-01**	**0.528**	**5.20E-01**	**0.35**	**LCV_DAPH**	**1.49**
Tin	W6MS3	3	4	0.272	2.73E-01	0.528	5.20E-01	2.7	S_ACU_V	0.19
Zinc	**HF-2**	**8**	**10**	**0.009**	**3.63E-02**	**0.285**	**1.42E-01**	**0.03**	**LCV_AQPL**	**4.74**
Zinc	**HF-2**	**8**	**10**	**0.009**	**3.63E-02**	**0.285**	**1.42E-01**	**0.03641**	**LCV_FISH**	**3.90**
Zinc	**HF-2**	**8**	**10**	**0.009**	**3.63E-02**	**0.285**	**1.42E-01**	**0.04673**	**LCV_DAPH**	**3.04**
Zinc	**HF-2**	**8**	**10**	**0.009**	**3.63E-02**	**0.285**	**1.42E-01**	**0.047**	**LTV_FISH**	**3.02**
Zinc	**HF-2**	**8**	**10**	**0.009**	**3.63E-02**	**0.285**	**1.42E-01**	**0.11**	**NAWQ_CHR**	**1.29**
Zinc	**HF-2**	**8**	**10**	**0.009**	**3.63E-02**	**0.285**	**1.42E-01**	**0.12**	**NAWQ_ACU**	**1.18**
Zinc	HF-2	8	10	0.009	3.63E-02	0.285	1.42E-01	5.243	LCV_NDI	0.03
Zinc	**Lower WOC**	**113**	**144**	**0.0024**	**2.20E-02**	**0.24**	**4.23E-02**	**0.03**	**LCV_AQPL**	**1.41**
Zinc	**Lower WOC**	**113**	**144**	**0.0024**	**2.20E-02**	**0.24**	**4.23E-02**	**0.03641**	**LCV_FISH**	**1.16**
Zinc	Lower WOC	113	144	0.0024	2.20E-02	0.24	4.23E-02	0.04673	LCV_DAPH	0.90
Zinc	Lower WOC	113	144	0.0024	2.20E-02	0.24	4.23E-02	0.047	LTV_FISH	0.90
Zinc	Lower WOC	113	144	0.0024	2.20E-02	0.24	4.23E-02	0.11	NAWQ_CHR	0.38
Zinc	Lower WOC	113	144	0.0024	2.20E-02	0.24	4.23E-02	0.12	NAWQ_ACU	0.35
Zinc	Lower WOC	113	144	0.0024	2.20E-02	0.24	4.23E-02	5.243	LCV_NDI	0.01
Benzene	**SWSA 5 Trib 1**	**1**	**2**	**0.01**	**7.07E-03**	**0.01**	**2.33E-02**	**0.021**	**LTV_FISH**	**1.11**
Benzene	SWSA 5 Trib 1	1	2	0.01	7.07E-03	0.01	2.33E-02	0.13	S_CHR_V	0.18
Benzene	SWSA 5 Trib 1	1	2	0.01	7.07E-03	0.01	2.33E-02	2.3	S_ACU_V	0.01
Benzene	SWSA 5 Trib 1	1	2	0.01	7.07E-03	0.01	2.33E-02	98	LCV_DAPH	0.00
Benzene	SWSA 5 Trib 1	1	2	0.01	7.07E-03	0.01	2.33E-02	525	LCV_AQPL	0.00
Benzene	**SWSA 5 WOC**	**1**	**2**	**0.01**	**7.07E-03**	**0.01**	**2.33E-02**	**0.021**	**LTV_FISH**	**1.11**
Benzene	SWSA 5 WOC	1	2	0.01	7.07E-03	0.01	2.33E-02	0.13	S_CHR_V	0.18
Benzene	SWSA 5 WOC	1	2	0.01	7.07E-03	0.01	2.33E-02	2.3	S_ACU_V	0.01
Benzene	SWSA 5 WOC	1	2	0.01	7.07E-03	0.01	2.33E-02	98	LCV_DAPH	0.00
Benzene	SWSA 5 WOC	1	2	0.01	7.07E-03	0.01	2.33E-02	525	LCV_AQPL	0.00
Benzene	W6MS3	4	34	0.001	2.50E-03	0.003	2.45E-03	0.021	LTV_FISH	0.12
Benzene	W6MS3	4	34	0.001	2.50E-03	0.003	2.45E-03	0.13	S_CHR_V	0.02
Benzene	W6MS3	4	34	0.001	2.50E-03	0.003	2.45E-03	2.3	S_ACU_V	0.00
Benzene	W6MS3	4	34	0.001	2.50E-03	0.003	2.45E-03	98	LCV_DAPH	0.00

Table 3.7 (Continued)

Analyte	Subbasin	Dets.	Obs.	Min Det.	Median	Max Det.	UCL95	Bmk Value	Bmk Name	HQ
Benzene	W6MS3	4	34	0.001	2.50E-03	0.003	2.45E-03	525	LCV_AQPL	0.00
Bis(2-Ethylhexyl)Phthalate	SWSA 5 WOC	1	1	0.001	.	0.001	1.00E-03	0.003	LTV_DAPH	0.33
Bis(2-Ethylhexyl)Phthalate	SWSA 5 WOC	1	1	0.001	.	0.001	1.00E-03	0.003	S_CHR_V	0.33
Bis(2-Ethylhexyl)Phthalate	SWSA 5 WOC	1	1	0.001	.	0.001	1.00E-03	0.027	S_ACU_V	0.04
Bis(2-Ethylhexyl)Phthalate	SWSA 5 WOC	1	1	0.001	.	0.001	1.00E-03	0.054	LTV_FISH	0.02
Bis(2-Ethylhexyl)Phthalate	SWSA 5 WOC	1	1	0.001	.	0.001	1.00E-03	0.912	LCV_DAPH	0.00
Bis(2-Ethylhexyl)Phthalate	**W6MS3**	**4**	**20**	**0.002**	**5.00E-03**	**0.01**	**6.23E-03**	**0.003**	**LTV_DAPH**	**2.08**
Bis(2-Ethylhexyl)Phthalate	**W6MS3**	**4**	**20**	**0.002**	**5.00E-03**	**0.01**	**6.23E-03**	**0.003**	**S_CHR_V**	**2.08**
Bis(2-Ethylhexyl)Phthalate	W6MS3	4	20	0.002	5.00E-03	0.01	6.23E-03	0.027	S_ACU_V	0.23
Bis(2-Ethylhexyl)Phthalate	W6MS3	4	20	0.002	5.00E-03	0.01	6.23E-03	0.054	LTV_FISH	0.12
Bis(2-Ethylhexyl)Phthalate	W6MS3	4	20	0.002	5.00E-03	0.01	6.23E-03	0.912	LCV_DAPH	0.01
Bis(2-Ethylhexyl)Phthalate	**W6MS1**	**2**	**4**	**0.004**	**5.00E-03**	**0.01**	**9.19E-03**	**0.003**	**LTV_DAPH**	**3.06**
Bis(2-Ethylhexyl)Phthalate	**W6MS1**	**2**	**4**	**0.004**	**5.00E-03**	**0.01**	**9.19E-03**	**0.003**	**S_CHR_V**	**3.06**
Bis(2-Ethylhexyl)Phthalate	W6MS1	2	4	0.004	5.00E-03	0.01	9.19E-03	0.027	S_ACU_V	0.34
Bis(2-Ethylhexyl)Phthalate	W6MS1	2	4	0.004	5.00E-03	0.01	9.19E-03	0.054	LTV_FISH	0.17
Bis(2-Ethylhexyl)Phthalate	W6MS1	2	4	0.004	5.00E-03	0.01	9.19E-03	0.912	LCV_DAPH	0.01
Carbon Disulfide	**HF-2**	**3**	**3**	**0.011**	**1.10E-02**	**0.011**	**1.10E-02**	**0.00092**	**S_CHR_V**	**11.96**
Carbon Disulfide	HF-2	3	3	0.011	1.10E-02	0.011	1.10E-02	0.017	S_ACU_V	0.65
Carbon Disulfide	HF-2	3	3	0.011	1.10E-02	0.011	1.10E-02	0.244	LCV_DAPH	0.05
Carbon Disulfide	HF-2	3	3	0.011	1.10E-02	0.011	1.10E-02	5.719	LTV_FISH	0.00
Carbon Disulfide	HF-2	3	3	0.011	1.10E-02	0.011	1.10E-02	9.538	LCV_FISH	0.00
Carbon Disulfide	**Intermediate Pond**	**3**	**3**	**0.005**	**5.00E-03**	**0.005**	**5.00E-03**	**0.00092**	**S_CHR_V**	**5.43**
Carbon Disulfide	Intermediate Pond	3	3	0.005	5.00E-03	0.005	5.00E-03	0.017	S_ACU_V	0.29
Carbon Disulfide	Intermediate Pond	3	3	0.005	5.00E-03	0.005	5.00E-03	0.244	LCV_DAPH	0.02
Carbon Disulfide	Intermediate Pond	3	3	0.005	5.00E-03	0.005	5.00E-03	5.719	LTV_FISH	0.00
Carbon Disulfide	Intermediate Pond	3	3	0.005	5.00E-03	0.005	5.00E-03	9.538	LCV_FISH	0.00
Carbon Disulfide	**Lower WOC**	**7**	**9**	**0.003**	**5.50E-03**	**0.017**	**1.63E-02**	**0.00092**	**S_CHR_V**	**17.77**
Carbon Disulfide	Lower WOC	7	9	0.003	5.50E-03	0.017	1.63E-02	0.017	S_ACU_V	0.96
Carbon Disulfide	Lower WOC	7	9	0.003	5.50E-03	0.017	1.63E-02	0.244	LCV_DAPH	0.07
Carbon Disulfide	Lower WOC	7	9	0.003	5.50E-03	0.017	1.63E-02	5.719	LTV_FISH	0.00
Carbon Disulfide	Lower WOC	7	9	0.003	5.50E-03	0.017	1.63E-02	9.538	LCV_FISH	0.00
Carbon Disulfide	**SWSA 5 SEEP A**	**3**	**3**	**0.005**	**5.00E-03**	**0.005**	**5.00E-03**	**0.00092**	**S_CHR_V**	**5.43**
Carbon Disulfide	SWSA 5 SEEP A	3	3	0.005	5.00E-03	0.005	5.00E-03	0.017	S_ACU_V	0.29
Carbon Disulfide	SWSA 5 SEEP A	3	3	0.005	5.00E-03	0.005	5.00E-03	0.244	LCV_DAPH	0.02
Carbon Disulfide	SWSA 5 SEEP A	3	3	0.005	5.00E-03	0.005	5.00E-03	5.719	LTV_FISH	0.00
Carbon Disulfide	SWSA 5 SEEP A	3	3	0.005	5.00E-03	0.005	5.00E-03	9.538	LCV_FISH	0.00

Table 3.7 (Continued)

Analyte	Subbasin	Dets.	Obs.	Min Det.	Median	Max Det.	UCL95	Bmk Value	Bmk Name	HQ
Carbon Disulfide	**W6MS3**	**14**	**42**	**0.002**	**2.50E-03**	**0.007**	**3.25E-03**	**0.00092**	**S_CHR_V**	**3.53**
Carbon Disulfide	W6MS3	14	42	0.002	2.50E-03	0.007	3.25E-03	0.017	S_ACU_V	0.19
Carbon Disulfide	W6MS3	14	42	0.002	2.50E-03	0.007	3.25E-03	0.244	LCV_DAPH	0.01
Carbon Disulfide	W6MS3	14	42	0.002	2.50E-03	0.007	3.25E-03	5.719	LTV_FISH	0.00
Carbon Disulfide	W6MS3	14	42	0.002	2.50E-03	0.007	3.25E-03	9.538	LCV_FISH	0.00
Carbon Disulfide	**W6MS1**	**7**	**18**	**0.002**	**2.50E-03**	**0.033**	**6.17E-03**	**0.00092**	**S_CHR_V**	**6.70**
Carbon Disulfide	W6MS1	7	18	0.002	2.50E-03	0.033	6.17E-03	0.017	S_ACU_V	0.36
Carbon Disulfide	W6MS1	7	18	0.002	2.50E-03	0.033	6.17E-03	0.244	LCV_DAPH	0.03
Carbon Disulfide	W6MS1	7	18	0.002	2.50E-03	0.033	6.17E-03	5.719	LTV_FISH	0.00
Carbon Disulfide	W6MS1	7	18	0.002	2.50E-03	0.033	6.17E-03	9.538	LCV_FISH	0.00
Carbon Disulfide	**West Seep**	**1**	**3**	**0.003**	**2.50E-03**	**0.003**	**3.15E-03**	**0.00092**	**S_CHR_V**	**3.43**
Carbon Disulfide	West Seep	1	3	0.003	2.50E-03	0.003	3.15E-03	0.017	S_ACU_V	0.19
Carbon Disulfide	West Seep	1	3	0.003	2.50E-03	0.003	3.15E-03	0.244	LCV_DAPH	0.01
Carbon Disulfide	West Seep	1	3	0.003	2.50E-03	0.003	3.15E-03	5.719	LTV_FISH	0.00
Carbon Disulfide	West Seep	1	3	0.003	2.50E-03	0.003	3.15E-03	9.538	LCV_FISH	0.00
Carbon Disulfide	**WOC**	**5**	**5**	**0.0007**	**1.30E-02**	**0.013**	**1.45E-02**	**0.00092**	**S_CHR_V**	**15.76**
Carbon Disulfide	WOC	5	5	0.0007	1.30E-02	0.013	1.45E-02	0.017	S_ACU_V	0.85
Carbon Disulfide	WOC	5	5	0.0007	1.30E-02	0.013	1.45E-02	0.244	LCV_DAPH	0.06
Carbon Disulfide	WOC	5	5	0.0007	1.30E-02	0.013	1.45E-02	5.719	LTV_FISH	0.00
Carbon Disulfide	WOC	5	5	0.0007	1.30E-02	0.013	1.45E-02	9.538	LCV_FISH	0.00
Carbon Tetrachloride	**SWSA 5 Trib 1**	**1**	**2**	**0.01**	**7.07E-03**	**0.01**	**2.33E-02**	**0.0098**	**S_CHR_V**	**2.38**
Carbon Tetrachloride	SWSA 5 Trib 1	1	2	0.01	7.07E-03	0.01	2.33E-02	0.065	LTV_FISH	0.36
Carbon Tetrachloride	SWSA 5 Trib 1	1	2	0.01	7.07E-03	0.01	2.33E-02	0.18	S_ACU_V	0.13
Carbon Tetrachloride	SWSA 5 Trib 1	1	2	0.01	7.07E-03	0.01	2.33E-02	1.97	LCV_FISH	0.01
Carbon Tetrachloride	SWSA 5 Trib 1	1	2	0.01	7.07E-03	0.01	2.33E-02	5.58	LCV_DAPH	0.00
Carbon Tetrachloride	**SWSA 5 WOC**	**1**	**2**	**0.01**	**7.07E-03**	**0.01**	**2.33E-02**	**0.0098**	**S_CHR_V**	**2.38**
Carbon Tetrachloride	SWSA 5 WOC	1	2	0.01	7.07E-03	0.01	2.33E-02	0.065	LTV_FISH	0.36
Carbon Tetrachloride	SWSA 5 WOC	1	2	0.01	7.07E-03	0.01	2.33E-02	0.18	S_ACU_V	0.13
Carbon Tetrachloride	SWSA 5 WOC	1	2	0.01	7.07E-03	0.01	2.33E-02	1.97	LCV_FISH	0.01
Carbon Tetrachloride	SWSA 5 WOC	1	2	0.01	7.07E-03	0.01	2.33E-02	5.58	LCV_DAPH	0.00
Ethylbenzene	**SWSA 5 Trib 1**	**1**	**2**	**0.01**	**7.07E-03**	**0.01**	**2.33E-02**	**0.0073**	**S_CHR_V**	**3.19**
Ethylbenzene	SWSA 5 Trib 1	1	2	0.01	7.07E-03	0.01	2.33E-02	0.13	S_ACU_V	0.18
Ethylbenzene	SWSA 5 Trib 1	1	2	0.01	7.07E-03	0.01	2.33E-02	0.44	LCV_FISH	0.05
Ethylbenzene	SWSA 5 Trib 1	1	2	0.01	7.07E-03	0.01	2.33E-02	12.922	LCV_DAPH	0.00
Ethylbenzene	SWSA 5 Trib 1	1	2	0.01	7.07E-03	0.01	2.33E-02	438	LCV_AQPL	0.00
Ethylbenzene	**SWSA 5 WOC**	**1**	**2**	**0.01**	**7.07E-03**	**0.01**	**2.33E-02**	**0.0073**	**S_CHR_V**	**3.19**

Table 3.7 (Continued)

Analyte	Subbasin	Dets.	Obs.	Min Det.	Median	Max Det.	UCL95	Bmk Value	Bmk Name	HQ
Ethylbenzene	SWSA 5 WOC	1	2	0.01	7.07E-03	0.01	2.33E-02	0.13	S_ACU_V	0.18
Ethylbenzene	SWSA 5 WOC	1	2	0.01	7.07E-03	0.01	2.33E-02	0.44	LCV_FISH	0.05
Ethylbenzene	SWSA 5 WOC	1	2	0.01	7.07E-03	0.01	2.33E-02	12.922	LCV_DAPH	0.00
Ethylbenzene	SWSA 5 WOC	1	2	0.01	7.07E-03	0.01	2.33E-02	438	LCV_AQPL	0.00
Naphthalene	**SWSA 5 Trib 1**	**1**	**2**	**0.01**	**7.07E-03**	**0.01**	**2.33E-02**	**0.012**	**S_CHR_V**	**1.94**
Naphthalene	SWSA 5 Trib 1	1	2	0.01	7.07E-03	0.01	2.33E-02	0.19	S_ACU_V	0.12
Naphthalene	SWSA 5 Trib 1	1	2	0.01	7.07E-03	0.01	2.33E-02	0.45	LTV_FISH	0.05
Naphthalene	SWSA 5 Trib 1	1	2	0.01	7.07E-03	0.01	2.33E-02	0.6	LTV_DAPH	0.04
Naphthalene	SWSA 5 Trib 1	1	2	0.01	7.07E-03	0.01	2.33E-02	0.62	LCV_FISH	0.04
Naphthalene	SWSA 5 Trib 1	1	2	0.01	7.07E-03	0.01	2.33E-02	1.163	LCV_DAPH	0.02
Naphthalene	SWSA 5 Trib 1	1	2	0.01	7.07E-03	0.01	2.33E-02	33	LCV_AQPL	0.00
Naphthalene	**SWSA 5 WOC**	**1**	**2**	**0.01**	**7.07E-03**	**0.01**	**2.33E-02**	**0.012**	**S_CHR_V**	**1.94**
Naphthalene	SWSA 5 WOC	1	2	0.01	7.07E-03	0.01	2.33E-02	0.19	S_ACU_V	0.12
Naphthalene	SWSA 5 WOC	1	2	0.01	7.07E-03	0.01	2.33E-02	0.45	LTV_FISH	0.05
Naphthalene	SWSA 5 WOC	1	2	0.01	7.07E-03	0.01	2.33E-02	0.6	LTV_DAPH	0.04
Naphthalene	SWSA 5 WOC	1	2	0.01	7.07E-03	0.01	2.33E-02	0.62	LCV_FISH	0.04
Naphthalene	SWSA 5 WOC	1	2	0.01	7.07E-03	0.01	2.33E-02	1.163	LCV_DAPH	0.02
Naphthalene	SWSA 5 WOC	1	2	0.01	7.07E-03	0.01	2.33E-02	33	LCV_AQPL	0.00
Naphthalene	W6MS1	1	4	0.002	5.00E-03	0.002	6.02E-03	0.012	S_CHR_V	0.50
Naphthalene	W6MS1	1	4	0.002	5.00E-03	0.002	6.02E-03	0.19	S_ACU_V	0.03
Naphthalene	W6MS1	1	4	0.002	5.00E-03	0.002	6.02E-03	0.45	LTV_FISH	0.01
Naphthalene	W6MS1	1	4	0.002	5.00E-03	0.002	6.02E-03	0.6	LTV_DAPH	0.01
Naphthalene	W6MS1	1	4	0.002	5.00E-03	0.002	6.02E-03	0.62	LCV_FISH	0.01
Naphthalene	W6MS1	1	4	0.002	5.00E-03	0.002	6.02E-03	1.163	LCV_DAPH	0.01
Naphthalene	W6MS1	1	4	0.002	5.00E-03	0.002	6.02E-03	33	LCV_AQPL	0.00
Polychlorinated Biphenyl	**Lower WOC**	**4**	**85**	**0.0001**	**1.00E-03**	**0.001**	**3.23E-02**	**0.00014**	**S_CHR_V**	**230.57**
Polychlorinated Biphenyl	**Lower WOC**	**4**	**85**	**0.0001**	**1.00E-03**	**0.001**	**3.23E-02**	**0.000144**	**LCV_AQPL**	**224.16**
Polychlorinated Biphenyl	**Lower WOC**	**4**	**85**	**0.0001**	**1.00E-03**	**0.001**	**3.23E-02**	**0.0002**	**LCV_FISH**	**161.40**
Polychlorinated Biphenyl	**Lower WOC**	**4**	**85**	**0.0001**	**1.00E-03**	**0.001**	**3.23E-02**	**0.0004**	**LTV_FISH**	**80.70**
Polychlorinated Biphenyl	**Lower WOC**	**4**	**85**	**0.0001**	**1.00E-03**	**0.001**	**3.23E-02**	**0.0008**	**LCV_NDI**	**40.35**
Polychlorinated Biphenyl	**Lower WOC**	**4**	**85**	**0.0001**	**1.00E-03**	**0.001**	**3.23E-02**	**0.0012**	**LTV_DAPH**	**26.90**
Polychlorinated Biphenyl	**Lower WOC**	**4**	**85**	**0.0001**	**1.00E-03**	**0.001**	**3.23E-02**	**0.002**	**NAWQ_ACU**	**16.14**
Polychlorinated Biphenyl	**Lower WOC**	**4**	**85**	**0.0001**	**1.00E-03**	**0.001**	**3.23E-02**	**0.0021**	**LCV_DAPH**	**15.37**
Polychlorinated Biphenyl	**WOC**	**3**	**42**	**0.0001**	**1.00E-03**	**0.001**	**1.01E-03**	**0.00014**	**S_CHR_V**	**7.19**
Polychlorinated Biphenyl	**WOC**	**3**	**42**	**0.0001**	**1.00E-03**	**0.001**	**1.01E-03**	**0.000144**	**LCV_AQPL**	**6.99**
Polychlorinated Biphenyl	**WOC**	**3**	**42**	**0.0001**	**1.00E-03**	**0.001**	**1.01E-03**	**0.0002**	**LCV_FISH**	**5.04**

Table 3.7 (Continued)

Analyte	Subbasin	Dets.	Obs.	Min Det.	Median	Max Det.	UCL95	Bmk Value	Bmk Name	HQ
Polychlorinated Biphenyl	**WOC**	**3**	**42**	**0.0001**	**1.00E-03**	**0.001**	**1.01E-03**	**0.0004**	**LTV_FISH**	**2.52**
Polychlorinated Biphenyl	**WOC**	**3**	**42**	**0.0001**	**1.00E-03**	**0.001**	**1.01E-03**	**0.0008**	**LCV_NDI**	**1.26**
Polychlorinated Biphenyl	WOC	3	42	0.0001	1.00E-03	0.001	1.01E-03	0.0012	LTV_DAPH	0.84
Polychlorinated Biphenyl	WOC	3	42	0.0001	1.00E-03	0.001	1.01E-03	0.002	NAWQ_ACU	0.50
Polychlorinated Biphenyl	WOC	3	42	0.0001	1.00E-03	0.001	1.01E-03	0.0021	LCV_DAPH	0.48
Toluene	**SWSA 5 Trib 1**	**1**	**2**	**0.01**	**7.07E-03**	**0.01**	**2.33E-02**	**0.0098**	**S_CHR_V**	**2.38**
Toluene	SWSA 5 Trib 1	1	2	0.01	7.07E-03	0.01	2.33E-02	0.026	LTV_FISH	0.90
Toluene	SWSA 5 Trib 1	1	2	0.01	7.07E-03	0.01	2.33E-02	0.12	S_ACU_V	0.19
Toluene	SWSA 5 Trib 1	1	2	0.01	7.07E-03	0.01	2.33E-02	1.269	LCV_FISH	0.02
Toluene	SWSA 5 Trib 1	1	2	0.01	7.07E-03	0.01	2.33E-02	25.229	LCV_DAPH	0.00
Toluene	SWSA 5 Trib 1	1	2	0.01	7.07E-03	0.01	2.33E-02	245	LCV_AQPL	0.00
Toluene	**SWSA 5 WOC**	**1**	**2**	**0.01**	**7.07E-03**	**0.01**	**2.33E-02**	**0.0098**	**S_CHR_V**	**2.38**
Toluene	SWSA 5 WOC	1	2	0.01	7.07E-03	0.01	2.33E-02	0.026	LTV_FISH	0.90
Toluene	SWSA 5 WOC	1	2	0.01	7.07E-03	0.01	2.33E-02	0.12	S_ACU_V	0.19
Toluene	SWSA 5 WOC	1	2	0.01	7.07E-03	0.01	2.33E-02	1.269	LCV_FISH	0.02
Toluene	SWSA 5 WOC	1	2	0.01	7.07E-03	0.01	2.33E-02	25.229	LCV_DAPH	0.00
Toluene	SWSA 5 WOC	1	2	0.01	7.07E-03	0.01	2.33E-02	245	LCV_AQPL	0.00
Toluene	W6MS3	11	34	0.001	2.50E-03	0.005	3.14E-03	0.0098	S_CHR_V	0.32
Toluene	W6MS3	11	34	0.001	2.50E-03	0.005	3.14E-03	0.026	LTV_FISH	0.12
Toluene	W6MS3	11	34	0.001	2.50E-03	0.005	3.14E-03	0.12	S_ACU_V	0.03
Toluene	W6MS3	11	34	0.001	2.50E-03	0.005	3.14E-03	1.269	LCV_FISH	0.00
Toluene	W6MS3	11	34	0.001	2.50E-03	0.005	3.14E-03	25.229	LCV_DAPH	0.00
Toluene	W6MS3	11	34	0.001	2.50E-03	0.005	3.14E-03	245	LCV_AQPL	0.00
Toluene	W6MS1	1	14	0.005	2.50E-03	0.005	2.80E-03	0.0098	S_CHR_V	0.29
Toluene	W6MS1	1	14	0.005	2.50E-03	0.005	2.80E-03	0.026	LTV_FISH	0.11
Toluene	W6MS1	1	14	0.005	2.50E-03	0.005	2.80E-03	0.12	S_ACU_V	0.02
Toluene	W6MS1	1	14	0.005	2.50E-03	0.005	2.80E-03	1.269	LCV_FISH	0.00
Toluene	W6MS1	1	14	0.005	2.50E-03	0.005	2.80E-03	25.229	LCV_DAPH	0.00
Toluene	W6MS1	1	14	0.005	2.50E-03	0.005	2.80E-03	245	LCV_AQPL	0.00
Toluene	West Seep	2	4	0.005	3.54E-03	0.005	5.45E-03	0.0098	S_CHR_V	0.56
Toluene	West Seep	2	4	0.005	3.54E-03	0.005	5.45E-03	0.026	LTV_FISH	0.21
Toluene	West Seep	2	4	0.005	3.54E-03	0.005	5.45E-03	0.12	S_ACU_V	0.05
Toluene	West Seep	2	4	0.005	3.54E-03	0.005	5.45E-03	1.269	LCV_FISH	0.00
Toluene	West Seep	2	4	0.005	3.54E-03	0.005	5.45E-03	25.229	LCV_DAPH	0.00
Toluene	West Seep	2	4	0.005	3.54E-03	0.005	5.45E-03	245	LCV_AQPL	0.00
Xylene (Total)	SWSA 5 Trib 1	1	2	0.002	3.16E-03	0.002	1.30E-02	0.013	S_CHR_V	1.00

Table 3.7 (Continued)

Analyte	Subbasin	Dets.	Obs.	Min Det.	Median	Max Det.	UCL95	Bmk Value	Bmk Name	HQ
Xylene (Total)	SWSA 5 Trib 1	1	2	0.002	3.16E-03	0.002	1.30E-02	0.23	S_ACU_V	0.06
Xylene (Total)	SWSA 5 Trib 1	1	2	0.002	3.16E-03	0.002	1.30E-02	2.68	LTV_FISH	0.00
Xylene (Total)	SWSA 5 Trib 1	1	2	0.002	3.16E-03	0.002	1.30E-02	62.308	LCV_FISH	0.00
Xylene (Total)	**SWSA 5 WOC**	**1**	**2**	**0.01**	**7.07E-03**	**0.01**	**2.33E-02**	**0.013**	**S_CHR_V**	**1.79**
Xylene (Total)	SWSA 5 WOC	1	2	0.01	7.07E-03	0.01	2.33E-02	0.23	S_ACU_V	0.10
Xylene (Total)	SWSA 5 WOC	1	2	0.01	7.07E-03	0.01	2.33E-02	2.68	LTV_FISH	0.01
Xylene (Total)	SWSA 5 WOC	1	2	0.01	7.07E-03	0.01	2.33E-02	62.308	LCV_FISH	0.00

All concentrations are mg/l. Only the chemicals for which at least one HQ was greater than 1 are included.
Does not include data for seeps and ephemeral tributaries. Bold indicates HQ>1.
95% upper confidence limit
Hazard Quotient = UCL95/ benchmark value.

Table 3.8 Summary of data availability for aquatic assessment endpoints

Basin	Subbasin	Chemistry			Toxicity Tests			Fish Bioaccumulation	Community Surveys		
		Surface Water	Seeps	Sediment	Standard	Medaka	Redbreast Bioindicators		Fish	Benthos - Riffles	Benthos - Sediment
MWOC/East	MV Drive		X								
MWOC/East	SWSA 5 WOC	X	X	X							
MWOC/East	SWSA 5 N WOC	X	X								
MWOC/East	SWSA 5 Trib-1	X	X	X							
MWOC/West	Haw Ridge										
MWOC/West	Intermediate Pond	X	X	X	X	X		X	X	X	
MWOC/West	SWSA 4 East										
MWOC/West	SWSA 4 Main		X	X							
MWOC/West	WAG 7 WOC		X								
MWOC/West	WOC	X	X	X	X	X	X	X	X	X	X
HFIR	HF-2	X	X	X							
HFIR	HFIR										
HFIR	HFIR East		X	X							
HFIR	HFIR South	X									
HFIR	MB-15	X	X	X	X				X	X	X
HRE	HRE	X	X	X							
SWSA 5 SeepA	SWSA 5 Seep A	X	X	X							
SWSA 5 SeepB	SWSA 5 Seep B West	X	X	X							
SWSA 5 SeepB	SWSA 5 Seep B East	X	X	X	X				X	X	
SWSA 5 SeepC	SWSA Seep C	X	X	X	X			X			X
SWSA 5 Drainage D-2	SWSA 5 Drainage D-2		X	X							
SWSA 6	W6MS3	X	X	X							
SWSA 6	W6MS1	X	X								
WCTrib1 & Co-60	^{60}Co Seep			X							
WCTrib1 & Co-60	WCTRIB-1		X	X							
East Seep	East Seep		X								
West Seep	West Seep	X	X	X							
NHF	NHF		X								
WOL, Creek, and Floodplain	Lower WOC	X	X	X		X	X	X	X	X	X
WOLCreek&Floodplain	Pit 4 South		X	X							

Table 3.8 (Continued)

Basin	Subbasin	Chemistry			Toxicity Tests				Community Surveys	
		Surface Water	Seeps	Sediment	Standard	Medaka	Redbreast Bioindicators	Fish Bioaccumulation Fish	Benthos - Riffles	Benthos - Sediment
WOLCreek&Floodplain	SWSA 6 East	X								
WOLCreek&Floodplain	SWSA 6 South									
WOLCreek&Floodplain	Trench 5 South									
WOLCreek&Floodplain	WOCE	X		X				X		

Source biological data: Ashwood 1994.

4. RISKS TO BENTHIC INVERTEBRATES

This chapter contains the exposure and effects assessments and characterization of risks to benthic invertebrates in mainstem surface waters and major tributaries. Benthic invertebrates are primarily exposed to contaminants in sediment, sediment pore water, and overlying surface water. Surface water exposures are more important in riffles because chemicals in sediments are primarily associated with fine grains and organic matter, which are eroded from riffles and accumulated in pools. Benthic invertebrates inhabiting sediment depositional areas are generally immersed in the fine sediments. Thus, the primary exposures in depositional areas are to contaminated sediments and sediment pore water. Therefore, exposures to chemicals in surface water and sediment were evaluated separately. Other exposure pathways, such as ingestion of contaminated food items, are not explicitly evaluated herein because the necessary exposure and literature toxicity data are not available. However, these exposure pathways are accounted for in the community surveys.

4.1 RIFFLE COMMUNITIES

4.1.1 Exposure Assessment

Benthic invertebrates in riffles are exposed primarily to contaminants in water. The exposure assessment of aqueous chemical concentrations and aqueous toxicity tests for the fish community (Sect. 3.1) are also representative of exposure for benthic invertebrates in erosional areas.

4.1.2 Effects Assessment

The effects assessments of aqueous chemical concentrations and aqueous toxicity tests are presented in Sect. 3.2.

Analysis of the benthic invertebrate community survey data provides a direct measure of impacts of human activities on aquatic ecosystems. Surveys of benthic invertebrates in riffles were performed beginning in 1987 with the last reported results from 1992 (Ashwood 1994). At that time, the taxonomic richness of all invertebrates and particularly of the Ephemeroptera, Plecoptera, and Trichoptera (EPT) was severely reduced at sites on WOC adjacent to and downstream of ORNL. Total richness, but not EPT richness, also was reduced in upper Melton Branch (subbasin MB-15) relative to the upstream and pooled reference sites. Total and EPT richness in lower Melton Branch were not different from references. These comparisons of upstream and downstream sites are confounded by habitat differences. However, it is often possible to judge which differences are attributable at least in part to contamination, because the differences in substrate are not great and riffle communities have been much more studied than soft sediment communities. Therefore, it can be judged with some confidence, that the reduced taxonomic richness was not due simply to stream habitat gradients (Ashwood 1994).

4.1.3 Risk Characterization

4.1.3.1 Chemical exposures

The characterization of risks based on the screening of aqueous chemical concentrations is presented in Sect. 3.3 and Table 3.2.

4.1.3.2 Ambient water toxicity

The characterization of risks based on the aqueous toxicity tests are presented in Sect. 3.3.

4.1.3.3 Biological surveys

The biological surveys reveal that the benthic invertebrate community in WOC below ORNL continues to be degraded relative to upstream and pooled references. The community in upper Melton Branch also appears to be degraded, but the community in lower Melton Branch is not different from reference communities. Unlike the fish community, there are no barriers to macroinvertebrate immigration and the differences in habitat among sites does not account for the observed differences in community structure.

4.1.3.4 Weight of evidence

Subbasins for which at least surface water chemistry data are available (Table 3.8) are discussed below. Chemical and biological data are available for the following seven subbasins.

Intermediate Pond

The weight-of-evidence suggests that water in this subbasin poses a significant risk to benthic macroinvertebrates. Total and EPT species richness are significantly degraded relative to upstream and pooled reference communities and the water has been lethal to medaka embryos and larvae. Copper, iron, silver, and thallium concentrations appear to present significant risks. However, aluminum concentrations are probably not toxic in this system.

White Oak Creek

The weight-of-evidence suggests that water in this subbasin poses a significant risk to benthic macroinvertebrates. Total and EPT richness are significantly degraded relative to upstream and pooled reference communities and the water has been lethal to Medaka embryos and larvae. Of the eight COECs, copper, iron, and thallium concentrations appear to be the most likely contributors to toxicity. Ammonia concentrations exceeded only the lowest benchmark, suggesting that it may be toxic to sensitive species. Lead and nickel concentrations may be toxic, but these metals were detected in less than 5% of the samples. Total PCBs were detected in only 7% of the samples and are likely to be bound to particulate matter and non bioavailable. Aluminum concentrations are not expected to be toxic in this system.

MB-15

Although the weight-of-evidence is not strong, it suggests that water in this subbasin does not pose a significant risk to benthic macroinvertebrates. Total richness and density are significantly lower than upstream and pooled reference communities. However, EPT richness is not different from references, the water has not been toxic in the standard toxicity tests, and none of the detected chemicals exceeded any benchmarks (i.e., there are no COPECs). Hence, there appears to be an effect on the community, but a causal agent could not be identified from the available data. Although it is possible that the sampling regime did not capture episodic contaminant fluxes, it also is possible that habitat difference contribute to the observed community differences. The fact that contaminant sensitive species (i.e., EPT) are not affected is further evidence that the observed differences are likely the result of something other than contamination.

Seep B East

The weight-of-evidence suggests that water in this subbasin does not pose a significant risk to benthic macroinvertebrates. Total and EPT species richness are comparable to that of the reference streams, the water has not been toxic in the standard toxicity tests, and none of the detected chemicals exceeded any benchmarks (i.e., there are no COPECs).

Seep C

Although the weight-of-evidence is not strong, it suggests that water in this subbasin does not pose a significant risk to benthic macroinvertebrates. Copper and nickel are COECs, but the concentrations measured may over estimate the fraction that is bioavailable. Furthermore, the water has not been toxic in the standard toxicity tests.

Lower WOC

The weight-of-evidence suggests that water in this subbasin poses a significant risk to benthic macroinvertebrates. Total and EPT richness are significantly degraded relative to upstream and pooled reference communities and the water has been lethal to medaka embryos and larvae. Of the eleven COECs, cobalt, copper, iron, nickel, thallium and zinc concentrations appear to be the most likely contributors to toxicity. Ammonia concentrations exceeded only the lowest benchmark, suggesting that it may be toxic to sensitive species. Cadmium, silver and Total PCB concentrations may be toxic, but these chemicals were detected in less than 5% of the samples. Aluminum concentrations are not expected to be toxic in this system.

WOCE

Although the weight-of-evidence is not strong, it suggests that water in this subbasin poses a significant risk to benthic macroinvertebrates. Cadmium is the only COEC and the concentrations measured may over estimate the fraction that is bioavailable. Although water from within the embayment was not tested, water entering the embayment reduced medaka embryo and larvae survival by 90%. Hence, there is no strong evidence to indicate that cadmium does not pose a risk in this subbasin.

Chemical concentrations in surface water is the only line of evidence available for eleven subbasins (Table 3.8). Significant risks are not indicated in three of these subbasin (SWSA 5 N WOC, HRE, and Seep B west), because none of the detected chemicals exceeded benchmarks (i.e., there are no COPECs). Even if the benchmarks for aluminum are set aside as inappropriate to this site, there is at least one COEC in each of the remaining subbasins (Table 3.2).. That is, significant risks are indicated in these subbasins.

In summary, the invertebrate communities of riffles have low species richness below ORNL which is likely to be primarily due to contaminants in water. The dominance of this mode of exposure is the reason that riffle invertebrates communities are monitored to determine whether water quality goals are being met (Ashwood 1994). However, the feeding habits of some species expose them to the small amount of particulate material that is deposited in such areas so sediment contamination may make a small contribution to this effect.

4.2 SEDIMENT COMMUNITIES

4.2.1 Exposure Assessment

Sediment chemical exposures

Benthic invertebrates that inhabit the soft sediments of pools are exposed to contaminants in the sediments. Two different expressions of sediment contamination are used in ecological risk assessments, whole sediment concentrations and filtered pore water concentrations. The use of pore water is based on the assumption that chemicals associated with the solid phase are largely unavailable and therefore sediment toxicity can be estimated by measuring or estimating the pore water concentration. This is the approach used by the EPA to calculate sediment quality criteria. Whole sediment concentrations do not account for effects of sediment properties on bioavailability. However, they are required by the EPA Region IV and may provide a better estimate of risk for highly particle-associated chemicals which may not be detectable in pore water.

Benthic invertebrates are exposed to surface sediments and not to deep sediments. In a compromise between realism and the desire to include data for all analytes, a maximum interval of zero to fifty centimeters was used. Analyses of cores with a depth greater than 50 centimeters were discarded and core sections other than the surface section were discarded. A complete description of the sediment sampling and analysis in WAG 2 is presented by Ford et al. (1996)

Because sediment is likely to be more variable in space than time, due its relative immobility, and because the organisms are relatively immobile it is not appropriate to think of benthic invertebrates as averaging their exposures to sediment over space or time. Therefore, the median sediment concentration is an appropriate measure of the central tendency of the contaminant data. An appropriate conservative estimate of this exposure for use in the contaminant screening is the maximum detected concentration.

As with water, many of the chemical concentrations in sediments are below analytical detection limits. Chemicals that were not detected in any sample in a reach were eliminated. If a subbasin contained some detects and some nondetects for a chemical, nondetects were included at half the detection limit.

4.2.2 Effects Assessment

4.2.2.1 Single-chemical sediment toxicity

The sets of screening benchmarks for sediment-associated biota (described in Table 4.1) are taken from Jones et al. (1996). Whole sediment concentrations are compared with these benchmarks. The use of multiple benchmarks provides greater assurance of detecting all COPECs. Sediment benchmarks derived using the equilibrium partitioning method were calculated assuming one percent organic carbon, because location-specific organic carbon concentrations were not available.

Ecotox Threshold values were issued by the EPA Office of Solid Waste and Emergency Response (OSWER 1996). They are not included as separate benchmarks in this assessment because the OSWER values are consistent with the ORNL benchmarks (Jones et al 1996). The exception is that the equilibrium partitioning benchmarks used in this assessment are based on recently updated water quality benchmarks (Suter and Tsao 1996), whereas the OSWER values are not. Although the EPA Region IV sediment screening values (EPA Region IV 1995) are consistent with the ORNL

benchmarks, they were included separately herein because they also contain a comparison to EPA's practical quantitation limits.

Toxicity profiles for chemicals that exceed benchmarks are presented in the attachment of this appendix. The toxicity profiles summarize the existing toxicity information for each chemical, including concentrations causing acute lethality and chronic lethal and sublethal effects, and physical-chemical conditions that modify toxicity. Most of the available sediment toxicity data are for marine and estuarine systems.

4.2.2.2 Sediment community surveys

Surveys of benthic invertebrates in soft sediments behind weirs and dams were performed in 1995 in support of the WAG 2 Remedial Investigation (Appendix A in Efroymson et el. 1996a). The surveys were conducted in large part to determine whether dredging these sediments to maintain pool depth would destroy communities that had any particular ecological value. However, they serve to indicate the effects of sediment contamination more generally, including natural pools where sediments accumulate. The survey included two weirs on WOC within WAG 2, two on Melton Branch, and two sites in White Oak Lake. These were compared to reference pools behind weirs on upper First Creek, WOC above ORNL, and Clear Creek. The locations are described in Appendix A in Efroymson et el. (1996a). The results are somewhat confounded by differences in sediment characteristics among the weirs. The reference weirs tended to have more coarse particulate organic matter (detritus) and less silt than the weirs in WAG 2. This is not surprising given the silt that would be expected to enter the streams from construction and remediation activities at ORNL. The two White Oak Lake sites are different from all of the weirs in the depth of water and associated physical characteristics.

The lowest taxonomic richness was found in White Oak Lake (~ 4 taxa per sample) and the highest were found in background WOC (~ 15 taxa/sample) and upper Clear Creek (~ 12 taxa/sample). The other two reference weirs and the WAG 2 weirs all had ~ 9-11 taxa/sample. Since chironomid midge larvae made up most of the taxa identified, they were tabulated separately and gave the same pattern of relative taxonomic richness. Hence, although taxonomic richness varies by more than a factor of three among sites, the difference could be attributed to physical habitat differences as well as contamination.

4.2.3 Risk Characterization

4.2.3.1 Single-chemical sediment toxicity

Screening of sediment exposures against chemical benchmarks

As with the surface water analysis, measured concentrations of inorganic chemicals were compared to the background criterion. Inorganics that exceeded the background criterion and all detected organic chemicals were screened against benchmarks and evaluated as COPECs. This was done by dividing the maximum detected concentration by each of the sediment screening benchmarks (Table 4.1). Chemicals that exceeded any benchmark (i.e., the quotient of Max Detect/sediment screening benchmark was >1) were identified as COPECs (Table 4.2).

A second step in the screening process involved determining the relative contribution of the COPECs to the distribution of toxicity in the WOC watershed. This was done by calculating each COPEC's average screening hazard quotient for a subbasin (sum of HQs based on maximum

detected concentration divided by the number of benchmarks) and adding these together to get the sum average HQ (Table 4.3). Use of the average HQ, rather than the maximum HQs, reduces the influence of highly conservative screening benchmarks (e.g., equilibrium partitioning benchmarks based on the SCV). It is important to note that average HQ are heuristic only, providing an indication of the relative toxicity of sites and the relative contributions of chemicals to that toxicity. That is, these values are not used to identify COECs

Exposure-effects profiles for sediment exposures

Risks were estimated by subbasin for each COPEC by comparing the distribution of observed concentrations to each sediment benchmark. As with aqueous exposures, these comparisons were performed mathematically, rather than graphically, in order to ensure consistency and facilitate the evaluation of large data sets. This was done by (1) identifying and then estimating points that define key segments of the exposure distributions; (2) classifying the available benchmarks with regard to the conservatism with which they estimate effects; (3) comparing each segment of the distribution to each benchmark; and (4) assigning a basin-specific risk score to each COPEC.

The distribution of sediment concentrations represents the variation in exposure in space, rather than time. Hence, the 80th percentile represents the concentration that is exceeded in approximately 20 percent of the soft sediments. As with aqueous exposures, the key segments of the distribution are defined by four points (the 100th, 80th, 50th, and 0 percentiles) and the benchmarks (Table 4.1) were classified as either possible-effects or probable-effects benchmarks. Possible-effects benchmarks are conservative estimates of concentrations at which toxicity may occur (i.e., the ER-L, TEL, MOE_LEL, REGIV_SV, and EqP_SCV. Probable-effects benchmarks are concentrations at which toxicity is likely (i.e., the ER-M, PEL, MOE_SEL, EPASQC01, and the equilibrium partitioning benchmarks derived using NAWQC, LCVs, or LTVs). Each segment of the distribution was compared to the benchmarks and a risk score of 1 to 8 was assigned. The rules and interpretations of this scoring process are presented in (Table 4.4).

It should be noted that nondetects were included in the distribution at 0.5 times the detection limit. Hence, it is possible that the maximum value (100th percentile) is not a detected concentration. The conservatism this introduces was countered by specifying that the maximum detected concentration must exceed at least one probable-effects benchmark in order for a chemical to receive a score of 5 or higher. That is, a chemical can not be a COEC unless it was detected at least once at a concentration that is expected to be toxic. Furthermore, exclusion of the nondetects at the low end of the distribution would bias the estimations of exposure high. It also should be noted that the 80th percentile was set equal to the 100th percentile if the data set was too small (generally less than 5 observations) to estimate an 80th percentile.

Each risk score also was given a confidence score. Confidence in the risk score is a function of the quality of the benchmark that was exceeded and the magnitude of the exceedence. Confidence scores consist of a set of plus (+) or minus (-) signs. The default is a moderate to high degree of confidence, which is given a score of zero (indicated by the absence of a plus or minus sign). Unlike the aqueous benchmarks (Sect. 3.3), the quality of the sediment benchmarks varies considerably. Estimates of confidence are available for two sets of sediment benchmarks, the NOAA ER-Ls and ER-Ms (Long et al. 1995) and the FDEP TELs and PELs (MacDonald 1994). An interpretation of these estimates for the purposes of ecological risk assessment is presented in Jones et al. (1996). Low confidence in an ER-M or PEL suggests that this benchmark may over estimate the likelihood of effects; such benchmarks are given a confidence score of minus (-). Low confidence in an ER-L or TEL suggests that this benchmark may under estimate the likelihood of effects; such benchmarks

are given a confidence score of plus (+). Jones et al. (1996) also present sediment benchmarks for non-ionic organic chemicals based on equilibrium partitioning models and aqueous benchmarks. Some of these benchmarks are for polar non-ionic chemicals, for which the benchmarks may over predict the likelihood of effects; such benchmarks are assigned a confidence score of minus (-). Only one benchmark, the WS_AET, is available for some ionic organic chemicals. Confidence in this benchmark is low because it is highly site-specific. The magnitude of the exceedence is determined by the largest hazard quotient (HQ) calculated for the final risk score. An HQ of 1-10 is indicated by the default score, an HQ of 10-100 is indicated by a single plus (+), and an HQ of more than 100 is indicated by a double plus (++).

The final confidence score is the sum of the quality and magnitude scores and ranges from single minus (-) to triple plus (+++) (Table 4.5). Hence, if a probable-effects benchmark that overestimates effects (quality score of minus [-]) is exceed by 100 fold (magnitude score of double plus [++]), we should still have considerable confidence in the resulting risk score and the effects it indicates (final confidence score of plus [+]). As an example, a COPEC would receive a final score of "7" if the 50th percentile of the exposure distribution was 50 times higher than one probable-effects benchmark, in which we have low confidence. This would suggest, with a moderate to high degree of confidence, that toxicity is likely most in most of the soft sediments in that subbasin.

The final risk scores were then used to characterize the risks to benthic invertebrates as negligible (1 to 2+++), marginal (3- to 5++), or significant (6- to 8++). That is, chemicals are considered to present a significant risk and to be of concern (CEOCs) if at least 20% of the concentrations exceeded probable-effects benchmarks. COPECs are considered to present a marginal risk if at least 50% of the concentrations exceeded possible-effects benchmarks or the maximum detected concentration exceeded probable-effects benchmarks. All other COPECs are considered to present negligible risks.

Table 4.2 presents, for each COPEC, the characterization of risks to benthic invertebrates and the final risk score by subbasin. Table 4.6 details the exposure estimates (maximum detected concentration) for each subbasin, benchmark values, and the corresponding HQs. Therefore, this section addresses only that information that aids in characterizing the risks associated with the COECs.

Metals

Of the twelve metal COPECs, only cadmium is not a COEC in one or more subbasins.

Antimony, Arsenic, and Chromium appear to present a significant risk to benthic invertebrates in Lower WOC only. Confidence is moderate to high in the benchmarks for antimony and chromium, which were exceeded by the maximum detected concentration and the 80th percentile. Confidence is low in the arsenic PEL and moderate to high in the MOE-SEL. These benchmarks were exceeded by the median concentration. Confidence in the arsenic ER-M is high to moderate.

Copper appears to present a significant risk to benthic invertebrates in two subbasins, WOC and SWSA 5 WOC. Confidence is moderate to high in the sediment benchmarks for copper. Although significant risks are indicated in 100% of SWSA 5 WOC, this was based on the collection of only one sediment sample. Copper was detected in six of six samples from WOC and the 80th percentile exceeded at least one probable-effects benchmark.

Iron and manganese appear to present a significant risk in every subbasin in which they were detected above background concentrations. However, caution should be exercised in deciding to remediate sediments for these metals because there is very little toxicological data for these chemicals. The only benchmarks available are the MOE_LEL and MOE_SEL. These benchmarks are based on effects to benthic organisms in Canada, which may or may not be representative of benthic invertebrates indigenous to this watershed. Still, they were derived with freshwater organisms and the severity of effects indicated by the MOE_SEL is high.

Lead appears to present a significant risk in SWSA 5 WOC only. Although confidence is moderate to high in the sediment benchmarks for lead, only one sediment sample was collected in this subbasin.

Mercury appears to present a significant risk in four subbasins along WOC above White Oak Lake (SWSA 5 Trib 1, SWSA 5 WOC, Intermediate pond, and WOC) and in WOCE, but not in Lower WOC. There were relatively few samples from the subbasins above White Oak Lake. 31 and 93 samples were collected from Lower WOC and WOCE, respectively. Confidence is low in the ER-M and PEL and only the WOCE score is based on an HQ of 10-100. It is possible that mercury in WOCE sediment is partially resulting from backflow from the Clinch River. This may account for the lack of a consistent down stream gradient in Mercury concentrations.

Nickel appears to present a significant risk in four subbasins along (WOC: SWSA 5 Trib 1, Intermediate pond, SWSA 4 Main, and Lower WOC). Confidence is low in the ER-M and PEL and none of the risk scores are based on HQs greater than 10. However, nickel was detected in all five sediment samples collected from SWSA 4 Main at concentrations higher than all of the probable-effects benchmarks (ER-M, PEL, and MOE_SEL).

Silver appears to present a significant risk in seven subbasins along WOC: SWSA 5 Trib 1, SWSA 5 Drainage D-2, Intermediate Pond, WOC, Lower WOC, and WOCE. Confidence is low for the PEL and moderate to high for the ER-M. The maximum detected concentration exceeded all benchmarks in all of these basins except SWSA 5 WOC, where all but the ER-M were exceeded.

Zinc appears to present a significant risk in four subbasins along WOC (SWSA 5 WOC, SWSA 5 Trib 1, Intermediate Pond, WOC, and Lower WOC) and subbasin HF-2. Confidence in the sediment benchmarks is moderate to high.

Pesticides

4,4'-DDT was the only pesticide detected at concentrations that are likely to present a significant risk to sediment-associated biota. It was detected in 2 of 26 samples from the WOCE only. This suggests that Clinch River sediment deposited in the embayment during backflow conditions may be source of this 4,4'-DDT contamination. Confidence is low in the ER-M and PEL and only the PEL was exceeded. However, the two detected concentrations and all detection limits exceeded the PEL, which is 10 times lower than the ER-M. Hence, DDT receives a risk score of 8 based on the possibility that all sediments may exceed the PEL, but confidence is low.

Polycyclic aromatic hydrocarbons

Seven PAHs (Acenaphthene, anthracene, benz(a)anthracene, benzo(a)pyrene, dibenz(a,h)anthracene, phenanthrene, and pyrene) appear to present a significant risk in four subbasins above White Oak Lake (SWSA 5 Trib 1, Intermediate pond, WOC, and Pit 4 south), but

not in Lower WOC or WOCE. Confidence is moderate of high for all benchmarks, but only a few samples (i.e., 1 to 3) were collected in subbasins with high scores.

Polychlorinated biphenyls

PCB-1248, PCB-1254, or PCB-1260 appear to present a significant risk in six subbasins along WOC (SWSA 5 Trib 1, SWSA 5 WOC, Intermediate pond, WOC, Lower WOC/White Oak Lake, and WOCE). Confidence is low in the ER-M and a PEL is not available.

Total PCBs was measured and detected in four of four samples from HRE. Confidence is low in the ER-M and ER-L and the median did not exceed any probable-effects benchmarks.

Polar and ionic organic chemicals

4-Methylphenol and phenol appear to present a significant risk in SWSA 5 Trib 1 only. However, caution should be exercised in deciding to remediate sediments for these chemicals because very little sediment toxicity data is available and equilibrium partitioning is likely to significantly over estimate the likelihood of effects for polar chemicals. Confidence is low for all of the benchmarks available for these chemicals: the WS_AET is site-specific and phenol is strongly polar. Still, the median and all detected concentrations of both chemicals exceeded all of the benchmarks.

Acetone appears to present a significant risk in SWSA 5 Trib 1, SWSA 5 WOC, and SWSA 5 Drainage D-2. However, caution should be exercised in deciding to remediate sediments for this chemical. The only sediment benchmarks available for acetone are based on equilibrium partitioning. Confidence in these benchmarks is low, because acetone is strongly polar. Still, the maximum concentration detected in SWSA 5 Trib 1 exceeded all of the benchmarks, including the EQPCVF1, which is more than 300 times higher than the other benchmarks.

Weight of evidence

Subbasins for which at least sediment chemistry data are available (Table 3.8) are discussed below. Sediment chemistry and community surveys are available for the following four subbasins.

WOC. Although the weight-of-evidence is not strong, it suggests that sediment in this subbasin does not pose a significant risk to benthic invertebrates. Chironomid taxa richness was slightly lower than in the reference pools, but total taxonomic richness of the sediment community was similar to the reference sites. Hence, all of the eleven COECs (Table 4.2) appear to be credible contributors to toxicity, but the community does not appear to be degraded.

MB-15. The weight-of-evidence suggests that sediment in this subbasin does not pose a significant risk to benthic invertebrates. The sediment community was similar to reference sites and none of the detected chemicals exceeded probable-effects benchmarks (i.e., there are no COECs).

Seep C. The weight-of-evidence suggests that sediment in this subbasin does not pose a significant risk to benthic invertebrates. The sediment community was similar to reference sites and none of the detected chemicals exceeded probable-effects benchmarks (i.e., there are no COECs).

Lower WOC. The weight-of-evidence suggests that sediment in Lower WOC poses a significant risk to benthic invertebrates. Eight sediment COECs were identified in this subbasin

(Table 4.2) and the sediment community surveys were inconclusive. The relative importance of habitat and contamination could not be determined because a good reference reservoir was not available. However, the very low taxonomic richness observed in White Oak Lake provides no evidence to refute the risks indicated by the sediment chemical concentrations.

Sediment chemical concentrations are the only evidence available for seventeen subbasins (Table 3.8). Significant risks are not indicated in five of these subbasin (^{60}Co Seep, MB-15, Seep B west, Seep B east, Seep C, WCTrib-1, and West Seep), because none of the detected chemicals appears to present a significant risk (i.e., there are no COECs). There is at least one COEC in the twelve other subbasins (Table 4.2) . That is, significant risks are indicated in these subbasins.

In summary, PCBs (both totals and Arochlor mixtures), 7 PAHs, 3 polar organics, and 11 metals were found at concentrations high enough to indicate a significant risk to benthic invertebrates. Sediment toxicity is unknown. Community surveys in depositional areas do not indicate a large effect of contamination except possibly in White Oak Lake, but they are confounded by habitat differences. That is, significant risks indicated by sediment chemical concentrations were not refuted by the community survey data in the Lower WOC subbasin. Eight sediment COECs were identified in this subbasin and the sediment community surveys were inconclusive. The relative importance of habitat and contamination could not be determined because a good reference was not available. However, the community survey suggests that sediment in subbasin WOC does not pose a significant risk to benthic invertebrates. Chironomid taxa richness was slightly lower than in the reference pools, but total taxonomic richness of the sediment community was similar to the reference sites. Hence, all of the eleven COECs appear to be credible contributors to toxicity, but the community does not appear to be degraded.

4.3 UNCERTAINTIES CONCERNING RISKS TO BENTHIC INVERTEBRATES

The following issues are believed to constitute the major sources of uncertainty in the risk assessment for the benthic invertebrate assemblage.

- The benchmarks against which the sediment concentrations are screened are from studies of estuaries and large lakes which may differ considerably in their physical and ecological properties from the steams being assessed.
- The toxicity of the sediments is unknown.
- A good invertebrate survey reference site was not available for White Oak Lake.

Table 4.1. Descriptions of the ecotoxicological screening benchmarks for benthic biota exposed to contaminated sediments[a]

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	REGIV_SV	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.
Threshold Effect Level	TEL	The geometric mean of the fifteenth percentile of reported concentrations which were associated with some level of effects and the fiftieth percentile of reported concentrations which were associated with no adverse effects. All data are for marine and estuarine sediments.
Probable Effect Level	PEL	The geometric mean of the fiftieth percentile of reported concentrations which were associated with some level of effects and the eighty-fifth percentile of reported concentrations which were associated with no adverse effects. All data are for marine and estuarine sediments.
National Sediment Quality Criteria	EPASQC1	Proposed 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) and pore water. Organic matter content is assumed to be one percent by weight..
Equilibrium Partitioning Benchmarks	EQPAWQC1 EQPAWQC1 EQPCVD1 EQPCVF1 EQPCVI1	Benchmarks derived in the same manner as sediment quality criteria except that the expression of aqueous toxicity is one of five benchmarks: the chronic NAWQC (EQPAWQC1), the Secondary Chronic Value (EQPAWQC1), the Lowest Chronic Value for Daphnids (EQPCVD1), the Lowest Chronic Value for Fish (EQPCVF1), or the Lowest Chronic Value for Nondaphnid Invertebrates (EQPCVI1). Organic matter content is assumed to be one percent by weight.
Ontario Ministry of the Environment Lowest Effect Level	MOE_LEL	Concentrations determined by the Ontario MOE to constitute thresholds for toxic effects in Ontario sediments.

Table 4.1. (continued)

Benchmark	Abbreviation	Description
Ontario Ministry of the Environment Severe Effect Level	MOE_SEL	Concentrations determined by the Ontario MOE to constitute thresholds for severe toxic effects in Ontario sediments.
Apparent Effect Threshold	WS_AET	A concentration above which toxic effects occurred at all sites in Puget Sound.

[a]More details are presented by Jones et al. (1996), Long et al. (1995), MacDonald (1994), and Region IV (1995).

Table 4.2. Sediment COPECs, risk scores, and the resulting characterization of risks to benthic invertebrates based on sediment contamination

Analyte	SWSA 5 WOC	SWSA 5 Trib 1	SWSA 4 Main	Interm. Pond	WOC	HFIR east	HF-2	MB-15	HRT-3
Antimony		M (5)				M (4)	M (3)	M (3)	M (4)
Arsenic									
Cadmium									N (2)
Chromium							M (5)		N (2)
Copper	S (8)	M (5)		M (3)	S (6)		N (1)		N (2)
Iron		S (7)							
Lead	S (8)	M (5)		M (3)	M (3)				
Manganese		S (7)	S (8)			S (8)	S (7)		S (7)
Mercury	S (8-)	S (7-)		S (8-)	S (8-)				
Nickel		S (6-)	S (8-)	S (6-)					M (5-)
Silver	S (8-)	S (7-)		S (8-)	S (8-)				
Zinc	M (4)	S (6)		S (7)	S (7)		S (6)	M (5)	
1,1-Dichloroethane									
1,2-Dichloroethene									
2-Butanone		N (2-)							
2-Methylnaphthalene				M (4)					
4,4'-DDT									
4-Methylphenol		S (7-)							
Acenaphthene				S (7)	S (8)				
Acetone	S (8-)	S (7)							
Alpha-BHC					N (2+)				
Anthracene				S (8)	S (8+)				
Benz(a)anthracene				M (3)	S (8)				
Benzo(a)pyrene				M (4)	S (8)				
Bis(2-ethyl-hexyl)phthalate		M (4)		M (3)	M (4+)				
Carbon disulfide									
Chrysene				M (3)					
Di-n-butylphthalate									
Dibenz(a,h)anthracene				S (8)					
Dibenzofuran					M (4)				
Diethylphthalate									
Endosulfan sulfate									
Fluoranthene				M (3)					
Fluorene				M (4+)					
Methylene chloride									
Naphthalene		N (2+)		M (3)					
PCB-1248		S (6-)							
PCB-1254	S (8)	S (6-)		S (6-)					
PCB-1260	S (8-)	M (5-)		S (6-)	S (6-)				
Phenanthrene				S (6)	S (8)				
Phenol		S (8)							
Polychlorinated biphenyl									S (6-)
Pyrene				M (3)	S (8)				
Toluene		N (1)							

Table 4.2. (continued)

Analyte	Seep A	Seep B East	Seep B West	Seep C	SWSA 5 Drainage D-2
Antimony		M (4)	M (4)	M (3)	
Arsenic					M (4)
Cadmium					
Chromium					
Copper					M (3)
Iron					**S (8)**
Lead					
Manganese	**S (8)**				**S (8)**
Mercury					M (3)
Nickel					
Silver					**S (8-)**
Zinc		M (4)	M (3)	M (3)	
1,1-Dichloroethane					M (3)
1,2-Dichloroethene					N (2)
2-Butanone					
2-Methylnaphthalene					
4,4'-DDT					
4-Methylphenol					
Acenaphthene					
Acetone					**S (8-)**
Alpha-BHC					
Anthracene					
Benz(a)anthracene					
Benzo(a)pyrene					
Bis(2-ethyl-hexyl)phthalate					
Carbon disulfide	M (4)				
Chrysene					
Di-n-butyl-phthalate					
Dibenz(a,h)anthracene					
Dibenzofuran					
Diethylphthalate					
Endosulfan sulfate					
Fluoranthene					
Fluorene					
Methylene chloride					
Naphthalene	M (3)				M (3)
PCB-1248					
PCB-1254				M (3)	
PCB-1260					M (4)
Phenanthrene					
Phenol					
Polychlorinated biphenyl					
Pyrene					
Toluene					

Table 4.2. (continued)

Analyte	^{60}Co Seep	WC TRIB-1	West Seep	SWSA 5 Drainage D-2	Pit 4 South	Lower WOC	WOCE
Antimony	M (4)	M (4)	M (3)			S (6)	N (2)
Arsenic						S (7)	N (1)
Cadmium						M (5)	M (5)
Chromium						S (6)	M (3)
Copper					M (4)	M (5)	N (2)
Iron							
Lead						M (5)	M (5)
Manganese				S (8)			
Mercury					N (2)	N (1)	S (6)
Nickel						S (6-)	
Silver						S (7-)	S (6-)
Zinc						S (6)	M (5)
1,1-Dichloroethane							
1,2-Dichloroethene							
2-Butanone							
2-Methylnaphthalene							
4,4'-DDT							S (8-)
4-Methylphenol							
Acenaphthene					M (4)		
Acetone							
Alpha-BHC						M (3+)	
Anthracene					S (8)		
Benz(a)anthracene					N (2)		
Benzo(a)pyrene					N (2)		M (4)
Bis(2-ethyl-hexyl)phthalate							M (3)
Carbon disulfide							
Chrysene					N (2)		M (4)
Di-n-butylphthalate						N (2)	
Dibenz(a,h)anthracene							
Dibenzofuran							
Diethylphthalate						M (4)	M (3)
Endosulfan sulfate							M (4)
Fluoranthene					N (2)		M (3+)
Fluorene					M (4+)		
Methylene chloride						N (1)	
Naphthalene					M (3)		
PCB-1248							
PCB-1254					M (4)	S (6-)	S (7-)
PCB-1260						S (7-)	S (6-)
Phenanthrene					M (4)		M (4)

Table 4.2. (continued)

Analyte	^{60}Co Seep	WC TRIB-1	West Seep	SWSA 5 Drainage D-2	Pit 4 South	Lower WOC	WOCE
Phenol							
Polychlorinated biphenyl							
Pyrene							M (3)
Toluene						N (1+)	

Blank indicates that if the chemical was detected it was not a COPEC in that subbasin (i.e., maximum detected concentration did not exceed any benchmarks)
S = Significant Risks (Risk score is 6, 7, or 8); Chemical is COEC
M = Marginal Risks (Risk score is 3, 4, or 5); Chemical is COPEC
N = Negligible Risks (Risk score is 1 or 2); Chemical is COPEC
Confidence score range from "-" to "+++" and are determined by the quality of the benchmark and the magnitude of the exceedence. A "-" suggests less confidence in the risk score, a "+" suggests more confidence in the risk score.
BOLD indicates COEC
Only one sediment sample was collected from this subbasin.

Table 4.3. Individual and sum of average hazard quotients (HQs) for sediment COPECs

Analyte	^{60}Co seep	HF-2	HFIR east	HRT-3	Intermediate Pond	Lower WOC	MB-15	Pit 4 south
Sum of Average HQs	**0.69**	**21.01**	**9.43**	**26.56**	**98.60**	**422.25**	**3.28**	**7.96**
Antimony	0.69	1.41	0.98	0.83		45.71	1.41	0.27
Arsenic						75.11		
Cadmium				2.56		3.79		
Chromium		2.57		1.53		74.96		
Chromium VI								
Copper		1.04		1.14	2.05	9.15		1.72
Iron								
Lead					1.23	3.33		
Manganese		12.81	8.46	10.61				
Mercury					16.50	3.00		0.74
Nickel				1.79	4.76	2.50		
Silver					12.80	35.52		
Zinc		3.19			1.81	10.44	1.87	
1,1-Dichloroethane								
1,2-Dichloroethene								
2-Butanone								
2-Methylnaphthalene					0.41			
4,4'-DDT								
4-Methylphenol					0.33			
Acenaphthene					3.31			0.56
Acetone								
alpha-BHC						1.68		
Anthracene					2.32			0.42
Benz(a)anthracene					3.05			0.15
Benzo(a)pyrene					2.03			0.13
Bis(2-ethylhexyl)phthalate					1.71			0.26
Carbon disulfide								
Chrysene					2.50			0.12
Di-n-butylphthalate					0.01	3.66		0.01
Dibenz(a,h)anthracene					9.16			
Dibenzofuran					0.08			0.08
Diethylphthalate						95.71		
Endosulfan sulfate								
Fluoranthene					2.57			0.22
Fluorene					2.65			1.82
Methylene chloride						1.15		
Naphthalene					0.23			0.18
PCB-1248								
PCB-1254					5.94	10.51		0.55
PCB-1260					17.30	41.61		
Phenanthrene					2.93			0.53
Phenol								
Polychlorinated biphenyl				8.10				
Pyrene					2.92			0.21
Toluene						4.40		

Table 4.3. (continued)

Analyte	SEEP A	SEEP B West	SEEP B East	SEEP C	SWSA 5 Trib 1	SWSA 5 WOC	SWSA 4 Main
Sum of Average HQs	**7.00**	**2.34**	**2.55**	**2.94**	**1082.40**	**117.14**	**47.52**
Antimony		1.08	1.23	1.31	5.73		
Arsenic							
Cadmium							
Chromium							
Chromium VI							
Copper					3.69	6.03	
Iron					3.86		
Lead					3.26	3.22	
Manganese	5.69				7.50		19.99
Mercury	0.39				127.67	13.46	
Nickel					2.94		27.53
Silver					1.70	4.37	
Zinc		1.26	1.32	1.37	8.74	0.85	
1,1-Dichloroethane							
1,2-Dichloroethene							
2-Butanone	0.04				1.43		
2-Methylnaphthalene							
4,4'-DDT							
4-Methylphenol					38.81		
Acenaphthene							
Acetone					365.88	35.84	
alpha-BHC							
Anthracene							
Benz(a)anthracene							
Benzo(a)pyrene							
Bis(2-ethylhexyl)phthalate					2.84		
Carbon disulfide	0.78						
Chrysene							
Di-n-butylphthalate							
Dibenz(a,h)anthracene							
Dibenzofuran							
Diethylphthalate							
Endosulfan sulfate							
Fluoranthene							
Fluorene							
Methylene chloride	0.01				0.01		
Naphthalene	0.06				0.06		
PCB-1248					20.16		
PCB-1254				0.26	17.47	26.79	
PCB-1260					35.03	26.59	
Phenanthrene							
Phenol					435.53		
Polychlorinated biphenyl							
Pyrene							
Toluene	0.03				0.07		

Table 4.3. (continued)

Analyte	W6MS3	WCTRIB-1	West Seep	SWSA 5 Drainage D-2	WOC	WOCE
Sum of Average HQs	**9.22**	**0.54**	**0.58**	**135.47**	**128.53**	**1685.97**
Antimony		0.54	0.58		0.12	3.55
Arsenic				1.27		1.57
Cadmium						3.41
Chromium						1.55
Chromium VI					0.38	
Copper				1.04	5.14	1.36
Iron				3.52		
Lead					1.56	3.06
Manganese	9.22			65.49		
Mercury				1.65	20.84	1563.25
Nickel						
Silver				5.40	18.65	13.61
Zinc					4.99	2.22
1,1-Dichloroethane				2.58		
1,2-Dichloroethene				2.79		
2-Butanone				0.22		
2-Methylnaphthalene						
4,4'-DDT						11.60
4-Methylphenol						
Acenaphthene					13.73	
Acetone				47.79		
alpha-BHC					5.57	
Anthracene					4.86	
Benz(a)anthracene					4.05	
Benzo(a)pyrene					3.07	2.22
Bis(2-ethylhexyl)phthalate					7.10	2.02
Carbon disulfide						
Chrysene						0.49
Di-n-butylphthalate						
Dibenz(a,h)anthracene						
Dibenzofuran					0.52	
Diethylphthalate						0.23
Endosulfan sulfate						5.45
Fluoranthene						0.37
Fluorene						
Methylene chloride				0.01		
Naphthalene				0.06		
PCB-1248						
PCB-1254						54.74
PCB-1260				3.59	25.32	13.50
Phenanthrene					8.72	1.06

Table 4.3. (continued)

Analyte	W6MS3	WCTRIB-1	West Seep	SWSA 5 Drainage D-2	WOC	WOCE
Phenol						
Polychlorinated biphenyl						
Pyrene					3.90	0.71
Toluene				0.07		

Hazard Quotients = Maximum detected concentration/benchmark value.
Average HQ = sum of HQs/number of HQs; calculated for each COPEC and subbasin combination
Sum of Average HQs is indicative of relative toxicity of sediment in each basin.

Table 4.4. Rules for assigning and interpreting risk scores for sediment COPECs

Estimated Exposure Concentration [a]	Class of Benchmark Exceeded	Interpretation	Risk Score
100th percentile	Possible-Effects	Toxicity is possible in at least 1% of the sediments in a subbasin.	1
80th percentile	Possible-Effects	Toxicity is possible in at least 20% of the sediments in a subbasin.	2
50th percentile	Possible-Effects	Toxicity is possible in at least 50% of the sediments in a subbasin.	3
Zero percentile	Possible-Effects	Toxicity is possible in 100% of the sediments in a subbasin.	4
100th percentile	Probable-Effects	Toxicity is likely in at least 1% of the sediments in a subbasin.	5
80th percentile	Probable-Effects	Toxicity is likely in at least 20% of the sediments in a subbasin	6
50th percentile	Probable-Effects	Toxicity is likely in at least 50% of the sediments in a subbasin	7
Zero percentile	Probable-Effects	Toxicity is likely in 100% of the sediments in a subbasin	8

[a] Percentiles indicate the concentration below which the specified percentage of concentrations measured in a subbasin occur (i.e., 80% of the concentrations were less than the 80th Percentile concentration).

Table 4.5. Calculation of final confidence scores[a] for sediment COPEC risk scores

Quality of benchmark (Score)	Magnitude of benchmark exceedence (Score)		
	HQ = 1-10 (0)	HQ = 10-100 (+)	HQ > 100 (++)
Low - may over estimate effects (-)	"-"	" "	"+"
Moderate to high - good estimate of effects (0)	" "	"+"	"++"
Low - may under estimate effects (+)	"+"	"++"	"+++"

[a] Final confidence scores are the sum of the benchmark quality score and the magnitude score.

Table 4.6. Exposure concentrations, benchmarks, and the resulting hazard quotients (HQs) for sediment COPECs

Analyte	Subbasin	Dets.	Obs.	Min Det.	Median	Max Det.	Benchmark Value	Benchmark Name	HQ
Antimony	**^{60}Co seep**	**1**	**1**	**3.3**		**3.3**	**2**	**ER_L**	**1.65**
Antimony	^{60}Co seep	1	1	3.3		3.3	12	REGIV_SV	0.28
Antimony	^{60}Co seep	1	1	3.3		3.3	25	ER_M	0.13
Antimony	**HF-2**	**11**	**11**	**0.76**	**5.70e+00**	**6.8**	**2**	**ER_L**	**3.40**
Antimony	HF-2	11	11	0.76	5.70e+00	6.8	12	REGIV_SV	0.57
Antimony	HF-2	11	11	0.76	5.70e+00	6.8	25	ER_M	0.27
Antimony	**HFIR East**	**8**	**8**	**3.3**	**4.00e+00**	**4.7**	**2**	**ER_L**	**2.35**
Antimony	HFIR East	8	8	3.3	4.00e+00	4.7	12	REGIV_SV	0.39
Antimony	HFIR East	8	8	3.3	4.00e+00	4.7	25	ER_M	0.19
Antimony	**HRE**	**2**	**6**	**2.3**	**2.55e+01**	**4**	**2**	**ER_L**	**2.00**
Antimony	HRE	2	6	2.3	2.55e+01	4	12	REGIV_SV	0.33
Antimony	HRE	2	6	2.3	2.55e+01	4	25	ER_M	0.16
Antimony	**Lower WOC**	**12**	**35**	**0.98**	**3.80e+00**	**220**	**2**	**ER_L**	**110.00**
Antimony	**Lower WOC**	**12**	**35**	**0.98**	**3.80e+00**	**220**	**12**	**REGIV_SV**	**18.33**
Antimony	**Lower WOC**	**12**	**35**	**0.98**	**3.80e+00**	**220**	**25**	**ER_M**	**8.80**
Antimony	**MB-15**	**20**	**21**	**3.7**	**5.70e+00**	**6.8**	**2**	**ER_L**	**3.40**
Antimony	MB-15	20	21	3.7	5.70e+00	6.8	12	REGIV_SV	0.57
Antimony	MB-15	20	21	3.7	5.70e+00	6.8	25	ER_M	0.27
Antimony	Pit 4 South	2	2	1.1	1.20e+00	1.3	2	ER_L	0.65
Antimony	Pit 4 South	2	2	1.1	1.20e+00	1.3	12	REGIV_SV	0.11
Antimony	Pit 4 South	2	2	1.1	1.20e+00	1.3	25	ER_M	0.05
Antimony	**SEEP B West**	**5**	**5**	**4.2**	**4.50e+00**	**5.2**	**2**	**ER_L**	**2.60**
Antimony	SEEP B West	5	5	4.2	4.50e+00	5.2	12	REGIV_SV	0.43
Antimony	SEEP B West	5	5	4.2	4.50e+00	5.2	25	ER_M	0.21
Antimony	**SEEP B East**	**7**	**7**	**4.3**	**5.20e+00**	**5.9**	**2**	**ER_L**	**2.95**
Antimony	SEEP B East	7	7	4.3	5.20e+00	5.9	12	REGIV_SV	0.49
Antimony	SEEP B East	7	7	4.3	5.20e+00	5.9	25	ER_M	0.24
Antimony	**SEEP C**	**10**	**11**	**3.2**	**3.90e+00**	**6.3**	**2**	**ER_L**	**3.15**
Antimony	SEEP C	10	11	3.2	3.90e+00	6.3	12	REGIV_SV	0.53
Antimony	SEEP C	10	11	3.2	3.90e+00	6.3	25	ER_M	0.25
Antimony	**SWSA 5 Trib 1**	**1**	**8**	**27.6**	**6.52e+00**	**27.6**	**2**	**ER_L**	**13.80**
Antimony	**SWSA 5 Trib 1**	**1**	**8**	**27.6**	**6.52e+00**	**27.6**	**12**	**REGIV_SV**	**2.30**
Antimony	**SWSA 5 Trib 1**	**1**	**8**	**27.6**	**6.52e+00**	**27.6**	**25**	**ER_M**	**1.10**
Antimony	**WCTRIB-1**	**2**	**2**	**2.4**	**2.50e+00**	**2.6**	**2**	**ER_L**	**1.30**
Antimony	WCTRIB-1	2	2	2.4	2.50e+00	2.6	12	REGIV_SV	0.22
Antimony	WCTRIB-1	2	2	2.4	2.50e+00	2.6	25	ER_M	0.10
Antimony	**West Seep**	**10**	**11**	**2**	**2.50e+00**	**2.8**	**2**	**ER_L**	**1.40**
Antimony	West Seep	10	11	2	2.50e+00	2.8	12	REGIV_SV	0.23
Antimony	West Seep	10	11	2	2.50e+00	2.8	25	ER_M	0.11
Antimony	WOC	1	5	0.6	2.75e-01	0.6	2	ER_L	0.30
Antimony	WOC	1	5	0.6	2.75e-01	0.6	12	REGIV_SV	0.05
Antimony	WOC	1	5	0.6	2.75e-01	0.6	25	ER_M	0.02
Antimony	**WOCE**	**15**	**46**	**0.3**	**2.72e-01**	**17.1**	**2**	**ER_L**	**8.55**
Antimony	**WOCE**	**15**	**46**	**0.3**	**2.72e-01**	**17.1**	**12**	**REGIV_SV**	**1.43**
Antimony	WOCE	15	46	0.3	2.72e-01	17.1	25	ER_M	0.68

Table 4.6. (continued)

Analyte	Subbasin	Dets.	Obs.	Min Det.	Median	Max Det.	Benchmark Value	Benchmark Name	HQ
Arsenic	Lower WOC	10	52	1.2	4.25e+01	830	6	MOE_LEL	138.33
Arsenic	Lower WOC	10	52	1.2	4.25e+01	830	7.24	REGIV_SV	114.64
Arsenic	Lower WOC	10	52	1.2	4.25e+01	830	7.24	TEL	114.64
Arsenic	Lower WOC	10	52	1.2	4.25e+01	830	8.2	ER_L	101.22
Arsenic	Lower WOC	10	52	1.2	4.25e+01	830	33	MOE_SEL	25.15
Arsenic	Lower WOC	10	52	1.2	4.25e+01	830	41.6	PEL	19.95
Arsenic	Lower WOC	10	52	1.2	4.25e+01	830	70	ER_M	11.86
Arsenic	SWSA 5 Drain. D-2	4	4	7.1	1.04e+01	14	6	MOE_LEL	2.33
Arsenic	SWSA 5 Drain. D-2	4	4	7.1	1.04e+01	14	7.24	REGIV_SV	1.93
Arsenic	SWSA 5 Drain. D-2	4	4	7.1	1.04e+01	14	7.24	TEL	1.93
Arsenic	SWSA 5 Drain. D-2	4	4	7.1	1.04e+01	14	8.2	ER_L	1.71
Arsenic	SWSA 5 Drain. D-2	4	4	7.1	1.04e+01	14	33	MOE_SEL	0.42
Arsenic	SWSA 5 Drain. D-2	4	4	7.1	1.04e+01	14	41.6	PEL	0.34
Arsenic	SWSA 5 Drain. D-2	4	4	7.1	1.04e+01	14	70	ER_M	0.20
Arsenic	WOCE	77	79	0.03	4.30e+00	17.4	6	MOE_LEL	2.90
Arsenic	WOCE	77	79	0.03	4.30e+00	17.4	7.24	REGIV_SV	2.40
Arsenic	WOCE	77	79	0.03	4.30e+00	17.4	7.24	TEL	2.40
Arsenic	WOCE	77	79	0.03	4.30e+00	17.4	8.2	ER_L	2.12
Arsenic	WOCE	77	79	0.03	4.30e+00	17.4	33	MOE_SEL	0.53
Arsenic	WOCE	77	79	0.03	4.30e+00	17.4	41.6	PEL	0.42
Arsenic	WOCE	77	79	0.03	4.30e+00	17.4	70	ER_M	0.25
Cadmium	HRE	2	9	3.1	1.50e-01	3.3	0.6	MOE_LEL	5.50
Cadmium	HRT-3	2	9	3.1	1.50e-01	3.3	0.676	TEL	4.88
Cadmium	HRT-3	2	9	3.1	1.50e-01	3.3	1	REGIV_SV	3.30
Cadmium	HRT-3	2	9	3.1	1.50e-01	3.3	1.2	ER_L	2.75
Cadmium	HRT-3	2	9	3.1	1.50e-01	3.3	4.21	PEL	0.78
Cadmium	HRT-3	2	9	3.1	1.50e-01	3.3	9.6	ER_M	0.34
Cadmium	HRT-3	2	9	3.1	1.50e-01	3.3	10	MOE_SEL	0.33
Cadmium	Lower WOC	15	51	0.13	4.90e-01	4.9	0.6	MOE_LEL	8.17
Cadmium	Lower WOC	15	51	0.13	4.90e-01	4.9	0.676	TEL	7.25
Cadmium	Lower WOC	15	51	0.13	4.90e-01	4.9	1	REGIV_SV	4.90
Cadmium	Lower WOC	15	51	0.13	4.90e-01	4.9	1.2	ER_L	4.08
Cadmium	Lower WOC	15	51	0.13	4.90e-01	4.9	4.21	PEL	1.16
Cadmium	Lower WOC	15	51	0.13	4.90e-01	4.9	9.6	ER_M	0.51
Cadmium	Lower WOC	15	51	0.13	4.90e-01	4.9	10	MOE_SEL	0.49
Cadmium	WOCE	37	55	0.1	1.40e+00	4.4	0.6	MOE_LEL	7.33
Cadmium	WOCE	37	55	0.1	1.40e+00	4.4	0.676	TEL	6.51
Cadmium	WOCE	37	55	0.1	1.40e+00	4.4	1	REGIV_SV	4.40
Cadmium	WOCE	37	55	0.1	1.40e+00	4.4	1.2	ER_L	3.67
Cadmium	WOCE	37	55	0.1	1.40e+00	4.4	4.21	PEL	1.05
Cadmium	WOCE	37	55	0.1	1.40e+00	4.4	9.6	ER_M	0.46
Cadmium	WOCE	37	55	0.1	1.40e+00	4.4	10	MOE_SEL	0.44
Chromium	HF-2	11	12	0.47	1.55e+01	168	26	MOE_LEL	6.46
Chromium	HF-2	11	12	0.47	1.55e+01	168	52.3	REGIV_SV	3.21
Chromium	HF-2	11	12	0.47	1.55e+01	168	52.3	TEL	3.21

Table 4.6. (continued)

Analyte	Subbasin	Dets.	Obs.	Min Det.	Median	Max Det.	Benchmark Value	Benchmark Name	HQ
Chromium	**HF-2**	**11**	**12**	**0.47**	**1.55e+01**	**168**	**81**	**ER_L**	**2.07**
Chromium	**HF-2**	**11**	**12**	**0.47**	**1.55e+01**	**168**	**110**	**MOE_SEL**	**1.53**
Chromium	**HF-2**	**11**	**12**	**0.47**	**1.55e+01**	**168**	**160**	**PEL**	**1.05**
Chromium	HF-2	11	12	0.47	1.55e+01	168	370	ER_M	0.45
Chromium	**HRT-3**	**15**	**15**	**0.81**	**9.30e+00**	**100**	**26**	**MOE_LEL**	**3.85**
Chromium	**HRT-3**	**15**	**15**	**0.81**	**9.30e+00**	**100**	**52.3**	**REGIV_SV**	**1.91**
Chromium	**HRT-3**	**15**	**15**	**0.81**	**9.30e+00**	**100**	**52.3**	**TEL**	**1.91**
Chromium	**HRT-3**	**15**	**15**	**0.81**	**9.30e+00**	**100**	**81**	**ER_L**	**1.23**
Chromium	HRT-3	15	15	0.81	9.30e+00	100	110	MOE_SEL	0.91
Chromium	HRT-3	15	15	0.81	9.30e+00	100	160	PEL	0.63
Chromium	HRT-3	15	15	0.81	9.30e+00	100	370	ER_M	0.27
Chromium	**Lower WOC**	**66**	**66**	**0.52**	**9.96e+01**	**4900**	**26**	**MOE_LEL**	**188.46**
Chromium	**Lower WOC**	**66**	**66**	**0.52**	**9.96e+01**	**4900**	**52.3**	**REGIV_SV**	**93.69**
Chromium	**Lower WOC**	**66**	**66**	**0.52**	**9.96e+01**	**4900**	**52.3**	**TEL**	**93.69**
Chromium	**Lower WOC**	**66**	**66**	**0.52**	**9.96e+01**	**4900**	**81**	**ER_L**	**60.49**
Chromium	**Lower WOC**	**66**	**66**	**0.52**	**9.96e+01**	**4900**	**110**	**MOE_SEL**	**44.55**
Chromium	**Lower WOC**	**66**	**66**	**0.52**	**9.96e+01**	**4900**	**160**	**PEL**	**30.63**
Chromium	**Lower WOC**	**66**	**66**	**0.52**	**9.96e+01**	**4900**	**370**	**ER_M**	**13.24**
Chromium	**WOCE**	**89**	**89**	**5.7**	**2.71e+01**	**101**	**26**	**MOE_LEL**	**3.88**
Chromium	**WOCE**	**89**	**89**	**5.7**	**2.71e+01**	**101**	**52.3**	**REGIV_SV**	**1.93**
Chromium	**WOCE**	**89**	**89**	**5.7**	**2.71e+01**	**101**	**52.3**	**TEL**	**1.93**
Chromium	**WOCE**	**89**	**89**	**5.7**	**2.71e+01**	**101**	**81**	**ER_L**	**1.25**
Chromium	WOCE	89	89	5.7	2.71e+01	101	110	MOE_SEL	0.92
Chromium	WOCE	89	89	5.7	2.71e+01	101	160	PEL	0.63
Chromium	WOCE	89	89	5.7	2.71e+01	101	370	ER_M	0.27
Chromium VI	WOC	1	1	51.1		51.1	81	ER_L	0.63
Chromium VI	WOC	1	1	51.1		51.1	370	ER_M	0.14
Copper	**HF-2**	**12**	**12**	**0.71**	**3.46e+00**	**32.8**	**16**	**MOE_LEL**	**2.05**
Copper	**HF-2**	**12**	**12**	**0.71**	**3.46e+00**	**32.8**	**18.7**	**REGIV_SV**	**1.75**
Copper	**HF-2**	**12**	**12**	**0.71**	**3.46e+00**	**32.8**	**18.7**	**TEL**	**1.75**
Copper	HF-2	12	12	0.71	3.46e+00	32.8	34	ER_L	0.96
Copper	HF-2	12	12	0.71	3.46e+00	32.8	108	PEL	0.30
Copper	HF-2	12	12	0.71	3.46e+00	32.8	110	MOE_SEL	0.30
Copper	HF-2	12	12	0.71	3.46e+00	32.8	270	ER_M	0.12
Copper	**HRT-3**	**13**	**13**	**0.27**	**1.90e+00**	**36**	**16**	**MOE_LEL**	**2.25**
Copper	**HRT-3**	**13**	**13**	**0.27**	**1.90e+00**	**36**	**18.7**	**REGIV_SV**	**1.93**
Copper	**HRT-3**	**13**	**13**	**0.27**	**1.90e+00**	**36**	**18.7**	**TEL**	**1.93**
Copper	**HRT-3**	**13**	**13**	**0.27**	**1.90e+00**	**36**	**34**	**ER_L**	**1.06**
Copper	HRT-3	13	13	0.27	1.90e+00	36	108	PEL	0.33
Copper	HRT-3	13	13	0.27	1.90e+00	36	110	MOE_SEL	0.33
Copper	HRT-3	13	13	0.27	1.90e+00	36	270	ER_M	0.13
Copper	**Intermediate Pond**	**5**	**5**	**15.1**	**4.44e+01**	**64.9**	**16**	**MOE_LEL**	**4.06**
Copper	**Intermediate Pond**	**5**	**5**	**15.1**	**4.44e+01**	**64.9**	**18.7**	**REGIV_SV**	**3.47**
Copper	**Intermediate Pond**	**5**	**5**	**15.1**	**4.44e+01**	**64.9**	**18.7**	**TEL**	**3.47**
Copper	**Intermediate Pond**	**5**	**5**	**15.1**	**4.44e+01**	**64.9**	**34**	**ER_L**	**1.91**

Table 4.6. (continued)

Analyte	Subbasin	Dets.	Obs.	Min Det.	Median	Max Det.	Benchmark Value	Benchmark Name	HQ
Copper	Intermediate Pond	5	5	15.1	4.44e+01	64.9	108	PEL	0.60
Copper	Intermediate Pond	5	5	15.1	4.44e+01	64.9	110	MOE_SEL	0.59
Copper	Intermediate Pond	5	5	15.1	4.44e+01	64.9	270	ER_M	0.24
Copper	**Lower WOC**	**48**	**63**	**0.21**	**2.10e+01**	**290**	**16**	**MOE_LEL**	**18.13**
Copper	**Lower WOC**	**48**	**63**	**0.21**	**2.10e+01**	**290**	**18.7**	**REGIV_SV**	**15.51**
Copper	**Lower WOC**	**48**	**63**	**0.21**	**2.10e+01**	**290**	**18.7**	**TEL**	**15.51**
Copper	**Lower WOC**	**48**	**63**	**0.21**	**2.10e+01**	**290**	**34**	**ER_L**	**8.53**
Copper	**Lower WOC**	**48**	**63**	**0.21**	**2.10e+01**	**290**	**108**	**PEL**	**2.69**
Copper	**Lower WOC**	**48**	**63**	**0.21**	**2.10e+01**	**290**	**110**	**MOE_SEL**	**2.64**
Copper	**Lower WOC**	**48**	**63**	**0.21**	**2.10e+01**	**290**	**270**	**ER_M**	**1.07**
Copper	**Pit 4 South**	**2**	**2**	**27.5**	**3.87e+01**	**54.4**	**16**	**MOE_LEL**	**3.40**
Copper	**Pit 4 South**	**2**	**2**	**27.5**	**3.87e+01**	**54.4**	**18.7**	**REGIV_SV**	**2.91**
Copper	**Pit 4 South**	**2**	**2**	**27.5**	**3.87e+01**	**54.4**	**18.7**	**TEL**	**2.91**
Copper	**Pit 4 South**	**2**	**2**	**27.5**	**3.87e+01**	**54.4**	**34**	**ER_L**	**1.60**
Copper	Pit 4 South	2	2	27.5	3.87e+01	54.4	108	PEL	0.50
Copper	Pit 4 South	2	2	27.5	3.87e+01	54.4	110	MOE_SEL	0.49
Copper	Pit 4 South	2	2	27.5	3.87e+01	54.4	270	ER_M	0.20
Copper	**SWSA 5 Trib 1**	**6**	**8**	**11.4**	**4.24e+01**	**117**	**16**	**MOE_LEL**	**7.31**
Copper	**SWSA 5 Trib 1**	**6**	**8**	**11.4**	**4.24e+01**	**117**	**18.7**	**REGIV_SV**	**6.26**
Copper	**SWSA 5 Trib 1**	**6**	**8**	**11.4**	**4.24e+01**	**117**	**18.7**	**TEL**	**6.26**
Copper	**SWSA 5 Trib 1**	**6**	**8**	**11.4**	**4.24e+01**	**117**	**34**	**ER_L**	**3.44**
Copper	**SWSA 5 Trib 1**	**6**	**8**	**11.4**	**4.24e+01**	**117**	**108**	**PEL**	**1.08**
Copper	**SWSA 5 Trib 1**	**6**	**8**	**11.4**	**4.24e+01**	**117**	**110**	**MOE_SEL**	**1.06**
Copper	SWSA 5 Trib 1	6	8	11.4	4.24e+01	117	270	ER_M	0.43
Copper	**SWSA 5 WOC**	**1**	**1**	**191**		**191**	**16**	**MOE_LEL**	**11.94**
Copper	**SWSA 5 WOC**	**1**	**1**	**191**		**191**	**18.7**	**REGIV_SV**	**10.21**
Copper	**SWSA 5 WOC**	**1**	**1**	**191**		**191**	**18.7**	**TEL**	**10.21**
Copper	**SWSA 5 WOC**	**1**	**1**	**191**		**191**	**34**	**ER_L**	**5.62**
Copper	**SWSA 5 WOC**	**1**	**1**	**191**		**191**	**108**	**PEL**	**1.77**
Copper	**SWSA 5 WOC**	**1**	**1**	**191**		**191**	**110**	**MOE_SEL**	**1.74**
Copper	SWSA 5 WOC	1	1	191		191	270	ER_M	0.71
Copper	**WG5 MID. Drn**	**4**	**4**	**10.5**	**1.95e+01**	**32.8**	**16**	**MOE_LEL**	**2.05**
Copper	**WG5 MID. Drn**	**4**	**4**	**10.5**	**1.95e+01**	**32.8**	**18.7**	**REGIV_SV**	**1.75**
Copper	**WG5 MID. Drn**	**4**	**4**	**10.5**	**1.95e+01**	**32.8**	**18.7**	**TEL**	**1.75**
Copper	WG5 MID. Drn	4	4	10.5	1.95e+01	32.8	34	ER_L	0.96
Copper	WG5 MID. Drn	4	4	10.5	1.95e+01	32.8	108	PEL	0.30
Copper	WG5 MID. Drn	4	4	10.5	1.95e+01	32.8	110	MOE_SEL	0.30
Copper	WG5 MID. Drn	4	4	10.5	1.95e+01	32.8	270	ER_M	0.12
Copper	**WOC**	**6**	**6**	**35.7**	**8.67e+01**	**163**	**16**	**MOE_LEL**	**10.19**
Copper	**WOC**	**6**	**6**	**35.7**	**8.67e+01**	**163**	**18.7**	**REGIV_SV**	**8.72**
Copper	**WOC**	**6**	**6**	**35.7**	**8.67e+01**	**163**	**18.7**	**TEL**	**8.72**
Copper	**WOC**	**6**	**6**	**35.7**	**8.67e+01**	**163**	**34**	**ER_L**	**4.79**
Copper	**WOC**	**6**	**6**	**35.7**	**8.67e+01**	**163**	**108**	**PEL**	**1.51**
Copper	**WOC**	**6**	**6**	**35.7**	**8.67e+01**	**163**	**110**	**MOE_SEL**	**1.48**
Copper	WOC	6	6	35.7	8.67e+01	163	270	ER_M	0.60

Table 4.6. (continued)

Analyte	Subbasin	Dets.	Obs.	Min Det.	Median	Max Det.	Benchmark Value	Benchmark Name	HQ
Copper	WOCE	86	86	5.9	1.38e+01	43.2	16	MOE_LEL	2.70
Copper	WOCE	86	86	5.9	1.38e+01	43.2	18.7	REGIV_SV	2.31
Copper	WOCE	86	86	5.9	1.38e+01	43.2	18.7	TEL	2.31
Copper	WOCE	86	86	5.9	1.38e+01	43.2	34	ER_L	1.27
Copper	WOCE	86	86	5.9	1.38e+01	43.2	108	PEL	0.40
Copper	WOCE	86	86	5.9	1.38e+01	43.2	110	MOE_SEL	0.39
Copper	WOCE	86	86	5.9	1.38e+01	43.2	270	ER_M	0.16
Iron	SWSA 5 Trib 1	8	8	21800	5.62e+04	103000	20000	MOE_LEL	5.15
Iron	SWSA 5 Trib 1	8	8	21800	5.62e+04	103000	40000	MOE_SEL	2.58
Iron	WG5 MID. Drn	4	4	56500	8.58e+04	93800	20000	MOE_LEL	4.69
Iron	WG5 MID. Drn	4	4	56500	8.58e+04	93800	40000	MOE_SEL	2.35
Lead	Intermediate Pond	5	5	23.3	3.96e+01	62.5	30.2	REGIV_SV	2.07
Lead	Intermediate Pond	5	5	23.3	3.96e+01	62.5	30.2	TEL	2.07
Lead	Intermediate Pond	5	5	23.3	3.96e+01	62.5	31	MOE_LEL	2.02
Lead	Intermediate Pond	5	5	23.3	3.96e+01	62.5	47	ER_L	1.33
Lead	Intermediate Pond	5	5	23.3	3.96e+01	62.5	112	PEL	0.56
Lead	Intermediate Pond	5	5	23.3	3.96e+01	62.5	218	ER_M	0.29
Lead	Intermediate Pond	5	5	23.3	3.96e+01	62.5	250	MOE_SEL	0.25
Lead	Lower WOC	33	54	2.1	4.27e+01	170	30.2	REGIV_SV	5.63
Lead	Lower WOC	33	54	2.1	4.27e+01	170	30.2	TEL	5.63
Lead	Lower WOC	33	54	2.1	4.27e+01	170	31	MOE_LEL	5.48
Lead	Lower WOC	33	54	2.1	4.27e+01	170	47	ER_L	3.62
Lead	Lower WOC	33	54	2.1	4.27e+01	170	112	PEL	1.52
Lead	Lower WOC	33	54	2.1	4.27e+01	170	218	ER_M	0.78
Lead	Lower WOC	33	54	2.1	4.27e+01	170	250	MOE_SEL	0.68
Lead	SWSA 5 Trib 1	8	8	13.8	4.64e+01	166	30.2	REGIV_SV	5.50
Lead	SWSA 5 Trib 1	8	8	13.8	4.64e+01	166	30.2	TEL	5.50
Lead	SWSA 5 Trib 1	8	8	13.8	4.64e+01	166	31	MOE_LEL	5.35
Lead	SWSA 5 Trib 1	8	8	13.8	4.64e+01	166	47	ER_L	3.53
Lead	SWSA 5 Trib 1	8	8	13.8	4.64e+01	166	112	PEL	1.48
Lead	SWSA 5 Trib 1	8	8	13.8	4.64e+01	166	218	ER_M	0.76
Lead	SWSA 5 Trib 1	8	8	13.8	4.64e+01	166	250	MOE_SEL	0.66
Lead	SWSA 5 WOC	1	1	164		164	30.2	REGIV_SV	5.43
Lead	SWSA 5 WOC	1	1	164		164	30.2	TEL	5.43
Lead	SWSA 5 WOC	1	1	164		164	31	MOE_LEL	5.29
Lead	SWSA 5 WOC	1	1	164		164	47	ER_L	3.49
Lead	SWSA 5 WOC	1	1	164		164	112	PEL	1.46
Lead	SWSA 5 WOC	1	1	164		164	218	ER_M	0.75
Lead	SWSA 5 WOC	1	1	164		164	250	MOE_SEL	0.66
Lead	WOC	6	6	29	5.06e+01	79.7	30.2	REGIV_SV	2.64
Lead	WOC	6	6	29	5.06e+01	79.7	30.2	TEL	2.64
Lead	WOC	6	6	29	5.06e+01	79.7	31	MOE_LEL	2.57
Lead	WOC	6	6	29	5.06e+01	79.7	47	ER_L	1.70
Lead	WOC	6	6	29	5.06e+01	79.7	112	PEL	0.71
Lead	WOC	6	6	29	5.06e+01	79.7	218	ER_M	0.37

Table 4.6. (continued)

Analyte	Subbasin	Dets.	Obs.	Min Det.	Median	Max Det.	Benchmark Value	Benchmark Name	HQ
Lead	WOC	6	6	29	5.06e+01	79.7	250	MOE_SEL	0.32
Lead	WOCE	89	89	5.3	3.11e+01	156	30.2	REGIV_SV	5.17
Lead	WOCE	89	89	5.3	3.11e+01	156	30.2	TEL	5.17
Lead	WOCE	89	89	5.3	3.11e+01	156	31	MOE_LEL	5.03
Lead	WOCE	89	89	5.3	3.11e+01	156	47	ER_L	3.32
Lead	WOCE	89	89	5.3	3.11e+01	156	112	PEL	1.39
Lead	WOCE	89	89	5.3	3.11e+01	156	218	ER_M	0.72
Lead	WOCE	89	89	5.3	3.11e+01	156	250	MOE_SEL	0.62
Manganese	HF-2	12	12	1100	1.75e+03	8330	460	MOE_LEL	18.11
Manganese	HF-2	12	12	1100	1.75e+03	8330	1110	MOE_SEL	7.50
Manganese	HFIR/east	8	8	1600	2.85e+03	5500	460	MOE_LEL	11.96
Manganese	HFIR/east	8	8	1600	2.85e+03	5500	1110	MOE_SEL	4.95
Manganese	HRT-3	14	14	340	1.95e+03	6900	460	MOE_LEL	15.00
Manganese	HRT-3	14	14	340	1.95e+03	6900	1110	MOE_SEL	6.22
Manganese	SEEP A	4	4	1560	2.35e+03	3700	460	MOE_LEL	8.04
Manganese	SEEP A	4	4	1560	2.35e+03	3700	1110	MOE_SEL	3.33
Manganese	SWSA 5 Trib 1	8	8	660	1.18e+03	4880	460	MOE_LEL	10.61
Manganese	SWSA 5 Trib 1	8	8	660	1.18e+03	4880	1110	MOE_SEL	4.40
Manganese	SWSA 4 main	5	5	1500	1.00e+04	13000	460	MOE_LEL	28.26
Manganese	SWSA 4 main	5	5	1500	1.00e+04	13000	1110	MOE_SEL	11.71
Manganese	W6MS3	4	4	3700	4.57e+03	6000	460	MOE_LEL	13.04
Manganese	W6MS3	4	4	3700	4.57e+03	6000	1110	MOE_SEL	5.41
Manganese	SWSA 5 Drain. D-2	4	4	4860	1.87e+04	42600	460	MOE_LEL	92.61
Manganese	SWSA 5 Drain. D-2	4	4	4860	1.87e+04	42600	1110	MOE_SEL	38.38
Mercury	Intermediate Pond	5	5	1.1	2.60e+00	3.8	0.13	REGIV_SV	29.23
Mercury	Intermediate Pond	5	5	1.1	2.60e+00	3.8	0.13	TEL	29.23
Mercury	Intermediate Pond	5	5	1.1	2.60e+00	3.8	0.15	ER_L	25.33
Mercury	Intermediate Pond	5	5	1.1	2.60e+00	3.8	0.2	MOE_LEL	19.00
Mercury	Intermediate Pond	5	5	1.1	2.60e+00	3.8	0.696	PEL	5.46
Mercury	Intermediate Pond	5	5	1.1	2.60e+00	3.8	0.71	ER_M	5.35
Mercury	Intermediate Pond	5	5	1.1	2.60e+00	3.8	2	MOE_SEL	1.90
Mercury	Lower WOC	26	31	0.01	5.00e-02	0.69	0.13	REGIV_SV	5.31
Mercury	Lower WOC	26	31	0.01	5.00e-02	0.69	0.13	TEL	5.31
Mercury	Lower WOC	26	31	0.01	5.00e-02	0.69	0.15	ER_L	4.60
Mercury	Lower WOC	26	31	0.01	5.00e-02	0.69	0.2	MOE_LEL	3.45
Mercury	Lower WOC	26	31	0.01	5.00e-02	0.69	0.696	PEL	0.99
Mercury	Lower WOC	26	31	0.01	5.00e-02	0.69	0.71	ER_M	0.97
Mercury	Lower WOC	26	31	0.01	5.00e-02	0.69	2	MOE_SEL	0.35
Mercury	Pit 4 South	1	2	0.17	1.24e-01	0.17	0.13	REGIV_SV	1.31
Mercury	Pit 4 South	1	2	0.17	1.24e-01	0.17	0.13	TEL	1.31
Mercury	Pit 4 South	1	2	0.17	1.24e-01	0.17	0.15	ER_L	1.13
Mercury	Pit 4 South	1	2	0.17	1.24e-01	0.17	0.2	MOE_LEL	0.85
Mercury	Pit 4 South	1	2	0.17	1.24e-01	0.17	0.696	PEL	0.24
Mercury	Pit 4 South	1	2	0.17	1.24e-01	0.17	0.71	ER_M	0.24
Mercury	Pit 4 South	1	2	0.17	1.24e-01	0.17	2	MOE_SEL	0.09

Table 4.6. (continued)

Analyte	Subbasin	Dets.	Obs.	Min Det.	Median	Max Det.	Benchmark Value	Benchmark Name	HQ
Mercury	SEEP A	1	1	0.09		0.09	0.13	REGIV_SV	0.69
Mercury	SEEP A	1	1	0.09		0.09	0.13	TEL	0.69
Mercury	SEEP A	1	1	0.09		0.09	0.15	ER_L	0.60
Mercury	SEEP A	1	1	0.09		0.09	0.2	MOE_LEL	0.45
Mercury	SEEP A	1	1	0.09		0.09	0.696	PEL	0.13
Mercury	SEEP A	1	1	0.09		0.09	0.71	ER_M	0.13
Mercury	SEEP A	1	1	0.09		0.09	2	MOE_SEL	0.05
Mercury	**SWSA 5 Trib 1**	**7**	**8**	**0.08**	**1.47e+00**	**29.4**	**0.13**	**REGIV_SV**	**226.15**
Mercury	**SWSA 5 Trib 1**	**7**	**8**	**0.08**	**1.47e+00**	**29.4**	**0.13**	**TEL**	**226.15**
Mercury	**SWSA 5 Trib 1**	**7**	**8**	**0.08**	**1.47e+00**	**29.4**	**0.15**	**ER_L**	**196.00**
Mercury	**SWSA 5 Trib 1**	**7**	**8**	**0.08**	**1.47e+00**	**29.4**	**0.2**	**MOE_LEL**	**147.00**
Mercury	**SWSA 5 Trib 1**	**7**	**8**	**0.08**	**1.47e+00**	**29.4**	**0.696**	**PEL**	**42.24**
Mercury	**SWSA 5 Trib 1**	**7**	**8**	**0.08**	**1.47e+00**	**29.4**	**0.71**	**ER_M**	**41.41**
Mercury	**SWSA 5 Trib 1**	**7**	**8**	**0.08**	**1.47e+00**	**29.4**	**2**	**MOE_SEL**	**14.70**
Mercury	**SWSA 5 WOC**	**1**	**1**	**3.1**		**3.1**	**0.13**	**REGIV_SV**	**23.85**
Mercury	**SWSA 5 WOC**	**1**	**1**	**3.1**		**3.1**	**0.13**	**TEL**	**23.85**
Mercury	**SWSA 5 WOC**	**1**	**1**	**3.1**		**3.1**	**0.15**	**ER_L**	**20.67**
Mercury	**SWSA 5 WOC**	**1**	**1**	**3.1**		**3.1**	**0.2**	**MOE_LEL**	**15.50**
Mercury	**SWSA 5 WOC**	**1**	**1**	**3.1**		**3.1**	**0.696**	**PEL**	**4.45**
Mercury	**SWSA 5 WOC**	**1**	**1**	**3.1**		**3.1**	**0.71**	**ER_M**	**4.37**
Mercury	**SWSA 5 WOC**	**1**	**1**	**3.1**		**3.1**	**2**	**MOE_SEL**	**1.55**
Mercury	**SWSA 5 Drain. D-2**	**3**	**4**	**0.17**	**2.22e-01**	**0.38**	**0.13**	**REGIV_SV**	**2.92**
Mercury	**SWSA 5 Drain. D-2**	**3**	**4**	**0.17**	**2.22e-01**	**0.38**	**0.13**	**TEL**	**2.92**
Mercury	**SWSA 5 Drain. D-2**	**3**	**4**	**0.17**	**2.22e-01**	**0.38**	**0.15**	**ER_L**	**2.53**
Mercury	**SWSA 5 Drain. D-2**	**3**	**4**	**0.17**	**2.22e-01**	**0.38**	**0.2**	**MOE_LEL**	**1.90**
Mercury	SWSA 5 Drain. D-2	3	4	0.17	2.22e-01	0.38	0.696	PEL	0.55
Mercury	SWSA 5 Drain. D-2	3	4	0.17	2.22e-01	0.38	0.71	ER_M	0.54
Mercury	SWSA 5 Drain. D-2	3	4	0.17	2.22e-01	0.38	2	MOE_SEL	0.19
Mercury	**WOC**	**5**	**5**	**1.2**	**4.40e+00**	**4.8**	**0.13**	**REGIV_SV**	**36.92**
Mercury	**WOC**	**5**	**5**	**1.2**	**4.40e+00**	**4.8**	**0.13**	**TEL**	**36.92**
Mercury	**WOC**	**5**	**5**	**1.2**	**4.40e+00**	**4.8**	**0.15**	**ER_L**	**32.00**
Mercury	**WOC**	**5**	**5**	**1.2**	**4.40e+00**	**4.8**	**0.2**	**MOE_LEL**	**24.00**
Mercury	**WOC**	**5**	**5**	**1.2**	**4.40e+00**	**4.8**	**0.696**	**PEL**	**6.90**
Mercury	**WOC**	**5**	**5**	**1.2**	**4.40e+00**	**4.8**	**0.71**	**ER_M**	**6.76**
Mercury	**WOC**	**5**	**5**	**1.2**	**4.40e+00**	**4.8**	**2**	**MOE_SEL**	**2.40**
Mercury	**WOCE**	**83**	**93**	**0.02**	**2.30e-01**	**360**	**0.13**	**REGIV_SV**	**2769.23**
Mercury	**WOCE**	**83**	**93**	**0.02**	**2.30e-01**	**360**	**0.13**	**TEL**	**2769.23**
Mercury	**WOCE**	**83**	**93**	**0.02**	**2.30e-01**	**360**	**0.15**	**ER_L**	**2400.00**
Mercury	**WOCE**	**83**	**93**	**0.02**	**2.30e-01**	**360**	**0.2**	**MOE_LEL**	**1800.00**
Mercury	**WOCE**	**83**	**93**	**0.02**	**2.30e-01**	**360**	**0.696**	**PEL**	**517.24**
Mercury	**WOCE**	**83**	**93**	**0.02**	**2.30e-01**	**360**	**0.71**	**ER_M**	**507.04**
Mercury	**WOCE**	**83**	**93**	**0.02**	**2.30e-01**	**360**	**2**	**MOE_SEL**	**180.00**
Nickel	**HRT-3**	**14**	**14**	**1.5**	**4.24e+00**	**43**	**15.9**	**REGIV_SV**	**2.70**
Nickel	**HRT-3**	**14**	**14**	**1.5**	**4.24e+00**	**43**	**15.9**	**TEL**	**2.70**
Nickel	**HRT-3**	**14**	**14**	**1.5**	**4.24e+00**	**43**	**16**	**MOE_LEL**	**2.69**

Table 4.6. (continued)

Analyte	Subbasin	Dets.	Obs.	Min Det.	Median	Max Det.	Benchmark Value	Benchmark Name	HQ
Nickel	HRT-3	14	14	1.5	4.24e+00	43	21	ER_L	2.05
Nickel	HRT-3	14	14	1.5	4.24e+00	43	42.8	PEL	1.00
Nickel	HRT-3	14	14	1.5	4.24e+00	43	51.6	ER_M	0.83
Nickel	HRT-3	14	14	1.5	4.24e+00	43	75	MOE_SEL	0.57
Nickel	Intermediate Pond	5	5	8.3	1.54e+01	114	15.9	REGIV_SV	7.17
Nickel	Intermediate Pond	5	5	8.3	1.54e+01	114	15.9	TEL	7.17
Nickel	Intermediate Pond	5	5	8.3	1.54e+01	114	16	MOE_LEL	7.13
Nickel	Intermediate Pond	5	5	8.3	1.54e+01	114	21	ER_L	5.43
Nickel	Intermediate Pond	5	5	8.3	1.54e+01	114	42.8	PEL	2.66
Nickel	Intermediate Pond	5	5	8.3	1.54e+01	114	51.6	ER_M	2.21
Nickel	Intermediate Pond	5	5	8.3	1.54e+01	114	75	MOE_SEL	1.52
Nickel	Lower WOC	60	63	3	3.42e+01	60	15.9	REGIV_SV	3.77
Nickel	Lower WOC	60	63	3	3.42e+01	60	15.9	TEL	3.77
Nickel	Lower WOC	60	63	3	3.42e+01	60	16	MOE_LEL	3.75
Nickel	Lower WOC	60	63	3	3.42e+01	60	21	ER_L	2.86
Nickel	Lower WOC	60	63	3	3.42e+01	60	42.8	PEL	1.40
Nickel	Lower WOC	60	63	3	3.42e+01	60	51.6	ER_M	1.16
Nickel	Lower WOC	60	63	3	3.42e+01	60	75	MOE_SEL	0.80
Nickel	SWSA 5 Trib 1	4	8	30.5	2.86e+01	70.6	15.9	REGIV_SV	4.44
Nickel	SWSA 5 Trib 1	4	8	30.5	2.86e+01	70.6	15.9	TEL	4.44
Nickel	SWSA 5 Trib 1	4	8	30.5	2.86e+01	70.6	16	MOE_LEL	4.41
Nickel	SWSA 5 Trib 1	4	8	30.5	2.86e+01	70.6	21	ER_L	3.36
Nickel	SWSA 5 Trib 1	4	8	30.5	2.86e+01	70.6	42.8	PEL	1.65
Nickel	SWSA 5 Trib 1	4	8	30.5	2.86e+01	70.6	51.6	ER_M	1.37
Nickel	SWSA 5 Trib 1	4	8	30.5	2.86e+01	70.6	75	MOE_SEL	0.94
Nickel	SWSA4main	5	5	99	6.10e+02	660	15.9	REGIV_SV	41.51
Nickel	SWSA4main	5	5	99	6.10e+02	660	15.9	TEL	41.51
Nickel	SWSA4main	5	5	99	6.10e+02	660	16	MOE_LEL	41.25
Nickel	SWSA4main	5	5	99	6.10e+02	660	21	ER_L	31.43
Nickel	SWSA4main	5	5	99	6.10e+02	660	42.8	PEL	15.42
Nickel	SWSA4main	5	5	99	6.10e+02	660	51.6	ER_M	12.79
Nickel	SWSA4main	5	5	99	6.10e+02	660	75	MOE_SEL	8.80
Silver	Intermediate Pond	5	5	2.3	5.10e+00	17.3	0.733	TEL	23.60
Silver	Intermediate Pond	5	5	2.3	5.10e+00	17.3	1	ER_L	17.30
Silver	Intermediate Pond	5	5	2.3	5.10e+00	17.3	1.77	PEL	9.77
Silver	Intermediate Pond	5	5	2.3	5.10e+00	17.3	2	REGIV_SV	8.65
Silver	Intermediate Pond	5	5	2.3	5.10e+00	17.3	3.7	ER_M	4.68
Silver	Lower WOC	20	50	0.86	8.50e+00	48	0.733	TEL	65.48
Silver	Lower WOC	20	50	0.86	8.50e+00	48	1	ER_L	48.00
Silver	Lower WOC	20	50	0.86	8.50e+00	48	1.77	PEL	27.12
Silver	Lower WOC	20	50	0.86	8.50e+00	48	2	REGIV_SV	24.00
Silver	Lower WOC	20	50	0.86	8.50e+00	48	3.7	ER_M	12.97
Silver	SWSA 5 Trib 1	3	8	1.1	2.37e+00	2.3	0.733	TEL	3.14
Silver	SWSA 5 Trib 1	3	8	1.1	2.37e+00	2.3	1	ER_L	2.30
Silver	SWSA 5 Trib 1	3	8	1.1	2.37e+00	2.3	1.77	PEL	1.30

Table 4.6. (continued)

Analyte	Subbasin	Dets.	Obs.	Min Det.	Median	Max Det.	Benchmark Value	Benchmark Name	HQ
Silver	SWSA 5 Trib 1	3	8	1.1	2.37e+00	2.3	2	REGIV_SV	1.15
Silver	SWSA 5 Trib 1	3	8	1.1	2.37e+00	2.3	3.7	ER_M	0.62
Silver	SWSA 5 WOC	1	1	5.9		5.9	0.733	TEL	8.05
Silver	SWSA 5 WOC	1	1	5.9		5.9	1	ER_L	5.90
Silver	SWSA 5 WOC	1	1	5.9		5.9	1.77	PEL	3.33
Silver	SWSA 5 WOC	1	1	5.9		5.9	2	REGIV_SV	2.95
Silver	SWSA 5WOC	1	1	5.9		5.9	3.7	ER_M	1.59
Silver	SWSA 5 Drain. D-2	2	4	6.9	4.15e+00	7.3	0.733	TEL	9.96
Silver	SWSA 5 Drain. D-2	2	4	6.9	4.15e+00	7.3	1	ER_L	7.30
Silver	SWSA 5 Drain. D-2	2	4	6.9	4.15e+00	7.3	1.77	PEL	4.12
Silver	SWSA 5 Drain. D-2	2	4	6.9	4.15e+00	7.3	2	REGIV_SV	3.65
Silver	SWSA 5 Drain. D-2	2	4	6.9	4.15e+00	7.3	3.7	ER_M	1.97
Silver	WOC	6	6	4.2	1.58e+01	25.2	0.733	TEL	34.38
Silver	WOC	6	6	4.2	1.58e+01	25.2	1	ER_L	25.20
Silver	WOC	6	6	4.2	1.58e+01	25.2	1.77	PEL	14.24
Silver	WOC	6	6	4.2	1.58e+01	25.2	2	REGIV_SV	12.60
Silver	WOC	6	6	4.2	1.58e+01	25.2	3.7	ER_M	6.81
Silver	WOCE	64	78	0.03	7.00e-01	18.4	0.733	TEL	25.10
Silver	WOCE	64	78	0.03	7.00e-01	18.4	1	ER_L	18.40
Silver	WOCE	64	78	0.03	7.00e-01	18.4	1.77	PEL	10.40
Silver	WOCE	64	78	0.03	7.00e-01	18.4	2	REGIV_SV	9.20
Silver	WOCE	64	78	0.03	7.00e-01	18.4	3.7	ER_M	4.97
Zinc	HF-2	9	9	4.5	2.30e+02	580	120	MOE_LEL	4.83
Zinc	HF-2	9	9	4.5	2.30e+02	580	124	REGIV_SV	4.68
Zinc	HF-2	9	9	4.5	2.30e+02	580	124	TEL	4.68
Zinc	HF-2	9	9	4.5	2.30e+02	580	150	ER_L	3.87
Zinc	HF-2	9	9	4.5	2.30e+02	580	271	PEL	2.14
Zinc	HF-2	9	9	4.5	2.30e+02	580	410	ER_M	1.41
Zinc	HF-2	9	9	4.5	2.30e+02	580	820	MOE_SEL	0.71
Zinc	Intermediate Pond	5	5	95.5	2.78e+02	330	120	MOE_LEL	2.75
Zinc	Intermediate Pond	5	5	95.5	2.78e+02	330	124	REGIV_SV	2.66
Zinc	Intermediate Pond	5	5	95.5	2.78e+02	330	124	TEL	2.66
Zinc	Intermediate Pond	5	5	95.5	2.78e+02	330	150	ER_L	2.20
Zinc	Intermediate Pond	5	5	95.5	2.78e+02	330	271	PEL	1.22
Zinc	Intermediate Pond	5	5	95.5	2.78e+02	330	410	ER_M	0.80
Zinc	Intermediate Pond	5	5	95.5	2.78e+02	330	820	MOE_SEL	0.40
Zinc	Lower WOC	67	70	3.9	8.80e+01	1900	120	MOE_LEL	15.83
Zinc	Lower WOC	67	70	3.9	8.80e+01	1900	124	REGIV_SV	15.32
Zinc	Lower WOC	67	70	3.9	8.80e+01	1900	124	TEL	15.32
Zinc	Lower WOC	67	70	3.9	8.80e+01	1900	150	ER_L	12.67
Zinc	Lower WOC	67	70	3.9	8.80e+01	1900	271	PEL	7.01
Zinc	Lower WOC	67	70	3.9	8.80e+01	1900	410	ER_M	4.63
Zinc	Lower WOC	67	70	3.9	8.80e+01	1900	820	MOE_SEL	2.32
Zinc	MB-15	13	13	5.7	1.50e+02	340	120	MOE_LEL	2.83
Zinc	MB-15	13	13	5.7	1.50e+02	340	124	REGIV_SV	2.74

Table 4.6. (continued)

Analyte	Subbasin	Dets.	Obs.	Min Det.	Median	Max Det.	Benchmark Value	Benchmark Name	HQ
Zinc	MB-15	13	13	5.7	1.50e+02	340	124	TEL	2.74
Zinc	MB-15	13	13	5.7	1.50e+02	340	150	ER_L	2.27
Zinc	MB-15	13	13	5.7	1.50e+02	340	271	PEL	1.25
Zinc	MB-15	13	13	5.7	1.50e+02	340	410	ER_M	0.83
Zinc	MB-15	13	13	5.7	1.50e+02	340	820	MOE_SEL	0.41
Zinc	SEEP B West	6	6	120	1.65e+02	230	120	MOE_LEL	1.92
Zinc	SEEP B West	6	6	120	1.65e+02	230	124	REGIV_SV	1.85
Zinc	SEEP B West	6	6	120	1.65e+02	230	124	TEL	1.85
Zinc	SEEP B West	6	6	120	1.65e+02	230	150	ER_L	1.53
Zinc	SEEP B West	6	6	120	1.65e+02	230	271	PEL	0.85
Zinc	SEEP B West	6	6	120	1.65e+02	230	410	ER_M	0.56
Zinc	SEEP B West	6	6	120	1.65e+02	230	820	MOE_SEL	0.28
Zinc	SEEP B East	7	7	130	2.00e+02	240	120	MOE_LEL	2.00
Zinc	SEEP B East	7	7	130	2.00e+02	240	124	REGIV_SV	1.94
Zinc	SEEP B East	7	7	130	2.00e+02	240	124	TEL	1.94
Zinc	SEEP B East	7	7	130	2.00e+02	240	150	ER_L	1.60
Zinc	SEEP B East	7	7	130	2.00e+02	240	271	PEL	0.89
Zinc	SEEP B East	7	7	130	2.00e+02	240	410	ER_M	0.59
Zinc	SEEP B East	7	7	130	2.00e+02	240	820	MOE_SEL	0.29
Zinc	SEEP C	9	9	100	1.40e+02	250	120	MOE_LEL	2.08
Zinc	SEEP C	9	9	100	1.40e+02	250	124	REGIV_SV	2.02
Zinc	SEEP C	9	9	100	1.40e+02	250	124	TEL	2.02
Zinc	SEEP C	9	9	100	1.40e+02	250	150	ER_L	1.67
Zinc	SEEP C	9	9	100	1.40e+02	250	271	PEL	0.92
Zinc	SEEP C	9	9	100	1.40e+02	250	410	ER_M	0.61
Zinc	SEEP C	9	9	100	1.40e+02	250	820	MOE_SEL	0.30
Zinc	SWSA 5 Trib 1	8	8	47.3	2.15e+02	1590	120	MOE_LEL	13.25
Zinc	SWSA 5 Trib 1	8	8	47.3	2.15e+02	1590	124	REGIV_SV	12.82
Zinc	SWSA 5 Trib 1	8	8	47.3	2.15e+02	1590	124	TEL	12.82
Zinc	SWSA 5 Trib 1	8	8	47.3	2.15e+02	1590	150	ER_L	10.60
Zinc	SWSA 5 Trib 1	8	8	47.3	2.15e+02	1590	271	PEL	5.87
Zinc	SWSA 5 Trib 1	8	8	47.3	2.15e+02	1590	410	ER_M	3.88
Zinc	SWSA 5 Trib 1	8	8	47.3	2.15e+02	1590	820	MOE_SEL	1.94
Zinc	SWSA 5 WOC	1	1	154		154	120	MOE_LEL	1.28
Zinc	SWSA 5 WOC	1	1	154		154	124	REGIV_SV	1.24
Zinc	SWSA 5 WOC	1	1	154		154	124	TEL	1.24
Zinc	SWSA 5 WOC	1	1	154		154	150	ER_L	1.03
Zinc	SWSA 5 WOC	1	1	154		154	271	PEL	0.57
Zinc	SWSA 5 WOC	1	1	154		154	410	ER_M	0.38
Zinc	SWSA 5 WOC	1	1	154		154	820	MOE_SEL	0.19
Zinc	WOC	6	6	254	5.52e+02	908	120	MOE_LEL	7.57
Zinc	WOC	6	6	254	5.52e+02	908	124	REGIV_SV	7.32
Zinc	WOC	6	6	254	5.52e+02	908	124	TEL	7.32
Zinc	WOC	6	6	254	5.52e+02	908	150	ER_L	6.05
Zinc	WOC	6	6	254	5.52e+02	908	271	PEL	3.35

Table 4.6. (continued)

Analyte	Subbasin	Dets.	Obs.	Min Det.	Median	Max Det.	Benchmark Value	Benchmark Name	HQ
Zinc	**WOC**	**6**	**6**	**254**	**5.52e+02**	**908**	**410**	**ER_M**	**2.21**
Zinc	**WOC**	**6**	**6**	**254**	**5.52e+02**	**908**	**820**	**MOE_SEL**	**1.11**
Zinc	**WOCE**	**90**	**90**	**21.7**	**7.14e+01**	**403**	**120**	**MOE_LEL**	**3.36**
Zinc	**WOCE**	**90**	**90**	**21.7**	**7.14e+01**	**403**	**124**	**REGIV_SV**	**3.25**
Zinc	**WOCE**	**90**	**90**	**21.7**	**7.14e+01**	**403**	**124**	**TEL**	**3.25**
Zinc	**WOCE**	**90**	**90**	**21.7**	**7.14e+01**	**403**	**150**	**ER_L**	**2.69**
Zinc	**WOCE**	**90**	**90**	**21.7**	**7.14e+01**	**403**	**271**	**PEL**	**1.49**
Zinc	WOCE	90	90	21.7	7.14e+01	403	410	ER_M	0.98
Zinc	WOCE	90	90	21.7	7.14e+01	403	820	MOE_SEL	0.49
1,1-Dichloroethane	**WG5 MID. Drn**	**3**	**4**	**0.017**	**3.57e-02**	**0.14**	**0.0272**	**EQPSCV1**	**5.15**
1,1-Dichloroethane	WG5 MID. Drn	3	4	0.017	3.57e-02	0.14	8.494	EQPCVF1	0.02
1,2-Dichloroethene	**WG5 MID. Drn**	**3**	**4**	**0.08**	**2.80e-01**	**2.1**	**0.4**	**EQPSCV1**	**5.25**
1,2-Dichloroethene	WG5 MID. Drn	3	4	0.08	2.80e-01	2.1	6.466	EQPCVF1	0.32
2-Butanone	SEEP A	1	1	0.034		0.034	0.271	EQPSCV1	0.13
2-Butanone	SEEP A	1	1	0.034		0.034	5.475	EQPCVF1	0.01
2-Butanone	SEEP A	1	1	0.034		0.034	27.066	EQPCVD1	0.00
2-Butanone	**SWSA 5 Trib 1**	**10**	**17**	**0.059**	**1.80e-01**	**1.1**	**0.271**	**EQPSCV1**	**4.06**
2-Butanone	SWSA 5 Trib 1	10	17	0.059	1.80e-01	1.1	5.475	EQPCVF1	0.20
2-Butanone	SWSA 5 Trib 1	10	17	0.059	1.80e-01	1.1	27.066	EQPCVD1	0.04
2-Butanone	WG5 MID. Drn	2	4	0.025	2.29e-02	0.17	0.271	EQPSCV1	0.63
2-Butanone	WG5 MID. Drn	2	4	0.025	2.29e-02	0.17	5.475	EQPCVF1	0.03
2-Butanone	WG5 MID. Drn	2	4	0.025	2.29e-02	0.17	27.066	EQPCVD1	0.01
2-Methylnaphthalene	**Intermediate Pond**	**2**	**3**	**0.023**	**2.80e-02**	**0.028**	**0.0202**	**TEL**	**1.39**
2-Methylnaphthalene	Intermediate Pond	2	3	0.023	2.80e-02	0.028	0.07	ER_L	0.40
2-Methylnaphthalene	Intermediate Pond	2	3	0.023	2.80e-02	0.028	0.201	PEL	0.14
2-Methylnaphthalene	Intermediate Pond	2	3	0.023	2.80e-02	0.028	0.33	REGIV_SV	0.08
2-Methylnaphthalene	Intermediate Pond	2	3	0.023	2.80e-02	0.028	0.67	ER_M	0.04
4,4'-DDT	**WOCE**	**2**	**26**	**0.026**	**2.75e-02**	**0.029**	**0.00119**	**TEL**	**24.37**
4,4'-DDT	**WOCE**	**2**	**26**	**0.026**	**2.75e-02**	**0.029**	**0.0016**	**ER_L**	**18.13**
4,4'-DDT	**WOCE**	**2**	**26**	**0.026**	**2.75e-02**	**0.029**	**0.0033**	**REGIV_SV**	**8.79**
4,4'-DDT	**WOCE**	**2**	**26**	**0.026**	**2.75e-02**	**0.029**	**0.00477**	**PEL**	**6.08**
4,4'-DDT	WOCE	2	26	0.026	2.75e-02	0.029	0.046	ER_M	0.63
4-Methylphenol	Intermediate Pond	1	2	0.22	1.91e-01	0.22	0.67	WS_AET	0.33
4-Methylphenol	**SWSA 5 Trib 1**	**4**	**8**	**4.9**	**1.24e+00**	**26**	**0.67**	**WS_AET**	**38.81**
Acenaphthene	**Intermediate Pond**	**2**	**3**	**0.028**	**1.30e-01**	**0.13**	**0.00671**	**TEL**	**19.37**
Acenaphthene	**Intermediate Pond**	**2**	**3**	**0.028**	**1.30e-01**	**0.13**	**0.016**	**ER_L**	**8.13**
Acenaphthene	**Intermediate Pond**	**2**	**3**	**0.028**	**1.30e-01**	**0.13**	**0.0889**	**PEL**	**1.46**
Acenaphthene	Intermediate Pond	2	3	0.028	1.30e-01	0.13	0.33	REGIV_SV	0.39
Acenaphthene	Intermediate Pond	2	3	0.028	1.30e-01	0.13	0.5	ER_M	0.26
Acenaphthene	Intermediate Pond	2	3	0.028	1.30e-01	0.13	1.3	EPASQC01	0.10
Acenaphthene	Intermediate Pond	2	3	0.028	1.30e-01	0.13	5.314	EQPCVF1	0.02
Acenaphthene	Intermediate Pond	2	3	0.028	1.30e-01	0.13	16.3	EQPCVI1	0.01
Acenaphthene	Intermediate Pond	2	3	0.028	1.30e-01	0.13	477.222	EQPCVD1	0.00
Acenaphthene	**Pit 4 South**	**1**	**2**	**0.022**	**5.93e-02**	**0.022**	**0.00671**	**TEL**	**3.28**
Acenaphthene	**Pit 4 South**	**1**	**2**	**0.022**	**5.93e-02**	**0.022**	**0.016**	**ER_L**	**1.38**

Table 4.6. (continued)

Analyte	Subbasin	Dets.	Obs.	Min Det.	Median	Max Det.	Benchmark Value	Benchmark Name	HQ
Acenaphthene	Pit 4 South	1	2	0.022	5.93e-02	0.022	0.0889	PEL	0.25
Acenaphthene	Pit 4 South	1	2	0.022	5.93e-02	0.022	0.33	REGIV_SV	0.07
Acenaphthene	Pit 4 South	1	2	0.022	5.93e-02	0.022	0.5	ER_M	0.04
Acenaphthene	Pit 4 South	1	2	0.022	5.93e-02	0.022	1.3	EPASQC01	0.02
Acenaphthene	Pit 4 South	1	2	0.022	5.93e-02	0.022	5.314	EQPCVF1	0.00
Acenaphthene	Pit 4 South	1	2	0.022	5.93e-02	0.022	16.3	EQPCVI1	0.00
Acenaphthene	Pit 4 South	1	2	0.022	5.93e-02	0.022	477.222	EQPCVD1	0.00
Acenaphthene	**WOC**	**1**	**1**	**0.54**		**0.54**	**0.00671**	**TEL**	**80.48**
Acenaphthene	**WOC**	**1**	**1**	**0.54**		**0.54**	**0.016**	**ER_L**	**33.75**
Acenaphthene	**WOC**	**1**	**1**	**0.54**		**0.54**	**0.0889**	**PEL**	**6.07**
Acenaphthene	**WOC**	**1**	**1**	**0.54**		**0.54**	**0.33**	**REGIV_SV**	**1.64**
Acenaphthene	**WOC**	**1**	**1**	**0.54**		**0.54**	**0.5**	**ER_M**	**1.08**
Acenaphthene	WOC	1	1	0.54		0.54	1.3	EPASQC01	0.42
Acenaphthene	WOC	1	1	0.54		0.54	5.314	EQPCVF1	0.10
Acenaphthene	WOC	1	1	0.54		0.54	16.3	EQPCVI1	0.03
Acenaphthene	WOC	1	1	0.54		0.54	477.222	EQPCVD1	0.00
Acetone	**SWSA 5 Trib 1**	**9**	**17**	**0.38**	**5.50e-01**	**4.9**	**0.00877**	**EQPSCV1**	**558.72**
Acetone	**SWSA 5 Trib 1**	**9**	**17**	**0.38**	**5.50e-01**	**4.9**	**0.00912**	**EQPCVD1**	**537.28**
Acetone	**SWSA 5 Trib 1**	**9**	**17**	**0.38**	**5.50e-01**	**4.9**	**2.968**	**EQPCVF1**	**1.65**
Acetone	**SWSA 5 WOC**	**2**	**3**	**0.23**	**2.30e-01**	**0.48**	**0.00877**	**EQPSCV1**	**54.73**
Acetone	**SWSA 5 WOC**	**2**	**3**	**0.23**	**2.30e-01**	**0.48**	**0.00912**	**EQPCVD1**	**52.63**
Acetone	SWSA 5 WOC	2	3	0.23	2.30e-01	0.48	2.968	EQPCVF1	0.16
Acetone	**SWSA 5 Drain. D-2**	**1**	**4**	**0.64**	**2.75e-02**	**0.64**	**0.00877**	**EQPSCV1**	**72.98**
Acetone	**SWSA 5 Drain. D-2**	**1**	**4**	**0.64**	**2.75e-02**	**0.64**	**0.00912**	**EQPCVD1**	**70.18**
Acetone	SWSA 5 Drain. D-2	1	4	0.64	2.75e-02	0.64	2.968	EQPCVF1	0.22
alpha-BHC	**Lower WOC**	**1**	**14**	**0.019**	**3.08e-01**	**0.019**	**0.006**	**MOE_LEL**	**3.17**
alpha-BHC	Lower WOC	1	14	0.019	3.08e-01	0.019	0.1	MOE_SEL	0.19
alpha-BHC	**WOC**	**2**	**6**	**0.063**	**1.65e-03**	**0.063**	**0.006**	**MOE_LEL**	**10.50**
alpha-BHC	WOC	2	6	0.063	1.65e-03	0.063	0.1	MOE_SEL	0.63
Anthracene	**Intermediate Pond**	**2**	**3**	**0.034**	**1.65e-01**	**0.22**	**0.0269**	**EQPCVF1**	**8.18**
Anthracene	**Intermediate Pond**	**2**	**3**	**0.034**	**1.65e-01**	**0.22**	**0.0469**	**TEL**	**4.69**
Anthracene	**Intermediate Pond**	**2**	**3**	**0.034**	**1.65e-01**	**0.22**	**0.085**	**ER_L**	**2.59**
Anthracene	**Intermediate Pond**	**2**	**3**	**0.034**	**1.65e-01**	**0.22**	**0.218**	**EQPSCV1**	**1.01**
Anthracene	Intermediate Pond	2	3	0.034	1.65e-01	0.22	0.245	PEL	0.90
Anthracene	Intermediate Pond	2	3	0.034	1.65e-01	0.22	0.33	REGIV_SV	0.67
Anthracene	Intermediate Pond	2	3	0.034	1.65e-01	0.22	0.628	EQPCVD1	0.35
Anthracene	Intermediate Pond	2	3	0.034	1.65e-01	0.22	1.1	ER_M	0.20
Anthracene	**Pit 4 South**	**1**	**2**	**0.04**	**8.00e-02**	**0.04**	**0.0269**	**EQPCVF1**	**1.49**
Anthracene	Pit 4 South	1	2	0.04	8.00e-02	0.04	0.0469	TEL	0.85
Anthracene	Pit 4 South	1	2	0.04	8.00e-02	0.04	0.085	ER_L	0.47
Anthracene	Pit 4 South	1	2	0.04	8.00e-02	0.04	0.218	EQPSCV1	0.18
Anthracene	Pit 4 South	1	2	0.04	8.00e-02	0.04	0.245	PEL	0.16
Anthracene	Pit 4 South	1	2	0.04	8.00e-02	0.04	0.33	REGIV_SV	0.12
Anthracene	Pit 4 South	1	2	0.04	8.00e-02	0.04	0.628	EQPCVD1	0.06
Anthracene	Pit 4 South	1	2	0.04	8.00e-02	0.04	1.1	ER_M	0.04

Table 4.6. (continued)

Analyte	Subbasin	Dets.	Obs.	Min Det.	Median	Max Det.	Benchmark Value	Benchmark Name	HQ
Anthracene	**WOC**	**1**	**1**	**0.46**		**0.46**	**0.0269**	**EQPCVF1**	**17.10**
Anthracene	**WOC**	**1**	**1**	**0.46**		**0.46**	**0.0469**	**TEL**	**9.81**
Anthracene	**WOC**	**1**	**1**	**0.46**		**0.46**	**0.085**	**ER_L**	**5.41**
Anthracene	**WOC**	**1**	**1**	**0.46**		**0.46**	**0.218**	**EQPSCV1**	**2.11**
Anthracene	**WOC**	**1**	**1**	**0.46**		**0.46**	**0.245**	**PEL**	**1.88**
Anthracene	**WOC**	**1**	**1**	**0.46**		**0.46**	**0.33**	**REGIV_SV**	**1.39**
Anthracene	WOC	1	1	0.46		0.46	0.628	EQPCVD1	0.73
Anthracene	WOC	1	1	0.46		0.46	1.1	ER_M	0.42
Benz(a)anthracene	**Intermediate Pond**	**3**	**3**	**0.019**	**1.30e-01**	**0.67**	**0.0748**	**TEL**	**8.96**
Benz(a)anthracene	**Intermediate Pond**	**3**	**3**	**0.019**	**1.30e-01**	**0.67**	**0.109**	**EQPSCV1**	**6.15**
Benz(a)anthracene	**Intermediate Pond**	**3**	**3**	**0.019**	**1.30e-01**	**0.67**	**0.26**	**ER_L**	**2.58**
Benz(a)anthracene	**Intermediate Pond**	**3**	**3**	**0.019**	**1.30e-01**	**0.67**	**0.33**	**REGIV_SV**	**2.03**
Benz(a)anthracene	Intermediate Pond	3	3	0.019	1.30e-01	0.67	0.693	PEL	0.97
Benz(a)anthracene	Intermediate Pond	3	3	0.019	1.30e-01	0.67	1.6	ER_M	0.42
Benz(a)anthracene	Intermediate Pond	3	3	0.019	1.30e-01	0.67	2.623	EQPCVD1	0.26
Benz(a)anthracene	Pit 4 South	1	2	0.032	7.16e-02	0.032	0.0748	TEL	0.43
Benz(a)anthracene	Pit 4 South	1	2	0.032	7.16e-02	0.032	0.109	EQPSCV1	0.29
Benz(a)anthracene	Pit 4 South	1	2	0.032	7.16e-02	0.032	0.26	ER_L	0.12
Benz(a)anthracene	Pit 4 South	1	2	0.032	7.16e-02	0.032	0.33	REGIV_SV	0.10
Benz(a)anthracene	Pit 4 South	1	2	0.032	7.16e-02	0.032	0.693	PEL	0.05
Benz(a)anthracene	Pit 4 South	1	2	0.032	7.16e-02	0.032	1.6	ER_M	0.02
Benz(a)anthracene	Pit 4 South	1	2	0.032	7.16e-02	0.032	2.623	EQPCVD1	0.01
Benz(a)anthracene	**WOC**	**1**	**1**	**0.89**		**0.89**	**0.0748**	**TEL**	**11.90**
Benz(a)anthracene	**WOC**	**1**	**1**	**0.89**		**0.89**	**0.109**	**EQPSCV1**	**8.17**
Benz(a)anthracene	**WOC**	**1**	**1**	**0.89**		**0.89**	**0.26**	**ER_L**	**3.42**
Benz(a)anthracene	**WOC**	**1**	**1**	**0.89**		**0.89**	**0.33**	**REGIV_SV**	**2.70**
Benz(a)anthracene	**WOC**	**1**	**1**	**0.89**		**0.89**	**0.693**	**PEL**	**1.28**
Benz(a)anthracene	WOC	1	1	0.89		0.89	1.6	ER_M	0.56
Benz(a)anthracene	WOC	1	1	0.89		0.89	2.623	EQPCVD1	0.34
Benzo(a)pyrene	**Intermediate Pond**	**2**	**3**	**0.12**	**1.65e-01**	**0.55**	**0.0888**	**TEL**	**6.19**
Benzo(a)pyrene	**Intermediate Pond**	**2**	**3**	**0.12**	**1.65e-01**	**0.55**	**0.143**	**EQPSCV1**	**3.85**
Benzo(a)pyrene	**Intermediate Pond**	**2**	**3**	**0.12**	**1.65e-01**	**0.55**	**0.33**	**REGIV_SV**	**1.67**
Benzo(a)pyrene	**Intermediate Pond**	**2**	**3**	**0.12**	**1.65e-01**	**0.55**	**0.43**	**ER_L**	**1.28**
Benzo(a)pyrene	Intermediate Pond	2	3	0.12	1.65e-01	0.55	0.763	PEL	0.72
Benzo(a)pyrene	Intermediate Pond	2	3	0.12	1.65e-01	0.55	1.6	ER_M	0.34
Benzo(a)pyrene	Intermediate Pond	2	3	0.12	1.65e-01	0.55	3.062	EQPCVD1	0.18
Benzo(a)pyrene	Pit 4 South	1	2	0.036	7.59e-02	0.036	0.0888	TEL	0.41
Benzo(a)pyrene	Pit 4 South	1	2	0.036	7.59e-02	0.036	0.143	EQPSCV1	0.25
Benzo(a)pyrene	Pit 4 South	1	2	0.036	7.59e-02	0.036	0.33	REGIV_SV	0.11
Benzo(a)pyrene	Pit 4 South	1	2	0.036	7.59e-02	0.036	0.43	ER_L	0.08
Benzo(a)pyrene	Pit 4 South	1	2	0.036	7.59e-02	0.036	0.763	PEL	0.05
Benzo(a)pyrene	Pit 4 South	1	2	0.036	7.59e-02	0.036	1.6	ER_M	0.02
Benzo(a)pyrene	Pit 4 South	1	2	0.036	7.59e-02	0.036	3.062	EQPCVD1	0.01
Benzo(a)pyrene	**WOC**	**1**	**1**	**0.83**		**0.83**	**0.0888**	**TEL**	**9.35**
Benzo(a)pyrene	**WOC**	**1**	**1**	**0.83**		**0.83**	**0.143**	**EQPSCV1**	**5.80**

Table 4.6. (continued)

Analyte	Subbasin	Dets.	Obs.	Min Det.	Median	Max Det.	Benchmark Value	Benchmark Name	HQ
Benzo(a)pyrene	**WOC**	**1**	**1**	**0.83**		**0.83**	**0.33**	**REGIV_SV**	**2.52**
Benzo(a)pyrene	**WOC**	**1**	**1**	**0.83**		**0.83**	**0.43**	**ER_L**	**1.93**
Benzo(a)pyrene	**WOC**	**1**	**1**	**0.83**		**0.83**	**0.763**	**PEL**	**1.09**
Benzo(a)pyrene	WOC	1	1	0.83		0.83	1.6	ER_M	0.52
Benzo(a)pyrene	WOC	1	1	0.83		0.83	3.062	EQPCVD1	0.27
Benzo(a)pyrene	**WOCE**	**9**	**47**	**0.32**	**1.00e+00**	**0.6**	**0.0888**	**TEL**	**6.76**
Benzo(a)pyrene	**WOCE**	**9**	**47**	**0.32**	**1.00e+00**	**0.6**	**0.143**	**EQPSCV1**	**4.20**
Benzo(a)pyrene	**WOCE**	**9**	**47**	**0.32**	**1.00e+00**	**0.6**	**0.33**	**REGIV_SV**	**1.82**
Benzo(a)pyrene	**WOCE**	**9**	**47**	**0.32**	**1.00e+00**	**0.6**	**0.43**	**ER_L**	**1.40**
Benzo(a)pyrene	WOCE	9	47	0.32	1.00e+00	0.6	0.763	PEL	0.79
Benzo(a)pyrene	WOCE	9	47	0.32	1.00e+00	0.6	1.6	ER_M	0.38
Benzo(a)pyrene	WOCE	9	47	0.32	1.00e+00	0.6	3.062	EQPCVD1	0.20
Bis(2-ethylhexyl)phthalate	**Intermediate Pond**	**3**	**3**	**0.078**	**3.20e-01**	**0.6**	**0.182**	**REGIV_SV**	**3.30**
Bis(2-ethylhexyl)phthalate	**Intermediate Pond**	**3**	**3**	**0.078**	**3.20e-01**	**0.6**	**0.182**	**TEL**	**3.30**
Bis(2-ethylhexyl)phthalate	Intermediate Pond	3	3	0.078	3.20e-01	0.6	2.647	PEL	0.23
Bis(2-ethylhexyl)phthalate	Intermediate Pond	3	3	0.078	3.20e-01	0.6	892.732	EQPAWQC1	0.00
Bis(2-ethylhexyl)phthalate	Pit 4 South	2	2	0.05	6.82e-02	0.093	0.182	REGIV_SV	0.51
Bis(2-ethylhexyl)phthalate	Pit 4 South	2	2	0.05	6.82e-02	0.093	0.182	TEL	0.51
Bis(2-ethylhexyl)phthalate	Pit 4 South	2	2	0.05	6.82e-02	0.093	2.647	PEL	0.04
Bis(2-ethylhexyl)phthalate	Pit 4 South	2	2	0.05	6.82e-02	0.093	892.732	EQPAWQC1	0.00
Bis(2-ethylhexyl)phthalate	**SWSA 5 Trib 1**	**2**	**8**	**0.74**	**4.83e-01**	**1**	**0.182**	**REGIV_SV**	**5.49**
Bis(2-ethylhexyl)phthalate	**SWSA 5 Trib 1**	**2**	**8**	**0.74**	**4.83e-01**	**1**	**0.182**	**TEL**	**5.49**
Bis(2-ethylhexyl)phthalate	SWSA 5 Trib 1	2	8	0.74	4.83e-01	1	2.647	PEL	0.38
Bis(2-ethylhexyl)phthalate	SWSA 5 Trib 1	2	8	0.74	4.83e-01	1	892.732	EQPAWQC1	0.00
bis(2-Ethylhexyl)phthalate	**WOC**	**1**	**1**	**2.5**		**2.5**	**0.182**	**REGIV_SV**	**13.74**
bis(2-Ethylhexyl)phthalate	**WOC**	**1**	**1**	**2.5**		**2.5**	**0.182**	**TEL**	**13.74**
bis(2-Ethylhexyl)phthalate	WOC	1	1	2.5		2.5	2.647	PEL	0.94
bis(2-Ethylhexyl)phthalate	WOC	1	1	2.5		2.5	892.732	EQPAWQC1	0.00
Bis(2-ethylhexyl)phthalate	**WOCE**	**10**	**45**	**0.12**	**1.00e+00**	**0.71**	**0.182**	**REGIV_SV**	**3.90**
Bis(2-ethylhexyl)phthalate	**WOCE**	**10**	**45**	**0.12**	**1.00e+00**	**0.71**	**0.182**	**TEL**	**3.90**
Bis(2-ethylhexyl)phthalate	WOCE	10	45	0.12	1.00e+00	0.71	2.647	PEL	0.27
Bis(2-ethylhexyl)phthalate	WOCE	10	45	0.12	1.00e+00	0.71	892.732	EQPAWQC1	0.00
Carbon disulfide	**SEEP A**	**1**	**1**	**0.002**		**0.002**	**0.00086**	**EQPSCV1**	**2.34**
Carbon disulfide	SEEP A	1	1	0.002		0.002	0.227	EQPCVD1	0.01
Carbon disulfide	SEEP A	1	1	0.002		0.002	8.877	EQPCVF1	0.00
Chrysene	**Intermediate Pond**	**3**	**3**	**0.027**	**1.90e-01**	**0.76**	**0.108**	**TEL**	**7.04**
Chrysene	**Intermediate Pond**	**3**	**3**	**0.027**	**1.90e-01**	**0.76**	**0.33**	**REGIV_SV**	**2.30**
Chrysene	**Intermediate Pond**	**3**	**3**	**0.027**	**1.90e-01**	**0.76**	**0.38**	**ER_L**	**2.00**
Chrysene	Intermediate Pond	3	3	0.027	1.90e-01	0.76	0.846	PEL	0.90
Chrysene	Intermediate Pond	3	3	0.027	1.90e-01	0.76	2.8	ER_M	0.27
Chrysene	Pit 4 South	1	2	0.035	7.48e-02	0.035	0.108	TEL	0.32
Chrysene	Pit 4 South	1	2	0.035	7.48e-02	0.035	0.33	REGIV_SV	0.11
Chrysene	Pit 4 South	1	2	0.035	7.48e-02	0.035	0.38	ER_L	0.09
Chrysene	Pit 4 South	1	2	0.035	7.48e-02	0.035	0.846	PEL	0.04
Chrysene	Pit 4 South	1	2	0.035	7.48e-02	0.035	2.8	ER_M	0.01

Table 4.6. (continued)

Analyte	Subbasin	Dets.	Obs.	Min Det.	Median	Max Det.	Benchmark Value	Benchmark Name	HQ
Chrysene	**WOCE**	**3**	**42**	**0.12**	**1.20e+00**	**0.15**	**0.108**	**TEL**	**1.39**
Chrysene	WOCE	3	42	0.12	1.20e+00	0.15	0.33	REGIV_SV	0.45
Chrysene	WOCE	3	42	0.12	1.20e+00	0.15	0.38	ER_L	0.39
Chrysene	WOCE	3	42	0.12	1.20e+00	0.15	0.846	PEL	0.18
Chrysene	WOCE	3	42	0.12	1.20e+00	0.15	2.8	ER_M	0.05
Di-n-butylphthalate	Intermediate Pond	3	3	0.23	3.90e-01	0.42	11.981	EQPSCV1	0.04
Di-n-butylphthalate	Intermediate Pond	3	3	0.23	3.90e-01	0.42	238.596	EQPCVD1	0.00
Di-n-butylphthalate	Intermediate Pond	3	3	0.23	3.90e-01	0.42	254.442	EQPCVF1	0.00
Di-n-butylphthalate	**Lower WOC**	**3**	**12**	**60**	**5.00e+00**	**120**	**11.981**	**EQPSCV1**	**10.02**
Di-n-butylphthalate	Lower WOC	3	12	60	5.00e+00	120	238.596	EQPCVD1	0.50
Di-n-butylphthalate	Lower WOC	3	12	60	5.00e+00	120	254.442	EQPCVF1	0.47
Di-n-butylphthalate	Pit 4 South	2	2	0.24	3.36e-01	0.47	11.981	EQPSCV1	0.04
Di-n-butylphthalate	Pit 4 South	2	2	0.24	3.36e-01	0.47	238.596	EQPCVD1	0.00
Di-n-butylphthalate	Pit 4 South	2	2	0.24	3.36e-01	0.47	254.442	EQPCVF1	0.00
Dibenz(a,h)anthracene	**Intermediate Pond**	**1**	**2**	**0.24**	**1.99e-01**	**0.24**	**0.00622**	**TEL**	**38.59**
Dibenz(a,h)anthracene	**Intermediate Pond**	**1**	**2**	**0.24**	**1.99e-01**	**0.24**	**0.063**	**ER_L**	**3.81**
Dibenz(a,h)anthracene	**Intermediate Pond**	**1**	**2**	**0.24**	**1.99e-01**	**0.24**	**0.135**	**PEL**	**1.78**
Dibenz(a,h)anthracene	Intermediate Pond	1	2	0.24	1.99e-01	0.24	0.26	ER_M	0.92
Dibenz(a,h)anthracene	Intermediate Pond	1	2	0.24	1.99e-01	0.24	0.33	REGIV_SV	0.73
Dibenzofuran	Intermediate Pond	1	2	0.067	1.05e-01	0.067	0.418	EQPSCV1	0.16
Dibenzofuran	Intermediate Pond	1	2	0.067	1.05e-01	0.067	113.256	EQPCVD1	0.00
Dibenzofuran	Pit 4 South	1	2	0.066	1.03e-01	0.066	0.418	EQPSCV1	0.16
Dibenzofuran	Pit 4 South	1	2	0.066	1.03e-01	0.066	113.256	EQPCVD1	0.00
Dibenzofuran	**WOC**	**1**	**1**	**0.43**		**0.43**	**0.418**	**EQPSCV1**	**1.03**
Dibenzofuran	WOC	1	1	0.43		0.43	113.256	EQPCVD1	0.00
Diethylphthalate	**Lower WOC**	**2**	**11**	**51**	**5.00e+00**	**58**	**0.606**	**EQPSCV1**	**95.71**
Diethylphthalate	WOCE	1	40	0.14	1.22e+00	0.14	0.606	EQPSCV1	0.23
Endosulfan sulfate	**WOCE**	**2**	**26**	**0.029**	**2.95e-02**	**0.03**	**0.0055**	**EQPSCV1**	**5.45**
Fluoranthene	**Intermediate Pond**	**3**	**3**	**0.047**	**3.70e-01**	**1.4**	**0.113**	**TEL**	**12.39**
Fluoranthene	**Intermediate Pond**	**3**	**3**	**0.047**	**3.70e-01**	**1.4**	**0.33**	**REGIV_SV**	**4.24**
Fluoranthene	**Intermediate Pond**	**3**	**3**	**0.047**	**3.70e-01**	**1.4**	**0.6**	**ER_L**	**2.33**
Fluoranthene	Intermediate Pond	3	3	0.047	3.70e-01	1.4	1.494	PEL	0.94
Fluoranthene	Intermediate Pond	3	3	0.047	3.70e-01	1.4	5.1	ER_M	0.27
Fluoranthene	Intermediate Pond	3	3	0.047	3.70e-01	1.4	6.2	EPASQC01	0.23
Fluoranthene	Intermediate Pond	3	3	0.047	3.70e-01	1.4	16.287	EQPCVD1	0.09
Fluoranthene	Intermediate Pond	3	3	0.047	3.70e-01	1.4	32.575	EQPCVF1	0.04
Fluoranthene	**Pit 4 South**	**2**	**2**	**0.027**	**5.69e-02**	**0.12**	**0.113**	**TEL**	**1.06**
Fluoranthene	Pit 4 South	2	2	0.027	5.69e-02	0.12	0.33	REGIV_SV	0.36
Fluoranthene	Pit 4 South	2	2	0.027	5.69e-02	0.12	0.6	ER_L	0.20
Fluoranthene	Pit 4 South	2	2	0.027	5.69e-02	0.12	1.494	PEL	0.08
Fluoranthene	Pit 4 South	2	2	0.027	5.69e-02	0.12	5.1	ER_M	0.02
Fluoranthene	Pit 4 South	2	2	0.027	5.69e-02	0.12	6.2	EPASQC01	0.02
Fluoranthene	Pit 4 South	2	2	0.027	5.69e-02	0.12	16.287	EQPCVD1	0.01
Fluoranthene	Pit 4 South	2	2	0.027	5.69e-02	0.12	32.575	EQPCVF1	0.00
Fluoranthene	**WOCE**	**5**	**44**	**0.11**	**1.17e+00**	**0.2**	**0.113**	**TEL**	**1.77**

Table 4.6. (continued)

Analyte	Subbasin	Dets.	Obs.	Min Det.	Median	Max Det.	Benchmark Value	Benchmark Name	HQ
Fluoranthene	WOCE	5	44	0.11	1.17e+00	0.2	0.33	REGIV_SV	0.61
Fluoranthene	WOCE	5	44	0.11	1.17e+00	0.2	0.6	ER_L	0.33
Fluoranthene	WOCE	5	44	0.11	1.17e+00	0.2	1.494	PEL	0.13
Fluoranthene	WOCE	5	44	0.11	1.17e+00	0.2	5.1	ER_M	0.04
Fluoranthene	WOCE	5	44	0.11	1.17e+00	0.2	6.2	EPASQC01	0.03
Fluoranthene	WOCE	5	44	0.11	1.17e+00	0.2	16.287	EQPCVD1	0.01
Fluoranthene	WOCE	5	44	0.11	1.17e+00	0.2	32.575	EQPCVF1	0.01
Fluorene	**Intermediate Pond**	**2**	**3**	**0.038**	**1.40e-01**	**0.14**	**0.019**	**ER_L**	**7.37**
Fluorene	**Intermediate Pond**	**2**	**3**	**0.038**	**1.40e-01**	**0.14**	**0.0212**	**TEL**	**6.60**
Fluorene	Intermediate Pond	2	3	0.038	1.40e-01	0.14	0.144	PEL	0.97
Fluorene	Intermediate Pond	2	3	0.038	1.40e-01	0.14	0.33	REGIV_SV	0.42
Fluorene	Intermediate Pond	2	3	0.038	1.40e-01	0.14	0.54	EQPSCV1	0.26
Fluorene	Intermediate Pond	2	3	0.038	1.40e-01	0.14	0.54	ER_M	0.26
Fluorene	**Pit 4 South**	**1**	**2**	**0.096**	**1.24e-01**	**0.096**	**0.019**	**ER_L**	**5.05**
Fluorene	**Pit 4 South**	**1**	**2**	**0.096**	**1.24e-01**	**0.096**	**0.0212**	**TEL**	**4.53**
Fluorene	Pit 4 South	1	2	0.096	1.24e-01	0.096	0.144	PEL	0.67
Fluorene	Pit 4 South	1	2	0.096	1.24e-01	0.096	0.33	REGIV_SV	0.29
Fluorene	Pit 4 South	1	2	0.096	1.24e-01	0.096	0.54	EQPSCV1	0.18
Fluorene	Pit 4 South	1	2	0.096	1.24e-01	0.096	0.54	ER_M	0.18
Methylene chloride	**Lower WOC**	**25**	**27**	**0.012**	**6.40e-02**	**1.212**	**0.375**	**EQPSCV1**	**3.23**
Methylene chloride	Lower WOC	25	27	0.012	6.40e-02	1.212	7.272	EQPCVD1	0.17
Methylene chloride	Lower WOC	25	27	0.012	6.40e-02	1.212	18.407	EQPCVF1	0.07
Methylene chloride	SEEP A	1	2	0.01	9.49e-03	0.01	0.375	EQPSCV1	0.03
Methylene chloride	SEEP A	1	2	0.01	9.49e-03	0.01	7.272	EQPCVD1	0.00
Methylene chloride	SEEP A	1	2	0.01	9.49e-03	0.01	18.407	EQPCVF1	0.00
Methylene chloride	SWSA 5 Trib 1	7	23	0.01	1.85e-02	0.01	0.375	EQPSCV1	0.03
Methylene chloride	SWSA 5 Trib 1	7	23	0.01	1.85e-02	0.01	7.272	EQPCVD1	0.00
Methylene chloride	SWSA 5 Trib 1	7	23	0.01	1.85e-02	0.01	18.407	EQPCVF1	0.00
Methylene chloride	SWSA 5 Drain. D-2	4	8	0.01	1.38e-02	0.01	0.375	EQPSCV1	0.03
Methylene chloride	SWSA 5 Drain. D-2	4	8	0.01	1.38e-02	0.01	7.272	EQPCVD1	0.00
Methylene chloride	SWSA 5 Drain. D-2	4	8	0.01	1.38e-02	0.01	18.407	EQPCVF1	0.00
Naphthalene	**Intermediate Pond**	**2**	**3**	**0.029**	**4.10e-02**	**0.041**	**0.0346**	**TEL**	**1.18**
Naphthalene	Intermediate Pond	2	3	0.029	4.10e-02	0.041	0.16	ER_L	0.26
Naphthalene	Intermediate Pond	2	3	0.029	4.10e-02	0.041	0.242	EQPSCV1	0.17
Naphthalene	Intermediate Pond	2	3	0.029	4.10e-02	0.041	0.33	REGIV_SV	0.12
Naphthalene	Intermediate Pond	2	3	0.029	4.10e-02	0.041	0.391	PEL	0.10
Naphthalene	Intermediate Pond	2	3	0.029	4.10e-02	0.041	2.1	ER_M	0.02
Naphthalene	Intermediate Pond	2	3	0.029	4.10e-02	0.041	12.533	EQPCVF1	0.00
Naphthalene	Intermediate Pond	2	3	0.029	4.10e-02	0.041	23.51	EQPCVD1	0.00
Naphthalene	Pit 4 South	1	2	0.031	7.04e-02	0.031	0.0346	TEL	0.90
Naphthalene	Pit 4 South	1	2	0.031	7.04e-02	0.031	0.16	ER_L	0.19
Naphthalene	Pit 4 South	1	2	0.031	7.04e-02	0.031	0.242	EQPSCV1	0.13
Naphthalene	Pit 4 South	1	2	0.031	7.04e-02	0.031	0.33	REGIV_SV	0.09
Naphthalene	Pit 4 South	1	2	0.031	7.04e-02	0.031	0.391	PEL	0.08
Naphthalene	Pit 4 South	1	2	0.031	7.04e-02	0.031	2.1	ER_M	0.01

Table 4.6. (continued)

Analyte	Subbasin	Dets.	Obs.	Min Det.	Median	Max Det.	Benchmark Value	Benchmark Name	HQ
Naphthalene	Pit 4 South	1	2	0.031	7.04e-02	0.031	12.533	EQPCVF1	0.00
Naphthalene	Pit 4 South	1	2	0.031	7.04e-02	0.031	23.51	EQPCVD1	0.00
Naphthalene	SEEP A	1	3	0.01	2.85e-01	0.01	0.0346	TEL	0.29
Naphthalene	SEEP A	1	3	0.01	2.85e-01	0.01	0.16	ER_L	0.06
Naphthalene	SEEP A	1	3	0.01	2.85e-01	0.01	0.242	EQPSCV1	0.04
Naphthalene	SEEP A	1	3	0.01	2.85e-01	0.01	0.33	REGIV_SV	0.03
Naphthalene	SEEP A	1	3	0.01	2.85e-01	0.01	0.391	PEL	0.03
Naphthalene	SEEP A	1	3	0.01	2.85e-01	0.01	2.1	ER_M	0.00
Naphthalene	SEEP A	1	3	0.01	2.85e-01	0.01	12.533	EQPCVF1	0.00
Naphthalene	SEEP A	1	3	0.01	2.85e-01	0.01	23.51	EQPCVD1	0.00
Naphthalene	SWSA 5 Trib 1	12	20	0.003	1.00e-02	0.01	0.0346	TEL	0.29
Naphthalene	SWSA 5 Trib 1	12	20	0.003	1.00e-02	0.01	0.16	ER_L	0.06
Naphthalene	SWSA 5 Trib 1	12	20	0.003	1.00e-02	0.01	0.242	EQPSCV1	0.04
Naphthalene	SWSA 5 Trib 1	12	20	0.003	1.00e-02	0.01	0.33	REGIV_SV	0.03
Naphthalene	SWSA 5 Trib 1	12	20	0.003	1.00e-02	0.01	0.391	PEL	0.03
Naphthalene	SWSA 5 Trib 1	12	20	0.003	1.00e-02	0.01	2.1	ER_M	0.00
Naphthalene	SWSA 5 Trib 1	12	20	0.003	1.00e-02	0.01	12.533	EQPCVF1	0.00
Naphthalene	SWSA 5 Trib 1	12	20	0.003	1.00e-02	0.01	23.51	EQPCVD1	0.00
Naphthalene	WG5 MID. Drn	4	8	0.01	8.06e-02	0.01	0.0346	TEL	0.29
Naphthalene	WG5 MID. Drn	4	8	0.01	8.06e-02	0.01	0.16	ER_L	0.06
Naphthalene	WG5 MID. Drn	4	8	0.01	8.06e-02	0.01	0.242	EQPSCV1	0.04
Naphthalene	WG5 MID. Drn	4	8	0.01	8.06e-02	0.01	0.33	REGIV_SV	0.03
Naphthalene	WG5 MID. Drn	4	8	0.01	8.06e-02	0.01	0.391	PEL	0.03
Naphthalene	WG5 MID. Drn	4	8	0.01	8.06e-02	0.01	2.1	ER_M	0.00
Naphthalene	WG5 MID. Drn	4	8	0.01	8.06e-02	0.01	12.533	EQPCVF1	0.00
Naphthalene	WG5 MID. Drn	4	8	0.01	8.06e-02	0.01	23.51	EQPCVD1	0.00
PAH, total	**Intermediate Pond**	**16**	**18**	**0.991**	**2.77e+00**	**8.619**	**1.684**	**REGIV_SV**	**5.12**
PAH, total	**Intermediate Pond**	**16**	**18**	**0.991**	**2.77e+00**	**8.619**	**1.684**	**TEL**	**5.12**
PAH, total	**Intermediate Pond**	**16**	**18**	**0.991**	**2.77e+00**	**8.619**	**2**	**MOE_LEL**	**4.31**
PAH, total	**Intermediate Pond**	**16**	**18**	**0.991**	**2.77e+00**	**8.619**	**4.022**	**ER_L**	**2.14**
PAH, total	Intermediate Pond	16	18	0.991	2.77e+00	8.619	16.77	PEL	0.51
PAH, total	Intermediate Pond	16	18	0.991	2.77e+00	8.619	44.792	ER_M	0.19
PAH, total	Intermediate Pond	16	18	0.991	2.77e+00	8.619	110	MOE_SEL	0.08
PAH, total	Pit 4 South	12	18	0.563	8.84e-01	0.744	1.684	REGIV_SV	0.44
PAH, total	Pit 4 South	12	18	0.563	8.84e-01	0.744	1.684	TEL	0.44
PAH, total	Pit 4 South	12	18	0.563	8.84e-01	0.744	2	MOE_LEL	0.37
PAH, total	Pit 4 South	12	18	0.563	8.84e-01	0.744	4.022	ER_L	0.18
PAH, total	Pit 4 South	12	18	0.563	8.84e-01	0.744	16.77	PEL	0.04
PAH, total	Pit 4 South	12	18	0.563	8.84e-01	0.744	44.792	ER_M	0.02
PAH, total	Pit 4 South	12	18	0.563	8.84e-01	0.744	110	MOE_SEL	0.01
PAH, total	SEEP A	1	18	0.01	2.85e-01	0.01	1.684	REGIV_SV	0.01
PAH, total	SEEP A	1	18	0.01	2.85e-01	0.01	1.684	TEL	0.01
PAH, total	SEEP A	1	18	0.01	2.85e-01	0.01	2	MOE_LEL	0.01
PAH, total	SEEP A	1	18	0.01	2.85e-01	0.01	4.022	ER_L	0.00
PAH, total	SEEP A	1	18	0.01	2.85e-01	0.01	16.77	PEL	0.00

Table 4.6. (continued)

Analyte	Subbasin	Dets.	Obs.	Min Det.	Median	Max Det.	Benchmark Value	Benchmark Name	HQ
PAH, total	SEEP A	1	18	0.01	2.85e-01	0.01	44.792	ER_M	0.00
PAH, total	SEEP A	1	18	0.01	2.85e-01	0.01	110	MOE_SEL	0.00
PAH, total	SWSA 5 Trib 1	1	18	0.003	1.00e-02	0.01	1.684	REGIV_SV	0.01
PAH, total	SWSA 5 Trib 1	1	18	0.003	1.00e-02	0.01	1.684	TEL	0.01
PAH, total	SWSA 5 Trib 1	1	18	0.003	1.00e-02	0.01	2	MOE_LEL	0.01
PAH, total	SWSA 5 Trib 1	1	18	0.003	1.00e-02	0.01	4.022	ER_L	0.00
PAH, total	SWSA 5 Trib 1	1	18	0.003	1.00e-02	0.01	16.77	PEL	0.00
PAH, total	SWSA 5 Trib 1	1	18	0.003	1.00e-02	0.01	44.792	ER_M	0.00
PAH, total	SWSA 5 Trib 1	1	18	0.003	1.00e-02	0.01	110	MOE_SEL	0.00
PAH, total	WG5 MID. Drn	1	18	0.01	8.06e-02	0.01	1.684	REGIV_SV	0.01
PAH, total	WG5 MID. Drn	1	18	0.01	8.06e-02	0.01	1.684	TEL	0.01
PAH, total	WG5 MID. Drn	1	18	0.01	8.06e-02	0.01	2	MOE_LEL	0.01
PAH, total	WG5 MID. Drn	1	18	0.01	8.06e-02	0.01	4.022	ER_L	0.00
PAH, total	WG5 MID. Drn	1	18	0.01	8.06e-02	0.01	16.77	PEL	0.00
PAH, total	WG5 MID. Drn	1	18	0.01	8.06e-02	0.01	44.792	ER_M	0.00
PAH, total	WG5 MID. Drn	1	18	0.01	8.06e-02	0.01	110	MOE_SEL	0.00
PAH, total	**WOC**	**9**	**18**	**9.37**		**9.37**	**1.684**	**REGIV_SV**	**5.56**
PAH, total	**WOC**	**9**	**18**	**9.37**		**9.37**	**1.684**	**TEL**	**5.56**
PAH, total	**WOC**	**9**	**18**	**9.37**		**9.37**	**2**	**MOE_LEL**	**4.69**
PAH, total	**WOC**	**9**	**18**	**9.37**		**9.37**	**4.022**	**ER_L**	**2.33**
PAH, total	WOC	9	18	9.37		9.37	16.77	PEL	0.56
PAH, total	WOC	9	18	9.37		9.37	44.792	ER_M	0.21
PAH, total	WOC	9	18	9.37		9.37	110	MOE_SEL	0.09
PAH, total	**WOCE**	**6**	**18**	**0.9**	**6.85e+00**	**1.69**	**1.684**	**REGIV_SV**	**1.00**
PAH, total	**WOCE**	**6**	**18**	**0.9**	**6.85e+00**	**1.69**	**1.684**	**TEL**	**1.00**
PAH, total	WOCE	6	18	0.9	6.85e+00	1.69	2	MOE_LEL	0.85
PAH, total	WOCE	6	18	0.9	6.85e+00	1.69	4.022	ER_L	0.42
PAH, total	WOCE	6	18	0.9	6.85e+00	1.69	16.77	PEL	0.10
PAH, total	WOCE	6	18	0.9	6.85e+00	1.69	44.792	ER_M	0.04
PAH, total	WOCE	6	18	0.9	6.85e+00	1.69	110	MOE_SEL	0.02
PCB-1248	**SWSA 5 Trib 1**	**2**	**8**	**0.62**	**5.51e-02**	**1.2**	**0.023**	**ER_L**	**52.17**
PCB-1248	**SWSA 5 Trib 1**	**2**	**8**	**0.62**	**5.51e-02**	**1.2**	**0.03**	**MOE_LEL**	**40.00**
PCB-1248	**SWSA 5 Trib 1**	**2**	**8**	**0.62**	**5.51e-02**	**1.2**	**0.18**	**ER_M**	**6.67**
PCB-1248	**SWSA 5 Trib 1**	**2**	**8**	**0.62**	**5.51e-02**	**1.2**	**1.014**	**EQPSCV1**	**1.18**
PCB-1248	SWSA 5 Trib 1	2	8	0.62	5.51e-02	1.2	1.5	MOE_SEL	0.80
PCB-1254	**Intermediate Pond**	**3**	**5**	**0.12**	**1.20e-01**	**0.51**	**0.023**	**ER_L**	**22.17**
PCB-1254	**Intermediate Pond**	**3**	**5**	**0.12**	**1.20e-01**	**0.51**	**0.06**	**MOE_LEL**	**8.50**
PCB-1254	**Intermediate Pond**	**3**	**5**	**0.12**	**1.20e-01**	**0.51**	**0.18**	**ER_M**	**2.83**
PCB-1254	**Intermediate Pond**	**3**	**5**	**0.12**	**1.20e-01**	**0.51**	**0.34**	**MOE_SEL**	**1.50**
PCB-1254	Intermediate Pond	3	5	0.12	1.20e-01	0.51	0.814	EQPSCV1	0.63
PCB-1254	Intermediate Pond	3	5	0.12	1.20e-01	0.51	71.564	EQPCVD1	0.01
PCB-1254	**Lower WOC**	**16**	**24**	**0.02242**	**9.75e-02**	**0.902**	**0.023**	**ER_L**	**39.22**
PCB-1254	**Lower WOC**	**16**	**24**	**0.02242**	**9.75e-02**	**0.902**	**0.06**	**MOE_LEL**	**15.03**
PCB-1254	**Lower WOC**	**16**	**24**	**0.02242**	**9.75e-02**	**0.902**	**0.18**	**ER_M**	**5.01**
PCB-1254	**Lower WOC**	**16**	**24**	**0.02242**	**9.75e-02**	**0.902**	**0.34**	**MOE_SEL**	**2.65**

Table 4.6. (continued)

Analyte	Subbasin	Dets.	Obs.	Min Det.	Median	Max Det.	Benchmark Value	Benchmark Name	HQ
PCB-1254	**Lower WOC**	**16**	**24**	**0.02242**	**9.75e-02**	**0.902**	**0.814**	**EQPSCV1**	**1.11**
PCB-1254	Lower WOC	16	24	0.02242	9.75e-02	0.902	71.564	EQPCVD1	0.01
PCB-1254	**Pit 4 South**	**1**	**2**	**0.047**	**3.53e-02**	**0.047**	**0.023**	**ER_L**	**2.04**
PCB-1254	Pit 4 South	1	2	0.047	3.53e-02	0.047	0.06	MOE_LEL	0.78
PCB-1254	Pit 4 South	1	2	0.047	3.53e-02	0.047	0.18	ER_M	0.26
PCB-1254	Pit 4 South	1	2	0.047	3.53e-02	0.047	0.34	MOE_SEL	0.14
PCB-1254	Pit 4 South	1	2	0.047	3.53e-02	0.047	0.814	EQPSCV1	0.06
PCB-1254	Pit 4 South	1	2	0.047	3.53e-02	0.047	71.564	EQPCVD1	0.00
PCB-1254	SEEP C	7	14	0.005	4.20e-02	0.022	0.023	ER_L	0.96
PCB-1254	SEEP C	7	14	0.005	4.20e-02	0.022	0.06	MOE_LEL	0.37
PCB-1254	SEEP C	7	14	0.005	4.20e-02	0.022	0.18	ER_M	0.12
PCB-1254	SEEP C	7	14	0.005	4.20e-02	0.022	0.34	MOE_SEL	0.06
PCB-1254	SEEP C	7	14	0.005	4.20e-02	0.022	0.814	EQPSCV1	0.03
PCB-1254	SEEP C	7	14	0.005	4.20e-02	0.022	71.564	EQPCVD1	0.00
PCB-1254	**SWSA 5 Trib 1**	**4**	**8**	**0.82**	**1.62e-01**	**1.5**	**0.023**	**ER_L**	**65.22**
PCB-1254	**SWSA 5 Trib 1**	**4**	**8**	**0.82**	**1.62e-01**	**1.5**	**0.06**	**MOE_LEL**	**25.00**
PCB-1254	**SWSA 5 Trib 1**	**4**	**8**	**0.82**	**1.62e-01**	**1.5**	**0.18**	**ER_M**	**8.33**
PCB-1254	**SWSA 5 Trib 1**	**4**	**8**	**0.82**	**1.62e-01**	**1.5**	**0.34**	**MOE_SEL**	**4.41**
PCB-1254	**SWSA 5 Trib 1**	**4**	**8**	**0.82**	**1.62e-01**	**1.5**	**0.814**	**EQPSCV1**	**1.84**
PCB-1254	SWSA 5 Trib 1	4	8	0.82	1.62e-01	1.5	71.564	EQPCVD1	0.02
PCB-1254	**SWSA 5 WOC**	**1**	**1**	**2.3**		**2.3**	**0.023**	**ER_L**	**100.00**
PCB-1254	**SWSA 5 WOC**	**1**	**1**	**2.3**		**2.3**	**0.06**	**MOE_LEL**	**38.33**
PCB-1254	**SWSA 5 WOC**	**1**	**1**	**2.3**		**2.3**	**0.18**	**ER_M**	**12.78**
PCB-1254	**SWSA 5 WOC**	**1**	**1**	**2.3**		**2.3**	**0.34**	**MOE_SEL**	**6.76**
PCB-1254	**SWSA 5 WOC**	**1**	**1**	**2.3**		**2.3**	**0.814**	**EQPSCV1**	**2.83**
PCB-1254	SWSA 5 WOC	1	1	2.3		2.3	71.564	EQPCVD1	0.03
PCB-1254	**WOCE**	**35**	**52**	**0.00049**	**2.17e-01**	**4.7**	**0.023**	**ER_L**	**204.35**
PCB-1254	**WOCE**	**35**	**52**	**0.00049**	**2.17e-01**	**4.7**	**0.06**	**MOE_LEL**	**78.33**
PCB-1254	**WOCE**	**35**	**52**	**0.00049**	**2.17e-01**	**4.7**	**0.18**	**ER_M**	**26.11**
PCB-1254	**WOCE**	**35**	**52**	**0.00049**	**2.17e-01**	**4.7**	**0.34**	**MOE_SEL**	**13.82**
PCB-1254	**WOCE**	**35**	**52**	**0.00049**	**2.17e-01**	**4.7**	**0.814**	**EQPSCV1**	**5.77**
PCB-1254	WOCE	35	52	0.00049	2.17e-01	4.7	71.564	EQPCVD1	0.07
PCB-1260	**Intermediate Pond**	**5**	**5**	**0.087**	**1.10e-01**	**0.41**	**0.005**	**MOE_LEL**	**82.00**
PCB-1260	**Intermediate Pond**	**5**	**5**	**0.087**	**1.10e-01**	**0.41**	**0.023**	**ER_L**	**17.83**
PCB-1260	**Intermediate Pond**	**5**	**5**	**0.087**	**1.10e-01**	**0.41**	**0.18**	**ER_M**	**2.28**
PCB-1260	**Intermediate Pond**	**5**	**5**	**0.087**	**1.10e-01**	**0.41**	**0.24**	**MOE_SEL**	**1.71**
PCB-1260	Intermediate Pond	5	5	0.087	1.10e-01	0.41	63.262	EQPCVF1	0.01
PCB-1260	Intermediate Pond	5	5	0.087	1.10e-01	0.41	4574.33	EQPSCV1	0.00
PCB-1260	**Lower WOC**	**24**	**27**	**0.026**	**2.59e-01**	**0.986**	**0.005**	**MOE_LEL**	**197.20**
PCB-1260	**Lower WOC**	**24**	**27**	**0.026**	**2.59e-01**	**0.986**	**0.023**	**ER_L**	**42.87**
PCB-1260	**Lower WOC**	**24**	**27**	**0.026**	**2.59e-01**	**0.986**	**0.18**	**ER_M**	**5.48**
PCB-1260	**Lower WOC**	**24**	**27**	**0.026**	**2.59e-01**	**0.986**	**0.24**	**MOE_SEL**	**4.11**
PCB-1260	Lower WOC	24	27	0.026	2.59e-01	0.986	63.262	EQPCVF1	0.02
PCB-1260	Lower WOC	24	27	0.026	2.59e-01	0.986	4574.33	EQPSCV1	0.00
PCB-1260	**SWSA 5 Trib 1**	**4**	**8**	**0.04**	**1.15e-01**	**0.83**	**0.005**	**MOE_LEL**	**166.00**

Table 4.6. (continued)

Analyte	Subbasin	Dets.	Obs.	Min Det.	Median	Max Det.	Benchmark Value	Benchmark Name	HQ
PCB-1260	**SWSA 5 Trib 1**	**4**	**8**	**0.04**	**1.15e-01**	**0.83**	**0.023**	**ER_L**	**36.09**
PCB-1260	**SWSA 5 Trib 1**	**4**	**8**	**0.04**	**1.15e-01**	**0.83**	**0.18**	**ER_M**	**4.61**
PCB-1260	**SWSA 5 Trib 1**	**4**	**8**	**0.04**	**1.15e-01**	**0.83**	**0.24**	**MOE_SEL**	**3.46**
PCB-1260	SWSA 5 Trib 1	4	8	0.04	1.15e-01	0.83	63.262	EQPCVF1	0.01
PCB-1260	SWSA 5 Trib 1	4	8	0.04	1.15e-01	0.83	4574.33	EQPSCV1	0.00
PCB-1260	**SWSA 5 WOC**	**1**	**1**	**0.63**		**0.63**	**0.005**	**MOE_LEL**	**126.00**
PCB-1260	**SWSA 5 WOC**	**1**	**1**	**0.63**		**0.63**	**0.023**	**ER_L**	**27.39**
PCB-1260	**SWSA 5 WOC**	**1**	**1**	**0.63**		**0.63**	**0.18**	**ER_M**	**3.50**
PCB-1260	**SWSA 5 WOC**	**1**	**1**	**0.63**		**0.63**	**0.24**	**MOE_SEL**	**2.63**
PCB-1260	SWSA 5 WOC	1	1	0.63		0.63	63.262	EQPCVF1	0.01
PCB-1260	SWSA 5 WOC	1	1	0.63		0.63	4574.33	EQPSCV1	0.00
PCB-1260	**WG5 MID. Drn**	**2**	**4**	**0.039**	**7.43e-02**	**0.085**	**0.005**	**MOE_LEL**	**17.00**
PCB-1260	**WG5 MID. Drn**	**2**	**4**	**0.039**	**7.43e-02**	**0.085**	**0.023**	**ER_L**	**3.70**
PCB-1260	WG5 MID. Drn	2	4	0.039	7.43e-02	0.085	0.18	ER_M	0.47
PCB-1260	WG5 MID. Drn	2	4	0.039	7.43e-02	0.085	0.24	MOE_SEL	0.35
PCB-1260	WG5 MID. Drn	2	4	0.039	7.43e-02	0.085	63.262	EQPCVF1	0.00
PCB-1260	WG5 MID. Drn	2	4	0.039	7.43e-02	0.085	4574.33	EQPSCV1	0.00
PCB-1260	**WOC**	**6**	**6**	**0.062**	**1.69e-01**	**0.6**	**0.005**	**MOE_LEL**	**120.00**
PCB-1260	**WOC**	**6**	**6**	**0.062**	**1.69e-01**	**0.6**	**0.023**	**ER_L**	**26.09**
PCB-1260	**WOC**	**6**	**6**	**0.062**	**1.69e-01**	**0.6**	**0.18**	**ER_M**	**3.33**
PCB-1260	**WOC**	**6**	**6**	**0.062**	**1.69e-01**	**0.6**	**0.24**	**MOE_SEL**	**2.50**
PCB-1260	WOC	6	6	0.062	1.69e-01	0.6	63.262	EQPCVF1	0.01
PCB-1260	WOC	6	6	0.062	1.69e-01	0.6	4574.33	EQPSCV1	0.00
PCB-1260	**WOCE**	**8**	**39**	**0.0021**	**1.30e-01**	**0.32**	**0.005**	**MOE_LEL**	**64.00**
PCB-1260	**WOCE**	**8**	**39**	**0.0021**	**1.30e-01**	**0.32**	**0.023**	**ER_L**	**13.91**
PCB-1260	**WOCE**	**8**	**39**	**0.0021**	**1.30e-01**	**0.32**	**0.18**	**ER_M**	**1.78**
PCB-1260	**WOCE**	**8**	**39**	**0.0021**	**1.30e-01**	**0.32**	**0.24**	**MOE_SEL**	**1.33**
PCB-1260	WOCE	8	39	0.0021	1.30e-01	0.32	63.262	EQPCVF1	0.01
PCB-1260	WOCE	8	39	0.0021	1.30e-01	0.32	4574.33	EQPSCV1	0.00
Phenanthrene	**Intermediate Pond**	**3**	**3**	**0.023**	**2.50e-01**	**0.94**	**0.0867**	**TEL**	**10.84**
Phenanthrene	**Intermediate Pond**	**3**	**3**	**0.023**	**2.50e-01**	**0.94**	**0.24**	**ER_L**	**3.92**
Phenanthrene	**Intermediate Pond**	**3**	**3**	**0.023**	**2.50e-01**	**0.94**	**0.33**	**REGIV_SV**	**2.85**
Phenanthrene	**Intermediate Pond**	**3**	**3**	**0.023**	**2.50e-01**	**0.94**	**0.544**	**PEL**	**1.73**
Phenanthrene	Intermediate Pond	3	3	0.023	2.50e-01	0.94	1.5	ER_M	0.63
Phenanthrene	Intermediate Pond	3	3	0.023	2.50e-01	0.94	1.8	EPASQC01	0.52
Phenanthrene	Intermediate Pond	3	3	0.023	2.50e-01	0.94	59.77	EQPCVD1	0.02
Phenanthrene	**Pit 4 South**	**1**	**2**	**0.17**	**1.65e-01**	**0.17**	**0.0867**	**TEL**	**1.96**
Phenanthrene	Pit 4 South	1	2	0.17	1.65e-01	0.17	0.24	ER_L	0.71
Phenanthrene	Pit 4 South	1	2	0.17	1.65e-01	0.17	0.33	REGIV_SV	0.52
Phenanthrene	Pit 4 South	1	2	0.17	1.65e-01	0.17	0.544	PEL	0.31
Phenanthrene	Pit 4 South	1	2	0.17	1.65e-01	0.17	1.5	ER_M	0.11
Phenanthrene	Pit 4 South	1	2	0.17	1.65e-01	0.17	1.8	EPASQC01	0.09
Phenanthrene	Pit 4 South	1	2	0.17	1.65e-01	0.17	59.77	EQPCVD1	0.00
Phenanthrene	**WOC**	**1**	**1**	**2.8**		**2.8**	**0.0867**	**TEL**	**32.30**
Phenanthrene	**WOC**	**1**	**1**	**2.8**		**2.8**	**0.24**	**ER_L**	**11.67**

Table 4.6. (continued)

Analyte	Subbasin	Dets.	Obs.	Min Det.	Median	Max Det.	Benchmark Value	Benchmark Name	HQ
Phenanthrene	**WOC**	**1**	**1**	**2.8**		**2.8**	**0.33**	**REGIV_SV**	**8.48**
Phenanthrene	**WOC**	**1**	**1**	**2.8**		**2.8**	**0.544**	**PEL**	**5.15**
Phenanthrene	**WOC**	**1**	**1**	**2.8**		**2.8**	**1.5**	**ER_M**	**1.87**
Phenanthrene	**WOC**	**1**	**1**	**2.8**		**2.8**	**1.8**	**EPASQC01**	**1.56**
Phenanthrene	WOC	1	1	2.8		2.8	59.77	EQPCVD1	0.05
Phenanthrene	**WOCE**	**5**	**44**	**0.14**	**1.17e+00**	**0.34**	**0.0867**	**TEL**	**3.92**
Phenanthrene	**WOCE**	**5**	**44**	**0.14**	**1.17e+00**	**0.34**	**0.24**	**ER_L**	**1.42**
Phenanthrene	**WOCE**	**5**	**44**	**0.14**	**1.17e+00**	**0.34**	**0.33**	**REGIV_SV**	**1.03**
Phenanthrene	WOCE	5	44	0.14	1.17e+00	0.34	0.544	PEL	0.63
Phenanthrene	WOCE	5	44	0.14	1.17e+00	0.34	1.5	ER_M	0.23
Phenanthrene	WOCE	5	44	0.14	1.17e+00	0.34	1.8	EPASQC01	0.19
Phenanthrene	WOCE	5	44	0.14	1.17e+00	0.34	59.77	EQPCVD1	0.01
Phenol	**SWSA 5 Trib 1**	**4**	**8**	**1.4**	**6.64e-01**	**33**	**0.032**	**EQPAWQC1**	**1031.25**
Phenol	**SWSA 5 Trib 1**	**4**	**8**	**1.4**	**6.64e-01**	**33**	**0.0574**	**EQPCVF1**	**574.91**
Phenol	**SWSA 5 Trib 1**	**4**	**8**	**1.4**	**6.64e-01**	**33**	**0.42**	**WS_AET**	**78.57**
Phenol	**SWSA 5 Trib 1**	**4**	**8**	**1.4**	**6.64e-01**	**33**	**0.575**	**EQPCVD1**	**57.39**
Polychlorinated biphenyl	**HRT-3**	**4**	**4**	**0.012**	**7.92e-02**	**0.39**	**0.0216**	**TEL**	**18.06**
Polychlorinated biphenyl	**HRT-3**	**4**	**4**	**0.012**	**7.92e-02**	**0.39**	**0.023**	**ER_L**	**16.96**
Polychlorinated biphenyl	**HRT-3**	**4**	**4**	**0.012**	**7.92e-02**	**0.39**	**0.033**	**REGIV_SV**	**11.82**
Polychlorinated biphenyl	**HRT-3**	**4**	**4**	**0.012**	**7.92e-02**	**0.39**	**0.07**	**MOE_LEL**	**5.57**
Polychlorinated biphenyl	**HRT-3**	**4**	**4**	**0.012**	**7.92e-02**	**0.39**	**0.18**	**ER_M**	**2.17**
Polychlorinated biphenyl	**HRT-3**	**4**	**4**	**0.012**	**7.92e-02**	**0.39**	**0.189**	**PEL**	**2.06**
Polychlorinated biphenyl	HRT-3	4	4	0.012	7.92e-02	0.39	5.3	MOE_SEL	0.07
Pyrene	**Intermediate Pond**	**3**	**3**	**0.036**	**2.70e-01**	**1.2**	**0.153**	**TEL**	**7.84**
Pyrene	**Intermediate Pond**	**3**	**3**	**0.036**	**2.70e-01**	**1.2**	**0.33**	**REGIV_SV**	**3.64**
Pyrene	**Intermediate Pond**	**3**	**3**	**0.036**	**2.70e-01**	**1.2**	**0.66**	**ER_L**	**1.82**
Pyrene	Intermediate Pond	3	3	0.036	2.70e-01	1.2	1.398	PEL	0.86
Pyrene	Intermediate Pond	3	3	0.036	2.70e-01	1.2	2.6	ER_M	0.46
Pyrene	Pit 4 South	2	2	0.022	4.37e-02	0.087	0.153	TEL	0.57
Pyrene	Pit 4 South	2	2	0.022	4.37e-02	0.087	0.33	REGIV_SV	0.26
Pyrene	Pit 4 South	2	2	0.022	4.37e-02	0.087	0.66	ER_L	0.13
Pyrene	Pit 4 South	2	2	0.022	4.37e-02	0.087	1.398	PEL	0.06
Pyrene	Pit 4 South	2	2	0.022	4.37e-02	0.087	2.6	ER_M	0.03
Pyrene	**WOC**	**1**	**1**	**1.6**		**1.6**	**0.153**	**TEL**	**10.46**
Pyrene	**WOC**	**1**	**1**	**1.6**		**1.6**	**0.33**	**REGIV_SV**	**4.85**
Pyrene	**WOC**	**1**	**1**	**1.6**		**1.6**	**0.66**	**ER_L**	**2.42**
Pyrene	**WOC**	**1**	**1**	**1.6**		**1.6**	**1.398**	**PEL**	**1.14**
Pyrene	WOC	1	1	1.6		1.6	2.6	ER_M	0.62
Pyrene	**WOCE**	**8**	**47**	**0.1**	**1.10e+00**	**0.29**	**0.153**	**TEL**	**1.90**
Pyrene	WOCE	8	47	0.1	1.10e+00	0.29	0.33	REGIV_SV	0.88
Pyrene	WOCE	8	47	0.1	1.10e+00	0.29	0.66	ER_L	0.44
Pyrene	WOCE	8	47	0.1	1.10e+00	0.29	1.398	PEL	0.21
Pyrene	WOCE	8	47	0.1	1.10e+00	0.29	2.6	ER_M	0.11
Toluene	**Lower WOC**	**3**	**6**	**0.024**	**1.55e-02**	**0.652**	**0.0498**	**EQPSCV1**	**13.09**
Toluene	Lower WOC	3	6	0.024	1.55e-02	0.652	6.449	EQPCVF1	0.10

Table 4.6. (continued)

Analyte	Subbasin	Dets.	Obs.	Min Det.	Median	Max Det.	Benchmark		HQ
							Value	Name	
Toluene	Lower WOC	3	6	0.024	1.55e-02	0.652	128.218	EQPCVD1	0.01
Toluene	SEEP A	2	2	0.003	3.46e-03	0.004	0.0498	EQPSCV1	0.08
Toluene	SEEP A	2	2	0.003	3.46e-03	0.004	6.449	EQPCVF1	0.00
Toluene	SEEP A	2	2	0.003	3.46e-03	0.004	128.218	EQPCVD1	0.00
Toluene	SWSA 5 Trib 1	11	26	0.002	1.00e-02	0.01	0.0498	EQPSCV1	0.20
Toluene	SWSA 5 Trib 1	11	26	0.002	1.00e-02	0.01	6.449	EQPCVF1	0.00
Toluene	SWSA 5 Trib 1	11	26	0.002	1.00e-02	0.01	128.218	EQPCVD1	0.00
Toluene	WG5 MID. Drn	6	8	0.005	1.00e-02	0.01	0.0498	EQPSCV1	0.20
Toluene	WG5 MID. Drn	6	8	0.005	1.00e-02	0.01	6.449	EQPCVF1	0.00
Toluene	WG5 MID. Drn	6	8	0.005	1.00e-02	0.01	128.218	EQPCVD1	0.00

All concentrations are mg/kg. Only the chemicals for which at least one HQ was greater than 1 are included.
Bold indicates HQ>1.
Hazard Quotient = maximum detected concentration / benchmark value.

5. RISKS TO SOIL INVERTEBRATES

This chapter addresses risks from chemicals to soil invertebrates, which are represented by earthworms. Radiological risks to earthworms are discussed in this report in Chapter 9.

Ten subbasins had contaminants that resulted in invertebrate hazard indices (HIs) greater than one including: HF-2, SWSA 5 Tributary 1, SWSA 5 WOC, Intermediate Pond, WOC, Seep A, Seep B West, SWSA 4 Main, HRE, and Lower WOC/White Oak Lake. The primary analytes contributing to these risks include chromium, copper, mercury, nickel, and zinc. Although many of the detected organics could not be evaluated due to a lack of appropriate toxicity values, those organic compounds that could be evaluated did not result in hazard quotients (HQ) above 1. The subsections that follow describe the risks to soil invertebrates in more detail. Table 5.1 provides a summary of the subbasins with HIs greater than one and the HQs for the primary risk contributors.

5.1 EXPOSURE ASSESSMENT FOR SOIL INVERTEBRATES

Earthworms absorb a variety of inorganic and organic soil contaminants through both feeding in soil and litter and burrowing in soil. It is assumed that these organisms represent highly exposed soil invertebrates. It is not possible or necessary to distinguish the exposure of earthworms to solid, liquid, and gaseous phases of the soil. Both in toxicity tests and the field, earthworms integrate exposure to all soil components by all uptake routes.

The bioavailability of the contaminants in soil and decomposing plant litter are controlled by soil, litter, and analyte characteristics; however, current knowledge is not sufficient to allow the prediction of bioavailability based on soil variables. An exception is the association of extremes in pH and metal availability (van Gestel 1992).

It is assumed that the earthworms spend their entire life span in soil with contaminant levels represented by the 0.5 m depth of soil sampled. The assumption is reasonable, though organisms feeding on well-decomposed organic material near the surface may be exposed to different quantities of organic chemicals than worms feeding on litter pulled down into burrows in the subsoil (Curl et al. 1987). Few earthworms are found in waterlogged soils so exposure to seeps is not considered. Because earthworms and other soil invertebrates may spend their entire lives at a single sampling location, the maximum detected contaminant concentrations were screened against toxicity benchmarks, as described in Section 5.2. These concentrations are used to assess potential negative impacts of contaminated soils on soil invertebrate populations.

5.2 EFFECTS ASSESSMENT FOR SOIL INVERTEBRATES

Toxicity tests and biological surveys were not performed at these sites. Earthworm sampling in the WOC Watershed was limited (2 samples in WAG 2 and 6 samples in WAG 5), and quantitative surveys were not performed. Thus the only line of evidence in the risk assessment is the comparison to benchmarks (Will and Suter 1995a), described in the following paragraphs. Where benchmarks were not available, risks could not be evaluated.

Contaminant concentrations in soils were compared to toxicological benchmarks (Will and Suter 1995a) 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. Chemicals that were not screened out because the maximum detected concentrations were greater than benchmarks may potentially pose significant risks to soil invertebrates. References used for the derivation of benchmarks were reports of toxicity tests of individual chemicals in laboratory, greenhouse, or field settings. Tests conducted with natural soils in the laboratory were assumed to represent the exposures of worms in floodplain soils. However, chemicals freshly added to soils in toxicity tests may be more bioavailable than the chemical forms that occur in field soils. Only experiments in which earthworms were exposed to soil (natural or artificial mixture of 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. 1995).

The method used for deriving soil benchmarks is described in Will and Suter (1995a). Benchmarks used to evaluate toxic effects of contaminants present in each of the subbasins are presented in Table 5.2. Toxicological profiles for analytes retained in the analysis are provided in the attachment of this appendix.

5.3 RISK CHARACTERIZATION FOR SOIL INVERTEBRATES

The evidence concerning risks to soil invertebrates consists of analyses of inorganic, organic, and radionuclide contaminants in soil. This single line of evidence is summarized in the following text. Toxicity tests and biological surveys were not available.

5.3.1 Single Chemical Soil Toxicity

Contaminants of potential ecological concern (COPECs) for soil invertebrates were identified by comparing maximum concentrations in soil at each location to the following: (1) background for soils (DOE 1995a); and (2) available benchmarks for toxicity to soil invertebrates (Will and Suter 1995a). Maximum detected concentrations in soil were used because earthworms and other soil invertebrates are relatively immobile and can therefore be exposed to the maximum concentration during the course of their lifetimes (Suter et al. 1995). If both background and benchmark criteria were exceeded, the contaminant was identified as a COPEC. The magnitude of exceedance of a benchmark is described by the hazard quotient, the maximum concentration in soil divided by the toxicity benchmark concentration. If background criteria were not available, exceedance of a benchmark was sufficient for the COPEC designation. A summary of sites with HIs above one and the analytes that contribute a HQ above 1 is provided in Table 5.1; supporting documentation including maximum detected concentrations and toxicity values is provided in Table 5.2. The major COPECs for soil invertebrates were chromium, copper, mercury, nickel, and zinc.

5.3.1.1 HF-2

The overall soil invertebrate HI for subbasin HF-2 soil was 423 (Table 5.1). Inorganics accounted for 100% of the HI. Of the 29 inorganics detected at HF-2, 16 were below background levels and eliminated from further consideration. Nine of the remaining inorganics could not be evaluated for invertebrate effects because toxicological benchmarks were not available. HQs exceeding one were estimated for two (chromium and zinc) of the four inorganics evaluated for invertebrate effects, indicating a potential risk of adverse effects for these elements.

Chromium contributed 99% of the overall HI for the subbasin. Chromium was detected in both of the soil samples collected at HF-2, but at levels higher than background in only one, and then at a concentration only about twice as high (168 mg/kg for HF-2 versus 78 mg/kg background). The analytical data did not specify the valence state of the chromium. Chromium (VI) is more toxic and bioavailable than chromium (III) (Smith et al. 1989, cited in Will and Suter 1995b), but in most soils chromium (VI) is likely to be reduced to chromium (III) (Bartlett and James 1979, cited in Will and Suter 1995b). However, the toxicological benchmark used to estimate effects of chromium is based on chromium (VI) studies. The use of the benchmark for the more toxic and available chromium (VI) when exposures may be predominantly from chromium (III) may lead to overestimation of the risks of adverse effects.

Benchmarks were not available for either of the two organics detected at HF-2.

These results indicate a potential risk of adverse effects on soil invertebrates from HF-2 soil, primarily resulting from chromium.

5.3.1.2 HRE

The overall soil invertebrate HI for the HRE subbasin was 261.4 (Table 5.1). HQs exceeding one were estimated for two metals: chromium and zinc, indicating a potential risk of adverse effects for these elements. Chromium was the risk driver in the subbasin, resulting in an HQ of 260.

While chromium was the primary risk driver in this subbasin, it was detected at only 1.3 times background. The analytical data did not specify the valence state of the chromium. Chromium (VI) is more toxic and bioavailable than chromium (III) (Will and Suter 1995a), but in most soils chromium (VI) is likely to be reduced to chromium (III). The toxicological benchmarks used in this assessment were based on chromium (VI) studies. The use of benchmarks for the more toxic and available chromium (VI) when exposures may be predominantly from chromium (III) may lead to overestimation of risks.

5.3.1.3 SWSA 5 Tributary 1

The overall soil invertebrate HI for SWSA 5 Trib 1 soil was 43 (Table 5.1). Inorganics accounted for 100% of the HI. Of the 23 inorganics detected at SWSA 5 Trib 1, 14 were below background levels and eliminated from further consideration. Six of the remaining inorganics could not be evaluated for invertebrate effects because toxicological benchmarks were not available. An HQ exceeding one was estimated for one (mercury) of the three inorganics evaluated for invertebrate effects, indicating a potential risk of adverse effects for this element. Mercury contributed over 99% of the overall HI for the subbasin.

Toxicological benchmarks were not available for any of the 45 organics detected at the site.

These results indicate a potential risk of adverse effects on soil invertebrates from SWSA 5 Trib 1 soil, primarily resulting from mercury,.

5.3.1.4 SWSA 5 WOC

The overall soil invertebrate HI for SWSA 5 WOC soil was 10 (Table 5.1). Inorganics accounted for over 99% of the HI. Organics contributed only 0.1%. Of the 23 inorganics detected at SWSA 5 WOC, 12 were below background levels and eliminated from further consideration.

Seven of the remaining inorganics (calcium, magnesium and sodium) could not be evaluated for invertebrate effects because toxicological benchmarks were not available. An HQ exceeding one was estimated for one (mercury) of the four inorganics evaluated for invertebrate effects, indicating a potential risk of adverse effects for this element. Mercury contributed 90% of the overall HI for the subbasin.

No toxicological benchmarks were available for 49 of the 50 organics detected at the site. The HQ for the one remaining organic was well below one, indicating no risk of adverse effects.

These results indicate a potential risk of adverse effects on soil invertebrates from SWSA 5 WOC soil, primarily resulting from mercury.

5.3.1.5 SWSA 5 N WOC

The overall soil invertebrate HI for SWSA 5 N WOC soil was 0.02. Inorganics accounted for 100% of the HI. Of the 19 inorganics detected at SWSA 5 N WOC, 17 were below background levels and eliminated from further consideration. One of the remaining inorganics, silver could not be evaluated for invertebrate effects because toxicological benchmarks were not available. The HQ for the other remaining inorganic, selenium, was 0.02, indicating no risk of adverse effects.

Toxicological benchmarks were not available for any of the 14 organics detected at the site.

These results indicate no risk of adverse effects on soil invertebrates from SWSA 5 N WOC soil for the contaminants that could be evaluated.

5.3.1.6 Intermediate Pond

The overall soil invertebrate HI for the Intermediate Pond soil was 767 (Table 5.1). Inorganics accounted for over 99.9% of the HI. Organics contributed only 0.002%. Of the 30 inorganics detected at the Intermediate Pond, 15 were below background levels and eliminated from further consideration. Ten of the remaining inorganics could not be evaluated for invertebrate effects because toxicological benchmarks were not available. HQs exceeding one were estimated for three (mercury, nickel and zinc) of the five inorganics evaluated for invertebrate effects, indicating a potential risk of adverse effects for these elements. Mercury contributed over 99% of the overall HI for the subbasin.

No toxicological benchmarks were available for 24 of the 26 organics detected at the site. The HQs for the two remaining organics were well below one, indicating no risk of adverse effects.

These results indicate a potential risk of adverse effects on soil invertebrates from the Intermediate Pond soil, primarily resulting from mercury.

5.3.1.7 SWSA 4 Main

The overall soil invertebrate HI for the SWSA 4 Main subbasin was 39.9 (Table 5.1). An HQ exceeding one was estimated for only one analyte (nickel), indicating a potential risk of adverse effects from this element. Nickel was the primary risk driver, resulting in an HQ of 39.3. However, the results are driven by the high nickel concentration (7860 mg/kg) at one sample locations (WAG 4 Seep 6). The highest concentration at two other locations in the subbasin was 49.6 mg/kg, suggesting that risks from nickel are spatially limited within the subbasin.

5.3.1.8 WAG 7 WOC

No risks were identified for soil invertebrates exposed to contaminants in WAG 7 WOC. Concentrations of all detected analytes were below toxicological benchmarks (Table 5.2).

5.3.1.9 WOC

The overall soil invertebrate HI for the WOC subbasin soil was 56 (Table 5.1). Inorganics accounted for 100% of the HI. Of the 30 inorganics detected at the WOC subbasin, 16 were below background levels and eliminated from further consideration. Nine of the remaining inorganics could not be evaluated for invertebrate effects because toxicological benchmarks were not available. HQs exceeding one were estimated for three (copper, mercury and zinc) of the five inorganics evaluated for invertebrate effects, indicating a potential risk of adverse effects for these elements. Mercury contributed 86% of the overall HI for the subbasin.

Toxicological benchmarks were not available for any of the 16 organics detected at the site.

These results indicate a potential risk of adverse effects on soil invertebrates from WOC subbasin soil, primarily resulting from mercury.

5.3.1.10 NHF

The overall soil invertebrate HI for NHF soil was 0.008 (Table 5.1). Organics accounted for 100% of the HI. Of the 18 inorganics detected at NHF, 15 were below background levels and eliminated from further consideration. The three remaining inorganics, barium, sodium and silver, could not be evaluated for invertebrate effects because toxicological benchmarks were not available.

No toxicological benchmarks were available for 12 of the 13 organics detected at the site. The HQ for the one remaining organic was well below one, indicating no risk of adverse effects.

These results indicate adverse effects on soil invertebrates from NHF soil are unlikely for those contaminants that could be evaluated.

5.3.1.11 SWSA 5 Drainage D-2

The overall soil invertebrate HI was not estimated for SWSA 5 Drainage D-2 soil. Of the 18 inorganics detected at WAG 5 Mid-drain, 14 were below background levels and eliminated from further consideration. The four remaining inorganics (barium, calcium, magnesium and silver) could not be evaluated for invertebrate effects because toxicological benchmarks were not available.

Toxicological benchmarks were not available for any of the 16 organics detected at the site.

5.3.1.12 Seep A

The overall soil invertebrate HI for Seep A soil was 1.7 (Table 5.1). Inorganics accounted for 100% of the HI. Of the 23 inorganics detected at Seep A, 16 were below background levels and eliminated from further consideration. Four of the remaining inorganics could not be evaluated for invertebrate effects because toxicological benchmarks were not available. HQs exceeding one were estimated for one (zinc) of the three inorganics evaluated for invertebrate effects. The HQ of 1.6 for zinc does not warrant concern.

Toxicological benchmarks were not available for any of the 45 organics detected at the site.

These results indicate no risk of adverse effects on soil invertebrates from Seep A soil for those contaminants that could be evaluated.

5.3.1.13 Seep B West

The overall soil invertebrate HI for Seep B soil was 20 (Table 5.1). Inorganics accounted for 100% of the HI. Of the 30 inorganics detected at Seep B, 21 were below background levels and eliminated from further consideration. Six of the remaining inorganics could not be evaluated for invertebrate effects because toxicological benchmarks were not available. HQs exceeding one were estimated for one (mercury) of the three inorganics evaluated for invertebrate effects, indicating a potential risk of adverse effects for this element. Mercury contributed over 99% of the overall HI for the subbasin.

Toxicological benchmarks were not available for any of the 17 organics detected at the site.

These results indicate a potential risk of adverse effects on soil invertebrates from Seep B soil, primarily resulting from mercury.

5.3.1.14 Seep B East

The overall soil invertebrate HI for the Seep B East soil was 0.005. Inorganics accounted for 100% of the HI. Of the 21 inorganics detected at Seep B East, 17 were below background levels and eliminated from further consideration. Three of the four remaining inorganics could not be evaluated for invertebrate effects because toxicological benchmarks were not available. The HQ for the one other remaining inorganic, selenium, was well below one, indicating no risk of adverse effects.

Toxicological benchmarks were not available for any of the 38 organics detected at the site.

These results indicate no risk of adverse effects on soil invertebrates from Seep B East soil for the contaminants that could be evaluated.

5.3.1.15 Seep C

The overall soil invertebrate HI for Seep C soil was 0.07. Inorganics accounted for 100% of the HI. Of the 31 inorganics detected at Seep C, 15 were below background levels and eliminated from further consideration. Fourteen of the remaining inorganics could not be evaluated for invertebrate effects because toxicological benchmarks were not available. The HQs for the two other remaining inorganics, cadmium and selenium, were well below one, indicating no risk of adverse effects.

Toxicological benchmarks were not available for any of the 21 organics detected at the site.

These results indicate no risk of adverse effects on soil invertebrates from the Seep C soil for the contaminants that could be evaluated.

5.3.1.16 W6MS3

The overall soil invertebrate HI for W6MS3 soil was 0.5. Inorganics accounted for 93% of the HI. Organics contributed 7%. Of the 22 inorganics detected at W6MS3, 14 were below background levels and eliminated from further consideration. Six of the remaining inorganics could not be evaluated for invertebrate effects because toxicological benchmarks were not available. The HQs for the two other remaining inorganics, arsenic and cadmium, were below one, indicating no risk of adverse effects.

No toxicological benchmarks were available for 29 of the 34 organics detected at the site. The HQs for the five remaining organics were well below one, indicating no risk of adverse effects.

These results indicate no risk of adverse effects on soil invertebrates from W6MS3 soil for the contaminants that could be evaluated.

5.3.1.17 W6MS1

The overall soil invertebrate HI for W6MS1 soil was 0.8. Inorganics accounted for 100% of the HI. Of the 18 inorganics detected at W6MS1, 11 were below background levels and eliminated from further consideration. Four of the remaining inorganics could not be evaluated for invertebrate effects because toxicological benchmarks were not available. The HQs for the three other remaining inorganics, arsenic, cadmium and nickel, were below one, indicating no risk of adverse effects.

Toxicological benchmarks were not available for any of the 19 organics detected at the site.

These results indicate no risk of adverse effects on soil invertebrates from W6MS1 soil for the contaminants that could be evaluated.

5.3.1.18 West Seep

The overall soil invertebrate HI for West Seep soil was 0.6. Inorganics accounted for 99% of the HI. Organics contributed only 0.9%. Of the 24 inorganics detected at West Seep, 15 were below background levels and eliminated from further consideration. Seven of the remaining inorganics could not be evaluated for invertebrate effects because toxicological benchmarks were not available. The HQs for the two other remaining inorganics, cadmium and nickel, were below one, indicating no risk of adverse effects.

No toxicological benchmarks were available for 30 of the 32 organics detected at the site. The HQs for the two remaining organics were well below one, indicating no risk of adverse effects.

These results indicate no risk of adverse effects on soil invertebrates from West Seep soil for the contaminants that could be evaluated.

5.3.1.19 East Seep

No risks were identified for soil invertebrates exposed to contaminants in the East Seep subbasin. Concentrations of all detected analytes were below toxicological benchmarks (Table 5.2).

5.3.1.20 Lower WOC/White Oak Lake

The overall soil invertebrate HI for Lower WOC/White Oak Lake soil was 343 (Table 5.1). Inorganics accounted for over 99.9% of the HI. Organics contributed only 0.01%. Of the 30 inorganics detected at Lower WOC/White Oak Lake, 16 were below background levels and eliminated from further consideration. Nine of the remaining inorganics could not be evaluated for invertebrate effects because toxicological benchmarks were not available. HQs exceeding one were estimated for three (chromium, mercury, and zinc) of the five inorganics evaluated for invertebrate effects, indicating a potential risk of adverse effects for these elements.

Chromium and mercury contributed 99% of the overall HI for the subbasin. The analytical data did not specify the valence state of the chromium. Chromium (VI) is more toxic and bioavailable than chromium (III) (Smith et al. 1989, cited in Will and Suter 1995b), but in most soils chromium (VI) is likely to be reduced to chromium (III) (Bartlett and James 1979, cited in Will and Suter 1995b). However, the toxicological benchmark used to estimate effects of chromium is based on chromium (VI) studies. The use of the benchmark for the more toxic and available chromium (VI) when exposures may be predominantly from chromium (III) may lead to overestimation of the risks of adverse invertebrate effects.

No toxicological benchmarks were available for 22 of the 24 organics detected at the site. The HQs for the two remaining organics were well below one, indicating no risk of adverse effects.

These results indicate a potential risk of adverse effects on soil invertebrates from Lower WOC/White Oak Lake soil, primarily resulting from chromium and mercury.

5.3.1.21 Pit 4 South

The overall soil invertebrate HI for Pit 4 South soil was 0.04. Inorganics accounted for 92% of the HI. Organics contributed 8%. Of the 29 inorganics detected at Pit 4 South, 18 were below background levels and eliminated from further consideration. Nine of the remaining inorganics could not be evaluated for invertebrate effects because toxicological benchmarks were not available. The HQs for the two other remaining inorganics, cadmium and selenium, were below one, indicating no risk of adverse effects.

No toxicological benchmarks were available for 15 of the 16 organics detected at the site. The HQ for the one remaining organic was well below one, indicating no risk of adverse effects.

These results indicate no risk of adverse effects on soil invertebrates from Pit 4/South soil for the contaminants that could be evaluated.

5.3.1.22 SWSA 6 East

The overall soil invertebrate HI for SWSA 6 East soil was 1.2. Inorganics accounted for approximately 100% of the HI. Of the 18 inorganics detected at SWSA 6 East, 12 were below background levels and eliminated from further consideration. Three of the remaining inorganics could not be evaluated for invertebrate effects because toxicological benchmarks were not available. The HQs for the three other remaining inorganics, cadmium, nickel and zinc, were below one, indicating no risk of adverse effects.

No toxicological benchmarks were available for 10 of the 11 organics detected at the site. The HQ for the one remaining organic was well below one, indicating no risk of adverse effects.

These results indicate no risk of adverse effects on soil invertebrates from SWSA 6 East soil for the contaminants that could be evaluated.

5.3.1.23 SWSA 6 South

The overall soil invertebrate HI for SWSA 6 South soil was 0.5. Inorganics accounted for 100% of the HI. Of the 17 inorganics detected at SWSA 6 South, 12 were below background levels and eliminated from further consideration. Three of the remaining inorganics could not be evaluated for invertebrate effects because toxicological benchmarks were not available. The HQs for the two other remaining inorganics, arsenic and cadmium, were below one, indicating no risk of adverse effects.

Benchmarks were not available for any of the three organics detected at SWSA 6 South.

These results indicate no risk of adverse effects on soil invertebrates from SWSA 6 South soil for the contaminants that could be evaluated.

5.3.2 Summary of Risk Characterization for Soil Invertebrates

In this ecological risk assessment potential hazard is indicated by the exceedance of toxicological benchmarks. COPECs for soil invertebrates include chromium, copper, mercury, nickel, and zinc. The subbasins with no contaminants above a HQ of one include NHF, SWSA 5 Drainage D-2, Pit 4 South, Seep B East, Seep C, SWSA 5 N WOC, SWSA 6 East, W6MS1, West Seep, SWSA 6 South, and W6MS3. A summary of those subbasins with HIs greater than one (Intermediate Pond, HF-2, Lower WOC, HRE, WOC, SWSA 5 Trib 1, SWSA 4 Main. Seep A, Seep B West, and SWSA 5 WOC) along with their primary risk contributors above a HQ of 1 can be found in Table 5.1.

5.4 UNCERTAINTIES CONCERNING RISKS TO SOIL INVERTEBRATES

The following factors create uncertainty in assessing the risk posed by the potential contaminants of concern in soils:

- **Bioavailability of elements.** The extraction methods used during sample collection may remove from the soil quantities of elements and compounds greater than those that are extracted from soil as they pass through the gut of the earthworm or those that are absorbed dermally.

- **Variable response to contaminants.** Various earthworm and other soil invertebrate species and earthworm growth stages tolerate contaminants to different degrees. 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 subbasins.

- **Multiple contaminant exposure.** Toxicity benchmark concentrations are derived form experiments in which earthworms are exposed to single contaminants. Soils of the subbasins

may expose earthworms to multiple contaminants which may not be adequately assessed on the basis of literature-derived benchmarks.

- **Lack of benchmarks for some metals and most organic compounds.** Little research has been conducted on the toxic effects of the 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.

- **Chemical speciation.** Earthworm toxicity benchmarks for metals are often derived from studies with a single species of a contaminant. For example, the analytical data did not specify the valence state of the chromium. Chromium (VI) is more toxic and bioavailable than chromium (III) (Smith et al. 1989, cited in Will and Suter 1995b), but in most soils chromium (VI) is likely to be reduced to chromium (III) (Bartlett and James 1979, cited in Will and Suter 1995b). However, the toxicological benchmark used to estimate effects of chromium is based on chromium (VI) studies. The use of the benchmark for the more toxic and available form of a contaminant when exposures may be predominantly from a less available or less toxic form may lead to overestimation of the risks of adverse effects.

Table 5.1. Summary of Potential Risks to Invertebrates Exposed to Soils in the White Oak Creek Watershed

		Hazard quotients for risk driving analytes				
Subbasin	**Hazard Index**	**Cr**	**Cu**	**Hg**	**Ni**	**Zn**
IntermediatePond	767.0			764.0	1.6	1.7
HF-2	423.0	420.0				2.9
LowerWOC/WOL	343.0	290.0		51.0		2.1
HRE	261.4	260.0				1.2
WOC	55.9		3.3	48.0		4.5
SWSA5Trib-1	43.1			43.0		
SWSA 4 Main	39.9				39.3	
Seep B West	20.1			20.0		
SWSA5/WOC	10.3			9.6		
SeepA	1.7					1.6

Notes:
Cr = chromium, Cu = copper, Hg = mercury, Ni = nickel, Zn = zinc
risk driving analytes = any detected contaminant present above background concentrations that contributes a hazard quotient above 1.

Table 5.2. Risk results for soil invertebrates and terrestrial plants exposed to contaminants in the White Oak Creek watershed

Subbasin	Chemical	Freq. of detect.	Mean conc. (mg/kg)	Max. detected conc. (mg/kg)	Background quotient	Plant tox. (mg/kg)	Invert. tox. (mg/kg)	Plant HQ	Invert. HQ
East Seep	Aluminum	3/3	2.44E+04	3.03E+04	6.84E-01	5.00E+01		6.06E+02	
East Seep	Arsenic	3/3	4.63E+00	6.00E+00	4.81E-01	1.00E+01	6.00E+01	6.00E-01	1.00E-01
East Seep	Barium	3/3	1.85E+02	3.09E+02	1.46E+00	5.00E+02		6.18E-01	
East Seep	Beryllium	3/3	1.11E+00	1.30E+00	5.91E-01	1.00E+01		1.30E-01	
East Seep	Calcium	3/3	2.72E+04	7.37E+04	1.04E+01				
East Seep	Chromium	3/3	3.40E+01	3.71E+01	4.73E-01	1.00E+00	4.00E-01	3.71E+01	9.28E+01
East Seep	Cobalt	3/3	2.08E+01	3.09E+01	8.42E-01	2.00E+01		1.55E+00	
East Seep	Copper	3/3	2.95E+01	4.80E+01	3.84E-01	1.00E+02	5.00E+01	4.80E-01	9.60E-01
East Seep	Iron	3/3	3.47E+04	4.25E+04	2.47E-01				
East Seep	Lead	3/3	2.76E+01	3.74E+01	2.50E-01	5.00E+01	5.00E+02	7.48E-01	7.48E-02
East Seep	Magnesium	3/3	6.35E+03	7.78E+03	1.05E+00				
East Seep	Manganese	3/3	2.60E+03	5.96E+03	4.31E-01	5.00E+02		1.19E+01	
East Seep	Nickel	3/3	3.12E+01	3.96E+01	6.98E-01	3.00E+01	2.00E+02	1.32E+00	1.98E-01
East Seep	Potassium	3/3	3.60E+03	4.56E+03	8.46E-01				
East Seep	Selenium	1/3	8.00E-01	1.20E+00		1.00E+00	7.00E+01	1.20E+00	1.71E-02
East Seep	Sodium	3/3	7.06E+02	8.43E+02					
East Seep	Thallium	1/3	1.42E+00	2.50E+00	3.16E+00	1.00E+00		2.50E+00	
East Seep	Vanadium	3/3	2.88E+01	3.36E+01	2.09E-01	2.00E+00		1.68E+01	
East Seep	Zinc	3/3	7.58E+01	7.95E+01	7.36E-01	5.00E+01	2.00E+02	1.59E+00	3.98E-01
East Seep	PCB-1016	3/3	1.87E-02	2.10E-02					
East Seep	PCB-1221	3/3	1.87E-02	2.10E-02					
East Seep	PCB-1232	3/3	1.87E-02	2.10E-02					
East Seep	PCB-1242	3/3	1.87E-02	2.10E-02					
East Seep	PCB-1248	3/3	1.87E-02	2.10E-02					
East Seep	PCB-1254	3/3	1.87E-02	2.10E-02					
HF-2	Aluminum	2/2	1.55E+04	1.58E+04	3.57E-01	5.00E+01		3.16E+02	
HF-2	Antimony	2/2	8.60E-01	9.60E-01		5.00E+00		1.92E-01	
HF-2	Arsenic	2/2	6.50E+00	7.30E+00	5.85E-01	1.00E+01	6.00E+01	7.30E-01	1.22E-01
HF-2	Barium	2/2	6.13E+02	9.61E+02	4.53E+00	5.00E+02		1.92E+00	
HF-2	Beryllium	2/2	1.45E+00	1.50E+00	6.82E-01	1.00E+01		1.50E-01	
HF-2	Boron	2/2	4.10E+00	4.20E+00	1.11E-01	5.00E-01		8.40E+00	
HF-2	Cadmium	2/2	2.55E-01	2.60E-01		3.00E+00	2.00E+01	8.67E-02	1.30E-02
HF-2	Calcium	2/2	1.44E+04	1.50E+04	2.12E+00				
HF-2	Chromium	2/2	1.20E+02	1.68E+02		1.00E+00	4.00E-01	1.68E+02	4.20E+02
HF-2	Cobalt	2/2	3.47E+01	4.06E+01	1.11E+00	2.00E+01		2.03E+00	
HF-2	Copper	2/2	2.78E+01	3.28E+01	2.62E-01	1.00E+02	5.00E+01	3.28E-01	6.56E-01
HF-2	Iron	2/2	6.67E+04	8.16E+04	4.75E-01				
HF-2	Lead	2/2	1.39E+01	1.51E+01	1.01E-01	5.00E+01	5.00E+02	3.02E-01	3.02E-02
HF-2	Lithium	2/2	2.35E+01	2.49E+01	8.98E-02	2.00E+00		1.25E+01	
HF-2	Magnesium	2/2	6.26E+03	7.02E+03	9.45E-01				
HF-2	Manganese	2/2	5.60E+03	8.33E+03	6.02E-01	5.00E+02		1.67E+01	
HF-2	Mercury	2/2	1.10E-01	1.10E-01	2.06E-01	3.00E-01	1.00E-01	3.67E-01	1.10E+00
HF-2	Molybdenum	2/2	2.85E+00	2.90E+00		2.00E+00		1.45E+00	
HF-2	Nickel	2/2	3.91E+01	4.04E+01	7.13E-01	3.00E+01	2.00E+02	1.35E+00	2.02E-01
HF-2	Osmium	1/2	6.20E+00	8.50E+00					
HF-2	Potassium	2/2	2.00E+03	2.02E+03	3.75E-01				

Table 5.2 (continued)

Subbasin	Chemical	Freq. of detect.	Mean conc. (mg/kg)	Max. detected conc. (mg/kg)	Background quotient	Plant tox. (mg/kg)	Invert. tox. (mg/kg)	Plant HQ	Invert. HQ
HF-2	Selenium	2/2	7.65E-01	7.80E-01		1.00E+00	7.00E+01	7.80E-01	1.11E-02
HF-2	Silicon	2/2	3.84E+02	4.43E+02	6.36E-01				
HF-2	Silver	2/2	2.55E-01	2.60E-01		2.00E+00		1.30E-01	
HF-2	Sodium	2/2	3.32E+02	3.64E+02					
HF-2	Thallium	2/2	7.65E-01	7.80E-01	9.87E-01	1.00E+00		7.80E-01	
HF-2	Tin	2/2	1.89E+01	2.25E+01		5.00E+01		4.50E-01	
HF-2	Vanadium	2/2	3.68E+01	3.86E+01	2.41E-01	2.00E+00		1.93E+01	
HF-2	Zinc	2/2	5.41E+02	5.80E+02	5.37E+00	5.00E+01	2.00E+02	1.16E+01	2.90E+00
HF-2	bis(2-Ethylhexyl)phthalate	2/2	9.20E-02	9.90E-02					
HF-2	Methoxychlor	1/2	1.38E-02	1.70E-02					
HRE	Aluminum	7/7	1.91E+04	2.30E+04	5.19E-01	5.00E+01		4.60E+02	
HRE	Arsenic	7/7	4.62E+00	5.80E+00	4.65E-01	1.00E+01	6.00E+01	5.80E-01	9.67E-02
HRE	Barium	7/7	2.08E+02	3.29E+02	1.55E+00	5.00E+02		6.58E-01	
HRE	Beryllium	7/7	8.43E-01	1.00E+00	4.55E-01	1.00E+01		1.00E-01	
HRE	Cadmium	3/7	1.31E+00	3.20E+00		3.00E+00	2.00E+01	1.07E+00	1.60E-01
HRE	Calcium	7/7	5.71E+03	1.42E+04	2.01E+00				
HRE	Chromium	7/7	4.69E+01	1.04E+02	1.33E+00	1.00E+00	4.00E-01	1.04E+02	2.60E+02
HRE	Cobalt	7/7	1.36E+01	1.70E+01	4.63E-01	2.00E+01		8.50E-01	
HRE	Copper	7/7	2.21E+01	2.76E+01	2.21E-01	1.00E+02	5.00E+01	2.76E-01	5.52E-01
HRE	Iron	7/7	2.68E+04	3.28E+04	1.91E-01				
HRE	Lead	7/7	2.28E+01	2.86E+01	1.91E-01	5.00E+01	5.00E+02	5.72E-01	5.72E-02
HRE	Magnesium	7/7	2.97E+03	5.37E+03	7.23E-01				
HRE	Manganese	7/7	1.06E+03	1.98E+03	1.43E-01	5.00E+02		3.96E+00	
HRE	Nickel	7/7	2.11E+01	2.92E+01	5.15E-01	3.00E+01	2.00E+02	9.73E-01	1.46E-01
HRE	Potassium	7/7	3.43E+03	4.43E+03	8.22E-01				
HRE	Sodium	7/7	6.69E+02	7.86E+02					
HRE	Vanadium	7/7	2.74E+01	3.44E+01	2.14E-01	2.00E+00		1.72E+01	
HRE	Zinc	7/7	1.18E+02	2.38E+02	2.20E+00	5.00E+01	2.00E+02	4.76E+00	1.19E+00
HRE	PCB-1016	7/7	2.03E-02	2.50E-02					
HRE	PCB-1221	7/7	2.03E-02	2.50E-02					
HRE	PCB-1232	7/7	2.03E-02	2.50E-02					
HRE	PCB-1242	7/7	2.03E-02	2.50E-02					
HRE	PCB-1248	7/7	2.03E-02	2.50E-02					
HRE	PCB-1254	7/7	2.03E-02	2.50E-02					
HRE	PCB-1260	7/7	6.29E-02	1.60E-01					
Intermediate Pond	Aluminum	15/15	1.66E+04	2.85E+04	6.43E-01	5.00E+01		5.70E+02	
Intermediate Pond	Antimony	4/15	4.95E+00	9.50E-01		5.00E+00		1.90E-01	
Intermediate Pond	Arsenic	15/15	5.47E+00	7.40E+00	5.93E-01	1.00E+01	6.00E+01	7.40E-01	1.23E-01
Intermediate Pond	Barium	15/15	1.51E+02	2.68E+02	1.26E+00	5.00E+02		5.36E-01	
Intermediate Pond	Beryllium	15/15	1.09E+00	1.70E+00	7.73E-01	1.00E+01		1.70E-01	
Intermediate Pond	Boron	15/15	5.74E+00	1.02E+01	2.71E-01	5.00E-01		2.04E+01	
Intermediate Pond	Cadmium	14/14	1.08E+00	1.50E+00		3.00E+00	2.00E+01	5.00E-01	7.50E-02
Intermediate Pond	Calcium	15/15	9.67E+03	2.65E+04	3.75E+00				
Intermediate Pond	Chromium	15/15	5.03E+01	7.16E+01		1.00E+00	4.00E-01	7.16E+01	1.79E+02
Intermediate Pond	Cobalt	15/15	1.20E+01	1.62E+01	4.41E-01	2.00E+01		8.10E-01	
Intermediate Pond	Copper	15/15	3.27E+01	6.49E+01	5.19E-01	1.00E+02	5.00E+01	6.49E-01	1.30E+00

Table 5.2 (continued)

Subbasin	Chemical	Freq. of detect.	Mean conc. (mg/kg)	Max. detected conc. (mg/kg)	Background quotient	Plant tox. (mg/kg)	Invert. tox. (mg/kg)	Plant HQ	Invert. HQ
Intermediate Pond	Iron	15/15	2.61E+04	3.40E+04	1.98E-01				
Intermediate Pond	Lead	15/15	5.37E+01	1.11E+02	7.41E-01	5.00E+01	5.00E+02	2.22E+00	2.22E-01
Intermediate Pond	Lithium	15/15	2.12E+01	4.14E+01	1.49E-01	2.00E+00		2.07E+01	
Intermediate Pond	Magnesium	15/15	2.55E+03	3.84E+03	5.17E-01				
Intermediate Pond	Manganese	15/15	1.05E+03	4.15E+03	3.00E-01	5.00E+02		8.30E+00	
Intermediate Pond	Mercury	14/14	1.21E+01	7.64E+01	1.43E+02	3.00E-01	1.00E-01	2.55E+02	7.64E+02
Intermediate Pond	Molybdenum	15/15	3.87E+00	5.20E+00		2.00E+00		2.60E+00	
Intermediate Pond	Nickel	15/15	3.69E+01	3.10E+02	5.47E+00	3.00E+01	2.00E+02	1.03E+01	1.55E+00
Intermediate Pond	Osmium	2/15	6.20E+00	1.01E+01					
Intermediate Pond	Potassium	15/15	2.02E+03	3.41E+03	6.33E-01				
Intermediate Pond	Selenium	12/14	6.13E-01	9.50E-01		1.00E+00	7.00E+01	9.50E-01	1.36E-02
Intermediate Pond	Silicon	15/15	4.73E+02	1.72E+03	2.47E+00				
Intermediate Pond	Silver	15/15	7.25E+00	1.73E+01		2.00E+00		8.65E+00	
Intermediate Pond	Sodium	15/15	4.71E+02	6.31E+02					
Intermediate Pond	Strontium	13/15	2.16E+01	4.65E+01	7.74E-02				
Intermediate Pond	Thallium	13/15	7.86E-01	9.80E-01	1.24E+00	1.00E+00		9.80E-01	
Intermediate Pond	Tin	15/15	1.04E+01	1.62E+01		5.00E+01		3.24E-01	
Intermediate Pond	Vanadium	15/15	2.49E+01	3.37E+01	2.10E-01	2.00E+00		1.69E+01	
Intermediate Pond	Zinc	15/15	1.42E+02	3.30E+02	3.06E+00	5.00E+01	2.00E+02	6.60E+00	1.65E+00
Intermediate Pond	2-Methylnaphthalene	3/10	3.08E-02	3.50E-02					
Intermediate Pond	4-Methylphenol	1/10	2.99E-01	2.20E-01					
Intermediate Pond	Acenaphthene	3/10	1.07E-01	1.30E-01		2.00E+01		6.50E-03	
Intermediate Pond	Anthracene	4/10	1.09E-01	2.20E-01					
Intermediate Pond	Benz(a)anthracene	8/10	1.89E-01	6.70E-01					
Intermediate Pond	Benzo(a)pyrene	8/10	2.01E-01	5.50E-01					
Intermediate Pond	Benzo(b)fluoranthene	10/10	2.09E-01	7.90E-01					
Intermediate Pond	Benzo(ghi)peryline	7/10	1.61E-01	3.80E-01					
Intermediate Pond	Benzo(k)fluoranthene	9/10	1.85E-01	6.30E-01					
Intermediate Pond	bis(2-Ethylhexyl)phthalate	5/10	2.91E-01	6.00E-01					
Intermediate Pond	Butylbenzylphthalate	1/10	3.13E-01	2.70E-02					
Intermediate Pond	Carbazole	3/10	1.34E-01	2.10E-01					
Intermediate Pond	Chrysene	10/10	2.39E-01	7.60E-01					
Intermediate Pond	Di-n-butylphthalate	8/10	1.85E-01	4.20E-01		2.00E+02		2.10E-03	
Intermediate Pond	Di-n-octylphthalate	1/10	3.07E-01	2.50E-02					
Intermediate Pond	Dibenz(a,h)anthracene	3/10	1.18E-01	2.40E-01					
Intermediate Pond	Dibenzofuran	2/10	7.07E-02	7.20E-02					
Intermediate Pond	Fluoranthene	10/10	4.66E-01	1.40E+00					
Intermediate Pond	Fluorene	3/10	1.20E-01	1.40E-01			3.00E+01		4.67E-03
Intermediate Pond	Indeno(1,2,3-cd)pyrene	8/10	1.45E-01	5.00E-01					
Intermediate Pond	Naphthalene	3/10	3.59E-02	4.10E-02					
Intermediate Pond	PCB-1254	5/10	2.16E-01	1.90E+00					
Intermediate Pond	PCB-1260	8/10	2.26E-01	6.10E-01					
Intermediate Pond	Pentachlorophenol	1/10	8.87E-01	2.90E-02		3.00E+00	4.00E+00	9.67E-03	7.25E-03
Intermediate Pond	Phenanthrene	9/10	2.45E-01	9.40E-01					
Intermediate Pond	Pyrene	10/10	3.63E-01	1.20E+00					
Little No-Name	Aluminum	2/2	9.91E+03	1.11E+04	2.51E-01	5.00E+01		2.22E+02	

Table 5.2 (continued)

Subbasin	Chemical	Freq. of detect.	Mean conc. (mg/kg)	Max. detected conc. (mg/kg)	Background quotient	Plant tox. (mg/kg)	Invert. tox. (mg/kg)	Plant HQ	Invert. HQ
Little No-Name	Arsenic	2/2	1.90E+00	2.20E+00	1.76E-01	1.00E+01	6.00E+01	2.20E-01	3.67E-02
Little No-Name	Barium	2/2	5.13E+01	5.37E+01	2.53E-01	5.00E+02		1.07E-01	
Little No-Name	Beryllium	2/2	7.05E-01	7.70E-01	3.50E-01	1.00E+01		7.70E-02	
Little No-Name	Cadmium	2/2	2.65E+00	2.80E+00		3.00E+00	2.00E+01	9.33E-01	1.40E-01
Little No-Name	Calcium	2/2	1.24E+03	1.24E+03	1.76E-01				
Little No-Name	Chromium	2/2	1.74E+01	1.80E+01	2.30E-01	1.00E+00	4.00E-01	1.80E+01	4.50E+01
Little No-Name	Cobalt	1/1	1.30E+01	1.30E+01	3.54E-01	2.00E+01		6.50E-01	
Little No-Name	Copper	2/2	1.25E+01	1.36E+01	1.09E-01	1.00E+02	5.00E+01	1.36E-01	2.72E-01
Little No-Name	Iron	2/2	2.42E+04	2.60E+04	1.51E-01				
Little No-Name	Lead	2/2	1.26E+01	1.31E+01	8.75E-02	5.00E+01	5.00E+02	2.62E-01	2.62E-02
Little No-Name	Magnesium	2/2	1.13E+03	1.19E+03	1.60E-01				
Little No-Name	Manganese	2/2	3.30E+02	3.39E+02	2.45E-02	5.00E+02		6.78E-01	
Little No-Name	Nickel	2/2	3.08E+01	3.33E+01	5.87E-01	3.00E+01	2.00E+02	1.11E+00	1.67E-01
Little No-Name	Potassium	2/2	6.95E+02	7.22E+02	1.34E-01				
Little No-Name	Sodium	2/2	7.63E+01	1.01E+02					
Little No-Name	Vanadium	2/2	1.64E+01	1.92E+01	1.20E-01	2.00E+00		9.60E+00	
Little No-Name	Zinc	2/2	3.22E+01	3.37E+01	3.12E-01	5.00E+01	2.00E+02	6.74E-01	1.69E-01
Little No-Name	4-Hydroxy-4-methyl-2-pentanone	2/2	2.75E+01	2.80E+01					
Little No-Name	Bis(2-ethylhexyl)phthalate	2/2	7.05E-02	9.00E-02					
Little No-Name	Ethylbenzene	1/1	2.70E-01	2.70E-01					
Little No-Name	Phenol	1/2	1.44E-01	9.20E-02		7.00E+01	3.00E+01	1.31E-03	3.07E-03
Little No-Name	Styrene	1/1	6.00E-01	6.00E-01		3.00E+02		2.00E-03	
Little No-Name	Totarol	2/2	4.70E-01	4.80E-01					
Lower WOC	Aluminum	12/12	1.38E+04	2.12E+04	4.79E-01	5.00E+01		4.24E+02	
Lower WOC	Antimony	7/12	8.00E-01	1.10E+00		5.00E+00		2.20E-01	
Lower WOC	Arsenic	8/12	3.65E+00	7.40E+00	5.93E-01	1.00E+01	6.00E+01	7.40E-01	1.23E-01
Lower WOC	Barium	12/12	1.56E+02	2.63E+02	1.24E+00	5.00E+02		5.26E-01	
Lower WOC	Beryllium	12/12	1.12E+00	1.50E+00	6.82E-01	1.00E+01		1.50E-01	
Lower WOC	Boron	12/12	5.99E+00	1.02E+01	2.71E-01	5.00E-01		2.04E+01	
Lower WOC	Cadmium	12/12	5.67E-01	1.00E+00		3.00E+00	2.00E+01	3.33E-01	5.00E-02
Lower WOC	Calcium	12/12	4.61E+03	1.46E+04	2.07E+00				
Lower WOC	Chromium	12/12	7.10E+01	1.16E+02		1.00E+00	4.00E-01	1.16E+02	2.90E+02
Lower WOC	Cobalt	12/12	2.00E+01	3.57E+01	9.73E-01	2.00E+01		1.79E+00	
Lower WOC	Copper	12/12	2.01E+01	3.52E+01	2.81E-01	1.00E+02	5.00E+01	3.52E-01	7.04E-01
Lower WOC	Iron	12/12	3.40E+04	5.96E+04	3.47E-01				
Lower WOC	Lead	12/12	2.37E+01	5.04E+01	3.37E-01	5.00E+01	5.00E+02	1.01E+00	1.01E-01
Lower WOC	Lithium	12/12	1.76E+01	2.73E+01	9.85E-02	2.00E+00		1.37E+01	
Lower WOC	Magnesium	12/12	3.47E+03	7.00E+03	9.42E-01				
Lower WOC	Manganese	12/12	1.33E+03	2.04E+03	1.47E-01	5.00E+02		4.08E+00	
Lower WOC	Mercury	12/12	1.23E+00	5.10E+00	9.54E+00	3.00E-01	1.00E-01	1.70E+01	5.10E+01
Lower WOC	Molybdenum	12/12	3.05E+00	3.90E+00		2.00E+00		1.95E+00	
Lower WOC	Nickel	12/12	2.74E+01	4.56E+01	8.04E-01	3.00E+01	2.00E+02	1.52E+00	2.28E-01
Lower WOC	Osmium	4/8	7.28E+00	1.24E+01					
Lower WOC	Potassium	12/12	1.57E+03	2.83E+03	5.25E-01				
Lower WOC	Selenium	9/12	7.88E-01	1.30E+00		1.00E+00	7.00E+01	1.30E+00	1.86E-02
Lower WOC	Silicon	12/12	3.26E+02	6.45E+02	9.25E-01				

Table 5.2 (continued)

Subbasin	Chemical	Freq. of detect.	Mean conc. (mg/kg)	Max. detected conc. (mg/kg)	Background quotient	Plant tox. (mg/kg)	Invert. tox. (mg/kg)	Plant HQ	Invert. HQ
Lower WOC	Silver	12/12	1.68E+00	6.80E+00		2.00E+00		3.40E+00	
Lower WOC	Sodium	12/12	3.65E+02	4.77E+02					
Lower WOC	Strontium	7/12	9.95E+00	2.04E+01	3.40E-02				
Lower WOC	Thallium	12/12	7.53E-01	1.00E+00	1.27E+00	1.00E+00		1.00E+00	
Lower WOC	Tin	12/12	8.77E+00	1.53E+01		5.00E+01		3.06E-01	
Lower WOC	Vanadium	12/12	2.33E+01	3.83E+01	2.39E-01	2.00E+00		1.92E+01	
Lower WOC	Zinc	12/12	1.89E+02	4.10E+02	3.80E+00	5.00E+01	2.00E+02	8.20E+00	2.05E+00
Lower WOC	2-Methylnaphthalene	1/12	6.04E-01	8.30E-02					
Lower WOC	4-Methylphenol	1/12	6.37E-01	4.20E-01					
Lower WOC	Acenaphthene	1/12	6.01E-01	9.20E-02		2.00E+01		4.60E-03	
Lower WOC	alpha-BHC	1/11	2.08E-03	1.90E-02					
Lower WOC	Anthracene	1/12	6.07E-01	7.80E-02					
Lower WOC	Benz(a)anthracene	2/12	9.68E-02	1.10E-01					
Lower WOC	Benzo(a)pyrene	4/12	1.07E-01	1.20E-01					
Lower WOC	Benzo(b)fluoranthene	2/12	1.12E-01	1.30E-01					
Lower WOC	Benzo(ghi)peryline	2/12	9.61E-02	1.10E-01					
Lower WOC	Benzo(k)fluoranthene	2/12	1.00E-01	1.10E-01					
Lower WOC	bis(2-Ethylhexyl)phthalate	8/12	1.39E-01	4.80E-01					
Lower WOC	Carbazole	2/12	9.04E-02	1.60E-01					
Lower WOC	Chrysene	3/12	2.23E-01	4.50E-01					
Lower WOC	Di-n-butylphthalate	3/12	1.16E-01	1.70E-01		2.00E+02		8.50E-04	
Lower WOC	Di-n-octylphthalate	1/12	6.19E-01	5.50E-02					
Lower WOC	Dibenz(a,h)anthracene	2/12	3.95E-02	4.60E-02					
Lower WOC	Dibenzofuran	1/12	6.05E-01	3.40E-01					
Lower WOC	Fluoranthene	5/12	1.54E-01	2.00E-01					
Lower WOC	Fluorene	1/12	6.17E-01	4.50E-01			3.00E+01		1.50E-02
Lower WOC	Indeno(1,2,3-cd)pyrene	2/12	7.93E-02	8.90E-02					
Lower WOC	N-Nitrosodiphenylamine	1/12	6.37E-01	4.20E-01			2.00E+01		2.10E-02
Lower WOC	PCB-1260	8/11	1.08E-01	4.50E-01					
Lower WOC	Phenanthrene	4/12	1.94E-01	7.70E-01					
Lower WOC	Pyrene	5/12	1.39E-01	2.30E-01					
NHF	Aluminum	3/3	1.71E+04	1.81E+04	4.09E-01	5.00E+01		3.62E+02	
NHF	Arsenic	3/3	2.97E+00	3.10E+00	2.48E-01	1.00E+01	6.00E+01	3.10E-01	5.17E-02
NHF	Barium	3/3	1.96E+02	2.23E+02	1.05E+00	5.00E+02		4.46E-01	
NHF	Beryllium	3/3	9.80E-01	1.00E+00	4.55E-01	1.00E+01		1.00E-01	
NHF	Calcium	3/3	4.35E+03	4.96E+03	7.02E-01				
NHF	Chromium	3/3	3.10E+01	3.51E+01	4.48E-01	1.00E+00	4.00E-01	3.51E+01	8.78E+01
NHF	Cobalt	3/3	1.93E+01	2.00E+01	5.45E-01	2.00E+01		1.00E+00	
NHF	Copper	3/3	2.29E+01	2.53E+01	2.02E-01	1.00E+02	5.00E+01	2.53E-01	5.06E-01
NHF	Iron	3/3	2.87E+04	3.01E+04	1.75E-01				
NHF	Lead	3/3	8.97E+00	1.07E+01	7.15E-02	5.00E+01	5.00E+02	2.14E-01	2.14E-02
NHF	Magnesium	3/3	4.64E+03	5.09E+03	6.85E-01				
NHF	Manganese	3/3	1.31E+03	1.81E+03	1.31E-01	5.00E+02		3.62E+00	
NHF	Nickel	3/3	2.87E+01	3.16E+01	5.57E-01	3.00E+01	2.00E+02	1.05E+00	1.58E-01
NHF	Potassium	3/3	1.92E+03	2.23E+03	4.14E-01				
NHF	Silver	3/3	1.17E+00	1.40E+00		2.00E+00		7.00E-01	

Table 5.2 (continued)

Subbasin	Chemical	Freq. of detect.	Mean conc. (mg/kg)	Max. detected conc. (mg/kg)	Background quotient	Plant tox. (mg/kg)	Invert. tox. (mg/kg)	Plant HQ	Invert. HQ
NHF	Sodium	3/3	5.47E+01	6.19E+01					
NHF	Vanadium	3/3	2.43E+01	2.63E+01	1.64E-01	2.00E+00		1.32E+01	
NHF	Zinc	3/3	5.66E+01	7.72E+01	7.15E-01	5.00E+01	2.00E+02	1.54E+00	3.86E-01
NHF	1,1-Dichloroethene	2/4	8.00E-03	1.00E-02					
NHF	4-Nitrophenol	1/3	3.34E-01	5.80E-02			7.00E+00		8.29E-03
NHF	Benzene	2/4	8.00E-03	1.00E-02					
NHF	Carbon tetrachloride	2/4	8.00E-03	1.00E-02					
NHF	Chloroform	2/4	8.00E-03	1.00E-02					
NHF	Di-n-butylphthalate	3/3	1.07E-01	1.50E-01		2.00E+02		7.50E-04	
NHF	Dimethylbenzene	2/4	8.00E-03	1.00E-02					
NHF	Ethylbenzene	2/4	8.00E-03	1.00E-02					
NHF	Methylene chloride	2/9	5.48E-03	1.00E-02					
NHF	Naphthalene	2/5	1.21E-01	1.00E-02					
NHF	Tetrachloroethene	2/4	8.00E-03	1.00E-02					
NHF	Toluene	3/5	6.60E-03	1.00E-02		2.00E+02		5.00E-05	
NHF	trans-1,2-Dichloroethene	2/2	1.00E-02	1.00E-02					
PIT 4 South	Aluminum	2/2	1.68E+04	1.77E+04	4.00E-01	5.00E+01		3.54E+02	
PIT 4 South	Antimony	2/2	1.20E+00	1.30E+00		5.00E+00		2.60E-01	
PIT 4 South	Arsenic	2/2	4.05E+00	4.80E+00	3.84E-01	1.00E+01	6.00E+01	4.80E-01	8.00E-02
PIT 4 South	Barium	2/2	2.24E+02	2.66E+02	1.25E+00	5.00E+02		5.32E-01	
PIT 4 South	Beryllium	2/2	1.05E+00	1.10E+00	5.00E-01	1.00E+01		1.10E-01	
PIT 4 South	Boron	2/2	5.60E+00	6.10E+00	1.62E-01	5.00E-01		1.22E+01	
PIT 4 South	Cadmium	2/2	3.50E-01	3.80E-01		3.00E+00	2.00E+01	1.27E-01	1.90E-02
PIT 4 South	Calcium	2/2	3.79E+04	4.25E+04	6.02E+00				
PIT 4 South	Chromium	2/2	3.39E+01	3.51E+01		1.00E+00	4.00E-01	3.51E+01	8.78E+01
PIT 4 South	Cobalt	2/2	1.67E+01	1.67E+01	4.55E-01	2.00E+01		8.35E-01	
PIT 4 South	Copper	2/2	4.10E+01	5.44E+01	4.35E-01	1.00E+02	5.00E+01	5.44E-01	1.09E+00
PIT 4 South	Iron	2/2	2.54E+04	2.80E+04	1.63E-01				
PIT 4 South	Lead	2/2	1.78E+01	1.92E+01	1.28E-01	5.00E+01	5.00E+02	3.84E-01	3.84E-02
PIT 4 South	Lithium	2/2	1.95E+01	2.00E+01	7.22E-02	2.00E+00		1.00E+01	
PIT 4 South	Magnesium	2/2	8.17E+03	8.84E+03	1.19E+00				
PIT 4 South	Manganese	2/2	2.03E+03	2.24E+03	1.62E-01	5.00E+02		4.48E+00	
PIT 4 South	Mercury	2/2	1.75E-01	1.80E-01	3.37E-01	3.00E-01	1.00E-01	6.00E-01	1.80E+00
PIT 4 South	Molybdenum	2/2	3.85E+00	4.20E+00		2.00E+00		2.10E+00	
PIT 4 South	Nickel	2/2	2.47E+01	2.69E+01	4.74E-01	3.00E+01	2.00E+02	8.97E-01	1.35E-01
PIT 4 South	Potassium	2/2	2.06E+03	2.10E+03	3.90E-01				
PIT 4 South	Selenium	2/2	1.08E+00	1.20E+00		1.00E+00	7.00E+01	1.20E+00	1.71E-02
PIT 4 South	Silicon	2/2	4.97E+02	6.05E+02	8.68E-01				
PIT 4 South	Silver	2/2	3.50E-01	3.80E-01		2.00E+00		1.90E-01	
PIT 4 South	Sodium	2/2	7.55E+02	7.60E+02					
PIT 4 South	Strontium	2/2	4.13E+01	4.58E+01	7.62E-02				
PIT 4 South	Thallium	2/2	1.08E+00	1.20E+00	1.52E+00	1.00E+00		1.20E+00	
PIT 4 South	Tin	2/2	1.02E+01	1.11E+01		5.00E+01		2.22E-01	
PIT 4 South	Vanadium	2/2	2.39E+01	2.53E+01	1.58E-01	2.00E+00		1.27E+01	
PIT 4 South	Zinc	2/2	7.67E+01	7.76E+01	7.19E-01	5.00E+01	2.00E+02	1.55E+00	3.88E-01
PIT 4 South	Acenaphthene	1/2	9.10E-02	2.20E-02		2.00E+01		1.10E-03	

Table 5.2 (continued)

Subbasin	Chemical	Freq. of detect.	Mean conc. (mg/kg)	Max. detected conc. (mg/kg)	Background quotient	Plant tox. (mg/kg)	Invert. tox. (mg/kg)	Plant HQ	Invert. HQ
PIT 4 South	Anthracene	1/2	1.00E-01	4.00E-02					
PIT 4 South	Benz(a)anthracene	1/2	9.60E-02	3.20E-02					
PIT 4 South	Benzo(a)pyrene	1/2	9.80E-02	3.60E-02					
PIT 4 South	Benzo(b)fluoranthene	2/2	3.50E-02	3.90E-02					
PIT 4 South	Benzo(k)fluoranthene	2/2	2.85E-02	3.60E-02					
PIT 4 South	bis(2-Ethylhexyl)phthalate	2/2	7.15E-02	9.30E-02					
PIT 4 South	Chrysene	1/2	9.75E-02	3.50E-02					
PIT 4 South	Di-n-butylphthalate	2/2	3.55E-01	4.70E-01		2.00E+02		2.35E-03	
PIT 4 South	Dibenzofuran	1/2	1.13E-01	6.60E-02					
PIT 4 South	Fluoranthene	2/2	7.35E-02	1.20E-01					
PIT 4 South	Fluorene	1/2	1.28E-01	9.60E-02			3.00E+01		3.20E-03
PIT 4 South	Naphthalene	1/2	9.55E-02	3.10E-02					
PIT 4 South	PCB-1254	1/2	3.68E-02	4.70E-02					
PIT 4 South	Phenanthrene	1/2	1.65E-01	1.70E-01					
PIT 4 South	Pyrene	2/2	5.45E-02	8.70E-02					
SWSA 5 Seep A	Aluminum	6/6	1.76E+04	2.24E+04	5.06E-01	5.00E+01		4.48E+02	
SWSA 5 Seep A	Antimony	2/2	3.45E+00	4.10E+00		5.00E+00		8.20E-01	
SWSA 5 Seep A	Arsenic	6/6	3.62E+00	5.50E+00	4.41E-01	1.00E+01	6.00E+01	5.50E-01	9.17E-02
SWSA 5 Seep A	Barium	6/6	1.49E+02	2.05E+02	9.67E-01	5.00E+02		4.10E-01	
SWSA 5 Seep A	Beryllium	5/5	8.64E-01	1.10E+00	5.00E-01	1.00E+01		1.10E-01	
SWSA 5 Seep A	Cadmium	2/5	3.87E-01	1.20E+00		3.00E+00	2.00E+01	4.00E-01	6.00E-02
SWSA 5 Seep A	Calcium	6/6	6.63E+03	1.70E+04	2.41E+00				
SWSA 5 Seep A	Chromium	6/6	2.97E+01	4.34E+01	5.54E-01	1.00E+00	4.00E-01	4.34E+01	1.09E+02
SWSA 5 Seep A	Cobalt	6/6	1.81E+01	2.46E+01	6.70E-01	2.00E+01		1.23E+00	
SWSA 5 Seep A	Copper	6/6	1.62E+01	1.98E+01	1.58E-01	1.00E+02	5.00E+01	1.98E-01	3.96E-01
SWSA 5 Seep A	Iron	6/6	3.05E+04	3.48E+04	2.03E-01				
SWSA 5 Seep A	Lead	6/6	2.43E+01	3.79E+01	2.53E-01	5.00E+01	5.00E+02	7.58E-01	7.58E-02
SWSA 5 Seep A	Magnesium	6/6	4.33E+03	6.14E+03	8.26E-01				
SWSA 5 Seep A	Manganese	6/6	2.22E+03	5.54E+03	4.00E-01	5.00E+02		1.11E+01	
SWSA 5 Seep A	Mercury	4/5	1.42E-01	4.10E-01	7.67E-01	3.00E-01	1.00E-01	1.37E+00	4.10E+00
SWSA 5 Seep A	Nickel	6/6	2.57E+01	3.74E+01	6.60E-01	3.00E+01	2.00E+02	1.25E+00	1.87E-01
SWSA 5 Seep A	Potassium	6/6	1.86E+03	2.34E+03	4.34E-01				
SWSA 5 Seep A	Selenium	5/5	2.02E+00	5.10E+00		1.00E+00	7.00E+01	5.10E+00	7.29E-02
SWSA 5 Seep A	Silver	6/6	1.55E+00	2.20E+00		2.00E+00		1.10E+00	
SWSA 5 Seep A	Sodium	3/6	7.16E+01	2.06E+02					
SWSA 5 Seep A	Thallium	2/6	3.73E-01	6.10E-01	7.72E-01	1.00E+00		6.10E-01	
SWSA 5 Seep A	Vanadium	6/6	2.66E+01	2.94E+01	1.83E-01	2.00E+00		1.47E+01	
SWSA 5 Seep A	Zinc	6/6	9.87E+01	3.21E+02	2.97E+00	5.00E+01	2.00E+02	6.42E+00	1.61E+00
SWSA 5 Seep A	1,1-Dichloroethene	4/9	7.92E-03	1.00E-02					
SWSA 5 Seep A	1,2-Dichloroethene	1/6	5.50E-03	2.00E-03					
SWSA 5 Seep A	2-Butanone	1/6	8.33E-03	1.90E-02					
SWSA 5 Seep A	4,4'-DDD	2/6	2.90E-03	4.80E-03					
SWSA 5 Seep A	4,4'-DDE	2/6	2.90E-03	4.80E-03					
SWSA 5 Seep A	4,4'-DDT	2/6	2.90E-03	4.80E-03					
SWSA 5 Seep A	Acetone	2/9	9.03E-03	1.10E-01					
SWSA 5 Seep A	Aldrin	2/6	1.51E-03	2.50E-03					

Table 5.2 (continued)

Subbasin	Chemical	Freq. of detect.	Mean conc. (mg/kg)	Max. detected conc. (mg/kg)	Background quotient	Plant tox. (mg/kg)	Invert. tox. (mg/kg)	Plant HQ	Invert. HQ
SWSA 5 Seep A	alpha-BHC	2/6	1.51E-03	2.50E-03					
SWSA 5 Seep A	alpha-Chlordane	2/6	1.51E-03	2.50E-03					
SWSA 5 Seep A	Benzene	4/9	7.92E-03	1.00E-02					
SWSA 5 Seep A	Benzo(k)fluoranthene	1/4	1.65E-01	4.90E-02					
SWSA 5 Seep A	beta-BHC	2/6	1.51E-03	2.50E-03					
SWSA 5 Seep A	Carbon tetrachloride	4/9	7.92E-03	1.00E-02					
SWSA 5 Seep A	Chloroform	5/9	7.33E-03	1.00E-02					
SWSA 5 Seep A	delta-BHC	2/6	1.51E-03	2.50E-03					
SWSA 5 Seep A	Dieldrin	2/6	2.90E-03	4.80E-03					
SWSA 5 Seep A	Dimethylbenzene	4/9	7.92E-03	1.00E-02					
SWSA 5 Seep A	Endosulfan I	2/6	1.51E-03	2.50E-03					
SWSA 5 Seep A	Endosulfan II	2/6	2.90E-03	4.80E-03					
SWSA 5 Seep A	Endosulfan sulfate	2/6	2.90E-03	4.80E-03					
SWSA 5 Seep A	Endrin	2/6	2.90E-03	4.80E-03					
SWSA 5 Seep A	Endrin aldehyde	2/6	2.90E-03	4.80E-03					
SWSA 5 Seep A	Endrin ketone	2/6	2.90E-03	4.80E-03					
SWSA 5 Seep A	Ethylbenzene	1/6	6.83E-03	1.00E-02					
SWSA 5 Seep A	Fluoranthene	1/4	1.63E-01	4.30E-02					
SWSA 5 Seep A	gamma-Chlordane	2/6	1.51E-03	2.50E-03					
SWSA 5 Seep A	Heptachlor	2/6	1.51E-03	2.50E-03					
SWSA 5 Seep A	Heptachlor epoxide	2/6	1.51E-03	2.50E-03					
SWSA 5 Seep A	Lindane	2/6	1.51E-03	2.50E-03					
SWSA 5 Seep A	Methoxychlor	2/6	1.51E-02	2.50E-02					
SWSA 5 Seep A	Methylene chloride	4/9	7.92E-03	1.00E-02					
SWSA 5 Seep A	Naphthalene	4/8	1.08E-01	1.00E-02					
SWSA 5 Seep A	PCB-1016	2/6	2.90E-02	4.80E-02					
SWSA 5 Seep A	PCB-1221	2/6	5.88E-02	9.80E-02					
SWSA 5 Seep A	PCB-1232	2/6	2.90E-02	4.80E-02					
SWSA 5 Seep A	PCB-1242	2/6	2.90E-02	4.80E-02					
SWSA 5 Seep A	PCB-1248	2/6	2.90E-02	4.80E-02					
SWSA 5 Seep A	PCB-1254	3/6	4.11E-02	9.30E-02					
SWSA 5 Seep A	PCB-1260	3/6	3.24E-02	7.80E-02					
SWSA 5 Seep A	Pyrene	1/4	1.66E-01	5.20E-02					
SWSA 5 Seep A	Tetrachloroethene	4/9	7.92E-03	1.00E-02					
SWSA 5 Seep A	Toluene	4/9	7.92E-03	1.00E-02		2.00E+02		5.00E-05	
SWSA 5 Seep A	Toxaphene	2/6	1.51E-01	2.50E-01					
SWSA 5 Seep A	trans-1,2-Dichloroethene	4/4	1.00E-02	1.00E-02					
SWSA 5 Seep B West	Aluminum	2/2	1.89E+04	2.45E+04	5.53E-01	5.00E+01		4.90E+02	
SWSA 5 Seep B West	Antimony	1/2	5.83E+00	6.20E+00		5.00E+00		1.24E+00	
SWSA 5 Seep B West	Arsenic	1/2	2.55E+00	4.00E+00	3.20E-01	1.00E+01	6.00E+01	4.00E-01	6.67E-02
SWSA 5 Seep B West	Barium	2/2	1.19E+02	1.19E+02	5.61E-01	5.00E+02		2.38E-01	
SWSA 5 Seep B West	Beryllium	2/2	7.55E-01	8.00E-01	3.64E-01	1.00E+01		8.00E-02	
SWSA 5 Seep B West	Boron	1/1	9.00E+00	9.00E+00	2.39E-01	5.00E-01		1.80E+01	
SWSA 5 Seep B West	Cadmium	1/2	9.30E-01	7.10E-01		3.00E+00	2.00E+01	2.37E-01	3.55E-02
SWSA 5 Seep B West	Calcium	2/2	7.68E+03	1.33E+04	1.88E+00				
SWSA 5 Seep B West	Chromium	1/1	3.19E+01	3.19E+01		1.00E+00	4.00E-01	3.19E+01	7.98E+01

Table 5.2 (continued)

Subbasin	Chemical	Freq. of detect.	Mean conc. (mg/kg)	Max. detected conc. (mg/kg)	Background quotient	Plant tox. (mg/kg)	Invert. tox. (mg/kg)	Plant HQ	Invert. HQ
SWSA 5 Seep B West	Cobalt	2/2	2.05E+01	2.31E+01	6.29E-01	2.00E+01		1.16E+00	
SWSA 5 Seep B West	Copper	2/2	2.33E+01	3.14E+01	2.51E-01	1.00E+02	5.00E+01	3.14E-01	6.28E-01
SWSA 5 Seep B West	Cyanide	1/1	7.00E-02	7.00E-02	1.59E-01				
SWSA 5 Seep B West	Iron	2/2	2.79E+04	3.25E+04	1.89E-01				
SWSA 5 Seep B West	Lead	2/2	2.82E+01	3.85E+01	2.57E-01	5.00E+01	5.00E+02	7.70E-01	7.70E-02
SWSA 5 Seep B West	Lithium	1/1	1.50E+01	1.50E+01	5.41E-02	2.00E+00		7.50E+00	
SWSA 5 Seep B West	Magnesium	2/2	3.51E+03	4.54E+03	6.11E-01				
SWSA 5 Seep B West	Manganese	2/2	1.21E+03	1.28E+03	9.25E-02	5.00E+02		2.56E+00	
SWSA 5 Seep B West	Mercury	1/2	1.02E+00	2.00E+00	3.74E+00	3.00E-01	1.00E-01	6.67E+00	2.00E+01
SWSA 5 Seep B West	Molybdenum	1/1	3.30E+00	3.30E+00		2.00E+00		1.65E+00	
SWSA 5 Seep B West	Nickel	2/2	2.72E+01	3.18E+01	5.61E-01	3.00E+01	2.00E+02	1.06E+00	1.59E-01
SWSA 5 Seep B West	Potassium	2/2	2.50E+03	3.16E+03	5.86E-01				
SWSA 5 Seep B West	Selenium	2/2	8.30E-01	1.30E+00		1.00E+00	7.00E+01	1.30E+00	1.86E-02
SWSA 5 Seep B West	Silicon	1/1	2.46E+02	2.46E+02	3.53E-01				
SWSA 5 Seep B West	Silver	1/2	7.25E-01	9.50E-01		2.00E+00		4.75E-01	
SWSA 5 Seep B West	Sodium	2/2	2.45E+02	3.48E+02					
SWSA 5 Seep B West	Strontium	1/1	7.20E+00	7.20E+00	1.20E-02				
SWSA 5 Seep B West	Thallium	2/2	5.35E-01	7.10E-01	8.99E-01	1.00E+00		7.10E-01	
SWSA 5 Seep B West	Tin	1/1	6.40E+00	6.40E+00		5.00E+01		1.28E-01	
SWSA 5 Seep B West	Vanadium	2/2	2.63E+01	3.45E+01	2.15E-01	2.00E+00		1.73E+01	
SWSA 5 Seep B West	Zinc	2/2	5.61E+01	5.81E+01	5.38E-01	5.00E+01	2.00E+02	1.16E+00	2.91E-01
SWSA 5 Seep B West	1,1-Dichloroethene	1/2	7.50E-03	1.00E-02					
SWSA 5 Seep B West	4-Methylphenol	1/2	3.05E-01	4.00E-01					
SWSA 5 Seep B West	Benzene	1/2	7.50E-03	1.00E-02					
SWSA 5 Seep B West	Bis(2-ethylhexyl)phthalate	1/1	5.20E-02	5.20E-02					
SWSA 5 Seep B West	bis(2-Ethylhexyl)phthalate	1/1	4.60E-02	4.60E-02					
SWSA 5 Seep B West	Carbon tetrachloride	1/2	7.50E-03	1.00E-02					
SWSA 5 Seep B West	Chloroform	1/2	7.50E-03	1.00E-02					
SWSA 5 Seep B West	Di-n-butylphthalate	1/2	1.17E-01	2.30E-02		2.00E+02		1.15E-04	
SWSA 5 Seep B West	Dimethylbenzene	1/2	7.50E-03	1.00E-02					
SWSA 5 Seep B West	Ethylbenzene	1/2	7.50E-03	1.00E-02					
SWSA 5 Seep B West	Methylene chloride	1/2	7.50E-03	1.00E-02					
SWSA 5 Seep B West	Naphthalene	1/3	1.40E-01	1.00E-02					
SWSA 5 Seep B West	PCB-1248	1/2	2.35E-02	2.60E-02					
SWSA 5 Seep B West	PCB-1254	1/2	3.55E-02	5.00E-02					
SWSA 5 Seep B West	Tetrachloroethene	1/2	7.50E-03	1.00E-02					
SWSA 5 Seep B West	Toluene	1/2	7.50E-03	1.00E-02		2.00E+02		5.00E-05	
SWSA 5 Seep B West	trans-1,2-Dichloroethene	1/1	1.00E-02	1.00E-02					
SWSA 5 Seep B East	Aluminum	3/3	1.98E+04	2.20E+04	4.97E-01	5.00E+01		4.40E+02	
SWSA 5 Seep B East	Antimony	1/1	3.40E+00	3.40E+00		5.00E+00		6.80E-01	
SWSA 5 Seep B East	Arsenic	3/3	3.33E+00	4.50E+00	3.60E-01	1.00E+01	6.00E+01	4.50E-01	7.50E-02
SWSA 5 Seep B East	Barium	3/3	1.64E+02	1.91E+02	9.01E-01	5.00E+02		3.82E-01	
SWSA 5 Seep B East	Beryllium	3/3	1.12E+00	1.40E+00	6.36E-01	1.00E+01		1.40E-01	
SWSA 5 Seep B East	Calcium	3/3	3.39E+03	5.89E+03	8.34E-01				
SWSA 5 Seep B East	Chromium	3/3	3.37E+01	3.62E+01	4.62E-01	1.00E+00	4.00E-01	3.62E+01	9.05E+01
SWSA 5 Seep B East	Cobalt	3/3	1.92E+01	2.32E+01	6.32E-01	2.00E+01		1.16E+00	

Table 5.2 (continued)

Subbasin	Chemical	Freq. of detect.	Mean conc. (mg/kg)	Max. detected conc. (mg/kg)	Background quotient	Plant tox. (mg/kg)	Invert. tox. (mg/kg)	Plant HQ	Invert. HQ
SWSA 5 Seep B East	Copper	3/3	3.82E+01	7.44E+01	5.95E-01	1.00E+02	5.00E+01	7.44E-01	1.49E+00
SWSA 5 Seep B East	Iron	3/3	3.05E+04	3.13E+04	1.82E-01				
SWSA 5 Seep B East	Lead	3/3	1.58E+01	2.60E+01	1.74E-01	5.00E+01	5.00E+02	5.20E-01	5.20E-02
SWSA 5 Seep B East	Magnesium	3/3	6.46E+03	6.72E+03	9.04E-01				
SWSA 5 Seep B East	Manganese	3/3	1.01E+03	1.17E+03	8.45E-02	5.00E+02		2.34E+00	
SWSA 5 Seep B East	Nickel	3/3	3.67E+01	3.92E+01	6.91E-01	3.00E+01	2.00E+02	1.31E+00	1.96E-01
SWSA 5 Seep B East	Potassium	3/3	2.19E+03	2.34E+03	4.34E-01				
SWSA 5 Seep B East	Selenium	1/3	3.48E-01	3.40E-01		1.00E+00	7.00E+01	3.40E-01	4.86E-03
SWSA 5 Seep B East	Silver	3/3	1.43E+00	1.60E+00		2.00E+00		8.00E-01	
SWSA 5 Seep B East	Sodium	2/3	5.44E+01	7.82E+01					
SWSA 5 Seep B East	Thallium	2/3	4.13E-01	7.00E-01	8.86E-01	1.00E+00		7.00E-01	
SWSA 5 Seep B East	Vanadium	3/3	2.54E+01	2.63E+01	1.64E-01	2.00E+00		1.32E+01	
SWSA 5 Seep B East	Zinc	3/3	6.90E+01	7.16E+01	6.63E-01	5.00E+01	2.00E+02	1.43E+00	3.58E-01
SWSA 5 Seep B East	1,1-Dichloroethene	2/4	7.88E-03	1.00E-02					
SWSA 5 Seep B East	4,4'-DDD	1/3	2.58E-03	3.90E-03					
SWSA 5 Seep B East	4,4'-DDE	1/3	2.58E-03	3.90E-03					
SWSA 5 Seep B East	4,4'-DDT	1/3	2.58E-03	3.90E-03					
SWSA 5 Seep B East	Aldrin	1/3	1.32E-03	2.00E-03					
SWSA 5 Seep B East	alpha-BHC	1/3	1.32E-03	2.00E-03					
SWSA 5 Seep B East	alpha-Chlordane	1/3	1.32E-03	2.00E-03					
SWSA 5 Seep B East	Benzene	2/4	7.88E-03	1.00E-02					
SWSA 5 Seep B East	beta-BHC	1/3	1.32E-03	2.00E-03					
SWSA 5 Seep B East	Carbon tetrachloride	2/4	7.88E-03	1.00E-02					
SWSA 5 Seep B East	Chloroform	2/4	7.88E-03	1.00E-02					
SWSA 5 Seep B East	delta-BHC	1/3	1.32E-03	2.00E-03					
SWSA 5 Seep B East	Dieldrin	1/3	2.58E-03	3.90E-03					
SWSA 5 Seep B East	Dimethylbenzene	2/4	7.88E-03	1.00E-02					
SWSA 5 Seep B East	Endosulfan I	1/3	1.32E-03	2.00E-03					
SWSA 5 Seep B East	Endosulfan II	1/3	2.58E-03	3.90E-03					
SWSA 5 Seep B East	Endosulfan sulfate	1/3	2.58E-03	3.90E-03					
SWSA 5 Seep B East	Endrin	1/3	2.58E-03	3.90E-03					
SWSA 5 Seep B East	Endrin aldehyde	1/3	2.58E-03	3.90E-03					
SWSA 5 Seep B East	Endrin ketone	1/3	2.58E-03	3.90E-03					
SWSA 5 Seep B East	gamma-Chlordane	1/3	1.32E-03	2.00E-03					
SWSA 5 Seep B East	Heptachlor	1/3	1.32E-03	2.00E-03					
SWSA 5 Seep B East	Heptachlor epoxide	1/3	1.32E-03	2.00E-03					
SWSA 5 Seep B East	Lindane	1/3	1.32E-03	2.00E-03					
SWSA 5 Seep B East	Methoxychlor	1/3	1.32E-02	2.00E-02					
SWSA 5 Seep B East	Methylene chloride	2/4	7.88E-03	1.00E-02					
SWSA 5 Seep B East	Naphthalene	2/4	1.00E-01	1.00E-02					
SWSA 5 Seep B East	PCB-1016	1/3	2.58E-02	3.90E-02					
SWSA 5 Seep B East	PCB-1221	1/3	5.22E-02	7.90E-02					
SWSA 5 Seep B East	PCB-1232	1/3	2.58E-02	3.90E-02					
SWSA 5 Seep B East	PCB-1242	1/3	2.58E-02	3.90E-02					
SWSA 5 Seep B East	PCB-1248	1/3	2.58E-02	3.90E-02					
SWSA 5 Seep B East	PCB-1254	1/3	2.58E-02	3.90E-02					

Table 5.2 (continued)

Subbasin	Chemical	Freq. of detect.	Mean conc. (mg/kg)	Max. detected conc. (mg/kg)	Background quotient	Plant tox. (mg/kg)	Invert. tox. (mg/kg)	Plant HQ	Invert. HQ
SWSA 5 Seep B East	PCB-1260	2/3	6.83E-02	1.40E-01					
SWSA 5 Seep B East	Tetrachloroethene	5/7	6.21E-03	1.00E-02					
SWSA 5 Seep B East	Toluene	3/5	6.50E-03	1.00E-02		2.00E+02		5.00E-05	
SWSA 5 Seep B East	Toxaphene	1/3	1.32E-01	2.00E-01					
SWSA 5 Seep B East	trans-1,2-Dichloroethene	2/2	1.00E-02	1.00E-02					
SWSA 5 Seep C	Aluminum	15/15	2.50E+04	3.68E+04	8.31E-01	5.00E+01		7.36E+02	
SWSA 5 Seep C	Antimony	3/6	6.61E+00	1.21E+01		5.00E+00		2.42E+00	
SWSA 5 Seep C	Arsenic	14/15	4.72E+00	1.12E+01	8.97E-01	1.00E+01	6.00E+01	1.12E+00	1.87E-01
SWSA 5 Seep C	Barium	15/15	2.18E+02	4.79E+02	2.26E+00	5.00E+02		9.58E-01	
SWSA 5 Seep C	Beryllium	14/15	1.28E+00	2.40E+00	1.09E+00	1.00E+01		2.40E-01	
SWSA 5 Seep C	Boron	4/4	5.70E+00	9.40E+00	2.49E-01	5.00E-01		1.88E+01	
SWSA 5 Seep C	Cadmium	4/15	2.54E-01	1.10E+00		3.00E+00	2.00E+01	3.67E-01	5.50E-02
SWSA 5 Seep C	Calcium	15/15	7.95E+03	4.90E+04	6.94E+00				
SWSA 5 Seep C	Chromium	11/11	3.81E+01	4.62E+01	5.89E-01	1.00E+00	4.00E-01	4.62E+01	1.16E+02
SWSA 5 Seep C	Cobalt	15/15	2.36E+01	5.27E+01	1.44E+00	2.00E+01		2.64E+00	
SWSA 5 Seep C	Copper	15/15	2.07E+01	3.06E+01	2.45E-01	1.00E+02	5.00E+01	3.06E-01	6.12E-01
SWSA 5 Seep C	Cyanide	1/8	3.37E-01	7.00E-01	1.59E+00				
SWSA 5 Seep C	Iron	15/15	3.31E+04	4.39E+04	2.56E-01				
SWSA 5 Seep C	Lead	15/15	1.49E+01	2.66E+01	1.78E-01	5.00E+01	5.00E+02	5.32E-01	5.32E-02
SWSA 5 Seep C	Lithium	4/4	2.13E+01	2.59E+01	9.35E-02	2.00E+00		1.30E+01	
SWSA 5 Seep C	Magnesium	15/15	6.62E+03	1.02E+04	1.37E+00				
SWSA 5 Seep C	Manganese	15/15	2.37E+03	9.40E+03	6.79E-01	5.00E+02		1.88E+01	
SWSA 5 Seep C	Mercury	5/14	8.15E-02	1.40E-01	2.62E-01	3.00E-01	1.00E-01	4.67E-01	1.40E+00
SWSA 5 Seep C	Molybdenum	4/4	6.13E+00	7.30E+00		2.00E+00		3.65E+00	
SWSA 5 Seep C	Nickel	15/15	3.57E+01	4.70E+01	8.29E-01	3.00E+01	2.00E+02	1.57E+00	2.35E-01
SWSA 5 Seep C	Osmium	3/3	8.50E+00	1.22E+01					
SWSA 5 Seep C	Potassium	15/15	3.01E+03	4.61E+03	8.55E-01				
SWSA 5 Seep C	Selenium	4/13	6.42E-01	8.40E-01		1.00E+00	7.00E+01	8.40E-01	1.20E-02
SWSA 5 Seep C	Silicon	4/4	7.02E+02	1.72E+03	2.47E+00				
SWSA 5 Seep C	Silver	8/14	1.47E+00	5.00E+00		2.00E+00		2.50E+00	
SWSA 5 Seep C	Sodium	10/15	2.11E+02	6.22E+02					
SWSA 5 Seep C	Strontium	4/4	1.25E+01	2.33E+01	3.88E-02				
SWSA 5 Seep C	Thallium	5/14	5.94E-01	1.40E+00	1.77E+00	1.00E+00		1.40E+00	
SWSA 5 Seep C	Tin	4/4	9.38E+00	1.13E+01		5.00E+01		2.26E-01	
SWSA 5 Seep C	Vanadium	15/15	3.28E+01	4.04E+01	2.52E-01	2.00E+00		2.02E+01	
SWSA 5 Seep C	Zinc	15/15	7.14E+01	9.17E+01	8.49E-01	5.00E+01	2.00E+02	1.83E+00	4.59E-01
SWSA 5 Seep C	1,1,1-Trichloroethane	2/11	5.32E-03	3.00E-03					
SWSA 5 Seep C	1,1-Dichloroethane	2/11	5.23E-03	2.00E-03					
SWSA 5 Seep C	1,1-Dichloroethene	10/19	8.15E-03	1.00E-02					
SWSA 5 Seep C	1,2-Dichloroethene	2/11	5.50E-03	4.00E-03					
SWSA 5 Seep C	4,4'-DDD	1/17	2.07E-03	8.20E-04					
SWSA 5 Seep C	Acetone	10/19	1.55E-02	8.10E-02					
SWSA 5 Seep C	Benzene	10/19	8.15E-03	1.00E-02					
SWSA 5 Seep C	bis(2-Ethylhexyl)phthalate	6/6	1.96E-01	2.80E-01					
SWSA 5 Seep C	Carbon tetrachloride	10/19	8.15E-03	1.00E-02					
SWSA 5 Seep C	Chloroform	10/19	8.15E-03	1.00E-02					

Table 5.2 (continued)

Subbasin	Chemical	Freq. of detect.	Mean conc. (mg/kg)	Max. detected conc. (mg/kg)	Background quotient	Plant tox. (mg/kg)	Invert. tox. (mg/kg)	Plant HQ	Invert. HQ
SWSA 5 Seep C	Di-n-butylphthalate	11/16	2.08E-01	4.40E-01		2.00E+02		2.20E-03	
SWSA 5 Seep C	Diethylphthalate	1/16	2.86E-01	6.10E-02		1.00E+02		6.10E-04	
SWSA 5 Seep C	Dimethylbenzene	11/20	7.88E-03	1.00E-02					
SWSA 5 Seep C	Endrin	1/17	2.05E-03	5.10E-04					
SWSA 5 Seep C	Ethylbenzene	9/18	8.05E-03	1.00E-02					
SWSA 5 Seep C	Methylene chloride	10/19	8.15E-03	1.00E-02					
SWSA 5 Seep C	Naphthalene	11/27	1.75E-01	1.00E-02					
SWSA 5 Seep C	Tetrachloroethene	11/20	7.83E-03	1.00E-02					
SWSA 5 Seep C	Toluene	12/21	7.45E-03	1.00E-02		2.00E+02		5.00E-05	
SWSA 5 Seep C	trans-1,2-Dichloroethene	10/10	1.00E-02	1.00E-02					
SWSA 5 Seep C	Trichloroethene	4/12	4.79E-03	4.00E-03					
SWSA 5 Trib 1	Aluminum	17/17	2.09E+04	2.72E+04	6.14E-01	5.00E+01		5.44E+02	
SWSA 5 Trib 1	Antimony	2/5	2.21E+00	3.60E+00		5.00E+00		7.20E-01	
SWSA 5 Trib 1	Arsenic	17/17	3.19E+00	1.16E+01	9.29E-01	1.00E+01	6.00E+01	1.16E+00	1.93E-01
SWSA 5 Trib 1	Barium	17/17	1.50E+02	2.58E+02	1.22E+00	5.00E+02		5.16E-01	
SWSA 5 Trib 1	Beryllium	17/17	1.14E+00	1.60E+00	7.27E-01	1.00E+01		1.60E-01	
SWSA 5 Trib 1	Cadmium	1/17	2.14E-01	5.40E-01		3.00E+00	2.00E+01	1.80E-01	2.70E-02
SWSA 5 Trib 1	Calcium	17/17	9.29E+03	6.85E+04	9.70E+00				
SWSA 5 Trib 1	Chromium	17/17	3.16E+01	3.80E+01	4.85E-01	1.00E+00	4.00E-01	3.80E+01	9.50E+01
SWSA 5 Trib 1	Cobalt	17/17	1.89E+01	3.38E+01	9.21E-01	2.00E+01		1.69E+00	
SWSA 5 Trib 1	Copper	16/17	1.82E+01	2.70E+01	2.16E-01	1.00E+02	5.00E+01	2.70E-01	5.40E-01
SWSA 5 Trib 1	Iron	17/17	3.12E+04	4.06E+04	2.36E-01				
SWSA 5 Trib 1	Lead	17/17	1.88E+01	1.31E+02	8.75E-01	5.00E+01	5.00E+02	2.62E+00	2.62E-01
SWSA 5 Trib 1	Magnesium	17/17	5.95E+03	1.19E+04	1.60E+00				
SWSA 5 Trib 1	Manganese	17/17	9.74E+02	2.84E+03	2.05E-01	5.00E+02		5.68E+00	
SWSA 5 Trib 1	Mercury	4/16	3.28E-02	4.30E+00	8.05E+00	3.00E-01	1.00E-01	1.43E+01	4.30E+01
SWSA 5 Trib 1	Nickel	17/17	3.12E+01	4.44E+01	7.83E-01	3.00E+01	2.00E+02	1.48E+00	2.22E-01
SWSA 5 Trib 1	Potassium	17/17	2.30E+03	2.96E+03	5.49E-01				
SWSA 5 Trib 1	Selenium	4/13	5.87E-01	3.30E+00		1.00E+00	7.00E+01	3.30E+00	4.71E-02
SWSA 5 Trib 1	Silver	11/17	1.56E+00	3.10E+00		2.00E+00		1.55E+00	
SWSA 5 Trib 1	Sodium	9/17	7.83E+01	1.87E+02					
SWSA 5 Trib 1	Thallium	3/17	3.15E-01	5.40E-01	6.84E-01	1.00E+00		5.40E-01	
SWSA 5 Trib 1	Vanadium	17/17	2.69E+01	3.11E+01	1.94E-01	2.00E+00		1.56E+01	
SWSA 5 Trib 1	Zinc	17/17	6.48E+01	7.61E+01	7.05E-01	5.00E+01	2.00E+02	1.52E+00	3.81E-01
SWSA 5 Trib 1	1,1-Dichloroethene	12/26	7.86E-03	1.00E-02					
SWSA 5 Trib 1	4,4'-DDD	2/17	3.60E-03	4.30E-03					
SWSA 5 Trib 1	4,4'-DDE	2/17	3.60E-03	4.30E-03					
SWSA 5 Trib 1	4,4'-DDT	2/17	3.60E-03	4.30E-03					
SWSA 5 Trib 1	Aldrin	2/17	1.86E-03	2.20E-03					
SWSA 5 Trib 1	alpha-BHC	2/17	1.86E-03	2.20E-03					
SWSA 5 Trib 1	alpha-Chlordane	2/17	1.86E-03	2.20E-03					
SWSA 5 Trib 1	Benzene	12/25	7.93E-03	1.00E-02					
SWSA 5 Trib 1	beta-BHC	2/17	1.86E-03	2.20E-03					
SWSA 5 Trib 1	Bis(2-ethylhexyl)phthalate	5/15	1.78E-01	3.90E-01					
SWSA 5 Trib 1	Butylbenzylphthalate	1/15	1.75E-01	4.30E-02					
SWSA 5 Trib 1	Carbon tetrachloride	12/25	7.93E-03	1.00E-02					

Table 5.2 (continued)

Subbasin	Chemical	Freq. of detect.	Mean conc. (mg/kg)	Max. detected conc. (mg/kg)	Background quotient	Plant tox. (mg/kg)	Invert. tox. (mg/kg)	Plant HQ	Invert. HQ
SWSA 5 Trib 1	Chloroform	14/27	7.44E-03	1.00E-02					
SWSA 5 Trib 1	delta-BHC	2/17	1.86E-03	2.20E-03					
SWSA 5 Trib 1	Di-n-butylphthalate	6/15	1.62E-01	1.50E-01		2.00E+02		7.50E-04	
SWSA 5 Trib 1	Dieldrin	2/17	3.60E-03	4.30E-03					
SWSA 5 Trib 1	Diethylphthalate	2/15	1.94E-01	3.00E-01		1.00E+02		3.00E-03	
SWSA 5 Trib 1	Dimethylbenzene	12/25	7.93E-03	1.00E-02					
SWSA 5 Trib 1	Endosulfan I	2/17	1.86E-03	2.20E-03					
SWSA 5 Trib 1	Endosulfan II	2/17	3.60E-03	4.30E-03					
SWSA 5 Trib 1	Endosulfan sulfate	2/17	3.60E-03	4.30E-03					
SWSA 5 Trib 1	Endrin	2/17	3.60E-03	4.30E-03					
SWSA 5 Trib 1	Endrin aldehyde	2/17	3.60E-03	4.30E-03					
SWSA 5 Trib 1	Endrin ketone	2/17	3.60E-03	4.30E-03					
SWSA 5 Trib 1	Ethylbenzene	2/15	6.53E-03	1.00E-02					
SWSA 5 Trib 1	gamma-Chlordane	2/17	1.86E-03	2.20E-03					
SWSA 5 Trib 1	Heptachlor	2/17	1.86E-03	2.20E-03					
SWSA 5 Trib 1	Heptachlor epoxide	2/17	1.86E-03	2.20E-03					
SWSA 5 Trib 1	Lindane	2/17	1.86E-03	2.20E-03					
SWSA 5 Trib 1	Methoxychlor	2/17	1.86E-02	2.20E-02					
SWSA 5 Trib 1	Methylene chloride	12/25	7.93E-03	1.00E-02					
SWSA 5 Trib 1	Naphthalene	12/27	1.13E-01	1.00E-02					
SWSA 5 Trib 1	PCB-1016	2/17	3.60E-02	4.30E-02					
SWSA 5 Trib 1	PCB-1221	2/17	7.28E-02	8.70E-02					
SWSA 5 Trib 1	PCB-1232	2/17	3.60E-02	4.30E-02					
SWSA 5 Trib 1	PCB-1242	2/17	3.60E-02	4.30E-02					
SWSA 5 Trib 1	PCB-1248	2/17	3.60E-02	4.30E-02					
SWSA 5 Trib 1	PCB-1254	2/17	1.50E-02	1.40E-01					
SWSA 5 Trib 1	PCB-1260	5/17	2.99E-02	2.80E-01					
SWSA 5 Trib 1	Pyrene	1/15	1.86E-01	4.10E-02					
SWSA 5 Trib 1	Styrene	1/14	5.71E-03	2.00E-03		3.00E+02		6.67E-06	
SWSA 5 Trib 1	Tetrachloroethene	12/25	7.93E-03	1.00E-02					
SWSA 5 Trib 1	Toluene	16/28	7.57E-03	1.00E-02		2.00E+02		5.00E-05	
SWSA 5 Trib 1	Toxaphene	2/17	1.86E-01	2.20E-01					
SWSA 5 Trib 1	trans-1,2-Dichloroethene	12/12	1.00E-02	1.00E-02					
SWSA 5 WOC	Aluminum	22/22	2.14E+04	3.31E+04	7.47E-01	5.00E+01		6.62E+02	
SWSA 5 WOC	Antimony	2/9	2.92E+00	3.70E+00		5.00E+00		7.40E-01	
SWSA 5 WOC	Arsenic	21/22	2.31E+00	5.10E+00	4.09E-01	1.00E+01	6.00E+01	5.10E-01	8.50E-02
SWSA 5 WOC	Barium	22/22	1.77E+02	2.74E+02	1.29E+00	5.00E+02		5.48E-01	
SWSA 5 WOC	Beryllium	19/22	1.37E+00	3.30E+00	1.50E+00	1.00E+01		3.30E-01	
SWSA 5 WOC	Cadmium	5/20	2.25E-01	2.00E+00		3.00E+00	2.00E+01	6.67E-01	1.00E-01
SWSA 5 WOC	Calcium	22/22	1.51E+04	2.46E+05	3.48E+01				
SWSA 5 WOC	Chromium	22/22	3.24E+01	4.98E+01	6.35E-01	1.00E+00	4.00E-01	4.98E+01	1.25E+02
SWSA 5 WOC	Cobalt	21/22	1.78E+01	2.24E+01	6.10E-01	2.00E+01		1.12E+00	
SWSA 5 WOC	Copper	20/22	2.43E+01	8.67E+01	6.93E-01	1.00E+02	5.00E+01	8.67E-01	1.73E+00
SWSA 5 WOC	Iron	22/22	2.98E+04	3.74E+04	2.18E-01				
SWSA 5 WOC	Lead	22/22	2.34E+01	5.57E+01	3.72E-01	5.00E+01	5.00E+02	1.11E+00	1.11E-01
SWSA 5 WOC	Magnesium	22/22	7.80E+03	2.26E+04	3.04E+00				

Table 5.2 (continued)

Subbasin	Chemical	Freq. of detect.	Mean conc. (mg/kg)	Max. detected conc. (mg/kg)	Background quotient	Plant tox. (mg/kg)	Invert. tox. (mg/kg)	Plant HQ	Invert. HQ
SWSA 5 WOC	Manganese	22/22	1.38E+03	3.71E+03	2.68E-01	5.00E+02		7.42E+00	
SWSA 5 WOC	Mercury	7/21	6.49E-02	9.60E-01	1.80E+00	3.00E-01	1.00E-01	3.20E+00	9.60E+00
SWSA 5 WOC	Nickel	19/22	3.14E+01	4.42E+01	7.80E-01	3.00E+01	2.00E+02	1.47E+00	2.21E-01
SWSA 5 WOC	Potassium	22/22	2.23E+03	3.35E+03	6.22E-01				
SWSA 5 WOC	Selenium	3/19	4.19E-01	1.70E+00		1.00E+00	7.00E+01	1.70E+00	2.43E-02
SWSA 5 WOC	Silver	10/22	1.08E+00	2.20E+00		2.00E+00		1.10E+00	
SWSA 5 WOC	Sodium	8/22	7.87E+01	1.76E+02					
SWSA 5 WOC	Thallium	1/21	2.79E-01	5.70E-01	7.22E-01	1.00E+00		5.70E-01	
SWSA 5 WOC	Vanadium	20/22	2.71E+01	3.55E+01	2.21E-01	2.00E+00		1.78E+01	
SWSA 5 WOC	Zinc	22/22	7.26E+01	1.18E+02	1.09E+00	5.00E+01	2.00E+02	2.36E+00	5.90E-01
SWSA 5 WOC	1,1,1-Trichloroethane	1/22	6.00E-03	2.00E-03					
SWSA 5 WOC	1,1-Dichloroethene	24/45	8.23E-03	1.00E-02					
SWSA 5 WOC	1,2-Dichloroethene	1/22	6.00E-03	2.00E-03					
SWSA 5 WOC	4,4'-DDD	1/19	2.11E-03	4.30E-03					
SWSA 5 WOC	4,4'-DDE	1/19	2.11E-03	4.30E-03					
SWSA 5 WOC	4,4'-DDT	1/19	2.11E-03	4.30E-03					
SWSA 5 WOC	4-Nitrophenol	1/19	4.60E-01	8.20E-02			7.00E+00		1.17E-02
SWSA 5 WOC	Acetone	5/36	3.63E-03	6.50E-01					
SWSA 5 WOC	Aldrin	1/19	1.10E-03	2.20E-03					
SWSA 5 WOC	alpha-BHC	1/19	1.10E-03	2.20E-03					
SWSA 5 WOC	alpha-Chlordane	1/19	1.10E-03	2.20E-03					
SWSA 5 WOC	Benzene	24/45	8.23E-03	1.00E-02					
SWSA 5 WOC	beta-BHC	1/19	1.10E-03	2.20E-03					
SWSA 5 WOC	Bis(2-ethylhexyl)phthalate	3/19	1.83E-01	1.10E-01					
SWSA 5 WOC	Butylbenzylphthalate	2/19	1.84E-01	5.20E-02					
SWSA 5 WOC	Carbon tetrachloride	28/49	7.73E-03	1.00E-02					
SWSA 5 WOC	Chloroform	30/51	7.39E-03	1.00E-02					
SWSA 5 WOC	Chloromethane	2/23	5.83E-03	2.00E-03					
SWSA 5 WOC	delta-BHC	1/19	1.10E-03	2.20E-03					
SWSA 5 WOC	Di-n-butylphthalate	4/19	1.40E-01	3.80E+00		2.00E+02		1.90E-02	
SWSA 5 WOC	Dieldrin	1/19	2.11E-03	4.30E-03					
SWSA 5 WOC	Diethylphthalate	1/19	1.94E-01	6.70E-02		1.00E+02		6.70E-04	
SWSA 5 WOC	Dimethylbenzene	32/53	7.38E-03	1.00E-02					
SWSA 5 WOC	Endosulfan I	1/19	1.10E-03	2.20E-03					
SWSA 5 WOC	Endosulfan II	1/19	2.11E-03	4.30E-03					
SWSA 5 WOC	Endosulfan sulfate	1/19	2.11E-03	4.30E-03					
SWSA 5 WOC	Endrin	1/19	2.11E-03	4.30E-03					
SWSA 5 WOC	Endrin aldehyde	1/19	2.11E-03	4.30E-03					
SWSA 5 WOC	Endrin ketone	1/19	2.11E-03	4.30E-03					
SWSA 5 WOC	Ethylbenzene	24/44	8.16E-03	1.80E-02					
SWSA 5 WOC	gamma-Chlordane	2/19	1.62E-03	2.20E-03					
SWSA 5 WOC	Heptachlor	1/19	1.10E-03	2.20E-03					
SWSA 5 WOC	Heptachlor epoxide	2/19	1.02E-03	2.20E-03					
SWSA 5 WOC	Lindane	1/19	1.10E-03	2.20E-03					
SWSA 5 WOC	Methoxychlor	1/19	1.10E-02	2.20E-02					
SWSA 5 WOC	Methylene chloride	24/48	7.94E-03	1.00E-02					

Table 5.2 (continued)

Subbasin	Chemical	Freq. of detect.	Mean conc. (mg/kg)	Max. detected conc. (mg/kg)	Background quotient	Plant tox. (mg/kg)	Invert. tox. (mg/kg)	Plant HQ	Invert. HQ
SWSA 5 WOC	Naphthalene	24/43	9.38E-02	1.00E-02					
SWSA 5 WOC	PCB-1016	1/19	2.11E-02	4.30E-02					
SWSA 5 WOC	PCB-1221	1/19	4.29E-02	8.70E-02					
SWSA 5 WOC	PCB-1232	1/19	2.11E-02	4.30E-02					
SWSA 5 WOC	PCB-1242	1/19	2.11E-02	4.30E-02					
SWSA 5 WOC	PCB-1248	1/19	2.11E-02	4.30E-02					
SWSA 5 WOC	PCB-1254	4/19	1.98E-02	4.60E-01					
SWSA 5 WOC	PCB-1260	6/19	2.38E-02	4.20E-01					
SWSA 5 WOC	Styrene	1/21	6.05E-03	3.00E-03		3.00E+02		1.00E-05	
SWSA 5 WOC	Tetrachloroethene	29/50	7.60E-03	1.00E-02					
SWSA 5 WOC	Toluene	28/48	7.69E-03	1.00E-02		2.00E+02		5.00E-05	
SWSA 5 WOC	Toxaphene	1/19	1.10E-01	2.20E-01					
SWSA 5 WOC	trans-1,2-Dichloroethene	24/24	1.00E-02	1.00E-02					
SWSA 5 WOC	Trichloroethene	4/25	5.92E-03	9.00E-03					
SWSA 4 Main	Aluminum	3/3	2.64E+04	3.92E+04	8.85E-01	5.00E+01		7.84E+02	
SWSA 4 Main	Arsenic	3/3	6.87E+00	1.00E+01	8.01E-01	1.00E+01	6.00E+01	1.00E+00	1.67E-01
SWSA 4 Main	Barium	3/3	2.91E+02	4.58E+02	2.16E+00	5.00E+02		9.16E-01	
SWSA 4 Main	Beryllium	3/3	1.73E+00	2.70E+00	1.23E+00	1.00E+01		2.70E-01	
SWSA 4 Main	Calcium	3/3	1.21E+04	2.26E+04	3.20E+00				
SWSA 4 Main	Chromium	3/3	3.77E+01	5.06E+01	6.46E-01	1.00E+00	4.00E-01	5.06E+01	1.27E+02
SWSA 4 Main	Cobalt	3/3	2.27E+01	2.88E+01	7.85E-01	2.00E+01		1.44E+00	
SWSA 4 Main	Copper	3/3	2.30E+01	2.99E+01	2.39E-01	1.00E+02	5.00E+01	2.99E-01	5.98E-01
SWSA 4 Main	Iron	3/3	4.03E+04	5.25E+04	3.06E-01				
SWSA 4 Main	Lead	3/3	3.49E+01	6.42E+01	4.29E-01	5.00E+01	5.00E+02	1.28E+00	1.28E-01
SWSA 4 Main	Magnesium	3/3	5.59E+03	5.96E+03	8.02E-01				
SWSA 4 Main	Manganese	3/3	1.86E+03	3.83E+03	2.77E-01	5.00E+02		7.66E+00	
SWSA 4 Main	Nickel	3/3	2.64E+03	7.86E+03	1.39E+02	3.00E+01	2.00E+02	2.62E+02	3.93E+01
SWSA 4 Main	Potassium	3/3	4.39E+03	7.18E+03	1.33E+00				
SWSA 4 Main	Selenium	1/3	1.03E+00	2.00E+00		1.00E+00	7.00E+01	2.00E+00	2.86E-02
SWSA 4 Main	Sodium	3/3	6.35E+02	8.86E+02					
SWSA 4 Main	Vanadium	3/3	3.18E+01	4.45E+01	2.77E-01	2.00E+00		2.23E+01	
SWSA 4 Main	Zinc	3/3	9.88E+01	1.22E+02	1.13E+00	5.00E+01	2.00E+02	2.44E+00	6.10E-01
SWSA 4 Main	PCB-1254	6/6	2.52E-02	3.90E-02					
SWSA 4 Main	PCB-1260	4/6	4.18E-02	8.40E-02					
SWSA 5 N WOC	Aluminum	4/4	2.46E+04	2.73E+04	6.16E-01	5.00E+01		5.46E+02	
SWSA 5 N WOC	Arsenic	4/4	2.68E+00	3.40E+00	2.72E-01	1.00E+01	6.00E+01	3.40E-01	5.67E-02
SWSA 5 N WOC	Barium	4/4	8.98E+01	1.00E+02	4.72E-01	5.00E+02		2.00E-01	
SWSA 5 N WOC	Beryllium	3/3	1.07E+00	1.10E+00	5.00E-01	1.00E+01		1.10E-01	
SWSA 5 N WOC	Calcium	4/4	8.16E+02	1.17E+03	1.66E-01				
SWSA 5 N WOC	Chromium	4/4	3.48E+01	3.79E+01	4.84E-01	1.00E+00	4.00E-01	3.79E+01	9.48E+01
SWSA 5 N WOC	Cobalt	4/4	1.35E+01	1.63E+01	4.44E-01	2.00E+01		8.15E-01	
SWSA 5 N WOC	Copper	4/4	2.75E+01	3.22E+01	2.57E-01	1.00E+02	5.00E+01	3.22E-01	6.44E-01
SWSA 5 N WOC	Iron	4/4	3.56E+04	3.82E+04	2.22E-01				
SWSA 5 N WOC	Lead	4/4	1.09E+01	1.64E+01	1.10E-01	5.00E+01	5.00E+02	3.28E-01	3.28E-02
SWSA 5 N WOC	Magnesium	4/4	3.78E+03	4.18E+03	5.63E-01				
SWSA 5 N WOC	Manganese	4/4	4.29E+02	5.53E+02	4.00E-02	5.00E+02		1.11E+00	

Table 5.2 (continued)

Subbasin	Chemical	Freq. of detect.	Mean conc. (mg/kg)	Max. detected conc. (mg/kg)	Background quotient	Plant tox. (mg/kg)	Invert. tox. (mg/kg)	Plant HQ	Invert. HQ
SWSA 5 N WOC	Mercury	3/4	7.00E-02	9.00E-02	1.68E-01	3.00E-01	1.00E-01	3.00E-01	9.00E-01
SWSA 5 N WOC	Nickel	4/4	2.62E+01	3.00E+01	5.29E-01	3.00E+01	2.00E+02	1.00E+00	1.50E-01
SWSA 5 N WOC	Potassium	4/4	2.23E+03	2.39E+03	4.43E-01				
SWSA 5 N WOC	Selenium	2/4	1.07E+00	1.40E+00		1.00E+00	7.00E+01	1.40E+00	2.00E-02
SWSA 5 N WOC	Silver	4/4	1.90E+00	2.20E+00		2.00E+00		1.10E+00	
SWSA 5 N WOC	Vanadium	4/4	2.98E+01	3.47E+01	2.16E-01	2.00E+00		1.74E+01	
SWSA 5 N WOC	Zinc	4/4	4.95E+01	5.33E+01	4.94E-01	5.00E+01	2.00E+02	1.07E+00	2.67E-01
SWSA 5 N WOC	1,1-Dichloroethene	4/7	8.41E-03	1.00E-02					
SWSA 5 N WOC	2-Butanone	1/4	5.38E-03	3.00E-03					
SWSA 5 N WOC	Benzene	4/7	8.41E-03	1.00E-02					
SWSA 5 N WOC	Bis(2-ethylhexyl)phthalate	1/4	1.73E-01	9.20E-02					
SWSA 5 N WOC	Carbon tetrachloride	4/7	8.41E-03	1.00E-02					
SWSA 5 N WOC	Chloroform	4/7	8.41E-03	1.00E-02					
SWSA 5 N WOC	Di-n-butylphthalate	2/4	1.24E-01	5.00E-02		2.00E+02		2.50E-04	
SWSA 5 N WOC	Diethylphthalate	1/3	1.52E-01	6.10E-02		1.00E+02		6.10E-04	
SWSA 5 N WOC	Dimethylbenzene	4/7	8.41E-03	1.00E-02					
SWSA 5 N WOC	Methylene chloride	6/8	9.02E-03	1.00E-02					
SWSA 5 N WOC	Naphthalene	4/7	9.14E-02	1.00E-02					
SWSA 5 N WOC	Tetrachloroethene	4/7	8.41E-03	1.00E-02					
SWSA 5 N WOC	Toluene	4/7	8.41E-03	1.00E-02		2.00E+02		5.00E-05	
SWSA 5 N WOC	trans-1,2-Dichloroethene	4/4	1.00E-02	1.00E-02					
SWSA 6 East	Aluminum	4/4	2.22E+04	2.71E+04	6.12E-01	5.00E+01		5.42E+02	
SWSA 6 East	Arsenic	3/3	1.83E+00	2.40E+00	1.92E-01	1.00E+01	6.00E+01	2.40E-01	4.00E-02
SWSA 6 East	Barium	4/4	1.34E+02	2.47E+02	1.17E+00	5.00E+02		4.94E-01	
SWSA 6 East	Beryllium	4/4	1.60E+00	2.00E+00	9.09E-01	1.00E+01		2.00E-01	
SWSA 6 East	Cadmium	4/4	4.35E+00	5.50E+00		3.00E+00	2.00E+01	1.83E+00	2.75E-01
SWSA 6 East	Calcium	2/2	3.85E+03	6.64E+03	9.40E-01				
SWSA 6 East	Chromium	4/4	3.28E+01	4.30E+01	5.49E-01	1.00E+00	4.00E-01	4.30E+01	1.08E+02
SWSA 6 East	Cobalt	4/4	2.55E+01	2.81E+01	7.66E-01	2.00E+01		1.41E+00	
SWSA 6 East	Copper	3/4	1.89E+01	2.52E+01	2.01E-01	1.00E+02	5.00E+01	2.52E-01	5.04E-01
SWSA 6 East	Iron	4/4	3.46E+04	3.99E+04	2.32E-01				
SWSA 6 East	Lead	4/4	1.21E+01	1.89E+01	1.26E-01	5.00E+01	5.00E+02	3.78E-01	3.78E-02
SWSA 6 East	Magnesium	4/4	6.23E+03	8.13E+03	1.09E+00				
SWSA 6 East	Manganese	4/4	9.56E+02	1.61E+03	1.16E-01	5.00E+02		3.22E+00	
SWSA 6 East	Nickel	4/4	5.24E+01	6.00E+01	1.06E+00	3.00E+01	2.00E+02	2.00E+00	3.00E-01
SWSA 6 East	Potassium	4/4	2.14E+03	2.26E+03	4.19E-01				
SWSA 6 East	Sodium	4/4	8.13E+01	1.53E+02					
SWSA 6 East	Vanadium	4/4	2.01E+01	2.25E+01	1.40E-01	2.00E+00		1.13E+01	
SWSA 6 East	Zinc	4/4	9.09E+01	1.31E+02	1.21E+00	5.00E+01	2.00E+02	2.62E+00	6.55E-01
SWSA 6 East	1,2-Dichloropropane	1/4	2.75E-03	1.00E-03			7.00E+02		1.43E-06
SWSA 6 East	2-Butanone	2/4	4.70E-02	1.10E-01					
SWSA 6 East	3-Methylpentane	2/2	1.48E-02	2.00E-02					
SWSA 6 East	4-Hydroxy-4-methyl-2-pentanone	4/4	1.90E+01	2.60E+01					
SWSA 6 East	Acetone	1/5	7.80E-03	1.70E-02					
SWSA 6 East	Bis(2-ethylhexyl)phthalate	2/4	2.44E-01	3.20E-01					
SWSA 6 East	Chloroform	1/4	9.50E-03	2.40E-02					

Table 5.2 (continued)

Subbasin	Chemical	Freq. of detect.	Mean conc. (mg/kg)	Max. detected conc. (mg/kg)	Background quotient	Plant tox. (mg/kg)	Invert. tox. (mg/kg)	Plant HQ	Invert. HQ
SWSA 6 East	Dioctyl hexanedioate	1/1	4.50E+00	4.50E+00					
SWSA 6 East	Methylcyclopentane	1/1	5.00E-03	5.00E-03					
SWSA 6 East	Methylene chloride	1/5	1.44E-02	1.50E-02					
SWSA 6 East	Toluene	2/4	2.88E-03	3.00E-03		2.00E+02		1.50E-05	
SWSA 6 South	Arsenic	1/1	2.16E+01	2.16E+01	1.73E+00	1.00E+01	6.00E+01	2.16E+00	3.60E-01
SWSA 6 South	Barium	1/1	6.86E+01	6.86E+01	3.24E-01	5.00E+02		1.37E-01	
SWSA 6 South	Beryllium	1/1	1.00E+00	1.00E+00	4.55E-01	1.00E+01		1.00E-01	
SWSA 6 South	Cadmium	1/1	3.20E+00	3.20E+00		3.00E+00	2.00E+01	1.07E+00	1.60E-01
SWSA 6 South	Calcium	1/1	3.17E+04	3.17E+04	4.49E+00				
SWSA 6 South	Chromium	1/1	3.48E+01	3.48E+01	4.44E-01	1.00E+00	4.00E-01	3.48E+01	8.70E+01
SWSA 6 South	Cobalt	1/1	1.73E+01	1.73E+01	4.71E-01	2.00E+01		8.65E-01	
SWSA 6 South	Copper	1/1	1.86E+01	1.86E+01	1.49E-01	1.00E+02	5.00E+01	1.86E-01	3.72E-01
SWSA 6 South	Lead	1/1	1.25E+01	1.25E+01	8.35E-02	5.00E+01	5.00E+02	2.50E-01	2.50E-02
SWSA 6 South	Magnesium	1/1	3.14E+03	3.14E+03	4.23E-01				
SWSA 6 South	Manganese	1/1	4.55E+02	4.55E+02	3.29E-02	5.00E+02		9.10E-01	
SWSA 6 South	Nickel	1/1	3.66E+01	3.66E+01	6.46E-01	3.00E+01	2.00E+02	1.22E+00	1.83E-01
SWSA 6 South	Potassium	1/1	2.64E+03	2.64E+03	4.90E-01				
SWSA 6 South	Sodium	1/1	1.09E+02	1.09E+02					
SWSA 6 South	Thallium	1/1	1.00E+00	1.00E+00	1.27E+00	1.00E+00		1.00E+00	
SWSA 6 South	Vanadium	1/1	1.81E+01	1.81E+01	1.13E-01	2.00E+00		9.05E+00	
SWSA 6 South	Zinc	1/1	3.89E+01	3.89E+01	3.60E-01	5.00E+01	2.00E+02	7.78E-01	1.95E-01
SWSA 6 South	Benzo(k)fluoranthene	1/1	4.00E-02	4.00E-02					
SWSA 6 South	Mono(2-ethylhexyl) phthalate	1/1	6.90E-01	6.90E-01					
SWSA 6 South	Totarol	1/1	1.60E-01	1.60E-01					
W6MS3	Aluminum	11/11	1.44E+04	2.65E+04	5.98E-01	5.00E+01		5.30E+02	
W6MS3	Antimony	1/2	3.38E+00	9.00E-01		5.00E+00		1.80E-01	
W6MS3	Arsenic	10/11	3.13E+00	1.51E+01	1.21E+00	1.00E+01	6.00E+01	1.51E+00	2.52E-01
W6MS3	Barium	11/11	1.11E+02	1.64E+02	7.74E-01	5.00E+02		3.28E-01	
W6MS3	Beryllium	4/11	1.46E+00	2.00E+00	9.09E-01	1.00E+01		2.00E-01	
W6MS3	Cadmium	10/11	2.36E+00	4.20E+00		3.00E+00	2.00E+01	1.40E+00	2.10E-01
W6MS3	Calcium	11/11	3.35E+03	1.19E+04	1.68E+00				
W6MS3	Chromium	11/11	2.44E+01	3.60E+01	4.59E-01	1.00E+00	4.00E-01	3.60E+01	9.00E+01
W6MS3	Cobalt	11/11	1.87E+01	2.61E+01	7.11E-01	2.00E+01		1.31E+00	
W6MS3	Copper	11/11	1.56E+01	3.00E+01	2.40E-01	1.00E+02	5.00E+01	3.00E-01	6.00E-01
W6MS3	Iron	11/11	2.56E+04	3.80E+04	2.21E-01				
W6MS3	Lead	10/11	1.05E+01	1.80E+01	1.20E-01	5.00E+01	5.00E+02	3.60E-01	3.60E-02
W6MS3	Magnesium	11/11	2.95E+03	5.94E+03	7.99E-01				
W6MS3	Manganese	11/11	7.73E+02	1.55E+03	1.12E-01	5.00E+02		3.10E+00	
W6MS3	Nickel	11/11	3.55E+01	5.36E+01	9.45E-01	3.00E+01	2.00E+02	1.79E+00	2.68E-01
W6MS3	Osmium	1/1	3.77E+02	3.77E+02					
W6MS3	Potassium	11/11	1.60E+03	3.80E+03	7.05E-01				
W6MS3	Silver	1/11	1.34E+00	3.60E+00		2.00E+00		1.80E+00	
W6MS3	Sodium	10/11	7.05E+01	9.33E+01					
W6MS3	Tin	1/1	2.57E+01	2.57E+01		5.00E+01		5.14E-01	
W6MS3	Vanadium	11/11	1.55E+01	2.80E+01	1.75E-01	2.00E+00		1.40E+01	
W6MS3	Zinc	11/11	4.61E+01	6.70E+01	6.20E-01	5.00E+01	2.00E+02	1.34E+00	3.35E-01

Table 5.2 (continued)

Subbasin	Chemical	Freq. of detect.	Mean conc. (mg/kg)	Max. detected conc. (mg/kg)	Background quotient	Plant tox. (mg/kg)	Invert. tox. (mg/kg)	Plant HQ	Invert. HQ
W6MS3	1,2-Dichloroethene	1/10	4.45E-03	1.50E-02					
W6MS3	1,2-Dichloropropane	1/10	3.35E-03	3.00E-03			7.00E+02		4.29E-06
W6MS3	2,4-Dimethyl-2-pentanol	1/1	1.70E+01	1.70E+01					
W6MS3	2,4-Dimethyl-3-heptanone	1/1	5.60E+00	5.60E+00					
W6MS3	2,6-Dinitrotoluene	2/11	2.05E-01	1.40E-01					
W6MS3	2-Butanone	6/10	9.48E-02	2.70E-01					
W6MS3	2-Chlorophenol	1/11	2.13E-01	5.60E-02					
W6MS3	2-Cyclohexen-1-one	1/1	1.90E-01	1.90E-01					
W6MS3	2-Heptanol acetate	1/1	5.20E-01	5.20E-01					
W6MS3	3-Methylpentane	6/6	1.78E-02	3.80E-02					
W6MS3	4-Chloro-3-methylphenol	1/11	2.16E-01	8.50E-02					
W6MS3	4-Hydroxy-4-methyl-2-pentanone	3/3	1.85E+01	3.30E+01					
W6MS3	4-Nitrophenol	1/11	1.01E+00	7.30E-02			7.00E+00		1.04E-02
W6MS3	5-Methyl-5-hexen-2-one	1/1	1.10E+00	1.10E+00					
W6MS3	Acetone	1/10	8.55E-03	1.80E-02					
W6MS3	Bis(2-ethylhexyl)phthalate	10/11	5.00E-01	1.70E+00					
W6MS3	Bromomethane	1/10	7.05E-03	1.00E-02					
W6MS3	Chloroform	7/10	1.65E-02	6.40E-02					
W6MS3	cis-1,3-Dichloropropene	1/10	3.15E-03	1.00E-03					
W6MS3	Dimethylbenzene	1/10	3.25E-03	2.00E-03					
W6MS3	Hexadecanoic acid	1/1	1.60E+00	1.60E+00					
W6MS3	Isobutanol	1/1	4.50E-02	4.50E-02					
W6MS3	Methylene chloride	4/10	2.44E-02	2.00E-01					
W6MS3	N-Nitrosodiphenylamine	1/11	2.09E-01	5.90E-02			2.00E+01		2.95E-03
W6MS3	Pentachlorophenol	1/11	1.01E+00	7.80E-02		3.00E+00	4.00E+00	2.60E-02	1.95E-02
W6MS3	Phenol	2/11	1.99E-01	1.00E-01		7.00E+01	3.00E+01	1.43E-03	3.33E-03
W6MS3	Propanoic acid, 2-methyl-, 1-(1	1/1	3.80E-01	3.80E-01					
W6MS3	Pyrene	1/11	2.13E-01	5.20E-02					
W6MS3	Styrene	1/10	3.89E-03	8.00E-03		3.00E+02		2.67E-05	
W6MS3	Tetrachloroethene	1/10	3.40E-03	3.00E-03					
W6MS3	Toluene	6/10	3.13E-03	5.00E-03		2.00E+02		2.50E-05	
W6MS3	Totarol	5/5	5.84E-01	1.30E+00					
W6MS3	Trichloroethene	9/10	5.01E-03	1.70E-02					
W6MS3	Trimethylsilanol	5/5	9.36E-03	1.30E-02					
W6MS1	Aluminum	5/5	1.89E+04	2.35E+04	5.30E-01	5.00E+01		4.70E+02	
W6MS1	Arsenic	6/6	7.35E+00	1.34E+01	1.07E+00	1.00E+01	6.00E+01	1.34E+00	2.23E-01
W6MS1	Barium	6/6	1.73E+02	1.97E+02	9.29E-01	5.00E+02		3.94E-01	
W6MS1	Beryllium	6/6	1.57E+00	2.40E+00	1.09E+00	1.00E+01		2.40E-01	
W6MS1	Cadmium	6/6	3.83E+00	4.90E+00		3.00E+00	2.00E+01	1.63E+00	2.45E-01
W6MS1	Calcium	6/6	7.05E+03	1.69E+04	2.39E+00				
W6MS1	Chromium	6/6	3.18E+01	3.87E+01	4.94E-01	1.00E+00	4.00E-01	3.87E+01	9.68E+01
W6MS1	Cobalt	6/6	2.69E+01	3.57E+01	9.73E-01	2.00E+01		1.79E+00	
W6MS1	Copper	4/6	1.68E+01	2.74E+01	2.19E-01	1.00E+02	5.00E+01	2.74E-01	5.48E-01
W6MS1	Iron	5/5	3.04E+04	3.64E+04	2.12E-01				
W6MS1	Lead	6/6	1.46E+01	2.22E+01	1.48E-01	5.00E+01	5.00E+02	4.44E-01	4.44E-02
W6MS1	Magnesium	6/6	6.01E+03	8.50E+03	1.14E+00				

Table 5.2 (continued)

Subbasin	Chemical	Freq. of detect.	Mean conc. (mg/kg)	Max. detected conc. (mg/kg)	Background quotient	Plant tox. (mg/kg)	Invert. tox. (mg/kg)	Plant HQ	Invert. HQ
W6MS1	Manganese	6/6	1.69E+03	3.45E+03	2.49E-01	5.00E+02		6.90E+00	
W6MS1	Nickel	6/6	5.05E+01	6.53E+01	1.15E+00	3.00E+01	2.00E+02	2.18E+00	3.27E-01
W6MS1	Potassium	6/6	1.96E+03	2.47E+03	4.58E-01				
W6MS1	Sodium	6/6	8.61E+01	1.39E+02					
W6MS1	Vanadium	6/6	1.62E+01	1.83E+01	1.14E-01	2.00E+00		9.15E+00	
W6MS1	Zinc	6/6	6.68E+01	8.08E+01	7.48E-01	5.00E+01	2.00E+02	1.62E+00	4.04E-01
W6MS1	2-Butanone	2/5	4.23E-02	1.00E-01					
W6MS1	3-Methylpentane	1/1	7.10E-03	7.10E-03					
W6MS1	4-Hydroxy-4-methyl-2-pentanone	3/3	1.23E+01	1.40E+01					
W6MS1	5-Methyl-5-hexen-2-one	1/1	2.20E-01	2.20E-01					
W6MS1	Acetone	1/5	1.29E-02	2.40E-02					
W6MS1	Benz(a)anthracene	1/6	1.89E-01	5.10E-02					
W6MS1	Benzenemethanol	1/6	2.42E-01	3.50E-01					
W6MS1	Bis(2-ethylhexyl)phthalate	3/6	2.63E-01	3.30E-01					
W6MS1	Butylbenzylphthalate	1/6	1.64E-01	6.80E-02					
W6MS1	Chloroform	1/5	4.60E-03	7.00E-03					
W6MS1	Chrysene	1/6	2.04E-01	1.40E-01					
W6MS1	Dimethylbenzene	2/5	2.50E-03	2.00E-03					
W6MS1	Docosane	1/1	3.60E-01	3.60E-01					
W6MS1	Methylene chloride	1/5	1.67E-02	3.90E-02					
W6MS1	Tetrachloroethene	1/5	3.00E-03	2.00E-03					
W6MS1	Toluene	2/5	2.60E-03	2.00E-03		2.00E+02		1.00E-05	
W6MS1	Totarol	2/2	2.80E-01	3.50E-01					
W6MS1	Trichloroethene	3/5	4.00E-03	1.00E-02					
W6MS1	Trimethylsilanol	1/1	1.20E-02	1.20E-02					
WAG 7 WOC	Aluminum	1/1	3.08E+04	3.08E+04	6.95E-01	5.00E+01		6.16E+02	
WAG 7 WOC	Arsenic	1/1	3.50E+00	3.50E+00	2.80E-01	1.00E+01	6.00E+01	3.50E-01	5.83E-02
WAG 7 WOC	Barium	1/1	9.22E+01	9.22E+01	4.35E-01	5.00E+02		1.84E-01	
WAG 7 WOC	Beryllium	1/1	1.20E+00	1.20E+00	5.45E-01	1.00E+01		1.20E-01	
WAG 7 WOC	Calcium	1/1	1.93E+03	1.93E+03	2.73E-01				
WAG 7 WOC	Chromium	1/1	3.06E+01	3.06E+01	3.90E-01	1.00E+00	4.00E-01	3.06E+01	7.65E+01
WAG 7 WOC	Cobalt	1/1	1.22E+01	1.22E+01	3.32E-01	2.00E+01		6.10E-01	
WAG 7 WOC	Copper	1/1	2.02E+01	2.02E+01	1.61E-01	1.00E+02	5.00E+01	2.02E-01	4.04E-01
WAG 7 WOC	Iron	1/1	3.45E+04	3.45E+04	2.01E-01				
WAG 7 WOC	Lead	1/1	1.45E+01	1.45E+01	9.68E-02	5.00E+01	5.00E+02	2.90E-01	2.90E-02
WAG 7 WOC	Magnesium	1/1	6.44E+03	6.44E+03	8.67E-01				
WAG 7 WOC	Manganese	1/1	5.57E+02	5.57E+02	4.02E-02	5.00E+02		1.11E+00	
WAG 7 WOC	Nickel	1/1	2.54E+01	2.54E+01	4.48E-01	3.00E+01	2.00E+02	8.47E-01	1.27E-01
WAG 7 WOC	Potassium	1/1	3.99E+03	3.99E+03	7.40E-01				
WAG 7 WOC	Sodium	1/1	4.74E+02	4.74E+02					
WAG 7 WOC	Vanadium	1/1	3.26E+01	3.26E+01	2.03E-01	2.00E+00		1.63E+01	
WAG 7 WOC	Zinc	1/1	7.12E+01	7.12E+01	6.59E-01	5.00E+01	2.00E+02	1.42E+00	3.56E-01
WAG 7 WOC	PCB-1016	1/1	1.70E-02	1.70E-02					
WAG 7 WOC	PCB-1221	1/1	1.70E-02	1.70E-02					
WAG 7 WOC	PCB-1232	1/1	1.70E-02	1.70E-02					
WAG 7 WOC	PCB-1242	1/1	1.70E-02	1.70E-02					

Table 5.2 (continued)

Subbasin	Chemical	Freq. of detect.	Mean conc. (mg/kg)	Max. detected conc. (mg/kg)	Background quotient	Plant tox. (mg/kg)	Invert. tox. (mg/kg)	Plant HQ	Invert. HQ
WAG 7 WOC	PCB-1248	1/1	1.70E-02	1.70E-02					
WAG 7 WOC	PCB-1254	1/1	1.70E-02	1.70E-02					
West Seep	Aluminum	32/32	2.06E+04	3.84E+04	8.67E-01	5.00E+01		7.68E+02	
West Seep	Arsenic	26/31	2.49E+00	7.00E+00	5.61E-01	1.00E+01	6.00E+01	7.00E-01	1.17E-01
West Seep	Barium	32/32	1.39E+02	2.35E+02	1.11E+00	5.00E+02		4.70E-01	
West Seep	Beryllium	30/32	1.38E+00	1.80E+00	8.18E-01	1.00E+01		1.80E-01	
West Seep	Cadmium	19/32	2.07E+00	5.00E+00		3.00E+00	2.00E+01	1.67E+00	2.50E-01
West Seep	Calcium	32/32	2.30E+03	5.87E+03	8.31E-01				
West Seep	Chromium	32/32	2.93E+01	4.89E+01	6.24E-01	1.00E+00	4.00E-01	4.89E+01	1.22E+02
West Seep	Cobalt	32/32	2.28E+01	3.98E+01	1.08E+00	2.00E+01		1.99E+00	
West Seep	Copper	30/32	1.99E+01	3.10E+01	2.48E-01	1.00E+02	5.00E+01	3.10E-01	6.20E-01
West Seep	Cyanide	1/24	5.72E+00	1.87E+00	4.25E+00				
West Seep	Iron	32/32	3.31E+04	4.53E+04	2.64E-01				
West Seep	Lead	31/31	2.29E+01	1.25E+02	8.35E-01	5.00E+01	5.00E+02	2.50E+00	2.50E-01
West Seep	Magnesium	32/32	4.79E+03	7.26E+03	9.77E-01				
West Seep	Manganese	32/32	1.03E+03	3.53E+03	2.55E-01	5.00E+02		7.06E+00	
West Seep	Mercury	5/20	4.80E-02	6.00E-02	1.12E-01	3.00E-01	1.00E-01	2.00E-01	6.00E-01
West Seep	Nickel	32/32	4.01E+01	6.88E+01	1.21E+00	3.00E+01	2.00E+02	2.29E+00	3.44E-01
West Seep	Osmium	3/3	3.85E+02	4.21E+02					
West Seep	Potassium	32/32	2.43E+03	5.05E+03	9.37E-01				
West Seep	Silver	5/28	1.11E+00	2.90E+00		2.00E+00		1.45E+00	
West Seep	Sodium	31/32	1.69E+02	1.47E+03					
West Seep	Thallium	1/29	3.75E-01	5.00E-01	6.33E-01	1.00E+00		5.00E-01	
West Seep	Tin	3/3	6.48E+01	8.71E+01		5.00E+01		1.74E+00	
West Seep	Vanadium	32/32	2.24E+01	3.61E+01	2.25E-01	2.00E+00		1.81E+01	
West Seep	Zinc	32/32	6.78E+01	1.03E+02	9.54E-01	5.00E+01	2.00E+02	2.06E+00	5.15E-01
West Seep	2,4-Dimethyl-3-heptanone	9/9	4.79E-01	1.40E+00					
West Seep	2,5-Hexanedione	1/1	2.10E-01	2.10E-01					
West Seep	2,6-Dinitrotoluene	1/23	2.06E-01	7.20E-02					
West Seep	2-Butanone	10/21	3.66E-02	3.40E-01					
West Seep	2-Heptanol acetate	1/1	3.10E-01	3.10E-01					
West Seep	3-Methylpentane	5/5	9.40E-03	1.30E-02					
West Seep	4-Chlorophenylphenylether	1/23	2.04E-01	7.00E-02					
West Seep	4-Hydroxy-4-methyl-2-pentanone	23/23	2.18E+01	5.90E+01					
West Seep	5-Methyl-2-hexanone	1/1	1.50E+00	1.50E+00					
West Seep	5-Methyl-5-hexen-2-one	9/9	8.88E-01	1.90E+00					
West Seep	6-(Acetyloxy)-2-hexanone	5/5	2.42E-01	3.10E-01					
West Seep	Acetone	8/27	9.82E-03	6.90E-02					
West Seep	Benzoic Acid	4/24	8.51E-01	6.70E-02					
West Seep	Bis(2-ethylhexyl)phthalate	7/24	1.53E-01	5.60E-01					
West Seep	Bromodichloromethane	1/25	3.08E-03	4.00E-03					
West Seep	Butyl 2-methylpropyl phthalate	1/1	2.40E-01	2.40E-01					
West Seep	Butylbenzylphthalate	1/23	2.03E-01	5.80E-02					
West Seep	Chloroform	8/27	6.10E-03	6.10E-02					
West Seep	Di-n-octylphthalate	1/23	2.04E-01	8.00E-02					
West Seep	Dioctyl hexanedioate	12/12	1.01E+01	3.40E+01					

Table 5.2 (continued)

Subbasin	Chemical	Freq. of detect.	Mean conc. (mg/kg)	Max. detected conc. (mg/kg)	Background quotient	Plant tox. (mg/kg)	Invert. tox. (mg/kg)	Plant HQ	Invert. HQ
West Seep	Hexadecanoic acid	8/8	3.72E-01	6.90E-01					
West Seep	Methylene chloride	8/27	1.12E-02	6.20E-02					
West Seep	N-Nitrosodiphenylamine	2/23	1.90E-01	4.60E-02			2.00E+01		2.30E-03
West Seep	Octamethylcyclotetrasiloxane	2/2	9.00E-03	1.30E-02					
West Seep	PCB-1016	8/32	4.21E-02	2.10E-02					
West Seep	PCB-1221	8/32	4.21E-02	2.10E-02					
West Seep	PCB-1232	8/32	4.21E-02	2.10E-02					
West Seep	PCB-1242	8/32	4.21E-02	2.10E-02					
West Seep	PCB-1248	8/32	4.21E-02	2.10E-02					
West Seep	PCB-1254	8/32	8.03E-02	2.10E-02					
West Seep	Phenol	2/23	1.99E-01	8.90E-02		7.00E+01	3.00E+01	1.27E-03	2.97E-03
West Seep	Prometon	1/1	3.30E-01	3.30E-01					
West Seep	Tetrachloroethene	1/25	3.04E-03	3.00E-03					
West Seep	Toluene	9/26	2.54E-03	4.00E-03		2.00E+02		2.00E-05	
West Seep	trans-4-Chlorocyclohexanol	4/4	2.48E-01	2.80E-01					
West Seep	Trichloroethene	2/26	2.88E-03	2.00E-03					
West Seep	Trichlorofluoromethane	4/4	5.33E-02	7.20E-02					
West Seep	Trimethylsilanol	4/4	7.23E-03	8.00E-03					
SWSA 5 Drainage D-2	Aluminum	5/5	2.07E+04	2.47E+04	5.58E-01	5.00E+01		4.94E+02	
SWSA 5 Drainage D-2	Arsenic	5/5	2.88E+00	3.70E+00	2.96E-01	1.00E+01	6.00E+01	3.70E-01	6.17E-02
SWSA 5 Drainage D-2	Barium	5/5	1.61E+02	2.38E+02	1.12E+00	5.00E+02		4.76E-01	
SWSA 5 Drainage D-2	Beryllium	5/5	1.18E+00	1.40E+00	6.36E-01	1.00E+01		1.40E-01	
SWSA 5 Drainage D-2	Calcium	5/5	6.27E+03	1.03E+04	1.46E+00				
SWSA 5 Drainage D-2	Chromium	5/5	3.00E+01	3.84E+01	4.90E-01	1.00E+00	4.00E-01	3.84E+01	9.60E+01
SWSA 5 Drainage D-2	Cobalt	5/5	1.84E+01	2.09E+01	5.69E-01	2.00E+01		1.05E+00	
SWSA 5 Drainage D-2	Copper	5/5	2.11E+01	2.51E+01	2.01E-01	1.00E+02	5.00E+01	2.51E-01	5.02E-01
SWSA 5 Drainage D-2	Iron	5/5	3.23E+04	3.55E+04	2.07E-01				
SWSA 5 Drainage D-2	Lead	5/5	2.07E+01	2.50E+01	1.67E-01	5.00E+01	5.00E+02	5.00E-01	5.00E-02
SWSA 5 Drainage D-2	Magnesium	5/5	5.89E+03	7.89E+03	1.06E+00				
SWSA 5 Drainage D-2	Manganese	5/5	1.11E+03	1.27E+03	9.18E-02	5.00E+02		2.54E+00	
SWSA 5 Drainage D-2	Mercury	1/4	4.00E-02	7.00E-02	1.31E-01	3.00E-01	1.00E-01	2.33E-01	7.00E-01
SWSA 5 Drainage D-2	Nickel	5/5	3.23E+01	3.85E+01	6.79E-01	3.00E+01	2.00E+02	1.28E+00	1.93E-01
SWSA 5 Drainage D-2	Potassium	5/5	2.24E+03	2.79E+03	5.18E-01				
SWSA 5 Drainage D-2	Silver	2/5	1.13E+00	2.20E+00		2.00E+00		1.10E+00	
SWSA 5 Drainage D-2	Vanadium	5/5	2.83E+01	3.05E+01	1.90E-01	2.00E+00		1.53E+01	
SWSA 5 Drainage D-2	Zinc	5/5	7.29E+01	8.76E+01	8.11E-01	5.00E+01	2.00E+02	1.75E+00	4.38E-01
SWSA 5 Drainage D-2	1,1-Dichloroethene	4/8	8.16E-03	1.00E-02					
SWSA 5 Drainage D-2	1,2-Dichloroethene	1/5	5.60E-03	3.00E-03					
SWSA 5 Drainage D-2	2-Butanone	2/6	1.05E-02	2.10E-02					
SWSA 5 Drainage D-2	Acetone	2/6	5.25E-02	1.80E-01					
SWSA 5 Drainage D-2	Benzene	4/8	8.16E-03	1.00E-02					
SWSA 5 Drainage D-2	Bis(2-ethylhexyl)phthalate	1/5	1.72E-01	5.30E-02					
SWSA 5 Drainage D-2	Carbon tetrachloride	4/8	8.16E-03	1.00E-02					
SWSA 5 Drainage D-2	Chloroform	5/9	7.33E-03	1.00E-02					
SWSA 5 Drainage D-2	Dimethylbenzene	4/8	8.16E-03	1.00E-02					
SWSA 5 Drainage D-2	Ethylbenzene	1/5	6.40E-03	7.00E-03					

Table 5.2 (continued)

Subbasin	Chemical	Freq. of detect.	Mean conc. (mg/kg)	Max. detected conc. (mg/kg)	Background quotient	Plant tox. (mg/kg)	Invert. tox. (mg/kg)	Plant HQ	Invert. HQ
SWSA 5 Drainage D-2	Methylene chloride	4/8	8.16E-03	1.00E-02					
SWSA 5 Drainage D-2	Naphthalene	4/9	1.16E-01	1.00E-02					
SWSA 5 Drainage D-2	PCB-1260	2/5	7.12E-01	2.30E+00					
SWSA 5 Drainage D-2	Tetrachloroethene	5/8	7.69E-03	1.00E-02					
SWSA 5 Drainage D-2	Toluene	6/10	1.16E-02	2.00E-02		2.00E+02		1.00E-04	
SWSA 5 Drainage D-2	trans-1,2-Dichloroethene	4/4	1.00E-02	1.00E-02					
WOC	Aluminum	6/6	8.75E+03	1.19E+04	2.69E-01	5.00E+01		2.38E+02	
WOC	Antimony	3/6	2.39E+00	5.50E-01		5.00E+00		1.10E-01	
WOC	Arsenic	4/6	3.30E+00	4.80E+00	3.84E-01	1.00E+01	6.00E+01	4.80E-01	8.00E-02
WOC	Barium	6/6	1.18E+02	1.38E+02	6.51E-01	5.00E+02		2.76E-01	
WOC	Beryllium	6/6	8.18E-01	9.90E-01	4.50E-01	1.00E+01		9.90E-02	
WOC	Boron	6/6	6.00E+00	1.09E+01	2.89E-01	5.00E-01		2.18E+01	
WOC	Cadmium	6/6	9.18E-01	1.60E+00		3.00E+00	2.00E+01	5.33E-01	8.00E-02
WOC	Calcium	6/6	2.36E+04	6.68E+04	9.46E+00				
WOC	Chromium	6/6	3.46E+01	4.68E+01		1.00E+00	4.00E-01	4.68E+01	1.17E+02
WOC	Cobalt	6/6	1.23E+01	1.48E+01	4.03E-01	2.00E+01		7.40E-01	
WOC	Copper	6/6	5.95E+01	1.63E+02	1.30E+00	1.00E+02	5.00E+01	1.63E+00	3.26E+00
WOC	Iron	6/6	1.96E+04	2.48E+04	1.44E-01				
WOC	Lead	6/6	3.94E+01	7.97E+01	5.32E-01	5.00E+01	5.00E+02	1.59E+00	1.59E-01
WOC	Lithium	6/6	1.01E+01	1.30E+01	4.69E-02	2.00E+00		6.50E+00	
WOC	Magnesium	6/6	4.36E+03	1.12E+04	1.51E+00				
WOC	Manganese	6/6	7.07E+02	9.09E+02	6.57E-02	5.00E+02		1.82E+00	
WOC	Mercury	6/6	1.95E+00	4.80E+00	8.98E+00	3.00E-01	1.00E-01	1.60E+01	4.80E+01
WOC	Molybdenum	6/6	3.00E+00	4.00E+00		2.00E+00		2.00E+00	
WOC	Nickel	6/6	1.85E+01	2.47E+01	4.36E-01	3.00E+01	2.00E+02	8.23E-01	1.24E-01
WOC	Osmium	4/4	7.33E+00	8.50E+00					
WOC	Potassium	6/6	7.30E+02	1.10E+03	2.04E-01				
WOC	Selenium	2/6	6.46E-01	1.60E+00		1.00E+00	7.00E+01	1.60E+00	2.29E-02
WOC	Silicon	6/6	2.48E+02	2.88E+02	4.13E-01				
WOC	Silver	6/6	8.43E+00	2.52E+01		2.00E+00		1.26E+01	
WOC	Sodium	6/6	3.65E+02	4.24E+02					
WOC	Strontium	6/6	2.82E+01	6.67E+01	1.11E-01				
WOC	Thallium	6/6	7.47E-01	8.60E-01	1.09E+00	1.00E+00		8.60E-01	
WOC	Tin	6/6	7.58E+00	1.07E+01		5.00E+01		2.14E-01	
WOC	Vanadium	6/6	1.31E+01	1.81E+01	1.13E-01	2.00E+00		9.05E+00	
WOC	Zinc	6/6	3.47E+02	9.08E+02	8.41E+00	5.00E+01	2.00E+02	1.82E+01	4.54E+00
WOC	Anthracene	2/6	2.61E-01	1.20E-01					
WOC	Benz(a)anthracene	2/6	3.10E-01	3.70E-01					
WOC	Benzo(a)pyrene	3/6	2.56E-01	4.00E-01					
WOC	Benzo(b)fluoranthene	3/6	2.63E-01	3.90E-01					
WOC	Benzo(ghi)peryline	3/6	2.23E-01	3.20E-01					
WOC	Benzo(k)fluoranthene	3/6	2.59E-01	4.50E-01					
WOC	bis(2-Ethylhexyl)phthalate	5/6	3.25E-01	9.40E-01					
WOC	Carbazole	1/6	3.56E-01	6.20E-02					
WOC	Chrysene	3/6	2.80E-01	4.50E-01					
WOC	Di-n-butylphthalate	5/6	2.18E-01	4.70E-01		2.00E+02		2.35E-03	

Table 5.2 (continued)

Subbasin	Chemical	Freq. of detect.	Mean conc. (mg/kg)	Max. detected conc. (mg/kg)	Background quotient	Plant tox. (mg/kg)	Invert. tox. (mg/kg)	Plant HQ	Invert. HQ
WOC	Dibenz(a,h)anthracene	2/6	2.63E-01	1.30E-01					
WOC	Fluoranthene	6/6	4.57E-01	1.30E+00					
WOC	Indeno(1,2,3-cd)pyrene	4/6	2.68E-01	4.00E-01					
WOC	PCB-1260	6/6	1.90E-01	6.10E-01					
WOC	Phenanthrene	4/6	3.13E-01	6.50E-01					
WOC	Pyrene	6/6	3.62E-01	9.50E-01					

Notes:
Background quotient = maximum detected concentration divided by background concentration. Values < 1.0 indicate concentrations below background.
Plant toxicity values are from Will and Suter (1995b). Soil invertebrate toxicity values are from Will and Suter (1995a).
Hazard quotients (HQ) = maximum detected concentrations divided by the plant or invertebrate toxicity values.

6. RISKS TO PLANTS

6.1 EXPOSURE ASSESSMENT FOR PLANTS

Vegetation growing in the WOC watershed is exposed to contaminants in soil and potentially in shallow groundwater seeps and intermittent tributaries.

6.1.1 Soil Exposures

Concentrations of analytes in the soil derived from double acid-extractions (nitric and hydrochloric) generally represent the total potential reservoir of contaminants, not the concentrations to which plants are exposed at any one time. Some metals are more readily available for uptake by plants than others, depending on the solubility and species of the compound, interactions with soil constituents (organic matter and clay) and with other contaminants, and mechanisms for bioaccumulation in particular plant species. Organic contaminants may interact strongly with soil organic matter and therefore be only be partially available for plant uptake.

Contaminants have vertical distributions in soil that reflect interactions between the soil and the contaminant, controlled by the chemical and physical characteristics of the soil and the quantity and chemical characteristics of the contaminant. The exposure of plant roots to a contaminant in the soil depends on these abiotic factors and the growth characteristics of individual plants, such as rooting depth and density. Deep-rooted trees and shallow-rooted grasses may be exposed to different concentrations of contaminants, depending on the location of the source. In the absence of data on root distribution, it is assumed that the plants are rooted within the zone from which the soil was sampled for analysis.

Two other routes of exposure cannot be addressed because of a lack of data. 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 in the WOC watershed.

6.1.2 Soil Solution Exposures

Plants growing in seep areas are exposed to contaminants in the aqueous phase. Numerous seeps, springs, or intermittent tributaries in the WOC watershed were sampled for contaminants. It is assumed that the roots of plants near the springs may be exposed to water containing contaminants at similar concentrations. Although the discharge in many of these seeps is seasonal and heightened during rainfall events, we make the conservative assumption that plants growing at these locations are exposed to contaminants in the water throughout the year. We also assume that the entire root systems of plants growing in seep areas are exposed to contaminants, and that this type of exposure is the only significant source for the plants.

Filtered water samples from seeps are better representations than unfiltered samples of concentrations to which plants are exposed because contaminants bound to particles in surface water are generally not bioavailable for absorption by plants. Samples for this assessment were not filtered; thus the data are conservative estimates of exposure.

6.2 EFFECTS ASSESSMENT FOR THE PLANT COMMUNITY

Contaminant concentrations in soils and springs were compared to toxicological benchmarks (Will and Suter 1995b) 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 in the laboratory were assumed to be representative of the exposure of plants to contaminants measured in floodplain soils, with the possibility that chemicals freshly added to soils in literature toxicity tests may be more bioavailable than contaminants in WOC soils. Tests conducted in nutrient and mineral solutions are the best available representation of exposures of plants to contaminants in the vicinity of seeps and springs. Toxicological profiles for analytes retained after screening against benchmarks are provided in the attachment to this appendix.

Benchmarks were not available for numerous organic contaminants, including polycyclic aromatic hydrocarbons.

6.3 RISK CHARACTERIZATION FOR THE PLANT COMMUNITY

The evidence concerning risks to the plant community consists of analyses of inorganic, organic and radionuclide contaminants in soil. This single line of evidence is summarized in the following text. Toxicity tests and biological surveys were not available.

6.3.1 Single chemical soil and solution toxicity

Contaminants of potential ecological concern (COPECs) for terrestrial plants in the WOC watershed were identified by comparing maximum detected site concentrations of soil to 1) twice the mean background for soils from Waste Area Grouping 5 (DOE 1995a) and 2) available benchmarks for toxicity to terrestrial plants (Will and Suter 1995b). The screening of maximum concentrations against benchmarks is intended to protect plants which spend their entire lives in a single, highly contaminated location. If both background and benchmark criteria were exceeded, the contaminant was identified as a COPEC. The magnitude of exceedence of a benchmark is described by the hazard quotient, the maximum concentration in soil divided by the toxicity benchmark concentration. If background criteria were not available, exceedence of a benchmark was sufficient for the COPEC designation. Benchmarks for plants growing in soils, maximum concentrations of analytes at each subbasin exceeding background and for which benchmarks are available, and hazard quotients for the contaminants are given in Table 5.2. COPECs for plants potentially exposed to water from seeps and springs were identified by a similar comparison of contaminant concentrations with background and toxicity benchmarks (Table 6.1).

6.3.1.1 Terrestrial plants

The screening of contaminant concentrations in soil against phytotoxicity benchmarks is provided in Table 5.2. The strength of the literature toxicity line of evidence is in its ability to relate the concentration of a single contaminant in soil to observed effects. The screening is most useful if the chemical species and bioavailability of contaminants in WOC soils are comparable to those of the chemicals in laboratory toxicity tests in other soils. For example, the fractions of mercuric chloride, methyl mercury, mercuric sulfide, etc. were not determined for WOC soils. Thus, the hazard quotients for mercury may be conservative.

HF-2

The overall plant HI for subbasin HF-2 soil was 187. Inorganics accounted for 100% of the HI. Of the 29 inorganics detected at HF-2, 16 were below background levels and eliminated from further consideration. Three of the remaining inorganics (calcium, osmium, and sodium) could not be evaluated for phytotoxic effects because toxicological benchmarks were not available. HQs exceeding one were estimated for five (chromium, zinc, cobalt, barium and molybdenum) of the ten inorganics evaluated for phytotoxic effects, indicating a potential risk of adverse effects from these elements.

Chromium accounted for 90% of the overall HI for the subbasin. Chromium was detected in both of the soil samples collected at HF-2, but at levels higher than background in only one, and then at a concentration only about twice as high (168 mg/kg for HF-2 versus 78 mg/kg background). The analytical data did not specify the valence state of the chromium. Chromium (VI) is more toxic and available to plants than chromium (III) (Smith et al. 1989, cited in Will and Suter 1995b), but in most soils chromium (VI) is likely to be reduced to chromium (III) (Bartlett and James 1979, cited in Will and Suter 1995b). However, the toxicological benchmark used to estimate effects of chromium is based on chromium (VI) studies. The use of the benchmark for the more toxic and available chromium (VI) when exposures may be predominantly from chromium (III) may lead to overestimation of the risks of adverse phytotoxic effects.

Benchmarks were not available for either of the two organics detected at HF-2.

These results indicate a potential risk of adverse effects on plants from HF-2 soil, primarily resulting from chromium.

HRE

The overall terrestrial plant HI for the HRE subbbasin was 110.5 (Table 6.2). HQs exceeding one were estimated for three metals: cadmium, chromium, and zinc, indicating a potential risk of adverse effects for these elements. Chromium was the primary risk driver in the subbasin, resulting in a HQ of 104.

While chromium was the primary risk driver in this subbasin, it was detected at only 1.3 times background. The analytical data did not specify the valence state of the chromium. Chromium (VI) is more toxic and bioavailable than chromium (III) (Will and Suter 1995a), but in most soils chromium (VI) is likely to be reduced to chromium (III). The toxicological benchmarks used in this assessment were based on chromium (VI) studies. The use of benchmarks for the more toxic and available chromium (VI) when exposures may be predominantly from chromium (III) may lead to overestimation of risks.

SWSA 5 Tributary 1

The overall plant HI for SWSA 5 Tributary 1 soil was 21. Inorganics accounted for over 99.9% of the HI. Organics accounted for only 0.02%. Of the 23 inorganics detected at SWSA 5 Tributary 1, 14 were below background levels and eliminated from further consideration. Three of the remaining inorganics (calcium, magnesium and sodium) could not be evaluated for phytotoxic effects because toxicological benchmarks were not available. HQs exceeding one were estimated for three (mercury, selenium and silver) of the six inorganics evaluated for phytotoxic effects,

indicating a potential risk of adverse effects for these elements. Mercury, selenium and silver accounted for over 90% of the overall HI for the subbasin.

No toxicological benchmarks were available for 41 of the 45 organics detected at the site. The HQs for the four remaining organics were well below one, indicating no risk of adverse effects.

These results indicate a potential risk of adverse effects on plants from SWSA 5 Tributary 1 soil, primarily resulting from mercury, selenium and silver.

SWSA 5 WOC

The overall plant HI for SWSA 5 WOC soil was 11. Inorganics accounted for over 99% of the HI. Organics accounted for only 0.2%. Of the 23 inorganics detected at SWSA 5 WOC, 12 were below background levels and eliminated from further consideration. Three of the remaining inorganics (calcium, magnesium and sodium) could not be evaluated for phytotoxic effects because toxicological benchmarks were not available. HQs exceeding one were estimated for four (mercury, selenium, silver and zinc) of the eight inorganics evaluated for phytotoxic effects, indicating a potential risk of adverse effects for these elements. Mercury, selenium, silver and zinc accounted for 78% of the overall HI for the subbasin.

No toxicological benchmarks were available for 46 of the 50 organics detected at the site. The HQs for the four remaining organics were well below one, indicating no risk of adverse effects.

These results indicate a potential risk of adverse effects on plants from SWSA 5 WOC soil, primarily resulting from mercury, selenium, silver and zinc.

SWSA 5 N WOC

The overall plant HI for SWSA 5 N WOC soil was 2.5. Inorganics accounted for over 99.9% of the HI. Organics accounted for only 0.04%. Of the 19 inorganics detected at SWSA 5 N WOC, 17 were below background levels and eliminated from further consideration. HQs exceeding one were estimated for the two (selenium and silver) inorganics evaluated for phytotoxic effects, indicating a potential risk of adverse effects for these elements. Selenium and silver accounted for 99% of the overall HI for the subbasin.

No toxicological benchmarks were available for 11 of the 14 organics detected at the site. The HQs for the three remaining organics were well below one, indicating no risk of adverse effects.

These results indicate a minor risk of adverse effects on plants from SWSA 5 N WOC soil, primarily resulting from selenium and silver.

Intermediate Pond

The overall plant HI for the Intermediate Pond soil was 287. Inorganics accounted for over 99.9% of the HI. Organics accounted for only 0.01%. Of the 30 inorganics detected at the Intermediate Pond, 15 were below background levels and eliminated from further consideration. [The analytical data reported chromium as chromium (VI) for this site, but we assumed this to be total chromium. This assumption resulted in elimination of chromium based on the background comparison. Inclusion of chromium would have resulted in exceedence of the benchmark and a higher HI for the subbasin.] Four of the remaining inorganics (calcium, osmium, silicon and sodium)

could not be evaluated for phytotoxic effects because toxicological benchmarks were not available. HQs exceeding one were estimated for five (mercury, molybdenum, nickel, silver and zinc) of the 11 inorganics evaluated for phytotoxic effects, indicating a potential risk of adverse effects for these elements. Mercury accounted for 89% of the overall HI for the subbasin.

No toxicological benchmarks were available for 23 of the 26 organics detected at the site. The HQs for the three remaining organics were well below one, indicating no risk of adverse effects.

These results indicate a potential risk of adverse effects on plants from the Intermediate Pond soil, primarily resulting from mercury.

SWSA 4 Main

The overall terrestrial plant HI for the SWSA 4 Main subbbasin was 267.6 (Table 6.2). HQs exceeding one were estimated for three analytes (nickel, selenium, and zinc), indicating a potential risk of adverse effects from these elements. Nickel was the primary risk driver, resulting in a HQ of 262. However, the results are driven by the high nickel concentration (7860 mg/kg) at one sample location (WAG4Seep6). The highest concentration at two other locations in the subbasin was 49.6 mg/kg, suggesting that risks from nickel are spatially limited within the subbasin.

WAG 7 WOC

No risks were identified for terrestrial plants exposed to contaminants in WAG 7 WOC. Concentrations of all detected analytes were below toxicological benchmarks (Table 5.2).

WOC

The overall plant HI for the WOC subbasin soil was 54. Inorganics accounted for over 99.9% of the HI. Organics accounted for only 0.004%. Of the 30 inorganics detected at the WOC subbasin, 16 were below background levels and eliminated from further consideration. [The analytical data reported chromium as chromium (VI) for this site, but we assumed this to be total chromium. This assumption resulted in elimination of chromium based on the background comparison. Inclusion of chromium would have resulted in exceedence of the benchmark and a higher HI for the subbasin.] Four of the remaining inorganics (calcium, magnesium, osmium, and sodium) could not be evaluated for phytotoxic effects because toxicological benchmarks were not available. HQs exceeding one were estimated for six (copper, mercury, molybdenum, selenium, silver and zinc) of the 10 inorganics evaluated for phytotoxic effects, indicating a potential risk of adverse effects for these elements. Mercury, silver and zinc accounted for 87% of the overall HI for the subbasin.

No toxicological benchmarks were available for 15 of the 16 organics detected at the site. The HQ for the one remaining organic was well below one, indicating no risk of adverse effects.

These results indicate a potential risk of adverse effects on plants from the WOC subbasin soil, primarily resulting from mercury, silver and zinc.

NHF

The overall plant HI for NHF soil was 1.15. Inorganics accounted for over 99.9% of the HI. Organics accounted for only 0.1%. Of the 18 inorganics detected at NHF, 15 were below background levels and eliminated from further consideration. One of the remaining inorganics,

sodium, could not be evaluated for phytotoxic effects because toxicological benchmarks were not available. The HQs for the two other remaining inorganics, barium and silver, were 0.4 and 0.7, respectively, indicating no risk of adverse effects.

No toxicological benchmarks were available for 11 of the 13 organics detected at the site. The HQs for the two remaining organics were well below one, indicating no risk of adverse effects.

These results indicate no risk of adverse effects on plants from NHF soil.

SWSA 5 Drainage D-2

The overall plant HI for SWSA 5 Drainage D-2 soil was 1.6. Inorganics accounted for over 99.9% of the HI. Organics accounted for only 0.01%. Of the 18 inorganics detected at SWSA 5 Drainage D-2, 14 were below background levels and eliminated from further consideration. Two of the remaining inorganics (calcium and magnesium) could not be evaluated for phytotoxic effects because toxicological benchmarks were not available. An HQ exceeding one was estimated for one (silver) of the two inorganics evaluated for phytotoxic effects. Silver was detected in only two of five soil samples, and the HQ of 1.1 does not warrant concern.

No toxicological benchmarks were available for 15 of the 16 organics detected at the site. The HQ for the one remaining organic was well below one, indicating no risk of adverse effects.

These results indicate no risk of adverse effects on plants from SWSA 5 Drainage D-2 soil.

Seep A

The overall plant HI for Seep A soil was 14. Inorganics accounted for approximately 100% of the HI. Of the 23 inorganics detected at Seep A, 16 were below background levels and eliminated from further consideration. Two of the remaining inorganics (calcium and sodium) could not be evaluated for phytotoxic effects because toxicological benchmarks were not available. HQs exceeding one were estimated for three (selenium, silver and zinc) of the five inorganics evaluated for phytotoxic effects, indicating a potential risk of adverse effects for these elements. Selenium, silver and zinc accounted for over 90% of the overall HI for the subbasin.

No toxicological benchmarks were available for 44 of the 45 organics detected at the site. The HQ for the one remaining organic was well below one, indicating no risk of adverse effects.

These results indicate a potential risk of adverse effects on plants from Seep A soil, primarily resulting from selenium, silver and zinc.

Seep B West

The overall plant HI for Seep B soil was 12. Inorganics accounted for over 99.9% of the HI. Organics accounted for only 0.001%. Of the 30 inorganics detected at Seep B, 21 were below background levels and eliminated from further consideration. [The analytical data reported chromium as chromium (VI) for this site, but we assumed this to be total chromium. This assumption resulted in elimination of chromium based on the background comparison. Inclusion of chromium would have resulted in exceedence of the benchmark and a higher HI for the subbasin.] Two of the remaining inorganics (calcium and sodium) could not be evaluated for phytotoxic effects because toxicological benchmarks were not available. HQs exceeding one were estimated for four

(antimony, mercury, molybdenum and selenium) of the seven inorganics evaluated for phytotoxic effects, indicating a potential risk of adverse effects for these elements. Antimony, mercury, molybdenum and selenium accounted for over 90% of the overall HI for the subbasin.

No toxicological benchmarks were available for 15 of the 17 organics detected at the site. The HQs for two remaining organics were well below one, indicating no risk of adverse effects.

These results indicate a potential risk of adverse effects on plants from Seep B soil, primarily resulting from antimony, mercury, molybdenum and selenium.

Seep B East

The overall plant HI for the Seep B/A soil was 1.8. Inorganics accounted for over 99.9% of the HI. Organics accounted for only 0.003%. Of the 21 inorganics detected at Seep B/A, 17 were below background levels and eliminated from further consideration. One of the four remaining inorganics, sodium, could not be evaluated for phytotoxic effects because toxicological benchmarks were not available. The HQs for the three other remaining inorganics, antimony, selenium and silver, were 0.7, 0.3 and 0.8, respectively, indicating no risk of adverse effects.

No toxicological benchmarks were available for 37 of the 38 six organics detected at the site. The HQ for the one remaining organic was well below one, indicating no risk of adverse effects.

These results indicate no risk of adverse effects on plants from Seep B/A soil.

Seep C

The overall plant HI for Seep C soil was 15. Inorganics accounted for over 99.9% of the HI. Organics accounted for only 0.02%. Of the 31 inorganics detected at Seep C, 15 were below background levels and eliminated from further consideration. [The analytical data reported chromium as chromium (VI) for this site, but we assumed this to be total chromium. This assumption resulted in elimination of chromium based on the background comparison. Inclusion of chromium would have resulted in exceedence of the benchmark and a higher HI for the subbasin.] Six of the remaining inorganics (calcium, cyanide, magnesium, osmium, silicon and sodium) could not be evaluated for phytotoxic effects because toxicological benchmarks were not available. HQs exceeding one were estimated for five (antimony, cobalt, molybdenum, silver and thallium) of the 10 inorganics evaluated for phytotoxic effects, indicating a potential risk of adverse effects for these elements. Antimony, cobalt, molybdenum, silver and thallium accounted for 82% of the overall HI for the subbasin.

No toxicological benchmarks were available for 18 of the 21 organics detected at the site. The HQs for the three remaining organics were well below one, indicating no risk of adverse effects.

These results indicate a potential risk of adverse effects on plants from the Seep C soil, primarily resulting from antimony, cobalt, molybdenum, silver and thallium.

W6MS3

The overall plant HI for WAG 6MS3 soil was 5. Inorganics accounted for over 99% of the HI. Organics accounted for only 0.5%. Of the 22 inorganics detected at WAG 6MS3, 14 were below background levels and eliminated from further consideration. Three of the remaining inorganics

(calcium, osmium and sodium) could not be evaluated for phytotoxic effects because toxicological benchmarks were not available. HQs exceeding one were estimated for three (arsenic, cadmium and silver) of the five inorganics evaluated for phytotoxic effects, indicating a potential risk of adverse effects for these elements. Arsenic, cadmium and silver accounted for 87% of the overall HI for the subbasin.

No toxicological benchmarks were available for 30 of the 34 organics detected at the site. The HQs for the four remaining organics were well below one, indicating no risk of adverse effects.

These results indicate a minor risk of adverse effects on plants from WAG 6MS3 soil, primarily resulting from arsenic, cadmium and silver.

W6MS1

The overall plant HI for W6MS1 soil was 5. Inorganics accounted for approximately 100% of the HI. Of the 18 inorganics detected at W6MS1, 11 were below background levels and eliminated from further consideration. Three of the remaining inorganics (calcium, magnesium and sodium) could not be evaluated for phytotoxic effects because toxicological benchmarks were not available. HQs exceeding one were estimated for three (arsenic, cadmium and nickel) of the four inorganics evaluated for phytotoxic effects, indicating a potential risk of adverse effects for these elements. Arsenic, cadmium and nickel accounted for 95% of the overall HI for the subbasin.

No toxicological benchmarks were available for 18 of the 19 organics detected at the site. The HQ for the one remaining organic was well below one, indicating no risk of adverse effects.

These results indicate a minor risk of adverse effects on plants from W6MS1 soil, primarily resulting from arsenic, cadmium and nickel.

West Seep

The overall plant HI for West Seep soil was 9.6. Inorganics accounted for over 99.9% of the HI. Organics accounted for only 0.5%. Of the 24 inorganics detected at West Seep, 15 were below background levels and eliminated from further consideration. Three of the remaining inorganics (cyanide, osmium and sodium) could not be evaluated for phytotoxic effects because toxicological benchmarks were not available. HQs exceeding one were estimated for five (cadmium, cobalt, nickel, silver and tin) of the six inorganics evaluated for phytotoxic effects, indicating a potential risk of adverse effects for these elements. Cadmium, cobalt, nickel, silver and tin accounted for 95% of the overall HI for the subbasin.

No toxicological benchmarks were available for 30 of the 32 organics detected at the site. The HQs for the two remaining organics were well below one, indicating no risk of adverse effects.

These results indicate a potential risk of adverse effects on plants from West Seep soil, primarily resulting from cadmium, cobalt, nickel, silver and tin.

East Seep

The overall terrestrial plant HI for the East Seep subbbasin was 4.3 (Table 6.2). HQs exceeding one were estimated for two analytes (selenium and thallium), indicating a potential risk of adverse

effects from these elements. Soil concentrations of these analytes marginally exceeded phytotoxicity benchmarks (maximum HQ of 2.5).

Lower WOC

The overall plant HI for Lower WOC/White Oak Lake soil was 150. Inorganics accounted for over 99.9% of the HI. Organics accounted for only 0.004%. Of the 30 inorganics detected at Lower WOC/White Oak Lake, 16 were below background levels and eliminated from further consideration. Three of the remaining inorganics (calcium, osmium, and sodium) could not be evaluated for phytotoxic effects because toxicological benchmarks were not available. HQs exceeding one were estimated for six (chromium, mercury, molybdenum, selenium, silver and zinc) of the 11 inorganics evaluated for phytotoxic effects, indicating a potential risk of adverse effects for these elements.

Chromium and mercury accounted for 89% of the overall HI for the subbasin. The analytical data did not specify the valence state of the chromium. Chromium (VI) is more toxic and available to plants than chromium (III) (Smith et al. 1989, cited in Will and Suter 1995b), but in most soils chromium (VI) is likely to be reduced to chromium (III) (Bartlett and James 1979, cited in Will and Suter 1995b). However, the toxicological benchmark used to estimate effects of chromium is based on chromium (VI) studies. The use of the benchmark for the more toxic and available chromium (VI) when exposures may be predominantly from chromium (III) may lead to overestimation of the risks of adverse phytotoxic effects.

No toxicological benchmarks were available for 22 of the 24 organics detected at the site. The HQs for the two remaining organics were well below one, indicating no risk of adverse effects.

These results indicate a potential risk of adverse effects on plants from Lower WOC/White Oak Lake soil, primarily resulting from chromium and mercury.

Pit 4 South

The overall plant HI for Pit 4/South soil was 6. Inorganics accounted for over 99.9% of the HI. Organics accounted for only 0.1%. Of the 29 inorganics detected at Pit 4/South, 18 were below background levels and eliminated from further consideration. [The analytical data reported chromium as chromium (VI) for this site, but we assumed this to be total chromium. This assumption resulted in elimination of chromium based on the background comparison. Inclusion of chromium would have resulted in exceedence of the benchmark and a higher HI for the subbasin.] Three of the remaining inorganics (calcium, magnesium and sodium) could not be evaluated for phytotoxic effects because toxicological benchmarks were not available. HQs exceeding one were estimated for three (molybdenum, selenium and thallium) of the eight inorganics evaluated for phytotoxic effects, indicating a potential risk of adverse effects for these elements. Molybdenum, selenium and thallium accounted for 78% of the overall HI for the subbasin.

No toxicological benchmarks were available for 14 of the 16 organics detected at the site. The HQs for the two remaining organics were well below one, indicating no risk of adverse effects.

These results indicate a minor risk of adverse effects on plants from Pit 4/South soil, primarily resulting from molybdenum, selenium and thallium.

SWSA 6 East

The overall plant HI for SWSA 6 East soil was 7. Inorganics accounted for approximately 100% of the HI. Of the 18 inorganics detected at SWSA 6 East, 12 were below background levels and eliminated from further consideration. Two of the remaining inorganics (magnesium and sodium) could not be evaluated for phytotoxic effects because toxicological benchmarks were not available. HQs exceeding one were estimated for three (cadmium, nickel and zinc) of the four inorganics evaluated for phytotoxic effects, indicating a potential risk of adverse effects for these elements. Cadmium, nickel and zinc accounted for 93% of the overall HI for the subbasin.

No toxicological benchmarks were available for 10 of the 11 organics detected at the site. The HQ for the one remaining organic was well below one, indicating no risk of adverse effects.

These results indicate a minor risk of adverse effects on plants from SWSA 6 East soil, primarily resulting from cadmium, nickel and zinc.

SWSA 6 South

The overall plant HI for SWSA 6 South soil was 4. Inorganics accounted for 100% of the HI. Of the 17 inorganics detected at SWSA 6 South, 12 were below background levels and eliminated from further consideration. Two of the remaining inorganics (calcium and sodium) could not be evaluated for phytotoxic effects because toxicological benchmarks were not available. HQs exceeding one were estimated for two (arsenic and cadmium) of the three inorganics evaluated for phytotoxic effects, indicating a potential risk of adverse effects for these elements. Arsenic and cadmium accounted for 76% of the overall HI for the subbasin.

Benchmarks were not available for any of the three organics detected at SWSA 6 South.

These results indicate a minor risk of adverse effects on plants from SWSA 6 South soil, primarily resulting from arsenic and cadmium.

6.3.1.2 Plants exposed to seeps and springs

The screening of contaminant concentrations in soil solution against phytotoxicity benchmarks is provided in Table 6.1. Unfiltered surface water samples were using resulting in conservative estimates of risk. Because individual seeps, not entire subbasins, potentially constitute risks to terrestrial plants rooted in these areas, the following text summarizes screening results by sampling station. Results are presented only for those stations where at least one contaminant exceeded a benchmark.

East Seep

SW7-3. The overall plant HI for SW7-3 surface water was 11.7. Inorganics accounted for 100% of the HI. Of the 14 inorganics detected at SW7-3 and that exceeded background levels if background data were available, 3 exceeded toxicological benchmarks for terrestrial plants associated with surface water. These were aluminum (HQ=3.88), arsenic (HQ=4.20), and chromium (HQ=1.83). Aluminum and arsenic accounted for most significantly to the overall HI for this station with 33% and 36%, respectively. Chromium accounted for 16% to the HI. Aluminum exceeded background by a factor of 1.3. Background data were not available for arsenic or chromium. No organic contaminants exceeded a hazard quotient of 1 for SW7-3. These results indicate a potential

risk of adverse effects on plants from SW7-3 surface water, primarily resulting from aluminum, arsenic, and chromium.

SW7-4. The overall plant HI for SW7-4 surface water was 16.7. Inorganics accounted for 100% of the HI. Of the 7 inorganics detected at SW7-4 and that exceeded background levels if background data were available, 2 exceeded toxicological benchmarks for terrestrial plants associated with surface water. These were manganese (HQ=1.85) and thallium (HQ=14.5). Thallium accounted for 86% to the overall HI for this station. No background data were available for thallium, but manganese exceeded background by a factor of 36. No organic contaminants exceeded a hazard quotient of 1 for SW7-4. These results indicate a potential risk of adverse effects on plants from SW7-4 surface water, primarily resulting primarily from thallium.

SW7-7. The overall plant HI for SW7-7 surface water was 8.6. Inorganics accounted for 100% of the HI. Of the 7 inorganics detected at SW7-7 and that exceeded background levels if background data were available, only thallium (HQ=8.0)exceeded toxicological benchmarks for terrestrial plants associated with surface water. Thallium accounted for 94% to the overall HI for this station. No background data were available for thallium, but manganese exceeded background by a factor of 36. No organic contaminants exceeded a hazard quotient of 1 for SW7-7. These results indicate a potential risk of adverse effects on plants from SW7-7 surface water, primarily resulting primarily from thallium.

SW7-8. The overall plant HI for SW7-8 surface water was 2.1. Inorganics accounted for 100% of the HI. Of the 3 inorganics detected at SW7-8 and that exceeded background levels if background data were available, only aluminum (HQ=2.1) exceeded its toxicological benchmark for terrestrial plants associated with surface water. Aluminum accounted for 97% to the overall HI for this station and exceeded background by a factor of 1.2. No organic contaminants exceeded a hazard quotient of 1 for SW7-8. These results indicate a potential risk of adverse effects on plants from SW7-8 surface water, primarily resulting from aluminum.

HF-2

05.SW005. The overall plant HI for 05.SW005 surface water was 224. Inorganics accounted for >99% of the HI. Of the 14 inorganics detected at 05.SW005 and that exceeded background levels if background data were available, 8 exceeded toxicological benchmarks for terrestrial plants associated with surface water. These were aluminum (HQ=202), arsenic (HQ=3.10), chromium (HQ=2.86), copper (HQ=2.40), iron (HQ=5.39), manganese (HQ=1.80), nickel (HQ=1.25), and lead (HQ=3.30). Aluminum accounted for 90.4% to the overall HI for this station. Aluminum exceeded background by a factor of 18. Background data were also available for iron, manganese, and lead which exceeded background by factors of 5.2, 3.5, and 1.4, respectively. No organic contaminants exceeded a hazard quotient of 1 for this station. These results indicate a potential risk of adverse effects on plants from 05.SW005 surface water, primarily resulting from aluminum.

HRE

05.SW004. The overall plant HI for 05.SW004 surface water was 98.2. Inorganics accounted for 100% of the HI. Of the 11 inorganics detected at this station, and that exceeded background levels if background data were available, 5 exceeded toxicological benchmarks for terrestrial plants associated with surface water. These were aluminum (HQ=88.5), arsenic (HQ=3.60), chromium (HQ=1.16), iron (HQ=2.85), and manganese (HQ=1.38). Aluminum accounted for 90.1% of the

overall HI for this station. Aluminum exceeded background by a factor of 4.1. Background data were also available for iron and manganese which exceeded background by factors of 2.2 and 4, respectively. No organic contaminants exceeded a hazard quotient of 1 for this station. These results indicate a potential risk of adverse effects on plants from 05.SW004 surface water, primarily resulting from aluminum.

SW9-1. The overall plant HI for SW9-1 surface water was 1.33. Inorganics accounted for 100% of the HI. Of the 3 inorganics detected at SW9-1 and that exceeded background levels if background data were available, only fluoride (HQ=1.1) exceeded its toxicological benchmark for terrestrial plants associated with surface water. Fluoride accounted for 84% to the overall HI for this station. No background data were available for this contaminant. No organic contaminants exceeded a hazard quotient of 1 for this station. These results indicate a potential risk of adverse effects on plants from SW9-1 surface water, primarily resulting from fluoride.

SW9-2. The overall plant HI for SW9-2 surface water was 9.23. Inorganics accounted for 100% of the HI. Of the 6 inorganics detected at SW9-2 and that exceeded background levels if background data were available, only aluminum (HQ=7.3) exceeded its toxicological benchmark for terrestrial plants associated with surface water. Aluminum accounted for 79% to the overall HI for this station and exceeded background by a factor of 4.3. No organic contaminants exceeded a hazard quotient of 1 for this station. These results indicate a potential risk of adverse effects on plants from SW9-2 surface water, primarily resulting from aluminum.

Intermediate Pond

WAG4 T2. The overall plant HI for WAG4 T2 surface water was 6.75. Inorganics accounted for >99% of the HI. Of the 11 inorganics detected at WAG4 T2, and that exceeded background levels if background data were available, only aluminum (HQ=5.0) exceeded its toxicological benchmark for terrestrial plants associated with surface water. Aluminum accounted for 74.1% to the overall HI for this station. Aluminum exceeded background by a factor of 1.9. No organic contaminants exceeded a hazard quotient of 1 for this station. These results indicate a potential risk of adverse effects on plants from WAG4 T2 surface water, primarily resulting from aluminum.

WCTRIB-4. The overall plant HI for WCTRIB-4 surface water was 14.0. Inorganics accounted for 100% of the HI. Of the 6 inorganics detected at WCTRIB-4, and that exceeded background levels if background data were available, only thallium (HQ=13.6) exceeded its toxicological benchmark for terrestrial plants associated with surface water. Thallium accounted for 96% to the overall HI for this station. No background data were available for thallium. No organic contaminants exceeded a hazard quotient of 1 for this station. These results indicate a potential risk of adverse effects on plants from WCTRIB-4 surface water, primarily resulting primarily from thallium.

Lower WOC

05.SW006. The overall plant HI for 05.SW006 surface water was 18.5. Inorganics accounted for >99% of the HI. Of the 9 inorganics detected at 05.SW006, and that exceeded background levels if background data were available, only aluminum (HQ=17.5) exceeded its toxicological benchmark for terrestrial plants associated with surface water. Aluminum accounted for 94% to the overall HI for this station. Aluminum exceeded background by a factor of 1.5. No organic contaminants

exceeded a hazard quotient of 1 for this station. These results indicate a potential risk of adverse effects on plants from 05.SW006 surface water, primarily resulting primarily from aluminum.

MBTRIB-3. The overall plant HI for MBTRIB-3 surface water was 16.8. Inorganics accounted for 100% of the HI. Of the 3 inorganics detected at MBTRIB-3, and that exceeded background levels if background data were available, only thallium (HQ=16.6) exceeded its toxicological benchmark for terrestrial plants associated with surface water. Thallium accounted for 99% to the overall HI for this station. No background data were available for thallium. No organic contaminants exceeded a hazard quotient of 1 for this station. These results indicate a potential risk of adverse effects on plants from MBTRIB-3 surface water, primarily resulting primarily from thallium.

SW2-5. The overall plant HI for SW2-5 surface water was 27.1. Inorganics accounted for 100% of the HI. Of the 10 inorganics detected at SW2-5, and that exceeded background levels if background data were available, only thallium (HQ=25.6) exceeded its toxicological benchmark for terrestrial plants associated with surface water. Thallium accounted for 95% to the overall HI for this station. No background data were available for thallium. No organic contaminants exceeded a hazard quotient of 1 for this station. These results indicate a potential risk of adverse effects on plants from SW2-5 surface water, primarily resulting primarily from thallium.

SW2-7. The overall plant HI for SW2-7 surface water was 3.9. Inorganics accounted for 100% of the HI. Of the 8 inorganics detected at SW2-7, and that exceeded background levels if background data were available, 2 exceeded toxicological benchmarks for terrestrial plants associated with surface water. These were arsenic (HQ=1.40) and iron (HQ=1.70). Arsenic accounted for 36% to the overall HI and iron accounted for 44% of the overall HI for this station. Iron exceeded background by a factor of 19. Background data were not available for arsenic. No organic contaminants exceeded a hazard quotient of 1 for this station. These results indicate a potential risk of adverse effects on plants from SW2-7 surface water, primarily resulting from arsenic and iron.

SW6-1. The overall plant HI for SW6-1 surface water was 24.8. Inorganics accounted for 100% of the HI. Of the 6 inorganics detected at SW6-1, and that exceeded background levels if background data were available, 2 exceeded toxicological benchmarks for terrestrial plants associated with surface water. These were iron (HQ=1.47) and thallium (HQ=22.5). Thallium accounted for 90.1% to the overall HI for this station. Iron exceeded background by a factor of 18, and no background data were available for thallium. No organic contaminants exceeded a hazard quotient of 1 for this station. These results indicate a potential risk of adverse effects on plants from SW6-1 surface water, primarily resulting from thallium.

SW7-5. The overall plant HI for SW7-5 surface water was 25.5. Inorganics accounted for 100% of the HI. Of the 18 inorganics detected at SW7-5 and that exceeded background levels if background data were available, 3 exceeded toxicological benchmarks for terrestrial plants associated with surface water. These were aluminum (HQ=19.0), copper (HQ=1.04), and thallium (HQ=3.00). Aluminum accounted for 75% to the overall HI for this station. Aluminum exceeded background by a factor of 6. No background data were available for arsenic and thallium. No organic contaminants exceeded a hazard quotient of 1 for this station. These results indicate a potential risk of adverse effects on plants from SW7-5 surface water, primarily resulting from aluminum.

WCTRIB-1. The overall plant HI for WCTRIB-1 surface water was 18.6. Inorganics accounted for 100% of the HI. Of the 5 inorganics detected at WCTRIB-1, and that exceeded background levels if background data were available, 2 exceeded toxicological benchmarks for terrestrial plants associated with surface water. These were aluminum (HQ=4.79) and thallium (HQ=13.4). Thallium accounted for 72% to the overall HI for this station. Aluminum exceeded background by a factor of 1.5, and no background data were available for thallium. No organic contaminants exceeded a hazard quotient of 1 for this station. These results indicate a potential risk of adverse effects on plants from WCTRIB-1 surface water, primarily resulting from thallium.

WSTRIB-1. The overall plant HI for WSTRIB-1 surface water was 17.5. Inorganics accounted for 100% of the HI. Of the 5 inorganics detected at WSTRIB-1, and that exceeded background levels if background data were available, only thallium (HQ=17.3) exceeded its toxicological benchmark for terrestrial plants associated with surface water. Thallium accounted for 99% to the overall HI for this station. No background data were available for thallium. No organic contaminants exceeded a hazard quotient of 1 for this station. These results indicate a potential risk of adverse effects on plants from WSTRIB-1 surface water, primarily resulting primarily from thallium.

MV Drive

5NNT. The overall plant HI for 5NNT surface water was 17.2. Inorganics accounted for 100% of the HI. Of the 18 inorganics detected at 5NNT and that exceeded background levels if background data were available, 2 exceeded toxicological benchmarks for terrestrial plants associated with surface water. These were aluminum (HQ=12.0) and thallium (HQ=3.27). Aluminum accounted for 70% to the overall HI for this station. Aluminum exceeded background by a factor of 6. No background data were available for thallium. No organic contaminants exceeded a hazard quotient of 1 for this station. These results indicate a potential risk of adverse effects on plants from 5NNT surface water, primarily resulting from aluminum.

Pit 4 South

East Seep. The overall plant HI for East Seep surface water was 197. Inorganics accounted for 100% of the HI. Of the 19 inorganics detected at East Seep and that exceeded background levels if background data were available, 6 exceeded toxicological benchmarks for terrestrial plants associated with surface water. These were aluminum (HQ=150), arsenic (HQ=28.2), boron (HQ=1.99), fluoride (HQ=2.10), iron (HQ=3.64), and thallium (HQ=7.75). Aluminum accounted for 76% to the overall HI for this station. Aluminum exceeded background by a factor of 20. Background data were also available for iron which exceeded background by a factor of nine. No organic contaminants exceeded a hazard quotient of 1 for this station. These results indicate a potential risk of adverse effects on plants from East Seep surface water, primarily resulting from aluminum.

Seep A

05.SP009. The overall plant HI for 05.SP009 surface water was 9.63. Inorganics accounted for >99% of the HI. Of the 4 inorganics detected at 05.SP009 and that exceeded background levels if background data were available, 2 exceeded toxicological benchmarks for terrestrial plants associated with surface water. These were aluminum (HQ=6.75) and manganese (HQ=2.19). Aluminum accounted for 71% to the overall HI and manganese accounted for 22% of the overall HI for this station. Aluminum exceeded background by a factor of 4 and manganese exceeded by a

factor of 43. No organic contaminants exceeded a hazard quotient of 1 for this station. These results indicate a potential risk of adverse effects on plants from 05.SP009 surface water, primarily resulting from aluminum and manganese.

05.SP016. The overall plant HI for 05.SP016 surface water was 63.9. Inorganics accounted for >99% of the HI. Of the 9 inorganics detected at 05.S016 and that exceeded background levels if background data were available, 2 exceeded toxicological benchmarks for terrestrial plants associated with surface water. These were aluminum (HQ=61.5) and iron (HQ=1.38). Aluminum accounted for 96% to the overall HI for this station. Aluminum exceeded background by a factor of 36, and iron exceeded background by a factor of 17. No organic contaminants exceeded a hazard quotient of 1 for this station. These results indicate a potential risk of adverse effects on plants from 05.SP016 surface water, primarily resulting from aluminum.

05.SP017. The overall plant HI for 05.SP017 surface water was 9.88. Inorganics accounted for >99% of the HI. Of the inorganics detected at 05.SP017 and that exceeded background levels if background data were available, 4 exceeded toxicological benchmarks for terrestrial plants associated with surface water. These were aluminum (HQ=1.90), arsenic (HQ=3.60), iron (HQ=1.72), and manganese (HQ=2.55). Aluminum accounted for 19% to the overall HI, arsenic accounted for 36%, iron accounted for 17%, and manganese accounted for 26% for this station. Aluminum exceeded background by a factor of 1.12, iron by a factor of 21, and manganese by a factor of 50. Background data were not available for arsenic. No organic contaminants exceeded a hazard quotient of 1 for this station. These results indicate a potential risk of adverse effects on plants from 05.SP017 surface water resulting from aluminum, arsenic, iron, and manganese.

05.SW003. The overall plant HI for 05.SW003 surface water was 46.3. Inorganics accounted for >99% of the HI. Of the 11 inorganics detected at 05.SW003 and that exceeded background levels if background data were available, only aluminum (HQ=44.5) exceeded its toxicological benchmark for terrestrial plants associated with surface water contributing 96% to the overall HI for this station. Aluminum exceeded background by a factor of 5. No organic contaminants exceeded a hazard quotient of 1 for this station. These results indicate a potential risk of adverse effects on plants from 05.SW003 surface water, primarily resulting from aluminum.

SW5-6. The overall plant HI for SW5-6 surface water was 35.4. Inorganics accounted for >99% of the HI. Of the 8 inorganics detected at SW5-6 and that exceeded background levels if background data were available, 3 exceeded toxicological benchmarks for terrestrial plants associated with surface water. These were aluminum (HQ=6.75), manganese (HQ=2.03), and thallium (HQ=25.3). Thallium accounted for 71% to the overall HI for this station. Aluminum exceeded background by a factor of 3 and manganese exceeded by factor of 40. Background data were not available for thallium. No organic contaminants exceeded a hazard quotient of 1 for this station. These results indicate a potential risk of adverse effects on plants from SW5-6 surface water, primarily resulting from thallium.

SW5-7. The overall plant HI for SW5-7 surface water was 6.72. Inorganics accounted for 100% of the HI. Of the 7 inorganics detected at SW5-7 and that exceeded background levels if background data were available, arsenic (HQ=3.00) and manganese (HQ=2.21) exceeded toxicological benchmarks for terrestrial plants associated with surface water. Arsenic accounted for 45% to the overall HI and manganese accounted for 33% to the overall HI for this station. Background data were available only for manganese which exceeded background by a factor of 43. No organic contaminants exceeded a hazard quotient of 1 for this station. These results indicate a

potential risk of adverse effects on plants from SW5-7 surface water, resulting from arsenic and manganese.

SW5-8. The overall plant HI for SW5-8 surface water was 24.5. Inorganics accounted for >99% of the HI. Of the 7 inorganics detected at SW5-8 and that exceeded background levels if background data were available, manganese (HQ=1.23) and thallium (HQ=22.0) exceeded toxicological benchmarks for terrestrial plants associated with surface water. Thallium accounted for 90% to the overall HI for this station. No background data were available for thallium. No organic contaminants exceeded a hazard quotient of 1 for this station. These results indicate a potential risk of adverse effects on plants from SW5-8 surface water, primarily resulting from thallium.

SW5-9. The overall plant HI for SW5-9 surface water was 31.9. Inorganics accounted for >99% of the HI. Of the 11 inorganics detected at SW5-9 and that exceeded background levels if background data were available, 4 exceeded toxicological benchmarks for terrestrial plants associated with surface water. These were aluminum (HQ=3.55), arsenic (HQ=3.00), manganese (HQ=1.26), and thallium (HQ=21.9). Thallium accounted for 69% to the overall HI for this station. No background data were available for thallium. Background data were available for aluminum and manganese which exceeded background by factors of 1.6 and 21, respectively. No organic contaminants exceeded a hazard quotient of 1 for this station. These results indicate a potential risk of adverse effects on plants from SW5-9 surface water, primarily resulting from thallium.

Seep C

05.SP005. The overall plant HI for 05.SP005 surface water was 11.8. Inorganics accounted for >99% of the HI. Of the 4 inorganics detected at 05.SP005 and that exceeded background levels if background data were available, only aluminum (HQ=11.5) exceeded toxicological benchmarks for terrestrial plants associated with surface water. Aluminum accounted for 97% to the overall HI for this station and exceeded background by a factor of 7. No organic contaminants exceeded a hazard quotient of 1 for this station. These results indicate a potential risk of adverse effects on plants from 05.SP005 surface water, primarily resulting from aluminum.

SW5-3. The overall plant HI for SW5-3 surface water was 15.2. Inorganics accounted for 100% of the HI. Of the 7 inorganics detected at SW5-3 and that exceeded background levels if background data were available, 2 exceeded toxicological benchmarks for terrestrial plants associated with surface water. These were aluminum (HQ=11.5) and fluoride (HQ=3.20). Aluminum accounted for 76% to the overall HI for this station. Aluminum exceeded background by a factor of 7. Background data were not available for fluoride. No organic contaminants exceeded a hazard quotient of 1 for this station. These results indicate a potential risk of adverse effects on plants from SW5-3 surface water, primarily resulting from aluminum.

SW5-4. The overall plant HI for SW5-4 surface water was 6.30. Inorganics accounted for >99% of the HI. Of the 11 inorganics detected at SW5-4 and that exceeded background levels if background data were available, 3 exceeded toxicological benchmarks for terrestrial plants associated with surface water. These were arsenic (HQ=3.00), fluoride (HQ=1.03), and manganese (HQ=1.44). Arsenic, fluoride, and manganese accounted for 48%, 16%, and 23% to the overall HI for this station, respectively. Background data were available only for manganese which exceeded background by a factor of 13. No organic contaminants exceeded a hazard quotient of 1 for this station. These results indicate a potential risk of adverse effects on plants from SW5-4 surface water, primarily resulting from arsenic, fluoride, and manganese.

SWSA 5 Trib 1

05.SP003. The overall plant HI for 05.SP003 surface water was 23.3. Inorganics accounted for >99% of the HI. Of the 7 inorganics detected at 05.SP003 and that exceeded background levels if background data were available, only aluminum (HQ=18.1) and arsenic (HQ=3.50) exceeded toxicological benchmarks for terrestrial plants associated with surface water. Aluminum accounted for 78% to the overall HI for this station and exceeded background by a factor of 11. Background data were not available for arsenic. No organic contaminants exceeded a hazard quotient of 1 for this station. These results indicate a potential risk of adverse effects on plants from 05.SP003 surface water, primarily resulting from aluminum.

05.SP015. The overall plant HI for 05.SP015 surface water was 8.32. Inorganics accounted for >99% of the HI. Of the 8 inorganics detected at 05.SP015 and that exceeded background levels if background data were available, only cobalt (HQ=4.88) and manganese (HQ=1.98) exceeded toxicological benchmarks for terrestrial plants associated with surface water. Cobalt and manganese accounted for 59% and 24% to the overall HI for this station, respectively. Manganese exceeded background by a factor of 38, but no background data were available for cobalt. No organic contaminants exceeded a hazard quotient of 1 for this station. These results indicate a potential risk of adverse effects on plants from 05.SP015 surface water, primarily resulting from cobalt and manganese.

05.SW001. The overall plant HI for 05.SW001 surface water was 24.3. Inorganics accounted for >99% of the HI. Of the 8 inorganics detected at 05.SW001 and that exceeded background levels if background data were available, only aluminum (HQ=20.2) and arsenic (HQ=3.70) exceeded toxicological benchmarks for terrestrial plants associated with surface water. Aluminum accounted for 83% to the overall HI for this station. Aluminum exceeded background by a factor of 3, but no background data were available for arsenic. No organic contaminants exceeded a hazard quotient of 1 for this station. These results indicate a potential risk of adverse effects on plants from 05.SW001 surface water, primarily resulting from aluminum.

SW5-1. The overall plant HI for SW5-1 surface water was 45.1. Inorganics accounted for 100% of the HI. Of the 10 inorganics detected at SW5-1 and that exceeded background levels if background data were available, 4 exceeded toxicological benchmarks for terrestrial plants associated with surface water. These were aluminum (HQ=18.1), arsenic (HQ=3.50), manganese (HQ=1.35), and thallium (HQ=21.1). Aluminum and thallium accounted for 40% and 47% to the overall HI for this station, respectively. Aluminum exceeded background by a factor of 9, and no background data were available thallium. No organic contaminants exceeded a hazard quotient of 1 for this station. These results indicate a potential risk of adverse effects on plants from SW5-1 surface water, primarily resulting from aluminum and thallium.

SWSA 5 WOC

05.SP004. The overall plant HI for 05.SP004 surface water was 8.62. Inorganics accounted for >99% of the HI. Of the 5 inorganics detected at 05.SP004 and that exceeded background levels if background data were available, only aluminum (HQ=6.00) and arsenic (HQ=2.30) exceeded toxicological benchmarks for terrestrial plants associated with surface water. Aluminum and arsenic accounted for 70% and 27% to the overall HI for this station, respectively. Aluminum exceeded background by a factor of 3.5, and no background data were available for arsenic. No organic contaminants exceeded a hazard quotient of 1 for this station. These results indicate a potential risk of adverse effects on plants from 05.SP004 surface water, primarily resulting from aluminum.

SW5-2. The overall plant HI for SW5-2 surface water was 6.66. Inorganics accounted for 100% of the HI. Of the 7 inorganics detected at SW5-2 and that exceeded background levels if background data were available, only aluminum (HQ=6.00) exceeded its toxicological benchmark for terrestrial plants associated with surface water. Aluminum accounted for 90% to the overall HI for this station. Aluminum exceeded background by a factor of 3.5. No organic contaminants exceeded a hazard quotient of 1 for this station. These results indicate a potential risk of adverse effects on plants from SW5-2 surface water, primarily resulting from aluminum.

SWSA 4 Main

SCS1B. The overall plant HI for SCS1B surface water was 53.9. Inorganics accounted for 100% of the HI. Of the 18 inorganics detected at SCS1B and that exceeded background levels if background data were available, only arsenic(HQ=50.0) and lead (HQ=2.50) exceeded toxicological benchmarks for terrestrial plants associated with surface water. Arsenic accounted for 93% to the overall HI for this station. No background data were available for arsenic, and lead exceeded background by a factor of 4. No organic contaminants exceeded a hazard quotient of 1 for this station. These results indicate a potential risk of adverse effects on plants from SCS1B surface water, primarily resulting from arsenic.

SW4-1. The overall plant HI for SW4-1 surface water was 30.2. Inorganics accounted for >99% of the HI. Of the 9 inorganics detected at SW4-1 and that exceeded background levels if background data were available, 4 exceeded toxicological benchmarks for terrestrial plants associated with surface water. These were arsenic (HQ=6.2), fluoride (HQ=3.1), iron (HQ=2.9), and thallium (HQ=16.6). Thallium accounted for 55% to the overall HI for this station. Iron exceeded background by a factor of 32 and background data were not available for arsenic, fluoride, and thallium. No organic contaminants exceeded a hazard quotient of 1 for this station. These results indicate a potential risk of adverse effects on plants from SW4-1 surface water, primarily resulting from thallium.

SW4-2. The overall plant HI for SW4-2 surface water was 21.5. Inorganics accounted for >99% of the HI. Of the 13 inorganics detected at SW4-2 and that exceeded background levels if background data were available, only nickel (HQ=18.9) exceeded toxicological its benchmark for terrestrial plants associated with surface water. Nickel accounted for 88% to the overall HI for this station. No background data were available for nickel. No organic contaminants exceeded a hazard quotient of 1 for this station. These results indicate a potential risk of adverse effects on plants from SW4-2 surface water, primarily resulting from nickel.

W4TRIB-5. The overall plant HI for W4TRIB-5 surface water was 12.6. Inorganics accounted for 100% of the HI. Of the 6 inorganics detected at W4TRIB-5 and that exceeded background levels if background data were available, aluminum (HQ=10.6) and fluoride (HQ=1.51) exceeded toxicological benchmarks for terrestrial plants associated with surface water. Aluminum accounted for 84% to the overall HI for this station and exceeded background by a factor of 5.5. No organic contaminants exceeded a hazard quotient of 1 for this station. These results indicate a potential risk of adverse effects on plants from W4TRIB-5 surface water, primarily resulting from aluminum.

W4TRIB-7. The overall plant HI for W4TRIB-7 surface water was 2.11. Inorganics accounted for 100% of the HI. Of the 5 inorganics detected at W4TRIB-7 and that exceeded background levels if background data were available, only manganese (HQ=1.43) exceeded its toxicological benchmark for terrestrial plants associated with surface water. Manganese accounted

for 68% to the overall HI for this station and exceeded background by a factor of 18. No organic contaminants exceeded a hazard quotient of 1 for this station. These results indicate a potential risk of adverse effects on plants from W4TRIB-7 surface water, primarily resulting from manganese.

WAG 4 MS1. The overall plant HI for WAG 4 MS1 surface water was 19.6. Inorganics accounted for 100% of the HI. Of the 13 inorganics detected at WAG 4 MS1, and that exceeded background levels if background data were available, only manganese (HQ=1.62) and thallium (HQ=16.7) exceeded toxicological benchmarks for terrestrial plants associated with surface water. Thallium accounted for 85% to the overall HI for this station. No background data were available for thallium. No organic contaminants exceeded a hazard quotient of 1 for this station. These results indicate a potential risk of adverse effects on plants from WAG 4 MS1 surface water, primarily resulting from thallium.

SWSA 5 North/WOC

05.SP002. The overall plant HI for 05.SP002 surface water was 2.23. Inorganics accounted for >99% of the HI. The only inorganic detected above background was aluminum (HQ=2.23) constituting 99.9% of the overall HI for this site. Aluminum exceeded background by a factor of 1.32. No organic contaminants exceeded a hazard quotient of 1 for this station. These results indicate a potential risk of adverse effects on plants from 05.SP002 surface water, primarily resulting from aluminum.

5NW-1. The overall plant HI for 5NW-1 surface water was 2.62. Inorganics accounted for 100% of the HI. Of the 5 inorganics detected at 5NW-1, and that exceeded background levels if background data were available, only aluminum (HQ=2.23) exceeded its toxicological benchmark for terrestrial plants associated with surface water. Manganese accounted for 85% to the overall HI for this station and exceeded background by a factor of 1.32. No organic contaminants exceeded a hazard quotient of 1 for this station. These results indicate a potential risk of adverse effects on plants from 5NW-1 surface water, primarily resulting from aluminum.

5NW-2. The overall plant HI for 5NW-2 surface water was 6.67. Inorganics accounted for >99% of the HI. Of the inorganics detected at 5NW-2, and that exceeded background levels if background data were available, only aluminum (HQ=4.90) and manganese (HQ=1.33) exceeded toxicological benchmarks for terrestrial plants associated with surface water. Aluminum and manganese accounted for 73% and 20% to the overall HI for this station, respectively. Aluminum and manganese exceeded background by factors 3 and 20, respectively. No organic contaminants exceeded a hazard quotient of 1 for this station. These results indicate a potential risk of adverse effects on plants from 5NW-2 surface water, primarily resulting from aluminum and manganese.

W6MS3

ETF-14. The overall plant HI for ETF-14 surface water was 8.64. Inorganics accounted for 100% of the HI. Of the 2 inorganics detected at ETF-14, and that exceeded background levels if background data were available, only copper (HQ=8.58) exceeded its toxicological benchmark for terrestrial plants associated with surface water. Copper accounted for 99% to the overall HI for this station. No background data were available for copper. No organic contaminants exceeded a hazard quotient of 1 for this station. These results indicate a potential risk of adverse effects on plants from ETF-14 surface water, primarily resulting from copper.

WAG 6 MS3A. The overall plant HI for WAG 6 MS3A surface water was 20.5. Inorganics accounted for 100% of the HI. Of the 8 inorganics detected at WAG 6 MS3A, and that exceeded background levels if background data were available, 3 exceeded toxicological benchmarks for terrestrial plants associated with surface water. These were arsenic (HQ=3.00), manganese (HQ=1.49), and thallium (HQ=15.6). Thallium accounted for 76% to the overall HI for this station. Manganese exceeded background by a factor of 29 and no background were available for arsenic and thallium. No organic contaminants exceeded a hazard quotient of 1 for this station. These results indicate a potential risk of adverse effects on plants from WAG 6 MS3A surface water, primarily resulting from thallium.

WAG 6 MS3A-1. The overall plant HI for WAG 6 MS3A-1 surface water was 13.2. Inorganics accounted for 100% of the HI. Of the 4 inorganics detected at WAG 6 MS3A-1, and that exceeded background levels if background data were available, 3 exceeded toxicological benchmarks for terrestrial plants associated with surface water. These were arsenic (HQ=2.80), manganese (HQ=1.49), and thallium (HQ=8.70). Thallium accounted for 67% to the overall HI for this station. Manganese exceeded background by a factor of 29 and no background were available for arsenic and thallium. No organic contaminants exceeded a hazard quotient of 1 for this station. These results indicate a potential risk of adverse effects on plants from WAG 6 MS3A-1 surface water, primarily resulting from thallium.

WAG 6 MS3B. The overall plant HI for WAG 6 MS3B surface water was 22.8. Inorganics accounted for >99% of the HI. Of the 11 inorganics detected at WAG 6 MS3B, and that exceeded background levels if background data were available, 3 exceeded toxicological benchmarks for terrestrial plants associated with surface water. These were arsenic (HQ=5.00), chromium (HQ=1.02), and thallium (HQ=15.5). Thallium accounted for 68% to the overall HI for this station. No background were available for arsenic, chromium, or thallium. No organic contaminants exceeded a hazard quotient of 1 for this station. These results indicate a potential risk of adverse effects on plants from WAG 6 MS3B surface water, primarily resulting from thallium.

WAG 6 MS1

French Dr South. The overall plant HI for French Dr South surface water was 10.8. Inorganics accounted for >99% of the HI. Thallium (HQ=10.8) was the only inorganic detected above background. No background data were available for thallium which constituted 99% of the overall HI for this station. No organic contaminants exceeded a hazard quotient of 1 for this station. These results indicate a potential risk of adverse effects on plants from French Dr South surface water, primarily resulting from thallium.

WAG 6 MS1. The overall plant HI for WAG 6 MS1 surface water was 20.5. Inorganics accounted for 100% of the HI. Of the 6 inorganics detected at WAG 6 MS1, and that exceeded background levels if background data were available, only thallium (HQ=19.2) exceeded its toxicological benchmark for terrestrial plants associated with surface water. No background data were available for thallium which accounted for 94% to the overall HI for this station. No organic contaminants exceeded a hazard quotient of 1 for this station. These results indicate a potential risk of adverse effects on plants from WAG 6 MS1 surface water, primarily resulting from thallium.

WAG 6 MS1-1. The overall plant HI for WAG 6 MS1-1 surface water was 22.7. Inorganics accounted for 100% of the HI. Of the 6 inorganics detected at WAG 6 MS1-1, and that exceeded background levels if background data were available, 3 exceeded toxicological benchmarks for terrestrial plants associated with surface water. These were arsenic (HQ=4.00), manganese

(HQ=3.05), and thallium (HQ=15.3). Thallium accounted for 68% to the overall HI for this station. Manganese exceeded background by a factor of 59 and no background were available for arsenic and thallium. No organic contaminants exceeded a hazard quotient of 1 for this station. These results indicate a potential risk of adverse effects on plants from WAG 6 MS1-1 surface water, primarily resulting from thallium.

W6MS2. The overall plant HI for W6MS2 surface water was 8.35. Inorganics accounted for 100% of the HI. Of the 4 inorganics detected at W6MS2, and that exceeded background levels if background data were available, only thallium (HQ=8.10) exceeded its toxicological benchmark for terrestrial plants associated with surface water. No background data were available for thallium which accounted for 97% to the overall HI for this station. No organic contaminants exceeded a hazard quotient of 1 for this station. These results indicate a potential risk of adverse effects on plants from W6MS2 surface water, primarily resulting from thallium.

WCTRIB-1

SW7-6. The overall plant HI for SW7-6 surface water was 3.87. Inorganics accounted for 100% of the HI. Of the 3 inorganics detected at SW7-6, and that exceeded background levels if background data were available, only aluminum (HQ=3.81) exceeded its toxicological benchmark for terrestrial plants associated with surface water. Aluminum which accounted for 98% to the overall HI for this station and exceeded background by a factor of 2. No organic contaminants exceeded a hazard quotient of 1 for this station. These results indicate a potential risk of adverse effects on plants from SW7-6 surface water, primarily resulting from aluminum.

West Seep

RS-1. The overall plant HI for RS-1 surface water was 29.1. Inorganics accounted for 100% of the HI. Of the 8 inorganics detected at RS-1, and that exceeded background levels if background data were available, 3 exceeded toxicological benchmarks for terrestrial plants associated with surface water. These were arsenic (HQ=14.0), manganese (HQ=1.83), and thallium (HQ=12.9). Arsenic and thallium accounted for 48% and 44% to the overall HI for this station, respectively. Manganese exceeded background by a factor of 31 and no background were available for arsenic and thallium. No organic contaminants exceeded a hazard quotient of 1 for this station. These results indicate a potential risk of adverse effects on plants from RS-1 surface water, primarily resulting from arsenic and thallium.

RS-3. The overall plant HI for RS-3 surface water was 34.5. Inorganics accounted for 100% of the HI. Of the 12 inorganics detected at RS-3, and that exceeded background levels if background data were available, 4 exceeded toxicological benchmarks for terrestrial plants associated with surface water. These were aluminum (HQ=7.85), arsenic (HQ=22.0), chromium (HQ=1.28), and fluoride (HQ=2.20). Arsenic accounted for 64% to the overall HI for this station. Aluminum exceeded background by a factor of 5 and no background were available for arsenic, chromium, or fluoride. No organic contaminants exceeded a hazard quotient of 1 for this station. These results indicate a potential risk of adverse effects on plants from RS-3 surface water, primarily resulting from arsenic.

RS-3A. The overall plant HI for RS-3A surface water was 120. Inorganics accounted for 100% of the HI. Of the 18 inorganics detected at RS-3A, and that exceeded background levels if background data were available, 5 exceeded toxicological benchmarks for terrestrial plants associated with surface water. These were aluminum (HQ=88.5), arsenic (HQ=23.6), chromium

(HQ=1.93), and fluoride (HQ=2.42). Aluminum accounted for 74% to the overall HI for this station and exceeded background by a factor of 5. No background were available for arsenic, chromium, or fluoride. No organic contaminants exceeded a hazard quotient of 1 for this station. These results indicate a potential risk of adverse effects on plants from RS-3A surface water, primarily resulting from aluminum.

RS-3B. The overall plant HI for RS-3B surface water was 7.35. Inorganics accounted for 100% of the HI. Of the 4 inorganics detected at RS-3B, and that exceeded background levels if background data were available, only aluminum (HQ=7.10) exceeded its toxicological benchmark for terrestrial plants associated with surface water. Aluminum accounted for 97% to the overall HI for this station and exceeded background by a factor of 4. These results indicate a potential risk of adverse effects on plants from RS-3B surface water, primarily resulting from aluminum.

SW6-2. The overall plant HI for SW6-2 surface water was 18.3. Inorganics accounted for 100% of the HI. Of the 5 inorganics detected at SW6-2, and that exceeded background levels if background data were available, arsenic (HQ=2.00) and thallium (HQ=15.6) exceeded toxicological benchmarks for terrestrial plants associated with surface water. Thallium accounted for 85% to the overall HI for this station. No background data were available for arsenic or thallium. No organic contaminants exceeded a hazard quotient of 1 for this station. These results indicate a potential risk of adverse effects on plants from SW6-2 surface water, primarily resulting from thallium.

SW7-1. The overall plant HI for SW7-1 surface water was 2.37. Inorganics accounted for 100% of the HI. Of the 5 inorganics detected at SW7-1, and that exceeded background levels if background data were available, only manganese (HQ=1.60) exceeded its toxicological benchmark for terrestrial plants associated with surface water. Manganese accounted for 68% to the overall HI for this station and exceeded background by a factor of 31. No organic contaminants exceeded a hazard quotient of 1 for this station. These results indicate a potential risk of adverse effects on plants from SW7-1 surface water, primarily resulting from manganese.

SW7-2. The overall plant HI for SW7-2 surface water was 6.64. Inorganics accounted for 100% of the HI. Of the 8 inorganics detected at SW7-2, and that exceeded background levels if background data were available, aluminum (HQ=3.26) and cobalt (HQ=2.37) exceeded toxicological benchmarks for terrestrial plants associated with surface water. Aluminum accounted for 49% to the overall HI for this station and exceeded background by a factor of 3. No background data were available for cobalt which accounted for 36% to the overall HI. No organic contaminants exceeded a hazard quotient of 1 for this station. These results indicate a potential risk of adverse effects on plants from SW7-2 surface water, primarily resulting from aluminum and cobalt.

WSS-025. The overall plant HI for WSS-025 surface water was 522. Inorganics accounted for 100% of the HI. Of the 21 inorganics detected at WSS-025, and that exceeded background levels if background data were available, 7 exceeded toxicological benchmarks for terrestrial plants associated with surface water. These were aluminum (HQ=485), arsenic (HQ=10.0), chromium (HQ=2.60), copper (HQ=1.06), iron (HQ=9.8), lead (HQ=1.6), and titanium (HQ=9.00). Aluminum accounted for 93% to the overall HI for this station and exceeded background by more than 2 orders of magnitude. No organic contaminants exceeded a hazard quotient of 1 for this station. These results indicate a potential risk of adverse effects on plants from WSS-025 surface water, primarily resulting from aluminum.

SWSA 5 Drainage D-2

05.SP007. The overall plant HI for 05.SP007 surface water was 32.1. Inorganics accounted for >99% of the HI. Of the 7 inorganics detected at 05.SP007, and that exceeded background levels if background data were available, aluminum (HQ=29.0) iron (HQ=1.68), and manganese (HQ=1.12) exceeded toxicological benchmarks for terrestrial plants associated with surface water. Aluminum accounted for 90% to the overall HI for this station and exceeded background by a factor of 17. No organic contaminants exceeded a hazard quotient of 1 for this station. These results indicate a potential risk of adverse effects on plants from 05.SP007 surface water, primarily resulting from aluminum.

05.SP014. The overall plant HI for 05.SP014 surface water was 12.7. Inorganics accounted for >99% of the HI. Of the 7 inorganics detected at 05.SP014, and that exceeded background levels if background data were available, only aluminum (HQ=11.5) exceeded toxicological its benchmark for terrestrial plants associated with surface water. Aluminum accounted for 90% to the overall HI for this station and exceeded background by a factor of 7. No organic contaminants exceeded a hazard quotient of 1 for this station. These results indicate a potential risk of adverse effects on plants from 05.SP014 surface water, primarily resulting from aluminum.

05.SW002. The overall plant HI for 05.SW002 surface water was 11.9. Inorganics accounted for >99% of the HI. Of the 10 inorganics detected at 05.SW002, and that exceeded background levels if background data were available, aluminum (HQ=6.1), arsenic (HQ=2.2), iron (HQ=2.2), and manganese (HQ=1.0) exceeded toxicological benchmarks for terrestrial plants associated with surface water. Aluminum accounted for 51% to the overall HI for this station and exceeded background by a factor of 1.5. No organic contaminants exceeded a hazard quotient of 1 for this station. These results indicate a potential risk of adverse effects on plants from 05.SW002 surface water, primarily resulting from aluminum.

SW5-5. The overall plant HI for SW5-5 surface water was 32.3. Inorganics accounted for 100% of the HI. Of the 9 inorganics detected at SW5-5, and that exceeded background levels if background data were available, aluminum (HQ=29.0), iron (HQ=1.7), and manganese (HQ=1.1) exceeded toxicological benchmarks for terrestrial plants associated with surface water. Aluminum accounted for 90% to the overall HI for this station and exceeded background by a factor of 17. No organic contaminants exceeded a hazard quotient of 1 for this station. These results indicate a potential risk of adverse effects on plants from SW5-5 surface water, primarily resulting from aluminum.

WOC

5NST. The overall plant HI for 5NST surface water was 13.8. Inorganics accounted for 100% of the HI. Of the 4 inorganics detected at 5NST, and that exceeded background levels if background data were available, only thallium (HQ=13.6) exceeded its toxicological benchmark for terrestrial plants associated with surface water. Thallium accounted for 99% to the overall HI for this station. No background data were available for thallium. No organic contaminants exceeded a hazard quotient of 1 for this station. These results indicate a potential risk of adverse effects on plants from 5NST surface water, primarily resulting from thallium.

SW2-4. The overall plant HI for SW2-4 surface water was 26.8. Inorganics accounted for 100% of the HI. Of the 8 inorganics detected at SW2-4, and that exceeded background levels if background data were available, arsenic (HQ=3.00) manganese (HQ=2.65), and thallium (HQ=20.9)

exceeded toxicological benchmarks for terrestrial plants associated with surface water. Thallium accounted for 78% to the overall HI for this station. No background data were available for arsenic or thallium. No organic contaminants exceeded a hazard quotient of 1 for this station. These results indicate a potential risk of adverse effects on plants from SW6-2 surface water, primarily resulting from thallium.

6.4 SUMMARY OF POTENTIAL RISKS TO PLANTS

Potential nonradionuclide risks to terrestrial plants were identified by comparing a representative soil concentration for each subbasin to conservative ecotoxicological benchmarks for plants. In addition, potential risks to plants exposed to surface water from seeps within the WOC watershed were evaluated by comparing a representative surface water concentration for each sampling location within each subbasin to conservative ecotoxicological benchmarks for plants grown in soil solution. Results of these screening procedures are summarized in Tables 6.2 for soils and 6.3 for surface water for those subbasins and sampling stations where at least one benchmark was exceeded.

For soil, potential risks were identified within 19 subbasins. Hazard quotients were generally low (<3.8) with the exception of mercury, nickel, silver, and zinc at the Intermediate Pond; chromium and zinc at HF-2; chromium, mercury, and zinc at Lower WOC; mercury, silver, and zinc at WOC; mercury at SWSA 5 Trib-1 and Seep B; nickel at SWSA 4 Main; chromium at HRE; and zinc and selenium at Seep A. Subbasins in which no risks to plants were identified were Seep B East, SWSA 5 Drainage D-2, SWSA 5 North WOC, and WAG 7 WOC.

For seeps, potential risks were identified at 71 sampling stations within 19 subbasins. Hazard quotients were generally low (<10) with the exception of thallium at East Seep, HF-2, Intermediate Pond, Lower WOC, Seep A, SWSA 5 Trib-1, SWSA 4 Main, W6MS3, WAG 6 MS-1, West Seep, and WOC; aluminum at HF-2, HRE, Lower WOC, MV Drive, Pit 4 South, Seep A, Seep C, SWSA Trib-1, SWSA 4 Main, West Seep, and SWSA 5 Drainage D-2; arsenic at Pit 4 South, SWSA 4 Main, and West Seep; and nickel at SWSA 4 Main.

6.5 UNCERTAINTIES CONCERNING RISKS TO PLANTS

The following factors create uncertainty in assessing the risk posed to plants by contaminants of potential concern in WOC watershed soils and seeps.

- **Bioavailability of elements in soil.** The extraction methods used may to evaluate soil samples remove from the soil quantities of chemicals greater than are available to plants. The double-acid extraction method 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. Estimates of exposure are confounded by the concentration- and species-dependent synergistic and antagonistic interactions between metals during uptake by roots and inside plants.

- **Bioavailability of elements in surface water and seeps.** Concentrations of contaminants such as aluminum in whole, unfiltered surface water are probably higher then the concentrations bioavailable to plants. In unfiltered water samples (i.e., containing suspended

particles), acidification will bring into solution metals strongly bounded to this particulate matter which would otherwise not be bioavailable to plants.

- **Variable response to toxicants.** Various plant species and plant growth stages tolerate contaminants to different extents. The literature from which benchmarks were derived is not based on experiments using plants found in ecosystems representative of the WOC watershed. It is difficult to extrapolate from largely agricultural species in early growth stages used in most of the published literature to trees and varied growth natural vegetation.

- **Multiple contaminant exposure.** Because of the lack of understanding of complex interactions between contaminants, benchmark levels are necessarily derived from experiments in which plants are exposed to single contaminants. Typical soils in the WOC watershed expose plants to multiple contaminants, the effects of which may not be adequately accounted for by literature derived, single-contaminant benchmarks.

- **Lack of benchmarks for some metals and most organic compounds.** For a variety of organic and inorganic contaminants, appropriate benchmark values are not available since little research has focused on phytotoxic effects from these compounds. Thus, it is not possible to assess the risk to plant growth posed by some of the analytes found in WOC soils and surface water.

- **Chemical speciation.** The analytical techniques did not generally differentiate among species of chemicals present in soils and surface water which have variable toxicity to plants. Toxicity benchmarks for metals are often derived from studies with a single species of a contaminant. For example, the analytical data did not specify the valence state of the chromium. Chromium (VI) is more toxic and bioavailable than chromium (III) (Smith et al. 1989, cited in Will and Suter 1995b), but in most soils chromium (VI) is likely to be reduced to chromium (III) (Bartlett and James 1979, cited in Will and Suter 1995b). However, the toxicological benchmark used to estimate effects of chromium is based on chromium (VI) studies. The use of the benchmark for the more toxic and available form of a contaminant when exposures may be predominantly from a less available or less toxic form may lead to overestimation of the risks of adverse effects.

Table 6.1. Results of single contaminant screening for plants exposed to surface water seeps in the White Oak Creek watershed. (Concentrations in mg/l)

Subasin	Station	Analyte	Detection Frequency	UCL95	Maximum Detected Concentration	Background Quotient	Soil Solution Benchmark	Hazard Quotient	Hazard Index	Percent Contribution
EAST SEEP	SW7-3	AL	8/12	4.33E-01	7.75E-01	1.28	2.00E-01	3.88E+00		33.03%
EAST SEEP	SW7-3	AS	4/10	4.02E-03	4.20E-03		1.00E-03	4.20E+00		35.75%
EAST SEEP	SW7-3	B	4/10	1.10E-01	1.78E-01		1.00E+00	1.78E-01		1.52%
EAST SEEP	SW7-3	BE	2/10	6.36E-04	5.00E-04		5.00E-01	1.00E-03		0.01%
EAST SEEP	SW7-3	CD	1/8	1.92E-03	6.00E-05		1.00E-01	6.00E-04		0.01%
EAST SEEP	SW7-3	CO	7/12	1.37E-02	2.16E-02		6.00E-02	3.60E-01		3.06%
EAST SEEP	SW7-3	CR	11/11	6.55E-02	9.13E-02		5.00E-02	1.83E+00		15.58%
EAST SEEP	SW7-3	CU	7/11	6.59E-03	8.30E-03		5.00E-02	1.66E-01		1.41%
EAST SEEP	SW7-3	FL	13/14	3.28E+00	4.01E+00		5.00E+00	8.02E-01		6.83%
EAST SEEP	SW7-3	HG	2/10	2.23E-04	4.30E-04		5.00E-03	8.60E-02		0.73%
EAST SEEP	SW7-3	MO	4/10	1.47E-02	1.67E-02		5.00E-01	3.34E-02		0.28%
EAST SEEP	SW7-3	NI	7/11	2.42E-02	3.28E-02		5.00E-01	6.56E-02		0.56%
EAST SEEP	SW7-3	SE	3/10	3.68E-03	4.00E-03		7.00E-01	5.71E-03		0.05%
EAST SEEP	SW7-3	V	3/10	1.04E-02	2.78E-02		2.00E-01	1.39E-01	1.17E+01	1.18%
EAST SEEP	SW7-4	B	1/2	3.65E-01	1.07E-01		1.00E+00	1.07E-01		0.64%
EAST SEEP	SW7-4	BE	1/2	2.33E-03	5.00E-04		5.00E-01	1.00E-03		0.01%
EAST SEEP	SW7-4	FL	1/3	7.18E-01	1.60E-01		5.00E+00	3.20E-02		0.19%
EAST SEEP	SW7-4	MN	2/2	2.68E+01	7.40E+00	36.00	4.00E+00	1.85E+00		11.08%
EAST SEEP	SW7-4	NI	1/3	5.48E-02	4.30E-02		5.00E-01	8.60E-02		0.51%
EAST SEEP	SW7-4	TL	1/3	3.73E-01	2.90E-01		2.00E-02	1.45E+01		86.83%
EAST SEEP	SW7-4	V	1/2	7.74E-02	2.48E-02		2.00E-01	1.24E-01	1.67E+01	0.74%
EAST SEEP	SW7-7	B	1/2	4.67E-01	1.35E-01		1.00E+00	1.35E-01		1.57%
EAST SEEP	SW7-7	BE	1/4	1.15E-03	2.00E-04		5.00E-01	4.00E-04		0.00%
EAST SEEP	SW7-7	FL	1/3	6.92E-01	2.00E-01		5.00E+00	4.00E-02		0.47%
EAST SEEP	SW7-7	MN	3/3	9.42E-01	7.57E-01	3.68	4.00E+00	1.89E-01		2.20%
EAST SEEP	SW7-7	NI	3/3	5.68E-02	4.60E-02		5.00E-01	9.20E-02		1.07%
EAST SEEP	SW7-7	TL	3/5	1.51E-01	1.61E-01		2.00E-02	8.05E+00		93.86%
EAST SEEP	SW7-7	V	2/4	1.49E-02	1.41E-02		2.00E-01	7.05E-02	8.58E+00	0.82%
EAST SEEP	SW7-8	AL	1/3	5.34E-01	4.12E-01	1.22	2.00E-01	2.06E+00		96.70%
EAST SEEP	SW7-8	BE	1/3	6.18E-04	2.00E-04		5.00E-01	4.00E-04		0.02%
EAST SEEP	SW7-8	V	1/2	4.19E-02	1.40E-02		2.00E-01	7.00E-02	2.13E+00	3.29%
HF-2	05.SW005	AL	10/17	6.10E+00	4.04E+01	18.00	2.00E-01	2.02E+02		90.37%
HF-2	05.SW005	AS	1/9	2.57E-03	3.10E-03		1.00E-03	3.10E+00		1.39%
HF-2	05.SW005	BE	1/10	7.56E-04	2.40E-03		5.00E-01	4.80E-03		0.00%
HF-2	05.SW005	CD	2/8	1.68E-03	1.80E-03		1.00E-01	1.80E-02		0.01%
HF-2	05.SW005	CO	4/10	1.86E-02	4.11E-02		6.00E-02	6.85E-01		0.31%
HF-2	05.SW005	CR	6/12	4.30E-02	1.43E-01		5.00E-02	2.86E+00		1.28%
HF-2	05.SW005	CU	3/17	1.73E-02	1.20E-01		5.00E-02	2.40E+00		1.07%
HF-2	05.SW005	FE	10/16	4.18E+00	5.39E+01	5.19	1.00E+01	5.39E+00		2.41%

Table 6.1. (continued)

Subasin	Station	Analyte	Detection Frequency	UCL95	Maximum Detected Concentration	Background Quotient	Soil Solution Benchmark	Hazard Quotient	Hazard Index	Percent Contribution
HF-2	05.SW005	FL	12/12	9.56E-01	1.80E+00		5.00E+00	3.60E-01		0.16%
HF-2	05.SW005	LI	4/4	2.00E-01	2.00E-01		3.00E+00	6.67E-02		0.03%
HF-2	05.SW005	MN	14/16	7.23E-01	7.20E+00	3.52	4.00E+00	1.80E+00		0.81%
HF-2	05.SW005	NAPHTHALENE	5/7	1.04E-02	1.00E-02		1.00E+01	1.00E-03		0.00%
HF-2	05.SW005	NI	12/16	7.78E-02	6.23E-01		5.00E-01	1.25E+00		0.56%
HF-2	05.SW005	PB	8/12	1.92E-02	6.60E-02	1.37	2.00E-02	3.30E+00		1.48%
HF-2	05.SW005	TETRACHLOROETHENE	5/11	8.70E-03	1.00E-02		1.00E+01	1.00E-03		0.00%
HF-2	05.SW005	TOLUENE	5/11	8.70E-03	1.00E-02		1.00E+01	1.00E-03		0.00%
HF-2	05.SW005	V	5/10	2.72E-02	5.64E-02		2.00E-01	2.82E-01		0.13%
HF-2	05.SW005	XYLENE (TOTAL)	5/11	8.70E-03	1.00E-02		1.00E+02	1.00E-04	2.24E+02	0.00%
HRE	05.SW004	AL	6/14	1.40E+00	1.77E+01	4.13	2.00E-01	8.85E+01		90.14%
HRE	05.SW004	AS	1/6	2.43E-03	3.60E-03		1.00E-03	3.60E+00		3.67%
HRE	05.SW004	CO	2/6	1.03E-02	1.86E-02		6.00E-02	3.10E-01		0.32%
HRE	05.SW004	CR	3/7	2.48E-02	5.78E-02		5.00E-02	1.16E+00		1.18%
HRE	05.SW004	FE	6/14	1.78E+00	2.85E+01	2.21	1.00E+01	2.85E+00		2.90%
HRE	05.SW004	FL	8/8	5.12E-01	6.20E-01		5.00E+00	1.24E-01		0.13%
HRE	05.SW004	LI	3/3	2.00E-01	2.00E-01		3.00E+00	6.67E-02		0.07%
HRE	05.SW004	MN	12/12	8.34E-01	5.52E+00	4.05	4.00E+00	1.38E+00		1.41%
HRE	05.SW004	NAPHTHALENE	3/5	1.06E-02	1.00E-02		1.00E+01	1.00E-03		0.00%
HRE	05.SW004	NI	3/7	1.42E-02	2.54E-02		5.00E-01	5.08E-02		0.05%
HRE	05.SW004	SE	1/5	2.31E-03	2.70E-03		7.00E-01	3.86E-03		0.00%
HRE	05.SW004	TETRACHLOROETHENE	3/9	8.22E-03	1.00E-02		1.00E+01	1.00E-03		0.00%
HRE	05.SW004	TOLUENE	3/9	8.22E-03	1.00E-02		1.00E+01	1.00E-03		0.00%
HRE	05.SW004	V	1/5	1.72E-02	2.62E-02		2.00E-01	1.31E-01		0.13%
HRE	05.SW004	XYLENE (TOTAL)	3/9	8.22E-03	1.00E-02		1.00E+02	1.00E-04	9.82E+01	0.00%
HRE	SW9-1	CU	1/4	5.93E-03	6.70E-03		5.00E-02	1.34E-01		10.06%
HRE	SW9-1	FL	2/3	7.22E+00	5.58E+00		5.00E+00	1.12E+00		84.10%
HRE	SW9-1	MN	3/5	2.85E-01	3.11E-01	1.39	4.00E+00	7.78E-02	1.33E+00	5.84%
HRE	SW9-2	AL	2/3	1.87E+00	1.46E+00	4.31	2.00E-01	7.30E+00		79.07%
HRE	SW9-2	CU	2/3	1.40E-02	9.20E-03		5.00E-02	1.84E-01		1.99%
HRE	SW9-2	FE	3/3	4.14E+00	3.37E+00	4.18	1.00E+01	3.37E-01		3.65%
HRE	SW9-2	FL	2/3	1.19E+00	7.30E-01		5.00E+00	1.46E-01		1.58%
HRE	SW9-2	MN	3/3	2.71E+00	2.18E+00	10.60	4.00E+00	5.45E-01		5.90%
HRE	SW9-2	ZN	3/3	3.68E-01	2.88E-01	1.34	4.00E-01	7.20E-01	9.23E+00	7.80%
Intermediate Po	SW2-2	B	1/2	6.67E-02	2.50E-02		1.00E+00	2.50E-02		4.05%
Intermediate Po	SW2-2	BE	1/2	8.66E-04	6.00E-04		5.00E-01	1.20E-03		0.19%
Intermediate Po	SW2-2	CO	1/2	1.94E-02	8.20E-03		6.00E-02	1.37E-01		22.20%
Intermediate Po	SW2-2	FL	1/1		2.80E-01		5.00E+00	5.60E-02		9.07%
Intermediate Po	SW2-2	MN	2/2	1.49E+00	9.86E-01	4.79	4.00E+00	2.47E-01		40.02%

Table 6.1. (continued)

Subasin	Station	Analyte	Detection Frequency	UCL95	Maximum Detected Concentration	Background Quotient	Soil Solution Benchmark	Hazard Quotient	Hazard Index	Percent Contribution
Intermediate Po	SW2-2	V	1/2	1.01E-01	3.02E-02		2.00E-01	1.51E-01	6.17E-01	24.47%
Intermediate Po	**WAG4 T2A**	AL	7/8	6.43E-01	1.00E+00	1.90	2.00E-01	5.00E+00		74.06%
Intermediate Po	**WAG4 T2A**	B	7/9	1.72E-01	2.06E-01		1.00E+00	2.06E-01		3.05%
Intermediate Po	**WAG4 T2A**	BE	2/7	5.07E-04	5.00E-04		5.00E-01	1.00E-03		0.01%
Intermediate Po	**WAG4 T2A**	CD	1/6	1.88E-03	9.00E-05		1.00E-01	9.00E-04		0.01%
Intermediate Po	**WAG4 T2A**	CR	1/7	1.31E-02	3.46E-02		5.00E-02	6.92E-01		10.25%
Intermediate Po	**WAG4 T2A**	CU	2/7	4.66E-03	5.50E-03		5.00E-02	1.10E-01		1.63%
Intermediate Po	**WAG4 T2A**	FE	7/8	1.02E+00	1.43E+00	1.26	1.00E+01	1.43E-01		2.12%
Intermediate Po	**WAG4 T2A**	FL	8/8	1.25E+00	1.47E+00		5.00E+00	2.94E-01		4.35%
Intermediate Po	**WAG4 T2A**	MN	8/9	2.10E-01	4.10E-01	1.02	4.00E+00	1.03E-01		1.53%
Intermediate Po	**WAG4 T2A**	NI	5/7	3.59E-02	3.71E-02		5.00E-01	7.42E-02		1.10%
Intermediate Po	**WAG4 T2A**	TETRACHLOROETHENE	3/3	3.00E-04	3.00E-04		1.00E+01	3.00E-05		0.00%
Intermediate Po	**WAG4 T2A**	V	2/8	2.61E-02	2.54E-02		2.00E-01	1.27E-01	6.75E+00	1.88%
Intermediate Po	WCTRIB-3	B	2/2	2.04E-01	1.99E-01		1.00E+00	1.99E-01		24.86%
Intermediate Po	WCTRIB-3	BE	1/2	8.66E-04	6.00E-04		5.00E-01	1.20E-03		0.15%
Intermediate Po	WCTRIB-3	FL	2/2	1.55E+00	1.10E+00		5.00E+00	2.20E-01		27.49%
Intermediate Po	WCTRIB-3	MN	2/2	1.63E+00	8.72E-01	4.24	4.00E+00	2.18E-01		27.24%
Intermediate Po	WCTRIB-3	NI	1/2	2.72E-02	1.11E-02		5.00E-01	2.22E-02		2.77%
Intermediate Po	WCTRIB-3	V	1/2	9.27E-02	2.79E-02		2.00E-01	1.40E-01	8.00E-01	17.49%
Intermediate Po	**WCTRIB-4**	B	1/2	2.48E-01	7.50E-02		1.00E+00	7.50E-02		0.53%
Intermediate Po	**WCTRIB-4**	BE	1/3	1.32E-03	5.00E-04		5.00E-01	1.00E-03		0.01%
Intermediate Po	**WCTRIB-4**	FL	1/3	6.41E-01	2.80E-01		5.00E+00	5.60E-02		0.40%
Intermediate Po	**WCTRIB-4**	MN	2/2	2.40E+00	6.79E-01	3.30	4.00E+00	1.70E-01		1.21%
Intermediate Po	**WCTRIB-4**	TL	2/3	4.33E-01	2.72E-01		2.00E-02	1.36E+01		96.83%
Intermediate Po	**WCTRIB-4**	V	1/3	3.58E-02	2.86E-02		2.00E-01	1.43E-01	1.40E+01	1.02%
Lower WOC	05.SP00D	FL	1/1		2.00E-01		5.00E+00	4.00E-02		36.43%
Lower WOC	05.SP00D	LI	1/1		2.00E-01		3.00E+00	6.67E-02		60.75%
Lower WOC	05.SP00D	NAPHTHALENE	1/1		1.00E-02		1.00E+01	1.00E-03		0.91%
Lower WOC	05.SP00D	TETRACHLOROETHENE	1/1		1.00E-02		1.00E+01	1.00E-03		0.91%
Lower WOC	05.SP00D	TOLUENE	1/1		1.00E-02		1.00E+01	1.00E-03		0.91%
Lower WOC	05.SP00D	XYLENE (TOTAL)	1/1		1.00E-02		1.00E+02	1.00E-04	1.10E-01	0.09%
Lower WOC	**05.SW006**	AL	5/17	5.02E-01	3.50E+00	1.48	2.00E-01	1.75E+01		94.44%
Lower WOC	**05.SW006**	BE	1/14	2.66E-04	7.30E-04		5.00E-01	1.46E-03		0.01%
Lower WOC	**05.SW006**	CO	2/8	3.03E-03	3.10E-03		6.00E-02	5.17E-02		0.28%
Lower WOC	**05.SW006**	CR	4/10	8.59E-03	1.21E-02		5.00E-02	2.42E-01		1.31%
Lower WOC	**05.SW006**	CU	1/14	3.98E-03	8.20E-03		5.00E-02	1.64E-01		0.89%
Lower WOC	**05.SW006**	FL	8/8	1.10E+00	1.35E+00		5.00E+00	2.70E-01		1.46%
Lower WOC	**05.SW006**	LI	3/3	2.00E-01	2.00E-01		3.00E+00	6.67E-02		0.36%
Lower WOC	**05.SW006**	MN	8/16	2.26E-01	8.79E-01	1.10	4.00E+00	2.20E-01		1.19%

Table 6.1. (continued)

Subasin	Station	Analyte	Detection Frequency	UCL95	Maximum Detected Concentration	Background Quotient	Soil Solution Benchmark	Hazard Quotient	Hazard Index	Percent Contribution
Lower WOC	05.SW006	NAPHTHALENE	4/6	1.05E-02	1.00E-02		1.00E+01	1.00E-03		0.01%
Lower WOC	05.SW006	NI	3/9	3.87E-03	5.40E-03		5.00E-01	1.08E-02		0.06%
Lower WOC	05.SW006	TETRACHLOROETHENE	4/10	8.50E-03	1.00E-02		1.00E+01	1.00E-03		0.01%
Lower WOC	05.SW006	TOLUENE	4/10	8.50E-03	1.00E-02		1.00E+01	1.00E-03		0.01%
Lower WOC	05.SW006	XYLENE (TOTAL)	4/10	8.50E-03	1.00E-02		1.00E+02	1.00E-04	1.85E+01	0.00%
Lower WOC	MBTRIB-3	B	2/4	7.06E-02	6.14E-02		1.00E+00	6.14E-02		0.37%
Lower WOC	MBTRIB-3	MN	3/3	5.56E-01	5.05E-01	2.46	4.00E+00	1.26E-01		0.75%
Lower WOC	MBTRIB-3	TL	1/3	4.33E-01	3.32E-01		2.00E-02	1.66E+01	1.68E+01	98.88%
Lower WOC	SW2-1	B	2/2	5.70E-02	2.96E-02		1.00E+00	2.96E-02		2.30%
Lower WOC	SW2-1	BE	1/2	7.66E-04	4.00E-04		5.00E-01	8.00E-04		0.06%
Lower WOC	SW2-1	FE	2/2	1.49E+01	5.75E+00	7.13	1.00E+01	5.75E-01		44.68%
Lower WOC	SW2-1	FL	1/1		2.00E-01		5.00E+00	4.00E-02		3.11%
Lower WOC	SW2-1	HG	1/3	3.37E-04	2.70E-04		5.00E-03	5.40E-02		4.20%
Lower WOC	SW2-1	MN	2/2	4.71E+00	2.01E+00	9.77	4.00E+00	5.03E-01		39.09%
Lower WOC	SW2-1	V	1/2	5.25E-02	1.69E-02		2.00E-01	8.45E-02	1.29E+00	6.57%
Lower WOC	SW2-5	B	6/11	2.68E-01	3.36E-01		1.00E+00	3.36E-01		1.24%
Lower WOC	SW2-5	BE	2/11	6.76E-04	1.70E-04		5.00E-01	3.40E-04		0.00%
Lower WOC	SW2-5	CD	1/8	3.02E-03	5.00E-05		1.00E-01	5.00E-04		0.00%
Lower WOC	SW2-5	CO	6/11	6.18E-03	8.60E-03		6.00E-02	1.43E-01		0.53%
Lower WOC	SW2-5	CR	2/11	4.87E-03	6.30E-03		5.00E-02	1.26E-01		0.46%
Lower WOC	SW2-5	CU	4/11	4.14E-03	4.10E-03		5.00E-02	8.20E-02		0.30%
Lower WOC	SW2-5	MN	11/11	1.24E+00	3.06E+00	6.05	4.00E+00	7.65E-01		2.82%
Lower WOC	SW2-5	NI	6/12	1.47E-02	1.70E-02		5.00E-01	3.40E-02		0.13%
Lower WOC	SW2-5	TL	1/8	3.10E-01	5.12E-01		2.00E-02	2.56E+01		94.47%
Lower WOC	SW2-5	V	1/11	4.15E-03	2.60E-03		2.00E-01	1.30E-02	2.71E+01	0.05%
Lower WOC	SW2-6	AS	1/2	2.83E-03	1.00E-03		1.00E-03	1.00E+00		38.38%
Lower WOC	SW2-6	B	2/3	1.39E-01	1.18E-01		1.00E+00	1.18E-01		4.53%
Lower WOC	SW2-6	BE	1/3	7.11E-04	1.70E-04		5.00E-01	3.40E-04		0.01%
Lower WOC	SW2-6	CO	1/3	6.50E-03	4.60E-03		6.00E-02	7.67E-02		2.94%
Lower WOC	SW2-6	CR	1/3	1.00E-02	8.20E-03		5.00E-02	1.64E-01		6.29%
Lower WOC	SW2-6	CU	1/3	2.79E-03	1.60E-03		5.00E-02	3.20E-02		1.23%
Lower WOC	SW2-6	FE	3/3	1.11E+01	8.52E+00	10.60	1.00E+01	8.52E-01		32.70%
Lower WOC	SW2-6	MN	3/3	1.56E+00	1.36E+00	6.61	4.00E+00	3.40E-01		13.05%
Lower WOC	SW2-6	NI	2/3	1.29E-02	1.14E-02		5.00E-01	2.28E-02	2.61E+00	0.87%
Lower WOC	SW2-7	AS	1/3	1.56E-03	1.40E-03		1.00E-03	1.40E+00		35.93%
Lower WOC	SW2-7	B	2/4	1.54E-01	1.41E-01		1.00E+00	1.41E-01		3.62%
Lower WOC	SW2-7	BE	1/4	5.71E-04	2.90E-04		5.00E-01	5.80E-04		0.01%
Lower WOC	SW2-7	CR	1/4	5.32E-03	5.90E-03		5.00E-02	1.18E-01		3.03%
Lower WOC	SW2-7	CU	1/4	2.49E-03	2.30E-03		5.00E-02	4.60E-02		1.18%

Table 6.1. (continued)

Subasin	Station	Analyte	Detection Frequency	UCL95	Maximum Detected Concentration	Background Quotient	Soil Solution Benchmark	Hazard Quotient	Hazard Index	Percent Contribution
Lower WOC	SW2-7	FE	4/4	1.51E+01	1.70E+01	18.80	1.00E+01	1.70E+00		43.63%
Lower WOC	SW2-7	MN	4/4	1.97E+00	1.90E+00	9.24	4.00E+00	4.75E-01		12.19%
Lower WOC	SW2-7	NI	1/4	7.53E-03	7.70E-03		5.00E-01	1.54E-02	3.90E+00	0.40%
Lower WOC	SW6-1	BE	1/3	1.26E-03	2.00E-04		5.00E-01	4.00E-04		0.00%
Lower WOC	SW6-1	FE	2/2	4.47E+01	1.47E+01	18.20	1.00E+01	1.47E+00		5.92%
Lower WOC	SW6-1	FL	1/3	6.92E-01	2.00E-01		5.00E+00	4.00E-02		0.16%
Lower WOC	SW6-1	MN	2/2	4.17E+00	3.00E+00	14.60	4.00E+00	7.50E-01		3.02%
Lower WOC	SW6-1	TL	1/3	5.82E-01	4.50E-01		2.00E-02	2.25E+01		90.67%
Lower WOC	SW6-1	V	1/2	2.66E-02	1.09E-02		2.00E-01	5.45E-02	2.48E+01	0.22%
Lower WOC	SW7-5	AG	1/12	3.12E-03	3.00E-03		1.00E-01	3.00E-02		0.12%
Lower WOC	SW7-5	AL	11/13	2.06E+00	3.79E+00	6.07	2.00E-01	1.90E+01		74.63%
Lower WOC	SW7-5	AS	1/10	6.92E-02	1.00E-03		1.00E-03	1.00E+00		3.93%
Lower WOC	SW7-5	B	5/12	6.20E-02	7.72E-02		1.00E+00	7.72E-02		0.30%
Lower WOC	SW7-5	BE	4/12	9.49E-04	1.10E-03		5.00E-01	2.20E-03		0.01%
Lower WOC	SW7-5	CD	2/10	1.87E-03	1.00E-03		1.00E-01	1.00E-02		0.04%
Lower WOC	SW7-5	CO	6/12	1.37E-02	2.46E-02		6.00E-02	4.10E-01		1.61%
Lower WOC	SW7-5	CR	3/12	6.10E-03	8.40E-03		5.00E-02	1.68E-01		0.66%
Lower WOC	SW7-5	CU	6/13	1.04E-02	5.20E-02		5.00E-02	1.04E+00		4.09%
Lower WOC	SW7-5	FE	11/13	2.17E+00	3.81E+00	2.69	1.00E+01	3.81E-01		1.50%
Lower WOC	SW7-5	FL	2/10	3.11E-01	4.11E-01		5.00E+00	8.22E-02		0.32%
Lower WOC	SW7-5	LI	1/2	4.40E-02	4.10E-03		3.00E+00	1.37E-03		0.01%
Lower WOC	SW7-5	MO	1/11	8.13E-03	3.00E-03		5.00E-01	6.00E-03		0.02%
Lower WOC	SW7-5	NI	6/13	2.47E-02	5.52E-02		5.00E-01	1.10E-01		0.43%
Lower WOC	SW7-5	SE	1/10	7.27E-02	1.00E-03		7.00E-01	1.43E-03		0.01%
Lower WOC	SW7-5	SN	1/3	7.40E-02	6.00E-02		1.00E+02	6.00E-04		0.00%
Lower WOC	SW7-5	TL	1/11	1.58E+00	6.00E-02		2.00E-02	3.00E+00		11.78%
Lower WOC	SW7-5	V	4/12	1.13E-02	2.75E-02		2.00E-01	1.38E-01	2.55E+01	0.54%
Lower WOC	WCTRIB-1	AL	1/6	4.97E-01	9.57E-01	1.47	2.00E-01	4.79E+00		25.72%
Lower WOC	WCTRIB-1	BE	1/5	9.61E-04	5.00E-04		5.00E-01	1.00E-03		0.01%
Lower WOC	WCTRIB-1	MN	4/4	1.11E+00	1.26E+00	5.37	4.00E+00	3.15E-01		1.69%
Lower WOC	WCTRIB-1	TL	2/6	2.06E-01	2.68E-01		2.00E-02	1.34E+01		71.95%
Lower WOC	WCTRIB-1	V	1/5	1.64E-02	2.37E-02		2.00E-01	1.19E-01	1.86E+01	0.64%
Lower WOC	WSTRIB-1	B	1/2	1.93E-01	6.00E-02		1.00E+00	6.00E-02		0.34%
Lower WOC	WSTRIB-1	BE	1/2	2.86E-03	3.00E-04		5.00E-01	6.00E-04		0.00%
Lower WOC	WSTRIB-1	MN	2/2	1.31E+00	4.43E-01	2.15	4.00E+00	1.11E-01		0.63%
Lower WOC	WSTRIB-1	TL	1/3	4.45E-01	3.45E-01		2.00E-02	1.73E+01		98.67%
Lower WOC	WSTRIB-1	V	1/2	3.17E-02	1.23E-02		2.00E-01	6.15E-02	1.75E+01	0.35%
MB-15	MBTRIB-2A	CU	1/1		1.57E-02		5.00E-02	3.14E-01		47.87%
MB-15	MBTRIB-2A	FL	1/1		1.71E+00		5.00E+00	3.42E-01	6.56E-01	52.13%

Table 6.1. (continued)

Subasin	Station	Analyte	Detection Frequency	UCL95	Maximum Detected Concentration	Background Quotient	Soil Solution Benchmark	Hazard Quotient	Hazard Index	Percent Contribution
MVDrive	5NNT	AL	1/4	2.01E+00	2.39E+00	5.92	2.00E-01	1.20E+01		69.81%
MVDrive	5NNT	AS	1/4	4.35E-03	1.00E-03		1.00E-03	1.00E+00		5.82%
MVDrive	5NNT	BE	2/4	1.20E-03	1.00E-03		5.00E-01	2.00E-03		0.01%
MVDrive	5NNT	CD	1/3	3.22E-03	1.00E-03		1.00E-01	1.00E-02		0.06%
MVDrive	5NNT	CO	1/4	5.34E-03	3.00E-03		6.00E-02	5.00E-02		0.29%
MVDrive	5NNT	CR	1/4	7.48E-03	7.60E-03		5.00E-02	1.52E-01		0.88%
MVDrive	5NNT	CU	1/4	6.40E-03	5.10E-03		5.00E-02	1.02E-01		0.59%
MVDrive	5NNT	FE	1/4	2.49E+00	2.97E+00	3.09	1.00E+01	2.97E-01		1.73%
MVDrive	5NNT	FL	2/4	5.24E-01	4.00E-01		5.00E+00	8.00E-02		0.47%
MVDrive	5NNT	HG	1/3	1.32E-04	1.00E-04		5.00E-03	2.00E-02		0.12%
MVDrive	5NNT	LI	1/1		3.40E-03		3.00E+00	1.13E-03		0.01%
MVDrive	5NNT	MN	3/3	3.37E-01	2.55E-01	1.24	4.00E+00	6.38E-02		0.37%
MVDrive	5NNT	MO	1/4	1.12E-02	3.00E-03		5.00E-01	6.00E-03		0.03%
MVDrive	5NNT	NI	1/4	1.10E-02	6.60E-03		5.00E-01	1.32E-02		0.08%
MVDrive	5NNT	SE	1/4	2.26E-03	1.00E-03		7.00E-01	1.43E-03		0.01%
MVDrive	5NNT	SN	1/1		7.00E-03		1.00E+02	7.00E-05		0.00%
MVDrive	5NNT	TL	1/4	8.98E-02	6.54E-02		2.00E-02	3.27E+00		19.02%
MVDrive	5NNT	V	1/4	2.10E-02	2.42E-02		2.00E-01	1.21E-01	1.72E+01	0.70%
PIT4/south	EAST SEEP	AG	1/14	3.22E-03	3.00E-03		1.00E-01	3.00E-02		0.02%
PIT4/south	EAST SEEP	AL	32/36	6.79E+00	2.99E+01	20.00	2.00E-01	1.50E+02		76.32%
PIT4/south	EAST SEEP	AS	5/17	1.94E-02	2.82E-02		1.00E-03	2.82E+01		14.35%
PIT4/south	EAST SEEP	B	6/33	3.16E-02	1.99E+00		1.00E+00	1.99E+00		1.01%
PIT4/south	EAST SEEP	BE	3/26	5.01E-04	1.00E-03		5.00E-01	2.00E-03		0.00%
PIT4/south	EAST SEEP	CD	3/18	1.43E-03	2.70E-03		1.00E-01	2.70E-02		0.01%
PIT4/south	EAST SEEP	CO	24/34	1.10E-02	2.70E-02		6.00E-02	4.50E-01		0.23%
PIT4/south	EAST SEEP	CR	21/30	2.05E-02	4.82E-02		5.00E-02	9.64E-01		0.49%
PIT4/south	EAST SEEP	CU	25/35	1.30E-02	3.07E-02		5.00E-02	6.14E-01		0.31%
PIT4/south	EAST SEEP	FE	31/36	7.33E+00	3.64E+01	9.09	1.00E+01	3.64E+00		1.85%
PIT4/south	EAST SEEP	FL	34/35	1.22E+00	1.05E+01		5.00E+00	2.10E+00		1.07%
PIT4/south	EAST SEEP	LI	1/1		3.50E-03		3.00E+00	1.17E-03		0.00%
PIT4/south	EAST SEEP	MN	34/35	6.05E-01	1.66E+00	2.94	4.00E+00	4.15E-01		0.21%
PIT4/south	EAST SEEP	MO	4/20	6.55E-03	1.48E-02		5.00E-01	2.96E-02		0.02%
PIT4/south	EAST SEEP	NI	19/30	2.89E-02	5.38E-02		5.00E-01	1.08E-01		0.05%
PIT4/south	EAST SEEP	SE	3/16	2.89E-02	6.36E-02		7.00E-01	9.09E-02		0.05%
PIT4/south	EAST SEEP	SN	1/2	1.82E-01	6.00E-02		1.00E+02	6.00E-04		0.00%
PIT4/south	EAST SEEP	TL	2/12	7.64E-02	1.55E-01		2.00E-02	7.75E+00		3.94%
PIT4/south	EAST SEEP	V	2/25	1.24E-02	2.62E-02		2.00E-01	1.31E-01	1.97E+02	0.07%
SWSA 5 Seep A	05.SP009	AL	2/2	4.09E+00	1.35E+00	3.98	2.00E-01	6.75E+00		70.09%
SWSA 5 Seep A	05.SP009	FE	2/2	1.15E+01	6.58E+00	8.16	1.00E+01	6.58E-01		6.83%

Table 6.1. (continued)

Subasin	Station	Analyte	Detection Frequency	UCL95	Maximum Detected Concentration	Background Quotient	Soil Solution Benchmark	Hazard Quotient	Hazard Index	Percent Contribution
SWSA 5 Seep A	05.SP009	FL	1/1		1.50E-01		5.00E+00	3.00E-02		0.31%
SWSA 5 Seep A	05.SP009	MN	2/2	1.04E+01	8.75E+00	42.50	4.00E+00	2.19E+00		22.74%
SWSA 5 Seep A	05.SP009	NAPHTHALENE	2/3	1.32E-02	1.00E-02		1.00E+01	1.00E-03		0.01%
SWSA 5 Seep A	05.SP009	TETRACHLOROETHENE	2/3	1.32E-02	1.00E-02		1.00E+01	1.00E-03		0.01%
SWSA 5 Seep A	05.SP009	TOLUENE	2/2	1.00E-02	1.00E-02		1.00E+01	1.00E-03		0.01%
SWSA 5 Seep A	05.SP009	XYLENE (TOTAL)	2/3	1.32E-02	1.00E-02		1.00E+02	1.00E-04	9.63E+00	0.00%
SWSA 5 Seep A	05.SP010	NAPHTHALENE	1/1		1.00E-02		1.00E+01	1.00E-03		32.26%
SWSA 5 Seep A	05.SP010	TETRACHLOROETHENE	1/1		1.00E-02		1.00E+01	1.00E-03		32.26%
SWSA 5 Seep A	05.SP010	TOLUENE	1/1		1.00E-02		1.00E+01	1.00E-03		32.26%
SWSA 5 Seep A	05.SP010	XYLENE (TOTAL)	1/1		1.00E-02		1.00E+02	1.00E-04	3.10E-03	3.23%
SWSA 5 Seep A	05.SP016	AL	1/2	4.48E+01	1.23E+01	36.30	2.00E-01	6.15E+01		96.25%
SWSA 5 Seep A	05.SP016	CO	1/2	3.15E-02	1.00E-02		6.00E-02	1.67E-01		0.26%
SWSA 5 Seep A	05.SP016	CR	1/2	5.52E-02	1.72E-02		5.00E-02	3.44E-01		0.54%
SWSA 5 Seep A	05.SP016	CU	1/2	1.31E-02	5.10E-03		5.00E-02	1.02E-01		0.16%
SWSA 5 Seep A	05.SP016	FE	2/2	4.99E+01	1.38E+01	17.10	1.00E+01	1.38E+00		2.16%
SWSA 5 Seep A	05.SP016	FL	2/2	7.46E-02	6.40E-02		5.00E+00	1.28E-02		0.02%
SWSA 5 Seep A	05.SP016	MN	2/2	2.76E+00	1.02E+00	4.96	4.00E+00	2.55E-01		0.40%
SWSA 5 Seep A	05.SP016	NAPHTHALENE	2/3	1.32E-02	1.00E-02		1.00E+01	1.00E-03		0.00%
SWSA 5 Seep A	05.SP016	NI	1/2	6.21E-02	1.92E-02		5.00E-01	3.84E-02		0.06%
SWSA 5 Seep A	05.SP016	TETRACHLOROETHENE	2/4	1.09E-02	1.00E-02		1.00E+01	1.00E-03		0.00%
SWSA 5 Seep A	05.SP016	TOLUENE	2/4	1.09E-02	1.00E-02		1.00E+01	1.00E-03		0.00%
SWSA 5 Seep A	05.SP016	V	1/2	6.58E-02	1.92E-02		2.00E-01	9.60E-02		0.15%
SWSA 5 Seep A	05.SP016	XYLENE (TOTAL)	2/4	1.09E-02	1.00E-02		1.00E+02	1.00E-04	6.39E+01	0.00%
SWSA 5 Seep A	05.SP017	AL	1/2	1.34E+00	3.79E-01	1.12	2.00E-01	1.90E+00		19.23%
SWSA 5 Seep A	05.SP017	AS	2/2	6.52E-03	3.60E-03		1.00E-03	3.60E+00		36.44%
SWSA 5 Seep A	05.SP017	FE	2/2	3.29E+01	1.72E+01	21.30	1.00E+01	1.72E+00		17.41%
SWSA 5 Seep A	05.SP017	FL	2/2	1.43E-01	1.30E-01		5.00E+00	2.60E-02		0.26%
SWSA 5 Seep A	05.SP017	HG	3/3	2.41E-04	1.90E-04		5.00E-03	3.80E-02		0.38%
SWSA 5 Seep A	05.SP017	MN	2/2	1.09E+01	1.02E+01	49.60	4.00E+00	2.55E+00		25.81%
SWSA 5 Seep A	05.SP017	NAPHTHALENE	1/2	2.33E-02	1.00E-02		1.00E+01	1.00E-03		0.01%
SWSA 5 Seep A	05.SP017	NI	2/2	2.52E-02	1.24E-02		5.00E-01	2.48E-02		0.25%
SWSA 5 Seep A	05.SP017	TETRACHLOROETHENE	1/3	1.15E-02	1.00E-02		1.00E+01	1.00E-03		0.01%
SWSA 5 Seep A	05.SP017	TOLUENE	1/3	1.15E-02	1.00E-02		1.00E+01	1.00E-03		0.01%
SWSA 5 Seep A	05.SP017	V	1/2	8.05E-03	3.40E-03		2.00E-01	1.70E-02		0.17%
SWSA 5 Seep A	05.SP017	XYLENE (TOTAL)	3/3	1.21E-02	1.00E-02		1.00E+02	1.00E-04	9.88E+00	0.00%
SWSA 5 Seep A	05.SW003	AL	9/15	1.73E+00	8.90E+00	5.10	2.00E-01	4.45E+01		96.13%
SWSA 5 Seep A	05.SW003	BE	1/12	2.84E-04	7.30E-04		5.00E-01	1.46E-03		0.00%
SWSA 5 Seep A	05.SW003	CO	1/8	2.83E-03	6.20E-03		6.00E-02	1.03E-01		0.22%
SWSA 5 Seep A	05.SW003	CR	3/10	5.57E-03	1.06E-02		5.00E-02	2.12E-01		0.46%

Table 6.1. (continued)

Subasin	Station	Analyte	Detection Frequency	UCL95	Maximum Detected Concentration	Background Quotient	Soil Solution Benchmark	Hazard Quotient	Hazard Index	Percent Contribution
SWSA 5 Seep A	05.SW003	FE	6/15	8.33E-01	9.64E+00	1.03	1.00E+01	9.64E-01		2.08%
SWSA 5 Seep A	05.SW003	FL	5/8	3.19E-01	2.00E-01		5.00E+00	4.00E-02		0.09%
SWSA 5 Seep A	05.SW003	LI	5/5	2.00E-01	2.00E-01		3.00E+00	6.67E-02		0.14%
SWSA 5 Seep A	05.SW003	MN	14/14	5.12E-01	1.25E+00	2.49	4.00E+00	3.13E-01		0.68%
SWSA 5 Seep A	05.SW003	NAPHTHALENE	7/10	9.90E-03	1.00E-02		1.00E+01	1.00E-03		0.00%
SWSA 5 Seep A	05.SW003	NI	1/8	4.83E-03	1.14E-02		5.00E-01	2.28E-02		0.05%
SWSA 5 Seep A	05.SW003	SE	1/8	1.91E-03	2.70E-03		7.00E-01	3.86E-03		0.01%
SWSA 5 Seep A	05.SW003	TETRACHLOROETHENE	7/15	8.51E-03	1.00E-02		1.00E+01	1.00E-03		0.00%
SWSA 5 Seep A	05.SW003	TOLUENE	7/15	8.51E-03	1.00E-02		1.00E+01	1.00E-03		0.00%
SWSA 5 Seep A	05.SW003	V	1/8	5.17E-03	1.19E-02		2.00E-01	5.95E-02		0.13%
SWSA 5 Seep A	05.SW003	XYLENE (TOTAL)	7/15	8.51E-03	1.00E-02		1.00E+02	1.00E-04	4.63E+01	0.00%
SWSA 5 Seep A	SW5-6	AL	1/4	1.13E+00	1.35E+00	3.35	2.00E-01	6.75E+00		19.05%
SWSA 5 Seep A	SW5-6	B	2/2	5.43E-01	5.22E-01		1.00E+00	5.22E-01		1.47%
SWSA 5 Seep A	SW5-6	BE	1/4	1.24E-03	3.00E-04		5.00E-01	6.00E-04		0.00%
SWSA 5 Seep A	SW5-6	FE	3/3	8.56E+00	6.58E+00	8.16	1.00E+01	6.58E-01		1.86%
SWSA 5 Seep A	SW5-6	FL	1/4	4.38E-01	1.45E-01		5.00E+00	2.90E-02		0.08%
SWSA 5 Seep A	SW5-6	MN	3/3	1.02E+01	8.13E+00	39.50	4.00E+00	2.03E+00		5.73%
SWSA 5 Seep A	SW5-6	NI	3/4	3.66E-02	3.22E-02		5.00E-01	6.44E-02		0.18%
SWSA 5 Seep A	SW5-6	TL	1/2	1.79E+00	5.05E-01		2.00E-02	2.53E+01		71.42%
SWSA 5 Seep A	SW5-6	TOLUENE	1/1		1.00E-02		1.00E+01	1.00E-03		0.00%
SWSA 5 Seep A	SW5-6	V	1/4	1.24E-02	1.38E-02		2.00E-01	6.90E-02	3.54E+01	0.19%
SWSA 5 Seep A	SW5-7	AS	2/3	5.91E-03	3.00E-03		1.00E-03	3.00E+00		44.64%
SWSA 5 Seep A	SW5-7	B	3/3	6.32E-01	5.49E-01		1.00E+00	5.49E-01		8.17%
SWSA 5 Seep A	SW5-7	BE	1/2	2.86E-03	3.00E-04		5.00E-01	6.00E-04		0.01%
SWSA 5 Seep A	SW5-7	CO	1/2	2.04E-02	9.20E-03		6.00E-02	1.53E-01		2.28%
SWSA 5 Seep A	SW5-7	FE	3/3	8.08E+00	7.15E+00	8.87	1.00E+01	7.15E-01		10.64%
SWSA 5 Seep A	SW5-7	MN	3/3	1.04E+01	8.83E+00	42.90	4.00E+00	2.21E+00		32.88%
SWSA 5 Seep A	SW5-7	V	1/2	5.51E-02	1.87E-02		2.00E-01	9.35E-02	6.72E+00	1.39%
SWSA 5 Seep A	SW5-8	B	5/5	6.50E-01	6.99E-01		1.00E+00	6.99E-01		2.85%
SWSA 5 Seep A	SW5-8	FE	5/5	4.44E+00	4.36E+00	5.41	1.00E+01	4.36E-01		1.78%
SWSA 5 Seep A	SW5-8	FL	2/6	3.94E-01	7.00E-02		5.00E+00	1.40E-02		0.06%
SWSA 5 Seep A	SW5-8	MN	5/5	4.54E+00	4.91E+00	22.10	4.00E+00	1.23E+00		5.02%
SWSA 5 Seep A	SW5-8	NAPHTHALENE	2/3	1.32E-02	1.00E-02		1.00E+01	1.00E-03		0.00%
SWSA 5 Seep A	SW5-8	NI	3/5	2.42E-02	2.40E-02		5.00E-01	4.80E-02		0.20%
SWSA 5 Seep A	SW5-8	TETRACHLOROETHENE	2/4	1.09E-02	1.00E-02		1.00E+01	1.00E-03		0.00%
SWSA 5 Seep A	SW5-8	TL	1/4	4.11E-01	4.39E-01		2.00E-02	2.20E+01		89.81%
SWSA 5 Seep A	SW5-8	TOLUENE	2/4	1.09E-02	1.00E-02		1.00E+01	1.00E-03		0.00%
SWSA 5 Seep A	SW5-8	V	1/5	1.01E-02	1.32E-02		2.00E-01	6.60E-02		0.27%
SWSA 5 Seep A	SW5-8	XYLENE (TOTAL)	2/4	1.83E-02	2.00E-02		1.00E+02	2.00E-04	2.45E+01	0.00%

Table 6.1. (continued)

Subasin	Station	Analyte	Detection Frequency	UCL95	Maximum Detected Concentration	Background Quotient	Soil Solution Benchmark	Hazard Quotient	Hazard Index	Percent Contribution
SWSA 5 Seep A	SW5-9	AL	2/6	5.50E-01	7.09E-01	1.62	2.00E-01	3.55E+00		11.14%
SWSA 5 Seep A	SW5-9	AS	2/5	4.15E-03	3.00E-03		1.00E-03	3.00E+00		9.41%
SWSA 5 Seep A	SW5-9	B	2/2	1.36E+00	9.38E-01		1.00E+00	9.38E-01		2.94%
SWSA 5 Seep A	SW5-9	BE	1/5	1.14E-03	4.00E-04		5.00E-01	8.00E-04		0.00%
SWSA 5 Seep A	SW5-9	CO	1/5	7.07E-03	8.30E-03		6.00E-02	1.38E-01		0.43%
SWSA 5 Seep A	SW5-9	FE	5/5	6.40E+00	9.03E+00	7.94	1.00E+01	9.03E-01		2.83%
SWSA 5 Seep A	SW5-9	FL	2/6	3.96E-01	9.00E-02		5.00E+00	1.80E-02		0.06%
SWSA 5 Seep A	SW5-9	MN	5/5	4.30E+00	5.02E+00	20.90	4.00E+00	1.26E+00		3.95%
SWSA 5 Seep A	SW5-9	NAPHTHALENE	2/3	1.32E-02	1.00E-02		1.00E+01	1.00E-03		0.00%
SWSA 5 Seep A	SW5-9	NI	4/6	4.04E-02	3.80E-02		5.00E-01	7.60E-02		0.24%
SWSA 5 Seep A	SW5-9	TETRACHLOROETHENE	2/4	1.09E-02	1.00E-02		1.00E+01	1.00E-03		0.00%
SWSA 5 Seep A	SW5-9	TL	1/3	5.69E-01	4.38E-01		2.00E-02	2.19E+01		68.73%
SWSA 5 Seep A	SW5-9	TOLUENE	2/4	1.09E-02	1.00E-02		1.00E+01	1.00E-03		0.00%
SWSA 5 Seep A	SW5-9	V	1/5	1.18E-02	1.58E-02		2.00E-01	7.90E-02		0.25%
SWSA 5 Seep A	SW5-9	XYLENE (TOTAL)	2/4	9.19E-03	1.00E-02		1.00E+02	1.00E-04	3.19E+01	0.00%
SWSA 5 Seep B West	SW5-11	AG	1/2	2.47E-02	1.04E-02		1.00E-01	1.04E-01		25.57%
SWSA 5 Seep B West	SW5-11	B	1/1		7.43E-02		1.00E+00	7.43E-02		18.27%
SWSA 5 Seep B West	SW5-11	BE	1/3	1.38E-03	4.00E-04		5.00E-01	8.00E-04		0.20%
SWSA 5 Seep B West	SW5-11	FL	2/4	1.54E-01	1.40E-01		5.00E+00	2.80E-02		6.88%
SWSA 5 Seep B West	SW5-11	MN	4/4	5.26E-01	4.66E-01	2.27	4.00E+00	1.17E-01		28.77%
SWSA 5 Seep B West	SW5-11	NAPHTHALENE	1/2	2.33E-02	1.00E-02		1.00E+01	1.00E-03		0.25%
SWSA 5 Seep B West	SW5-11	TETRACHLOROETHENE	1/3	1.15E-02	1.00E-02		1.00E+01	1.00E-03		0.25%
SWSA 5 Seep B West	SW5-11	TOLUENE	1/3	1.15E-02	1.00E-02		1.00E+01	1.00E-03		0.25%
SWSA 5 Seep B West	SW5-11	V	1/3	1.92E-02	1.59E-02		2.00E-01	7.95E-02		19.55%
SWSA 5 Seep B West	SW5-11	XYLENE (TOTAL)	1/3	1.15E-02	1.00E-02		1.00E+02	1.00E-04	4.07E-01	0.02%
SWSA 5 Seep C	05.SP005	AL	1/2	8.32E+00	2.30E+00	6.78	2.00E-01	1.15E+01		97.18%
SWSA 5 Seep C	05.SP005	FE	2/2	8.83E+00	2.58E+00	3.20	1.00E+01	2.58E-01		2.18%
SWSA 5 Seep C	05.SP005	FL	1/1		7.00E-02		5.00E+00	1.40E-02		0.12%
SWSA 5 Seep C	05.SP005	MN	2/2	2.41E-01	2.33E-01	1.13	4.00E+00	5.83E-02		0.49%
SWSA 5 Seep C	05.SP005	NAPHTHALENE	1/2	2.33E-02	1.00E-02		1.00E+01	1.00E-03		0.01%
SWSA 5 Seep C	05.SP005	TETRACHLOROETHENE	1/2	2.33E-02	1.00E-02		1.00E+01	1.00E-03		0.01%
SWSA 5 Seep C	05.SP005	TOLUENE	1/2	2.33E-02	1.00E-02		1.00E+01	1.00E-03		0.01%
SWSA 5 Seep C	05.SP005	XYLENE (TOTAL)	1/2	2.33E-02	1.00E-02		1.00E+02	1.00E-04	1.18E+01	0.00%
SWSA 5 Seep C	05.SP018	FL	1/1		2.00E-01		5.00E+00	4.00E-02		36.43%
SWSA 5 Seep C	05.SP018	LI	1/1		2.00E-01		3.00E+00	6.67E-02		60.75%
SWSA 5 Seep C	05.SP018	NAPHTHALENE	1/1		1.00E-02		1.00E+01	1.00E-03		0.91%
SWSA 5 Seep C	05.SP018	TETRACHLOROETHENE	1/1		1.00E-02		1.00E+01	1.00E-03		0.91%
SWSA 5 Seep C	05.SP018	TOLUENE	1/1		1.00E-02		1.00E+01	1.00E-03		0.91%
SWSA 5 Seep C	05.SP018	XYLENE (TOTAL)	1/1		1.00E-02		1.00E+02	1.00E-04	1.10E-01	0.09%

Table 6.1. (continued)

Subasin	Station	Analyte	Detection Frequency	UCL95	Maximum Detected Concentration	Background Quotient	Soil Solution Benchmark	Hazard Quotient	Hazard Index	Percent Contribution
SWSA 5 Seep C	SW5-3	AL	1/2	8.37E+00	2.30E+00	6.78	2.00E-01	1.15E+01		75.62%
SWSA 5 Seep C	SW5-3	B	1/1		8.06E-02		1.00E+00	8.06E-02		0.53%
SWSA 5 Seep C	SW5-3	BE	1/2	1.06E-03	4.00E-04		5.00E-01	8.00E-04		0.01%
SWSA 5 Seep C	SW5-3	FE	2/2	4.15E+00	2.58E+00	3.20	1.00E+01	2.58E-01		1.70%
SWSA 5 Seep C	SW5-3	FL	2/4	1.34E+01	1.60E+01		5.00E+00	3.20E+00		21.04%
SWSA 5 Seep C	SW5-3	MN	2/2	4.53E-01	2.91E-01	1.41	4.00E+00	7.28E-02		0.48%
SWSA 5 Seep C	SW5-3	V	1/2	6.42E-02	1.89E-02		2.00E-01	9.45E-02	1.52E+01	0.62%
SWSA 5 Seep C	SW5-4	AS	1/7	1.21E-02	3.00E-03		1.00E-03	3.00E+00		47.63%
SWSA 5 Seep C	SW5-4	B	5/9	1.52E-01	2.34E-01		1.00E+00	2.34E-01		3.71%
SWSA 5 Seep C	SW5-4	BE	1/9	6.21E-04	4.00E-04		5.00E-01	8.00E-04		0.01%
SWSA 5 Seep C	SW5-4	CD	1/8	2.06E-03	2.40E-03		1.00E-01	2.40E-02		0.38%
SWSA 5 Seep C	SW5-4	FE	11/12	1.66E+00	3.58E+00	2.06	1.00E+01	3.58E-01		5.68%
SWSA 5 Seep C	SW5-4	FL	6/23	2.13E-01	5.17E+00		5.00E+00	1.03E+00		16.35%
SWSA 5 Seep C	SW5-4	HG	2/7	1.08E-04	1.10E-04		5.00E-03	2.20E-02		0.35%
SWSA 5 Seep C	SW5-4	LI	2/3	3.18E-01	2.00E-01		3.00E+00	6.67E-02		1.06%
SWSA 5 Seep C	SW5-4	MN	11/12	2.76E+00	5.76E+00	13.40	4.00E+00	1.44E+00		22.86%
SWSA 5 Seep C	SW5-4	NAPHTHALENE	4/5	1.11E-02	1.00E-02		1.00E+01	1.00E-03		0.02%
SWSA 5 Seep C	SW5-4	NI	2/10	1.35E-02	1.54E-02		5.00E-01	3.08E-02		0.49%
SWSA 5 Seep C	SW5-4	TETRACHLOROETHENE	4/6	1.05E-02	1.00E-02		1.00E+01	1.00E-03		0.02%
SWSA 5 Seep C	SW5-4	TOLUENE	4/6	1.05E-02	1.00E-02		1.00E+01	1.00E-03		0.02%
SWSA 5 Seep C	SW5-4	V	1/10	6.91E-03	1.79E-02		2.00E-01	8.95E-02		1.42%
SWSA 5 Seep C	SW5-4	XYLENE (TOTAL)	4/6	9.85E-03	1.00E-02		1.00E+02	1.00E-04	6.30E+00	0.00%
SWSA 5 Trib 1	05.SP003	AL	1/2	1.32E+01	3.62E+00	10.70	2.00E-01	1.81E+01		77.71%
SWSA 5 Trib 1	05.SP003	AS	1/2	9.74E-03	3.50E-03		1.00E-03	3.50E+00		15.03%
SWSA 5 Trib 1	05.SP003	CO	1/2	2.06E-02	7.00E-03		6.00E-02	1.17E-01		0.50%
SWSA 5 Trib 1	05.SP003	FE	2/2	2.67E+01	7.46E+00	9.26	1.00E+01	7.46E-01		3.20%
SWSA 5 Trib 1	05.SP003	FL	1/1		1.60E-01		5.00E+00	3.20E-02		0.14%
SWSA 5 Trib 1	05.SP003	MN	2/2	8.62E+00	3.01E+00	14.60	4.00E+00	7.53E-01		3.23%
SWSA 5 Trib 1	05.SP003	NAPHTHALENE	2/3	1.32E-02	1.00E-02		1.00E+01	1.00E-03		0.00%
SWSA 5 Trib 1	05.SP003	TETRACHLOROETHENE	2/3	1.32E-02	1.00E-02		1.00E+01	1.00E-03		0.00%
SWSA 5 Trib 1	05.SP003	TOLUENE	2/3	1.32E-02	1.00E-02		1.00E+01	1.00E-03		0.00%
SWSA 5 Trib 1	05.SP003	V	1/2	2.45E-02	7.90E-03		2.00E-01	3.95E-02		0.17%
SWSA 5 Trib 1	05.SP003	XYLENE (TOTAL)	2/3	1.32E-02	1.00E-02		1.00E+02	1.00E-04	2.33E+01	0.00%
SWSA 5 Trib 1	05.SP015	CO	2/2	4.42E-01	2.93E-01		6.00E-02	4.88E+00		58.68%
SWSA 5 Trib 1	05.SP015	CR	1/3	5.24E-03	4.40E-03		5.00E-02	8.80E-02		1.06%
SWSA 5 Trib 1	05.SP015	FE	2/2	1.11E+01	4.88E+00	6.05	1.00E+01	4.88E-01		5.87%
SWSA 5 Trib 1	05.SP015	FL	1/1		6.20E-01		5.00E+00	1.24E-01		1.49%
SWSA 5 Trib 1	05.SP015	HG	1/3	1.41E-04	1.20E-04		5.00E-03	2.40E-02		0.29%
SWSA 5 Trib 1	05.SP015	MN	2/2	1.35E+01	7.90E+00	38.40	4.00E+00	1.98E+00		23.81%

Table 6.1. (continued)

Subasin	Station	Analyte	Detection Frequency	UCL95	Maximum Detected Concentration	Background Quotient	Soil Solution Benchmark	Hazard Quotient	Hazard Index	Percent Contribution
SWSA 5 Trib 1	05.SP015	NAPHTHALENE	2/3	1.32E-02	1.00E-02		1.00E+01	1.00E-03		0.01%
SWSA 5 Trib 1	05.SP015	NI	2/2	3.76E-01	3.28E-01		5.00E-01	6.56E-01		7.89%
SWSA 5 Trib 1	05.SP015	SE	3/3	5.55E-02	5.08E-02		7.00E-01	7.26E-02		0.87%
SWSA 5 Trib 1	05.SP015	TETRACHLOROETHENE	2/4	1.09E-02	1.00E-02		1.00E+01	1.00E-03		0.01%
SWSA 5 Trib 1	05.SP015	TOLUENE	2/4	1.09E-02	1.00E-02		1.00E+01	1.00E-03		0.01%
SWSA 5 Trib 1	05.SP015	XYLENE (TOTAL)	2/4	1.09E-02	1.00E-02		1.00E+02	1.00E-04	8.32E+00	0.00%
SWSA 5 Trib 1	05.SW001	AL	9/18	1.17E+00	4.03E+00	3.45	2.00E-01	2.02E+01		83.20%
SWSA 5 Trib 1	05.SW001	AS	1/10	1.70E-03	3.70E-03		1.00E-03	3.70E+00		15.24%
SWSA 5 Trib 1	05.SW001	CR	5/11	5.68E-03	7.80E-03		5.00E-02	1.56E-01		0.64%
SWSA 5 Trib 1	05.SW001	CU	1/17	6.89E-03	4.60E-03		5.00E-02	9.20E-02		0.38%
SWSA 5 Trib 1	05.SW001	FL	7/7	2.08E-01	2.00E-01		5.00E+00	4.00E-02		0.16%
SWSA 5 Trib 1	05.SW001	LI	5/5	2.00E-01	2.00E-01		3.00E+00	6.67E-02		0.27%
SWSA 5 Trib 1	05.SW001	NAPHTHALENE	7/10	1.18E-02	1.00E-02		1.00E+01	1.00E-03		0.00%
SWSA 5 Trib 1	05.SW001	NI	4/10	7.59E-03	9.10E-03		5.00E-01	1.82E-02		0.07%
SWSA 5 Trib 1	05.SW001	SE	2/9	2.22E-03	3.00E-03		7.00E-01	4.29E-03		0.02%
SWSA 5 Trib 1	05.SW001	TETRACHLOROETHENE	6/14	8.36E-03	1.00E-02		1.00E+01	1.00E-03		0.00%
SWSA 5 Trib 1	05.SW001	TOLUENE	6/14	8.36E-03	1.00E-02		1.00E+01	1.00E-03		0.00%
SWSA 5 Trib 1	05.SW001	XYLENE (TOTAL)	6/14	8.36E-03	1.00E-02		1.00E+02	1.00E-04	2.43E+01	0.00%
SWSA 5 Trib 1	SW5-1	AL	1/4	3.04E+00	3.62E+00	8.96	2.00E-01	1.81E+01		40.13%
SWSA 5 Trib 1	SW5-1	AS	1/4	4.95E-03	3.50E-03		1.00E-03	3.50E+00		7.76%
SWSA 5 Trib 1	SW5-1	B	3/3	8.01E-02	7.56E-02		1.00E+00	7.56E-02		0.17%
SWSA 5 Trib 1	SW5-1	BE	1/4	1.12E-03	8.00E-04		5.00E-01	1.60E-03		0.00%
SWSA 5 Trib 1	SW5-1	CO	1/4	6.81E-03	7.00E-03		6.00E-02	1.17E-01		0.26%
SWSA 5 Trib 1	SW5-1	FE	3/4	6.26E+00	7.46E+00	7.77	1.00E+01	7.46E-01		1.65%
SWSA 5 Trib 1	SW5-1	FL	2/4	5.64E-01	3.20E-01		5.00E+00	6.40E-02		0.14%
SWSA 5 Trib 1	SW5-1	MN	3/3	7.30E+00	5.41E+00	26.30	4.00E+00	1.35E+00		2.99%
SWSA 5 Trib 1	SW5-1	TL	1/2	1.48E+00	4.20E-01		2.00E-02	2.10E+01		46.57%
SWSA 5 Trib 1	SW5-1	V	2/4	2.51E-02	2.87E-02		2.00E-01	1.44E-01	4.51E+01	0.32%
SWSA 5/WOC	05.SP004	AL	1/2	4.36E+00	1.20E+00	3.54	2.00E-01	6.00E+00		69.57%
SWSA 5/WOC	05.SP004	AS	1/2	5.36E-03	2.30E-03		1.00E-03	2.30E+00		26.67%
SWSA 5/WOC	05.SP004	CU	1/2	2.26E-02	7.70E-03		5.00E-02	1.54E-01		1.79%
SWSA 5/WOC	05.SP004	FE	1/2	5.41E+00	1.49E+00	1.85	1.00E+01	1.49E-01		1.73%
SWSA 5/WOC	05.SP004	FL	1/1		9.00E-02		5.00E+00	1.80E-02		0.21%
SWSA 5/WOC	05.SP004	NAPHTHALENE	2/3	1.32E-02	1.00E-02		1.00E+01	1.00E-03		0.01%
SWSA 5/WOC	05.SP004	TETRACHLOROETHENE	2/3	1.32E-02	1.00E-02		1.00E+01	1.00E-03		0.01%
SWSA 5/WOC	05.SP004	TOLUENE	2/3	1.32E-02	1.00E-02		1.00E+01	1.00E-03		0.01%
SWSA 5/WOC	05.SP004	XYLENE (TOTAL)	2/3	1.32E-02	1.00E-02		1.00E+02	1.00E-04	8.62E+00	0.00%
SWSA 5/WOC	SW5-2	AL	2/3	1.56E+00	1.20E+00	3.54	2.00E-01	6.00E+00		90.08%
SWSA 5/WOC	SW5-2	B	3/3	1.89E-01	1.75E-01		1.00E+00	1.75E-01		2.63%

Table 6.1. (continued)

Subasin	Station	Analyte	Detection Frequency	UCL95	Maximum Detected Concentration	Background Quotient	Soil Solution Benchmark	Hazard Quotient	Hazard Index	Percent Contribution
SWSA 5/WOC	SW5-2	BE	1/3	8.63E-04	7.00E-04		5.00E-01	1.40E-03		0.02%
SWSA 5/WOC	SW5-2	CU	1/3	9.66E-03	7.70E-03		5.00E-02	1.54E-01		2.31%
SWSA 5/WOC	SW5-2	FE	2/3	1.93E+00	1.49E+00	1.85	1.00E+01	1.49E-01		2.24%
SWSA 5/WOC	SW5-2	FL	3/3	1.28E-01	1.20E-01		5.00E+00	2.40E-02		0.36%
SWSA 5/WOC	SW5-2	V	2/4	3.52E-02	3.13E-02		2.00E-01	1.57E-01	6.66E+00	2.36%
SWSA4main	BTT	B	3/8	8.67E-02	1.13E-01		1.00E+00	1.13E-01		9.81%
SWSA4main	BTT	BE	2/7	6.27E-04	8.00E-04		5.00E-01	1.60E-03		0.14%
SWSA4main	BTT	CD	1/6	1.88E-03	1.00E-04		1.00E-01	1.00E-03		0:09%
SWSA4main	BTT	CO	1/7	4.13E-03	2.80E-03		6.00E-02	4.67E-02		4.06%
SWSA4main	BTT	CR	1/8	2.46E-03	3.00E-03		5.00E-02	6.00E-02		5.21%
SWSA4main	BTT	CU	2/7	4.62E-03	5.70E-03		5.00E-02	1.14E-01		9.90%
SWSA4main	BTT	FL	6/7	8.34E-01	1.10E+00		5.00E+00	2.20E-01		19.11%
SWSA4main	BTT	MO	6/8	1.01E-01	1.71E-01		5.00E-01	3.42E-01		29.71%
SWSA4main	BTT	NI	7/8	4.45E-02	5.09E-02		5.00E-01	1.02E-01		8.86%
SWSA4main	BTT	V	1/7	1.39E-02	3.02E-02		2.00E-01	1.51E-01	1.15E+00	13.12%
SWSA4main	SCS1B	AG	1/1		5.00E-03		1.00E-01	5.00E-02		0.09%
SWSA4main	SCS1B	AS	1/1		5.00E-02		1.00E-03	5.00E+01		92.76%
SWSA4main	SCS1B	B	1/1		1.00E-01		1.00E+00	1.00E-01		0.19%
SWSA4main	SCS1B	BE	1/1		1.00E-03		5.00E-01	2.00E-03		0.00%
SWSA4main	SCS1B	CD	1/1		5.00E-03		1.00E-01	5.00E-02		0.09%
SWSA4main	SCS1B	CO	1/1		4.50E-03		6.00E-02	7.50E-02		0.14%
SWSA4main	SCS1B	CR	1/1		4.00E-03		5.00E-02	8.00E-02		0.15%
SWSA4main	SCS1B	CU	1/1		7.00E-03		5.00E-02	1.40E-01		0.26%
SWSA4main	SCS1B	FL	1/1		1.00E+00		5.00E+00	2.00E-01		0.37%
SWSA4main	SCS1B	LI	1/1		2.40E-02		3.00E+00	8.00E-03		0.01%
SWSA4main	SCS1B	MN	1/1		6.50E-01	3.16	4.00E+00	1.63E-01		0.30%
SWSA4main	SCS1B	MO	1/1		4.00E-02		5.00E-01	8.00E-02		0.15%
SWSA4main	SCS1B	NI	1/1		2.00E-02		5.00E-01	4.00E-02		0.07%
SWSA4main	SCS1B	PB	1/1		5.00E-02	3.57	2.00E-02	2.50E+00		4.64%
SWSA4main	SCS1B	SE	1/1		5.00E-02		7.00E-01	7.14E-02		0.13%
SWSA4main	SCS1B	SN	1/1		5.00E-02		1.00E+02	5.00E-04		0.00%
SWSA4main	SCS1B	TI	1/1		2.00E-02		6.00E-02	3.33E-01		0.62%
SWSA4main	SCS1B	V	1/1		2.00E-03		2.00E-01	1.00E-02	5.39E+01	0.02%
SWSA4main	SW4-1	AS	3/5	5.53E-03	6.20E-03		1.00E-03	6.20E+00		20.52%
SWSA4main	SW4-1	B	2/4	1.72E-01	1.71E-01		1.00E+00	1.71E-01		0.57%
SWSA4main	SW4-1	BE	1/5	9.99E-04	8.00E-04		5.00E-01	1.60E-03		0.01%
SWSA4main	SW4-1	CO	1/5	6.88E-03	8.20E-03		6.00E-02	1.37E-01		0.45%
SWSA4main	SW4-1	FE	4/4	2.55E+01	2.88E+01	31.60	1.00E+01	2.88E+00		9.53%
SWSA4main	SW4-1	FL	5/5	1.46E+01	1.57E+01		5.00E+00	3.14E+00		10.39%

Table 6.1. (continued)

Subasin	Station	Analyte	Detection Frequency	UCL95	Maximum Detected Concentration	Background Quotient	Soil Solution Benchmark	Hazard Quotient	Hazard Index	Percent Contribution
SWSA4main	SW4-1	MN	4/4	3.69E+00	3.81E+00	17.90	4.00E+00	9.53E-01		3.15%
SWSA4main	SW4-1	TETRACHLOROETHENE	3/5	8.09E-03	7.00E-04		1.00E+01	7.00E-05		0.00%
SWSA4main	SW4-1	TL	1/4	2.79E-01	3.31E-01		2.00E-02	1.66E+01		54.94%
SWSA4main	SW4-1	V	1/5	1.79E-02	2.61E-02		2.00E-01	1.31E-01	3.02E+01	0.43%
SWSA4main	SW4-2	B	4/7	1.90E-01	2.31E-01		1.00E+00	2.31E-01		1.08%
SWSA4main	SW4-2	BE	2/7	6.29E-04	8.00E-04		5.00E-01	1.60E-03		0.01%
SWSA4main	SW4-2	CD	1/6	2.02E-03	6.00E-05		1.00E-01	6.00E-04		0.00%
SWSA4main	SW4-2	CO	4/7	3.05E-02	3.32E-02		6.00E-02	5.53E-01		2.57%
SWSA4main	SW4-2	CU	2/7	4.39E-03	5.10E-03		5.00E-02	1.02E-01		0.47%
SWSA4main	SW4-2	FE	6/7	4.17E+00	7.06E+00	5.17	1.00E+01	7.06E-01		3.29%
SWSA4main	SW4-2	FL	8/8	1.50E+00	2.26E+00		5.00E+00	4.52E-01		2.10%
SWSA4main	SW4-2	HG	1/5	1.06E-04	6.00E-05		5.00E-03	1.20E-02		0.06%
SWSA4main	SW4-2	LI	1/1		1.13E-01		3.00E+00	3.77E-02		0.18%
SWSA4main	SW4-2	MN	7/7	1.03E+00	1.23E+00	5.00	4.00E+00	3.08E-01		1.43%
SWSA4main	SW4-2	MO	1/7	9.19E-03	7.70E-03		5.00E-01	1.54E-02		0.07%
SWSA4main	SW4-2	NI	7/7	8.43E+00	9.46E+00		5.00E-01	1.89E+01		88.01%
SWSA4main	SW4-2	TETRACHLOROETHENE	2/4	1.09E-02	3.00E-03		1.00E+01	3.00E-04		0.00%
SWSA4main	SW4-2	TOLUENE	2/4	1.09E-02	3.00E-03		1.00E+01	3.00E-04		0.00%
SWSA4main	SW4-2	V	1/7	1.41E-02	3.11E-02		2.00E-01	1.56E-01		0.73%
SWSA4main	SW4-2	XYLENE (TOTAL)	2/3	2.96E-03	1.00E-03		1.00E+02	1.00E-05	2.15E+01	0.00%
SWSA4main	W4TRIB-11	AG	1/7	2.84E-03	3.90E-03		1.00E-01	3.90E-02		1.54%
SWSA4main	W4TRIB-11	AS	1/4	2.15E-02	5.50E-04		1.00E-03	5.50E-01		21.71%
SWSA4main	W4TRIB-11	B	2/9	1.14E-01	1.85E-01		1.00E+00	1.85E-01		7.30%
SWSA4main	W4TRIB-11	BE	1/7	5.40E-04	2.00E-04		5.00E-01	4.00E-04		0.02%
SWSA4main	W4TRIB-11	CD	2/6	1.85E-03	2.10E-03		1.00E-01	2.10E-02		0.83%
SWSA4main	W4TRIB-11	CO	1/8	3.89E-03	2.90E-03		6.00E-02	4.83E-02		1.91%
SWSA4main	W4TRIB-11	CU	6/9	2.57E-02	3.40E-02		5.00E-02	6.80E-01		26.84%
SWSA4main	W4TRIB-11	FE	9/9	2.35E+00	1.46E+00	1.81	1.00E+01	1.46E-01		5.76%
SWSA4main	W4TRIB-11	FL	9/10	6.65E-01	1.01E+00		5.00E+00	2.02E-01		7.97%
SWSA4main	W4TRIB-11	MN	7/9	2.23E+00	2.10E+00	10.20	4.00E+00	5.25E-01		20.72%
SWSA4main	W4TRIB-11	MO	5/9	2.74E-02	4.70E-02		5.00E-01	9.40E-02		3.71%
SWSA4main	W4TRIB-11	NI	4/8	1.59E-02	2.13E-02		5.00E-01	4.26E-02	2.53E+00	1.68%
SWSA4main	W4TRIB-5	AL	4/4	1.86E+00	2.11E+00	5.48	2.00E-01	1.06E+01		279781.33%
SWSA4main	W4TRIB-5	B	1/4	1.39E-01	1.44E-01		1.00E+00	1.44E-01		279057.18%
SWSA4main	W4TRIB-5	CR	1/4	3.58E-03	3.80E-03		5.00E-02	7.60E-02		279057.18%
SWSA4main	W4TRIB-5	FE	4/4	1.75E+00	2.00E+00	2.17	1.00E+01	2.00E-01		279781.33%
SWSA4main	W4TRIB-5	FL	4/4	7.74E+00	7.55E+00		5.00E+00	1.51E+00		279781.33%
SWSA4main	W4TRIB-5	NI	1/4	1.90E-02	1.83E-02		5.00E-01	3.66E-02	1.26E+01	279057.18%
SWSA4main	W4TRIB-7	B	4/5	4.10E-01	4.13E-01		1.00E+00	4.13E-01		1669040.16%

Table 6.1. (continued)

Subasin	Station	Analyte	Detection Frequency	UCL95	Maximum Detected Concentration	Background Quotient	Soil Solution Benchmark	Hazard Quotient	Hazard Index	Percent Contribution
SWSA4main	W4TRIB-7	CR	1/5	3.66E-03	4.30E-03		5.00E-02	8.60E-02		1664720.40%
SWSA4main	W4TRIB-7	FL	2/5	6.95E-01	7.73E-01		5.00E+00	1.55E-01		1666191.97%
SWSA4main	W4TRIB-7	MN	5/5	3.69E+00	5.70E+00	17.90	4.00E+00	1.43E+00		1670464.26%
SWSA4main	W4TRIB-7	MO	1/5	1.18E-02	1.13E-02		5.00E-01	2.26E-02	2.11E+00	1664720.40%
SWSA4main	WAG4 MS1	B	6/13	1.81E-01	1.96E-01		1.00E+00	1.96E-01		1.00%
SWSA4main	WAG4 MS1	BE	3/10	1.01E-03	1.50E-03		5.00E-01	3.00E-03		0.02%
SWSA4main	WAG4 MS1	CD	2/8	3.18E-04	2.80E-04		1.00E-01	2.80E-03		0.01%
SWSA4main	WAG4 MS1	CO	3/12	5.54E-03	7.00E-03		6.00E-02	1.17E-01		0.60%
SWSA4main	WAG4 MS1	CR	1/12	3.82E-03	5.90E-03		5.00E-02	1.18E-01		0.60%
SWSA4main	WAG4 MS1	CU	4/12	5.07E-03	7.30E-03		5.00E-02	1.46E-01		0.75%
SWSA4main	WAG4 MS1	FL	15/17	1.30E+00	1.69E+00		5.00E+00	3.38E-01		1.73%
SWSA4main	WAG4 MS1	HG	1/6	1.45E-04	2.00E-04		5.00E-03	4.00E-02		0.20%
SWSA4main	WAG4 MS1	MN	12/13	9.50E-01	6.47E+00	4.62	4.00E+00	1.62E+00		8.28%
SWSA4main	WAG4 MS1	MO	2/11	7.23E-03	7.00E-03		5.00E-01	1.40E-02		0.07%
SWSA4main	WAG4 MS1	NI	13/14	3.91E-02	6.66E-02		5.00E-01	1.33E-01		0.68%
SWSA4main	WAG4 MS1	TL	1/8	2.62E-01	3.34E-01		2.00E-02	1.67E+01		85.36%
SWSA4main	WAG4 MS1	V	1/10	8.87E-03	2.73E-02		2.00E-01	1.37E-01	1.96E+01	0.70%
SWSA5N/WOC	05.SP002	AL	1/2	1.61E+00	4.46E-01	1.32	2.00E-01	2.23E+00		99.86%
SWSA5N/WOC	05.SP002	NAPHTHALENE	1/2	2.33E-02	1.00E-02		1.00E+01	1.00E-03		0.04%
SWSA5N/WOC	05.SP002	TETRACHLOROETHENE	1/2	2.33E-02	1.00E-02		1.00E+01	1.00E-03		0.04%
SWSA5N/WOC	05.SP002	TOLUENE	1/2	2.33E-02	1.00E-02		1.00E+01	1.00E-03		0.04%
SWSA5N/WOC	05.SP002	XYLENE (TOTAL)	1/2	8.66E-03	6.00E-03		1.00E+02	6.00E-05	2.23E+00	0.00%
SWSA5N/WOC	5NW-1	AL	1/2	1.59E+00	4.46E-01	1.32	2.00E-01	2.23E+00		85.16%
SWSA5N/WOC	5NW-1	B	1/1		2.07E-02		1.00E+00	2.07E-02		0.79%
SWSA5N/WOC	5NW-1	BE	1/2	1.43E-03	5.00E-04		5.00E-01	1.00E-03		0.04%
SWSA5N/WOC	5NW-1	MN	2/2	2.99E+00	9.22E-01	4.48	4.00E+00	2.31E-01		8.82%
SWSA5N/WOC	5NW-1	V	1/2	9.63E-02	2.71E-02		2.00E-01	1.36E-01	2.62E+00	5.19%
SWSA5N/WOC	5NW-2	AL	4/5	9.09E-01	9.80E-01	2.68	2.00E-01	4.90E+00		73.47%
SWSA5N/WOC	5NW-2	B	1/2	1.78E-01	5.60E-02		1.00E+00	5.60E-02		0.84%
SWSA5N/WOC	5NW-2	BE	1/4	9.23E-04	5.00E-04		5.00E-01	1.00E-03		0.01%
SWSA5N/WOC	5NW-2	CO	2/4	4.74E-03	3.00E-03		6.00E-02	5.00E-02		0.75%
SWSA5N/WOC	5NW-2	CR	1/5	4.24E-03	3.60E-03		5.00E-02	7.20E-02		1.08%
SWSA5N/WOC	5NW-2	FE	5/5	1.13E+00	1.20E+00	1.40	1.00E+01	1.20E-01		1.80%
SWSA5N/WOC	5NW-2	FL	2/6	5.41E-01	5.20E-02		5.00E+00	1.04E-02		0.16%
SWSA5N/WOC	5NW-2	MN	5/5	4.17E+00	5.33E+00	20.30	4.00E+00	1.33E+00		19.94%
SWSA5N/WOC	5NW-2	NAPHTHALENE	2/3	1.32E-02	1.00E-02		1.00E+01	1.00E-03		0.01%
SWSA5N/WOC	5NW-2	TETRACHLOROETHENE	2/4	1.09E-02	1.00E-02		1.00E+01	1.00E-03		0.01%
SWSA5N/WOC	5NW-2	TOLUENE	2/4	1.09E-02	1.00E-02		1.00E+01	1.00E-03		0.01%
SWSA5N/WOC	5NW-2	V	1/4	2.18E-02	2.53E-02		2.00E-01	1.27E-01		1.90%

Table 6.1. (continued)

Subasin	Station	Analyte	Detection Frequency	UCL95	Maximum Detected Concentration	Background Quotient	Soil Solution Benchmark	Hazard Quotient	Hazard Index	Percent Contribution
SWSA5N/WOC	5NW-2	XYLENE (TOTAL)	2/4	1.09E-02	1.00E-02		1.00E+02	1.00E-04	6.67E+00	0.00%
W6MS3	ETF-14	CU	2/2	1.52E+00	4.29E-01		5.00E-02	8.58E+00		99.30%
W6MS3	ETF-14	NI	1/2	8.46E-02	3.04E-02		5.00E-01	6.08E-02	8.64E+00	0.70%
W6MS3	WAG6 MS3A	AS	1/5	4.91E-03	3.00E-03		1.00E-03	3.00E+00		170884.90%
W6MS3	WAG6 MS3A	B	1/3	1.04E-01	8.30E-02		1.00E+00	8.30E-02		170875.16%
W6MS3	WAG6 MS3A	BE	1/2	2.33E-03	5.00E-04		5.00E-01	1.00E-03		170870.29%
W6MS3	WAG6 MS3A	FE	4/5	1.56E+00	1.70E+00	1.93	1.00E+01	1.70E-01		171328.33%
W6MS3	WAG6 MS3A	FL	1/3	6.28E-01	3.00E-01		5.00E+00	6.00E-02		170875.16%
W6MS3	WAG6 MS3A	MN	5/5	6.30E+00	5.94E+00	28.90	4.00E+00	1.49E+00		171474.52%
W6MS3	WAG6 MS3A	TL	3/6	2.25E-01	3.12E-01		2.00E-02	1.56E+01		171182.15%
W6MS3	WAG6 MS3A	V	1/2	7.30E-02	2.36E-02		2.00E-01	1.18E-01	2.05E+01	1.37%
W6MS3	WAG6 MS3A-1	AS	1/2	7.58E-03	2.80E-03		1.00E-03	2.80E+00		21.25%
W6MS3	WAG6 MS3A-1	FE	2/2	2.21E+00	1.84E+00	2.28	1.00E+01	1.84E-01		1.40%
W6MS3	WAG6 MS3A-1	MN	2/2	6.50E+00	5.94E+00	28.90	4.00E+00	1.49E+00		11.31%
W6MS3	WAG6 MS3A-1	TL	1/2	4.37E-01	1.74E-01		2.00E-02	8.70E+00	1.32E+01	66.04%
W6MS3	WAG6 MS3B	AS	1/4	6.35E-03	5.00E-03		1.00E-03	5.00E+00		21.95%
W6MS3	WAG6 MS3B	B	5/5	1.65E-01	1.82E-01		1.00E+00	1.82E-01		0.80%
W6MS3	WAG6 MS3B	BE	1/2	2.59E-03	4.00E-04		5.00E-01	8.00E-04		0.00%
W6MS3	WAG6 MS3B	CO	1/4	1.08E-02	1.20E-02		6.00E-02	2.00E-01		0.88%
W6MS3	WAG6 MS3B	CR	1/4	4.33E-02	5.10E-02		5.00E-02	1.02E+00		4.48%
W6MS3	WAG6 MS3B	FL	1/3	6.92E-01	2.00E-01		5.00E+00	4.00E-02		0.18%
W6MS3	WAG6 MS3B	MN	4/5	2.03E+00	2.76E+00	9.86	4.00E+00	6.90E-01		3.03%
W6MS3	WAG6 MS3B	NI	1/4	2.24E-02	2.50E-02		5.00E-01	5.00E-02		0.22%
W6MS3	WAG6 MS3B	SE	1/5	3.40E-03	4.00E-03		7.00E-01	5.71E-03		0.03%
W6MS3	WAG6 MS3B	TETRACHLOROETHENE	3/3	6.00E-04	6.00E-04		1.00E+01	6.00E-05		0.00%
W6MS3	WAG6 MS3B	TL	3/6	2.88E-01	3.10E-01		2.00E-02	1.55E+01		68.06%
W6MS3	WAG6 MS3B	V	1/2	4.96E-02	1.72E-02		2.00E-01	8.60E-02	2.28E+01	0.38%
W6MS1	FRENCH DR S	B	1/1		1.30E-01		1.00E+00	1.30E-01		1.20%
W6MS1	FRENCH DR S	TETRACHLOROETHENE	4/4	1.07E-01	9.90E-02		1.00E+01	9.90E-03		0.09%
W6MS1	FRENCH DR S	TL	1/1		2.14E-01		2.00E-02	1.07E+01	1.08E+01	98.71%
W6MS1	FRENCH DRAIN	B	1/1		1.30E-01		1.00E+00	1.30E-01		1.20%
W6MS1	FRENCH DRAIN	TL	1/1		2.14E-01		2.00E-02	1.07E+01	1.08E+01	98.80%
W6MS1	WAG6 MS1	B	3/3	1.31E-01	1.12E-01		1.00E+00	1.12E-01		0.55%
W6MS1	WAG6 MS1	BE	1/2	2.06E-03	6.00E-04		5.00E-01	1.20E-03		0.01%
W6MS1	WAG6 MS1	FL	1/3	7.56E-01	1.00E-01		5.00E+00	2.00E-02		0.10%
W6MS1	WAG6 MS1	MN	3/3	5.94E+00	3.93E+00	19.10	4.00E+00	9.83E-01		4.81%
W6MS1	WAG6 MS1	TL	2/4	3.77E-01	3.84E-01		2.00E-02	1.92E+01		93.87%
W6MS1	WAG6 MS1	V	1/2	8.69E-02	2.74E-02		2.00E-01	1.37E-01	2.05E+01	0.67%
W6MS1	WAG6 MS1-1	AS	2/2	5.33E-03	4.00E-03		1.00E-03	4.00E+00		17.66%

Table 6.1. (continued)

Subasin	Station	Analyte	Detection Frequency	UCL95	Maximum Detected Concentration	Background Quotient	Soil Solution Benchmark	Hazard Quotient	Hazard Index	Percent Contribution
W6MS1	WAG6 MS1-1	B	2/2	8.25E-02	8.14E-02		1.00E+00	8.14E-02		0.36%
W6MS1	WAG6 MS1-1	FE	1/1		1.65E+00	2.05	1.00E+01	1.65E-01		0.73%
W6MS1	WAG6 MS1-1	MN	1/1		1.22E+01	59.30	4.00E+00	3.05E+00		13.46%
W6MS1	WAG6 MS1-1	MO	1/1		2.80E-02		5.00E-01	5.60E-02		0.25%
W6MS1	WAG6 MS1-1	TL	1/1		3.05E-01		2.00E-02	1.53E+01	2.27E+01	67.54%
W6MS1	WAG6 MS2	B	3/3	1.58E-01	1.30E-01		1.00E+00	1.30E-01		1.56%
W6MS1	WAG6 MS2	BE	1/2	2.33E-03	5.00E-04		5.00E-01	1.00E-03		0.01%
W6MS1	WAG6 MS2	TL	1/4	1.48E-01	1.62E-01		2.00E-02	8.10E+00		97.06%
W6MS1	WAG6 MS2	V	1/2	7.01E-02	2.28E-02		2.00E-01	1.14E-01	8.35E+00	1.37%
WAG 7 WOC	WCTRIB-2	BE	1/2	5.00E-04	5.00E-04		5.00E-01	1.00E-03		0.78%
WAG 7 WOC	WCTRIB-2	V	1/2	8.36E-02	2.54E-02		2.00E-01	1.27E-01	1.28E-01	99.22%
WCTRIB-1	SW7-6	AL	1/3	9.90E-01	7.61E-01	2.24	2.00E-01	3.81E+00		98.40%
WCTRIB-1	SW7-6	BE	1/3	6.18E-04	2.00E-04		5.00E-01	4.00E-04		0.01%
WCTRIB-1	SW7-6	V	1/2	3.57E-02	1.23E-02		2.00E-01	6.15E-02	3.87E+00	1.59%
West Seep	RS-1	AS	1/5	1.03E-02	1.40E-02		1.00E-03	1.40E+01		48.18%
West Seep	RS-1	B	1/3	1.12E-01	8.90E-02		1.00E+00	8.90E-02		0.31%
West Seep	RS-1	BE	1/5	7.73E-04	4.00E-04		5.00E-01	8.00E-04		0.00%
West Seep	RS-1	FE	4/4	1.17E+00	1.27E+00	1.45	1.00E+01	1.27E-01		0.44%
West Seep	RS-1	MN	4/4	6.34E+00	7.33E+00	30.80	4.00E+00	1.83E+00		6.30%
West Seep	RS-1	NI	2/4	1.51E-02	1.24E-02		5.00E-01	2.48E-02		0.09%
West Seep	RS-1	TL	1/4	2.18E-01	2.57E-01		2.00E-02	1.29E+01		44.40%
West Seep	RS-1	V	2/4	1.68E-02	1.70E-02		2.00E-01	8.50E-02	2.91E+01	0.29%
West Seep	RS-3	AL	2/2	5.35E+00	1.57E+00	4.63	2.00E-01	7.85E+00		22.73%
West Seep	RS-3	AS	1/3	2.72E-02	2.20E-02		1.00E-03	2.20E+01		63.70%
West Seep	RS-3	B	2/2	9.28E-01	2.81E-01		1.00E+00	2.81E-01		0.81%
West Seep	RS-3	BE	1/2	2.59E-03	4.00E-04		5.00E-01	8.00E-04		0.00%
West Seep	RS-3	CO	2/2	1.80E-02	1.80E-02		6.00E-02	3.00E-01		0.87%
West Seep	RS-3	CR	2/2	1.38E-01	6.40E-02		5.00E-02	1.28E+00		3.71%
West Seep	RS-3	CU	1/2	9.39E-03	6.20E-03		5.00E-02	1.24E-01		0.36%
West Seep	RS-3	FL	2/2	2.77E+01	1.10E+01		5.00E+00	2.20E+00		6.37%
West Seep	RS-3	HG	2/2	1.44E-03	5.40E-04		5.00E-03	1.08E-01		0.31%
West Seep	RS-3	MO	2/2	6.52E-02	4.10E-02		5.00E-01	8.20E-02		0.24%
West Seep	RS-3	NI	2/2	1.39E-01	9.10E-02		5.00E-01	1.82E-01		0.53%
West Seep	RS-3	V	1/2	7.92E-02	2.53E-02		2.00E-01	1.27E-01	3.45E+01	0.37%
West Seep	RS-3A	AG	3/9	5.29E-03	6.40E-03		1.00E-01	6.40E-02		0.05%
West Seep	RS-3A	AL	10/10	1.27E+01	1.77E+01	37.60	2.00E-01	8.85E+01		73.71%
West Seep	RS-3A	AS	8/8	2.00E-02	2.36E-02		1.00E-03	2.36E+01		19.66%
West Seep	RS-3A	B	3/10	1.11E-01	1.18E-01		1.00E+00	1.18E-01		0.10%
West Seep	RS-3A	BE	4/9	1.11E-03	1.10E-03		5.00E-01	2.20E-03		0.00%

Table 6.1. (continued)

Subasin	Station	Analyte	Detection Frequency	UCL95	Maximum Detected Concentration	Background Quotient	Soil Solution Benchmark	Hazard Quotient	Hazard Index	Percent Contribution
West Seep	RS-3A	CD	2/8	1.71E-03	2.10E-03		1.00E-01	2.10E-02		0.02%
West Seep	RS-3A	CO	9/10	3.14E-02	3.63E-02		6.00E-02	6.05E-01		0.50%
West Seep	RS-3A	CR	10/10	8.39E-02	9.64E-02		5.00E-02	1.93E+00		1.61%
West Seep	RS-3A	CU	8/10	2.35E-02	2.76E-02		5.00E-02	5.52E-01		0.46%
West Seep	RS-3A	FE	10/10	9.84E+00	1.39E+01	12.20	1.00E+01	1.39E+00		1.16%
West Seep	RS-3A	FL	10/10	1.11E+01	1.21E+01		5.00E+00	2.42E+00		2.02%
West Seep	RS-3A	HG	9/9	1.00E-03	1.10E-03		5.00E-03	2.20E-01		0.18%
West Seep	RS-3A	MN	10/10	3.31E-01	5.31E-01	1.61	4.00E+00	1.33E-01		0.11%
West Seep	RS-3A	MO	10/10	5.19E-02	5.63E-02		5.00E-01	1.13E-01		0.09%
West Seep	RS-3A	NI	9/9	1.02E-01	1.08E-01		5.00E-01	2.16E-01		0.18%
West Seep	RS-3A	SE	1/7	5.41E-02	1.70E-03		7.00E-01	2.43E-03		0.00%
West Seep	RS-3A	SN	1/2	1.52E-01	5.22E-02		1.00E+02	5.22E-04		0.00%
West Seep	RS-3A	V	9/10	2.66E-02	3.43E-02		2.00E-01	1.72E-01	1.20E+02	0.14%
West Seep	RS-3B	AL	2/2	1.82E+00	1.42E+00	4.19	2.00E-01	7.10E+00		96.58%
West Seep	RS-3B	B	1/2	1.30E-01	3.36E-02		1.00E+00	3.36E-02		0.46%
West Seep	RS-3B	FE	2/2	1.16E+00	1.08E+00	1.34	1.00E+01	1.08E-01		1.47%
West Seep	RS-3B	FL	1/2	6.76E-01	5.48E-01		5.00E+00	1.10E-01	7.35E+00	1.50%
West Seep	SW6-2	AS	2/2	2.00E-03	2.00E-03		1.00E-03	2.00E+00		10.95%
West Seep	SW6-2	B	2/2	6.25E-02	6.20E-02		1.00E+00	6.20E-02		0.34%
West Seep	SW6-2	FE	1/1		1.55E+00	1.92	1.00E+01	1.55E-01		0.85%
West Seep	SW6-2	MN	1/1		1.76E+00	8.56	4.00E+00	4.40E-01		2.41%
West Seep	SW6-2	TL	1/1		3.11E-01		2.00E-02	1.56E+01	1.83E+01	85.45%
West Seep	SW7-1	BE	1/2	7.66E-04	4.00E-04		5.00E-01	8.00E-04		0.03%
West Seep	SW7-1	FE	3/3	7.65E+00	6.57E+00	8.15	1.00E+01	6.57E-01		27.72%
West Seep	SW7-1	FL	1/1		2.00E-01		5.00E+00	4.00E-02		1.69%
West Seep	SW7-1	MN	3/3	6.60E+00	6.40E+00	31.10	4.00E+00	1.60E+00		67.50%
West Seep	SW7-1	V	1/2	4.37E-02	1.45E-02		2.00E-01	7.25E-02	2.37E+00	3.06%
West Seep	SW7-2	AL	4/6	4.47E-01	6.52E-01	1.32	2.00E-01	3.26E+00		49.13%
West Seep	SW7-2	B	2/5	1.85E-01	1.43E-01		1.00E+00	1.43E-01		2.16%
West Seep	SW7-2	BE	1/4	9.19E-04	4.00E-04		5.00E-01	8.00E-04		0.01%
West Seep	SW7-2	CO	4/4	1.52E-01	1.42E-01		6.00E-02	2.37E+00		35.72%
West Seep	SW7-2	CU	1/5	1.69E-02	2.54E-02		5.00E-02	5.08E-01		7.66%
West Seep	SW7-2	FL	2/5	7.20E-01	8.32E-01		5.00E+00	1.66E-01		2.50%
West Seep	SW7-2	MN	5/5	2.12E-01	2.55E-01	1.03	4.00E+00	6.38E-02		0.96%
West Seep	SW7-2	V	1/4	2.14E-02	2.48E-02		2.00E-01	1.24E-01	6.64E+00	1.87%
West Seep	WSS-025	AG	1/1		5.00E-03		1.00E-01	5.00E-02		0.01%
West Seep	WSS-025	AL	1/1		9.70E+01	286.00	2.00E-01	4.85E+02		92.83%
West Seep	WSS-025	AS	1/1		1.00E-02		1.00E-03	1.00E+01		1.91%
West Seep	WSS-025	B	1/1		8.00E-02		1.00E+00	8.00E-02		0.02%

Table 6.1. (continued)

Subasin	Station	Analyte	Detection Frequency	UCL95	Maximum Detected Concentration	Background Quotient	Soil Solution Benchmark	Hazard Quotient	Hazard Index	Percent Contribution
West Seep	WSS-025	BE	1/1		5.80E-03		5.00E-01	1.16E-02		0.00%
West Seep	WSS-025	CD	1/1		5.00E-03		1.00E-01	5.00E-02		0.01%
West Seep	WSS-025	CO	1/1		4.60E-02		6.00E-02	7.67E-01		0.15%
West Seep	WSS-025	CR	1/1		1.30E-01		5.00E-02	2.60E+00		0.50%
West Seep	WSS-025	CU	1/1		5.30E-02		5.00E-02	1.06E+00		0.20%
West Seep	WSS-025	FE	1/1		9.80E+01	122.00	1.00E+01	9.80E+00		1.88%
West Seep	WSS-025	HG	1/1		4.10E-04		5.00E-03	8.20E-02		0.02%
West Seep	WSS-025	LI	1/1		1.30E-01		3.00E+00	4.33E-02		0.01%
West Seep	WSS-025	MN	1/1		2.50E+00	12.20	4.00E+00	6.25E-01		0.12%
West Seep	WSS-025	MO	1/1		4.00E-02		5.00E-01	8.00E-02		0.02%
West Seep	WSS-025	NI	1/1		1.20E-01		5.00E-01	2.40E-01		0.05%
West Seep	WSS-025	PB	1/1		3.20E-02	2.29	2.00E-02	1.60E+00		0.31%
West Seep	WSS-025	SE	1/1		5.00E-03		7.00E-01	7.14E-03		0.00%
West Seep	WSS-025	SN	1/1		5.00E-02		1.00E+02	5.00E-04		0.00%
West Seep	WSS-025	TI	1/1		5.40E-01		6.00E-02	9.00E+00		1.72%
West Seep	WSS-025	V	1/1		1.40E-01		2.00E-01	7.00E-01		0.13%
West Seep	WSS-025	ZN	1/1		2.60E-01	1.21	4.00E-01	6.50E-01	5.22E+02	0.12%
SWSA 5 Drainage D-2	05.SP007	AL	2/2	1.96E+01	5.80E+00	17.10	2.00E-01	2.90E+01		90.46%
SWSA 5 Drainage D-2	05.SP007	BE	1/2	1.36E-03	4.80E-04		5.00E-01	9.60E-04		0.00%
SWSA 5 Drainage D-2	05.SP007	CO	1/2	1.96E-02	6.40E-03		6.00E-02	1.07E-01		0.33%
SWSA 5 Drainage D-2	05.SP007	CR	1/2	1.90E-02	6.40E-03		5.00E-02	1.28E-01		0.40%
SWSA 5 Drainage D-2	05.SP007	FE	2/2	3.94E+01	1.68E+01	20.80	1.00E+01	1.68E+00		5.24%
SWSA 5 Drainage D-2	05.SP007	FL	1/1		1.00E-01		5.00E+00	2.00E-02		0.06%
SWSA 5 Drainage D-2	05.SP007	MN	2/2	4.89E+00	4.49E+00	21.80	4.00E+00	1.12E+00		3.49%
SWSA 5 Drainage D-2	05.SP007	NAPHTHALENE	2/3	1.32E-02	1.00E-02		1.00E+01	1.00E-03		0.00%
SWSA 5 Drainage D-2	05.SP007	TETRACHLOROETHENE	2/3	1.32E-02	1.00E-02		1.00E+01	1.00E-03		0.00%
SWSA 5 Drainage D-2	05.SP007	TOLUENE	2/3	1.32E-02	1.00E-02		1.00E+01	1.00E-03		0.00%
SWSA 5 Drainage D-2	05.SP007	XYLENE (TOTAL)	2/3	1.32E-02	1.00E-02		1.00E+02	1.00E-04	3.21E+01	0.00%
SWSA 5 Drainage D-2	05.SP014	AL	1/2	8.33E+00	2.29E+00	6.76	2.00E-01	1.15E+01		90.30%
SWSA 5 Drainage D-2	05.SP014	CO	1/2	8.85E-03	3.80E-03		6.00E-02	6.33E-02		0.50%
SWSA 5 Drainage D-2	05.SP014	FE	2/2	2.37E+01	8.21E+00	10.20	1.00E+01	8.21E-01		6.45%
SWSA 5 Drainage D-2	05.SP014	FL	2/2	1.05E-01	1.00E-01		5.00E+00	2.00E-02		0.16%
SWSA 5 Drainage D-2	05.SP014	MN	2/2	2.05E+00	1.15E+00	5.59	4.00E+00	2.88E-01		2.26%
SWSA 5 Drainage D-2	05.SP014	NAPHTHALENE	2/3	1.32E-02	1.00E-02		1.00E+01	1.00E-03		0.01%
SWSA 5 Drainage D-2	05.SP014	NI	1/2	2.52E-02	9.10E-03		5.00E-01	1.82E-02		0.14%
SWSA 5 Drainage D-2	05.SP014	TETRACHLOROETHENE	3/3	4.67E-02	3.50E-02		1.00E+01	3.50E-03		0.03%
SWSA 5 Drainage D-2	05.SP014	TOLUENE	2/4	1.09E-02	1.00E-02		1.00E+01	1.00E-03		0.01%
SWSA 5 Drainage D-2	05.SP014	V	1/2	9.51E-03	3.80E-03		2.00E-01	1.90E-02		0.15%
SWSA 5 Drainage D-2	05.SP014	XYLENE (TOTAL)	2/3	1.32E-02	1.00E-02		1.00E+02	1.00E-04	1.27E+01	0.00%

Table 6.1. (continued)

Subasin	Station	Analyte	Detection Frequency	UCL95	Maximum Detected Concentration	Background Quotient	Soil Solution Benchmark	Hazard Quotient	Hazard Index	Percent Contribution
SWSA 5 Drainage D-2	05.SP019	FL	1/1		2.00E-01		5.00E+00	4.00E-02		36.43%
SWSA 5 Drainage D-2	05.SP019	LI	1/1		2.00E-01		3.00E+00	6.67E-02		60.75%
SWSA 5 Drainage D-2	05.SP019	NAPHTHALENE	1/1		1.00E-02		1.00E+01	1.00E-03		0.91%
SWSA 5 Drainage D-2	05.SP019	TETRACHLOROETHENE	1/1		1.00E-02		1.00E+01	1.00E-03		0.91%
SWSA 5 Drainage D-2	05.SP019	TOLUENE	1/1		1.00E-02		1.00E+01	1.00E-03		0.91%
SWSA 5 Drainage D-2	05.SP019	XYLENE (TOTAL)	1/1		1.00E-02		1.00E+02	1.00E-04	1.10E-01	0.09%
SWSA 5 Drainage D-2	05.SW002	AL	3/10	5.27E-01	1.22E+00	1.56	2.00E-01	6.10E+00		51.32%
SWSA 5 Drainage D-2	05.SW002	AS	3/9	1.58E-03	2.20E-03		1.00E-03	2.20E+00		18.51%
SWSA 5 Drainage D-2	05.SW002	CR	7/13	4.67E-03	7.10E-03		5.00E-02	1.42E-01		1.19%
SWSA 5 Drainage D-2	05.SW002	CU	5/12	3.59E-03	5.30E-03		5.00E-02	1.06E-01		0.89%
SWSA 5 Drainage D-2	05.SW002	FE	13/15	5.82E+00	2.16E+01	7.22	1.00E+01	2.16E+00		18.17%
SWSA 5 Drainage D-2	05.SW002	FL	5/5	2.12E-01	2.00E-01		5.00E+00	4.00E-02		0.34%
SWSA 5 Drainage D-2	05.SW002	LI	3/3	2.00E-01	2.00E-01		3.00E+00	6.67E-02		0.56%
SWSA 5 Drainage D-2	05.SW002	MN	14/14	3.02E+00	4.07E+00	14.70	4.00E+00	1.02E+00		8.58%
SWSA 5 Drainage D-2	05.SW002	NAPHTHALENE	6/9	9.88E-03	1.00E-02		1.00E+01	1.00E-03		0.01%
SWSA 5 Drainage D-2	05.SW002	NI	6/10	1.89E-02	2.28E-02		5.00E-01	4.56E-02		0.38%
SWSA 5 Drainage D-2	05.SW002	SE	2/10	3.28E-03	1.60E-03		7.00E-01	2.29E-03		0.02%
SWSA 5 Drainage D-2	05.SW002	TETRACHLOROETHENE	6/12	1.13E-02	1.00E-02		1.00E+01	1.00E-03		0.01%
SWSA 5 Drainage D-2	05.SW002	TOLUENE	6/12	8.85E-03	1.00E-02		1.00E+01	1.00E-03		0.01%
SWSA 5 Drainage D-2	05.SW002	XYLENE (TOTAL)	6/12	8.85E-03	1.00E-02		1.00E+02	1.00E-04	1.19E+01	0.00%
SWSA 5 Drainage D-2	SW5-5	AL	1/2	2.12E+01	5.80E+00	17.10	2.00E-01	2.90E+01		89.79%
SWSA 5 Drainage D-2	SW5-5	B	1/1		1.75E-01		1.00E+00	1.75E-01		0.54%
SWSA 5 Drainage D-2	SW5-5	BE	1/2	1.49E-03	4.80E-04		5.00E-01	9.60E-04		0.00%
SWSA 5 Drainage D-2	SW5-5	CO	1/2	1.41E-02	6.40E-03		6.00E-02	1.07E-01		0.33%
SWSA 5 Drainage D-2	SW5-5	CR	1/2	1.68E-02	6.40E-03		5.00E-02	1.28E-01		0.40%
SWSA 5 Drainage D-2	SW5-5	FE	2/2	5.04E+01	1.68E+01	20.80	1.00E+01	1.68E+00		5.20%
SWSA 5 Drainage D-2	SW5-5	FL	2/2	1.04E-01	1.01E-01		5.00E+00	2.02E-02		0.06%
SWSA 5 Drainage D-2	SW5-5	MN	2/2	7.76E+00	4.49E+00	21.80	4.00E+00	1.12E+00		3.47%
SWSA 5 Drainage D-2	SW5-5	V	1/2	3.43E-02	1.30E-02		2.00E-01	6.50E-02	3.23E+01	0.20%
WOC	5NST	B	1/3	4.32E-02	3.89E-02		1.00E+00	3.89E-02		0.28%
WOC	5NST	BE	1/3	1.26E-03	6.00E-04		5.00E-01	1.20E-03		0.01%
WOC	5NST	TL	2/3	4.33E-01	2.72E-01		2.00E-02	1.36E+01		98.54%
WOC	5NST	V	1/3	4.05E-02	3.22E-02		2.00E-01	1.61E-01	1.38E+01	1.17%
WOC	SW2-3	BE	1/2	5.00E-04	5.00E-04		5.00E-01	1.00E-03		0.79%
WOC	SW2-3	V	1/2	8.25E-02	2.51E-02		2.00E-01	1.26E-01	1.27E-01	99.21%
WOC	SW2-4	AG	1/4	5.63E-03	3.00E-03		1.00E-01	3.00E-02		0.11%
WOC	SW2-4	AS	2/4	3.09E-03	3.00E-03		1.00E-03	3.00E+00		11.19%
WOC	SW2-4	B	2/4	7.53E-02	5.22E-02		1.00E+00	5.22E-02		0.19%
WOC	SW2-4	FE	3/3	1.24E+00	9.83E-01	1.22	1.00E+01	9.83E-02		0.37%

Table 6.1. (continued)

Subasin	Station	Analyte	Detection Frequency	UCL95	Maximum Detected Concentration	Background Quotient	Soil Solution Benchmark	Hazard Quotient	Hazard Index	Percent Contribution
WOC	SW2-4	FL	1/4	5.76E-01	1.41E-01		5.00E+00	2.82E-02		0.11%
WOC	SW2-4	HG	1/3	2.31E-04	2.00E-04		5.00E-03	4.00E-02		0.15%
WOC	SW2-4	MN	3/3	1.34E+01	1.06E+01	51.50	4.00E+00	2.65E+00		9.89%
WOC	SW2-4	TL	1/3	5.44E-01	4.17E-01		2.00E-02	2.09E+01	2.68E+01	77.99%

Table 6.2. Summary of Potential Risks to Plants Exposed to Contaminants in Soil in the White Oak Creek Watershed

		Hazard quotients for risk driving analytes													
Subbasin	**Hazard Index**	**Ag**	**As**	**Cd**	**Co**	**Cr**	**Cu**	**Hg**	**Mo**	**Ni**	**Sb**	**Se**	**Sn**	**Tl**	**Zn**
IntermediatePond	287.0	8.7						255.0	2.6	10.3					6.6
SWSA 4 Main	267.6									262.0		2.0			2.4
Lower WOC	150.0	3.4				116.0		17.0	2.0			1.3			8.2
HRE	110.5			1.1		104.0									4.8
WOC	53.7	12.6					1.6	16.0	2.0			1.6			18.2
SWSA 5 Trib 1	20.6	1.6						14.3				3.3			
SWSA 5 Seep C	15.2	2.5			2.6				3.7		2.4			1.4	
SWSA 5 Seep A	13.8	1.1										5.1			6.4
SWSA 5 Seep B West	11.7							6.7	1.7		1.2	1.3			
SWSA 5 WOC	10.6	1.1						3.2				1.7			2.4
West Seep	9.6	1.4		1.7	2.0					2.3			1.7		
SWSA 6 East	6.9			1.8						2.0					2.6
Pit 4 South	5.8								2.1			1.2		1.2	
W6MS3	5.4	1.8	1.5	1.4											
W6MS1	5.4		1.3	1.6						2.2					
East Seep	4.3											1.2		2.5	
SWSA 6 South	4.2		2.2	1.1											
SWSA 5 N WOC	2.5	1.1										1.4			
SWSA 5 Drainage D-2	1.6	1.1													

Notes:
Abbreviations: Ag = silver, As = arsenic, Cd = cadmium, Co = cobalt, Cr = chromium, Cu =copper, Hg = mercury, Mo = molybdenum, Ni = nickel, Sb = antimony, Se = selenium, Sn = tin, Tl = thallium, Zn = zinc
Risk driving analytes = any detected contaminant present above background concentrations that contributes a HQ above 1.

Table 6.3. Summary of risks to plants from contaminants in seeps in White Oak Creek subbasins

Subbasin	Station ID	Hazard Index	Hazard quotients for risk driving analytes											
			Al	As	B	Co	Cr	Cu	Fe	Fl	Mn	Ni	Pb	Tl
East Seep	SW7-4	16.7									1.9			**14.5**
	SW7-3	11.7	3.9	**4.2**			1.8							
	SW7-7	8.6												**8.1**
	SW7-8	2.1	2.1											
HF-2	05.SW005	224.0	**202.0**	3.1			2.9	2.4	5.4		1.8	1.3	3.3	
HRE	05.SW004	98.2	**88.5**	3.6			1.2		2.9		1.4			
	SW9-2	9.2	**7.3**											
	SW9-1	1.3								1.1				
Intermediate Pond	WCTRIB-4	14.0												**13.6**
	WAG4 T2A	6.8	5.0											
Lower WOC	SW2-5	27.1												**25.6**
	SW7-5	25.5	**19.0**	1.0				1.0						3.0
	SW6-1	24.8							1.5					**22.5**
	WCTRIB-1	18.6	4.8											**13.4**
	05.SW006	18.5	**17.5**											
	WSTRIB-1	17.5												**17.3**
	MBTRIB-3	16.8												**16.6**
	SW2-7	3.9		1.4					**1.7**					
MV Drive	5NNT	17.2	**12.0**	1.0										3.3
PIT4/South	East Seep	197.0	**150.0**	28.2	2.0				3.6	2.1				7.8
SWSA 5 Seep A	05.SP016	63.9	**61.5**						1.4					
	05.SW003	46.3	**44.5**											
	SW5-6	35.4	6.8								2.0			**25.3**
	SW5-9	31.9	3.6	3.0							1.3			**21.9**
	SW5-8	24.5									1.2			**22.0**
	05.SP017	9.9	1.9	**3.6**					1.7		2.6			
	05.SP009	9.6	**6.8**	2.2										
	SW5-7	6.7		**3.0**							2.2			
SWSA 5 Seep C	SW5-3	15.2	**11.5**							3.2				
	05.SP005	11.8	**11.5**											
	SW5-4	6.3		**3.0**							1.4			
SWSA 5 Trib 1	SW5-1	45.1	18.1	3.5							1.4			**21.0**
	05.SW001	24.3	**20.2**	3.7										
	05.SP003	23.3	**18.1**	3.5										
	05.SP015	8.3				**4.9**					2.0			
SWSA 5/WOC	05.SP004	8.6	**6.0**	2.3										
	SW5-2	6.7	**6.0**											
SWSA4main	SCS1B	53.9		**50.0**									2.5	
	SW4-1	30.2		6.2					2.9	3.1				**16.6**
	SW4-2	21.5										**18.9**		
	WAG4 MS1	19.6									**1.6**			**16.7**
	W4TRIB-5	12.6	**10.6**							1.5				
	W4TRIB-7	2.1									**1.4**			
SWSA5N/WOC	5NW-2	6.7	**4.9**								1.3			
	5NW-1	2.6	**2.2**											

Table 6.3. (continued)

Subbasin	Station ID	Hazard Index	Hazard quotients for risk driving analytes										
			Al	As	B	Co	Cr	Cu	Fe	Fl	Mn	Ni	Pb	Tl
	WAG6 MS3A	20.5		3.0							1.5			**15.6**
	WAG6 MS3A-1	13.2		2.8							1.5			**8.7**
	ETF-14	8.6						**8.6**						
W6MS1	WAG6 MS1-1	22.7		4.0							3.1			**15.3**
	WAG6 MS1	20.5												**19.2**
	FRENCH DR S	10.8												**10.7**
	FRENCH DRAIN	10.8												**10.7**
	WAG6 MS2	8.4												**8.1**
WCTRIB-1	SW7-6	3.9	**3.8**											
West Seep	WSS-025	522.0	**485.0**	10.0			2.6	1.1	9.8				1.6	9.0
	RS-3A	120.0	**88.5**	23.6			1.9		1.4	2.4				
	RS-3	34.5	7.9	**22.0**			1.3			2.2				
	RS-1	29.1		**14.0**							1.8			1.3
	SW6-2	18.3		2.0										**15.6**
	RS-3B	7.4	**7.1**											
	SW7-2	6.6	**3.3**			2.4								
	SW7-1	2.4									**1.6**			
SWSA 5 Drainage D-2	SW5-5	32.3	**29.0**						1.7		1.1			
	05.SP007	32.1	**29.0**						1.7		1.1			
	05.SP014	12.7	**1.2**											
	05.SW002	11.9	**6.1**	2.2					2.2		1.0			
WOC	SW2-4	26.8		3.0							2.7			**20.9**
	5NST	13.8												**13.6**

7. RISKS TO TERRESTRIAL WILDLIFE

Risks from radionuclides and nonradionuclides (e.g., organic and inorganic chemicals) were estimated for small mammals and wide-ranging wildlife species within the WOCW. Because the methods for risk estimation differ between radionuclide and nonradionuclide contaminants, each is addressed separately. Risks from exposure to radionuclides are discussed in Chapter 9.

7.1 EXPOSURE ASSESSMENT

Wildlife may be exposed to contaminants through ingestion of food, soil and water. In this assessment, exposure through ingestion of food, soil, and water was estimated using exposure models (described in the following paragraphs). Exposure through water for terrestrial wildlife was assessed by comparing unfiltered water concentrations to water benchmarks for wildlife (see Sect 7.2.1). Contaminant exposure through ingestion was estimated for small mammals (short-tailed shrew and white-footed mouse) and wide-ranging species (white-tailed deer, wild turkey, red-tailed hawk, red fox, and mink). Soil-related ingestion exposures and combined watershed-wide water- and soil-related exposures for mink are addressed in this section; water-related ingestion exposures for mink are addressed with the other piscivores in Sec. 8. Exposure estimates were calculated using soil and soil-biota uptake factors for small mammals, earthworms, and plants. Uptake factors for small mammals and plants were derived from data from 15 locations within the Bear Creek watershed (four within BCOU1 and 11 within the Bear Creek floodplain). Uptake factors for earthworms were derived from data from Bear Creek, WAG 5 and 2 locations within WAG 2. When measured data on uptake factors were unavailable, values were derived from available literature.

7.1.1 Oral Ingestion Exposure Model

Oral exposure to contaminants experienced by terrestrial wildlife may come from multiple sources. They may consume contaminated food (either plant or animal), drink contaminated water, or ingest soil or sediment. Soil or sediment 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:

$$E_{total} \approx E_{food} + E_{water} + E_{soil} \quad (1)$$

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 Sample et al. (1996a), 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:

$$E_j = \sum_{i=1}^{m} p_{ik}\left(\frac{IR_i \times C_{ijk}}{BW}\right) \quad (2)$$

where:

E_j = total exposure to contaminant (j) (mg/kg/d)
m = total number of ingested media (e.g., food, soil, or water)
IR_i = consumption rate for medium (i) (kg/d or L/d)
p_{ik} = proportion of type (k) of medium (i) consumed (unitless)
C_{ij} = concentration of contaminant (j) in type (k) of medium (i) (mg/kg or mg/L)
BW = body weight of endpoint species (kg)

Exposure estimates were calculated for all contaminants detected in soil or water from the WOCW. Because wildlife are mobile, their exposure is best represented by the mean contaminant concentration in media. To be conservative, the lower of the 95% upper confidence limit (UCL) and the maximum detected concentration was used in exposure estimates. These data were used in the initial exposure estimates. Exposure estimates for contaminants that may potentially present a risk to wildlife (based upon comparisons to LOAELs) were reevaluated using Monte Carlo simulations.

7.1.2 Uptake Factors

Contaminant concentrations in biota were not available for the WOCW. To estimate contaminant concentrations in biota, soil-to-tissue uptake factors developed as part of the Bear Creek Valley RI were used. Uptake factors for small mammals and plants were developed exclusively with data from the Bear Creek assessment. In addition to the Bear Creek data, data from two samples in WAG 2 and 6 from WAG 5 were used to develop the earthworm uptake factors Uptake factors for plants are available in Efroymson et al. (1996b); uptake factors for earthworms and small mammals are available in Sample et al. (1996b). When ORR-specific uptake factors were available from Efroymson et al. (1996b) or Sample et al. (1996b), contaminant concentrations in biota were estimated by multiplying the biota type-specific uptake factor by the soil concentration:

$$C_{tissue} = UF_i \quad C_{soil} \tag{3}$$

where:

UF_i = Soil-to-tissue uptake factor for plant, worm, or wildlife receptor (unitless)
C_{soil} = Concentration of chemical *i* in soil (mg/kg)

When ORR-specific soil-to-tissue uptake factors were unavailable, literature-derived uptake factors were used. For plants and soil invertebrates, equation 3 was used to estimate tissue concentrations. However, literature-derived uptake factors for small mammals were food-to-tissue uptake factors, not soil-to-tissue. Therefore, small mammal tissue concentrations were estimated by multiplying the food-to-tissue uptake factor by the concentration in plant or invertebrate food consumed by the small mammal:

$$C_{tissue} = BAF_i \ (C_{ij} \quad P_j + C_{soil} \quad P_{soil}) \tag{4}$$

where:

BAF_i = Food-to-tissue uptake factor for chemical *i*. (mg/kg tissue over mg/kg food)
C_{ij} = Concentration of chemical *i* in food type *j* (mg/kg)
P_j = Proportion of food type *j* in small mammal's diet (unitless)
C_{soil} = Concentration of chemical *i* in surface soil.

P_{soil} = Proportion of soil in small mammal diet. (unitless)

Uptake factors used in this assessment are provided in Table 7.1. It was assumed that contaminant uptake from ingested food and soil was similar.

7.1.3 Contaminant Concentrations in Media

Soil and water data were aggregated into subbasins within the WOCW. Subbasins were identified based on drainage patterns and relation to potential sources. Figure 1.1 portrays the relative location of all identified subbasins within the watershed. Summary statistics for contaminants detected in soil from each subbasin in the WOCW are presented in Table 5.2 and in Attachment A of Appendix B of this RI report. Surface water data are also presented in Attachment A of Appendix B.

7.1.4 Exposure Modeling using Point-Estimates

Initial estimates of exposure of terrestrial wildlife to contaminants were performed for each of the subbasins using point estimates of parameters in the exposure model. Species-specific parameters necessary to estimate exposure using Eq. 2 are listed in Tables 7.2 through 7.8.

To estimate contaminant exposure experienced by short-tailed shrew, the following assumptions were made:

- body weight = 0.015 kg
- food consumption = 0.009 kg/d (fresh weight)
- soil consumption = 0.00117 kg/d (dry weight)
- water consumption = 0.033 L/d
- diet consists 100% of earthworms or soil invertebrates.
- contaminant concentration in earthworms is representative of that in other invertebrate prey.

To estimate contaminant exposure experienced by white-footed mouse, the following assumptions were made:

- body weight = 0.022 kg
- food consumption = 0.0034 kg/d (fresh weight)
- soil consumption = 0.000068 kg/d (dry weight)
- water consumption = 0.0066 L/d
- diet consists 50% of earthworms or soil invertebrates and 50% herbaceous plant material.
- contaminant concentration in earthworms is representative of that in other invertebrate prey.

To estimate contaminant exposure experienced by white-tailed deer, the following assumptions were made:

- body weight = 56.5 kg
- food consumption = 1.74 kg/d (fresh weight)
- soil consumption = 0.0348 kg/d (dry weight)
- water consumption = 3.7 L/d

To estimate contaminant exposure experienced by red fox, the following assumptions were made:

- body weight = 4.5 kg
- food consumption = 0.45 kg/d (fresh weight)
- soil consumption = 0.0126 kg/d (dry weight)
- water consumption = 0.38 L/d
- diet consists 80.8% of small mammals and birds, 10.4% plant material, and 8.8% earthworms or other invertebrates
- contaminant concentration in small mammals is representative of that in other vertebrate prey.
- contaminant concentration in earthworms is representative of that in other invertebrate prey.

To estimate contaminant exposure experienced by red-tailed hawk, the following assumptions were made:

- body weight = 1.126 kg
- food consumption = 0.109 kg/d (fresh weight)
- soil consumption = 0 kg/d (dry weight)
- water consumption = 0.064 L/d
- diet consists 100% of small mammals and other vertebrates
- contaminant concentration in small mammals is representative of that in other vertebrate prey.

To estimate contaminant exposure experienced by mink, the following assumptions were made:

- body weight = 1 kg
- food consumption = 0.137 kg/d (fresh weight)
- water consumption = 0.099 L/d
- diet consists 54.6% of fish or other aquatic prey and 45.4% small mammals.
- contaminant concentration in small mammals is representative of that in other terrestrial vertebrate prey.
- contaminant concentration in fish is representative of that in other aquatic prey.

To estimate contaminant exposure experienced by wild turkey, the following assumptions were made:

- body weight = 5.8 kg
- food consumption = 0.174 kg/d (fresh weight)
- soil consumption = 0.0162 kg/d (dry weight)
- water consumption = 0.19 L/d
- diet consists 90.3% of plant material, and 9.7% invertebrates
- contaminant concentration in earthworms is representative of that in other invertebrate prey.

Using Equation 2 and the assumptions and data described above, point estimates of exposure to contaminants within each of the subbasins within the watershed were estimated for each endpoint (Tables 7.9 through 7.15).

7.1.5 Exposure Modeling using Monte Carlo Simulations

Employing point estimates for the input parameters in the exposure model does not take into account the variation and uncertainty associated with the parameters and therefore may over- or

underestimate the contaminant exposure that endpoints may receive. In addition, calculating the model using point estimates produces a point estimate of exposure. This estimate provides no information concerning the distribution of exposures or the likelihood that individuals within the watershed will actually experience potentially hazardous exposures. To incorporate the variation in exposure parameters and to provide a better estimate of the potential exposure experienced by wildlife in the WOCW, the exposure model was re-calculated using Monte Carlo simulations.

Monte Carlo simulation is a resampling technique frequently used in uncertainty analysis in risk assessment (Hammonds et al. 1994). In practice, distributions are assigned to input parameters in a model, and the model is recalculated many times to produce a distribution of output parameters (e.g., estimates of contaminant exposure). Each time the model is recalculated, a value is selected from within the distribution assigned for each input parameter. As a result, a distribution of exposure estimates is produced that reflects the variability of the input parameters.

For all endpoints, Monte Carlo simulations were performed for the entire WOCW area. The percentiles of the resulting exposure distributions represent the likelihood that an individual within the modeled area will experience a given exposure level. It was assumed that each subbasin contributed equally to the overall mean exposure (i.e., individuals within the watershed do not preferentially forage at any one location within a subbasin). While this assumption is not likely to be ecologically correct (foraging effort and therefore exposure is likely to be biased toward those locations with the most abundant food), data were not available to estimate preferential use among subbasins. For short-tailed shrews and white-footed mice, species with small home ranges for which an individual subbasin is a relevant scale to address populations, Monte Carlo simulations were performed for individual subbasins.

Simulations were performed for each contaminant where comparison of point estimates of exposure to LOAELs produced HQs≥1 for at least one subbasin (LOAELs are discussed in Sect 7.2.; results of screening of exposure estimates against LOAELs are discussed in Sect. 7.3.).

Distributions were used for the following parameters in the exposure model: contaminant concentrations in soil and soil-biota uptake factors. Distributions for soil contaminant concentrations were identified as normal or lognormal using the UNIVARIATE procedure in SAS (SAS 1990). When sample sizes were adequate (>6 observations), the Shapiro-Wilk test (Shapiro and Wilk 1965) was used to determine whether a normal or lognormal distribution provided the best fit of the data. For small sample sizes or data with no variation, a normal distribution was assumed. Distributions for soil-to-biota uptake factors were obtained from Efroymson et al. (1996b) and Sample et al. (1996b).

Monte Carlo simulations were performed using Crystal Ball software (Decisioneering 1996). Samples from each distribution were selected using latin hypercube sampling. The number of model iterations performed for each exposure estimate was set at 1000.

7.2 CHEMICAL EFFECTS ASSESSMENT FOR WILDLIFE

7.2.1 Single Chemical Toxicity Data

Single chemical toxicity data consist of no observed adverse effects levels (NOAELs) and lowest observed adverse effects levels (LOAELs) of toxicity studies reported in the literature. NOAELs and LOAELs for wildlife endpoints were estimated from these data using the allometric

methods outlined in Sample et al. (1996a). This methodology for toxicity extrapolation 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. Using the allometric scaling factor recommended in EPA (1995), the equation for estimating mammalian LOAELs was:

$$LOAEL_w = LOAEL_t \left(\frac{bw_t}{bw_w} \right)^{1/4} \quad (5)$$

where $LOAEL_t$ and $LOAEL_w$ represent LOAELs for a mammalian test species and a wildlife species, respectively. Toxicity values for birds were estimated using the scaling factor derived from Mineau (1996) where:

$$LOAEL_w = LOAEL_t \left(\frac{bw_t}{bw_w} \right)^{0} = LOAEL_t\ (1) = LOAEL_t \quad (6)$$

To evaluate the potential risk that contaminants in water may present, water benchmarks were derived according to the methods outlined in Sample et al. (1996a). Water benchmarks represent the concentration of a contaminant in water (C_w, in mg/L) that would result in a dose equivalent to a $NOAEL_w$ or $LOAEL_w$. NOAEL's and LOAEL's and water benchmarks were derived for all seven endpoints. Experimental information used to estimate avian and mammalian benchmarks and NOAEL's and LOAEL's for avian and mammalian endpoints are available in Sample et al. (1996a).

Toxicological profiles for analytes of concern are provided in the attachment of this appendix.

7.2.2 Biological Surveys

7.2.2.1 Mink survey

Stevens (1995) investigated bioaccumulation of mercury in mink on the ORR in 1993 through 1995. The methods used in the mink survey, while indicating that mink are present on the Reservation, cannot be used to estimate abundance or density of mink on the ORR. A total of four male mink were live-trapped over the course of 6073 trapnights (trapnight=1 trap set for 24 h). One juvenile was captured along East Fork Poplar Creek, two adults were captured along Bear Creek, and one adult was captured along WOC. Captured mink were fitted with an intraperitoneal radio transmitter (to monitor movements and home range) and released. Prior to release samples of hair were collected for metals analysis. An additional 8 roadkilled mink (5 male and 3 female) were collected from the ORR and surrounding areas of Roane and Anderson counties. While one roadkill sample (a male) was collected on a bridge over Bear Creek and was assumed to be a resident of Bear Creek, all others were collected off the ORR and were used as references. Results of metals analysis are presented in Table 7.16.

Radiotelemetry data on home ranges and movements were obtained for 3 mink - one each from the East Fork Poplar Creek, Bear Creek, and WOC watersheds. Mean (± standard deviation) home range for these three individuals was found to be 7.5±3 km of stream. The home range of the WOC mink included all of WOC from the headwater tributaries to the Clinch River, including the X-10 facility. This individual was observed to use dens within the X-10 facility and moved through the facility on several occasions.

7.3 CHARACTERIZATION OF CHEMICAL RISKS TO WILDLIFE

Risk Characterization integrates the results of the exposure assessment (Sect. 7.1) and effects assessment (Sect. 7.2) 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. In an ideal risk assessment there are three lines of evidence: literature-derived single chemical toxicity data (which indicate the toxic effects of the concentrations measured in site media); biological surveys of the affected system (these indicate the actual state of the receiving environment); and toxicity tests with ambient media (these indicate the toxic effects of the concentrations measured in site media). With the exception of the biosurvey data for mink (Sect 7.2.2), only one line of evidence, single chemical toxicity data, was available to assess risk to wildlife in the WOCW.

7.3.1 Single Chemical Toxicity Data

Exposure estimates generated by the exposure model (see Sect. 7.1) produced by both point estimates of parameter values and Monte Carlo simulation represent exposure at the individual level. The exposure estimates using point estimates of parameter values at each subbasin are used to identify COPECs and locations that contribute significantly to risk. In contrast, the WOCW-wide exposure distributions generated by Monte Carlo simulation represent the likelihood that an individual within the watershed will experience a particular exposure.

Two types of single chemical toxicity data are available with which to evaluate wildlife contaminant exposure: NOAELs and LOAELs. In this baseline assessment, the evaluation is based on comparison to LOAELs. LOAELs are compared to the exposure distribution generated by the Monte Carlo simulation. If the LOAEL is lower than the 80th percentile of the exposure distribution, there is a >20% likelihood that individuals within the modeled location are experiencing contaminant exposures that are likely to produce adverse effects. By combining measured or literature-derived population density data with the likelihood or probability of exceeding the LOAEL, the magnitude of population-level impacts may be estimated.

7.3.1.1 Screening point estimates of exposure

To determine if the contaminant exposures experienced by wildlife in each subbasin and throughout the WOCW are potentially hazardous, the dietary contaminant exposure estimates (generated using point estimates of parameter values) were compared to estimated NOAELs and LOAELs for these species (Sample et al. 1996a). To quantify the magnitude of hazard, a hazard quotient (HQ) was calculated where: HQ = exposure/LOAEL. Hazard quotients greater than 1 indicate that individuals may be experiencing exposures that are in excess of LOAELs. While exceeding the NOAEL suggests that adverse effects are possible, exceeding the LOAEL suggests that adverse effects are likely. Hazard quotients for all endpoints are presented along with the point estimates of exposure in Tables 7.9 through 7.15 for all instances where the NOAEL- or LOAEL-based HQ was greater than 1.0.

Mercury was the dominant contaminant presenting risks to terrestrial wildlife in the WOCW. Mercury exposure in the WOCW exceeded LOAELs for all endpoints within at least one subbasin and in as many as six subbasins for the shrew (Tables 7.17 through 7.23). The next most important contaminants presenting risks were PCBs, presenting risks to shrews, mice, and fox (Table 7.17 through 7.19). Other analytes presenting likely risks were chromium (shrew, mouse, fox); barium (shrew, fox, deer); arsenic (shrew and mouse); zinc (shrew, hawk); nickel (shrew, mouse, fox, hawk,

deer, turkey, and mink); and cadmium, copper, molybdenum, and selenium (shrew). With the exception of short-tailed shrews, only one to at most five contaminants were identified as presenting risks to any endpoint. In the case of shrews, 12 contaminants resulted in potentially significant risks (Table 7.17).

Tables 7.17 through 7.23 display the sum of the LOAEL-based HQs (e.g., sum of toxic units or HI) for those contaminants where at least one LOAEL-based HQ>1 was obtained. For all endpoint species, the greatest risks were identified in the mainstem of WOC. The highest HIs are in the Intermediate Holding Pond subbasin. The WOC and Lower WOC subbasins also result in relatively high HIs, all primarily due to mercury contamination. The HF-2 subbasin in the HFIR basin along Melton Branch results in high HIs due to chromium, barium, and zinc. HIs decline with increasing distance downstream in the mainstem of WOC (Intermediate Holding Pond > WOC > Lower WOC). The high HI for SWSA 4 Main is caused by the extremely high nickel concentrations at WAG 4 Seep 6 and probably represents a hot spot rather than widespread contamination.

The following paragraphs in this subsection provide a subbasin by subbasin description of risk results for exposure of terrestrial wildlife to contaminants in surface soil.

HFIR BASIN

HF-2 Subbasin. Risks to terrestrial biota were evaluated for nonradionuclides in soil in the HF-2 subbasin. Likely risks were identified for short-tailed shrews, white-footed mice, red fox, white-tailed deer, and red-tailed hawk (Tables 7.17 through 7.21). Inorganics contributed 100% of the HI for all receptors. HQs exceeding one were estimated for four (chromium, barium, zinc, and molybdenum) for shrews, two (chromium and barium) for foxes, and one for mice, deer, and hawks (chromium, barium, and zinc, respectively). With the exception of chromium, most exceedances of toxicological benchmarks were relatively low (less than a factor of 3.8). This subbasin was not a major contributor to the estimated watershed-wide population effects for shrews exposed to molybdenum.

Chromium was the primary risk driver for shrews, mice, and foxes, contributing 51-99% of the HI for each. Chromium was detected in both of the soil samples collected at HF-2, but at levels higher than background in only one, and then at a concentration only about twice as high (168 mg/kg for HF-2 versus 78 mg/kg background). The analytical data did not specify the valence state of the chromium. Chromium (VI) is more toxic and bioavailable than chromium (III) (Will and Suter 1995b), but in most soils chromium (VI) is likely to be reduced to chromium (III) (Will and Suter 1995b). However, the toxicological benchmark used to estimate effects of chromium is based on chromium (VI) studies. The use of the benchmark for the more toxic and available chromium (VI) when exposures may be predominantly from chromium (III) may lead to overestimation of the risks of adverse effects. Terrestrial wildlife exposures to chromium were below the NOAEL for chromium (III) for all receptors.

SWSA 5 Seep A Basin

Seep A Subbasin. Risks to terrestrial biota were evaluated for nonradionuclides in soil in the Seep A subbasin. Likely risks from nonradionuclides were identified for short-tailed shrews (HI = 6.9), but no risks were identified for any other receptors (HIs < 1). Inorganics contributed >90% of the HI for all receptors. HQs exceeding one were estimated for two analytes (selenium and zinc) for shrews (Table 7.17). This subbasin was the major contributor to the estimated watershed-wide population effects for shrews exposed to selenium.

HRE

Risks to terrestrial biota were evaluated for exposure to nonradionuclides in soil in the HRE subbasin. Likely risks were identified for shrews and mice (Tables 7.17 and 7.18). HQs exceeding one were estimated for three analytes for shrews (barium, chromium, and PCBs) and one for mice (chromium). Barium and PCBs were not predicted to result in population level effects within the subbasin for shrews or mice, but chromium was predicted to result in population level effects on shrews and mice within the subbasin and in watershed-wide effects on shrews. However, while chromium was the primary risk driver in this subbasin, it was detected at only 1.3 times background. The analytical data did not specify the valence state of the chromium. Chromium (VI) is more toxic and bioavailable than chromium (III) (Will and Suter 1995a), but in most soils chromium (VI) is likely to be reduced to chromium (III). The toxicological benchmarks used in this assessment were based on chromium (VI) studies. The use of benchmarks for the more toxic and available chromium (VI) when exposures may be predominantly from chromium (III) may lead to overestimation of risks. Exposures were below NOAELs for chromium (III) for all receptors. Therefore, while risks to individuals are possible in this subbasin due to barium, chromium, and PCBs, these analytes probably do not represent a significant concern at the population level.

SWSA 5 Seep B Basin

Seep B West Subbasin. Risks to terrestrial biota were evaluated for nonradionuclides in soil in the Seep B West subbasin. Likely risks from nonradionuclides were identified for short-tailed shrews, white-footed mice, red fox, red-tailed hawk, and mink (Table 7.17 through 7.19, 7.21, and 7.23). Inorganics contributed >99% of the HI for all receptors. HQs exceeding one were estimated for three analytes for shrews (mercury, selenium, and molybdenum) and one (mercury) for mice, fox, hawk, and mink. While not as significant as the Intermediate Holding Pond, this subbasin was a significant contributor to estimated watershed-wide risks to shrews and foxes from exposure to mercury. It is also a contributor to estimated watershed-wide risks to shrews from exposure to selenium.

Seep B East Subbasin. Risks to terrestrial biota were evaluated for nonradionuclides in soil in the Seep B East subbasin. Likely risks from nonradionuclides were only identified for short-tailed shrews (Table 7.17). While PCB-1260 contributed >72% of the HI for the shrew and was the only analyte resulting in a HQ exceeding one, this subbasin was not a major contributor to estimated watershed-wide risks to shrews from exposure to PCB-1260.

SWSA 5 Drainage D-2

SWSA 5 Drainage D-2 Subbasin. Risks to terrestrial biota were evaluated for nonradionuclides in soil in the SWSA 5 Drainage D-2 subbasin. Likely risks were identified for short-tailed shrews, white-footed mice, and red fox from exposure to nonradionuclides (Table 7.17 through 7.19). The organic PCB-1260 was the risk driver for all three receptors, contributing >90% of the HI. The PCB-1260 HQ for the shrew was 19.0. This subbasin was the primary contributor to the watershed-wide risks estimated for shrews from exposure to PCB-1260. PCB-1260 was detected in 2 of 5 samples within the subbasin.

SWSA 5 Seep C Basin

Seep C Subbasin. Risks to terrestrial biota were evaluated for nonradionuclides in soil in the Seep C subbasin. Likely risks from nonradionuclides were identified for short-tailed shrews

(Table 7.17). Inorganics contributed >99% of the HI. HQs exceeding one were estimated for three inorganics for shrews (molybdenum, barium, and selenium). This subbasin was the primary contributor to estimated watershed-wide risks to shrews from exposure to molybdenum.

MWOC/East Basin

SWSA 5 Tributary 1. Risks to terrestrial biota were evaluated for nonradionuclides in soil in the SWSA5 Trib-1 subbasin. Likely risks from nonradionuclides were identified for short-tailed shrews and red fox (Table 7.17 and 7.19). Inorganics contributed >84% of the HI for both receptors. HQs exceeding one were estimated for two inorganics for shrews (mercury and selenium) and one for red fox (mercury). Mercury was the primary risk driver for all receptors, accounting for 40% of the shrew HI, and 73% of the fox HI.

SWSA 5 WOC. Risks to terrestrial biota were evaluated for nonradionuclides in soil in the SWSA 5 WOC subbasin. Likely risks were identified for short-tailed shrews (Table 7.17) from exposure to nonradionuclides. Inorganics contributed >86% of the HI. HQs exceeding one were estimated for two inorganics (mercury and selenium) for shrews. Exceedances of toxicological benchmarks were relatively low (less than a factor of 1.2).

SWSA 5 N WOC. Risks to terrestrial biota were evaluated for nonradionuclides in soil in the SWSA 5 N WOC subbasin. Likely risks were identified for short-tailed shrews from exposure to nonradionuclides (Table 7.17). Inorganics contributed >99% of the HI. Only selenium resulted in a HQ exceeding one for the shrew, and the exceedance of the toxicological benchmark was low (HQ = 1.8), but this subbasin was an important contributor to the estimated watershed-wide risks to shrews from exposure to selenium in soil.

MWOC/West Basin

Intermediate Pond. Risks to terrestrial biota were evaluated for nonradionuclides in soil in the Intermediate Pond subbasin. Likely risks from nonradionuclides were identified for short-tailed shrews, white-footed mice, red fox, white-tailed deer, red-tailed hawk, wild turkey, and mink (Tables 7.17 through 7.23). Inorganics contributed >98% of the HI for all receptors. HQs exceeding one were estimated for four inorganics for shrews (mercury, molybdenum, nickel, and zinc) and one (mercury) for mice, fox, deer, hawk, turkey, and mink. The organic, PCB-1260, was an additional risk driver for shrews with a HQ of 4.6. The Intermediate Holding Pond was the primary contributor to estimated watershed-wide risks to shrews and foxes from exposure to mercury. It is also an important contributor to estimated watershed-wide risks to shrews from exposure to PCB-1260 and molybdenum.

SWSA 4 Main. Risks to terrestrial biota were evaluated for exposure to nonradionuclides in soil in the SWSA 4 Main subbasin. Likely risks were identified for all receptors (Tables 7.17 through 7.23). HQs exceeding one were estimated for three analytes for shrews (barium, nickel, and selenium) and one for all other receptors (nickel). Barium, nickel, and selenium were all predicted to result in population level effects on shrews within the subbasin, and nickel was predicted to result in within basin population level effects for mice. This subbasin was the primary reason for a predicted watershed-wide effect on shrews from exposure to nickel and an important contributor to predicted watershed-wide effects on shrews from exposure to selenium.

While nickel was the primary risk driver for wildlife in the subbasin, it should be noted that the results are driven by the high nickel concentration (7860 mg/kg) at one sample location

(WAG4Seep6). The highest concentration at two other locations in the subbasin was 49.6 mg/kg, suggesting that risks from nickel are spatially limited within the subbasin. Therefore, watershed-wide effects on shrews from exposure to nickel are not likely.

WAG 7 WOC. Risks to terrestrial biota were evaluated for exposure to nonradionuclides in soil in the WAG 7 WOC subbasin. No risks were identified for wildlife receptors; estimated exposures were below LOAELs for all receptors.

WOC Subbasin. Risks to terrestrial biota were evaluated for nonradionuclides in soil in the WOC subbasin. Likely risks from nonradionuclides were identified for short-tailed shrews, white-footed mice, red fox, red-tailed hawk, wild turkey, and mink (Tables 7.17 through 7.19 and 7.21 through 7.23). Inorganics contributed >89% of the HI for all receptors. HQs exceeding one were estimated for five inorganics for shrews (mercury, zinc, molybdenum, copper, and selenium), two for red-tailed hawks (mercury and zinc), and one (mercury) for mice, fox, turkey, and mink. This subbasin was second to the Intermediate Holding Pond in contribution to estimated watershed-wide risks to shrews and foxes from exposure to mercury. Mercury accounted for >65% of the HI for wildlife receptors. The organic, PCB-1260, was an additional risk driver for shrews with a HQ of 4.1 and accounting for 11% of the shrew HI.

West Seep Basin

West Seep Subbasin. Risks to terrestrial biota were evaluated for nonradionuclides in soil in the West Seep subbasin. No analytes resulted in HQs >1.0 for any receptors, thereby indicating that risks to wildlife are negligible in this subbasin.

East Seep Basin

East Seep Subbasin. Risks to terrestrial biota were evaluated for exposure to nonradionuclides in soil in the East Seep subbasin. Likely risks were identified only for shrews (Tables 7.17). HQs exceeding one were estimated for three analytes for shrews (barium, selenium, and thallium). Although HQs were low (<1.5), selenium and thallium were predicted to result in population level effects on shrews within the subbasin. This subbasin was a minor contributor to predicted watershed-wide effects on shrews from exposure to selenium. Watershed-wide effects were not predicted for thallium or barium.

SWSA 6 BASIN

W6MS3 Subbasin. Risks to terrestrial biota were evaluated for nonradionuclides in soil in the WAG6MS3 subbasin. Likely risks from exposure to nonradionuclides were identified for short-tailed shrews (Table 7.17). Inorganics contributed >99% of the HI. Only arsenic resulted in an HQ exceeding one for shrews. Exceedance of the toxicological benchmark was relatively low (HQ = 1.8).

W6MS1 Subbasin. Risks to terrestrial biota were evaluated for nonradionuclides in soil in the W6MS1 subbasin. Likely risks from exposure to nonradionuclides were identified for short-tailed shrews (Table 7.17). Inorganics contributed >99% of the HI. HQs exceeding one were estimated for only two analytes for shrews (arsenic and nickel). The nickel HQ was only 1.2 while the arsenic HQ was 4.3.

White Oak Lake, Creek, and Floodplain Basin

Lower WOC Subbasin. Risks to terrestrial biota were evaluated for nonradionuclides in soil in the Lower WOC subbasin. Likely risks from nonradionuclides were identified for short-tailed shrews, white-footed mice, red fox, red-tailed hawk, wild turkey, and mink (Table 7.17 through 7.19 and 7.21 through 7.23). Inorganics contributed >95% of the HI for all receptors. HQs exceeding one were estimated for five inorganics for shrews (mercury, chromium, zinc, molybdenum, and selenium), two for mice and foxes (mercury and chromium), and one (mercury) for hawks, turkeys, and mink. The organic, PCB-1260, was an additional risk driver for shrews with a HQ of 2.3. This subbasin was third behind Intermediate Holding Pond and WOC subbasins in contribution to watershed-wide risks to shrews and foxes exposed to mercury. Hazard quotients for mercury were as high as 23.2 for shrews. Chromium was a significant risk driver for shrews, mice, and foxes, but the UCL95 of the chromium concentration only exceeded background by 1.1x. The analytical data did not specify the valence state of the chromium. Chromium (VI) is more toxic and bioavailable than chromium (III) (Will and Suter 1995b), but in most soils chromium (VI) is likely to be reduced to chromium (III) (Will and Suter 1995b). However, the toxicological benchmark used to estimate effects of chromium is based on chromium (VI) studies. The use of the benchmark for the more toxic and available chromium (VI) when exposures may be predominantly from chromium (III) may lead to overestimation of the risks of adverse effects. Terrestrial wildlife exposures to chromium were below the NOAEL for chromium (III) for all receptors.

SWSA 6 South Subbasin. Risks to terrestrial biota were evaluated for nonradionuclides in soil in the SWSA 6 SOUTH subbasin. Likely risks from exposure to nonradionuclides were identified for short-tailed shrews and white-footed mice (Tables 7.17 and 7.18). Inorganics contributed 100% of the HI for both receptors as benchmarks were unavailable for the three organics detected in the single sample from the subbasin. Only arsenic resulted in a HQ exceeding one for shrews and mice. The shrew HQ of 8.1 was the highest HQ for arsenic for any wildlife receptor at any of the subbasins.

SWSA 6 East Subbasin. Risks to terrestrial biota were evaluated for nonradionuclides in soil in SWSA 6 East subbasin. Likely risks from exposure to nonradionuclides were identified for short-tailed shrews (Table 7.17). Inorganics accounted for >99% of the HI. HQs exceeding one were estimated for only two analytes for shrews (nickel and cadmium). Exceedances of toxicological benchmarks were less than 1.2 for both analytes. Relative to other subbasins within the watershed, the SWSA 6 East subbasin presents a minor risk of adverse effects.

Pit 4 South Subbasin. Risks to terrestrial biota were evaluated for nonradionuclides in soil in the Pit 4 South subbasin. Likely risks from exposure to nonradionuclides were identified for short-tailed shrews (Table 7.17). Inorganics contributed >99% of the HI. HQs exceeding one were estimated for three inorganics for shrews (molybdenum, selenium, and barium). Exceedances of toxicological benchmarks were low (less than a factor of 1.8) for all analytes.

NHF Basin

NHF Subbasin. Risks to terrestrial biota were evaluated for nonradionuclides in soil in the NHF subbasin. No risks were identified for exposure of terrestrial biota to nonradionuclides in soil. Exposures for all receptors were below toxicological benchmarks for all analytes.

7.3.1.2 Screening Monte Carlo simulation estimates of exposure

To incorporate the variation present in the parameters employed in the exposure model, Monte Carlo simulations were performed for the exposure estimates of each species to analytes where at least one LOAEL-based HQ>1 was observed. For all endpoints, simulations were performed only at the watershed-wide level.

By superimposing NOAEL and LOAEL values on the exposure distributions generated from the Monte Carlo simulation, the likelihood of an individual experiencing potentially hazardous exposures can be estimated and the magnitude of risk may be determined. An interpretation of the comparison of exposure distributions to NOAELs and LOAELs is given in Table 7.24.

To evaluate the likelihood and magnitude of population-level effects on wildlife, literature-derived population density data (expressed as number of individuals/ ha or km of stream) were combined with hectares of suitable habitat (within the WOCW) to estimate the number of individuals of each endpoint species expected to be present in the watershed. For the terrestrial species (shrew, mice, deer, fox, turkey and hawk) habitat preferences follow those reported in the Preliminary Reservation-wide Ecological Risk Assessment (Sample et al. 1995). These habitat preferences were compared to the habitat types identified in WAGs within the WOCW in Washington-Allen et al. (1995) and extrapolated to address the entire Melton Valley area of the WOCW. Because streams are the preferred habitats for mink, the length of WOC was assumed to represent suitable habitat. The estimated abundance of wildlife endpoint species is reported in Table 7.25.

The number of individuals within the WOCW likely to experience exposures >LOAELs can be estimated using cumulative binomial probability functions (Dowdy and Wearden 1983). Binomial probability functions are estimated using the following equation:

$$b(y;n;p) = \binom{n}{y} p^{y} (1-p)^{n-y} \qquad (7)$$

where:

y = the number (or percent) of individuals experiencing exposures > LOAEL
n = total number (or percent) of individuals within the watershed
p = probability of experiencing an exposure in excess of the LOAEL
b (y; n; p) = probability of y individuals out of a total of n, experiencing an exposure > LOAEL, given the probability of exceeding the LOAEL=p.

By solving Equation 8 for y=0 to y=n, a cumulative binomial probability distribution may be generated that can be used to estimate the number of individuals within the WOCW that are likely to experience adverse effects.

Binomial probability distributions were generated only for contaminant-endpoint combinations where the percent of the exposure distribution exceeding the LOAEL was 20% to 80% (these values are reported in Table 7.26). If the percent of the exposure distribution exceeding the LOAEL was <20%, it was assumed that no individuals within the area of interest were experiencing adverse effects. Conversely, if the percent of the exposure distribution exceeding the LOAEL was >80%, it was assumed that all individuals within the area of interest were experiencing adverse effects. Exposure estimates for 5 contaminant-endpoint combinations met the 20% to 80% exceedance criterion at the watershed level: PCB, mercury, molybdenum, and selenium exposure to shrews, and

mercury exposure to fox. The total numbers of individuals for each endpoint species estimated to be experiencing adverse effects within the WOCW are summarized in Table 7.26.

Based on the Monte Carlo analysis and binomial distribution analysis, the following conclusions may be made:

1. Because < 20% of the WOCW populations are estimated to be experiencing exposures >LOAEL, the following contaminants do not present significant risks:

Endpoint	Analytes
Short-tailed shrew	As, Ba, Cd, Cu, Tl, and Zn
White-footed mouse	Aroclor 1260, As, Cr, Hg, and Ni
Red fox	Aroclor 1260, Ba, and Ni
White-tailed deer	Ba, Hg, and Ni
Red-tailed hawk	Hg, Zn, and Ni
Wild turkey	Hg and Ni
Mink	Aroclor 1260, Hg, and Ni (soil-related exposures only)

2. Because >20% of the WOCW shrew population is estimated to be experiencing exposures >LOAEL, Aroclor-1260, chromium, mercury, molybdenum, nickel, and selenium present significant watershed-wide risks to shrews;

3. Because >20% of the population was estimated to be experiencing exposures >LOAEL, mercury presents a significant watershed-wide risk to red fox.

4. Because >20% of the population within some subbasins was estimated to experience exposures >LOAEL, arsenic, barium, chromium, mercury, molybdenum, nickel, PCBs, selenium, and zinc present significant risks to shrews at the subbasin scale. Table 7.27 identifies the subbasin/analyte combinations presenting significant risks.

5. Because >20% of the population within the subbasins was estimated to experience exposures >LOAEL, chromium at the HF-2 subbasin, mercury at the Intermediate Pond and WOC subbasins, and nickel at SWSA 4 Main present significant risks to white-footed mice at the subbasin scale (Table 7.27).

6. Because <20% of the individuals in the mink population were likely to experience combined water- and soil-related exposures >LOAELs, mercury and PCBs are not expected to present significant watershed-wide risks to mink.

While significant watershed-wide and within subbasin population-level risks to shrews were predicted for chromium, it should be noted that chromium risks are based on comparison to the benchmark for chromium (VI). The analytical data did not specify the valence state of the chromium. Chromium (VI) is more toxic and bioavailable than chromium (III) (Will and Suter 1995b), but in most soils chromium (VI) is likely to be reduced to chromium (III) (Will and Suter 1995b). The use of the benchmark for the more toxic and available chromium (VI) when exposures may be predominantly from chromium (III) may lead to overestimation of the risks of adverse effects. Terrestrial wildlife exposures to chromium were below the NOAEL for chromium (III) for all receptors. In addition, chromium was detected above background in only two subbasins (HF-2 and Lower WOC/WHITE OAK LAKE) and then at a concentration only about twice as high.

Watershed-side effects on shrews from exposure to nickel may also be overestimated bacause a single sample location, WAG 4 Seep 6, in the SWSA 4 Main subbasin drives the analysis. The concentration at WAG 4 Seep 6 is two orders of magnitude higher than at other locations in the subbasin, suggesting the area of high contamination is spatially limited.

7.3.1.3 Screening point estimates of exposure: surface water

To evaluate the potential risk that contaminants in surface water present to wildlife, the 95% UCLs for concentrations in unfiltered water were compared to LOAEL water benchmarks for all species. Surface water data for this comparison included both mainstem and seep/small tributary data. HQs (water concentration/benchmark value) were calculated for all species.

Potential risks to white-tailed deer exposed to thallium by drinking surface water were identified for three subbasins (WOC, HF-2, and SWSA 5 Trib-1). Risks were not identified for any other receptors, and thallium was the only analyte which exceeded the LOAEL for deer. However, it is unlikely that thallium in drinking water poses a risk to deer. The thallium benchmark is conservative, based on a reduction in sperm motility, and was derived using a subchronic to chronic uncertainty factor of 10. In addition, the frequency of detection was low (3 of 8, 1 of 9, and 1 of 8 samples) in all three subbasins.

7.3.2 Effects of Retained Contaminants

Chromium

For the purposes of this assessment, it was assumed that 100% of the chromium to which wildlife are exposed consists of chromium (VI). This is a very conservative assumption. The mammalian NOAEL for chromium was based on a study of rats fed Cr^{+6} in water for one year (Mackenzie et al. 1958). No adverse effects were observed at the highest dose of 3.28 mg/kg-d. The 3.28 mg/kg-d exposure was considered to be a chronic NOAEL. The mammalian LOAEL for chromium was based on a study of rats fed Cr^{+6} in water for 3 months (Steven et al. 1976). Mortality significantly increased among rats consuming 131.4 mg/kg-d. The study was considered to represent a subchronic exposure, therefore a 0.1 subchronic-chronic correction factor was employed. The 13.14 mg/kg-d exposure was considered to be a chronic LOAEL. Based on the results of Steven et al. (1976), shrews experiencing exposure ≥ LOAEL are likely to display increased mortality.

Mercury

For the purposes of this assessment, it was assumed that 100% of the mercury to which wildlife are exposed consists of methylmercury. The fox and mink NOAELs and LOAELs for mercury were derived from a study of mink fed methyl mercury for 93 d (Wobeser et al. 1976). While consumption of 0.247 mg/kg-d methyl mercury resulted in significant mortality, weight loss, and behavioral impairment, no effects were observed at the 0.15 mg/kg-d exposure level. The 0.15 mg/kg-d exposure was considered to be a NOAEL and the 0.247 mg/kg-d exposure was considered to be a LOAEL. Because the study was subchronic in duration (<1 yr), a subchronic-chronic correction factor was applied (NOAEL=0.015, LOAEL=0.025). Based on the results of Wobeser et al. (1976), shrews and fox experiencing exposures ≥ LOAEL are likely to display increased mortality, weight loss, and behavioral impairment.

Molybdenum

The mammalian NOAEL and LOAEL for molybdenum were derived from a study of mice given molybdate in water and food for three generations (Schroeder and Mitchner 1971). Total exposure of 2.58 mg/kg/d resulted in reduced reproductive success and a high incidence of runts. This dose was considered to be a chronic LOAEL. A chronic NOAEL was estimated by multiplying the chronic LOAEL by a LOAEL-NOAEL uncertainty factor of 0.1. Based on the results of Schroeder and Mitchner (1971), shrews experiencing exposures ≥ LOAEL are likely to reduced reproductive success.

PCBs

The mammalian NOAEL and LOAEL for PCBs were derived from a study of mink fed Aroclor 1254 for 4.5 mo. (Aulerich and Ringer 1977). While consumption of 0.69 mg/kg-d Aroclor 1254 reduced kit survivorship, no effects were observed at the 0.14 mg/kg-d exposure level. The 0.14 mg/kg-d exposure was considered to be a chronic NOAEL; the 0.69 mg/kg-d exposure was considered to be a chronic LOAEL Based on the results of Aulerich and Ringer (1977), shrews experiencing exposure ≥ LOAEL are likely to display reduced survivorship of young.

Selenium

The mammalian NOAELs and LOAELs for selenium were derived from a study of mice fed Se for 3 generations. (Schroeder and Mitchner 1971). Consumption of 0.76 mg/kg-d selenium resulted in reduced reproductive success, increased incidence of runts, and failure to breed. Only one dose level was tested. The study was considered to represent a chronic exposure. A NOAEL was estimated using a LOAEL-NOAEL correction factor of 0.1. The 0.076 mg/kg-d exposure was considered to be a chronic NOAEL; the 0.76 mg/kg-d exposure was considered to be a chronic LOAEL Based on the results of Schroeder and Mitchner (1971), shrews experiencing exposure ≥ LOAEL are likely to display impaired reproduction.

7.3.3 Biological Surveys

Mink survey

Results of the mink survey (see Sect. 7.2.2) indicate that mink are present on the ORR and within the WOCW, have large home ranges, and do not avoid the industrial facilities on the ORR. The methods employed in the study do not allow numbers or density of mink to be determined. Concentrations of metals in hair of the single mink collected from the WOCW were comparable to that from mink collected offsite.

7.3.4 Weight of Evidence

7.3.4.1 Short-tailed shrews

One line of evidence, literature toxicity data, was available to evaluate potential risk to short-tailed shrews in the WOCW. Point estimates of exposure indicated that 15 contaminants detected above background concentrations exceeded NOAELs with 12 also exceeding LOAELs (Table 7.9). Monte Carlo simulation of exposure and comparison of these estimates to NOAELs and LOAELs (Table 7.26), and calculation of binomial probability distributions suggest that Aroclor 1260, chromium, mercury, molybdenum, nickel, and selenium present significant watershed-wide risks to

the shrew population in the WOCW. In addition, arsenic, barium, chromium, mercury, molybdenum, nickel, PCBs, selenium, and zinc present significant population-level risks within at least one subbasin (Table 7.27).

7.3.4.2 White-footed mice

One line of evidence, literature toxicity data, was available to evaluate potential risk to white-footed mice in the WOCW. Point estimates of exposure indicated that 10 contaminants exceeded NOAELs with 5 also exceeding LOAELs (Table 7.10). Monte Carlo simulation of exposure and comparison of these estimates to NOAELs and LOAELs (Table 7.26), and calculation of binomial probability distributions suggest that no analytes present a significant watershed-wide risk to the mouse population in the WOCW. However, chromium at the HF-2 subbasin, mercury at the Intermediate Pond and WOC subbasins, and nickel at SWSA 4 Main present significant risks to white-footed mice at the subbasin scale (Table 7.27).

7.3.4.3 Red fox

One line of evidence, literature toxicity data, was available to evaluate potential risk to red fox in the WOCW. Point estimates of exposure indicated that 10 contaminants exceeded NOAELs with 5 also exceeding LOAELs (Table 7.11). Monte Carlo simulation of exposure and comparison of these estimates to NOAELs and LOAELs (Table 7.26), and calculation of binomial probability distributions suggest that only mercury presents a significant risks to the fox population in the WOCW.

7.3.4.4 White-tailed deer

One line of evidence, literature toxicity data, was available to evaluate potential risk to white-tailed deer in the WOCW. Point estimates of exposure indicated that 5 contaminants exceeded NOAELs with 3 also exceeding LOAELs (Table 7.12). Monte Carlo simulation of exposure and comparison of these estimates to NOAELs and LOAELs (Table 7.26), and calculation of binomial probability distributions suggest that no analytes present a significant risk to the deer population in the WOCW.

7.3.4.5 Red-tailed hawk

One line of evidence, literature toxicity data, was available to evaluate potential risk to red-tailed hawk in the WOCW. Point estimates of exposure indicated that 5 contaminants exceeded NOAELs with 3 also exceeding LOAELs (Table 7.13). Monte Carlo simulation of exposure and comparison of these estimates to NOAELs and LOAELs (Table 7.26), and calculation of binomial probability distributions suggest that no analytes present a significant risk to the hawk population in the WOCW.

7.3.4.6 Wild turkey

One line of evidence, literature toxicity data, was available to evaluate potential risk to wild turkey in the WOCW. Point estimates of exposure indicated that 4 contaminants exceeded NOAELs with 2 also exceeding LOAELs (Table 7.14). Monte Carlo simulation of exposure and comparison of these estimates to NOAELs and LOAELs (Table 7.26), and calculation of binomial probability distributions suggest that no analytes present a significant risk to the turkey population in the WOCW.

7.3.4.7 Mink

Two lines of evidence, biological survey data and literature toxicity data, were available to evaluate potential risks to mink within The WOCW. The biological survey data indicate that mink are present within the WOCW, but due to the sampling methods employed, estimates of the abundance of the mink population cannot be made from these data. Residue analysis indicates that mink in the WOCW have contaminant concentrations in hair similar to that in mink from offsite.

Point estimates of exposure indicated that 3 contaminants exceeded NOAELs with 2 also exceeding LOAELs (Tables 7.15). Monte Carlo simulation of exposure and comparison of these estimates to NOAELs and LOAELs (Table 7.26), and calculation of binomial probability distributions suggest that no analytes present a significant risk to the mink population in the WOCW.

7.3.5 Summary of Risks to Terrestrial Wildlife

Ecological risks were evaluated for terrestrial wildlife exposed to nonradionuclide contaminants in surface soil within each subbasin in the watershed for which surface soil data were available (radionuclide exposures are discussed in Chapter 9). Nonradiological data were available from 22 subbasins. Only one formal line of evidence, single chemical toxicity data, was available to evaluate potential risks for terrestrial wildlife receptors with the exception of biological surveys for mink.

Likely risks to short-tailed shrews were identified for 20 subbasins, 9 for white-footed mice, 10 for red fox, 3 for white-tailed deer, 6 for red-tailed hawks, 4 for wild turkeys, and 5 for mink (Table 7.17 through 7.23). The Intermediate Pond resulted in the highest risks for all receptors due to high soil mercury concentrations.

LOAELs for at least one wildlife receptor (short-tailed shrew, white-footed mouse, red fox, white-tailed deer, red-tailed hawk, wild turkey, or mink) were exceeded in at least one subbasin as a result of arsenic, barium, cadmium, chromium, copper, mercury, molybdenum, nickel, selenium, thallium, zinc, and PCB-1260 (Tables 7.17 through 7.23). However, only mercury, molybdenum, nickel, selenium, and PCB-1260 for the shrew and mercury for the fox were predicted to result in potential watershed-wide effects. Fewer than 20% of the individuals in populations within the watershed were likely to exceed LOAELs for all other receptor-contaminant combinations. The Intermediate Pond was the primary contributor to mercury exposures; the average mercury concentration there was an order of magnitude higher than in any other subbasin. The WOC, Lower WOC/White Oak Lake, and Seep B subbasins were also major contributors to high mercury exposures. The SWSA 5 Drainage D-2 subbasin was the primary contributor to PCB-1260 exposures, followed by the Intermediate Pond and WOC subbasins. Seep C subbasin was the most significant contributor to molybdenum exposures. Selenium exposures were highest in the Seep A, Pit 4 South, and SWSA 5 N/WOC subbasins. Significant population-level risks within at least one subbasin from exposure to arsenic, barium, chromium, mercury, molybdenum, nickel, PCBs, selenium, and zinc were identified for short-tailed shrews (see Table 7.27 for list of subbasin/analyte combinations). Chromium at the HF-2 subbasin, mercury at the Intermediate Pond and WOC subbasins, and nickel at SWSA 4 Main present significant risks to white-footed mice at the subbasin scale (Table 7.27).

7.4 UNCERTAINTIES CONCERNING RISKS TO WILDLIFE

7.4.1 Bioavailability of Contaminants

Bioavailability of contaminants was assumed to be comparable between soil and water from the WOCW and the diets used in the literature toxicity tests. Because bioavailability may not be comparable, exposure estimates based upon the contaminant concentrations may either under- or overestimate the actual contaminant exposure experienced.

7.4.2 Extrapolation from Published Toxicity Data

While published toxicity studies are available for mink, there are no published data for the other endpoints. To estimate toxicity of contaminants at the site, it was necessary to extrapolate from studies performed on test species (i.e., mallard ducks, ring-necked pheasant, and rats). While it was assumed that toxicity could be estimated as a function of body size, the accuracy of the estimate is not known. For example, hawks may be more or less sensitive to contaminants than ducks or pheasants, due to factors other than metabolic rate.

Additional extrapolation uncertainty exists for those contaminants for which data consisted of only LOAELs or tests were subchronic in duration. For either case, an 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.

Toxicity of PCBs to piscivorous wildlife was evaluated using toxicity data from studies on Aroclor 1254. Because toxicity of PCB congeners can vary dramatically, the applicability of data for Aroclor 1254 is unknown.

7.4.3 Variable Food 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 in the WOCW may be greater or less than that reported in the literature, resulting in either an increase or decrease in contaminant exposure.

7.4.4 Single Contaminant Tests vs Exposure to Multiple Contaminants in the Field

While wildlife in the WOCW 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 additively or synergistically, single contaminant studies may underestimate their toxic potential.

7.4.5 Inorganic Forms or Species Present in the Environment

Toxicity of metal species varies dramatically depending upon the valence state or form (organic or inorganic) of the metal. For example, arsenic (III), chromium (VI), and methyl mercury are more toxic than arsenic (V), chromium (III), and inorganic mercury, respectively. The available data on the contaminant concentrations in media do not report which species or form of contaminant was observed. Because benchmarks used for comparison represented the more toxic species/forms of the metals (particularly for arsenic, chromium, and mercury), if the less toxic species/form of the

metal was actually present in media from the WOCW, potential toxicity at the sites may be overestimated.

7.4.6 Uptake Factors

Soil to biota uptake factors specific to the WOCW were unavailable. Therefore it was assumed that the uptake factors developed as part of the Bear Creek assessment were applicable. Due to the differing geologies and histories between the WOCW and Bear Creek, the Bear Creek uptake factors may over- or under estimate the actual biota concentrations in the WOCW. Uncertainties associated with literature-derived uptake factors may also result in over- or underestimates of actual biota concentrations.

7.4.7 Contaminant Concentrations in Unanalyzed Food Types

Uptake factors were not available for all food types consumed by the endpoint species. It was assumed that the uptake factors for food types for which we had data were representative of that for those without data. Due to different life histories among food types, contaminant burdens are likely to differ from the measured data. Therefore, assuming comparability among food types may either over- or underestimate exposure.

7.4.8 Monte Carlo Simulation

To perform Monte Carlo simulations, distributions must be assigned to parameters. Distributions for uptake factors and soil concentrations were determined using available data, but sample sizes within some subbasins were limited. The distributions used may or may not accurately reflect the actual distribution of these parameters within the WOCW.

Table 7.1 Contaminant biotransfer factors for selected ecological receptors in the White Oak Creek watershed[1]

Analyte	Log Kow	Soil-plant (kg/kg)		Soil-invertebrate (kg/kg)		Food-bird (kg/d)		Food-mammal (kg/d)		Soil-mammal (kg/kg)
1,1,1-Trichloroethane	2.5	3.47E-01	o,g	5.00E-02	m	7.94E-06	i	7.94E-06	f,j	
1,1,2,2-Tetrachloroethane	2.4	3.97E-01	f,g	5.00E-02	m	6.31E-06	i	6.31E-06	f,j	
1,1,2-Trichloroethane	2	6.76E-01	f,g	5.00E-02	m	2.51E-06	i	2.51E-06	f,j	
1,1-Dichloroethane	1.8	8.82E-01	f,g	5.00E-02	m	1.58E-06	i	1.58E-06	f,j	
1,1-Dichloroethene	1.8	8.82E-01	f,g	5.00E-02	m	1.58E-06	i	1.58E-06	f,j	
1,2-Benzenedicarboxylic acid				5.00E-02	m					
1,2-Dichloroethane	1.5	1.32E+00	f,g	5.00E-02	m	7.94E-07	i	7.94E-07	f,j	
1,2-Dichloroethene	0.48	5.11E+00	f,g	5.00E-02	m	7.59E-08	i	7.59E-08	f,j	
1,2-Dichloropropane	2	6.76E-01	f,g	5.00E-02	m	2.51E-06	i	2.51E-06	f,j	
2,4-D	2.5	3.47E-01	f,g	5.00E-02	m	4.79E-06	i	4.79E-06	f	
2,4-Dichlorophenol	3.3	1.20E-01	f,g	5.00E-02	m	5.01E-05	i	5.01E-05	f,j	
2,4-Dimethyl-2-pentanol				5.00E-02	m					
2,4-Dimethyl-3-heptanone				5.00E-02	m					
2,4-Dinitrophenol	1.5	1.32E+00	f,g	5.00E-02	m	7.94E-07	i	7.94E-07	f,j	
2,4-Dinitrotoluene	2	6.76E-01	f,g	5.00E-02	m	2.51E-06	i	2.51E-06	f,j	
2,5-Hexanedione				5.00E-02	m					
2,6-Dinitrotoluene	1.7	1.01E+00	f,g	5.00E-02	m	1.26E-06	i	1.26E-06	f,j	
2-Butanone	0.27	6.76E+00	f,g	5.00E-02	m	4.68E-08	i	4.68E-08	f,j	
2-Chlorophenol	2.2	5.18E-01	f,g	5.00E-02	m	3.98E-06	i	3.98E-06	f,j	
2-Cyclohexen-1-one				5.00E-02	m					
2-Heptanol acetate				5.00E-02	m					
2-Hexanone	1.4	1.50E+00	f,g	5.00E-02	m	6.31E-07	i	6.31E-07	f,j	
2-Methylnaphthalene	3.9	5.39E-02	f,g	5.00E-02	m	2.00E-04	i	2.00E-04	f,j	
2-Methylphenol	1.9	7.72E-01	f,g	5.00E-02	m	2.00E-06	i	2.00E-06	f,j	
2-Nitroaniline	1.4	1.50E+00	f,g	5.00E-02	m	6.31E-07	i	6.31E-07	f,j	
3,3'-Dichlorobenzidine	3.5	9.18E-02	f,g	5.00E-02	m	7.94E-05	i	7.94E-05	f,j	
3-Methylpentane				5.00E-02	m					
4,4'-DDD	5.8	4.30E-03	f,g	5.00E-02	m	1.26E-02	i	1.26E-02	f	
4,4'-DDE	5.7	2.62E-02	f	5.00E-02	m	4.90E-02	i	4.90E-02	f	
4,4'-DDT	6.36	3.96E-03	f	5.00E-02	m	2.82E-02	i	2.82E-02	f	
4-Chloro-3-methylphenol				5.00E-02	m					
4-Chlorobenzenamine	2.8	2.33E-01	f,g	5.00E-02	m	1.58E-05	i	1.58E-05	f,j	
4-Chlorophenylphenylether				5.00E-02	m					
4-Hydroxy-4-methyl-2-pentanone				5.00E-02	m					
4-Methyl-2-pentanone	1.2	1.96E+00	f,g	5.00E-02	m	3.98E-07	i	3.98E-07	f,j	
4-Methylphenol	1.9	7.72E-01	f,g	5.00E-02	m	2.00E-06	i	2.00E-06	f,j	
4-Nitrophenol	1.9	7.72E-01	f,g	5.00E-02	m	2.00E-06	i	2.00E-06	f,j	
5-Methyl-2-hexanone				5.00E-02	m					

Table 7.1 Contaminant biotransfer factors for selected ecological receptors in the White Oak Creek watershed[1]

Analyte	Log Kow	Soil-plant (kg/kg)		Soil-invertebrate (kg/kg)		Food-bird (kg/d)		Food-mammal (kg/d)		Soil-mammal (kg/kg)	
5-Methyl-5-hexen-2-one				5.00E-02	m						
6-(Acetyloxy)-2-hexanone				5.00E-02	m						
Acenaphthene	4.33	3.04E-02	f,g	5.00E-02	m	5.37E-04	i	5.37E-04	f,j		
Acenaphthylene	4.07	4.30E-02	f,g	5.00E-02	m	2.95E-04	i	2.95E-04	f,j		
Acetone	-0.24	1.33E+01	f,g	5.00E-02	m	1.45E-08	i	1.45E-08	f,j		
Aldol Condensation Product				5.00E-02	m						
Aldrin	3	5.34E-03	f	5.60E+00	k	8.51E-02	i	8.51E-02	f		
alpha BHC	3.8	9.73E-02	f, o	2.60E+00	n	1.66E-02	i, o	1.66E-02	f, o		
alpha-Chlordane	5.5	3.87E-03	f, p	5.00E-02	m	7.41E-03	i, p	7.41E-03	f, p		
Aluminum		3.00E-02	b	1.18E-01	a	1.50E-03	i	1.50E-03	e	1.40E-02	a
Anthracene	4.4	2.77E-02	f,g	5.00E-02	m	6.31E-04	i	6.31E-04	f,j		
Antimony		1.00E-02	d			1.00E-03	i	1.00E-03	e		
Arsenic		3.20E-02	b	8.11E-01	a	2.00E-03	i	2.00E-03	e	8.00E-03	a
Barium		2.37E-01	b	1.60E-01	a	9.00E-03	c	1.50E-04	e	6.10E-02	a
Benz(A)Anthracene	5.7	4.91E-03	f,g	4.32E-02	l	1.26E-02	i	1.26E-02	f,j		
Benzene	2.1	5.92E-01	f,g	5.00E-02	m	3.16E-06	i	3.16E-06	f,j		
Benzenemethanol	1.1	2.24E+00	f,g	5.00E-02	m	3.16E-07	i	3.16E-07	f,j		
Benzidine	1.3	1.72E+00	f,g	5.00E-02	m	5.01E-07	i	5.01E-07	f,j		
Benzo(A)Pyrene	6	1.41E-02	f	5.44E-02	l	2.51E-02	i	2.51E-02	f,j		
Benzo(B)Fluoranthene	5	1.25E-02	f,g	3.36E-02	l	2.51E-03	i	2.51E-03	f,j		
Benzo(ghi)peryline	6.6	1.48E-03	f,g	5.00E-02	m	1.00E-01	i	1.00E-01	f,j		
Benzo(K)Fluoranthene	5	1.25E-02	f,g	3.36E-02	l	2.51E-03	i	2.51E-03	f,j		
Benzoic Acid	1.9	7.72E-01	f,g	5.00E-02	m	2.00E-06	i	2.00E-06	f,j		
Beryllium		4.00E-02	b	1.18E+00	a	1.00E-03	i	1.00E-03	e		
beta BHC	3.8	9.73E-02	f, o	2.60E+00	n	1.66E-02	i, o	1.66E-02	f, o		
Bis(2-Chloroethyl)Ether	1.3	1.72E+00	f,g	5.00E-02	m	5.01E-07	i	5.01E-07	f,j		
Bis(2-Chloroisopropyl)Ether Technical	2.1	5.92E-01	f,g,h	5.00E-02	m	3.16E-06	i	3.16E-06	f,j		
Bis(2-Ethylhexyl)Phthalate	5.1	1.09E-02	f,g	5.00E-02	m	3.16E-03	i	3.16E-03	f,j		
Boron		1.00E+00	e			8.00E-04	i	8.00E-04	e		
Bromodichloromethane	2.1	5.92E-01	f,g	5.00E-02	m	3.16E-06	i	3.16E-06	f,j		
Bromoform	2.4	3.97E-01	f,g	5.00E-02	m	6.31E-06	i	6.31E-06	f,j		
Bromomethane	1.2	1.96E+00	f,g	5.00E-02	m	3.98E-07	i	3.98E-07	f,j		
Butyl 2-methylpropyl phthalate				5.00E-02	m						
Butylbenzylphthalate	4.9	1.42E-02	f,g	5.00E-02	m	2.00E-03	i	2.00E-03	f,j		
C14H22O				5.00E-02	m						
Cadmium		1.12E+00	b	6.41E+00	a	8.00E-01	c	5.50E-04	e	1.32E-01	a
Calcium		3.87E+00	b	1.90E+00	a	4.00E-02	c	7.00E-04	e	9.38E+00	a
Carbazole	3.8	6.16E-02	f,g	5.00E-02	m	1.58E-04	i	1.58E-04	f,j		

Table 7.1 Contaminant biotransfer factors for selected ecological receptors in the White Oak Creek watershed[1]

Analyte	Log Kow	Soil-plant (kg/kg)		Soil-invertebrate (kg/kg)		Food-bird (kg/d)		Food-mammal (kg/d)		Soil-mammal (kg/kg)	
Carbon disulfide	2.2	5.18E-01	f,g	5.00E-02	m	3.98E-06	i	3.98E-06	f,j		
Carbon tetrachloride	2.8	2.33E-01	f,g	5.00E-02	m	1.58E-05	i	1.58E-05	f,j		
Cerium		2.00E-03	d			4.00E-03	c	7.50E-04	e		
Cesium		5.30E-02	c			1.00E+01	c	2.00E-02	e		
Chlordane	5.5	3.87E-03	f	5.00E-02	m	7.41E-03	i	7.41E-03	f		
Chlorobenzene	2.8	2.33E-01	f,g	5.00E-02	m	1.58E-05	i	1.58E-05	f,j		
Chloroethane	1.4	1.50E+00	f,g	5.00E-02	m	6.31E-07	i	6.31E-07	f,j		
Chloroform	2	6.76E-01	f,g	5.00E-02	m	2.51E-06	i	2.51E-06	f,j		
Chloromethane	0.91	2.88E+00	f,g	5.00E-02	m	2.04E-07	i	2.04E-07	f,j		
Chromium		6.70E-02	b	8.33E+00	a	5.50E-03	i	5.50E-03	e	2.21E-01	a
Chrysene	5.7	4.91E-03	f,g	5.00E-02	m	1.26E-02	i	1.26E-02	f,j		
cis-1,3-Dichloropropene	1.6	1.15E+00	f,g	5.00E-02	m	1.00E-06	i	1.00E-06	f,j		
Cobalt		1.20E-02	b	2.91E-01	a	2.00E+00	c	2.00E-02	e	1.00E-02	a
Copper		3.81E-01	b	8.26E-01	a	5.00E-01	c	1.00E-02	e	7.40E-01	a
Cyanide	1.1	2.24E+00	f,g	5.00E-02	m	3.16E-07	i	3.16E-07	f,j		
delta-BHC	2.8	2.33E-01	f,g	5.00E-02	m	1.58E-05	i	1.58E-05	f,j		
Di-n-butylphthalate	4.9	1.42E-02	f,g	5.00E-02	m	2.00E-03	i	2.00E-03	f,j		
Di-n-octylphthalate	9.2	4.66E-05	f,g	5.00E-02	m	3.98E+01	i	3.98E+01	f,j		
Dibenz(a,h)anthracene	6.8	1.14E-03	f,g	5.00E-02	m	1.58E-01	i	1.58E-01	f,j		
Dibenzofuran				5.00E-02	m						
Dibromochloromethane	2.2	5.18E-01	f,g	5.00E-02	m	3.98E-06	i	3.98E-06	f,j		
Dieldrin	4.6	2.44E-02	f	5.50E+00	n	7.94E-03	i	7.94E-03	f		
Diethylphthalate	2.5	3.47E-01	f,g	5.00E-02	m	7.94E-06	i	7.94E-06	f,j		
Dimethylbenzene	3.3	1.20E-01	f,g	5.00E-02	m	5.01E-05	i	5.01E-05	f,j		
Dimethylphthalate	1.6	1.15E+00	f,g	5.00E-02	m	1.00E-06	i	1.00E-06	f,j		
Dioctyl hexanedioate				5.00E-02	m						
Docosane				5.00E-02	m						
Endosulfan I				5.00E-02	m	2.19E-04	q	2.19E-04	q		
Endosulfan II				5.00E-02	m	2.19E-04	q	2.19E-04	q		
Endosulfan sulfate				5.00E-02	m	2.19E-04	q	2.19E-04	q		
Endrin	5.6	3.78E-03	f	1.90E+00	n	1.20E-02	i	1.20E-02	f		
Endrin aldehyde		3.78E-03	f, r	5.00E-02	m	1.20E-02	r	1.20E-02	r		
Endrin ketone		3.78E-03	f, r	5.00E-02	m	1.20E-02	r	1.20E-02	r		
Ethylbenzene	3.1	1.56E-01	f,g	5.00E-02	m	3.16E-05	i	3.16E-05	f,j		
Europium		2.00E-03	d			5.00E-03	i	5.00E-03	e		
Fluoranthene	4.9	1.42E-02	f,g	5.00E-02	m	2.00E-03	i	2.00E-03	f,j		
Fluorene	4.4	2.77E-02	f,g	5.00E-02	m	6.31E-04	i	6.31E-04	f,j		
Gallium		3.00E-03	d			5.00E-04	i	5.00E-04	e		

Table 7.1 Contaminant biotransfer factors for selected ecological receptors in the White Oak Creek watershed[1]

Analyte	Log Kow	Soil-plant (kg/kg)		Soil-invertebrate (kg/kg)		Food-bird (kg/d)		Food-mammal (kg/d)		Soil-mammal (kg/kg)	
gamma-Chlordane	5.5	3.87E-03	f, p	5.00E-02	m	7.41E-03	p	7.41E-03	p		
Gold		1.00E-01	d			8.00E-03	i	8.00E-03	e		
Hafnium		3.00E-03	r			1.00E-03	i	1.00E-03	e		
Heptachlor	4.3	8.28E-03	f	1.00E+00	n	1.55E-02	i	1.55E-02	f		
Heptachlor Epoxide	5.4	6.00E-03	f	1.00E+00	n	7.94E-02	i	7.94E-02	f		
Hexachlorobenzene	6.2	1.20E-01	f	5.00E-02	m	4.47E-02	i	4.47E-02	f		
Hexachlorobiphenyl				5.00E-02	m						
Hexachloroethane	3.8	6.16E-02	f,g	5.00E-02	m	1.58E-04	i	1.58E-04	f,j		
Hexadecanoic acid				5.00E-02	m						
Hexadecanoic acid ester				5.00E-02	m						
Hexanedioic acid ester				5.00E-02	m						
Hydrazobenzene	-1.1	4.19E+01	f,g	5.00E-02	m	2.00E-09	i	2.00E-09	f,j		
Indeno(1,2,3-Cd)Pyrene	6.6	1.48E-03	f,g	5.00E-02	m	1.00E-01	i	1.00E-01	f,j		
Iron		1.40E-02	b	7.80E-02	a	1.00E+00	c	2.00E-02	e	7.00E-03	a
Isobutanol	0.83	3.21E+00	f,g	5.00E-02	m	1.70E-07	i	1.70E-07	f,j		
Lanthanum		2.50E-03	e			1.00E-01	c	3.00E-04	e		
Lead		5.20E-02	b	1.64E-01	a	3.00E-04	i	3.00E-04	e	4.50E-02	a
Lindane	4.1	9.73E-02	f	2.60E+00	n	1.66E-02	i	1.66E-02	f		
Lithium		3.40E-02	b	2.17E-01	a	1.00E-02	i	1.00E-02	e	3.30E-02	a
Lutetium		2.50E-03	e			4.50E-03	i	4.50E-03	e		
Magnesium		1.70E+00	b	4.25E-01	a	5.00E-03	i	5.00E-03	e	8.75E-01	a
Manganese		3.62E-01	b	1.17E-01	a	5.00E-02	c	4.00E-04	e	5.00E-03	a
MCPA	2.3	4.53E-01	f,g	5.00E-02	m	5.01E-06	i	5.01E-06	f,j		
Mercury		9.50E-02	b	4.44E+00	a	3.00E-02	c	2.50E-01	e	7.47E-01	a
Methoxychlor	4.4	2.77E-02	f,g	5.00E-02	m	6.31E-04	i	6.31E-04	f,j		
Methylcyclopentane				5.00E-02	m						
Methylene chloride	1.3	1.72E+00	f,g	5.00E-02	m	5.01E-07	i	5.01E-07	f,j		
Methylpyrene				5.00E-02	m						
Molybdenum		8.50E-02	b	2.09E+00	a	1.00E+00	c	6.00E-03	e	1.00E-02	a
Mono(2-ethylhexyl) phthalate				5.00E-02	m						
N-Nitroso-di-n-propylamine	1.4	1.50E+00	f,g	5.00E-02	m	6.31E-07	i	6.31E-07	f,j		
N-Nitrosodiphenylamine	3.1	1.56E-01	f,g	5.00E-02	m	3.16E-05	i	3.16E-05	f,j		
Naphthalene	3.3	1.20E-01	f,g	5.00E-02	m	5.01E-05	i	5.01E-05	f,j		
Nickel		1.56E-01	b	5.78E+00	a	6.00E-03	i	6.00E-03	e	2.32E-01	a
Nitrobenzene	1.9	7.72E-01	f,g	5.00E-02	m	2.00E-06	i	2.00E-06	f,j		
Nitrosodiethylamine, N-	0.48	5.11E+00	f,g	5.00E-02	m	7.59E-08	i	7.59E-08	f,j		
Octamethylcyclotetrasiloxane				5.00E-02	m						
Osmium		3.75E-03	e			4.00E-01	i	4.00E-01	e		

Table 7.1 Contaminant biotransfer factors for selected ecological receptors in the White Oak Creek watershed[1]

Analyte	Log Kow	Soil-plant (kg/kg)		Soil-invertebrate (kg/kg)		Food-bird (kg/d)		Food-mammal (kg/d)		Soil-mammal (kg/kg)	
PCB-1016	5.9	3.76E-03	f,g	5.00E-02	m	2.00E-02	i	2.00E-02	f,j		
PCB-1221	4.1	4.13E-02	f,g	5.00E-02	m	3.16E-04	i	3.16E-04	f,j		
PCB-1232	3.2	1.37E-01	f,g	5.00E-02	m	3.98E-05	i	3.98E-05	f,j		
PCB-1242	4.1	4.13E-02	f,g	5.00E-02	m	3.16E-04	i	3.16E-04	f,j		
PCB-1248	5.8	4.30E-03	f,g	5.00E-02	m	1.58E-02	i	1.58E-02	f,j		
PCB-1254	6	4.25E-03	f	6.25E-01	a	5.25E-02	i	5.25E-02	f		
PCB-1260	7.1	7.62E-04	f,g	1.24E+01	a					5.22E+00	a
Pentachlorophenol	5.9	3.76E-03	f,g	5.00E-02	m	2.00E-02	i	2.00E-02	f,j		
Phenanthrene	4.6	2.12E-02	f,g	5.00E-02	m	1.00E-03	i	1.00E-03	f,j		
Phenol	1.5	1.32E+00	f,g	5.00E-02	m	7.94E-07	i	7.94E-07	f,j		
Polychlorinated biphenyl	6	3.30E-03	f,g	5.00E-02	m	2.51E-02	i	2.51E-02	f,j		
Polycyclic aromatic hydrocarbon (PAH)				5.00E-02	m						
Potassium		9.24E+00	b	5.96E+00	a	2.00E-02	i	2.00E-02	e	5.11E+00	a
Prometon	2.3	4.53E-01	f,g	5.00E-02	m	5.01E-06	i	5.01E-06	f,j		
Propanoic acid, 2-methyl-, 1-(1				5.00E-02	m						
Pyrene	4.9	1.42E-02	f,g	5.00E-02	m	2.00E-03	i	2.00E-03	f,j		
Rubidium		2.25E-01	c			1.50E-02	i	1.50E-02	e		
Scandium		2.00E-03	d			1.50E-02	i	1.50E-02	e		
Selenium		6.00E-02	b	1.40E+00	a	9.00E+00	c	1.50E-02	e	2.31E-01	a
Silicon		8.75E-02	e			4.00E-03	i	4.00E-03	e		
Silver		4.90E-02	b	1.53E+01	a	2.00E+00	c	3.00E-03	e		
Sodium		6.18E-01	b	6.45E+01	a	5.50E-02	i	5.50E-02	e	1.02E+01	a
Strontium		1.82E-01	b	2.78E-01	a	8.00E-02	c	3.00E-04	e	2.60E-02	a
Styrene	2.9	2.04E-01	f,g	5.00E-02	m	2.00E-05		2.00E-05	f,j		
Sulfate											
Sulfide											
Terbium		2.50E-03	e			4.50E-03	i	4.50E-03	e		
Tetrachloroethene	2.6	3.04E-01	f,g	5.00E-02	m	1.00E-05	i	1.00E-05	f,j		
Thallium		2.30E-02	b			4.00E-02	i	4.00E-02	e		
Tin		3.00E-01	d			8.00E-02	i	8.00E-02	e		
Titanium		1.38E-03	e			3.00E-02	i	3.00E-02	e		
Toluene	2.7	2.66E-01	f,g	5.00E-02	m	1.26E-05	i	1.26E-05	f,j		
Totarol				5.00E-02	m						
Toxaphene	4.8	1.63E-02	f,g	5.00E-02	m	1.62E-03	i	1.62E-03	f		
trans-1,2-Dichloroethene	0.48	5.11E+00	f,g	5.00E-02	m	7.59E-08	i	7.59E-08	f,j		
trans-1,3-Dichloropropene	1.6	1.15E+00	f,g	5.00E-02	m	1.00E-06	i	1.00E-06	f,j		
trans-4-Chlorocyclohexanol				5.00E-02	m						
Trichloroethene	2.4	3.97E-01	f,g	5.00E-02	m	6.31E-06	i	6.31E-06	f,j		

Table 7.1 Contaminant biotransfer factors for selected ecological receptors in the White Oak Creek watershed[1]

Analyte	Log Kow	Soil-plant (kg/kg)		Soil-invertebrate (kg/kg)		Food-bird (kg/d)		Food-mammal (kg/d)		Soil-mammal (kg/kg)	
Trichlorofluoromethane	2.5	3.47E-01	f,g	5.00E-02	m	7.94E-06	i	7.94E-06	f,j		
Trimethylsilanol				5.00E-02	m						
Uranium		2.00E-03	b	6.30E-02	a	1.00E+00	c	2.00E-04	e		
Vanadium		8.40E-02	b	8.80E-02	a	2.50E-03	i	2.50E-03	e		
Vinyl acetate	0.73	3.66E+00	f,g	5.00E-02	m	1.35E-07		1.35E-07	f,j		
Vinyl Chloride	1.4	1.50E+00	f,g	5.00E-02	m	6.31E-07	i	6.31E-07	f,j		
Ytterbium		2.50E-03	e			4.00E-03	i	4.00E-03	e		
Zinc		7.16E-01	b	6.48E+00	a	7.00E+00	c	1.00E-01	e	2.38E+00	a

[1] = All transfer factors based on wet tissue concentrations.

a = ES/ER/TM-197

b = ES/ER/TM-198

c = IAEA 1994

d = NCRP 1989

e = Baes et al., 1984

f = Travis and Arms 1988

g = Plant BAF calculated using the following equation presented by Travis and Arms (1988) unless otherwise noted: log (plant Uptake Factor) = 1.588 - 0.578 log Kow; if log Kow < 5, BAF assumed to be 0.02 assuming plant are 80% water.

h = EPA 1990

i = surrogate mammal BAF was used

j = Mammal BAF calculated using the following equation presented by Travis and Arms (1988): log BTF = log Kow - 7.6 where BAF = BTF * 50

k = Korschgen 1971.

l = Beyer and Stafford, 1993

m = Menzie et al., 1992

n = ABB, 1996

o = Used value for lindane

p = Used value for chlordane

q = Used value for endosulfan

r = Used value for endrin

Conversion factors:

wet wt = dry weight (1-%H20)

% H2O in mammals = 0.68

% H2O in Invertebrates = 0.84

% H2O in terrestrial dicots = 0.85

% H2O in terrestrial grass = 0.9

% H2O in terrestrial fodder = .81

% H2O in general plants using Travis and Arms equation = .75

Table 7.2. Life history parameters for the short-tailed shrew (*Blarina brevicauda*)

Parameter	Value[a]	Comments	Reference
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
	2.5-45/ha	Depending on habitat	
Behavior	nocturnal, semifossorial, spends little time above surface		George et al. 1986
	active year-round - does not hibernate		EPA 1993a

Table 7.2 (continued)

Parameter	Value[a]	Comments	Reference
Other	appear to be unpalatable to most predators due to lateral gland		van Zyll de Jong 1983

[a] Suggested values for use in exposure assessment are in bold.

Table 7.3. Life history parameters for the white-footed mouse (*Peromyscus leucopus*)

Parameter	Value[a]	Comments	Reference
Body Weight	**0.022** kg		Green and Millar 1987
Food Consumption Rate	**0.0034** kg/d	lab study	Green and Millar 1987
Water Consumption Rate	**0.0066** L/d	nonreproductive ♀ (lab)	Oswald et al. 1993
Soil Consumption Rate	<2%		Beyer et al. 1994
	0.000068 kg/d	assuming diet of 0.0034 kg/d and a 2% soil consumption rate	
Diet Composition	omnivorous and opportunistic		
	arthropods - 57% seeds, fruit, vegetation - 34%	Virginia	Wolff et al. 1985
	arthropods - 30% seeds, fruit, vegetation - 67%	Indiana	Whitaker 1966
	arthropods - 50% seeds, fruit, vegetation - 48%	Illinois	Batzli 1977
Home Range	**0.059** ha	mean:♂+♀; Virginia, mixed deciduous forest	Wolff 1985
Habitat Requirements	wooded, brushy areas; sometimes open areas		Burt and Grossenheider 1976
Population Density	6 - 57 /ha	Virginia, mixed deciduous forest	Wolff 1985
Behavior	while semi-arboreal, spends most of time on ground.		Lackey et al. 1985
	primarily nocturnal		
	enters torpor to reduce metabolic demands in winter and during food stress		EPA 1993a

[a] Suggested values for use in exposure assessment are in bold.

Table 7.4. Life history parameters for red fox (*Vulpes fulva*)

Parameter	Value[a]	Comments	Reference
Body Weight	5.25 ± 0.18 kg (♂) 4.13 ± 0.11 kg (♀)	Illinois	Storm et al. 1976
	4.82 ± 0.081 kg (♂) 3.94 ± 0.079 kg (♀)	Iowa	
	4.5 kg	mean ♂+♀ for both Illinois and Iowa	
Food Consumption Rate	0.596 kg/d	see calculation below[b]	Vogtsberger and Barret 1973
	0.31 kg/d	0.069 g/g/d for nonbreeding adult times 4.5 kg bw	Sargent 1978
	0.45 kg/d	mean of both estimates	
Water Consumption Rate	**0.38** L/d	Estimated using allometric equation[c]; assuming 4.5 kg bw	Calder and Braun 1983
Soil Consumption Rate	2.8%		Beyer et al. 1994
	0.0126 kg/d	assuming diet of 0.45 kg/d	
Diet Composition	mammals - 68.8% birds - 12.0% plants - 10.4% insects - 0.9% misc. - 5.5%	Maryland, Appalachian region	Hockman and Chapman 1983
Home Range	699 ± 137 ha (♀ spring)	Minnesota - forest, field, swamp	Sargent 1972
	717 ha (♂ all year) 96 ha (♀ all year)	Wisconsin - multiple habitats	Ables 1969

Table 7.4 (continued)

Parameter	Value[a]	Comments	Reference
Habitat Requirements	wide and diverse - occur in many habitats prefer mixture of forest and open habitat		EPA 1993a Burt and Grossenheider 1976
Population Density	0.046 - 0.077 /ha	"good fox range" in North America	EPA 1993a
Behavior	active year round - does not hibernate		EPA 1993a

[a] Suggested values for use in exposure assessment are in bold.

[b] The following parameters were presented by Vogtsberger and Barret (1973):

food ingestion = 223 kcal/kg bw/d
energy content of vertebrate food = 5.606 kcal/g dry wt.
wet-dry weight conversion = 1 g wet wt = 0.3 g dry wt

therefore:

223 kcal/kg bw/d x 4.5 kg bw = 1003.5 kcal/d

1003.5 kcal/d x 1g dry wt./5.606 kcal = 179 g dry/d

179 g dry/d x 1 g wet/0.3 g dry (wet-dry conversion) = 596 g/d

[c] Allometric equation for estimation of water consumption by mammals is:

$$W=0.099(bw)^{0.90}$$

where: W = water consumption (L/d)
bw = body weight (kg)

Table 7.5. Life history parameters for white-tailed deer (*Odocoileus virginianus*)

Parameter	Value[a]	Comments	Reference
Body Weight	68 kg (♂) 45 kg (♀) **56.5 kg** (mean♂+♀)		Smith 1991
Food Consumption Rate	**1.74 kg/d**		Mautz et al. 1976
Water Consumption Rate	**3.7 L/d**	Estimated using allometric equation[b] assuming 56.5 kg bw	Calder and Braun 1983
Soil Consumption Rate	<2%		Beyer et al. 1994
	0.0348 kg/d	assuming 2% soil and 1.74 kg/d food consumption rates	
Diet Composition	exclusively herbivorous		
	diet diverse and variable, depends on availability.		Martin et al. 1951
	major foods: - buds and twigs of trees and shrubs - grasses and forbs (summer) - mast and fruits (fall)		Smith 1991
Home Range	**59 - 520 ha**		Marchinton and Hirth 1984
Habitat Requirements	uses a wide variety of habitats; favors forest-field-farmland mosaic; population density directly related to number and distribution of forest openings		Smith 1991
Population Density	0.06 /ha	eastern mixed deciduous forest - Tennessee	Barber 1984
	0.39 - 0.78 /ha	oak-hickory forest - midwest	Torgerson and Porath 1984
	0.1704/ha	(calculated based upon 2000 deer on the ORR and available habitat)	J. Evans (pers. comm., 1995)

Table 7.5 (continued)

Parameter	Value[a]	Comments	Reference
Behavior	generally crepuscular		Smith 1991
	active year-round; does not hibernate		

[a] Suggested values for use in exposure assessment are in bold.

[b] Allometric equation for estimation of water consumption by mammals is:

$$W=0.099(bw)^{0.90}$$

where: W = water consumption (L/d)
bw = body weight (kg)

Table 7.6. Life History parameters for red-tailed hawks (*Buteo jamaicensis*)

Parameter	Value[a]	Comments	Reference
Body Weight	1.028 kg (♂) 1.224 kg (♀) **1.126** kg (mean♂+♀)		Dunning 1984
Food Consumption Rate	**0.109** kg/d		Craighead and Craighead 1969
Water Consumption Rate	**0.064** L/d	Estimated using allometric equation[b]; assuming 1.126 kg bw	Calder and Braun 1983
Soil Consumption Rate	while some soil attached to prey may be ingested, amount is assumed to negligible		
Diet Composition	predominantly small mammals small mammal - 78.5 % bird - 8.5 % snake - 13.0 %	 Oregon - pasture and wheat fields	EPA 1993a Janes 1984
Home Range	233 ha 1936 ha (957 - 2465 ha range)	Oregon - pasture and wheat fields Colorado - prairie-pinyon/juniper woodland; mean of 4 birds; 95% ellipse and systematic relocation	Janes 1984 Anderson and Rongstad 1989
Habitat Requirements	use wide range of habitats. prefer landscapes containing mixture of oldfields, wetlands and pasture for foraging with trees interspersed for perching and nesting		EPA 1993a DeGraaf et al. 1981
Population Density	0.03 - >0.005 pairs/ha		EPA 1993a
Behavior	territorial throughout year northerly populations migrate; those in the south do not		Brown and Amadon 1968[b] National Geographic Society 1987

[a] Suggested values for use in exposure assessment are in bold.

[b] Allometric equation for estimation of water consumption by birds is:

$$W=0.059(bw)^{0.67}$$

Table 7.6 (continued)

where:	W	=	water consumption (L/d)
	bw	=	body weight (kg)

Table 7.7. Life History Parameters for the Wild Turkey (*Meleagris gallopavo*)

Parameter	Value[a]	Comments	Reference
Body Weight	7.400 kg (♂) 4.222 kg (♀) **5.8 kg** (mean♂+♀)		Dunning 1984
Food Consumption Rate	13.6 g/lb bw/d **0.174** kg/d	 assuming 5.8 kg bw	Korschgen 1967
Water Consumption Rate	**0.19** L/d	estimated using allometric equation[c] assuming 5.8 kg bw	Calder and Braun 1983
Soil Consumption Rate	9.3 % **0.0162** kg/d	 assuming 0.174 kg/d food consumption rates	Beyer et al. 1994
Diet Composition	plant material (mast, fruit, seeds, some foliage) - 90.3% animal material (insects, crayfish, snails, salamanders) - 9.7 %		Korschgen 1967
Home Range	150 - 190 ha		Pough 1951[b]
Habitat Requirements	mast-producing woodlands with associated fields and abundant water		Schorger 1966[b]
Population Density	0.03 /ha 0.06 - 0.076 /ha **0.0426 /ha** (calculated based on @ 500 turkey observed on ORR and suitable habitat)	West Virginia in 'ideal' habitat Oak Ridge Reservation	Uhling 1950[b] Pough 1951[b] Personal Communication, Jim Evans 1995
Behavior	forage primarily on the ground roost in trees at night year-round resident; does not migrate		National Geographic Society 1987

[a] Suggested values for use in exposure assessment are in bold.

[b] Cited in DeGraaf et al. 1981.

[c] Allometric equation for estimation of water consumption for birds is:

Table 7.7 (continued)

$$WIR = 0.059(BW)^{0.67}$$

where:

WIR= water ingestion rate (L water/individual/day).

Table 7.8. Life history parameters for mink

Parameter	Value	Comments	Reference
Body Weight	**1.0** kg (mean ♂+♀)		EPA 1993b
Food Consumption Rate	**0.137** kg/d (mean ♂+♀)		Bleavins and Aulerich 1981
Water Consumption Rate	**0.099** L/d	estimated using allometric equation[a] assuming 1.0 kg bw	Calder and Braun 1983
Diet Composition	Diverse diet includes: mammals, fish, aquatic invertebrates, amphibians, and birds		Hamilton 1940, Sealander 1943, Korschgen 1958, Burgess and Bider 1980 Alexander 1977
	Proportion of aquatic prey (fish, amphibians, inverts, etc.) = 0.546±0.21	Proportion represents means of values from five studies	
	fish sizes: 0-10 cm=72% 11-20 cm=28%		
Home Range	2.63 km (♂) 1.85 km (♀)	stream - Sweden	Gerell 1970
	770 ha (♂)	prairie potholes, Manitoba	Arnold and Fritzell 1987
		range size and shape depends on habitat - linear along streams, circular in marshes	EPA 1993a.
Habitat Requirements	aquatic habitats - streams, lakes, marshes;		Burt and Grossenheider 1976
Population Density	0.03 - 0.085 /ha	river - Montana	Mitchell 1961
	0.6/km	river - Michigan	EPA 1993a
Behavior	nocturnal active year-round, does not hibernate		EPA 1993a

[a] Allometric equation for estimation of water consumption by mammals is:

$$W=0.099(bw)^{0.90}$$

where: W = water consumption (L/d)
bw = body weight (kg)

Table 7.9. Exposure (mg/kg/d) and risk estimates for short-tailed shrews exposed to contaminants in surface soil subbasins in the White Oak Creek watershed

Subbasin	ANATYPE	Analyte	Frequency Detection	Total Exposure[a]	NOAEL HQ[b]	LOAEL HQ[b]
SWSA 5 Seep A	Inorganics	Antimony	2/2	0.32	2.15	0.22
SWSA 5 Seep B East	Inorganics	Antimony	1/1	0.27	1.78	0.18
SWSA 5 Seep B West	Inorganics	Antimony	1/2	0.48	3.25	0.33
SWSA 5 Seep C	Inorganics	Antimony	3/6	0.80	5.38	0.54
SWSA 5 Trib 1	Inorganics	Antimony	2/5	0.26	1.72	0.17
SWSA 5 WOC	Inorganics	Antimony	2/9	0.27	1.79	0.18
SWSA 6 South	Inorganics	Arsenic	1/1	12.20	81.33	8.14
W6MS1	Inorganics	Arsenic	6/6	6.43	42.87	4.29
W6MS3	Inorganics	Arsenic	10/11	2.74	18.27	1.83
East Seep	Inorganics	Barium	3/3	53.80	4.56	1.24
HF-2	Inorganics	Barium	2/2	167.00	14.15	3.84
HRE	Inorganics	Barium	7/7	44.60	3.78	1.03
Intermediate Pond	Inorganics	Barium	15/15	31.90	2.70	0.73
Lower WOC	Inorganics	Barium	12/12	31.20	2.64	0.72
NHF	Inorganics	Barium	3/3	38.80	3.29	0.89
PIT 4 South	Inorganics	Barium	2/2	46.30	3.92	1.06
SWSA 4 Main	Inorganics	Barium	3/3	79.70	6.75	1.83
SWSA 5 Drainage D-2	Inorganics	Barium	5/5	36.90	3.13	0.85
SWSA 5 Seep C	Inorganics	Barium	15/15	47.90	4.06	1.10
SWSA 5 Trib 1	Inorganics	Barium	17/17	30.90	2.62	0.71
SWSA 5 WOC	Inorganics	Barium	22/22	35.10	2.97	0.81
SWSA6 East	Inorganics	Barium	4/4	38.80	3.29	0.89
West Seep	Inorganics	Barium	32/32	26.10	2.21	
SWSA 4 Main	Inorganics	Beryllium	3/3	2.13	1.47	
W6MS1	Inorganics	Beryllium	6/6	1.54	1.06	
HRE	Inorganics	Cadmium	3/7	9.71	4.58	0.46
Intermediate Pond	Inorganics	Cadmium	14/14	4.78	2.25	0.23
Lower WOC	Inorganics	Cadmium	12/12	2.75	1.30	0.13
SWSA 5 Seep A	Inorganics	Cadmium	2/5	3.23	1.52	0.15
SWSA 5 Seep B West	Inorganics	Cadmium	1/2	2.79	1.32	0.13
SWSA 5 Seep C	Inorganics	Cadmium	4/15	2.69	1.27	0.13
SWSA 6 South	Inorganics	Cadmium	1/1	12.60	5.94	0.59
SWSA6 East	Inorganics	Cadmium	4/4	21.60	10.19	1.02
W6MS1	Inorganics	Cadmium	6/6	17.80	8.40	0.84
W6MS3	Inorganics	Cadmium	10/11	11.90	5.61	0.56
West Seep	Inorganics	Cadmium	19/32	10.00	4.72	0.47
WOC	Inorganics	Cadmium	6/6	4.71	2.22	0.22
HF-2	Inorganics	Chromium	2/2	853.00	118.31	29.50
HRE	Inorganics	Chromium	7/7	334.00	46.32	11.50
Lower WOC	Inorganics	Chromium	12/12	446.00	61.86	15.40
WOC	Inorganics	Copper	6/6	59.40	1.78	1.35
Intermediate Pond	Inorganics	Mercury	14/14	98.00	1394.03	279.00
Lower WOC	Inorganics	Mercury	12/12	8.15	115.93	23.20
SWSA 5 Seep B West	Inorganics	Mercury	1/2	5.49	78.09	15.60
SWSA 5 Trib 1	Inorganics	Mercury	4/16	0.75	10.73	2.14
SWSA 5 WOC	Inorganics	Mercury	7/21	0.41	5.83	1.17
WOC	Inorganics	Mercury	6/6	8.80	125.18	25.00
HF-2	Inorganics	Molybdenum	2/2	3.86	12.49	1.25

Table 9 (continued)

Subbasin	ANATYPE	Analyte	Frequency Detection	Total Exposure[a]	NOAEL HQ[b]	LOAEL HQ[b]
Intermediate Pond	Inorganics	Molybdenum	15/15	5.61	18.16	1.81
Lower WOC	Inorganics	Molybdenum	12/12	4.56	14.76	1.47
PIT 4 South	Inorganics	Molybdenum	2/2	5.60	18.12	1.81
SWSA 5 Seep B West	Inorganics	Molybdenum	1/1	4.40	14.24	1.42
SWSA 5 Seep C	Inorganics	Molybdenum	4/4	9.73	31.49	3.15
WOC	Inorganics	Molybdenum	6/6	4.77	15.44	1.54
Intermediate Pond	Inorganics	Nickel	15/15	205.00	2.33	1.16
SWSA 4 Main	Inorganics	Nickel	3/3	27900.00	317.41	159.00
SWSA6 East	Inorganics	Nickel	4/4	213.00	2.42	1.21
W6MS1	Inorganics	Nickel	6/6	219.00	2.49	1.24
West Seep	Inorganics	Nickel	32/32	155.00	1.76	0.88
East Seep	Inorganics	Selenium	1/3	1.10	2.50	1.51
HF-2	Inorganics	Selenium	2/2	0.71	1.62	0.98
Intermediate Pond	Inorganics	Selenium	12/14	0.64	1.45	0.88
Lower WOC	Inorganics	Selenium	9/12	0.89	2.02	1.22
PIT 4 South	Inorganics	Selenium	2/2	1.10	2.50	1.51
SWSA 4 Main	Inorganics	Selenium	1/3	1.83	4.16	2.52
SWSA 5 N /WOC	Inorganics	Selenium	2/4	1.28	2.91	1.77
SWSA 5 Seep A	Inorganics	Selenium	5/5	3.43	7.80	4.73
SWSA 5 Seep B West	Inorganics	Selenium	2/2	1.19	2.70	1.64
SWSA 5 Seep C	Inorganics	Selenium	4/13	0.72	1.65	1.00
SWSA 5 Trib 1	Inorganics	Selenium	4/13	0.97	2.21	1.34
SWSA 5 WOC	Inorganics	Selenium	3/19	0.79	1.78	1.08
WOC	Inorganics	Selenium	2/6	0.98	2.22	1.34
East Seep	Inorganics	Thallium	1/3	0.20	11.89	1.19
Intermediate Pond	Inorganics	Thallium	13/15	0.07	4.11	0.41
Lower WOC	Inorganics	Thallium	12/12	0.06	3.96	0.40
PIT 4 South	Inorganics	Thallium	2/2	0.09	5.71	0.57
SWSA 5 Seep C	Inorganics	Thallium	5/14	0.08	4.72	0.47
SWSA 6 South	Inorganics	Thallium	1/1	0.08	4.76	0.48
WOC	Inorganics	Thallium	6/6	0.06	3.90	0.39
HF-2	Inorganics	Zinc	2/2	2300.00	6.53	3.27
HRE	Inorganics	Zinc	7/7	651.00	1.85	0.93
Intermediate Pond	Inorganics	Zinc	15/15	722.00	2.05	1.03
Lower WOC	Inorganics	Zinc	12/12	1100.00	3.13	1.56
SWSA 4 Main	Inorganics	Zinc	3/3	484.00	1.38	0.69
SWSA 5 Seep A	Inorganics	Zinc	6/6	749.00	2.13	1.06
SWSA6 East	Inorganics	Zinc	4/4	513.00	1.46	0.73
WOC	Inorganics	Zinc	6/6	2380.00	6.76	3.38
Intermediate Pond	Organics	PCB-1254	5/10	0.40	5.94	0.59
Intermediate Pond	Organics	PCB-1260	8/10	3.07	45.96	4.60
Lower WOC	Organics	PCB-1260	8/11	1.51	22.60	2.26
SWSA 5 Drainage D-2	Organics	PCB-1260	2/5	12.70	190.12	19.01
SWSA 5 Seep A	Organics	PCB-1260	3/6	0.40	5.94	0.59
SWSA 5 Seep B East	Organics	PCB-1260	2/3	1.05	15.72	1.57
SWSA 5 Trib 1	Organics	PCB-1260	5/17	0.50	7.51	0.75
SWSA 5 WOC	Organics	PCB-1260	6/19	0.34	5.09	0.51
WOC	Organics	PCB-1260	6/6	2.75	41.17	4.12

Table 9 (continued)

Subbasin	ANATYPE	Analyte	Frequency Detection	Total Exposure[a]	NOAEL HQ[b]	LOAEL HQ[b]

[a] See section 7.1 for methods used to estimate total exposure

[b] Hazard quotients (HQ) were calculated by dividing the total exposure (mg/kg/d) by the NOAEL or the LOAEL. Only analytes whose concentrations were above background and resulted in NOAEL HQs > 1 are included in this table.

Table 7.10. Exposure (mg/kg/d) and risk estimates for white-footed mice exposed to contaminants in surface soil at subbasins in the White Oak Creek watershed

Subbasin	Analyte	Frequency Detection	Total Exposure[a]	NOAEL HQ[b]	LOAEL HQ[b]
SWSA 6 South	Arsenic	1/1	1.44	10.59	1.06
W6MS1	Arsenic	6/6	0.76	5.58	0.56
W6MS3	Arsenic	10/11	0.32	2.38	0.24
HF-2	Barium	2/2	31.00	2.87	0.78
SWSA 4 Main	Barium	3/3	14.80	1.37	
SWSA 6 East	Cadmium	4/4	3.21	1.66	0.17
W6MS1	Cadmium	6/6	2.65	1.37	0.14
HF-2	Chromium	2/2	109.00	16.64	4.16
HRE	Chromium	7/7	42.70	6.52	1.63
Lower WOC	Chromium	12/12	57.10	8.72	2.18
Intermediate Pond	Mercury	14/14	12.60	197.18	39.40
Lower WOC	Mercury	12/12	1.05	16.43	3.27
SWSA 5 Seep B West	Mercury	1/2	0.71	11.03	2.20
SWSA 5 Trib 1	Mercury	4/16	0.10	1.51	0.30
WOC	Mercury	6/6	1.13	17.68	3.53
HF-2	Molybdenum	2/2	0.49	1.75	0.18
Intermediate Pond	Molybdenum	15/15	0.71	2.54	0.25
Lower WOC	Molybdenum	12/12	0.58	2.06	0.21
PIT 4 South	Molybdenum	2/2	0.71	2.54	0.25
SWSA 5 Seep B West	Molybdenum	1/1	0.56	1.99	0.20
SWSA 5 Seep C	Molybdenum	4/4	1.24	4.41	0.44
WOC	Molybdenum	6/6	0.61	2.16	0.22
SWSA 4 Main	Nickel	3/3	3620.00	45.31	22.70
SWSA 5 Seep A	Selenium	5/5	0.43	1.07	0.65
HF-2	Zinc	2/2	323.00	1.01	0.51
WOC	Zinc	6/6	334.00	1.04	0.52
Intermediate Pond	PCB-1260	8/10	0.39	6.46	0.65
Lower WOC	PCB-1260	8/11	0.19	3.18	0.32
SWSA 5 Drainage D-2	PCB-1260	2/5	1.62	26.69	2.67
SWSA 5 Seep B East	PCB-1260	2/3	0.13	2.21	0.22
SWSA 5 Trib 1	PCB-1260	5/17	0.06	1.06	0.11
WOC	PCB-1260	6/6	0.35	5.78	0.58

[a] See section 7.1 for methods used to estimate total exposure

[b] Hazard quotients (HQ) were calculated by dividing the total exposure (mg/kg/d) by the NOAEL or the LOAEL. Only analytes whose concentrations were above background and resulted in NOAEL HQs > 1 are included in this table.

Table 7.11. Exposure (mg/kg/d) and risk estimates for red fox exposed to contaminants in surface soil at subbasins in the White Oak Creek watershed

Subbasin	Analyte	Frequency Detection	Total Exposure[a]	NOAEL HQ[b]	LOAEL HQ[b]
SWSA 5 South	Arsenic	1/1	0.24	6.56	0.66
W6MS1	Arsenic	6/6	0.12	3.44	0.35
W6MS3	Arsenic	10/11	0.05	1.47	0.15
East Seep	Barium	3/3	3.58	1.26	
HF-2	Barium	2/2	11.10	3.91	1.07
HRE	Barium	7/7	2.98	1.05	
Pit 4 South	Barium	2/2	3.09	1.09	0.30
SWSA 4 Main	Barium	3/3	5.31	1.87	
SWSA 5 Seep C	Barium	15/15	3.20	1.13	0.31
HF-2	Chromium	2/2	15.90	9.19	2.29
HRE	Chromium	7/7	6.22	3.60	0.90
Lower WOC	Chromium	12/12	8.31	4.80	1.20
Intermediate Pond	Mercury	14/14	3.69	358.25	215.00
Lower WOC	Mercury	12/12	0.31	29.81	17.90
SWSA 5 Seep B West	Mercury	1/2	0.21	20.10	12.00
SWSA 5 Trib 1	Mercury	4/16	0.03	2.76	1.65
SWSA 5 WOC	Mercury	7/21	0.02	1.50	0.90
WOC	Mercury	6/6	0.33	32.14	19.30
Intermediate Pond	Molybdenum	15/15	0.10	1.30	0.13
Lower WOC	Molybdenum	12/12	0.08	1.05	0.11
Pit 4 South	Molybdenum	2/2	0.10	1.29	0.13
SWSA 5 Seep B West	Molybdenum	1/1	0.08	1.02	0.10
SWSA 5 Seep C	Molybdenum	4/4	0.17	2.25	0.23
WOC	Molybdenum	6/6	0.08	1.10	0.11
SWSA 4 Main	Nickel	3/3	582.00	27.58	13.80
SWSA 5 Seep A	Selenium	5/5	0.13	1.22	0.74
East Seep	Thallium	1/3	0.01	1.93	0.19
HF-2	Zinc	2/2	150.00	1.78	0.89
WOC	Zinc	6/6	156.00	1.85	0.92
Intermediate Pond	PCB-1260	8/10	0.22	2.27	0.46
Lower WOC	PCB-1260	8/11	0.11	1.11	0.23
SWSA 5 Drainage D-2	PCB-1260	2/5	0.90	9.38	1.90
WOC	PCB-1260	6/6	0.20	2.03	0.41

[a] See section 7.1 for methods used to estimate total exposure

[b] Hazard quotients (HQ) were calculated by dividing the total exposure (mg/kg/d) by the NOAEL or the LOAEL. Only analytes whose concentrations were above background and resulted in NOAEL HQs > 1 are included in this table.

Table 7.12. Exposure (mg/kg/d) and risk estimates for white-tailed deer exposed to contaminants in surface soil at subbasins in the White Oak Creek watershed

Subbasin	Analyte	Frequency Detection	Total Exposure[a]	NOAEL HQ[b]	LOAEL HQ[b]
SWSA 6 South	Arsenic	1/1	0.03	1.46	0.15
East Seep	Barium	3/3	2.35	1.56	
HF-2	Barium	2/2	7.30	4.83	1.31
HRE	Barium	7/7	1.95	1.29	
NHF	Barium	3/3	1.69	1.12	0.30
PIT 4 South	Barium	2/2	2.02	1.34	0.36
SEEP C	Barium	15/15	2.09	1.38	0.38
SWSA 4 Main	Barium	3/3	3.48	2.30	
SWSA 5 Drainage D-2	Barium	5/5	1.61	1.07	0.29
SWSA 5 WOC	Barium	22/22	1.53	1.01	0.28
SWSA 6 East	Barium	4/4	1.69	1.12	0.30
Intermediate Pond	Mercury	14/14	0.12	12.81	2.57
Lower WOC	Mercury	12/12	0.01	1.07	0.21
WOC	Mercury	6/6	0.01	1.15	0.23
SWSA 4 Main	Nickel	3/3	40.10	3.58	1.79
East Seep	Thallium	1/3	0.00	1.21	0.12

[a] See section 7.1 for methods used to estimate total exposure

[b] Hazard quotients (HQ) were calculated by dividing the total exposure (mg/kg/d) by the NOAEL or the LOAEL. Only analytes whose concentrations were above background and resulted in NOAEL HQs > 1 are included in this table.

Table 7.13. Exposure (mg/kg/d) and risk estimates for red-tailed hawks exposed to contaminants in surface soil at subbasins in the White Oak Creek watershed

Subbasin	Analyte	Frequency Detection	Total Exposure[a]	NOAEL HQ[b]	LOAEL HQ[b]
HRE	Chromium	7/7	1.41	1.41	0.28
Intermediate Pond	Mercury	14/14	2.58	403.13	40.40
Lower WOC	Mercury	12/12	0.22	33.59	3.35
SWSA 5 Seep B West	Mercury	1/2	0.15	22.66	2.26
SWSA 5 Trib 1	Mercury	4/16	0.02	3.11	0.31
SWSA 5WOC	Mercury	7/21	0.01	1.69	0.17
WOC	Mercury	6/6	0.23	36.25	3.62
SWSA 4 Main	Nickel		177.00	2.29	1.65
HF-2	Zinc	2/2	133.00	9.17	1.02
HRE	Zinc	7/7	37.80	2.61	0.29
Intermediate Pond	Zinc	15/15	41.90	2.89	0.32
Lower WOC	Zinc	12/12	63.70	4.39	0.49
SWSA 4 Main	Zinc	3/3	28.10	1.94	0.21
SWSA 5 Seep A	Zinc	6/6	43.40	2.99	0.33
SWSA 5WOC	Zinc	22/22	18.10	1.25	0.14
SWSA 6 East	Zinc	4/4	29.80	2.06	0.23
WOC	Zinc	6/6	138.00	9.52	1.05
Intermediate Pond	PCB-1260	8/10	0.21	1.15	0.12
SWSA 5 Drainage D-2	PCB-1260	2/5	0.85	4.74	0.47
WOC	PCB-1260	6/6	0.19	1.03	0.10

[a] See section 7.1 for methods used to estimate total exposure

[b] Hazard quotients (HQ) were calculated by dividing the total exposure (mg/kg/d) by the NOAEL or the LOAEL. Only analytes whose concentrations were above background and resulted in NOAEL HQs > 1 are included in this table.

Table 7.14. Exposure (mg/kg/d) and risk estimates for wild turkeys exposed to contaminants in surface soil at subbasins in the White Oak Creek watershed

Subbasin	Analyte	Frequency Detection	Total Exposure[a]	NOAEL HQ[b]	LOAEL HQ[b]
HRE	Chromium	7/7	1.96	1.96	0.39
Intermediate Pond	Mercury	14/14	0.68	105.47	10.50
Lower WOC	Mercury	12/12	0.06	8.77	0.88
SWSA Seep B West	Mercury	1/2	0.04	5.91	0.59
WOC	Mercury	6/6	0.06	9.47	0.95
SWSA 4 Main	Nickel	3/3	193.00	2.49	1.80
HF-2	Zinc	2/2	24.20	1.67	0.19
WOC	Zinc	6/6	25.10	1.73	0.19

[a] See section 7.1 for methods used to estimate total exposure

[b] Hazard quotients (HQ) were calculated by dividing the total exposure (mg/kg/d) by the NOAEL or the LOAEL. Only analytes whose concentrations were above background and resulted in NOAEL HQs > 1 are included in this table.

Table 7.15. Exposure (mg/kg/d) and risk estimates for mink exposed to contaminants in surface soil at subbasins in the White Oak Creek watershed

Subbasin	ANATYPE	Analyte	Frequency Detection	Total Exposure[a]	NOAEL HQ[b]	LOAEL HQ[b]
Intermediate Pond	Inorganics	Mercury	14/14	1.66	110.67	66.40
Lower WOC	Inorganics	Mercury	12/12	0.14	9.20	5.52
SWSA 5 Seep B,West	Inorganics	Mercury	1/2	0.09	6.19	3.72
WOC	Inorganics	Mercury	6/6	0.15	9.93	5.96
SWSA4 Main	Inorganics	Nickel	3/3	113.00	3.67	1.84
SWSA 5 Drainage D-2	Organics	PCB-1260	2/5	0.55	3.91	0.79

[a] See section 7.1 for methods used to estimate total exposure. The exposure estimate for mink is based on terrestrial exposures (ingestion of small mammal prey) only. Aquatic exposure are addressed separately.

[b] Hazard quotients (HQ) were calculated by dividing the total exposure (mg/kg/d) by the NOAEL or the LOAEL. Only analytes whose concentrations were above background and resulted in NOAEL HQs > 1 are included in this table.

Table 7.16. Metal Concentrations in Hair of Mink from the ORR and from Offsite Reference Samples[a]

Site	N	Hg	Se	As	Cd	Pb
East Fork Poplar Creek	1	104	0.69	ND[b]	ND	0.33
Bear Creek	3	10.97±3.42	1.88±.1.41	0.15±0.09	0.04±.0.02	0.97±1.28
WOC	1	8.8	1	ND	ND	0.37
Offsite	7	5.15±3.43	1.11±0.25	0.22±0.31	0.04±0.02	0.7±0.31

[a] Mean ± standard deviation mg/kg dry weight
[b] ND = Not Detected

Table 7.17. Summary of potential risks (HQs > 1) from soils to the short-tailed shrew in the White Oak Creek Watershed

		Hazard quotients for risk driving analytes											
Subbasin	HI	As	Ba	Cd	Cr	Cu	Hg	Mo	Ni	PCB-1260	Se	Tl	Zn
Intermediate Pond	290.2						279.0	1.8	1.2	4.6			1.0
SWSA 4 Main	165.0		1.8						159.0		2.5		
Lower WOC	44.2				15.4		23.2	1.5		2.3	1.2		1.6
HF-2	39.0		3.8		29.5			1.2					3.3
WOC	41.5					1.4	25.0	1.5		4.1	1.3		3.4
SWSA 5 Drainage D-2	19.8									19.0			
SWSA 5 Seep B West	19.1						15.6	1.4			1.6		
HRE	15.2		1.0		11.5					1.2			
SWSA 6 South	9.2	8.1											
SWSA 5 Seep C	6.4		1.1					3.2			1.0		
W6MS1	6.4	4.3							1.2				
SWSA 5 Seep A	6.2										4.7		1.1
SWSA 5 Trib 1	5.2						2.1				1.3		
Pit 4 South	5.1		1.1					1.8			1.5		
SWSA 5 WOC	4.4						1.2				1.1		
East Seep	4.0		1.2								1.5	1.2	
SWSA 6 East	3.8			1.0					1.2				
W6MS3	2.5	1.8											
West Seep	2.3								0.9				
SWSA 5 Seep B East	2.2									1.6			
SWSA 5 N WOC	1.8										1.8		

Notes:

As = arsenic, Ba = barium, Cd = cadmium, Cr = chromium, Cu = copper, Hg = mercury, Mo = molybdenum, Ni = nickel, Se = selenium, Tl = thallium, Zn = zinc

HI = Sum of hazard quotients for all analytes detected.

HQ = Ratio of daily dose to LOAEL-based toxicological benchmarks.

Risk driving analytes = any detected contaminant present above background concentrations that contributes a HQ above 1.

Table 7.18. Summary of potential risks (HQs > 1) from soils to the white-footed mouse in the White Oak Creek Watershed

		HQs for risk driving analytes				
Subbasin	**HI**	**As**	**Cr**	**Hg**	**Ni**	**PCB-1260**
Intermediate Pond	41.0			39.4		
SWSA 4 Main	23.6				22.7	
Lower WOC	6.6		2.2	3.3		
HF-2	5.8		4.2			
WOC	5.4			3.5		
SWSA 5 Drainage D-2	2.9					2.7
SWSA 5 Seep B West	2.7			2.2		
HRE	2.2		1.6			
SWSA 6 South	1.2	1.1				

Notes:
As = arsenic, Cr = chromium, Hg = mercury, Ni = nickel
HI = Sum of hazard quotients for all analytes detected.
HQ = Ratio of daily dose to LOAEL-based toxicological benchmarks.
Risk driving analytes = any detected contaminant present above background concentrations that contributes a HQ above 1.

Table 7.19. Summary of potential risks (HQs > 1) from soils to the red fox in the White Oak Creek Watershed

		HQs for risk driving analytes				
Subbasin	**HI**	**Ba**	**Cr**	**Hg**	**Ni**	**PCB-1260**
Intermediate Pond	216.5			215.0		
WOC	21.8			19.3		
Lower WOC	20.3		1.2	17.9		
SWSA 4 Main	15.0				13.8	
SWSA 5 Seep B West	12.4			12.0		
HF-2	4.5	1.1	2.3			
SWSA 5 Trib 1	2.2			1.6		
SWSA 5 Drainage D-	2.1					1.9
HRE	1.6		0.9			
SWSA 5 WOC	1.5			0.9		

Notes:
Ba = barium, Cr = chromium, Hg = mercury, Ni = nickel
HI = Sum of hazard quotients for all analytes detected.
HQ = Ratio of daily dose to LOAEL-based toxicological benchmarks.
Risk driving analytes = any detected contaminant present above background concentrations that contributes a HQ above 1.

Table 7.20. Summary of potential risks (HQs > 1) from soils to the white-tailed deer in the White Oak Creek Watershed

		HQs for risk driving analytes		
Subbasin	**HI**	**Ba**	**Hg**	**Ni**
Intermediate Pond	3.0		2.6	
SWSA 4 Main	2.5			1.8
HF-2	1.6	1.3		

Notes:
Ba = barium, Hg = mercury, Ni = nickel
HI = Sum of hazard quotients for all analytes detected.
HQ = Ratio of daily dose to LOAEL-based toxicological benchmarks.
Risk driving analytes = any detected contaminant present above background concentrations that contributes a HQ above 1.

Table 7.21. Summary of potential risks (HQs > 1) from soils to the red-tailed hawk in the White Oak Creek Watershed

		HQs for risk driving analytes		
Subbasin	**HI**	**Hg**	**Ni**	**Zn**
Intermediate Pond	40.9	40.4		
WOC	4.9	3.6		1.0
Lower WOC	4.0	3.4		
SWSA 5 Seep B We	2.3	2.3		
SWSA 4 Main	2.0		1.6	
HF-2	1.2			1.0

Notes:
Hg = mercury, Ni = nickel, Zn = zinc
HI = Sum of hazard quotients for all analytes detected.
HQ = Ratio of daily dose to LOAEL-based toxicological benchmarks.
Risk driving analytes = any detected contaminant present above background concentrations that contributes a HQ above 1.

Table 7.22. Summary of potential risks (HQs > 1) from soils to the wild turkey in the White Oak Creek Watershed

		HQs for risk driving analytes	
Subbasin	**HI**	**Hg**	**Ni**
Intermediate Pond	10.6	10.5	
SWSA 4 Main	2.0		1.8
WOC	1.3	1.0	
Lower WOC	1.0		

Notes:
Hg = mercury, Ni = nickel
HI = Sum of hazard quotients for all analytes detected.
HQ = Ratio of daily dose to LOAEL-based toxicological benchmarks.
Risk driving analytes = any detected contaminant present above background concentrations that contributes a HQ above 1.

Table 7.23. Summary of potential risks (HQs > 1) from soils to mink in the White Oak Creek Watershed

		HQs for risk driving analytes	
Subbasin	**HI**	**Hg**	**Ni**
Intermediate Pond	66.8	66.4	
WOC	6.9	6.0	
Lower WOC	6.0	5.5	
SWSA 5 Seep B West	3.8	3.7	
SWSA 4 Main	2.2		1.8

Notes:
Hg = mercury, Ni = nickel
HI = Sum of hazard quotients for all analytes detected.
HQ = Ratio of daily dose to LOAEL-based toxicological benchmarks.
Risk driving analytes = any detected contaminant present above background concentrations that contributes a HQ above 1.

Table 7.24. Interpretation of effects level/exposure distribution comparisons

Comparison	Meaning	Risk-based Interpretation
NOAEL>80th percentile of exposure distribution	less than 20% of exposures> NOAEL	Individual- and population-level adverse effects are highly unlikely
NOAEL<80th percentile<LOAEL	More than 20% of exposures > NOAEL, but less than 20% of exposures> LOAEL	Individuals experiencing exposures at the high end of the distribution may experience adverse effects, but those effects are unlikely to significantly contribute to effects on the WOCW population.
LOAEL<80th percentile of exposure distribution	More than 20% of exposures> LOAEL	Effects on some individuals are likely and they may contribute significantly to effects on the WOCW population.

Table 7.25. Estimated Size of Wildlife Populations within the White Oak Creek Watershed

Endpoint	Population Density[1]	Units	Amount of Suitable Habitat	Units	Estimated Population Size[1]
Short-tailed Shrew	23	indiv/ha	350	ha	8050
White-footed Mouse	57	indiv/ha	350	ha	19950
White-tailed Deer	0.1704	indiv/ha	350	ha	60
Red Fox	0.077	indiv/ha	350	ha	27
Red-Tailed Hawk	0.03	indiv/ha	350	ha	11
Wild Turkey	0.0426	indiv/ha	350	ha	15
Mink	0.6	indiv/stream km	6.4	stream km	4
Belted Kingfisher	0.4	indiv/stream km	6.4	stream km	3

[1]Number of individuals

Table 7.26. Summary of the number of individuals of terrestrial wildlife endpoints estimated to be experiencing adverse effects in the White Oak Creek Watershed

Species	Analyte	%>NOAEL	%>LOAEL	Number in Area	Number Adversely Affected[2]	% Adversely Affected
Short-tailed Shrew	Aroclor 1260	85%	27%	8050	2254	28%
	Arsenic	100%	20%	8050	0	0%
	Barium	100%	2%	8050	0	0%
	Cadmium	94%	2%	8050	0	0%
	Chromium	100%	90%	8050	8050	100%
	Copper	3%	1%	8050	0	0%
	Mercury	100%	70%	8050	5635	70%
	Molybdenum	100%	58%	8050	4790	60%
	Nickel	95%	76%	8050	6118	76%
	Selenium	97%	59%	8050	4910	61%
	Thallium	100%	0.4%	8050	0	0%
	Zinc	18%	2%	8050	0	0%
White-footed Mice	Aroclor 1260	37%	2%	19950	0	0%
	Arsenic	34%	1%	19950	0	0%
	Chromium	49%	1%	19950	0	0%
	Mercury	56%	13%	19950	0	0%
	Nickel	28%	5%	19950	0	0%
Red Fox	Aroclor 1260	11%	2%	27	0	0%
	Barium	<1%	<1%	27	0	0%
	Mercury	90%	63 %	27	18	67%
	Nickel	11%	2%	27	0	0%
Mink[1]	Mercury	20%	11%	4	0	0%
	PCB-1260	5%	2%	4	0	0%
	Nickel	2%	<1%	4	0	0%
White-tailed Deer	Mercury	4%	<1%	60	0	0%
	Nickel	1%	<1%	60	0	0%
	Barium	2%	0%	60	0	0%

Table 7.26. (continued)

Species	Analyte	%>NOAEL	%>LOAEL	Number in Area	Number Adversely Affected[2]	% Adversely Affected
Red-tailed Hawk	Mercury	70%	6%	11	0	0%
	Nickel	2%	<1%	11	0	0%
	Zinc	75%	2%	11	0	0%
Wild Turkey	Mercury	60%	2%	15	0	0%
	Nickel	0%	0%	15	0	0%

[1] Exposure through consumption of small mammals, vegetation, invertebrates, and soil.
[2]If predicted number was below 0.5, it was rounded to zero while if it was between 0.5 and 1.0, it was rounded to 1.

Table 7.27. Summary of Monte Carlo results estimating population-level risks[a] for white-footed mice and short-tailed shrews exposed to contaminants in soil within subbasins

Species	Subbasin	Analyte	%>NOAEL[b]	%>LOAEL[b]	Population-level risk in subbasin?
Short-tailed Shrew	East Seep	Barium		13	
	East Seep	Selenium		34	yes
	East Seep	Thallium		45	yes
	HF-2	Barium	95	76	yes
	HF-2	Chromium	98	71	yes
	HF-2	Molybdenum	99	33	yes
	HF-2	Zinc	58	38	yes
	HRE	Barium		12	
	HRE	Chromium		43	yes
	HRE	PCB-1260		5	
	Intermediate Pond	Mercury	100	79	yes
	Intermediate Pond	Molybdenum	100	51	yes
	Intermediate Pond	Nickel	20	9	
	Intermediate Pond	PCB-1260	82	24	yes
	Intermediate Pond	Zinc	20	9	
	Lower WOC	Chromium	92	56	yes
	Lower WOC	Mercury	82	47	yes
	Lower WOC	Molybdenum	99	35	yes
	Lower WOC	PCB-1260	56	10	
	Lower WOC	Selenium	56	33	yes
	Lower WOC	Zinc	26	12	
	PIT 4 South	Barium	97	13	
	PIT 4 South	Molybdenum	100	52	yes
	PIT 4 South	Selenium	74	48	yes
	SWSA 5 Seep A	Selenium	85	73	yes
	SWSA 5 Seep A	Zinc	20	10	
	SWSA 5 Seep B East	PCB-1260	61	8	
	SWSA 5 Seep B West	Mercury	87	56	yes
	SWSA 5 Seep B West	Molybdenum	99	42	yes
	SWSA 5 Seep B West	Selenium	58	40	yes
	SWSA 5 Seep C	Barium	89	16	
	SWSA 5 Seep C	Molybdenum	100	70	yes
	SWSA 5 Seep C	Selenium	44	26	yes
	SWSA 4 Main	Barium		37	yes
	SWSA 4 Main	Nickel		99	yes
	SWSA 4 Main	Selenium		49	yes
	SWSA 5 Trib 1	Mercury	6	2	
	SWSA 5 Trib 1	Selenium	31	18	
	SWSA 5 WOC	Mercury	15	4	
	SWSA 5 WOC	Selenium	23	13	
	SWSA 5 N WOC	Selenium	67	46	yes
	SWSA 6 East	Cadmium	85	18	
	SWSA 6 East	Nickel	54	14	
	SWSA 6 South	Arsenic	100	100	yes
	W6MS3	Arsenic	71	12	
	W6MS1	Arsenic	97	36	yes

Table 7.27. (continued)

Species	Subbasin	Analyte	%>NOAEL[b]	%>LOAEL[b]	Population-level risk in subbasin?
	SWSA 5 Drainage D-2	PCB-1260	96	67	yes
	WOC	Copper	22	17	
	WOC	Mercury	94	72	yes
	WOC	Molybdenum	98	36	yes
	WOC	PCB-1260	86	29	yes
	WOC	Selenium	48	31	yes
	WOC	Zinc	45	29	yes
White-footed mouse	HF-2	Chromium	54	20	yes
	HRE	Chromium		7	
	Intermediate Pond	Mercury	72	46	yes
	Lower WOC	Chromium	39	12	
	Lower WOC	Mercury	35	10	
	SWSA 5 Seep B West	Mercury	43	15	
	SWSA 4 Main	Nickel		86	yes
	SWSA 6 South	Arsenic	82	8	
	SWSA 5 Drainage D-2	PCB-1260	72	18	
	WOC	Mercury	60	20	yes

[a] See section 7.1 for methods used to estimate exposures and section 7.3.1.2 for discussion of Monte Carlo analysis.

[b] Percent of individuals in population experiencing exposures (mg/kg/d) greater than the No Observed Adverse Effects Level (NOAEL) or the Lowest Observed Adverse Effects Level (LOAEL).

8. ASSESSMENT OF RISKS TO PISCIVORES ON THE WHITE OAK CREEK WATERSHED

An ecological assessment has been performed to evaluate potential adverse effects to piscivorous (fish-eating) wildlife receptors resulting from exposures to contaminants in the aquatic environment in the WOCW. The assessment includes evaluations of two separate analytical data sets: 1) contaminant concentration data for water samples taken from the individual subbasins within the WOCW, and 2) fish tissue mercury and PCB concentration data taken at eight sampling locations throughout the WOCW. The analysis of water samples was limited to comparisons with benchmark concentrations associated with NOAELs and LOAELs. The water sample data were included to provide complete coverage of the entire suite of contaminants present at individual subbasins in order to identify contaminants and subbasins of potential concern.

The assessment focuses primarily on the fish tissue mercury and PCB data because these represent exposures through the immediate food source of piscivores and assumptions about the degree of bioaccumulation of contaminants through the food chain are not necessary. Mercury and PCBs are among the most important contaminants at the WOCW and on the ORR as a whole. They were the only two contaminants retained as being of potential concern as a result of the comparison of water samples with benchmarks, and fish tissue data for these contaminants were available at all sampling locations. The fish tissue data were used to estimate exposure doses which were compared to NOAELs and LOAELs in order to determine the potential for adverse effects to individuals or populations of piscivores throughout the watershed as a whole.

Results from biological surveys at the ORR and from toxicity tests performed using fish from the ORR are also presented and discussed in terms of evidence for or against potential adverse affects at the WOCW.

The following assessment endpoints were selected for the assessment of risks to piscivorous wildlife: toxicity to mink (*Mustela vison*), river otter (*Lutra canadensis*), belted kingfisher (*Ceryle alcyon*), great blue heron (*Ardea herodias*) and osprey (*Pandion haliaetus*) resulting in a reduction in population abundance or production. These assessment endpoints are those that have been agreed to be appropriate for the ORR by the FFA parties (Suter et al. 1995). The criteria for selection of the entities are those recommended by the EPA (Risk Assessment Forum 1992), plus considerations of scale and practical considerations.

Both osprey and river otter are listed as threatened species by the TWRA (Tennessee Wildlife Resources Agency). Osprey are found along the Clinch River and Poplar Creek, adjacent to the ORR and use larger bodies of water on the ORR such as the White Oak Lake and embayment. While otter are not known to occur on the ORR at the present time, they have been included in this assessment because the ORR, including the WOCW, contains suitable habitat, a reintroduction program is underway in east Tennessee, and they may become established on the ORR in the future. To determine if the ORR could support this threatened species, it is important to evaluate the nature and magnitude of risk that contaminants in the watersheds on the ORR may present to otter.

The conceptual model for exposure of piscivores to contaminants is presented in Fig. 8.1. Components of this model include aquatic biota (aquatic plants, invertebrates, fish, and amphibians) that reside in ponds and streams in the WOCW and the piscivorous wildlife that feed on aquatic biota. The aquatic biota are exposed to contaminants from surface water and sediments.

Contaminants are bioaccumulated in lower trophic levels (i.e., plants or invertebrates) and transferred to higher trophic levels (i.e., invertebrates, fish, or amphibians). Piscivorous wildlife consume fish, amphibians, and invertebrates and are therefore exposed to accumulated contaminants (Fig. 8.1).

8.1 EXPOSURE ASSESSMENT

Piscivorous wildlife may be exposed to contaminants through ingestion of contaminated media such as fish, other aquatic prey, and water. For the evaluation of water samples, concentration data were simply compared to benchmark concentrations for mink, otter, belted kingfisher, great blue heron and osprey based on water ingestion combined with ingestion of aquatic prey. It is not necessary to discuss the exposure assessment for the water samples further in this section.

For the evaluation of the fish tissue mercury and PCB concentration data, ingestion of fish and other aquatic prey was the only pathway considered. Contaminant exposure through ingestion was estimated for mink, otter, belted kingfisher, great blue heron and osprey. This assessment focused only on the two contaminants, mercury and PCBs, for which there are watershed-scale data on concentrations in fish. Exposure estimates were calculated for 8 locations in the White Oak Creek basin. Locations of fish sampling locations within White Oak Creek are presented in Fig. 8.2. WOCW subbasins for which fish samples are available are White Oak Creek Embayment (WCK 0.3 and WCK 0.9), Lower WOC/White Oak Lake (WCK 1.5 and WCK 2.3), Seep C (MEK 0.2) and WOC (WCK 2.9). The two other locations, WCK 3.5 and NTK 0.2, are immediately north of the Melton Valley portion of the WOCW, but were included because ecological receptors in Melton Valley would likely be exposed to fish at these locations due to their immediate proximity and movements of individual fish and piscivores.

8.1.1 Exposure Through Oral Ingestion of Fish

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 with toxicological doses for wildlife, such as those derived by Sample et al. (1996a), or to doses reported in the toxicological literature. Estimation of the daily contaminant dose an individual may receive for a particular contaminant may be calculated as described in Sect. 7.1.

Exposure estimates were calculated for mercury and PCB at all 8 WOCW fish sampling locations. Because wildlife are mobile, their exposure is best represented by the mean contaminant concentration in media. To be conservative, the 95% upper confidence limit (UCL) was used in exposure estimates. To prevent bias that may result from calculating 95% UCLs using data with values below detection limits, the product limit estimator (PLE) was used to calculate the 95% UCLs. These data were used in the initial exposure estimates. Exposure estimates for contaminants that may potentially present a risk to piscivorous wildlife (based upon comparisons to NOAELs and LOAELs) were recalculated using Monte Carlo simulations.

8.1.1.1 Estimation of whole fish contaminant concentrations from fillet data

Fish data from the WOCW consisted of analyses of both whole body concentrations (generally in stonerollers, shiners, and shad) and concentrations in fillets (in sunfish, largemouth bass, and carp). Because piscivores consume whole fish (not fillets) and fillet concentrations do not accurately

represent whole body concentrations, it was necessary to estimate concentrations in whole fish for those sample for which only fillet analyses were performed. Whole-fish concentrations were estimated using the following equations:

for mercury:

$$C_{WB} = e^{[-0.8+0.76*\ln(C_F)]} \quad (1)$$

for PCBs in catfish:

$$C_{WB} = e^{[0.16+0.54*\ln(C_F)]} \quad (2)$$

for PCBs in bass or other fish:

$$C_{WB} = e^{[0.81+0.95*\ln(C_F)]} \quad (3)$$

where:

C_{WB} = whole body contaminant concentration
C_F = fillet contaminant concentration

A detailed discussion of the development of these equations is presented in Bevelheimer et al. (1996).

8.1.1.2 Contaminant concentrations in fish

Contaminant concentrations in fish are needed to estimate exposure. Fish tissue contaminant concentration data were aggregated into two size classes: <30 cm and >30 cm in length. This is because piscivore species forage on different size fish and contaminant body burdens are related to size (larger, older fish generally have higher contaminant concentrations). While mink, belted kingfisher, and great blue heron generally consume fish <30 cm in size, osprey and otter forage equally on small and large fish (see Tables 7.8 and 8.1 through 8.4). To more accurately reflect exposure, data were segregated according to size and exposure was estimated using data from the size of fish most likely to be consumed by that endpoint species. Because it was assumed that piscivores would select fish according to size and not by species, all species were pooled within each size class. The 95% UCLs (calculated using the PLE) for contaminants detected in fish from the WOCW are presented in Table 8.5.

8.1.1.3 Exposure modeling using point-estimates

Initial estimates of exposure of piscivorous wildlife to contaminants were performed for each sampling point using point estimates of parameters in the exposure model (Equation 1). Species-specific parameters necessary to estimate exposure using the Equation 1 are listed in Tables 7.8 and 8.1 through 8.4.

To estimate contaminant exposure experienced by mink, the following assumptions were made:

- Body weight = 1 kg.
- Food consumption = 0.137 kg/d (fresh weight).
- Diet consists 54.6% of fish or other aquatic prey.
- Contaminant concentration in fish is representative of that in other aquatic prey.
- Fish sizes consumed = 100% <30 cm.

To estimate contaminant exposure experienced by otter, the following assumptions were made:

- Body weight = 8 kg.
- Food consumption = 0.9 kg/d (fresh weight).
- Diet consists 100% of fish or other aquatic prey.
- Contaminant concentration in fish is representative of that in other aquatic prey.
- Fish sizes consumed = 50% <30 cm and 50% >30 cm.

To estimate contaminant exposure experienced by kingfisher, the following assumptions were made:

- Body weight = 0.148 kg.
- Food consumption = 0.075 kg/d (fresh weight).
- Diet consists 100% of fish.
- Fish sizes consumed = 100% <30 cm.

To estimate contaminant exposure experienced by great blue heron, the following assumptions were made:

- Body weight = 2.39 kg.
- Food consumption = 0.42 kg/d (fresh weight).
- Diet consists 100% of fish or other aquatic prey.
- Contaminant concentration in fish is representative of that in other aquatic prey.
- Fish sizes consumed = 100% <30 cm.

To estimate contaminant exposure experienced by osprey, the following assumptions were made:

- Body weight = 1.5 kg.
- Food consumption = 0.3 kg/d (fresh weight).
- Diet consists 100% of fish or other aquatic prey.
- Contaminant concentration in fish is representative of that in other aquatic prey.
- Fish sizes consumed = 92.1% <30 cm and 7.9% >30 cm.

Using Equation 1 and the assumptions and data described above, exposure to contaminants was estimated for mink (Table 8.6), otter (Table 8.7), kingfisher (Table 8.8), and great blue heron (Table 8.9) for each location on the WOCW. Because osprey use only large bodies of water, exposure estimates were generated for only for those areas where suitable habitat was available (White Oak Lake and embayment; Table 8.10).

8.1.1.4 Exposure modeling using Monte Carlo simulations

Employing point estimates for the input parameters in the exposure model does not take into account the variation and uncertainty associated with the parameters and therefore may over or under estimate the contaminant exposure that endpoints may receive in any given reach. In addition, calculating the model using point estimates produces a point estimate of exposure. This estimate provides no information concerning the distribution of exposures or the likelihood that individuals within a watershed will actually experience potentially hazardous exposures. To incorporate the variation in exposure parameters and to provide a better estimate of the potential exposure experienced by piscivores on the WOCW, the exposure model was re-calculated using Monte Carlo simulations.

Monte Carlo simulation is a resampling technique frequently used in uncertainty analysis in risk assessment (Hammonds et al. 1994). In practice, distributions are assigned to input parameters in a model and the model is recalculated many times to produce a distribution of output parameters (e.g., estimates of contaminant exposure). Each time the model is recalculated, a value is selected from within the distribution assigned for each input parameter. As a result, a distribution of exposure estimates is produced that reflects the variability of the input parameters. To determine which input parameters most strongly influence the final exposure estimate, a sensitivity analysis is performed (Hammonds et al. 1994). Detailed discussions of sensitivity and uncertainty analysis, and the use of Monte Carlo simulations in risk assessment are provided by Hammonds et al. (1994).

Monte Carlo simulations were performed to estimate WOCW-wide exposures. It was assumed that wildlife were more likely to forage in areas where food is most abundant. The biomass of fish at or near locations where fish bioaccumulation data were collected was assumed to represent measures of food abundance. The relative proportion that each location contributed to overall watershed biomass data was used to weight the contribution to the watershed-level exposure. The watershed-level exposure was estimated to be the weighted average of the exposure at each location sampled within the watershed. In this way, locations with greater fish biomass contribute more to exposure than do locations with lower biomass. Fish biomass data used to weight exposure for the WOCW are presented in Table 8.11.

The percentiles of the resulting exposure distributions represent the likelihood that an individual piscivore within a watershed will experience a given exposure level. Watershed-wide simulations were performed for mercury and PCBs because these contaminants are among the most important at WOCW and on the ORR as a whole, and data for these contaminants were available at all sampling locations.

Distributions were used for the contaminant concentrations in fish and for the proportion of fish in the diet of mink. All contaminant distributions were assumed to be lognormal. Lognormal means and standard deviations for contaminants in fish are presented in Table 8.5.

The proportion of aquatic prey in the diets of otter, kingfisher, heron and osprey were assumed to be 100%. No data suggest that non-aquatic prey constitute a significant portion of their diet (see endpoint discussion, above). In contrast, mink have a very variable diet. Aquatic prey (fish, amphibians, crayfish, etc.) may make up from 16% to 92%. Nine observations from five studies indicate the proportion of aquatic prey to be 0.546±0.21 (mean ± standard deviation; Table 7.8). The proportion of aquatic prey in the diet of mink was assumed to be normally distributed.

Monte Carlo simulations were performed using the @Risk software. Samples from each distribution were selected using Latin hypercube sampling. The number of iterations, or recalculations, of each exposure simulation was determined by the convergence criteria set in the software. Under these criteria, iterations are performed until the between-iteration percent change in the percentiles, mean, and standard deviation are below 1.5% (i.e., the percentile, mean, and standard deviation for the latest iteration is less than 1.5% different than the those from the previous iteration). Using this convergence criteria, from 600 to 1000 model iterations were performed for each exposure estimate. Monte Carlo estimates of contaminant exposures are presented in Table 8.12.

8.2 EFFECTS ASSESSMENT FOR PISCIVOROUS WILDLIFE

8.2.1 Single Chemical Toxicity Data

Single-chemical toxicity data consist of NOAELs and LOAELs of toxicity studies reported in the literature. Derivation of toxicological benchmarks is as described in Sect. 7.2. Mammalian and avian NOAEL's and experimental information used to estimate wildlife NOAEL's and LOAEL's (e.g., test species, test endpoints, citation) for mercury and PCBs are listed in Tables 8.13 and 8.14. Water benchmarks available for WOCW surface water contaminants detected above background concentrations or for which no background values were available are listed in Table 8.15. Ecotoxicological profiles of the effects of contaminants to wildlife are presented in Appendix B.5.

8.2.2 Effects of Contaminants on the Reproductive Performance of Mink

Halbrook (unpubl. data collected at Michigan State University Experimental Fur Farm), evaluated bioaccumulation of contaminants and reproductive effects in mink fed fish collected from Poplar Creek, the Clinch River (upstream of Melton Hill Dam) and the ocean. Even though the study did not include fish collected from the WOCW, these data are deemed to be relevant because they provide ORR-specific fish toxicity data, which are likely to be more appropriate for evaluating effects at the WOCW than data from the general toxicological literature. Mink were fed five diets consisting of 75% fish and 25% commercial mink diet. The diet composition and contaminant concentrations for each diet are described in the following table:

		Contaminant concentration (mg/kg)	
Diet	Fish composition	Mercury	PCB 1260
A	75% ocean	0.02 ± 0.00	0.169 ± 0.002
B	75% Clinch River	0.05 ± 0.00	11.44 ± 0.327
C	25% Poplar Creek 50% ocean	0.09 ± 0.00	4.69 ± 0.174
D	50% Poplar Creek 25% ocean	0.15 ± 0.01	10.41 ± 0.250
E	75% Poplar Creek	0.22 ± 0.01	20.67 ± 0.458

Twenty-three PCB congeners were also present in varying amounts. Concentrations of most congeners increased progressively from diets A through E.

Ten mink (eight females and two males) were fed each diet for ~7 months (3 months before breeding—6 weeks postpartum). Reproductive indices measured included: number of females mated; number of females whelping; length of gestation; number of kits whelped (alive, dead); kit sex ratio; average kit body weight at birth, 3, and 6 weeks of age; and kit survival to 3 to 6 weeks of age. At 6 weeks of age, 3 kits from dietary groups A, B, C, and E were euthanized, organs (liver, spleen, and kidneys) were weighed, and tissue samples (liver, kidney, and remaining carcass) were analyzed for contaminant accumulation. (note: kits from diet D were not sampled). At the termination of the study, all adult mink were necropsied. Organs (brain, liver, kidneys, heart, lungs, gonads, and adrenal glands) were weighed and examined for histopathologies. Adipose tissue, liver, kidney, and hair were analyzed for contaminant accumulation. Liver tissue also was analyzed for ethoxyresorufin-o-deethylase (EROD) activity.

The bioaccumulation of mercury in liver, kidney, and hair, and Aroclor 1260 (and other PCB congeners) in liver and fat substantially increased in adult female mink from groups fed diet A up to diet E. Mink offspring also bioaccumulated mercury in kidney tissue and carcasses and many other PCB congeners in the liver and carcasses, increasing progressively from mink fed diets A through E. The lowest levels were observed for mink fed diet A and increased to a maximum observed among mink fed diet E.

Significant effects were observed only among mink fed diet E; no adverse effects were observed for any other diet. Adverse effects from diet E included: weight reduction in adult mink and their offspring, reduction in litter size, and increase in liver EROD activity in adult females. Weight reduction was observed at the end of the experimental period, increasing magnitude from diet groups A to E. At the end of the experiment, the mean whole body weights of female mink in diet group E were significantly less ($p = 0.03$) than mean weights of females in diet group A (percent reduction = 20%). Mean female relative organ weights (organ weights/body weight) were not significantly different among diet groups. At 6 weeks of age, mean whole body weights were also significantly lower ($p = 0.004$) in male kits from diet group E compared to those from diet group A (percent reduction = 17%). Similar trends were observed for female kits, although differences were not statistically significant. No histological lesions were attributed to any diet. Mean litter size was significantly reduced ($p = 0.01$) in diet group E compared to diet groups A, B, and C (percent reduction relative to diet A = 38%); but not diet group D. Liver EROD activity was significantly increased in adult female mink from diet groups D and E compared with those from diet group A.

8.2.3 Biological Surveys

8.2.3.1 Mink survey

Stevens (1995) investigated bioaccumulation of mercury in mink on the ORR in 1993 through 1995. The methods used in the mink survey, while indicating that mink are present at the WOCW, cannot be used to estimate abundance or density on mink at the WOCW. A total of four male mink were live-trapped over the course of 6073 trapnights (trapnight = 1 trap set for 24 h) on the ORR as a whole. Of these, one adult was captured along White Oak Creek. Captured mink were fitted with an intraperitoneal radio transmitter (to monitor movements and home range) and released. Prior to release, samples of hair were collected and metals analysis. An additional 8 roadkill mink (5 male and 3 female) were collected from the ORR and surrounding areas of Roane and Anderson counties.

While one roadkill sample (a male) was collected on a bridge over Bear Creek and was assumed to be a resident of Bear Creek, all others were collected off the ORR and were used as references.

The Results of metals analysis are presented in the following table:

Metal concentrations in hair of mink from the WOCW and from off-site reference samples[a]

Site	N	Hg	Se	As	Cd	Pb
White Oak Creek	1	8.8	1	ND[b]	ND	0.37
Off site	7	5.15 ± 3.43	1.11 ± 0.25	0.22 ± 0.31	0.04 ± 0.02	0.7 ± 0.31

[a]Mean ± standard deviation mg/kg dry weight.
[b]ND = Not detected.

Radiotelemetry data on home ranges and movements were obtained for 3 mink, including the one from the WOCW. Mean (± standard deviation) home range for these three individuals was found to be 7.5 ± 3 km of stream. The home range of the White Oak Creek mink included all of White Oak Creek from the headwater tributaries to the Clinch River, including the X-10 facility. This individual was observed to use dens within the X-10 facility and moved through the facility on several occasions.

8.2.3.2 Belted kingfisher survey

A field monitoring effort (Baron et al. 1996) was initiated in 1994 to evaluate population parameters and contaminant bioaccumulation by belted kingfisher on the ORR. Areas surveyed included: WOC, White Oak Lake, White Oak Lake Embayment, Melton Branch, Poplar Creek, portions of East Fork Poplar Creek , and portions of Bear Creek.

Methods

Nest burrows were monitored for nesting activity. If activity was observed, samples of feathers and eggshells were collected and analyzed for metals and radionuclides. In addition to specimens collected from the burrows, three carcasses of adult kingfisher were found on the ORR (one from WOC and two from East Fork Poplar Creek). These carcasses were necropsied, and organs were extracted and analyzed for metals and radionuclides. Additional detail concerning methods are reported in Baron et al. (1996).

Results

During April-July of 1994, a total of 27 potential kingfisher burrows were identified on the ORR; 11 of which contained swallow nests. Twenty-five of these burrows were found on the Clinch River. One kingfisher burrow, containing a single unhatched kingfisher egg, was found on White Oak Creek (downstream of WCK 3.5).

A burrow on the Clinch River contained fragments of egg shells and fish vertebrae from regurgitant. Analysis of the egg shells indicated that minimal metal contamination was present (CRD, Table 8.16). Metal concentrations in the egg from the burrow found on White Oak Creek (WOC, Table 8.16) were similar to that for the Clinch River egg, except for elevated cesium-137. The presence of this radionuclide in the egg indicates that the parent kingfisher bioaccumulated

cesium-137 from foraging within White Oak Creek or a nearby surface impoundment (cesium-137 is a typical contaminant of this stream and the impoundments).

Cesium-137, cadmium, lead, selenium, and mercury were each detected in at least one kingfisher carcass collected from the ORR (Table 8.17). As was analyzed for but was not detected. The greatest burdens of mercury, selenium, lead, and cesium-137 were observed in the bird from the White Oak Creek watershed (Bird 3; Table 8.17). In contrast, cadmium levels were higher in the birds from East Fork Poplar Creek (Birds 1 and 2) than in the White Oak Creek bird (Table 8.17).

8.3 RISK CHARACTERIZATION FOR PISCIVOROUS WILDLIFE

Risk Characterization integrates the results of the exposure assessment (Sect. 8.1) and effects assessment (Sect. 8.2) 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. In an ideal risk assessment there are three lines of evidence: literature-derived single chemical toxicity data (which indicate the potential toxic effects of the concentrations measured in site media), biological surveys of the affected system (which indicate the actual state of the receiving environment), and toxicity tests with ambient media (which indicate the toxic effects of exposures to site media). While three lines of evidence are available to assess risks to piscivorous wildlife, not all are available for each endpoint for the WOCW. Single chemical toxicity data are available for all five endpoints. Toxicity tests and a field survey/bioaccumulation study were available for mink. Field survey/bioaccumulation data were available for kingfisher.

Procedurally, the risk characterization is performed for each assessment endpoint by (1) screening all measured contaminants against literature-derived toxicological benchmarks and background concentrations (if available), (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. A detailed discussion of methods and the approach to risk characterization on the ORR is presented in Suter et al. (1995).

8.3.1 Single Chemical Toxicity Data

Two types of single chemical toxicity data are available with which to evaluate piscivore contaminant exposure: NOAELs and LOAELs. To quantify the magnitude of hazard, a hazard quotient (HQ) was calculated where: HQ = exposure/NOAEL or LOAEL. Hazard quotients greater than 1 indicate that individuals may be experiencing exposures that are in excess of NOAELs or LOAELs. While exceeding the NOAEL suggests that adverse effects are possible, exceeding the LOAEL suggests that adverse effects are likely.

8.3.1.1 Surface water contaminant concentration data

To evaluate the potential risk to piscivores from contaminants detected in surface water samples, the lower of the 95% UCL and maximum concentrations in unfiltered water was used as an exposure concentration to compare with NOAEL and LOAEL-based water benchmark concentrations. HQs (water concentration/benchmark value) were calculated for all piscivorous receptor species and for all chemicals for which benchmark concentrations were available. These

HQs are presented in Tables 8.15. Concentration data that were below background concentrations were excluded from the evaluation.

NOAEL- and LOAEL-based HQs exceeded one for the inorganics aluminum, cadmium, mercury, selenium and thallium, and the organics bis-2-ethylhexylphthalate, di-n-butyl phthalate and PCBs, indicating potential risks of adverse effects.

LOAEL-based aluminum HQs exceeded one for mink and otter at Lower WOC/WOL, SWSA 6 East, WAG6MS3, WAG6MS1, SWSA5/WOC and West Seep. However, aluminum is probably not highly soluble and bioavailable in the WOCW because the aquatic environment is not highly acidic. Furthermore, the aluminum benchmarks for mink and otter are based on aluminum chloride, which may not be the prevalent form of the element in the environment. Thus, it is not expected that aluminum poses a threat to piscivores in the WOCW, and it is therefore eliminated from further consideration.

LOAEL-based cadmium HQs exceeded one for otter and kingfisher at WAG6MS1. Cadmium was detected in only five of 18 samples at this subbasin and HQs were only 1.3 for both species. Furthermore, cadmium was not detected in fish tissue samples taken at three locations in the WOCW in winter 1992/1993 (Ashwood 1994). Thus, it is not expected that cadmium poses a threat to piscivores in the WOCW, and it is therefore eliminated from further consideration.

LOAEL-based mercury HQs exceeded one for all five piscivorous receptors at HF-2, Lower WOC/WOL, SWSA 6 East, WAG6MS3, WAG6MS1, SWSA5/WOC and WOC. Mercury was also detected at elevated concentrations in fish tissue samples collected in the WOCW, and is retained as a contaminant of concern.

LOAEL-based selenium HQs exceeded one for heron and osprey at SWSA 5/WOC, and for mink, otter and kingfisher at Lower WOC/WOL, SWSA 5/WOC and WAG6MS1. Selenium was detected only once out of the 42, two and 14 samples taken at Lower WOC/WOL, SWSA 5/WOC and WAG6MS1, respectively. Mean selenium concentrations in fish tissue samples taken at three locations in the WOCW in winter 1992/1993 ranged from 0.21 to 0.5 mg/kg (Ashwood 1994). These concentrations are comparable to the mean selenium concentration of 0.25 mg/kg in fish tissue samples collected at Hinds Creek, a reference stream located in Anderson County, TN (Ashwood 1994). Thus, it is not expected that selenium poses a threat to piscivores in the WOCW, and it is therefore eliminated from further consideration.

LOAEL-based thallium HQs exceeded one for mink and otter at HF-2, Seep A , the Intermediate Pond and WOC subbasins. Thallium was detected only once out of the nine, nine and 12 samples taken at HF-2, Seep A and the Intermediate Pond, respectively, and five times out of the 20 samples taken at WOC. Furthermore, thallium was not detected in fish tissue samples taken at three locations in the WOCW in winter 1992/1993 (Ashwood 1994). Thus, it is not expected that thallium poses a threat to piscivores in the WOCW, and it is therefore eliminated from further consideration.

LOAEL-based bis-2-ethylhexylphthalate HQs exceeded one for mink and otter at SWSA 5/WOC, W6MS3 and W6MS1. Bis-2-ethylhexylphthalate was detected in a total of seven out of the 25 samples taken at three subbasins combined. Being a common laboratory contaminant, it is highly likely that these detections of bis-2-ethylhexylphthalate are spurious. Thus, it is not expected that bis-2-ethylhexylphthalate poses a threat to piscivores in the WOCW, and it is therefore eliminated from further consideration.

LOAEL-based di-n-butyl phthalate HQs exceeded one for kingfisher, heron and osprey at W6MS3 and W6MS1. Di-n-butyl phthalate was detected in only three out of 20 samples taken at W6MS3, and in one out of 4 samples at W6MS1. Being a common laboratory contaminant, it is highly likely that these detections of di-n-butyl phthalate are spurious. Thus, it is not expected that di-n-butyl phthalate poses a threat to piscivores in the WOCW, and it is therefore eliminated from further consideration.

LOAEL-based PCB HQs exceeded one for all five piscivorous receptors at Lower WOC/WOL and WOC. PCBs were also detected at elevated concentrations in fish tissue samples collected in the WOCW, and are retained as contaminants of concern.

Therefore, mercury and PCBs are the contaminants retained as contaminants of concern.

8.3.1.2 Fish tissue mercury and PCB concentration data

The fish tissue mercury and PCB data were used to generate both point estimates of exposure doses and Monte Carlo simulation estimates of exposure. Exposure estimates generated by the exposure model (see Sect. 8.1.1.) produced by both point estimates of parameter values and Monte Carlo simulation represent exposure at the individual level. Point estimates of exposure parameters are first screened against NOAELs and LOAELs to identify contaminants and locations that contribute significantly to risk; if the estimate is greater than the NOAEL or LOAEL, adverse effects are possible and additional evaluation is necessary. LOAELs are then compared to the watershed-level exposure distributions generated by the Monte Carlo simulation to determine the likelihood that an individual within the entire area will experience adverse effects. If the LOAEL is lower than the 80th percentile of the exposure distribution, there is a >20% likelihood that individuals within the modeled location are experiencing contaminant exposures that are likely to produce adverse effects. By combining literature-derived population density data with the likelihood or probability of exceeding the LOAEL, population-level impacts may be estimated.

Initial point estimates of exposure

To determine if the mercury and PCB exposures experienced by mink, river otter, belted kingfisher, great blue heron, and osprey on the WOCW are potentially hazardous, the dietary contaminant exposure estimates (generated using point estimates of parameter values; Tables 8.6 through 8.10) were compared to estimated NOAELs and LOAELs for these species (Tables 8.13 and 8.14). Resulting hazard quotients for mink, river otter, belted kingfisher, and great blue heron on the WOCW are presented along with the point estimates of exposure in Tables 8.6 through 8.10. It should be noted that because few data are available for specific PCB (Aroclor) mixtures, all PCBs were summed and the total was compared to Aroclor-1254 toxicity data.

A summary of the number of locations within the WOCW where HQs>1 were observed is presented in Table 8.18. NOAELs for mercury and PCBs were exceeded at at least one location for all endpoints. LOAELs for mercury and PCBs were exceeded at at least one location for both otter and belted kingfisher, but not for mink, heron and osprey (Table 8.18).

The spatial distribution of contamination and potential risks to piscivores in White Oak Creek are illustrated in Fig. 8.3. This figure displays the sum of the LOAEL-based HQs (e.g., sum of toxic units or ΣTUs) for total PCBs and mercury. Sampling locations were arranged upstream to downstream (right to left); side tributaries or ponds are included in the order in which they enter the main stream.

The pattern of cumulative risk in the WOCW was similar for mink, kingfisher, and herons but different for otters (Fig. 8.3). The pattern for osprey differed from all other species because only suitable habitat (large bodies of water; White Oak Lake and the embayment) were considered. In general, cumulative risk was greater in White Oak Creek than in it's tributaries (NTK and MEK). Mercury was the primary risk agent throughout the watershed, except at WCK 0.3 in the White Oak Creek embayment, where PCBs dominated. A peak for risk to otters from PCBs was observed at White Oak Lake (WCK 1.5). This peak can be attributed to the presence of data for large fish (>30 cm); PCBs in large fish were 3 to 5 times higher than that in small fish (Table 8.5).

Risk estimates from fish tissue data are available from four of the WOCW subbasins:

WOCE. Risk estimates from point exposures are available from two fish sampling locations in this subbasin, WCK 0.3 and WCK 0.9 (Tables 8.6 through 8.10). Based on comparison with LOAELs, no adverse effects from mercury were predicted for any of the piscivorous receptors. Adverse effects from PCBs were predicted to be likely for otter (max. HQ = 1.9) and kingfisher (max. HQ=1.9).

Lower WOC/White Oak Lake. Risk estimates from point exposures are available from two fish sampling locations in this subbasin, WCK 1.5 and WCK 2.3 (Tables 8.6 through 8.10). Based on comparisons with LOAELs, adverse effects from mercury were predicted to be likely for otter (max. HQ = 1.4) and kingfisher (Max. HQ = 1.5). Adverse effects from PCBs were predicted to be likely only for otter (max. HQ = 2.6).

Seep C. Risk estimates from point exposures are available from one sampling location in this subbasin, MEK 0.2 (Tables 8.6 through 8.10). Based on comparison with LOAELs, no adverse effects from mercury or PCBs were predicted for any of the piscivorous receptors.

WOC. Risk estimates from point exposures are available from one sampling location in this subbasin, WCK 2.9 (Tables 8.6 through 8.10). Based on comparisons with LOAELs, adverse effects from mercury were predicted to be likely for otter (HQ = 1.6) and kingfisher (HQ = 1.6). No adverse effects from PCBs were predicted for any of the piscivorous receptors.

Monte Carlo simulation estimates of exposure

To incorporate the variation present in the parameters employed in the exposure model, Monte Carlo simulations were performed for exposure of each species to mercury and PCBs in WOCW. Simulations were performed on the average exposure, weighted by the biomass of fish observed at each sampling location (see Section 8.1.1.4). The mean, standard deviation, and 80th percentile of the simulated exposures are presented in Table 8.12. By superimposing NOAEL and LOAEL values on these distributions, the likelihood of an individual experiencing potentially hazardous exposures can be estimated and the magnitude of risk may be determined. Interpretation of the comparison of exposure distributions to NOAELs and LOAELs is described in Table 7.24.

To evaluate the likelihood and magnitude of population-level effects on piscivores, literature-derived population density data (expressed as number of individuals/km of stream or pond shoreline) were combined with the length of stream or pond shorelines for which risks were assessed to estimate the number of individuals of each endpoint species expected to be present at WOCW. Literature-derived population densities used for each endpoint species were: mink: 0.6/km; river otter 0.37/km; belted kingfisher: 0.4/km; and great blue heron; 2.3/km. It should be noted that density values for all endpoint species except the great blue heron represent the maximum values

obtained from the literature (see Tables 7.8, 8.1, and 8.2). The values for herons (see Table 8.3) appear inflated and are not believed to accurately represent densities on the ORR. For this reason, the minimum value was used. Population estimates based upon these densities are listed in the following table.

	Watershed length (km)			Estimated number of individuals by watershed			
Watershed	Stream length	Pond shoreline length	Total length	Mink	River otter	Belted kingfisher	Great blue heron
White Oak Creek	3.9	2.5	6.4	4	2	3	15

Population risk estimates were not performed for osprey because as a T&E species, adverse effects to any individual are significant and because suitable density data were not available. Population risk estimates however were performed for otter, another T&E species. While otter are not currently known to reside on the ORR, population estimates indicate the numbers that could reside on the WOCW given available habitat and the risks that contaminant exposure could present.

The number of individuals within the watershed likely to experience exposures >LOAELs can be estimated using cumulative binomial probability functions (Dowdy and Wearden 1983) as described in Sect. 7.1.3.1.

Binomial probability distributions were generated only for contaminant-endpoint combinations where the percent of the exposure distribution exceeding the LOAEL was 20% to 80% (these values are reported in Table 8.12). If the percent of the exposure distribution exceeding the LOAEL was <20%, it was assumed that no individuals within the area of interest were experiencing adverse effects. Conversely, if the percent of the exposure distribution exceeding the LOAEL was >80%, it was assumed that all individuals within the area of interest were experiencing adverse effects. Estimates for mercury and PCB exposure to otter met the 20% to 80% exceedance criterion. Less than 20% of the exposure distribution exceeded the LOAEL for all other contaminant-endpoint combinations. The total numbers of individuals for each endpoint species estimated to be experiencing adverse effects within the WOCW are summarized in Table 8.19.

Based on the Monte Carlo and binomial distribution analyses (Table 8.19), the following conclusions may be made:

- Because 1 individual is estimated to be experiencing exposures >LOAEL, PCBs present a significant risk to otter in the WOCW.

- Although <1 individual otter is estimated to be experiencing exposures >LOAEL for mercury, individual risks are >20% (Table 8.12). Because of the otter's status as a state threatened species, mercury presents a significant risk to otter in the WOCW.

- Because <1 individual is estimated to be experiencing exposures >LOAEL, neither mercury nor PCBs presents a significant risk to osprey in the WOCW.

- Because <20% of the WOCW populations of mink, kingfisher, and heron are estimated to be experiencing exposures >LOAEL, neither mercury nor PCBs present a significant risk to these.

8.3.1.3 Effects of retained contaminants

Mercury

For the purposes of this assessment, it is assumed that 100% of the mercury to which wildlife are exposed consists of methyl mercury.

Both the avian NOAEL and LOAEL are based upon a study of mallard ducks fed methyl mercury for three generations (Heinz 1979). The study was considered to represent a chronic exposure, and a subchronic-chronic correction factor was not employed. The only dose level administered, 0.064 mg/kg/d, caused hens to lay fewer eggs, lay more eggs outside of the nest box, and produce fewer ducklings. This dose level was considered to be an LOAEL. Because an experimental NOAEL was not established, the NOAEL was estimated using LOAEL-NOAEL correction factor of 0.1. Based on the results of Heinz (1979), kingfisher experiencing exposure ≥LOAEL are likely to display impaired reproduction.

The mink and otter NOAELs and LOAELs for mercury were derived from a study of mink fed methyl mercury for 93 d (Wobeser et al. 1976). While consumption of 0.247 mg/kg/d methyl mercury resulted in significant mortality, weight loss, and behavioral impairment, no effects were observed at the 0.15 mg/kg/d exposure level. The 0.15 mg/kg/d exposure was considered to be an NOAEL, and the 0.247 mg/kg/d exposure was considered to be an LOAEL. Because the study was subchronic in duration (<1 year), a subchronic-chronic correction factor was applied (NOAEL = 0.015, LOAEL = 0.025). Based on the results of Wobeser et al. (1976), shrews, mice, and fox experiencing exposure ≥LOAEL are likely to display increased mortality, weight loss, and behavioral impairment.

PCBs

The otter NOAEL and LOAEL for PCBs was derived from a study of mink fed Aroclor 1254 for 4.5 months (Aulerich and Ringer 1977). While consumption of 0.69 mg/kg/d Aroclor 1254 reduced kit survivorship, no effects were observed at the 0.14 mg/kg/d exposure level. The 0.14 mg/kg/d exposure was considered to be a chronic NOAEL; the 0.69 mg/kg/d exposure was considered to be a chronic LOAEL Based on the results of Aulerich and Ringer (1977), mink experiencing exposure ≥LOAEL are likely to display reduced kit survivorship.

8.3.2 Mink Toxicity Tests

To evaluate the nature and magnitude of toxicity of contaminants in fish from the ORR to mink, fish were collected from the Poplar Creek embayment, Clinch River and the ocean, formulated into mink diets, and fed to mink. Mink were fed five different diets (A through E, see Sect. 8.2.2). Ten mink (2 males, 8 females) were fed each diet for 7 months; starting approximately 3 months prior to breeding, extending to 6 weeks post-partum. Bioaccumulation, growth, histopathology, and reproduction were recorded. Significant effects were observed only among mink fed diet E (75% diet from Poplar Creek fish). These effects included statistically significant reductions in body weights of adult females and male kits and in litter size. Percent reductions were 20% and 17% for adult female and male kit weights, respectively, and 37.7% for litter size.

To estimate exposures experienced by the mink in the toxicity test, Monte Carlo simulations of mink exposure were performed using the concentrations of mercury and PCB 1260 measured in the five diets (see section 8.2.2). Parameter values in the exposure model were as follows: body weight = 0.974 ± 0.202 kg; food ingestion rate = 0.137 kg/d. Results of the exposure simulation are presented in Table 8.20.

The mercury exposure estimate for the WOCW (mean = 0.008 ± 0.002) is below that estimated for diet E (mean = 0.033 ± 0.008). The PCB exposure estimate for the WOCW (mean = 0.18 ± 0.06) is also below that estimated for diet E (mean = 3.07 ± 0.77).

The mean mercury exposure from diet D (0.022 mg/kg/d; the highest exposure at which no adverse effects were observed) was less than the LOAEL of 0.025 mg/kg/day used in the risk assessment, while that of diet E (0.033 mg/kg/d; the lowest exposure at which adverse effects were observed) was greater (Table 8.20). This suggests that the estimated mercury LOAEL for mink is appropriate and representative of toxicity of mercury to mink on the ORR.

Exposures to Aroclor 1260 in diets B, C, D, and E were greater than the LOAEL (Table 8.20). However, adverse reproductive and other effects were observed only from Diet E. Estimating that toxicity should be observed in four diets, but actually observing it only in the highest concentration diet suggests that the LOAEL value for PCBs used in this assessment is too low and is not representative of the toxicity of the PCBs present on the ORR. ORR-specific NOAEL and LOAEL values for PCBs (represented by PCB 1260) of 1.7 mg/kg/d and 3 mg/kg/d can be derived from the toxicity test exposure estimate for diets B and E, respectively (Table 8.20). The estimated total PCB exposure to mink in WOCW (mean = 0.18 ± 0.06 mg/kg/d, Table 8.12) is less than the ORR-specific NOAEL, corroborating the conclusion from the literature-derived toxicity data that PCBs do not present a significant risk to mink in the WOCW.

Adverse effects from PCB were predicted for the otter at WOCW using the literature-derived toxicity data for the mink. Using the ORR-specific NOAEL and LOAEL for the mink and standardizing for differences in body weight (equation 6), one can derive ORR-specific NOAEL and LOAEL values for the otter of 1 mg/kg/d and 1.8 mg/kg/d, respectively. The estimated total PCB exposure to otter in WOCW (mean = 0.52 ± 0.18 mg/kg/d, Table 8.12) is less the ORR-specific NOAEL, bringing into question the conclusion from the literature-derived toxicity data that PCBs present a significant risk to otter in the WOCW.

Several conclusions may be drawn from these toxicity test data.

- Estimated mercury and PCB exposures for WOCW mink are below those observed to cause adverse reproductive and other effects in minks fed fish from Poplar Creek.

- Because the estimated LOAEL used in this assessment is comparable to the exposure level that resulted in adverse effects in the toxicity test, the estimated mercury LOAEL for mink is appropriate and representative of toxicity of mercury to mink on the ORR.

- Given the difference between predicted and observed toxicity from the test diets, the PCB LOAEL used in this assessment is too low and does not reflect toxicity observed among mink exposed to ORR fish, at least those obtained from Poplar Creek.

- ORR-specific NOAEL and LOAEL values can be derived for the otter, based on the mink study. Using the ORR-specific value rather than the literature value, PCBs would not be expected to cause toxic effects on survival, growth, or reproduction of otter in WOCW.

8.3.3 Biological Surveys

8.3.3.1 Mink survey

Results of the mink survey (see Sect. 8.2.3) indicate that mink are present on the ORR, including the WOCW, have large home ranges and do not avoid the industrial facilities on the ORR. The methods employed in the study do not allow numbers or density of mink to be determined. Arsenic, cadmium, lead, mercury and selenium were either not detected in the hair of a White Oak Creek mink or at levels compatible with those in reference samples.

8.3.3.2 Belted kingfisher survey

Results of the kingfisher survey indicate that contaminants are being accumulated in both eggs and adult birds at the WOCW. Metal concentrations in the egg from a burrow found on White Oak Creek contained elevated levels of cesium-137, indicating that the parent kingfisher bioaccumulated cesium-137 from foraging within White Oak Creek or a nearby surface impoundment. While contaminants in eggshells indicate exposure, there is insufficient information to evaluate the toxicological significance of this contamination.

Cadmium, mercury, selenium, lead, and cesium-137 were detected in a kingfisher carcass collected from the White Oak Creek watershed. Cesium-137 levels in the White Oak Creek bird were extremely elevated (91.27 pCi/g) compared to those in a bird collected from East Fork Poplar Creek (<2 pCi/g). The internal dose rate (mrad/d) expected from the cesium-137 (and its daughter product barium-137m) for the White Oak Creek kingfishers was estimated following the methodology of Blaylock et al. (1993):

$$D = \sum C_{tissue} \; \dot{E}_i \; CFa \qquad (10)$$

where:

D	=	Internal dose rate (mrad/d)
C_{tissue}	=	Activity (pCi/g) of radionuclide *i* in kingfisher tissue
ϵ_i	=	Energy for α, β, or λ emissions by nuclide *i* (MeV/nuclear transformation). Obtained from Eckerman and Ryman (1993). (Cesium-137: $\beta = 0.187$, no α or γ emissions. Barium-137m: $\beta = 0.065$, $\gamma = 0.597$, no α emissions)
CFa	=	Conversion factor to convert MeV/nt to g mrad/pCi d. (5.12×10^{-2})

The measured tissue activity level of 91.27 pCi/g results in an estimated internal dose rate of 3.81 mrad/d. While this body burden is relatively high, the internal dose rate is well below the 100 mrad/d dose limit recommended for terrestrial organisms by the International Atomic Energy Agency (IAEA 1992). This level of exposure to the maximally exposed individual is thought to be protective of the overall population (IAEA 1992, DOE 1995a).

The toxicological significance of the tissue metals concentrations in adult kingfisher was evaluated by comparison of burdens and effects levels reported in other bird species. This

comparison suggests that it is unlikely that cadmium or lead in the kingfisher from White Oak Creek contribute significantly to risk. Leach et al. (1979) observed a 50% reduction in egg production among chickens consuming a diet containing 48 mg/kg cadmium. Cadmium concentrations in the livers and kidneys of these birds were 100 mg/kg and 40 mg/kg, respectively. Cadmium concentrations in healthy birds from unpolluted areas ranged from 0.1 to 32 mg/kg in liver and 0.3 to 137 mg/kg in kidney (Furness 1996). In comparison, the cadmium concentration in the kidney (1.53 mg/kg) and liver (0.90 mg/kg) of the kingfisher collected from the White Oak Creek were significantly less than concentrations associated with reproductive impairment and at the low end of the ranges observed among healthy birds from unpolluted areas. Lead concentrations in the kidney (0.42 mg/kg) and liver (0.4 mg/kg) of the White Oak Creek kingfisher were approximately one order of magnitude lower than the minimal level at which overt toxicity is observed in birds (3 to 6 mg/kg; Franson 1996), suggesting that lead accumulation is unlikely to be contributing to risks to kingfishers on the ORR.

In contrast to cadmium and lead, selenium and mercury burdens may present a hazard to kingfishers on the WOCW. The concentration of selenium observed in the liver of the White Oak Creek kingfisher (7.5 mg/kg) is less than the 10 mg/kg toxicity threshold recommended by Heinz (1996), but greater than the 3 mg/kg reproductive impairment threshold, suggesting the potential for adverse effects on reproduction. Mercury concentrations of 49 to 125 mg/kg in kidney and 4.6 to 91 mg/kg in liver have been reported for free-living birds found dead or dying (Thompson 1996). Nephrotoxicity and kidney lesions occur in birds at mercury concentrations in the kidney of 5 to 13 mg/kg (Nicholson and Osborn 1983). While observed mercury concentrations in the kidney (26.8 mg/kg) and liver (17.6 mg/kg) of the kingfisher were generally lower than concentrations associated with mortality, the kidney concentration exceeds nephrotoxic levels, suggesting that mercury accumulation may be causing kidney damage to kingfishers on the WOCW.

8.3.4 Weight of Evidence

8.3.4.1 Mink

Three lines of evidence, literature toxicity data, toxicity test data, and field surveys were available to evaluate risk to mink.

Literature toxicity data

Based on comparisons of water concentrations to literature-derived benchmark concentrations, mercury was predicted to pose a potential risk to mink at HF-2, Lower WOC/WOL, SWSA 6 East, W6MS3, W6MS1, SWSA5/WOC and WOC. PCBs were predicted to pose a potential risk at Lower WOC/WOL and WOC. No other chemicals were retained as being of potential concern. Note that results of analyses using measured fish tissue data take precedence over comparison to screening water concentration benchmarks, and modeling with fish tissue data suggests no risks from mercury or PCBs in the watershed.

Based on the fish tissue data, point estimates of exposure did not exceed literature-derived LOAELs for mercury and PCBs at any location within the WOCW, indicating no significant risk to individual mink (Table 8.6). Monte Carlo simulation and comparison of exposure estimates to literature-derived LOAELs (Table 8.12) and calculation of binomial probability distributions (Table 8.19) also indicate no significant risk from mercury or PCBs for the WOCW-wide mink population.

Toxicity test data

Estimated mercury and PCB exposures for WOCW mink are below those observed to cause adverse reproductive and other effects in the toxicity test.

Field surveys

Limited data from field surveys indicate that while mink are present on the reservation, including the WOCW, the health and abundance of the population is unknown (the trapping methods that were employed, while suitable for capturing animals for radiotelemetry purposes, were not adequate to estimate population abundance and density). Mink on the ORR have large home ranges and make use of the creeks within the industrial facilities. Metals concentrations in the hair of a White Oak Creek mink were similar to those from off-site locations.

- The weight of evidence suggests that risks to the WOCW mink population from mercury and PCBs are not significant.

8.3.4.2 River otter

Two lines of evidence, literature toxicity data and PCB and mercury NOAEL and LOAEL values derived from the Poplar Creek mink toxicity test, were available to evaluate potential risk to river otter.

Literature toxicity data

Based on comparisons of water concentrations to literature-derived benchmark concentrations, mercury was predicted to pose a potential risk to otter at HF-2, Lower WOC/WOL, SWSA 6 East, WAG6MS3, WAG6MS1, SWSA5/WOC and WOC. PCBs were predicted to pose a potential risk at Lower WOC/WOL and WOC. No other chemicals were retained as being of potential concern.

Based on the fish tissue data, point estimates of exposure exceeded literature-derived LOAELs for mercury at the Lower WOC/WOL and WOC subbasins, indicating significant risk to individual otters from mercury at these locations (Table 8.7). Monte Carlo simulation and comparison of exposure estimates to literature-derived LOAELs (Table 8.12) also indicate a significant risk from mercury for a future WOCW otter individual (i.e. >20%). However, because the future WOCW-wide otter population was estimated to be only two, calculation of the binomial probability distribution indicated no risk to the population as a whole (Table 8.19). Because of the special concern for individuals of T&E species, we conclude that the literature toxicity data indicate a potential risk for the otter from mercury.

Point estimates of exposure exceeded literature-derived LOAELs for PCBs at the White Oak Creek Embayment and Lower WOC/WOL subbasins, indicating significant risk to individual otters from PCBs at these locations (Table 8.7). Monte Carlo simulation and comparison of exposure estimates to literature-derived LOAELs (Table 8.12) and calculation of binomial probability distributions (Table 8.19) indicate a significant risk (50% or 1 individual) from PCBs in a future WOCW otter population.

Toxicity tests data

Using Equation 6 and the ORR-specific NOAELs and LOAELs for PCBs and mercury from mink toxicity tests (see Sect. 8.3.2), ORR-specific values for otter were estimated to be as follows:

Analyte	Estimated NOAEL (mg/kg/d)	Estimated LOAEL (mg/kg/d)
PCBs	0.92	1.8
Mercury	0.013	0.02

The ORR-specific mercury LOAEL is somewhat higher, but still comparable to the literature-derived LOAEL (0.015 mg/kg/d; Table 8.13). Therefore, the results of the Poplar Creek mink toxicity test do not significantly alter the conclusions derived from evaluation of the literature-based toxicity data. Because the river otter is a state threatened species, effects to any individual is significant. Therefore, the weight of evidence suggests that mercury is a significant risk to any individual otter that may occupy the WOCW in the future, particularly from levels at the Lower White Oak Creek/White Oak Lake and White Oak Creek subbasins. Based on water concentrations, mercury may also be of concern at HF-2, SWSA 6 East, WAG6MS3, WAG6MS and SWSA5/WOC.

Comparison of the ORR-specific PCB LOAEL to the exposure distributions presented in Table 8.12 indicate that there is a <1% likelihood of individuals in the WOCW experiencing PCB exposure greater than the ORR-specific LOAEL. Therefore, based upon the results of the Poplar Creek mink toxicity test, PCBs are unlikely to present a significant risk to WOCW otters.

- The weight of evidence suggests that risks to an individual WOCW otter are potentially significant from exposure to mercury, but not PCBs.

8.3.4.3 Belted kingfisher

Two lines of evidence, literature toxicity data and biomonitoring data, were available to evaluate potential risk to belted kingfisher.

Literature toxicity data

Based on comparisons of water concentrations to literature-derived benchmark concentrations, mercury was predicted to pose a potential risk to kingfisher at HF-2, Lower WOC/WOL, SWSA 6 East, WAG6MS3, WAG6MS1, SWSA5/WOC and WOC. PCBs were predicted to pose a potential risk at Lower WOC/WOL and WOC. No other chemicals were retained as being of potential concern

Based on the fish tissue data, point estimates of exposure exceeded literature-derived LOAELs for mercury at the Lower White Oak Creek/White Oak Lake and White Oak Creek subbasins, indicating significant risk to individual kingfishers from mercury at these locations (Table 8.8). Point estimates of exposure exceeded literature-derived LOAELs for PCBs at the White Oak Creek Embayment, indicating a significant risk to individual kingfishers from mercury at this location (Table 8.8). However, Monte Carlo simulation and comparison of exposure estimates to literature-derived LOAELs (Table 8.12) and calculation of binomial probability distributions (Table 8.19) indicate no significant risk from mercury or PCBs for the WOCW-wide population.

Biomonitoring data

The limited biomonitoring data indicate that kingfisher in the White Oak Creek area are accumulating mercury to potentially nephrotoxicty levels and selenium to levels potentially associated with impaired reproduction.

- The weight of evidence suggests mercury and selenium in WOCW may present a significant risk to the WOCW belted kingfisher population. Risks from PCBs are not significant.

8.3.4.4 Great blue heron

One line of evidence, literature toxicity data, was available to evaluate ecological risk to great blue heron. Based on comparisons of water concentrations to literature-derived benchmark concentrations, mercury was predicted to pose a potential risk to heron at HF-2, Lower WOC/WOL, SWSA 6 East, WAG6MS3, WAG6MS1, SWSA5/WOC and WOC. PCBs were predicted to pose a potential risk at Lower WOC/WOL and WOC. No other chemicals were retained as being of potential concern

Based on the fish tissue data, point estimates of exposure did not exceed literature-derived LOAELs for mercury and PCBs at any location within the WOCW, indicating no significant risk to individual herons (Table 8.9). Monte Carlo simulation and comparison of exposure estimates to literature-derived LOAELs (Table 8.12) and calculation of binomial probability distributions (Table 8.19) also indicate no significant risk from mercury or PCBs in the WOCW-wide population.

- The weight of evidence suggests mercury and PCB do not present a significant risk to great blue heron on or near the WOCW.

8.3.4.5 Osprey

One line of evidence, literature toxicity data, was available to evaluate ecological risk to osprey. As a T&E species, any adverse impact to individual osprey is significant. Based on comparisons of water concentrations to literature-derived benchmark concentrations, mercury was predicted to pose a potential risk to osprey at HF-2, Lower WOC/WOL, SWSA 6 East, WAG6MS3, WAG6MS1, SWSA5/WOC and WOC. PCBs were predicted to pose a potential risk at Lower WOC/WOL and WOC. No other chemicals were retained as being of potential concern.

Based on the fish tissue data, point estimates of exposure did not exceed literature-derived LOAELs for mercury and PCBs at any location within the WOCW that provides suitable habitat (i.e., White Oak Lake and embayment), indicating no significant risk to individual ospreys (Table 8.10). Monte Carlo simulation and comparison of exposure estimates to literature-derived LOAELs (Table 8.12) also indicate no significant risk from mercury or PCBs.

- The weight of evidence suggests mercury and PCB do not present a significant risks to osprey on or near the WOCW.

8.3.5 Uncertainties Concerning Risks to Piscivorous Wildlife

8.3.5.1 Bioavailability of contaminants

Bioavailability of contaminants was assumed to be comparable between fish collected from the WOCW and the diets used in the literature toxicity tests. Because bioavailability may not be comparable, exposure estimates based upon the contaminant concentrations in WOCW fish may either under- or overestimate the actual contaminant exposure experienced.

8.3.5.2 Extrapolation from published toxicity data

While published toxicity studies are available for mink, there are no published data for otter, kingfisher, great blue heron or osprey. To estimate toxicity of contaminants at the site, it was necessary to extrapolate from studies performed on test species (i.e., mallard ducks, ring-necked pheasant, and rats). While it was assumed that toxicity could be estimated as a function of body size, the accuracy of the estimate is not known. For example, osprey or herons may be more or less sensitive to contaminants than ducks or pheasants, due to factors other than metabolic rate.

Additional extrapolation uncertainty exists for those contaminants for which data consisted of only LOAELs or tests were subchronic in duration. For either case, an 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.

Toxicity of PCBs to piscivorous wildlife was evaluated using toxicity data from studies on Aroclor 1254. Because toxicity of PCB congeners can vary dramatically, the applicability of data for Aroclor 1254 is unknown. Comparison of the results of the mink toxicity test results and the estimated LOAELs for mink, suggests the Aroclor 1254 data do not accurately reflect (i.e., they overestimate) the toxicity of the PCB mixture present in WOCW fish.

8.3.5.3 Variable food consumption

While food consumption by piscivorous 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 the WOCW may be greater or less than that reported in the literature, resulting in either an increase or decrease in contaminant exposure.

8.3.5.4 Single contaminant tests vs exposure to multiple contaminants in the field

While piscivores on the WOCW 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 additively or synergistically, single contaminant studies may underestimate their toxic potential.

8.3.5.5 Inorganic forms or species present in the environment

Toxicity of metal species varies dramatically depending upon the valence state or form (organic or inorganic) of the metal. For example, Arsenic (III) and methyl mercury are more toxic than arsenic (V) and inorganic mercury, respectively. The available data on the contaminant concentrations in media do not report which species or form of contaminant was observed. Because

benchmarks used for comparison represented the more toxic species/forms of the metals (particularly for arsenic and mercury), if the less toxic species/form of the metal was actually present in fish from the WOCW, potential toxicity at the sites may be overestimated.

8.3.5.6 Contaminant concentrations in aquatic prey

While fish are the primary prey of piscivores, other aquatic prey are also consumed. It was assumed that the contaminant concentration in fish was representative of that in other aquatic prey. Due to the different life histories of other aquatic prey (i.e., amphibians, crayfish, benthic invertebrates), their contaminant burdens are likely to differ from that in fish. Therefore, assuming comparability to fish may either over or underestimate exposure.

8.3.5.7 Fish size selection

Data concerning the sizes of fish consumed by piscivores were obtained from the literature. Because fish sizes consumed by piscivores on the WOCW may differ from that reported in the literature, exposure may be overestimated or underestimated.

8.3.5.8 Monte Carlo simulation

To perform Monte Carlo simulations, distributions must be assigned to parameters. Because wildlife are mobile, the mean of the contaminant concentration is likely to best represent their exposure. For this report, the contaminant concentrations in fish were assumed to be normally distributed. In future revisions of this report, goodness-of-fit analyses will be performed to determine which distribution best fits the data.

The literature values used for body weights of each endpoint are nationwide values which may overestimate or underestimate the body weight of species found at the site. Similarly the proportion of fish and aquatic prey in mink diet were derived from data from northern locations (i.e., MI, Canada, etc.). The applicability of these data to the percentage of fish and aquatic prey consumed by mink in Tennessee is unknown.

8.3.5.9 Estimated whole fish concentrations

Contaminant concentrations in whole fish were estimated using contaminant specific fillet to whole fish ratios. Data to generate ratios were available only for PCBs in largemouth bass and channel catfish from the Clinch River. Ratios for metals were obtained from spotted bass samples from near the PORTS facility in Ohio. Applicability of these ratios to species other than those from which they were developed is unknown. Similarly, applicability of metal ratios from Ohio spotted bass to fish on the ORR is unknown.

Table 8.1. Life history parameters for river otter

Parameter	Value	Comments	Reference
Body Weight	8.0 kg (mean ♂+♀)		EPA 1993b
Food Consumption Rate	0.9 kg/d (mean ♂+♀)		EPA 1993b
Water Consumption Rate	0.64 L/d		EPA 1993b
Diet Composition	Almost exclusively fish 2-50 cm in size; most ≥30 cm.		Melquist and Hornocker 1983
	50% large and 50% small fish		EPA 1993b
Home Range	10-78 km	river-Idaho	Melquist and Hornocker 1983
		range size and shape depends on habitat - linear along streams, circular in marshes	EPA 1993b
Habitat Requirements	aquatic habitats - streams, lakes, marshes;		EPA 1993b
Population Density	0.17 - 0.37 /km	river-Idaho	Melquist and Hornocker 1983
	0.0094-0.014/ha		EPA 1993b
Behavior	Generally most active morning and evening, but may be active at any time in day.		Melquist and Hornocker 1983
	active year-round, does not hibernate		EPA 1993b

Table 8.2. Life history parameters for belted kingfisher

Parameter	Value	Comments	Reference
Body Weight	**0.148** kg		Dunning 1984
Food Consumption Rate	50% bw		Alexander 1977
	0.075 kg/d	assuming 0.148 kg bw	
Water Consumption Rate	**0.016** L/d	estimated using allometric equation[a] assuming 0.148 kg bw	
Soil Consumption Rate	as a piscivore, assumed to be negligible		
Diet Composition	Cyprinids - 76.4% other fish - 10.2% crayfish - 13.3%	Ohio - creek	Davis 1982
	lizards, small snakes, frogs, salamanders, and insects may be consumed if fish are unavailable		Landrum et al. 1993
Home Range	1.03 km (breeding) 0.39 km (non-breeding)	Ohio - creek	Davis 1982
	2.19 km (breeding)	Pennsylvania - stream summer	Brooks and Davis 1987
Habitat Requirements	uses a diverse aquatic habitats (stream, river, lake, marsh, coastline)		Brooks and Davis 1987
	require high vertical banks composed of >75% sand and <7% clay for nest construction		
	prefer relatively clear waters free of thick vegetation		Bent 1940.
Population Density	0.11 - 0.19 pairs/km shore	Pennsylvania - stream summer	Brooks and Davis 1987
Behavior	while most migrate from northern parts of range, some may stay in areas where water remains ice-free		Bent 1940.

Table 8.3. Life history parameters for great blue heron

Parameter	Value	Comments	Reference
Body Weight	2.576 kg (♂) 2.204 kg (♀) **2.39** kg (mean♂+♀)		Dunning 1984
Food Consumption Rate	**0.42** kg/d	estimated using allometric equation[a] specific for herons and egrets assuming 2.39 kg bw	Kushlan 1978
Water Consumption Rate	**0.1058** L/d	estimated using allometric equation[b] assuming 2.39 kg bw	After Calder and Braun 1983
Diet Composition	diet predominantly fish but may include crustaceans, insects, snails, amphibians, reptiles, birds, and mammals fish sizes: 0-10 cm=39.2% 11-20 cm=47.1% 21-30 cm=13.7%		Kushlan 1978 Collazo 1985 Hoffman 1978 Alexander 1977
Home Range (foraging distance from colony)	3.1 km 7 - 8 km	up to 24.2 km - S. Dakota - river N. Carolina - coastal	EPA 1993a. Short and Cooper 1985
Habitat Requirements	use both coastal and inland water-associated habitats Foraging: shallow shores of ponds, lakes, streams, wet meadows, wooded swamps, bays, and marshes breeding: trees for rookery sites. In absence of trees will use rock ledges, cliffs, and artificial structures		Short and Cooper 1985 DeGraaf et al. 1981 Short and Cooper 1985

Table 8.3. (continued)

Parameter	Value	Comments	Reference
Population Density	nest colonially, therefore population density depends on availability of nest habitat and suitable foraging habitat		EPA 1993a
	2.3 - 3.6 /km	North Dakota rivers and streams	
Behavior	may or may not defend a feeding territory depending on local population size and food availability		Kushlan 1978
	Migrates in northern U.S. and southern Canada; year round resident from WV, PA south.		National Geographic Society 1987.

Table 8.4. Life history parameters for osprey

Parameter	Value	Comments	Reference
Body Weight	1.5 kg (♂+♀)		EPA 1993c
Food Consumption Rate	0.3 kg/d	fresh weight	EPA 1993c
Water Consumption Rate	0.077 L/d		EPA 1993c
Diet Composition	almost 100% fish	all parts of fish consumed except large bones	EPA 1993c
	fish sizes: 0-10 cm=3.3% 11-20 cm=42.1% 21-30 cm=46.7% 31-40 cm=6.6% >41 cm=1.3%		VanDaele and VanDaele 1982
Home Range (foraging distance from nest site)	10-15 km		VanDaele and VanDaele 1982
Habitat Requirements	Coastal areas plus large rivers and lakes Nesting habitat requires open, shallow water nearby plus abundant fish. Nests atop isolated (often dead) trees and man-made structures		EPA 1993b
Population Density	0.005-0.1 nests/ha		EPA 1993b
Behavior	year-round resident in southern part of range (i.e. Florida) Migratory in Tennessee		EPA 1993b

Table 8.5. Summary statistics for fish data from the White Oak Creek watershed

					Contaminant concentrations in fish (mg/kg)					
Analyte	Location	Size	Obs	Det	Mean	Standard error	95% UCL	Maximum	Lognormal mean	Lognormal standard deviation
Mercury	WCK 0.9	small	16	16	0.103	0.006	0.114	0.161	0.103	0.024
Mercury	WCK 1.5	small	16	16	0.096	0.009	0.111	0.166	0.096	0.035
Mercury	WCK 1.5	large	16	16	0.154	0.018	0.185	0.301	0.155	0.082
Mercury	WCK 2.3	small	8	8	0.154	0.020	0.191	0.261	0.155	0.052
Mercury	MEK 0.2	small	24	24	0.090	0.006	0.099	0.161	0.090	0.025
Mercury	WCK 2.9	small	8	8	0.176	0.016	0.207	0.245	0.177	0.046
Mercury	WCK 3.5	small	16	16	0.111	0.007	0.124	0.166	0.112	0.033
Mercury	NTK 0.2	small	8	8	0.123	0.008	0.139	0.157	0.124	0.026
PCBs	WCK 0.3	large	4	4	5.829	0.421	6.819	6.702	5.847	0.887
PCBs	WCK 0.9	small	13	13	0.587	0.110	0.783	1.724	0.609	0.470
PCBs	WCK 0.9	large	10	10	6.483	1.236	8.748	13.008	7.501	8.244
PCBs	WCK 1.5	small	24	24	2.097	0.284	2.584	6.587	2.100	1.371
PCBs	WCK 1.5	large	16	16	13.149	1.814	16.329	28.445	13.520	9.065
PCBs	WCK 2.3	small	8	8	1.592	0.304	2.169	3.502	1.603	0.805
PCBs	MEK 0.2	small	20	15	0.247	0.062	0.355	1.330	0.257	0.384
PCBs	WCK 2.9	small	16	16	1.107	0.195	1.448	2.915	1.141	0.978
PCBs	WCK 3.5	small	16	16	1.300	0.160	1.580	2.303	1.349	0.889
PCBs	NTK 0.2	small	8	8	0.290	0.108	0.495	0.992	0.300	0.344

Table 8.6. Estimated exposure of mink on the WOCW to mercury and PCBs

Analyte	Sampling station	Dietary exposure (mg/kg-d)	NOAEL HQ	LOAEL HQ
Mercury	WCK 0.9	0.0085	0.57	0.34
Mercury	WCK 1.5	0.0083	0.55	0.33
Mercury	WCK 2.3	0.0143	0.95	0.57
Mercury	MEK 0.2	0.0074	0.49	0.30
Mercury	WCK 2.9	0.0155	1.03	0.62
Mercury	WCK 3.5	0.0093	0.62	0.37
Mercury	NTK 0.2	0.0104	0.69	0.42
PCBs	WCK 0.3	0.5101	3.64	0.74
PCBs	WCK 0.9	0.0586	0.42	0.08
PCBs	WCK 1.5	0.1933	1.38	0.28
PCBs	WCK 2.3	0.1622	1.16	0.24
PCBs	MEK 0.2	0.0265	0.19	0.04
PCBs	WCK 2.9	0.1083	0.77	0.16
PCBs	WCK 3.5	0.1182	0.84	0.17
PCBs	NTK 0.2	0.0370	0.26	0.05

Table 8.7. Estimated exposure of river otter on the WOCW to mercury and PCBs

Analyte	Drainage	Dietary exposure (mg/kg-d)	NOAEL HQ	LOAEL HQ
Mercury	WCK 0.9	0.0128	1.43	0.86
Mercury	WCK 1.5	0.0166	1.85	1.11
Mercury	WCK 2.3	0.0215	2.39	1.43
Mercury	MEK 0.2	0.0111	1.24	0.74
Mercury	WCK 2.9	0.0233	2.59	1.55
Mercury	WCK 3.5	0.0140	1.55	0.93
Mercury	NTK 0.2	0.0157	1.74	1.04
PCBs	WCK 0.3	0.7671	9.24	1.87
PCBs	WCK 0.9	0.5362	6.46	1.31
PCBs	WCK 1.5	1.0638	12.82	2.59
PCBs	WCK 2.3	0.2440	2.94	0.60
PCBs	MEK 0.2	0.0399	0.48	0.10
PCBs	WCK 2.9	0.1629	1.96	0.40
PCBs	WCK 3.5	0.1777	2.14	0.43
PCBs	NTK 0.2	0.0557	0.67	0.14

Table 8.8. Estimated exposure of belted kingfisher on the WOCW to mercury and PCBs

Analyte	Drainage	Dietary exposure (mg/kg-d)	NOAEL HQ	LOAEL HQ
Mercury	WCK 0.9	0.0579	9.65	0.90
Mercury	WCK 1.5	0.0560	9.34	0.88
Mercury	WCK 2.3	0.0969	16.16	1.51
Mercury	MEK 0.2	0.0502	8.37	0.78
Mercury	WCK 2.9	0.1048	17.47	1.64
Mercury	WCK 3.5	0.0630	10.50	0.98
Mercury	NTK 0.2	0.0706	11.77	1.10
PCBs	WCK 0.3	3.4556	19.20	1.92
PCBs	WCK 0.9	0.3969	2.21	0.22
PCBs	WCK 1.5	1.3093	7.27	0.73
PCBs	WCK 2.3	1.0990	6.11	0.61
PCBs	MEK 0.2	0.1797	1.00	0.10
PCBs	WCK 2.9	0.7339	4.08	0.41
PCBs	WCK 3.5	0.8005	4.45	0.44
PCBs	NTK 0.2	0.2508	1.39	0.14

Table 8.9. Estimated exposure of great blue heron on the WOCW to mercury and PCBs

Analyte	Drainage	Dietary exposure (mg/kg-d)	NOAEL HQ	LOAEL HQ
Mercury	WCK 0.9	0.0201	3.34	0.31
Mercury	WCK 1.5	0.0194	3.24	0.30
Mercury	WCK 2.3	0.0336	5.60	0.53
Mercury	MEK 0.2	0.0174	2.90	0.27
Mercury	WCK 2.9	0.0364	6.06	0.57
Mercury	WCK 3.5	0.0218	3.64	0.34
Mercury	NTK 0.2	0.0245	4.08	0.38
PCBs	WCK 0.3	1.1983	6.66	0.67
PCBs	WCK 0.9	0.1377	0.76	0.08
PCBs	WCK 1.5	0.4540	2.52	0.25
PCBs	WCK 2.3	0.3811	2.12	0.21
PCBs	MEK 0.2	0.0623	0.35	0.03
PCBs	WCK 2.9	0.2545	1.41	0.14
PCBs	WCK 3.5	0.2776	1.54	0.15
PCBs	NTK 0.2	0.0870	0.48	0.05

Table 8.10. Estimated exposure of osprey on the WOCW to mercury and PCBs

Analyte	Drainage	Dietary exposure (mg/kg-d)	NOAEL HQ	LOAEL HQ
Mercury	WCK 0.9	0.0228	3.81	0.36
Mercury	WCK 1.5	0.0233	3.88	0.36
PCBs	WCK 0.3	1.3638	7.58	0.76
PCBs	WCK 0.9	0.2825	1.57	0.16
PCBs	WCK 1.5	0.7339	4.08	0.41

Table 8.11. Total biomass of fish observed at fish sampling locations in WOCW

Sample location		Fish biomass (g/m^2)				Proportion of total biomass at sampled locations	
Fish community	Bioaccumulation	Spring	Fall	Year	Mean annual biomass	data from all 8 locations	data from only 7 locations
WOL [a]	WCK 0.3	-	-	1987	53.66	0.248	
WOL [a]	WCK 0.9	-	-	1987	53.66	0.248	0.33
WOL [a]	WCK 1.5	-	-	1987	53.66	0.248	0.33
WCK 2.3 [b]	WCK 2.3	10.49	17.06	1993	13.78	0.064	0.085
MEK 0.6 [b]	MEK 0.2	10.52	9.6	1993	10.06	0.046	0.062
WCK 2.9 [b]	WCK 2.9	10.80	13.34	1993	12.07	0.056	0.075
WCK 3.4 [b]	WCK 3.5	17.16	14.30	1993	15.73	0.073	0.097
NTK 0.3 [b]	NTK 0.2	3.27	4.50	1993	3.89	0.018	0.024

[a] Source:Loar et al. 1992.
[b] Source:Ashwood et al. 1994.

Table 8.12. Results of Monte Carlo simulation of exposure for piscivores on the WOCW

Analyte	Species	Number of sampling locations	Mean	Standard deviation	80th percentile	%> NOAEL	%> LOAEL
Mercury	Mink	7	0.0083	0.0019	0.0098	<5%	<5%
Mercury	Otter	7	0.0136	0.0018	0.0150	>95%	25%
Mercury	Kingfisher	7	0.0564	0.0077	0.0625	>95%	15%
Mercury	Heron	7	0.0198	0.0028	0.0220	>95%	<5%
Mercury	Osprey	7	0.0202	0.0037	0.0229	>95%	<5%
PCBs	Mink	8	0.1785	0.0563	0.2194	75%	<5%
PCBs	Otter	8	0.5242	0.1784	0.6249	>95%	70-75%
PCBs	Kingfisher	8	1.2136	0.2056	1.3590	>95%	<5%
PCBs	Heron	8	0.4202	0.0753	0.4721	>95%	<5%
PCBs	Osprey	8	0.6605	0.1144	0.7489	>95%	<5%

Table 8.13. Estimated NOAELs and LOAELs for mink and river otter

Contaminant	Experimental information						Estimated NOAEL (mg/kg/d)		Estimated LOAEL (mg/kg/d)	
	Form	Test species	NOAEL (mg/kg/d) and duration	LOAEL (mg/kg/d) and duration	Endpoint	Citation	mink	otter	mink	otter
Mercury	methyl	mink	0.015[2] 93 d	0.025[2] 93 d	mortality	Wobeser et al. 1976	0.015	0.009	0.025	0.015
PCB's	Aroclor 1254	mink	0.14 4.5 mo.	0.69 4.5 mo.	reproduction	Aulerich and Ringer 1987	0.14	0.083	0.69	0.41

[2] Estimated value: subchronic-chronic factor of 10 applied.

Table 8.14. Estimated NOAEL's and LOAEL's for belted kingfisher, great blue heron, and osprey

Contaminant	Experimental information						Estimated Values (mg/kg/d)	
	Form	Test species	NOAEL (mg/kg/d) and duration	LOAEL (mg/kg/d) and duration	Endpoint	Citation	NOAEL	LOAEL
Mercury	methyl	mallard duck	0.006[2] 3 gen.	0.064 3 gen.	reproduction	Heinz 1979	0.006	0.064
PCB's	Aroclor 1254	Ring-necked Pheasant	0.18[2] 17 wk	1.8 17 wk	reproduction	Dahlgren et al. 1972	0.18	1.8

[2] Estimated NOAEL: LOAEL-NOAEL factor of 10 applied.

Table 8.15. Comparison of mainstem water concentrations (mg/L) in White Oak Creek watershed subbasins to piscivore water benchmarks[a]

Subbasin	Analyte	Freq. of detection	Mean conc.	Exposure conc.[b]	Receptor	NOAEL	LOAEL	NOAEL_HQ	LOAEL_HQ
HF-2	AS	4/10	2.80E-03	3.78E-03	Belted Kingfisher	2.82E-01	8.46E-01	1.34E-02	4.47E-03
HF-2	CU	7/11	9.55E-03	1.75E-02	Belted Kingfisher	3.20E-01	4.20E-01	5.47E-02	4.17E-02
HF-2	HG	1/8	7.23E-03	1.34E-01	Belted Kingfisher	4.53E-07	4.53E-06	2.96E+05	2.96E+04
Intermediate Pond	CU	7/14	5.32E-03	7.87E-03	Belted Kingfisher	3.20E-01	4.20E-01	2.46E-02	1.88E-02
Lower WOC	AL	120/149	7.07E-01	9.00E-01	Belted Kingfisher	9.36E-01		9.62E-01	
Lower WOC	AS	11/128	1.72E-02	1.40E-02	Belted Kingfisher	2.82E-01	8.46E-01	4.96E-02	1.65E-02
Lower WOC	CD	3/127	1.73E-03	1.00E-03	Belted Kingfisher	2.31E-04	3.18E-03	4.33E+00	3.14E-01
Lower WOC	CU	58/147	5.23E-03	6.19E-03	Belted Kingfisher	3.20E-01	4.20E-01	1.93E-02	1.48E-02
Lower WOC	HG	33/120	7.97E-05	9.40E-05	Belted Kingfisher	4.53E-07	4.53E-06	2.08E+02	2.08E+01
Lower WOC	NI	11/141	6.35E-03	6.81E-03	Belted Kingfisher	1.44E+00	1.99E+00	4.73E-03	3.43E-03
Lower WOC	SE	1/42	1.07E-02	1.00E-03	Belted Kingfisher	3.79E-04	7.59E-04	2.64E+00	1.32E+00
SWSA 5 SEEP A	AS	1/8	1.05E-02	5.50E-04	Belted Kingfisher	2.82E-01	8.46E-01	1.95E-03	6.50E-04
SWSA 5 SEEP A	CU	1/10	2.11E-03	2.20E-03	Belted Kingfisher	3.20E-01	4.20E-01	6.88E-03	5.24E-03
SWSA 5 SEEP C	AS	2/3	1.40E-02	2.00E-03	Belted Kingfisher	2.82E-01	8.46E-01	7.09E-03	2.36E-03
SWSA 5 SEEP C	CU	3/4	3.35E-03	4.90E-03	Belted Kingfisher	3.20E-01	4.20E-01	1.53E-02	1.17E-02
SWSA 5 SEEP C	NI	1/3	4.37E-03	6.70E-03	Belted Kingfisher	1.44E+00	1.99E+00	4.65E-03	3.37E-03
SWSA 5 Trib 1	AS	1/2	9.75E-04	1.30E-03	Belted Kingfisher	2.82E-01	8.46E-01	4.61E-03	1.54E-03
SWSA 5 Trib 1	NI	1/2	3.45E-03	5.20E-03	Belted Kingfisher	1.44E+00	1.99E+00	3.61E-03	2.62E-03
SWSA 5/WOC	AL	1/2	3.06E+00	6.09E+00	Belted Kingfisher	9.36E-01		6.51E+00	
SWSA 5/WOC	CU	1/2	7.03E-03	1.26E-02	Belted Kingfisher	3.20E-01	4.20E-01	3.94E-02	3.00E-02
SWSA 5/WOC	NI	1/2	3.18E-03	4.40E-03	Belted Kingfisher	1.44E+00	1.99E+00	3.06E-03	2.21E-03
SWSA 5/WOC	SE	1/2	2.15E-03	3.10E-03	Belted Kingfisher	3.79E-04	7.59E-04	8.18E+00	4.08E+00
SWSA 5/WOC	BIS(2-ETHYLHEXYL)PHTHALATE	1/1	1.00E-03	1.00E-03	Belted Kingfisher	7.59E-07		1.32E+03	
SWSA 6 East	AL	2/2	2.65E+00	5.22E+00	Belted Kingfisher	9.36E-01		5.58E+00	
SWSA 6 East	AS	1/2	2.95E-03	4.90E-03	Belted Kingfisher	2.82E-01	8.46E-01	1.74E-02	5.79E-03
SWSA 6 East	HG	1/2	2.00E-04	3.00E-04	Belted Kingfisher	4.53E-07	4.53E-06	6.62E+02	6.63E+01
W6MS1	AL	44/45	2.22E+00	3.56E+00	Belted Kingfisher	9.36E-01		3.80E+00	
W6MS1	AS	2/15	1.06E-03	2.99E-03	Belted Kingfisher	2.82E-01	8.46E-01	1.06E-02	3.54E-03
W6MS1	CD	5/18	2.15E-03	4.07E-03	Belted Kingfisher	2.31E-04	3.18E-03	1.76E+01	1.28E+00
W6MS1	CU	10/21	1.07E-02	1.45E-02	Belted Kingfisher	3.20E-01	4.20E-01	4.53E-02	3.46E-02
W6MS1	HG	6/19	1.87E-04	4.06E-04	Belted Kingfisher	4.53E-07	4.53E-06	8.96E+02	8.97E+01
W6MS1	NI	2/16	1.01E-02	1.24E-02	Belted Kingfisher	1.44E+00	1.99E+00	8.61E-03	6.22E-03
W6MS1	SE	1/14	1.35E-03	1.69E-03	Belted Kingfisher	3.79E-04	7.59E-04	4.46E+00	2.23E+00
W6MS1	BIS(2-ETHYLHEXYL)PHTHALATE	2/4	6.00E-03	9.19E-03	Belted Kingfisher	7.59E-07		1.21E+04	
W6MS1	DI-N-BUTYLPHTHALATE	1/4	4.50E-03	3.00E-03	Belted Kingfisher	5.93E-05	5.93E-04	5.06E+01	5.06E+00
W6MS3	AL	66/80	2.13E+00	3.56E+00	Belted Kingfisher	9.36E-01		3.80E+00	

Table 8.15 (continued)

Subbasin	Analyte	Freq. of detection	Mean conc.	Exposure conc.[b]	Receptor	NOAEL	LOAEL	NOAEL_HQ	LOAEL_HQ
W6MS3	AS	9/37	1.68E-03	2.19E-03	Belted Kingfisher	2.82E-01	8.46E-01	7.77E-03	2.59E-03
W6MS3	CD	18/45	2.58E-03	2.97E-03	Belted Kingfisher	2.31E-04	3.18E-03	1.29E+01	9.32E-01
W6MS3	CU	41/63	1.88E-02	2.27E-02	Belted Kingfisher	3.20E-01	4.20E-01	7.09E-02	5.41E-02
W6MS3	HG	9/35	1.78E-04	2.69E-04	Belted Kingfisher	4.53E-07	4.53E-06	5.94E+02	5.94E+01
W6MS3	NI	10/39	1.43E-02	2.10E-02	Belted Kingfisher	1.44E+00	1.99E+00	1.46E-02	1.05E-02
W6MS3	1,2-DICHLOROETHANE	3/35	2.26E-03	2.00E-03	Belted Kingfisher	4.28E+00	8.57E+00	4.67E-04	2.33E-04
W6MS3	BIS(2-ETHYLHEXYL)PHTHALATE	4/20	4.20E-03	6.23E-03	Belted Kingfisher	7.59E-07		8.21E+03	
W6MS3	DI-N-BUTYLPHTHALATE	3/20	4.96E-03	7.23E-03	Belted Kingfisher	5.93E-05	5.93E-04	1.22E+02	1.22E+01
West Seep	AL	4/6	2.04E-01	5.22E-01	Belted Kingfisher	9.36E-01		5.58E-01	
West Seep	AS	1/4	1.25E-03	1.84E-03	Belted Kingfisher	2.82E-01	8.46E-01	6.52E-03	2.17E-03
West Seep	CD	2/5	1.56E-03	2.34E-03	Belted Kingfisher	2.31E-04	3.18E-03	1.01E+01	7.35E-01
West Seep	CU	1/4	6.25E-03	9.19E-03	Belted Kingfisher	3.20E-01	4.20E-01	2.87E-02	2.19E-02
WOC	AS	8/61	1.67E-02	1.95E-02	Belted Kingfisher	2.82E-01	8.46E-01	6.91E-02	2.31E-02
WOC	CD	1/57	1.82E-03	5.00E-05	Belted Kingfisher	2.31E-04	3.18E-03	2.16E-01	1.57E-02
WOC	CU	18/66	3.56E-03	4.99E-03	Belted Kingfisher	3.20E-01	4.20E-01	1.56E-02	1.19E-02
WOC	HG	15/56	5.72E-05	7.48E-05	Belted Kingfisher	4.53E-07	4.53E-06	1.65E+02	1.65E+01
WOC	NI	1/61	6.89E-03	8.79E-03	Belted Kingfisher	1.44E+00	1.99E+00	6.10E-03	4.42E-03
WOC	PB	1/57	1.71E-02	2.00E-02	Belted Kingfisher	4.93E-02	4.93E-01	4.06E-01	4.05E-02
WOC	PB	1/57	1.71E-02	2.00E-02	Belted Kingfisher	1.68E-01		1.19E-01	
WOCE	CD	2/2	1.38E-03	2.40E-03	Belted Kingfisher	2.31E-04	3.18E-03	1.04E+01	7.54E-01
HF-2	AS	4/10	2.80E-03	3.78E-03	Great Blue Heron	8.11E-01	2.43E+00	4.66E-03	1.55E-03
HF-2	CU	7/11	9.55E-03	1.75E-02	Great Blue Heron	9.21E-01	1.21E+00	1.90E-02	1.45E-02
HF-2	HG	1/8	7.23E-03	1.34E-01	Great Blue Heron	1.31E-06	1.31E-05	1.02E+05	1.03E+04
Intermediate Pond	CU	7/14	5.32E-03	7.87E-03	Great Blue Heron	9.21E-01	1.21E+00	8.55E-03	6.51E-03
Lower WOC	AL	120/149	7.07E-01	9.00E-01	Great Blue Heron	2.70E+00		3.33E-01	
Lower WOC	AS	11/128	1.72E-02	1.40E-02	Great Blue Heron	8.11E-01	2.43E+00	1.73E-02	5.75E-03
Lower WOC	CD	3/127	1.73E-03	1.00E-03	Great Blue Heron	6.65E-04	9.18E-03	1.50E+00	1.09E-01
Lower WOC	CU	58/147	5.23E-03	6.19E-03	Great Blue Heron	9.21E-01	1.21E+00	6.72E-03	5.12E-03
Lower WOC	HG	33/120	7.97E-05	9.40E-05	Great Blue Heron	1.31E-06	1.31E-05	7.18E+01	7.20E+00
Lower WOC	NI	11/141	6.35E-03	6.81E-03	Great Blue Heron	4.15E+00	5.73E+00	1.64E-03	1.19E-03
Lower WOC	SE	1/42	1.07E-02	1.00E-03	Great Blue Heron	1.09E-03	2.19E-03	9.17E-01	4.57E-01
SWSA 5 SEEP A	AS	1/8	1.05E-02	5.50E-04	Great Blue Heron	8.11E-01	2.43E+00	6.78E-04	2.26E-04
SWSA 5 SEEP A	CU	1/10	2.11E-03	2.20E-03	Great Blue Heron	9.21E-01	1.21E+00	2.39E-03	1.82E-03
SWSA 5 SEEP C	AS	2/3	1.40E-02	2.00E-03	Great Blue Heron	8.11E-01	2.43E+00	2.47E-03	8.22E-04
SWSA 5 SEEP C	CU	3/4	3.35E-03	4.90E-03	Great Blue Heron	9.21E-01	1.21E+00	5.32E-03	4.05E-03
SWSA 5 SEEP C	NI	1/3	4.37E-03	6.70E-03	Great Blue Heron	4.15E+00	5.73E+00	1.61E-03	1.17E-03
SWSA 5 Trib 1	AS	1/2	9.75E-04	1.30E-03	Great Blue Heron	8.11E-01	2.43E+00	1.60E-03	5.34E-04
SWSA 5 Trib 1	NI	1/2	3.45E-03	5.20E-03	Great Blue Heron	4.15E+00	5.73E+00	1.25E-03	9.07E-04

Table 8.15 (continued)

Subbasin	Analyte	Freq. of detection	Mean conc.	Exposure conc.[b]	Receptor	NOAEL	LOAEL	NOAEL_HQ	LOAEL_HQ
SWSA 5/WOC	AL	1/2	3.06E+00	6.09E+00	Great Blue Heron	2.70E+00		2.26E+00	
SWSA 5/WOC	CU	1/2	7.03E-03	1.26E-02	Great Blue Heron	9.21E-01	1.21E+00	1.37E-02	1.04E-02
SWSA 5/WOC	NI	1/2	3.18E-03	4.40E-03	Great Blue Heron	4.15E+00	5.73E+00	1.06E-03	7.68E-04
SWSA 5/WOC	SE	1/2	2.15E-03	3.10E-03	Great Blue Heron	1.09E-03	2.19E-03	2.84E+00	1.42E+00
SWSA 5/WOC	BIS(2-ETHYLHEXYL)PHTHALATE	1/1	1.00E-03	1.00E-03	Great Blue Heron	2.19E-06		4.57E+02	
SWSA 6 East	AL	2/2	2.65E+00	5.22E+00	Great Blue Heron	2.70E+00		1.93E+00	
SWSA 6 East	AS	1/2	2.95E-03	4.90E-03	Great Blue Heron	8.11E-01	2.43E+00	6.04E-03	2.01E-03
SWSA 6 East	HG	1/2	2.00E-04	3.00E-04	Great Blue Heron	1.31E-06	1.31E-05	2.29E+02	2.30E+01
W6MS1	AL	44/45	2.22E+00	3.56E+00	Great Blue Heron	2.70E+00		1.32E+00	
W6MS1	AS	2/15	1.06E-03	2.99E-03	Great Blue Heron	8.11E-01	2.43E+00	3.69E-03	1.23E-03
W6MS1	CD	5/18	2.15E-03	4.07E-03	Great Blue Heron	6.65E-04	9.18E-03	6.12E+00	4.43E-01
W6MS1	CU	10/21	1.07E-02	1.45E-02	Great Blue Heron	9.21E-01	1.21E+00	1.57E-02	1.20E-02
W6MS1	HG	6/19	1.87E-04	4.06E-04	Great Blue Heron	1.31E-06	1.31E-05	3.10E+02	3.11E+01
W6MS1	NI	2/16	1.01E-02	1.24E-02	Great Blue Heron	4.15E+00	5.73E+00	2.99E-03	2.16E-03
W6MS1	SE	1/14	1.35E-03	1.69E-03	Great Blue Heron	1.09E-03	2.19E-03	1.55E+00	7.72E-01
W6MS1	BIS(2-ETHYLHEXYL)PHTHALATE	2/4	6.00E-03	9.19E-03	Great Blue Heron	2.19E-06		4.20E+03	
W6MS1	DI-N-BUTYLPHTHALATE	1/4	4.50E-03	3.00E-03	Great Blue Heron	1.71E-04	1.71E-03	1.75E+01	1.75E+00
W6MS3	AL	66/80	2.13E+00	3.56E+00	Great Blue Heron	2.70E+00		1.32E+00	
W6MS3	AS	9/37	1.68E-03	2.19E-03	Great Blue Heron	8.11E-01	2.43E+00	2.70E-03	9.01E-04
W6MS3	CD	18/45	2.58E-03	2.97E-03	Great Blue Heron	6.65E-04	9.18E-03	4.47E+00	3.23E-01
W6MS3	CU	41/63	1.88E-02	2.27E-02	Great Blue Heron	9.21E-01	1.21E+00	2.46E-02	1.88E-02
W6MS3	HG	9/35	1.78E-04	2.69E-04	Great Blue Heron	1.31E-06	1.31E-05	2.05E+02	2.06E+01
W6MS3	NI	10/39	1.43E-02	2.10E-02	Great Blue Heron	4.15E+00	5.73E+00	5.06E-03	3.66E-03
W6MS3	1,2-DICHLOROETHANE	3/35	2.26E-03	2.00E-03	Great Blue Heron	1.23E+01	2.46E+01	1.63E-04	8.13E-05
W6MS3	BIS(2-ETHYLHEXYL)PHTHALATE	4/20	4.20E-03	6.23E-03	Great Blue Heron	2.19E-06		2.84E+03	
W6MS3	DI-N-BUTYLPHTHALATE	3/20	4.96E-03	7.23E-03	Great Blue Heron	1.71E-04	1.71E-03	4.23E+01	4.23E+00
West Seep	AL	4/6	2.04E-01	5.22E-01	Great Blue Heron	2.70E+00		1.93E-01	
West Seep	AS	1/4	1.25E-03	1.84E-03	Great Blue Heron	8.11E-01	2.43E+00	2.27E-03	7.55E-04
West Seep	CD	2/5	1.56E-03	2.34E-03	Great Blue Heron	6.65E-04	9.18E-03	3.52E+00	2.55E-01
West Seep	CU	1/4	6.25E-03	9.19E-03	Great Blue Heron	9.21E-01	1.21E+00	9.98E-03	7.60E-03
WOC	AS	8/61	1.67E-02	1.95E-02	Great Blue Heron	8.11E-01	2.43E+00	2.40E-02	8.01E-03
WOC	CD	1/57	1.82E-03	5.00E-05	Great Blue Heron	6.65E-04	9.18E-03	7.52E-02	5.45E-03
WOC	CU	18/66	3.56E-03	4.99E-03	Great Blue Heron	9.21E-01	1.21E+00	5.42E-03	4.13E-03
WOC	HG	15/56	5.72E-05	7.48E-05	Great Blue Heron	1.31E-06	1.31E-05	5.71E+01	5.73E+00
WOC	NI	1/61	6.89E-03	8.79E-03	Great Blue Heron	4.15E+00	5.73E+00	2.12E-03	1.53E-03
WOC	PB	1/57	1.71E-02	2.00E-02	Great Blue Heron	1.42E-01	1.42E+00	1.41E-01	1.41E-02
WOC	PB	1/57	1.71E-02	2.00E-02	Great Blue Heron	4.84E-01		4.13E-02	
WOCE	CD	2/2	1.38E-03	2.40E-03	Great Blue Heron	6.65E-04	9.18E-03	3.61E+00	2.61E-01

Table 8.15 (continued)

Subbasin	Analyte	Freq. of detection	Mean conc.	Exposure conc.[b]	Receptor	NOAEL	LOAEL	NOAEL_HQ	LOAEL_HQ
HF-2	AS	4/10	2.80E-03	3.78E-03	Mink	2.16E-02	2.16E-01	1.75E-01	1.75E-02
HF-2	BE	2/11	3.26E-04	4.00E-04	Mink	1.88E-01		2.13E-03	
HF-2	CR	2/11	2.91E-03	5.26E-03	Mink	4.95E+00	1.98E+01	1.06E-03	2.66E-04
HF-2	CU	7/11	9.55E-03	1.75E-02	Mink	2.94E-01	3.87E-01	5.95E-02	4.53E-02
HF-2	HG	1/8	7.23E-03	1.34E-01	Mink	3.92E-06	6.54E-06	3.42E+04	2.05E+04
HF-2	TL	1/9	2.82E-01	4.10E-01	Mink	1.21E-03	1.21E-02	3.39E+02	3.39E+01
HF-2	ACETONE	1/3	2.67E-03	3.00E-03	Mink	5.05E+01	2.52E+02	5.94E-05	1.19E-05
HF-2	METHYLENE CHLORIDE	3/3	1.00E-04	1.00E-04	Mink	5.50E+00	4.70E+01	1.82E-05	2.13E-06
Intermediate Pond	BE	2/13	5.11E-04	5.00E-04	Mink	1.88E-01		2.66E-03	
Intermediate Pond	CU	7/14	5.32E-03	7.87E-03	Mink	2.94E-01	3.87E-01	2.68E-02	2.04E-02
Intermediate Pond	TL	1/12	1.72E-01	1.69E-01	Mink	1.21E-03	1.21E-02	1.40E+02	1.40E+01
Intermediate Pond	ACETONE	3/3	3.00E-03	3.00E-03	Mink	5.05E+01	2.52E+02	5.94E-05	1.19E-05
Intermediate Pond	CHLOROFORM	3/3	2.00E-03	2.00E-03	Mink	4.74E+00	1.30E+01	4.22E-04	1.54E-04
Lower WOC	AL	120/149	7.07E-01	9.00E-01	Mink	2.53E-02	2.53E-01	3.56E+01	3.56E+00
Lower WOC	AS	11/128	1.72E-02	1.40E-02	Mink	2.16E-02	2.16E-01	6.48E-01	6.48E-02
Lower WOC	BE	10/53	4.65E-04	5.94E-04	Mink	1.88E-01		3.16E-03	
Lower WOC	CD	3/127	1.73E-03	1.00E-03	Mink	4.37E-04	4.37E-03	2.29E+00	2.29E-01
Lower WOC	CR	62/142	7.26E-03	9.31E-03	Mink	4.95E+00	1.98E+01	1.88E-03	4.70E-04
Lower WOC	CU	58/147	5.23E-03	6.19E-03	Mink	2.94E-01	3.87E-01	2.11E-02	1.60E-02
Lower WOC	HG	33/120	7.97E-05	9.40E-05	Mink	3.92E-06	6.54E-06	2.40E+01	1.44E+01
Lower WOC	NI	11/141	6.35E-03	6.81E-03	Mink	2.10E+00	4.21E+00	3.24E-03	1.62E-03
Lower WOC	SB	3/53	1.79E-02	1.91E-02	Mink	2.20E-01	2.20E+00	8.68E-02	8.66E-03
Lower WOC	SE	1/42	1.07E-02	1.00E-03	Mink	4.32E-04	7.12E-04	2.31E+00	1.40E+00
Lower WOC	TL	5/50	1.66E-04	7.56E-03	Mink	1.21E-03	1.21E-02	6.25E+00	6.25E-01
Lower WOC	ACETONE	1/9	2.56E-03	2.66E-03	Mink	5.05E+01	2.52E+02	5.27E-05	1.05E-05
Lower WOC	CHLOROFORM	5/93	2.27E-03	1.00E-03	Mink	4.74E+00	1.30E+01	2.11E-04	7.72E-05
Lower WOC	METHYLENE CHLORIDE	5/9	2.09E-04	3.46E-04	Mink	5.50E+00	4.70E+01	6.29E-05	7.36E-06
Lower WOC	TRICHLOROETHENE	2/93	2.35E-03	2.50E-03	Mink	3.08E-02	3.08E-01	8.12E-02	8.09E-03
MB-15	1,1-DICHLOROETHENE	1/1	5.00E-04	5.00E-04	Mink	1.28E+00		3.91E-04	
MB-15	METHYLENE CHLORIDE	1/1	2.00E-04	2.00E-04	Mink	5.50E+00	4.70E+01	3.64E-05	4.26E-06
MB-15	TETRACHLOROETHENE	1/1	7.00E-04	7.00E-04	Mink	6.61E-02	3.31E-01	1.06E-02	2.12E-03
MB-15	TRICHLOROETHENE	1/1	9.00E-03	9.00E-03	Mink	3.08E-02	3.08E-01	2.92E-01	2.92E-02
MB-15	VINYL CHLORIDE	1/1	1.50E-02	1.50E-02	Mink	1.08E-01	1.08E+00	1.39E-01	1.39E-02
SWSA 5 SEEP A	AS	1/8	1.05E-02	5.50E-04	Mink	2.16E-02	2.16E-01	2.55E-02	2.55E-03
SWSA 5 SEEP A	BE	1/10	4.88E-04	2.80E-04	Mink	1.88E-01		1.49E-03	
SWSA 5 SEEP A	CR	1/10	2.49E-03	3.00E-03	Mink	4.95E+00	1.98E+01	6.06E-04	1.51E-04
SWSA 5 SEEP A	CU	1/10	2.11E-03	2.20E-03	Mink	2.94E-01	3.87E-01	7.48E-03	5.69E-03
SWSA 5 SEEP A	SB	1/9	1.98E-02	1.91E-02	Mink	2.20E-01	2.20E+00	8.68E-02	8.66E-03

Table 8.15 (continued)

Subbasin	Analyte	Freq. of detection	Mean conc.	Exposure conc.[b]	Receptor	NOAEL	LOAEL	NOAEL_HQ	LOAEL_HQ
SWSA 5 SEEP A	TL	1/9	1.84E-01	1.68E-01	Mink	1.21E-03	1.21E-02	1.39E+02	1.39E+01
SWSA 5 SEEP A	ACETONE	1/3	2.00E-03	1.00E-03	Mink	5.05E+01	2.52E+02	1.98E-05	3.96E-06
SWSA 5 SEEP C	AS	2/3	1.40E-02	2.00E-03	Mink	2.16E-02	2.16E-01	9.26E-02	9.26E-03
SWSA 5 SEEP C	BE	2/3	2.67E-04	1.90E-04	Mink	1.88E-01		1.01E-03	
SWSA 5 SEEP C	CU	3/4	3.35E-03	4.90E-03	Mink	2.94E-01	3.87E-01	1.67E-02	1.27E-02
SWSA 5 SEEP C	NI	1/3	4.37E-03	6.70E-03	Mink	2.10E+00	4.21E+00	3.19E-03	1.59E-03
SWSA 5 Trib 1	AS	1/2	9.75E-04	1.30E-03	Mink	2.16E-02	2.16E-01	6.02E-02	6.02E-03
SWSA 5 Trib 1	CR	2/2	3.15E-03	4.10E-03	Mink	4.95E+00	1.98E+01	8.28E-04	2.07E-04
SWSA 5 Trib 1	NI	1/2	3.45E-03	5.20E-03	Mink	2.10E+00	4.21E+00	2.48E-03	1.24E-03
SWSA 5 Trib 1	1,1-DICHLOROETHENE	1/2	7.50E-03	1.00E-02	Mink	1.28E+00		7.81E-03	
SWSA 5 Trib 1	BENZENE	1/2	7.50E-03	1.00E-02	Mink	3.16E+00	3.16E+01	3.16E-03	3.16E-04
SWSA 5 Trib 1	CARBON TETRACHLORIDE	1/2	7.50E-03	1.00E-02	Mink	1.26E+00		7.94E-03	
SWSA 5 Trib 1	CHLOROFORM	1/2	7.50E-03	1.00E-02	Mink	4.74E+00	1.30E+01	2.11E-03	7.72E-04
SWSA 5 Trib 1	METHYLENE CHLORIDE	1/2	7.50E-03	1.00E-02	Mink	5.50E+00	4.70E+01	1.82E-03	2.13E-04
SWSA 5 Trib 1	TETRACHLOROETHENE	1/2	7.50E-03	1.00E-02	Mink	6.61E-02	3.31E-01	1.51E-01	3.03E-02
SWSA 5 Trib 1	TOLUENE	1/2	7.50E-03	1.00E-02	Mink	1.05E+00	1.05E+01	9.52E-03	9.52E-04
SWSA 5 Trib 1	XYLENE (TOTAL)	1/2	3.50E-03	2.00E-03	Mink	3.83E-02	4.74E-02	5.22E-02	4.22E-02
SWSA 5/WOC	AL	1/2	3.06E+00	6.09E+00	Mink	2.53E-02	2.53E-01	2.41E+02	2.41E+01
SWSA 5/WOC	CR	1/2	3.63E-03	5.20E-03	Mink	4.95E+00	1.98E+01	1.05E-03	2.62E-04
SWSA 5/WOC	CU	1/2	7.03E-03	1.26E-02	Mink	2.94E-01	3.87E-01	4.29E-02	3.26E-02
SWSA 5/WOC	NI	1/2	3.18E-03	4.40E-03	Mink	2.10E+00	4.21E+00	2.10E-03	1.05E-03
SWSA 5/WOC	SE	1/2	2.15E-03	3.10E-03	Mink	4.32E-04	7.12E-04	7.18E+00	4.35E+00
SWSA 5/WOC	1,1-DICHLOROETHENE	1/2	7.50E-03	1.00E-02	Mink	1.28E+00		7.81E-03	
SWSA 5/WOC	BENZENE	1/2	7.50E-03	1.00E-02	Mink	3.16E+00	3.16E+01	3.16E-03	3.16E-04
SWSA 5/WOC	BIS(2-ETHYLHEXYL)PHTHALATE	1/1	1.00E-03	1.00E-03	Mink	1.94E-05	1.94E-04	5.15E+01	5.14E+00
SWSA 5/WOC	CARBON TETRACHLORIDE	1/2	7.50E-03	1.00E-02	Mink	1.26E+00		7.94E-03	
SWSA 5/WOC	CHLOROFORM	1/2	7.50E-03	1.00E-02	Mink	4.74E+00	1.30E+01	2.11E-03	7.72E-04
SWSA 5/WOC	METHYLENE CHLORIDE	1/2	7.50E-03	1.00E-02	Mink	5.50E+00	4.70E+01	1.82E-03	2.13E-04
SWSA 5/WOC	TETRACHLOROETHENE	1/2	7.50E-03	1.00E-02	Mink	6.61E-02	3.31E-01	1.51E-01	3.03E-02
SWSA 5/WOC	TOLUENE	1/2	7.50E-03	1.00E-02	Mink	1.05E+00	1.05E+01	9.52E-03	9.52E-04
SWSA 5/WOC	XYLENE (TOTAL)	1/2	7.50E-03	1.00E-02	Mink	3.83E-02	4.74E-02	2.61E-01	2.11E-01
SWSA 6 East	AL	2/2	2.65E+00	5.22E+00	Mink	2.53E-02	2.53E-01	2.06E+02	2.06E+01
SWSA 6 East	AS	1/2	2.95E-03	4.90E-03	Mink	2.16E-02	2.16E-01	2.27E-01	2.27E-02
SWSA 6 East	CR	1/2	7.60E-03	1.02E-02	Mink	4.95E+00	1.98E+01	2.06E-03	5.15E-04
SWSA 6 East	HG	1/2	2.00E-04	3.00E-04	Mink	3.92E-06	6.54E-06	7.65E+01	4.59E+01
SWSA 6 East	METHYLENE CHLORIDE	1/1	5.00E-03	5.00E-03	Mink	5.50E+00	4.70E+01	9.09E-04	1.06E-04
W6MS1	AL	44/45	2.22E+00	3.56E+00	Mink	2.53E-02	2.53E-01	1.41E+02	1.41E+01
W6MS1	AS	2/15	1.06E-03	2.99E-03	Mink	2.16E-02	2.16E-01	1.38E-01	1.39E-02

Table 8.15 (continued)

Subbasin	Analyte	Freq. of detection	Mean conc.	Exposure conc.[b]	Receptor	NOAEL	LOAEL	NOAEL_HQ	LOAEL_HQ
W6MS1	CD	5/18	2.15E-03	4.07E-03	Mink	4.37E-04	4.37E-03	9.31E+00	9.31E-01
W6MS1	CR	12/22	1.13E-02	1.40E-02	Mink	4.95E+00	1.98E+01	2.83E-03	7.05E-04
W6MS1	CU	10/21	1.07E-02	1.45E-02	Mink	2.94E-01	3.87E-01	4.93E-02	3.75E-02
W6MS1	HG	6/19	1.87E-04	4.06E-04	Mink	3.92E-06	6.54E-06	1.04E+02	6.21E+01
W6MS1	NI	2/16	1.01E-02	1.24E-02	Mink	2.10E+00	4.21E+00	5.90E-03	2.94E-03
W6MS1	SB	1/14	1.36E-02	5.00E-03	Mink	2.20E-01	2.20E+00	2.27E-02	2.27E-03
W6MS1	SE	1/14	1.35E-03	1.69E-03	Mink	4.32E-04	7.12E-04	3.91E+00	2.37E+00
W6MS1	1,1,1-TRICHLOROETHANE	1/15	2.07E-03	2.00E-03	Mink	6.81E+01		2.94E-05	
W6MS1	2-BUTANONE	11/19	7.16E-03	8.96E-03	Mink	5.91E+03	1.53E+04	1.52E-06	5.87E-07
W6MS1	4-METHYL-2-PENTANONE	2/16	1.67E-03	2.07E-02	Mink	2.58E+01		8.02E-04	
W6MS1	ACETONE	17/21	1.04E-02	1.57E-02	Mink	5.05E+01	2.52E+02	3.11E-04	6.23E-05
W6MS1	BIS(2-ETHYLHEXYL)PHTHALATE	2/4	6.00E-03	9.19E-03	Mink	1.94E-05	1.94E-04	4.74E+02	4.72E+01
W6MS1	DI-N-BUTYLPHTHALATE	1/4	4.50E-03	3.00E-03	Mink	4.56E-01	1.52E+00	6.58E-03	1.97E-03
W6MS1	METHYLENE CHLORIDE	15/19	6.71E-03	8.69E-03	Mink	5.50E+00	4.70E+01	1.58E-03	1.85E-04
W6MS1	TETRACHLOROETHENE	1/14	2.11E-03	2.52E-03	Mink	6.61E-02	3.31E-01	3.81E-02	7.64E-03
W6MS1	TOLUENE	1/14	2.25E-03	2.80E-03	Mink	1.05E+00	1.05E+01	2.67E-03	2.66E-04
W6MS1	TOTAL-1,2-DICHLOROETHENE	3/14	2.32E-03	2.00E-03	Mink	8.54E+00		2.34E-04	
W6MS1	TRICHLOROETHENE	7/17	3.49E-03	5.45E-03	Mink	3.08E-02	3.08E-01	1.77E-01	1.77E-02
W6MS3	AL	66/80	2.13E+00	3.56E+00	Mink	2.53E-02	2.53E-01	1.41E+02	1.41E+01
W6MS3	AS	9/37	1.68E-03	2.19E-03	Mink	2.16E-02	2.16E-01	1.01E-01	1.02E-02
W6MS3	BE	16/47	1.06E-03	1.25E-03	Mink	1.88E-01		6.65E-03	
W6MS3	CD	18/45	2.58E-03	2.97E-03	Mink	4.37E-04	4.37E-03	6.80E+00	6.79E-01
W6MS3	CR	39/60	1.85E-02	2.22E-02	Mink	4.95E+00	1.98E+01	4.48E-03	1.12E-03
W6MS3	CU	41/63	1.88E-02	2.27E-02	Mink	2.94E-01	3.87E-01	7.72E-02	5.87E-02
W6MS3	HG	9/35	1.78E-04	2.69E-04	Mink	3.92E-06	6.54E-06	6.86E+01	4.11E+01
W6MS3	NI	10/39	1.43E-02	2.10E-02	Mink	2.10E+00	4.21E+00	1.00E-02	4.98E-03
W6MS3	SB	3/31	1.40E-02	5.00E-03	Mink	2.20E-01	2.20E+00	2.27E-02	2.27E-03
W6MS3	1,1-DICHLOROETHENE	3/33	2.30E-03	2.51E-03	Mink	1.28E+00		1.96E-03	
W6MS3	1,2-DICHLOROETHANE	3/35	2.26E-03	2.00E-03	Mink	1.87E+01		1.07E-04	
W6MS3	1,4-DIOXANE	1/3	1.01E+00	2.30E-02	Mink	2.75E+00	5.49E+00	8.36E-03	4.19E-03
W6MS3	2-BUTANONE	41/50	1.06E-02	1.24E-02	Mink	5.91E+03	1.53E+04	2.10E-06	8.13E-07
W6MS3	4-METHYL-2-PENTANONE	4/34	4.84E-03	5.34E-03	Mink	2.58E+01		2.07E-04	
W6MS3	ACETONE	35/50	9.42E-03	1.19E-02	Mink	5.05E+01	2.52E+02	2.36E-04	4.73E-05
W6MS3	BENZENE	4/34	2.26E-03	2.45E-03	Mink	3.16E+00	3.16E+01	7.75E-04	7.74E-05
W6MS3	BIS(2-ETHYLHEXYL)PHTHALATE	4/20	4.20E-03	6.23E-03	Mink	1.94E-05	1.94E-04	3.21E+02	3.20E+01
W6MS3	CHLOROFORM	3/35	4.82E-04	5.20E-03	Mink	4.74E+00	1.30E+01	1.10E-03	4.01E-04
W6MS3	DI-N-BUTYLPHTHALATE	3/20	4.96E-03	7.23E-03	Mink	4.56E-01	1.52E+00	1.59E-02	4.75E-03
W6MS3	METHYLENE CHLORIDE	38/48	5.77E-03	6.62E-03	Mink	5.50E+00	4.70E+01	1.20E-03	1.41E-04

Table 8.15 (continued)

Subbasin	Analyte	Freq. of detection	Mean conc.	Exposure conc.[b]	Receptor	NOAEL	LOAEL	NOAEL_HQ	LOAEL_HQ
W6MS3	TETRACHLOROETHENE	12/39	3.21E-03	7.30E-03	Mink	6.61E-02	3.31E-01	1.10E-01	2.21E-02
W6MS3	TOLUENE	11/34	2.78E-03	3.14E-03	Mink	1.05E+00	1.05E+01	2.99E-03	2.99E-04
W6MS3	TOTAL-1,2-DICHLOROETHENE	19/42	7.82E-03	1.44E-02	Mink	8.54E+00		1.69E-03	
W6MS3	TRICHLOROETHENE	19/43	8.27E-03	2.18E-02	Mink	3.08E-02	3.08E-01	7.08E-01	7.06E-02
W6MS3	VINYL CHLORIDE	5/33	4.77E-03	5.43E-03	Mink	1.08E-01	1.08E+00	5.03E-02	5.03E-03
West Seep	AL	4/6	2.04E-01	5.22E-01	Mink	2.53E-02	2.53E-01	2.06E+01	2.06E+00
West Seep	AS	1/4	1.25E-03	1.84E-03	Mink	2.16E-02	2.16E-01	8.52E-02	8.51E-03
West Seep	BE	1/4	6.25E-04	9.19E-04	Mink	1.88E-01		4.89E-03	
West Seep	CD	2/5	1.56E-03	2.34E-03	Mink	4.37E-04	4.37E-03	5.35E+00	5.36E-01
West Seep	CR	2/4	9.25E-03	1.40E-02	Mink	4.95E+00	1.98E+01	2.83E-03	7.06E-04
West Seep	CU	1/4	6.25E-03	9.19E-03	Mink	2.94E-01	3.87E-01	3.13E-02	2.38E-02
West Seep	2-BUTANONE	2/4	5.00E-03	5.00E-03	Mink	5.91E+03	1.53E+04	8.46E-07	3.28E-07
West Seep	ACETONE	3/4	1.55E-02	3.49E-02	Mink	5.05E+01	2.52E+02	6.91E-04	1.38E-04
West Seep	METHYLENE CHLORIDE	3/4	3.63E-03	5.00E-03	Mink	5.50E+00	4.70E+01	9.09E-04	1.06E-04
West Seep	TOLUENE	2/4	3.75E-03	5.00E-03	Mink	1.05E+00	1.05E+01	4.76E-03	4.76E-04
West Seep	TRICHLOROETHENE	1/4	2.38E-03	2.00E-03	Mink	3.08E-02	3.08E-01	6.49E-02	6.48E-03
WOC	AS	8/61	1.67E-02	1.95E-02	Mink	2.16E-02	2.16E-01	9.03E-01	9.03E-02
WOC	BE	5/20	3.89E-04	5.00E-04	Mink	1.88E-01		2.66E-03	
WOC	CD	1/57	1.82E-03	5.00E-05	Mink	4.37E-04	4.37E-03	1.14E-01	1.14E-02
WOC	CR	16/61	2.66E-03	4.26E-03	Mink	4.95E+00	1.98E+01	8.61E-04	2.15E-04
WOC	CU	18/66	3.56E-03	4.99E-03	Mink	2.94E-01	3.87E-01	1.70E-02	1.29E-02
WOC	HG	15/56	5.72E-05	7.48E-05	Mink	3.92E-06	6.54E-06	1.91E+01	1.14E+01
WOC	NI	1/61	6.89E-03	8.79E-03	Mink	2.10E+00	4.21E+00	4.19E-03	2.09E-03
WOC	PB	1/57	1.71E-02	2.00E-02	Mink	9.82E-01	9.82E+00	2.04E-02	2.03E-03
WOC	SB	4/22	1.80E-02	2.18E-02	Mink	2.20E-01	2.20E+00	9.91E-02	9.89E-03
WOC	TL	5/20	6.58E-03	6.09E-02	Mink	1.21E-03	1.21E-02	5.03E+01	5.03E+00
WOC	ACETONE	1/4	3.13E-03	4.60E-03	Mink	5.05E+01	2.52E+02	9.11E-05	1.82E-05
WOC	CHLOROFORM	36/47	1.87E-03	2.02E-03	Mink	4.74E+00	1.30E+01	4.26E-04	1.56E-04
WOC	METHYLENE CHLORIDE	3/5	2.20E-04	3.00E-04	Mink	5.50E+00	4.70E+01	5.45E-05	6.38E-06
WOCE	CD	2/2	1.38E-03	2.40E-03	Mink	4.37E-04	4.37E-03	5.49E+00	5.50E-01
WOCE	CR	1/2	7.45E-03	1.00E-02	Mink	4.95E+00	1.98E+01	2.02E-03	5.05E-04
HF-2	AS	4/10	2.80E-03	3.78E-03	Osprey	7.13E-01	2.14E+00	5.30E-03	1.77E-03
HF-2	CU	7/11	9.55E-03	1.75E-02	Osprey	8.10E-01	1.06E+00	2.16E-02	1.65E-02
HF-2	HG	1/8	7.23E-03	1.34E-01	Osprey	1.15E-06	1.15E-05	1.17E+05	1.17E+04
Intermediate Pond	CU	7/14	5.32E-03	7.87E-03	Osprey	8.10E-01	1.06E+00	9.72E-03	7.41E-03
Lower WOC	AL	120/149	7.07E-01	9.00E-01	Osprey	2.37E+00		3.80E-01	
Lower WOC	AS	11/128	1.72E-02	1.40E-02	Osprey	7.13E-01	2.14E+00	1.96E-02	6.55E-03
Lower WOC	CD	3/127	1.73E-03	1.00E-03	Osprey	5.85E-04	8.06E-03	1.71E+00	1.24E-01

Table 8.15 (continued)

Subbasin	Analyte	Freq. of detection	Mean conc.	Exposure conc.[b]	Receptor	NOAEL	LOAEL	NOAEL_HQ	LOAEL_HQ
Lower WOC	CU	58/147	5.23E-03	6.19E-03	Osprey	8.10E-01	1.06E+00	7.64E-03	5.83E-03
Lower WOC	HG	33/120	7.97E-05	9.40E-05	Osprey	1.15E-06	1.15E-05	8.17E+01	8.20E+00
Lower WOC	NI	11/141	6.35E-03	6.81E-03	Osprey	3.64E+00	5.03E+00	1.87E-03	1.35E-03
Lower WOC	SE	1/42	1.07E-02	1.00E-03	Osprey	9.61E-04	1.92E-03	1.04E+00	5.20E-01
SWSA 5 SEEP A	AS	1/8	1.05E-02	5.50E-04	Osprey	7.13E-01	2.14E+00	7.71E-04	2.57E-04
SWSA 5 SEEP A	CU	1/10	2.11E-03	2.20E-03	Osprey	8.10E-01	1.06E+00	2.72E-03	2.07E-03
SWSA 5 SEEP C	AS	2/3	1.40E-02	2.00E-03	Osprey	7.13E-01	2.14E+00	2.81E-03	9.35E-04
SWSA 5 SEEP C	CU	3/4	3.35E-03	4.90E-03	Osprey	8.10E-01	1.06E+00	6.05E-03	4.61E-03
SWSA 5 SEEP C	NI	1/3	4.37E-03	6.70E-03	Osprey	3.64E+00	5.03E+00	1.84E-03	1.33E-03
SWSA 5 Trib 1	AS	1/2	9.75E-04	1.30E-03	Osprey	7.13E-01	2.14E+00	1.82E-03	6.08E-04
SWSA 5 Trib 1	NI	1/2	3.45E-03	5.20E-03	Osprey	3.64E+00	5.03E+00	1.43E-03	1.03E-03
SWSA 5/WOC	AL	1/2	3.06E+00	6.09E+00	Osprey	2.37E+00		2.57E+00	
SWSA 5/WOC	CU	1/2	7.03E-03	1.26E-02	Osprey	8.10E-01	1.06E+00	1.56E-02	1.19E-02
SWSA 5/WOC	NI	1/2	3.18E-03	4.40E-03	Osprey	3.64E+00	5.03E+00	1.21E-03	8.74E-04
SWSA 5/WOC	SE	1/2	2.15E-03	3.10E-03	Osprey	9.61E-04	1.92E-03	3.23E+00	1.61E+00
SWSA 5/WOC	BIS(2-ETHYLHEXYL)PHTHALATE	1/1	1.00E-03	1.00E-03	Osprey	1.92E-06		5.21E+02	
SWSA 6 East	AL	2/2	2.65E+00	5.22E+00	Osprey	2.37E+00		2.20E+00	
SWSA 6 East	AS	1/2	2.95E-03	4.90E-03	Osprey	7.13E-01	2.14E+00	6.87E-03	2.29E-03
SWSA 6 East	HG	1/2	2.00E-04	3.00E-04	Osprey	1.15E-06	1.15E-05	2.61E+02	2.62E+01
W6MS1	AL	44/45	2.22E+00	3.56E+00	Osprey	2.37E+00		1.50E+00	
W6MS1	AS	2/15	1.06E-03	2.99E-03	Osprey	7.13E-01	2.14E+00	4.19E-03	1.40E-03
W6MS1	CD	5/18	2.15E-03	4.07E-03	Osprey	5.85E-04	8.06E-03	6.96E+00	5.04E-01
W6MS1	CU	10/21	1.07E-02	1.45E-02	Osprey	8.10E-01	1.06E+00	1.79E-02	1.37E-02
W6MS1	HG	6/19	1.87E-04	4.06E-04	Osprey	1.15E-06	1.15E-05	3.53E+02	3.54E+01
W6MS1	NI	2/16	1.01E-02	1.24E-02	Osprey	3.64E+00	5.03E+00	3.41E-03	2.45E-03
W6MS1	SE	1/14	1.35E-03	1.69E-03	Osprey	9.61E-04	1.92E-03	1.76E+00	8.79E-01
W6MS1	BIS(2-ETHYLHEXYL)PHTHALATE	2/4	6.00E-03	9.19E-03	Osprey	1.92E-06		4.79E+03	
W6MS1	DI-N-BUTYLPHTHALATE	1/4	4.50E-03	3.00E-03	Osprey	1.50E-04	1.50E-03	2.00E+01	2.00E+00
W6MS3	AL	66/80	2.13E+00	3.56E+00	Osprey	2.37E+00		1.50E+00	
W6MS3	AS	9/37	1.68E-03	2.19E-03	Osprey	7.13E-01	2.14E+00	3.07E-03	1.03E-03
W6MS3	CD	18/45	2.58E-03	2.97E-03	Osprey	5.85E-04	8.06E-03	5.08E+00	3.68E-01
W6MS3	CU	41/63	1.88E-02	2.27E-02	Osprey	8.10E-01	1.06E+00	2.80E-02	2.13E-02
W6MS3	HG	9/35	1.78E-04	2.69E-04	Osprey	1.15E-06	1.15E-05	2.34E+02	2.34E+01
W6MS3	NI	10/39	1.43E-02	2.10E-02	Osprey	3.64E+00	5.03E+00	5.77E-03	4.17E-03
W6MS3	1,2-DICHLOROETHANE	3/35	2.26E-03	2.00E-03	Osprey	1.08E+01	2.16E+01	1.85E-04	9.26E-05
W6MS3	BIS(2-ETHYLHEXYL)PHTHALATE	4/20	4.20E-03	6.23E-03	Osprey	1.92E-06		3.24E+03	
W6MS3	DI-N-BUTYLPHTHALATE	3/20	4.96E-03	7.23E-03	Osprey	1.50E-04	1.50E-03	4.82E+01	4.81E+00
West Seep	AL	4/6	2.04E-01	5.22E-01	Osprey	2.37E+00		2.20E-01	

Table 8.15 (continued)

Subbasin	Analyte	Freq. of detection	Mean conc.	Exposure conc.[b]	Receptor	NOAEL	LOAEL	NOAEL_HQ	LOAEL_HQ
West Seep	AS	1/4	1.25E-03	1.84E-03	Osprey	7.13E-01	2.14E+00	2.58E-03	8.60E-04
West Seep	CD	2/5	1.56E-03	2.34E-03	Osprey	5.85E-04	8.06E-03	4.00E+00	2.90E-01
West Seep	CU	1/4	6.25E-03	9.19E-03	Osprey	8.10E-01	1.06E+00	1.13E-02	8.65E-03
WOC	AS	8/61	1.67E-02	1.95E-02	Osprey	7.13E-01	2.14E+00	2.73E-02	9.12E-03
WOC	CD	1/57	1.82E-03	5.00E-05	Osprey	5.85E-04	8.06E-03	8.55E-02	6.20E-03
WOC	CU	18/66	3.56E-03	4.99E-03	Osprey	8.10E-01	1.06E+00	6.16E-03	4.70E-03
WOC	HG	15/56	5.72E-05	7.48E-05	Osprey	1.15E-06	1.15E-05	6.50E+01	6.52E+00
WOC	NI	1/61	6.89E-03	8.79E-03	Osprey	3.64E+00	5.03E+00	2.41E-03	1.74E-03
WOC	PB	1/57	1.71E-02	2.00E-02	Osprey	1.25E-01	1.25E+00	1.60E-01	1.60E-02
WOC	PB	1/57	1.71E-02	2.00E-02	Osprey	4.25E-01		4.71E-02	
WOCE	CD	2/2	1.38E-03	2.40E-03	Osprey	5.85E-04	8.06E-03	4.10E+00	2.98E-01
HF-2	AS	4/10	2.80E-03	3.78E-03	River Otter	1.56E-02	1.56E-01	2.42E-01	2.42E-02
HF-2	BE	2/11	3.26E-04	4.00E-04	River Otter	1.36E-01		2.94E-03	
HF-2	CR	2/11	2.91E-03	5.26E-03	River Otter	3.59E+00	1.44E+01	1.47E-03	3.66E-04
HF-2	CU	7/11	9.55E-03	1.75E-02	River Otter	2.13E-01	2.80E-01	8.22E-02	6.25E-02
HF-2	HG	1/8	7.23E-03	1.34E-01	River Otter	1.58E-06	2.63E-06	8.48E+04	5.10E+04
HF-2	TL	1/9	2.82E-01	4.10E-01	River Otter	8.76E-04	8.76E-03	4.68E+02	4.68E+01
HF-2	ACETONE	1/3	2.67E-03	3.00E-03	River Otter	3.32E+01	1.66E+02	9.04E-05	1.81E-05
HF-2	METHYLENE CHLORIDE	3/3	1.00E-04	1.00E-04	River Otter	3.99E+00	3.41E+01	2.51E-05	2.93E-06
Intermediate Pond	BE	2/13	5.11E-04	5.00E-04	River Otter	1.36E-01		3.68E-03	
Intermediate Pond	CU	7/14	5.32E-03	7.87E-03	River Otter	2.13E-01	2.80E-01	3.69E-02	2.81E-02
Intermediate Pond	TL	1/12	1.72E-01	1.69E-01	River Otter	8.76E-04	8.76E-03	1.93E+02	1.93E+01
Intermediate Pond	ACETONE	3/3	3.00E-03	3.00E-03	River Otter	3.32E+01	1.66E+02	9.04E-05	1.81E-05
Intermediate Pond	CHLOROFORM	3/3	2.00E-03	2.00E-03	River Otter	3.44E+00	9.40E+00	5.81E-04	2.13E-04
Lower WOC	AL	120/149	7.07E-01	9.00E-01	River Otter	1.83E-02	1.83E-01	4.92E+01	4.91E+00
Lower WOC	AS	11/128	1.72E-02	1.40E-02	River Otter	1.56E-02	1.56E-01	8.97E-01	8.95E-02
Lower WOC	BE	10/53	4.65E-04	5.94E-04	River Otter	1.36E-01		4.37E-03	
Lower WOC	CD	3/127	1.73E-03	1.00E-03	River Otter	3.16E-04	3.16E-03	3.16E+00	3.16E-01
Lower WOC	CR	62/142	7.26E-03	9.31E-03	River Otter	3.59E+00	1.44E+01	2.59E-03	6.47E-04
Lower WOC	CU	58/147	5.23E-03	6.19E-03	River Otter	2.13E-01	2.80E-01	2.91E-02	2.21E-02
Lower WOC	HG	33/120	7.97E-05	9.40E-05	River Otter	1.58E-06	2.63E-06	5.95E+01	3.58E+01
Lower WOC	NI	11/141	6.35E-03	6.81E-03	River Otter	1.52E+00	3.05E+00	4.48E-03	2.23E-03
Lower WOC	SB	3/53	1.79E-02	1.91E-02	River Otter	1.61E-01	1.61E+00	1.19E-01	1.19E-02
Lower WOC	SE	1/42	1.07E-02	1.00E-03	River Otter	2.36E-04	3.90E-04	4.24E+00	2.56E+00
Lower WOC	TL	5/50	1.66E-04	7.56E-03	River Otter	8.76E-04	8.76E-03	8.63E+00	8.63E-01
Lower WOC	ACETONE	1/9	2.56E-03	2.66E-03	River Otter	3.32E+01	1.66E+02	8.01E-05	1.60E-05
Lower WOC	CHLOROFORM	5/93	2.27E-03	1.00E-03	River Otter	3.44E+00	9.40E+00	2.91E-04	1.06E-04
Lower WOC	METHYLENE CHLORIDE	5/9	2.09E-04	3.46E-04	River Otter	3.99E+00	3.41E+01	8.67E-05	1.01E-05

Table 8.15 (continued)

Subbasin	Analyte	Freq. of detection	Mean conc.	Exposure conc.[b]	Receptor	NOAEL	LOAEL	NOAEL_HQ	LOAEL_HQ
Lower WOC	TRICHLOROETHENE	2/93	2.35E-03	2.50E-03	River Otter	2.24E-02	2.24E-01	1.12E-01	1.12E-02
MB-15	1,1-DICHLOROETHENE	1/1	5.00E-04	5.00E-04	River Otter	9.29E-01		5.38E-04	
MB-15	METHYLENE CHLORIDE	1/1	2.00E-04	2.00E-04	River Otter	3.99E+00	3.41E+01	5.01E-05	5.87E-06
MB-15	TETRACHLOROETHENE	1/1	7.00E-04	7.00E-04	River Otter	4.80E-02	2.40E-01	1.46E-02	2.92E-03
MB-15	TRICHLOROETHENE	1/1	9.00E-03	9.00E-03	River Otter	2.24E-02	2.24E-01	4.02E-01	4.03E-02
MB-15	VINYL CHLORIDE	1/1	1.50E-02	1.50E-02	River Otter	7.82E-02	7.82E-01	1.92E-01	1.92E-02
SWSA 5 SEEP A	AS	1/8	1.05E-02	5.50E-04	River Otter	1.56E-02	1.56E-01	3.53E-02	3.51E-03
SWSA 5 SEEP A	BE	1/10	4.88E-04	2.80E-04	River Otter	1.36E-01		2.06E-03	
SWSA 5 SEEP A	CR	1/10	2.49E-03	3.00E-03	River Otter	3.59E+00	1.44E+01	8.36E-04	2.08E-04
SWSA 5 SEEP A	CU	1/10	2.11E-03	2.20E-03	River Otter	2.13E-01	2.80E-01	1.03E-02	7.86E-03
SWSA 5 SEEP A	SB	1/9	1.98E-02	1.91E-02	River Otter	1.61E-01	1.61E+00	1.19E-01	1.19E-02
SWSA 5 SEEP A	TL	1/9	1.84E-01	1.68E-01	River Otter	8.76E-04	8.76E-03	1.92E+02	1.92E+01
SWSA 5 SEEP A	ACETONE	1/3	2.00E-03	1.00E-03	River Otter	3.32E+01	1.66E+02	3.01E-05	6.02E-06
SWSA 5 SEEP C	AS	2/3	1.40E-02	2.00E-03	River Otter	1.56E-02	1.56E-01	1.28E-01	1.28E-02
SWSA 5 SEEP C	BE	2/3	2.67E-04	1.90E-04	River Otter	1.36E-01		1.40E-03	
SWSA 5 SEEP C	CU	3/4	3.35E-03	4.90E-03	River Otter	2.13E-01	2.80E-01	2.30E-02	1.75E-02
SWSA 5 SEEP C	NI	1/3	4.37E-03	6.70E-03	River Otter	1.52E+00	3.05E+00	4.41E-03	2.20E-03
SWSA 5 Trib 1	AS	1/2	9.75E-04	1.30E-03	River Otter	1.56E-02	1.56E-01	8.33E-02	8.31E-03
SWSA 5 Trib 1	CR	2/2	3.15E-03	4.10E-03	River Otter	3.59E+00	1.44E+01	1.14E-03	2.85E-04
SWSA 5 Trib 1	NI	1/2	3.45E-03	5.20E-03	River Otter	1.52E+00	3.05E+00	3.42E-03	1.71E-03
SWSA 5 Trib 1	1,1-DICHLOROETHENE	1/2	7.50E-03	1.00E-02	River Otter	9.29E-01		1.08E-02	
SWSA 5 Trib 1	BENZENE	1/2	7.50E-03	1.00E-02	River Otter	2.29E+00	2.29E+01	4.37E-03	4.36E-04
SWSA 5 Trib 1	CARBON TETRACHLORIDE	1/2	7.50E-03	1.00E-02	River Otter	9.13E-01		1.10E-02	
SWSA 5 Trib 1	CHLOROFORM	1/2	7.50E-03	1.00E-02	River Otter	3.44E+00	9.40E+00	2.91E-03	1.06E-03
SWSA 5 Trib 1	METHYLENE CHLORIDE	1/2	7.50E-03	1.00E-02	River Otter	3.99E+00	3.41E+01	2.51E-03	2.93E-04
SWSA 5 Trib 1	TETRACHLOROETHENE	1/2	7.50E-03	1.00E-02	River Otter	4.80E-02	2.40E-01	2.08E-01	4.17E-02
SWSA 5 Trib 1	TOLUENE	1/2	7.50E-03	1.00E-02	River Otter	7.64E-01	7.64E+00	1.31E-02	1.31E-03
SWSA 5 Trib 1	XYLENE (TOTAL)	1/2	3.50E-03	2.00E-03	River Otter	2.79E-02	3.45E-02	7.17E-02	5.79E-02
SWSA 5/WOC	AL	1/2	3.06E+00	6.09E+00	River Otter	1.83E-02	1.83E-01	3.33E+02	3.32E+01
SWSA 5/WOC	CR	1/2	3.63E-03	5.20E-03	River Otter	3.59E+00	1.44E+01	1.45E-03	3.61E-04
SWSA 5/WOC	CU	1/2	7.03E-03	1.26E-02	River Otter	2.13E-01	2.80E-01	5.92E-02	4.50E-02
SWSA 5/WOC	NI	1/2	3.18E-03	4.40E-03	River Otter	1.52E+00	3.05E+00	2.89E-03	1.44E-03
SWSA 5/WOC	SE	1/2	2.15E-03	3.10E-03	River Otter	2.36E-04	3.90E-04	1.31E+01	7.95E+00
SWSA 5/WOC	1,1-DICHLOROETHENE	1/2	7.50E-03	1.00E-02	River Otter	9.29E-01		1.08E-02	
SWSA 5/WOC	BENZENE	1/2	7.50E-03	1.00E-02	River Otter	2.29E+00	2.29E+01	4.37E-03	4.36E-04
SWSA 5/WOC	BIS(2-ETHYLHEXYL)PHTHALATE	1/1	1.00E-03	1.00E-03	River Otter	1.24E-05	1.24E-04	8.06E+01	8.04E+00
SWSA 5/WOC	CARBON TETRACHLORIDE	1/2	7.50E-03	1.00E-02	River Otter	9.13E-01		1.10E-02	
SWSA 5/WOC	CHLOROFORM	1/2	7.50E-03	1.00E-02	River Otter	3.44E+00	9.40E+00	2.91E-03	1.06E-03

Table 8.15 (continued)

Subbasin	Analyte	Freq. of detection	Mean conc.	Exposure conc.[b]	Receptor	NOAEL	LOAEL	NOAEL_HQ	LOAEL_HQ
SWSA 5/WOC	METHYLENE CHLORIDE	1/2	7.50E-03	1.00E-02	River Otter	3.99E+00	3.41E+01	2.51E-03	2.93E-04
SWSA 5/WOC	TETRACHLOROETHENE	1/2	7.50E-03	1.00E-02	River Otter	4.80E-02	2.40E-01	2.08E-01	4.17E-02
SWSA 5/WOC	TOLUENE	1/2	7.50E-03	1.00E-02	River Otter	7.64E-01	7.64E+00	1.31E-02	1.31E-03
SWSA 5/WOC	XYLENE (TOTAL)	1/2	7.50E-03	1.00E-02	River Otter	2.79E-02	3.45E-02	3.58E-01	2.90E-01
SWSA 6 East	AL	2/2	2.65E+00	5.22E+00	River Otter	1.83E-02	1.83E-01	2.85E+02	2.85E+01
SWSA 6 East	AS	1/2	2.95E-03	4.90E-03	River Otter	1.56E-02	1.56E-01	3.14E-01	3.13E-02
SWSA 6 East	CR	1/2	7.60E-03	1.02E-02	River Otter	3.59E+00	1.44E+01	2.84E-03	7.09E-04
SWSA 6 East	HG	1/2	2.00E-04	3.00E-04	River Otter	1.58E-06	2.63E-06	1.90E+02	1.14E+02
SWSA 6 East	METHYLENE CHLORIDE	1/1	5.00E-03	5.00E-03	River Otter	3.99E+00	3.41E+01	1.25E-03	1.47E-04
W6MS1	AL	44/45	2.22E+00	3.56E+00	River Otter	1.83E-02	1.83E-01	1.95E+02	1.94E+01
W6MS1	AS	2/15	1.06E-03	2.99E-03	River Otter	1.56E-02	1.56E-01	1.92E-01	1.91E-02
W6MS1	CD	5/18	2.15E-03	4.07E-03	River Otter	3.16E-04	3.16E-03	1.29E+01	1.29E+00
W6MS1	CR	12/22	1.13E-02	1.40E-02	River Otter	3.59E+00	1.44E+01	3.90E-03	9.71E-04
W6MS1	CU	10/21	1.07E-02	1.45E-02	River Otter	2.13E-01	2.80E-01	6.81E-02	5.18E-02
W6MS1	HG	6/19	1.87E-04	4.06E-04	River Otter	1.58E-06	2.63E-06	2.57E+02	1.55E+02
W6MS1	NI	2/16	1.01E-02	1.24E-02	River Otter	1.52E+00	3.05E+00	8.16E-03	4.05E-03
W6MS1	SB	1/14	1.36E-02	5.00E-03	River Otter	1.61E-01	1.61E+00	3.11E-02	3.11E-03
W6MS1	SE	1/14	1.35E-03	1.69E-03	River Otter	2.36E-04	3.90E-04	7.16E+00	4.34E+00
W6MS1	1,1,1-TRICHLOROETHANE	1/15	2.07E-03	2.00E-03	River Otter	4.94E+01		4.05E-05	
W6MS1	2-BUTANONE	11/19	7.16E-03	8.96E-03	River Otter	4.31E+03	1.11E+04	2.08E-06	8.05E-07
W6MS1	4-METHYL-2-PENTANONE	2/16	1.67E-03	2.07E-02	River Otter	1.87E+01		1.11E-03	
W6MS1	ACETONE	17/21	1.04E-02	1.57E-02	River Otter	3.32E+01	1.66E+02	4.73E-04	9.46E-05
W6MS1	BIS(2-ETHYLHEXYL)PHTHALATE	2/4	6.00E-03	9.19E-03	River Otter	1.24E-05	1.24E-04	7.41E+02	7.39E+01
W6MS1	DI-N-BUTYLPHTHALATE	1/4	4.50E-03	3.00E-03	River Otter	3.48E-01	1.16E+00	8.62E-03	2.59E-03
W6MS1	METHYLENE CHLORIDE	15/19	6.71E-03	8.69E-03	River Otter	3.99E+00	3.41E+01	2.18E-03	2.55E-04
W6MS1	TETRACHLOROETHENE	1/14	2.11E-03	2.52E-03	River Otter	4.80E-02	2.40E-01	5.25E-02	1.05E-02
W6MS1	TOLUENE	1/14	2.25E-03	2.80E-03	River Otter	7.64E-01	7.64E+00	3.66E-03	3.66E-04
W6MS1	TOTAL-1,2-DICHLOROETHENE	3/14	2.32E-03	2.00E-03	River Otter	6.20E+00		3.23E-04	
W6MS1	TRICHLOROETHENE	7/17	3.49E-03	5.45E-03	River Otter	2.24E-02	2.24E-01	2.43E-01	2.44E-02
W6MS3	AL	66/80	2.13E+00	3.56E+00	River Otter	1.83E-02	1.83E-01	1.95E+02	1.94E+01
W6MS3	AS	9/37	1.68E-03	2.19E-03	River Otter	1.56E-02	1.56E-01	1.40E-01	1.40E-02
W6MS3	BE	16/47	1.06E-03	1.25E-03	River Otter	1.36E-01		9.19E-03	
W6MS3	CD	18/45	2.58E-03	2.97E-03	River Otter	3.16E-04	3.16E-03	9.40E+00	9.38E-01
W6MS3	CR	39/60	1.85E-02	2.22E-02	River Otter	3.59E+00	1.44E+01	6.18E-03	1.55E-03
W6MS3	CU	41/63	1.88E-02	2.27E-02	River Otter	2.13E-01	2.80E-01	1.07E-01	8.10E-02
W6MS3	HG	9/35	1.78E-04	2.69E-04	River Otter	1.58E-06	2.63E-06	1.70E+02	1.02E+02
W6MS3	NI	10/39	1.43E-02	2.10E-02	River Otter	1.52E+00	3.05E+00	1.38E-02	6.88E-03
W6MS3	SB	3/31	1.40E-02	5.00E-03	River Otter	1.61E-01	1.61E+00	3.11E-02	3.11E-03

Table 8.15 (continued)

Subbasin	Analyte	Freq. of detection	Mean conc.	Exposure conc.[b]	Receptor	NOAEL	LOAEL	NOAEL_HQ	LOAEL_HQ
W6MS3	1,1-DICHLOROETHENE	3/33	2.30E-03	2.51E-03	River Otter	9.29E-01		2.70E-03	
W6MS3	1,2-DICHLOROETHANE	3/35	2.26E-03	2.00E-03	River Otter	1.36E+01		1.47E-04	
W6MS3	1,4-DIOXANE	1/3	1.01E+00	2.30E-02	River Otter	2.01E+00	4.02E+00	1.14E-02	5.72E-03
W6MS3	2-BUTANONE	41/50	1.06E-02	1.24E-02	River Otter	4.31E+03	1.11E+04	2.88E-06	1.12E-06
W6MS3	4-METHYL-2-PENTANONE	4/34	4.84E-03	5.34E-03	River Otter	1.87E+01		2.86E-04	
W6MS3	ACETONE	35/50	9.42E-03	1.19E-02	River Otter	3.32E+01	1.66E+02	3.58E-04	7.18E-05
W6MS3	BENZENE	4/34	2.26E-03	2.45E-03	River Otter	2.29E+00	2.29E+01	1.07E-03	1.07E-04
W6MS3	BIS(2-ETHYLHEXYL)PHTHALATE	4/20	4.20E-03	6.23E-03	River Otter	1.24E-05	1.24E-04	5.02E+02	5.01E+01
W6MS3	CHLOROFORM	3/35	4.82E-04	5.20E-03	River Otter	3.44E+00	9.40E+00	1.51E-03	5.53E-04
W6MS3	DI-N-BUTYLPHTHALATE	3/20	4.96E-03	7.23E-03	River Otter	3.48E-01	1.16E+00	2.08E-02	6.23E-03
W6MS3	METHYLENE CHLORIDE	38/48	5.77E-03	6.62E-03	River Otter	3.99E+00	3.41E+01	1.66E-03	1.94E-04
W6MS3	TETRACHLOROETHENE	12/39	3.21E-03	7.30E-03	River Otter	4.80E-02	2.40E-01	1.52E-01	3.05E-02
W6MS3	TOLUENE	11/34	2.78E-03	3.14E-03	River Otter	7.64E-01	7.64E+00	4.11E-03	4.12E-04
W6MS3	TOTAL-1,2-DICHLOROETHENE	19/42	7.82E-03	1.44E-02	River Otter	6.20E+00		2.32E-03	
W6MS3	TRICHLOROETHENE	19/43	8.27E-03	2.18E-02	River Otter	2.24E-02	2.24E-01	9.73E-01	9.74E-02
W6MS3	VINYL CHLORIDE	5/33	4.77E-03	5.43E-03	River Otter	7.82E-02	7.82E-01	6.94E-02	6.94E-03
West Seep	AL	4/6	2.04E-01	5.22E-01	River Otter	1.83E-02	1.83E-01	2.85E+01	2.85E+00
West Seep	AS	1/4	1.25E-03	1.84E-03	River Otter	1.56E-02	1.56E-01	1.18E-01	1.17E-02
West Seep	BE	1/4	6.25E-04	9.19E-04	River Otter	1.36E-01		6.76E-03	
West Seep	CD	2/5	1.56E-03	2.34E-03	River Otter	3.16E-04	3.16E-03	7.41E+00	7.40E-01
West Seep	CR	2/4	9.25E-03	1.40E-02	River Otter	3.59E+00	1.44E+01	3.90E-03	9.73E-04
West Seep	CU	1/4	6.25E-03	9.19E-03	River Otter	2.13E-01	2.80E-01	4.31E-02	3.28E-02
West Seep	2-BUTANONE	2/4	5.00E-03	5.00E-03	River Otter	4.31E+03	1.11E+04	1.16E-06	4.50E-07
West Seep	ACETONE	3/4	1.55E-02	3.49E-02	River Otter	3.32E+01	1.66E+02	1.05E-03	2.10E-04
West Seep	METHYLENE CHLORIDE	3/4	3.63E-03	5.00E-03	River Otter	3.99E+00	3.41E+01	1.25E-03	1.47E-04
West Seep	TOLUENE	2/4	3.75E-03	5.00E-03	River Otter	7.64E-01	7.64E+00	6.54E-03	6.55E-04
West Seep	TRICHLOROETHENE	1/4	2.38E-03	2.00E-03	River Otter	2.24E-02	2.24E-01	8.93E-02	8.94E-03
WOC	AS	8/61	1.67E-02	1.95E-02	River Otter	1.56E-02	1.56E-01	1.25E+00	1.25E-01
WOC	BE	5/20	3.89E-04	5.00E-04	River Otter	1.36E-01		3.68E-03	
WOC	CD	1/57	1.82E-03	5.00E-05	River Otter	3.16E-04	3.16E-03	1.58E-01	1.58E-02
WOC	CR	16/61	2.66E-03	4.26E-03	River Otter	3.59E+00	1.44E+01	1.19E-03	2.96E-04
WOC	CU	18/66	3.56E-03	4.99E-03	River Otter	2.13E-01	2.80E-01	2.34E-02	1.78E-02
WOC	HG	15/56	5.72E-05	7.48E-05	River Otter	1.58E-06	2.63E-06	4.73E+01	2.85E+01
WOC	NI	1/61	6.89E-03	8.79E-03	River Otter	1.52E+00	3.05E+00	5.78E-03	2.88E-03
WOC	PB	1/57	1.71E-02	2.00E-02	River Otter	7.11E-01	7.11E+00	2.81E-02	2.81E-03
WOC	SB	4/22	1.80E-02	2.18E-02	River Otter	1.61E-01	1.61E+00	1.35E-01	1.36E-02
WOC	TL	5/20	6.58E-03	6.09E-02	River Otter	8.76E-04	8.76E-03	6.95E+01	6.95E+00
WOC	ACETONE	1/4	3.13E-03	4.60E-03	River Otter	3.32E+01	1.66E+02	1.39E-04	2.77E-05

Table 8.15 (continued)

Subbasin	Analyte	Freq. of detection	Mean conc.	Exposure conc.[b]	Receptor	NOAEL	LOAEL	NOAEL_HQ	LOAEL_HQ
WOC	CHLOROFORM	36/47	1.87E-03	2.02E-03	River Otter	3.44E+00	9.40E+00	5.87E-04	2.15E-04
WOC	METHYLENE CHLORIDE	3/5	2.20E-04	3.00E-04	River Otter	3.99E+00	3.41E+01	7.52E-05	8.80E-06
WOCE	CD	2/2	1.38E-03	2.40E-03	River Otter	3.16E-04	3.16E-03	7.59E+00	7.59E-01
WOCE	CR	1/2	7.45E-03	1.00E-02	River Otter	3.59E+00	1.44E+01	2.79E-03	6.95E-04

Note: Only analytes with a NOAEL or a LOAEL and detected concentrations above background (or with no background value available) are included in the table.

[a] Piscivore NOAELs and LOAELs were obtained from Sample et al. (1996).

[b] The exposure concentration used was the minimum of the UCL95 and the maximum detected concentration.

Table 8.16. Contaminant concentrations (mg/kg) found in Kingfisher egg shells on the ORR

Matrix	Burrow [a]	As	Cd	Se	Pb	Hg	^{60}Co (pCi/g)	^{137}Cs (pCi/g)
egg shell	CRD	0.135	< 0.0333[b]	1.58	2.0	< 0.020	< 7.45	< 9.09
egg shell	WOC	0.0536	0.0583	1.41	5.31	0.182	< 1.89	58.1

[a] CRD = Clinch River downstream of WOL Embayment; WOC = White Oak Creek downstream of WCK 3.5; CRU = Clinch River upstream of Oak Ridge Reservation.

[b] Less than values are below minimum detection limit.

Table 8.17. Contaminant concentrations in tissues of the three kingfishers found on the ORR

Bird No.	Watershed and Location	Organ	^{137}Cs (pCi/g)	Cd (mg/kg)[a]	Pb (mg/kg)a	Se (mg/kg)	Hg (mg/kg)
1	East Fork Poplar Creek, Lake Reality	whole body	<2				
		feathers		ND	2.67	5.38	13.9
		kidney		4.04	ND	5.81	8.65
		liver		0.95	ND	2.71	3.69
		heart		ND	ND	1.25	1.1
		muscle		ND	ND	ND	0.572
2	East Fork Poplar Creek	feathers		7.21	1.86	5.63	4.55
		kidney		0.40	ND	3.14	1.46
		liver		0.23	ND	3.45	0.955
		heart		ND	ND	2.01	0.594
		muscle	3	ND	ND	1.04	0.805
3	White Oak Creek, Bldg. 4505	whole body	91.27				
		feathers		0.34	4.88	7.29	2.72
		kidney	69	1.53	0.42	6.01	26.8
		liver	76	0.90	0.40	7.5	17.6
		heart	81	ND	ND	2.2	9.52
		muscle	151	ND	0.58	1.84	6.34

[a]ND= Nondetect: As- <0.40 mg/kg, Cd- <0.20 mg/kg, Pb- <0.40 mg/kg, and Se-<0.40 mg/kg.

Table 8.18. Summary of number of locations where HQs>1 were observed

Watershed	Endpoint	Analyte	No. locations where NOAEL-based HQ>1	No. locations where LOAEL-based HQ>1
Bear Creek	Mink	Hg	2	0
		PCBs	2	0
	River Otter	Hg	4	3
		PCBs	4	1
	Kingfisher	Hg	5	3
		PCBs	5	1
	Heron	Hg	5	0
		PCBs	3	0
East Fork Poplar Creek	Mink	Hg	7	6
		PCBs	3	1
	Otter	Hg	7	7
		PCBs	6	2
	Kingfisher	Hg	7	7
		PCBs	7	3
	Heron	Hg	7	6
		PCBs	5	1
K-25	Mink	Hg	9	1
		PCBs	7	0
	Otter	Hg	13	11
		PCBs	15	5
	Kingfisher	Hg	16	10
		PCBs	14	4
	Heron	Hg	16	0
		PCBs	13	0
	Osprey	Hg	16	3
		PCBs	14	1
White Oak Creek	Mink	Hg	1	0
		PCBs	3	0

Table 8.18. (continued)

Watershed	Endpoint	Analyte	No. locations where NOAEL-based HQ>1	No. locations where LOAEL-based HQ>1
	Otter	Hg	7	3
		PCBs	6	3
	Kingfisher	Hg	7	3
		PCBs	7	1
	Heron	Hg	7	0
		PCBs	5	0
	Osprey	Hg	2	0
		PCBs	3	0

Table 8.19. Summary of number of individuals of piscivore endpoint species estimated to be experiencing adverse effects by watershed and for the ORR

Location	Analyte	Species	%> LOAEL	Number in Watershed	Number Adversely Affected	Percent Adversely Affected
Bear Creek	Mercury	Mink	<5%	7	0	0%
East Fork Poplar Creek	Mercury	Mink	80%	15	12	80%
K-25	Mercury	Mink	<5%	14	0	0%
White Oak Creek	Mercury	Mink	<5%	4	0	0%
ORR-wide	Mercury	Mink		40	12	30%
Bear Creek	Mercury	Otter	50%	5	2	40%
East Fork Poplar Creek	Mercury	Otter	>95%	9	9	100%
K-25	Mercury	Otter	>95%	9	9	100%
White Oak Creek	Mercury	Otter	25%	2	0	0%
ORR-wide	Mercury	Otter		25	20	80%
Bear Creek	Mercury	Kingfisher	65-70%	5	3	60%
East Fork Poplar Creek	Mercury	Kingfisher	>95%	10	10	100%
K-25	Mercury	Kingfisher	>95%	9	9	100%
White Oak Creek	Mercury	Kingfisher	15%	3	0	0%
ORR-wide	Mercury	Kingfisher		27	22	81.5%
Bear Creek	Mercury	Heron	<5%	29	0	0%
East Fork Poplar Creek	Mercury	Heron	>95%	57	57	100%
K-25	Mercury	Heron	<5%	54	0	0%
White Oak Creek	Mercury	Heron	<5%	15	0	0%
ORR-wide	Mercury	Heron		155	57	36.8%
K-25	Mercury	Osprey	<5%		0	0%
White Oak Creek	Mercury	Osprey	<5%		0	0%
Bear Creek	PCBs	Mink	<5%	7	0	0%
East Fork Poplar Creek	PCBs	Mink	<5%	15	0	0%
K-25	PCBs	Mink	<5%	14	0	0%

Table 8.19. (continued)

Location	Analyte	Species	%> LOAEL	Number in Watershed	Number Adversely Affected	Percent Adversely Affected
White Oak Creek	PCBs	Mink	<5%	4	0	0%
ORR-wide	PCBs	Mink		40	0	0%
Bear Creek	PCBs	Otter	<5%	5	0	0%
East Fork Poplar Creek	PCBs	Otter	15-20%	9	1	11%
K-25	PCBs	Otter	5-10%	9	0	0%
White Oak Creek	PCBs	Otter	70-75%	2	1	50%
ORR-wide	PCBs	Otter		25	2	8%
Bear Creek	PCBs	Kingfisher	<5%	5	0	0%
East Fork Poplar Creek	PCBs	Kingfisher	10-15%	10	0	0%
K-25	PCBs	Kingfisher	<5%	9	0	0%
White Oak Creek	PCBs	Kingfisher	<5%	3	0	0%
ORR-wide	PCBs	Kingfisher		27	0	0%
Bear Creek	PCBs	Heron	<5%	29	0	0%
East Fork Poplar Creek	PCBs	Heron	<5%	57	0	0%
K-25	PCBs	Heron	<5%	54	0	0%
White Oak Creek	PCBs	Heron	<5%	15	0	0%
ORR-wide	PCBs	Heron		155	0	0%
K-25	PCBs	Osprey	<5%		0	0%
White Oak Creek	PCBs	Osprey	<5%		0	0%

Table 8.20. Simulation of exposure of mink to mercury and PCBs in toxicity test diets

Diet	Analyte	Concentration in diet				Distribution used in simulation	Modeled exposure (mg/kg-d)		
		Mean	STD	Min	Max		Mean	STD	80th percentile
A	Mercury	0.02	0	0.02	0.03	Triangular	0.0034	0.0009	0.0042
B	Mercury	0.05	0	0.04	0.06	Triangular	0.0074	0.0019	0.0088
C	Mercury	0.09	0	0.08	0.11	Triangular	0.0138	0.0035	0.016
D	Mercury	0.15	0.01			Normal	0.022	0.0059	0.026
E	Mercury	0.22	0.01			Normal	0.033	0.008	0.038
A	PCB 1260	0.169	0.002			Normal	0.025	0.0063	0.029
B	PCB 1260	11.44	0.327			Normal	1.70	0.43	1.97
C	PCB 1260	4.697	0.174			Normal	0.698	0.18	0.82
D	PCB 1260	10.41	0.25			Normal	1.54	0.39	1.79
E	PCB 1260	20.67	0.458			Normal	3.07	0.77	3.55

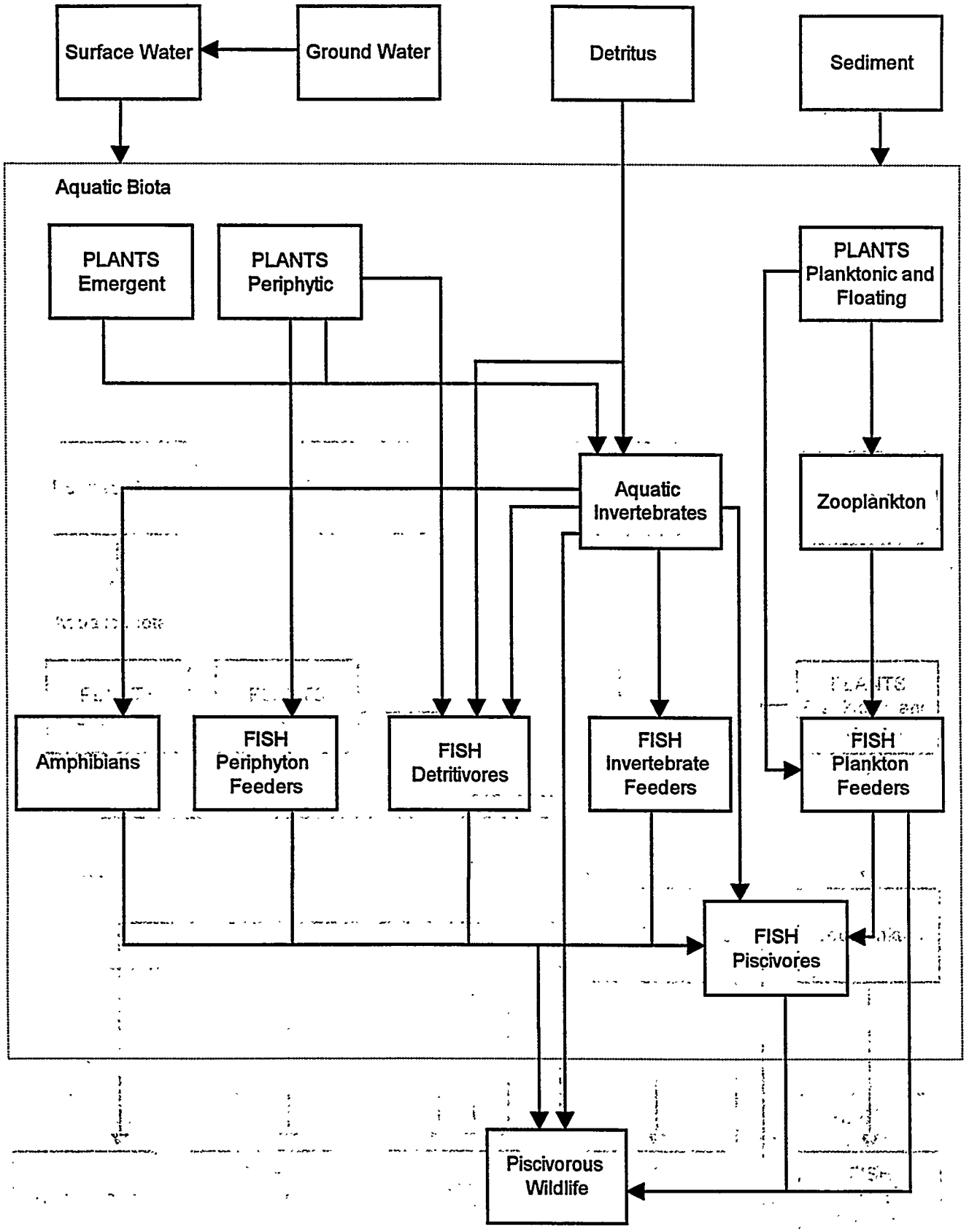

Figure 8.1 **Conceptual model of the mechanisms by which piscivorous wildlife are exposed to contamiants in the White Oak Creek watershed.**

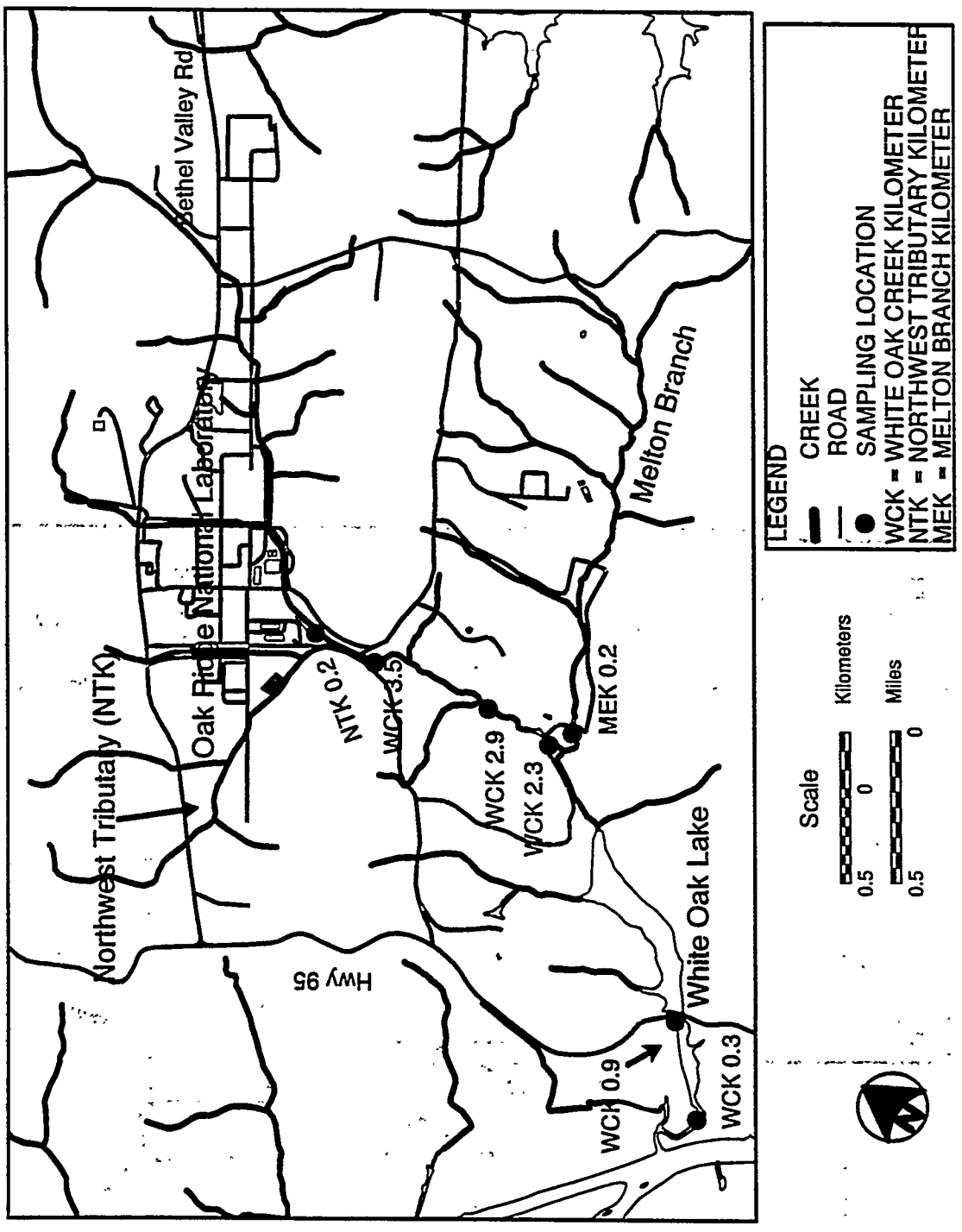

Figure 8.2 Fish sampling locations within the White Oak Creek watershed

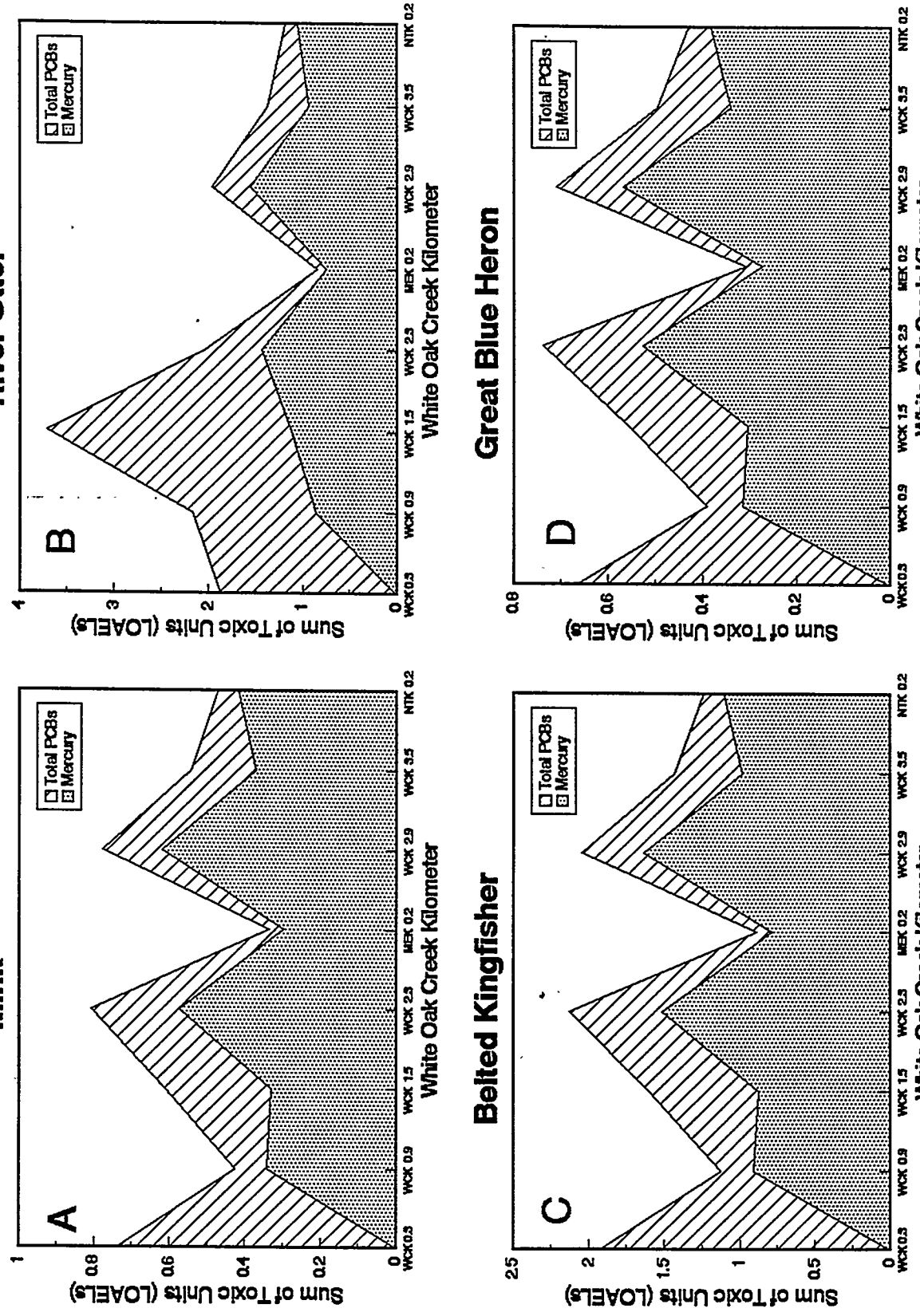

Figure 8.3 Summary of LOAEL-based toxic units for piscivorous wildlife in the White Oak Creek watershed.

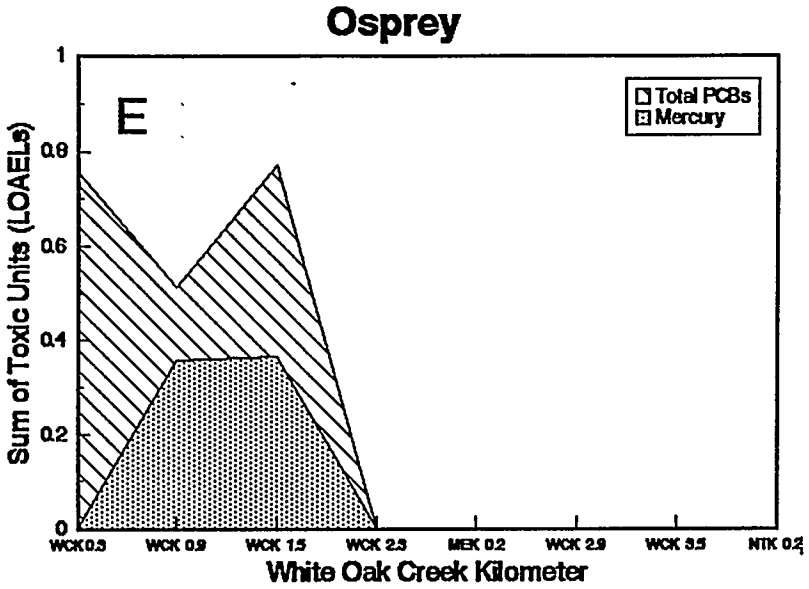

Figure 8.3 (cont.) **Summary of LOAEL-based toxic units for piscivorous wildlife in the White Oak Creek watershed.**

9. RISKS TO ECOLOGICAL RECEPTORS FROM EXPOSURE TO RADIONUCLIDES

Aquatic and terrestrial organisms may be exposed to radionuclides via internal exposures after ingestion of contaminated food, soil, or water or via external exposures to contaminated media (surface soil, surface water, sediment). An assessment of the total radiation dose received from internal and external exposures was conducted for aquatic organisms, piscivorous wildlife, and terrestrial biota. In the assessment it is assumed that all parts of an organism are exposed equally to radionuclide energies. While ecological receptors are exposed to radiation from natural sources, doses were only quantified for radiation from nuclides detected in the WOCW. This section discusses the potential risks to terrestrial and aquatic biota (fish, aquatic macroinvertebrates, soil invertebrates, plants, terrestrial wildlife, and piscivorous wildlife) from current exposure to radionuclides in surface soil, surface water, and sediment collected from subbasins within the WOCW.

9.1 EXPOSURE ASSESSMENT

Native biota may receive external radiation exposure from radionuclides in water, soil, and sediment. Organisms also receive internal radiation exposure from radionuclides ingested via food and water and from radionuclides absorbed through the skin and respiratory organs (Templeton et al. 1971, IAEA 1976, Blaylock and Trabalka 1978, Woodhead 1984). Evaluation of the resulting radiation doses received by biota requires quantitative information on the radionuclides to which they are exposed. In all cases, the radiation source must be known in terms of the quantity of each specific radionuclide and the corresponding energy released per disintegration. Factors to correct for specific conditions that may effect exposures are applied when appropriate.

Radiation dose rates (mrad/d) from radionuclide exposures were calculated for plants, earthworms, and representative terrestrial and semiaquatic wildlife species in the White Oak Creek watershed using methodology adapted from Blaylock et al. (1993) and Baker and Soldat (1992). The methodology was modified to address site-specific conditions and receptors. Dose rates from internal exposures via ingestion of food and soil and inhalation of dust were evaluated, as were dose rates from external exposures via soil. Dose rates for large aquatic invertebrates and large fish were calculated using the methodology described in Blaylock et al. (1993).

The representative terrestrial and semiaquatic wildlife selected as endpoints for the radiological assessment were the same as those for the chemical data assessment: short-tailed shrew, white-footed mouse, red fox, white-tailed deer, red-tailed hawk, wild turkey, river otter, mink, great blue heron, mink, osprey, and belted kingfisher (refer to Sect. 7 and 8). Life history parameters used in the radiological assessment were identical to those used for the chemical data assessment (Tables 7.2 through 7.8 and 8.1 through 8.4). In addition, it was necessary to assume species-specific values for fraction of time spent above and below ground, underwater, or at the water's surface (Table 9.1). Mink were assumed to spend 50% of their time above ground, 20% below ground (in burrows), 20% swimming at the water's surface, and, conservatively, 10% of their time immersed in water. Otter were assumed to split time equally above and below ground, immersed in water, and at the water's surface. Kingfishers were assumed to split their time equally among perching above water or soil and roosting in burrows. The short-tailed shrew, white-footed mouse, and red fox were all assumed to spend 75% of their time above ground and 25% below the soil surface in dens or burrows. White-tailed deer and wild turkey spend 100% of their time above ground and were assigned a value

of 1. Red-tailed hawks and osprey also spend 100% of their time above ground, but much of this is flying or perched high in trees; thus, it was assumed that they would only be exposed to external radiation 10% of the time. Great blue herons were assumed to spend 50% of their time exposed to surface soil, 25% exposed to the water's surface, and 25% wading in water.

9.1.1 Exposure models

Biotic receptors may receive both external and internal doses of radiation. Internal exposures are a result of ingestion of contaminated food, soil, or water or inhalation of contaminated soil. Receptors on the ground surface receive external exposures from contaminated surface soil via direct radiation. Both above-ground and below-ground exposures are possible, depending on the habits of the receptor. Baker and Soldat (1992) provide general equations for estimating dose rates to wildlife. An adaptation of Blaylock et al.'s (1993) methodology was used in estimating radiation dose rates in the RI for Waste Area Grouping 5 at Oak Ridge National Laboratory (DOE 1995a). The Blaylock et al. methodology was further modified for the current assessment to account for the availability of site-specific uptake and biota data. The general methodology and the equations specific to each exposure route used in estimation of dose rates for White Oak Creek biota are described in this subsection. Equations used in this assessment estimate the daily dose from current conditions. Dose from α, β, and γ emissions (only β and γ for external exposures of earthworms and plants and only γ for external exposures of wildlife receptors) were calculated for each radionuclide, including the dose rates from all short-lived daughter products. Dose from each radionuclide was then summed over all exposure routes and all radionuclides to arrive at the overall dose received for each receptor at each site.

9.1.1.1 Plants, soil invertebrates, and terrestrial and piscivorous wildlife

External exposures: direct radiation from soil

The equation for estimating above ground external dose rates (mrad/d) for terrestrial receptors exposed to contaminated soil uses dose coefficients published by Eckerman and Ryman (1993). Dose rate reduction factors are used to account for the fraction of time the receptor spends above ground. Dose coefficients assume the source region is a smooth plane (Eckerman and Ryman 1993), but this is rarely the case in a terrestrial habitat. A representative average dose reduction factor for ground roughness is 0.7 (Eckerman and Ryman 1993). For the shrew, mouse, and mink, all relatively small mammals which are effectively much closer than 1 m to the source, an elevation correction factor of 2 was applied to account for the increased dose expected at ground level relative to the effective height of a standard human used to derive the dose coefficients. For plants it was assumed that the dose represents that to the reproductive part of the plant with an effective height similar to that of the standard human. The equation for above ground dose from external exposures for a plant or wildlife receptor is written:

Above soil exposures:

$$D_{abovegrd} = F_{above} \; F_{ruf} \sum C_{soil,i} \; DF_{grd,i} \; CFb \; ECF \qquad (5)$$

where:

$D_{above\ grd}$ = External dose rate to receptor from above-ground exposures to contaminated soil (mrad/d)

F_{above}	=	Dose rate reduction factor accounting for the fraction of time the receptor spends above ground (unitless)
F_{ruf}	=	Dose rate reduction factor accounting for ground roughness (unitless). Representative average of 0.7 (Eckerman and Ryman 1993) used for this assessment.
$C_{soil,i}$	=	Activity of radionuclide *i* in surface soil (pCi/g)
$DF_{grd,i}$	=	Dose coefficient for radionuclide *i* in soil contaminated to depth of 15 cm (Table III.6, Eckerman and Ryman 1993) (Sv/s per Bq/m^3)
CFb	=	Conversion factor to change Sv/s per Bq/m^3 to mrad g/pCi d. Equals 5.12×10^{14}.
ECF	=	Elevation correction factor to adjust dose coefficients to value representative of effective height of animal above ground.

Dose from alpha radiation is not a concern for external sources, as alpha radiation lacks penetrating power. The effective dose coefficients from Eckerman and Ryman (1993) incorporate both high energy β and γ emissions. Radionuclide-specific parameters are provided in Table 9.2. The lower of the UCL95 and the maximum detected concentration in surface soil within a subbasin were used in estimating the dose from external exposures. Summary statistics for surface soil collected from the White Oak Creek watershed are provided in Appendix A.

Below-ground exposures are calculated assuming immersion in a continuous soil medium. Dose coefficients were unavailable for the immersion scenario, so exposures were modeled as dose to soil adjusted for absorption by a small volume of tissue. The exposure fraction reflects the fraction of time the receptor spends below ground. Because white-tailed deer, red-tailed hawks, wild turkey, osprey, and great blue heron do not go below ground, they do not receive a dose via this exposure route. Only γ radiations with energies greater than 0.01 MeV were evaluated for wildlife receptors as those with lower energies are unlikely to penetrate skin. Both β and γ radiations were evaluated for earthworms. The equation for below-ground external exposures of earthworms and wildlife receptors is written:

Below-ground exposures:

$$D_{belowgrd} = 1.05 \quad F_{below} \sum C_{soil,i} \quad \epsilon_i \quad CFa \qquad (6)$$

where:

$D_{below\ grd}$	=	External dose rate to earthworm or wildlife receptor in burrow from contaminated soil (mrad/d)
F_{below}	=	Dose rate reduction factor accounting for the fraction of time the receptor spends below ground (unitless)
$C_{soil,\ i}$	=	Activity of radionuclide *i* in surface soil (pCi/g)
ϵ_i	=	Energy for γ emissions by nuclide *i* (MeV/nt).
1.05	=	Conversion factor to account for immersion in soil vs water (Estimated value; Keith Eckerman, Health Sciences Research Division, Oak Ridge National Laboratory, personal communication, June 1996)
CFa	=	Conversion factor to go from MeV/nt to g mrad/pCi d. (5.12×10^{-2})

External Exposures: Direct radiation from water

The equation for estimating external dose rates (mrad/d) for wildlife receptors exposed to radionuclides in water uses dose coefficients published by Eckerman and Ryman (1993) and is similar to the equation used for soil. Dose rate reduction factors are used to account for the fraction of time the receptor spends underwater or at the water's surface. The equation for dose from external exposures for a wildlife receptor immersed in water is written:

Underwater exposures:

$$_{underwater} = F_{underwater} \sum C_{water,i} \frac{1}{WD} DF_{water,i} CF \quad (7)$$

where:

$D_{underwater}$	=	External dose rate to receptor from underwater exposures (mrad/d)
$F_{underwater}$	=	Dose rate reduction factor accounting for the fraction of time the receptor spends underwater (unitless)
$C_{water,i}$	=	Activity of radionuclide *i* in water (pCi/L)
WD	=	Density of water (1000 g/L)
$DF_{water,i}$	=	Dose coefficient for radionuclide *i* for organism immersed in water (Eckerman and Ryman 1993) (Sv m^3/Bq s)
CFw	=	Conversion factor to change Sv m^3/Bq s to mrad g/pCi d. Equals 3.20 x 10^{14}.

Dose from alpha radiation is not a concern for external sources, as alpha radiation lacks penetrating power. The effective dose coefficients from Eckerman and Ryman (1993) incorporate both high energy β and γ emissions. Radionuclide-specific parameters are provided in Table 9.3. The mink and otter are the only representative wildlife species likely to spend significant time underwater.

Exposures at the water surface are calculated similarly. However, the exposure fraction is adjusted to reflect the fraction of time the receptor spends at the water surface. Because organisms at the water's surface are exposed from below instead of from above and below, a dose reduction factor of 0.5 is applied. Mink were assumed to spend 20% of their time swimming at the water surface, otters 25%. Herons were assumed to spend 25% of their time standing at the water's edge; kingfishers were assumed to spend 33% of their time perched close to the water surface; and osprey were assumed to spend 10% of their time near the water surface. Other receptors were not expected to spend significant time in water, so external water exposures were not addressed. The equation for external exposures at the water surface is written:

Water surface exposures:

$$_{surface} = F_{surface} \; 0.5 \sum C_{water,i} \frac{1}{WD} DF_{water,i} CF \quad (8)$$

where:

$D_{surface}$	=	External dose rate to receptor from exposures at the water surface (mrad/d)

$F_{surface}$	=	Dose rate reduction factor accounting for the fraction of time the receptor spends at the water surface (unitless)
0.5	=	Dose reduction factor to account for the difference between being immersed in water and being at the water surface (unitless).

All other parameters are the same as those defined for underwater exposures (see Eq. 3).

Internal exposures: ingestion

Wildlife receptors may receive internal radiation doses after ingesting contaminated prey, soil, or water or after inhaling contaminated dust. Blaylock et al. (1993) provide an equation for estimating the internal dose to fish contaminated with radionuclides. This equation can be modified to address consumers eating a variety of prey types, ingesting soil, and drinking water as well as plants and invertebrates taking up contaminants directly from the soil:

$$D_{ing} = \sum QF \; C_{tissue} \; \epsilon_i \; CFa \; AF \qquad (9)$$

where:

D_{ing}	=	Internal dose rate received after ingestion of contaminated prey and soil (mrad/d).
QF	=	Quality factor to account for the greater biological effectiveness of α particles. (20 for α; 1 for β and γ emissions; unitless).
C_{tissue}	=	Activity (pCi/g) of radionuclide *i* in tissue of organism.
ϵ_i	=	Energy for α, β, or γ emissions by nuclide *i* (MeV/nt).
CFa	=	Conversion factor to go from MeV/nt to g mrad/pCi d. (5.12×10^{-2})
AF	=	Absorption factor (unitless)

Radionuclide activity in tissue was determined a number of ways depending on data availability. Measured plant, earthworm, and small mammal data were unavailable. ORR-specific soil-to-tissue uptake factors were available for a number of analytes. When they were available, tissue concentrations were calculated as discussed in Sect. 7.1. When soil-to-tissue uptake factors were unavailable for wildlife receptors, literature-derived uptake factors were used to obtain terrestrial biota tissue concentrations (see Sect. 7.1). Concentrations in fish were estimated by multiplying water concentrations by fish bioconcentration factors obtained from Blaylock et al. (1993).

ORR-specific uptake factors for plants, earthworms, and small mammals were available for a number of radionuclides and were used in the assessment. When site-specific uptake factors were unavailable for specific radionuclides, values were derived from those for related isotopes with measured values, from measured values of the elemental form of the radionuclide, or from available literature sources. Uptake factors used in this assessment are provided in Table 9.3 and 9.4. It was assumed that uptake of radionuclides from ingested food, water, and soil was similar.

Absorbed energy fractions for α radiations were assumed unity for all receptors. Absorption fractions for β radiations were assumed unity for wildlife receptors, but β absorption fractions for large insects from Blaylock et al. (1993) were used for plants (assuming small reproductive parts of greatest concern) and earthworms. Absorption fractions for γ radiations for plants and earthworms were also obtained from those for large insects presented in Blaylock et al. (1993). Absorption fractions for γ radiations derived for infant, 1 yr-old, and adult humans using the methodology

described in Cristy and Eckerman (1987) were used for wildlife receptors of similar sizes. Tables 9.2 and 9.3 present absorption factors used for each receptor-radionuclide combination evaluated in this report.

Dose from internal exposures was calculated for α, β, and γ energies of each radionuclide. Energies were obtained from Eckerman and Ryman (1993) and are provided in Tables 9.2 and 9.3 for radionuclides detected in surface soil and surface water, respectively. Because different types of radiation differ in their relative biological effectiveness per unit of absorbed dose, a quality factor derived from data on humans is normally applied (NCRP 1987). A quality factor of 1 is used for β and γ radiation and 20 for α radiation (Blaylock et al. 1993).

The lower of the UCL95 and the maximum detected concentration in surface soil collected from the WOCW was used in estimating dose rates from internal exposures within each subbasin. Summary statistics for surface soil collected from the WOCW are provided in Appendix A.

Internal exposures: inhalation

Wildlife species using burrows receive an additional internal dose from inhalation of dust originating from contaminated soil. Intake of radionuclide *i* by inhalation is estimated as (DOE 1995b):

$$D_{inh} = QF \; F_{below} \sum C_{soil,i} \; A \; \frac{1}{AD} \; \epsilon_i \; CFa \; AF \qquad \textbf{(10)}$$

where:

D_{inh}	=	Internal dose rate from inhalation of contaminated soil (mrad/d)
F_{exp}	=	Dose reduction factor for fraction of time receptor spends below ground (unitless)
A	=	Mass of respirable dust per volume of air breathed (0.1 g/m^3; DOE 1995b)
AD	=	Air density (1200 g/m^3; Eckerman and Ryman 1993)
ϵ_i	=	α, β, or γ radiation energies for radionuclide *i* (MeV)
CFa	=	Conversion factor to go from MeV to mrad g/pCi/d (5.12 x 10^{-2})
AF	=	Absorption factor (unitless)

Healy (1980) suggests that 0.0001 g/m^3 would be a conservative value when addressing human exposures to dust. Because burrowing animals are likely to spend a greater portion of their time in a confined space (burrow) than humans and are physically closer to the soil surface, an air mass loading of 0.1 g/m^3 was selected as a conservative estimate of the mass of respirable dust (A) to which these animals may be exposed.

Total internal exposures are obtained by adding ingestion and inhalation dose rates over all radionuclides, including all short-lived daughter products.

9.1.1.2 Aquatic organisms

The Point Source Dose Distribution approach presented in Blaylock et al. (1993) was used to estimate doses to aquatic organisms. Aquatic organisms representing two geometries (large aquatic invertebrate and large fish) were evaluated for each site. The equations used to estimate α, β, and γ radiation doses to aquatic organisms were obtained from Blaylock et al. (1993) and are provided

in Table 9.5. Internal exposures were estimated using the activity in tissue of each organism. Organism tissue concentrations were calculated by multiplying water-to-fish tissue bioconcentration factors provided in Blaylock et al. (1993) by surface water concentrations. External exposures to radionuclides in surface water and sediment were estimated separately using surface water or sediment activity levels, respectively. In estimating external exposures from sediment, it was assumed that sediment-associated invertebrates spend 100% of their time at the sediment-water interface while fish spend 50% of their time at this interface. The average energy of decay for α, β, and γ particles emitted by each radionuclide were obtained from ICRP (1983) and are presented in Table 9.3. Transfer factors used in estimation of radiation doses are presented in Table 9.3. Dose estimates for α, β, and γ radiation were summed for each radionuclide to obtain the total dose from that radionuclide. Total doses from all radionuclides detected at a site were then summed to obtain the overall dose rate for each receptor type at each site.

Summary statistics for surface water data collected from the WOCW are provided in Appendix A. Radionuclide exposures were determined for mainstem and seep surface water data summarized by subbasin. The 95% upper confidence limit on the mean was considered an appropriately conservative estimate of exposure and was used in dose rate calculations.

9.2 EFFECTS LEVELS FOR RADIONUCLIDES

The discharge of radioactive waste into the environment results in long-term, low-dose exposure to organisms. In most cases, acute mortality can be discounted. Any potential increase in morbidity and mortality that might result from the exposure to chronic irradiation above background is unlikely to be detected because of natural fluctuations in the size of populations.

The International Atomic Energy Agency (IAEA) recommends limiting the dose for terrestrial organisms to 100 mrad/d (IAEA 1992). Studies evaluating reproductive success and survival were used to determine the dose limit. Species-specific effects data were not available, so 100 mrad/d was selected as the threshold dose for all representative wildlife receptors. A dose rate of this magnitude is unlikely to cause observable changes in terrestrial animal populations (IAEA 1992). Higher dose rates may result in impaired reproduction or reduced survivorship. A dose rate of 1 rad/d is generally considered protective of plant and invertebrate populations (IAEA 1992, Barnthouse 1995) based on studies of productivity and community characteristics. This dose rate or less is unlikely to cause observable changes in terrestrial plant populations (IAEA 1992). Higher dose rates may result in reduced productivity or changes in species composition within communities. Therefore, 1 rad/d was selected as the threshold dose for effects on plant and invertebrate populations. Invertebrates tend to be less radiosensitive than plants or animals, and indirect responses to radiation-induced vegetation changes appear more critical than direct effects from radiation (IAEA 1992).

Blaylock et al. (1993) summarize reviews of the effects of radiation on aquatic organisms. DOE recommends limiting the radiation dose to aquatic biota to 1 rad/d (Blaylock et al. 1993). The recommended acceptable dose rate to natural populations of aquatic biota is 1 rad/d (NCRP 1991). If the dose rate to aquatic organisms is less than the recommended level, there should be no detrimental effects from radiation exposure at the population level (Blaylock et al. 1993).

9.3 RISK CHARACTERIZATION FOR BIOTA EXPOSED TO RADIONUCLIDES

Risk characterization integrates the results of the exposure assessment (Sect. 9.1) and the effects assessment (Sect. 9.2) to estimate the likelihood of effects based on exposures. Generally a weight-of-evidence approach is used to determine the best estimate of risk to each assessment endpoint. Only a single line of evidence, comparison of estimated exposures to recommended dose rate limits, was available for the radionuclide assessment. Current exposures to radionuclides in floodplain soils along White Oak Creek and in surface water and sediment of White Oak Creek and its tributaries are evaluated in this assessment.

Monte Carlo simulations of radionuclide exposures were not performed; therefore, all results represent point estimates of exposures. Computational limitations associated with defining and drawing from distributions of all radionuclides detected within a subbasin for multiple subbasins prevented evaluation of watershed-wide exposures. However, the effects levels to which estimated dose rates are compared are already interpreted as population-level effects (IAEA 1992).

Estimated dose rates are provided in Tables 9.6a-c for terrestrial biota, Table 9.7 for piscivorous wildlife, and Tables 9.8 (surface water) and 9.9 (sediment) for aquatic biota within each subbasin. The East Seep subbasin resulted in the highest dose rates to terrestrial biota with ^{137}Cs accounting for nearly all of the dose rate (Table 9.10). The Intermediate Pond, MB-15, West Seep, SWSA 4 Main, and Lower WOC/WOL subbasins also resulted in high dose rates with risk drivers including combinations of $^{239/240}Pu$, ^{241}Am, ^{137}Cs, $^{233/234}U$, ^{238}U, ^{60}Co, and ^{238}Pu (Table 9.10). Only one subbasin, SWSA5/WOC presented a risk to piscivorous wildlife (Table 9.11). While dose rates from ^{137}Cs were high, data from this subbasin were limited to the OHF Pond and do not represent a widespread ecological problem. Risks to aquatic organisms from exposure to radionuclides in surface water and sediment were also limited. The OHF Pond in the SWSA5/WOC subbasin also presented risks to aquatic biota as a result of ^{137}Cs in sediment, and ^{90}Sr in Seep C surface water resulted in dose rates exceeding 1 rad/d for large aquatic invertebrates (Table 9.12).

The following paragraphs present risks for each receptor by basin and subbasin within the WOCW.

9.3.1 HFIR Basin

- **HFIR Subbasin.** Risks to terrestrial biota were evaluated for radionuclides in soil in the HFIR subbasin. Potential risks from exposure to the 7 radionuclides detected in soil were identified for soil invertebrates (HI = 2.0), red fox (1.4), white-tailed deer (3.1), and wild turkey (3.7). Strontium-90 was the primary risk driver, contributing >90% of the HI for all receptors (Table 9.10).

- **HFIR East.** Risks to biota were evaluated for radionuclides in soil and surface water in the HFIR East subbasin. Only one radionuclide (potassium-40) was detected in three soil samples from this subbasin, and no risks are anticipated for terrestrial biota. No risks were identified for aquatic organisms exposed to radionuclides in surface water in the HFIR East subbasin. Dose rates estimated for large invertebrates and large fish were below recommended dose rate limits.

- **MB-15 Subbasin.** Risks to biota were evaluated for radionuclides in soil and surface water in the MB-15 subbasin. Potential risks from exposure to the 2 radionuclides detected in soil were identified for all receptors with HIs ranging from 1.1 for plants to 30.6 for shrews and

mice (Table 9.10). Cobalt-60 was the primary risk driver, contributing >95% of the HI for all receptors. No risks were identified for aquatic organisms exposed to radionuclides in surface water in the MB-15 subbasin. Dose rates estimated for large invertebrates and large fish were below recommended dose rate limits.

- **HF-2 Subbasin.** Risks to biota were evaluated for radionuclides in soil and surface water in the HF-2 subbasin. Overall dose rates from exposure to the 8 radionuclides detected in soil were well below the recommended dose limits for all receptors. No risks were identified for aquatic organisms exposed to radionuclides in surface water in the HF-2 subbasin. Dose rates estimated for large invertebrates and large fish were below recommended dose rate limits.

9.3.2 HRE Basin

HRE Subbasin. Risks to biota were evaluated for radionuclides in soil and surface water in the HRE subbasin. Seventeen radionuclides were detected in soil samples from the HRE, but risks are only anticipated for wild turkey (Table 9.10). The overall Hi for turkeys was 4.0 with ^{234}Th and $^{233/234}$U as the risk drivers. Overall dose rates for all other receptors were well below recommended dose limits. No risks were identified for aquatic organisms exposed to radionuclides in surface water in the HRT-3 subbasin. Dose rates estimated for large invertebrates and large fish were below recommended dose rate limits.

9.3.3 SWSA5 Seep A Basin

Seep A Subbasin. Risks to biota were evaluated for radionuclides in soil, surface water, and sediment in the Seep A subbasin. Overall dose rates from exposure to the 27 radionuclides detected in soil marginally exceeded recommended dose limits for shrews and mice (HI = 1.0) but were well below the recommended dose limits for all other receptors (Table 9.10). Plutonium-239/240 was the primary risk driver, contributing 60% of the dose for both mice and shrews. No risks were identified for aquatic organisms exposed to radionuclides in surface water and sediment in the Seep A subbasin. Combined surface water and sediment dose rates estimated for large invertebrates and large fish were below recommended dose rate limits.

9.3.4 SWSA5 Seep B Basin

- **Seep B West Subbasin.** Risks to biota were evaluated for radionuclides in soil and surface water in the Seep B West subbasin. Overall dose rates from exposure to the 18 radionuclides detected exceeded recommended dose limits for soil invertebrates (HI = 1.2), shrews and mice (HI = 8.0), deer (1.4), and turkeys (2.3), but were below the recommended dose limits for all other receptors (Table 9.10). Strontium-90 was the risk driver for soil invertebrates, deer, and turkey, contributing >57% of the dose rate, while curium-244 and americium-241 contributed 71% and 14%, respectively, to the dose rate received by shrews and mice. No risks were identified for aquatic organisms exposed to radionuclides in surface water in the Seep B West subbasin. Dose rates estimated for large invertebrates and large fish were below recommended dose rate limits.

- **Seep B East Subbasin.** Risks to biota were evaluated for radionuclides in soil and surface water in the Seep B East subbasin. Overall dose rates from exposure to the 13 radionuclides detected marginally exceeded recommended dose limits for short-tailed shrews (HI = 2.6), white-footed mice (HI = 2.3), red fox (1.9), wild turkeys (1.7), and mink (1.7) but were below the recommended dose limits for all other receptors (Table 9.10). Cs-137 was the risk driver

for all receptors, contributing >91% of the dose rate. No risks were identified for aquatic organisms exposed to radionuclides in surface water in the Seep B East subbasin. Dose rates estimated for large invertebrates and large fish were below recommended dose rate limits.

9.3.5 SWSA 5 Drainage D-2 Basin

SWSA 5 Drainage D-2 Basin. Risks to biota were evaluated for radionuclides in soil, surface water, and sediment in the SWSA 5 Drainage D-2 subbasin. Overall dose rates from exposure to the 18 radionuclides detected in soil were well below the recommended dose limits for all receptors. No risks were identified for aquatic organisms exposed to radionuclides in surface water and sediment in the SWSA 5 Drainage D-2 subbasin. Combined surface water and sediment dose rates estimated for large invertebrates and large fish were below recommended dose rate limits.

9.3.6 SWSA5 Seep C Basin

Seep C Subbasin. Risks to biota were evaluated for radionuclides in soil, surface water, and sediment in the Seep C subbasin. Overall dose rates from exposure to the 22 radionuclides detected exceeded recommended dose limits for shrews and mice (HI = 1.7), but were below the recommended dose limits for all other receptors (Table 9.10). Curium-244 contributed >52% of the dose rate received by shrews and mice. Radionuclides in surface water in the Seep C subbasin result in some of the highest dose rates to aquatic organisms of all the subbasins in the watershed. The hazard index for large aquatic invertebrates was 2.2, and the HI for large fish was 0.4. Sr-90 contributed virtually all (99.6%) of the dose rate. The Sr-90 activity recorded at station SW5-4 was two orders of magnitude higher than at any of the other stations and may represent a hot spot. Sediment exposures did not account for a significant fraction of the overall dose rate to aquatic organisms in the Seep C subbasin.

9.3.7 MWOC/East Basin

- **SWSA 5 Tributary 1.** Risks to biota were evaluated for radionuclides in soil, surface water, and sediment in the SWSA5 Trib-1 subbasin. Overall dose rates from exposure to the 27 radionuclides detected in soil marginally exceeded recommended dose limits for shrews, mice and turkeys (HI = 2.2, 2.1, and 1.1), but were below the recommended dose limits for all other receptors (Table 9.10). Plutonium-238 contributed >59% of the dose rate received by shrews and mice. No risks were identified for aquatic organisms exposed to radionuclides in surface water and sediment in the SWSA5 Trib1 subbasin. Combined surface water and sediment dose rates estimated for large invertebrates and large fish were below recommended dose rate limits.

- **MVDrive Subbasin.** Risks to biota were evaluated for radionuclides in soil in the MVDrive subbasin. Only 5 radionuclides were detected in up to three soil samples from this subbasin, and no risks are anticipated for terrestrial biota. Overall dose rates were well below recommended dose limits for all receptors. No risks were identified for aquatic organisms exposed to radionuclides in surface water in the MVDrive subbasin. Dose rates estimated for large invertebrates and large fish were below recommended dose rate limits.

- **SWSA 5 WOC.** Risks to biota were evaluated for radionuclides in soil, surface water, and sediment in the SWSA 5 WOC subbasin. No risks were identified for exposure to radionuclides in soil. Overall dose rates from exposure to the 27 radionuclides detected in soil were well below the recommended dose limits for all receptors. Radionuclides in surface water

and sediment in the SWSA 5 WOC subbasin result in the highest dose rates to aquatic and piscivorous organisms of all the subbasins in the watershed. Risks for piscivorous wildlife exposed to radionuclides were predicted to be likely for the SWSA 5 WOC subbasin based on exposures modeled from surface water concentrations. Hazard indices ranged from 12.7 for the kingfisher to 24.2 for the otter (Table 9.11). Cs-137 accounted for >94% of the dose, and Strontium-90 accounted for 5.7%. The hazard index for large aquatic invertebrates from water exposures was 0.5, and the HI for large fish was 1.1 (Table 9.12). Cs-137 contributed 98.6% of the dose rate, and Co-60 accounted for 1.3%. Radionuclides in sediment in the SWSA 5 WOC subbasin result in the highest dose rates in the watershed (Table 9.12). The hazard index for large aquatic invertebrates from sediment exposures was 202, and the HI for large fish was 91. Cs-137 accounted for 98.6% of the dose rate from sediment, and Co-60 accounted for 1.3%. While the risks are high, the surface water and sediment data for this subbasin were collected from a single location, the OHF Pond, and do not represent a widespread ecological concern.

- **SWSA5 N WOC.** Risks to biota were evaluated for radionuclides in soil and surface water in the SWSA5 N WOC subbasin. No risks were identified for exposure to radionuclides. Overall dose rates from exposure to the 18 radionuclides detected were well below the recommended dose limits for all receptors. No risks were identified for aquatic organisms exposed to radionuclides in surface water in the SWSA5 N WOC subbasin. Dose rates estimated for large invertebrates and large fish were below recommended dose rate limits.

9.3.8 MWOC/West Basin

- **SWSA 4 Main.** Risks to biota were evaluated for radionuclides in surface soil, surface water, and sediment in the SWSA 4 Main. Potential risks from exposure to the 4 radionuclides detected in soil were identified for all receptors except plants with HIs ranging from 4.7 for soil invertebrates to 18.8 for shrews (Table 9.10). Cesium-137 was the primary risk driver, contributing >82% of the HI for all receptors. Strontium-90 was an additional risk driver for deer and turkey, accounting for 17% and 9% of the overall dose rate, respectively. No risks were identified for aquatic organisms exposed to radionuclides in surface water and sediment in the SWSA 4 Main subbasin. Combined surface water and sediment dose rates estimated for large invertebrates and large fish were below recommended dose rate limits.

- **WAG 7 WOC.** Risks to terrestrial biota exposed to radionuclides and nonradionuclides in WAG 7 WOC soil were evaluated. Potential risks to shrews, mice, and turkeys from exposure to radionuclides were identified (Table 9.10), but dose rates were below dose limits for all other receptors. Cesium-137 was the primary risk driver in all cases.

- **Intermediate Pond.** Risks to biota were evaluated for radionuclides in surface soil, surface water, and sediment in the Intermediate Pond subbasin. Overall dose rates from exposure to the 14 radionuclides detected in soil exceeded recommended dose limits for plants, soil invertebrates, shrews and mice, fox, and turkeys, but were below the recommended dose limits for all other receptors (Table 9.10). Plutonium-239/240 was the primary risk driver for plants, soil invertebrates, shrews, and mice, contributing 52-81% of the dose rate for these receptors while Americium-241 contributed 11-26%. Cesium-137 accounted for virtually all of the dose rate to the fox, 21.3% for turkeys, and 3% for shrews and mice. The primary radionuclide risk driver for wild turkeys was Uranium-233/234 (contributing 53% of the overall dose rate). Uranium was a risk driver for turkey but not for shrews or other mammals because the uranium uptake factor for turkeys was higher than that for mammals (Table 9.4).

No risks were identified for aquatic organisms exposed to radionuclides in surface water and sediment in the Intermediate Pond subbasin. Combined surface water and sediment dose rates estimated for large invertebrates and large fish were below recommended dose rate limits.

- **WOC Subbasin.** Risks to biota were evaluated for radionuclides in surface soil, surface water, and sediment in the WOC subbasin. Overall dose rates from exposure to the 14 radionuclides detected in soil exceeded recommended dose limits for shrews and mice, but were below the recommended dose limits for all other receptors (Table 9.10). Plutonium-239/240 was the primary risk driver, contributing 67% of the dose rate for shrews and mice while Curium-244 and Americium-241 contributed 12% and 10%, respectively. No risks were identified for aquatic organisms exposed to radionuclides in surface water and sediment in the Intermediate Pond subbasin. Combined surface water and sediment dose rates estimated for large invertebrates and large fish were below recommended dose rate limits.

- **Haw Ridge Subbasin.** Risks to terrestrial biota were evaluated for radionuclides in soil in the Haw Ridge subbasin. Only 3 radionuclides were detected in the one sample from this subbasin, and no risks are anticipated for terrestrial biota. Overall dose rates were below recommended dose limits for all receptors.

9.3.9 West Seep Basin

West Seep Subbasin. Risks to biota were evaluated for radionuclides in soil and surface water in the West Seep subbasin. Overall dose rates from exposure to the 29 radionuclides detected exceeded recommended dose limits for all receptors with HIs ranging from 2.0 for plants to 53.0 for shrews (Table 9.10). Cobalt-60 was the primary risk driver for all receptors, contributing >68% of the dose rate for all receptors. No risks were identified for aquatic organisms exposed to radionuclides in surface water in the West Seep subbasin. Dose rates estimated for large invertebrates and large fish were below recommended dose rate limits.

9.3.10 SWSA6 Basin

- **W6MS3 Subbasin.** Risks to biota were evaluated for radionuclides in soil and surface water in the W6MS3 subbasin. No risks were identified for exposure to radionuclides. Overall dose rates to terrestrial biota from exposure to the 21 radionuclides detected in soil were below the recommended dose limits for all receptors. No risks were identified for aquatic organisms exposed to radionuclides in surface water in the W6MS3 subbasin. Dose rates estimated for large invertebrates and large fish were below recommended dose rate limits.

- **W6MS1 Subbasin.** Risks to biota were evaluated for radionuclides in soil and surface water in the W6MS1 subbasin. No risks were identified for exposure to radionuclides. Overall dose rates to terrestrial biota from exposure to the 17 radionuclides detected in soil were below the recommended dose limits for all receptors. Dose rates estimated for large invertebrates and large fish exposed to radionuclides in surface water were below recommended dose rate limits.

9.3.11 WOL, Creek, and Floodplain Basin

- **Lower WOC/WOL Subbasin.** Risks to biota were evaluated for radionuclides in surface soil, surface water, and sediment in the Lower WOC/WOL subbasin. Overall dose rates from exposure to the 14 radionuclides detected in soil exceeded recommended dose limits for plants (HI = 1.4), shrews (HI = 17.4), and mice (HI = 17.3), but were below the recommended dose

limits for all other receptors (Table 9.10). Plutonium-239/240 was the primary risk driver for all receptors, contributing >86% of the dose rate. Americium-241 accounted for 6% of the HI for shrews and mice. No risks were identified for aquatic organisms exposed to radionuclides in surface water and sediment in the Lower WOC/WOL subbasin. Combined surface water and sediment dose rates estimated for large invertebrates and large fish were below recommended dose rate limits.

- **SWSA6Sth Subbasin.** Risks to terrestrial biota were evaluated for radionuclides in soil in the SWSA6Sth subbasin. No risks were identified for exposure to radionuclides. Overall dose rates from exposure to the 14 radionuclides detected were below the recommended dose limits for all receptors.

- **SWSA6 East Subbasin.** Risks to biota were evaluated for radionuclides in soil and surface water in SWSA6 East subbasin. No risks were identified for exposure to radionuclides. Overall dose rates from exposure to the 15 radionuclides detected in soil were below the recommended dose limits for all receptors, and dose rates estimated for large invertebrates and large fish exposed to radionuclides in surface water were below recommended dose rate limits.

- **Pit 4 South Subbasin.** Risks to biota were evaluated for radionuclides in soil and surface water in the Pit 4 South subbasin. No risks were identified for exposure to radionuclides. Overall dose rates from exposure to the 12 radionuclides detected were below the recommended dose limits for all receptors, and dose rates estimated for large invertebrates and large fish exposed to radionuclides in surface water were below recommended dose rate limits.

- **WOC Embayment.** Risks to aquatic biota were evaluated for radionuclides in surface water and sediment. No risks were identified for aquatic organisms exposed to radionuclides in surface water and sediment in the WOC Embayment subbasin. Combined surface water and sediment dose rates estimated for large invertebrates and large fish were below recommended dose rate limits.

9.3.12 NHF Basin

NHF Subbasin. Risks to terrestrial biota were evaluated for radionuclides in soil in the NHF subbasin. No risks were identified for exposure to radionuclides. Overall dose rates from exposure to the 16 radionuclides detected were below the recommended dose limits for all receptors.

9.3.13 East Seep Basin

East Seep Subbasin. Risks to biota were evaluated for radionuclides in soil and surface water in the East Seep subbasin. Potential risks from exposure to the 19 radionuclides detected in soil were identified for all receptors with HIs ranging from 8.6 for plants to 148 for shrews (Table 9.10). Cesium-137 was the primary risk driver, contributing >99% of the HI for all receptors, except turkeys (^{234}Th and $^{233/234}$U were additional risk drivers for turkeys). Cesium-137 in East Seep soil resulted in the highest soil-related radiological risks identified for terrestrial biota in the Melton Valley area of the White Oak Creek Watershed. No risks were identified for aquatic organisms exposed to radionuclides in surface water in the East Seep subbasin. Dose rates estimated for large invertebrates and large fish were below recommended dose rate limits.

9.3.14 WCTrib1 & ^{60}Co Basin

WCTrib1 Subbasin. Risks to terrestrial biota were evaluated for radionuclides in soil in the WCTrib1 subbasin. Potential risks from exposure to the 3 radionuclides detected in soil were identified for shrews, mice, foxes, turkeys, and mink with HIs ranging from 1.3 for mink to 2.0 for shrews (Table 9.10). Cesium-137 was the primary risk driver, contributing >80% of the HI for all receptors.

9.4 SUMMARY OF RISKS TO BIOTA FROM EXPOSURE TO RADIONUCLIDES

9.4.1 Risks to terrestrial biota from exposure to radionuclides

Potential risks to plants from exposure to radionuclides were identified in 5 subbasins (Table 9.10). Cesium-137 was the risk driver in East Seep soils. Plutonium-239/240 was the primary risk driver at the Intermediate Pond and Lower WOC/WOL subbasins, and Co-60 was the risk driver at MB-15 and West Seep.

Potential risks to soil invertebrates from exposure to radionuclides in surface soil were identified in 7 subbasins (Table 9.10). Cesium-137 was the risk driver in East Seep and SWSA 4 Main soils. Cobalt-60 was the primary risk driver at MB-15 and West Seep, and Plutonium-239/240 was the primary risk driver at the Intermediate Pond. Strontium-90 was the risk driver at the HFIR and Seep B subbasins.

Potential risks from exposure to radionuclides in surface soil were identified for at least one wildlife receptor at 16 subbasins (Table 9.10). Shrews and mice generally received the highest dose rates. Cs-137 was the primary risk driver in East Seep, SWSA 4 Main, Seep B East, WCTrib-1, and WAG 7 WOC soils. Plutonium-239/240 was the primary risk driver at the Intermediate Pond, Lower WOC/WOL, WOC, and SWSA 5 Seep A. Cobalt-60 contributed the highest dose rate at MB-15 and West Seep. Curium-244 was the risk driver at Seep B West and SWSA 5 Seep C and was a significant contributor at WOC. Strontium-90 was a risk driver at the HFIR subbasin and at Seep B West. Plutonium-238 was the primary risk driver at SWSA 5 Trib-1.

9.4.2 Risks to piscivorous wildlife from exposure to radionuclides

Risks from exposure of piscivorous wildlife to radionuclides are not anticipated in the White Oak Creek watershed. Exposure of piscivorous wildlife to radionuclides were modeled using available surface water data and measured fish body burden data. Potential risks were identified in only one subbasin: SWSA5/WOC. As noted above, the sample from this subbasin was associated with the OHF Pond and does not represent a widespread problem. Estimated exposures were below recommended dose rate limits for all receptors in all other subbasins.

9.4.3 Risks to aquatic biota from exposure to radionuclides

Potential risks to aquatic organisms exposed to radionuclides in surface water within the watershed were identified for only two subbasins: SWSA5/WOC and Seep C. The dose rate to large fish in the SWSA5/WOC subbasin marginally exceeded the recommended dose rate limit (HI = 1.1) as a result of high Cs-137 activity. This dose was associated with the 05.OHF station at the OHF Pond and does not represent a widespread problem. The dose rate for large insects at Seep C also

marginally exceeded the dose limit (HI = 2.2) but was a result of Sr-90, which contributed >99% of the dose. No aquatic receptors received doses above the dose rate limit in any of the other subbasins.

9.5 UNCERTAINTIES IN THE RADIOLOGICAL RISK ASSESSMENT

A number of areas of uncertainty exist in the estimation of risks to wildlife from exposure to radionuclides in the White Oak Creek watershed. It is believed that the methodology used in this assessment overestimates the dose rates that would be received. Whereas some of the information needed to implement the methodology is well-known, much is unknown or unspecified statistically. A conservative but reasonable approach to model assumptions and radiological exposure scenarios was adopted for this assessment in order to avoid underestimating risks to biota. Many of the uncertainties identified in the plant, soil invertebrate, and wildlife sections also apply to the radionuclide assessment. Specific uncertainties identified in the radionuclide assessment are presented here.

- It was assumed that uptake of radionuclides from soil, food, and water are similar. Radionuclides bound to soil may be less available than those in tissue or water. Therefore, assuming uptake from soil equal to uptake from food may result in a conservative estimate of actual uptake.
- Uptake factors from soil to earthworms were not available for many radionuclides. If uptake factors were unavailable, the higher of the plant or mammal uptake factors was used for earthworms. It is unknown whether actual earthworm uptake factors for these radionuclides would be higher or lower than those used, but use of the larger of the plant and mammal values was a conservative approach. Where measured values were available, earthworm uptake factors were generally lower than at least one of the corresponding plant or small mammal values.
- Uptake factors were not available for birds for all radionuclides. In the absence of bird-specific uptake factors, radionuclide activities in bird tissue were estimated using mammal uptake factors assuming that uptake would be similar for birds and mammals. It is unknown whether actual bird uptake factors would be higher or lower than those used here.
- Mammal soil-to-tissue uptake factors were calculated from ORR-specific data on small rodents. While these clearly apply directly to white-footed mice, they were also used for the other small mammalian receptor, the short-tailed shrew. Short-tailed shrew diets differ somewhat from that of white-footed mice as shrews eat a higher proportion of invertebrates. However, it was assumed that site-specific data on mice was more applicable to shrews than literature-derived bioaccumulation factors.
- Literature-derived uptake factors were used to estimate radionuclide activities in mammal and bird tissues when ORR-specific data were unavailable. While these values are believed to be representative of bioaccumulation likely to be observed on site, actual values may be higher or lower than those used in this assessment.
- Species-specific time budget information is lacking, so it was necessary to make a number of assumptions regarding the fraction of time each receptor spends above or below ground, underwater, or at the water's surface. The fractions used in this assessment were selected based on general knowledge of species behavior patterns, but actual fractions may be higher or lower.

- Wide-ranging wildlife species such as the red fox, white-tailed deer, and red-tailed hawk are unlikely to receive 100% of their exposure at any one location. Therefore, dose rates presented for these species are likely overestimated as they would average their exposures over a broader area than a single subbasin.

- The dose coefficients obtained from Eckerman and Ryman (1993) used to estimate dose rates from external exposures were developed for application in determining dose rates to humans. These dose coefficients were applied directly for wildlife receptors or adjusted based on the effective height of the receptors, but the actual dose coefficients for wildlife, given differences in size, behavior, and general morphology, may be greater or lesser than those developed for humans.

- Dietary information for the wildlife receptors evaluated here was obtained from available literature. Diets of given species in the White Oak Creek watershed may vary somewhat from those reported in the literature from other areas.

- The air mass loading factor of 0.1 g/m^3 used in estimating exposures from inhalation of radionuclide-contaminated dust was selected as a conservative value. Healy (1980) suggested 0.0001 g/m^3 would be a conservative value for estimating human exposures from inhalation of dust.

- Monte Carlo simulation were not performed for radionuclide exposures. Therefore, exposure estimates assume that UCL95 activity levels represent the activities to which organisms were exposed. This is a conservative assumption and likely results in overestimates of exposures, particularly for wide-ranging wildlife species that average their exposures over larger areas than individual subbasins.

Table 9.1. Species-specific exposure parameters used in estimating wildlife exposures to radionuclides

Receptor Species	% Dietary composition										
	plants	inverts	small mammals	birds	fish	soil[a]	Soil above grd[b]	Soil below grd[c]	ECF[d]	Water immersion[e]	water surface[f]
mink	0	0	0.454	0	0.546	0	0.5	0.2	2	0.1	0.2
belted kingfisher	0	0	0	0	1	0	0.33	0.33	1	0	0.33
short-tailed shrew	0	1	0	0	0	0.13	0.75	0.25	2		
white-footed mouse	0.5	0.5	0	0	0	0.02	0.75	0.25	2		
red fox	0.104	0.088	0.688	0.12	0	0.028	0.75	0.25	1		
white-tailed deer	1	0	0	0	0	0.02	1	0	1		
red-tailed hawk	0	0	1	0	0	0	0.1	0	1		
turkey	0.903	0.097	0	0	0	0.093	1	0	1		
Osprey	0	0	0	0	1	0	0.9	0	1	0	0.1
Heron	0	0	0	0	1	0	0.5	0	1	0.25	0.25
Otter	0	0	0	0	1	0	0.25	0.25	2	0.25	0.25

[a] Soil ingetion as a percentage of overall dietary intake.

[b] Dose rate reduction factor accounting for the fraction of time the receptor spends above ground (unitless).

[c] Dose rate reduction factor accounting for the fraction of time the receptor spends below ground (unitless).

[d] Elevation correction factor to adjust dose coefficients derived for 1 m height to value representative of effective height of animal above ground.

[e] Fraction of time organism spends underwater (unitless).

[f] Fraction of time organism spends at or just above water (unitless).

Table 9.2 Average energy of decay and absorbed fractions for radionuclides detected in soil in the WOCW

Radionuclide	Average energy of decay[a]			Absorbed fractions (gamma)[b]					DFgrd 0-15 (Sv m3/s Bq)[c]
	alpha	beta	gamma	A	B	C	D	E	
Actinium-228		0.475	0.971	0.06	0.01	0.0127	0.04	0.14	2.76E-17
Americium-241	5.479	0.052	0.033	0.16	0.04	0.05	0.12	0.3	2.34E-19
Antimony-126		0.283	2.834	0.04	0.008	0.01	0.03	0.11	8.13E-17
Antimony-126m		0.591	1.548	0.05	0.085	0.0123	0.03	0.12	4.44E-17
Astatine-218	6.697	0.04	0.007	0.94	0.63	0.79	0.94	0.94	3.13E-20
Barium-137m		0.065	0.597	0.06	0.011	0.015	0.04	0.15	1.71E-17
Beryllium-7			0.049	0.09	0.012	0.017	0.06	0.2	1.40E-18
Bismuth-210		0.389							1.86E-20
Bismuth-211	6.55	0.01	0.047	0.15	0.027	0.04	0.11	0.29	1.28E-18
Bismuth-212	2.174	0.472	0.186	0.06	0.0085	0.011	0.04	0.14	5.36E-18
Bismuth-214		0.659	1.508	0.05	0.085	0.0123	0.03	0.12	4.36E-17
Cadmium-109		0.083	0.026	0.21	0.09	0.126	0.16	0.36	7.88E-20
Calcium-45		0.077							3.35E-22
Carbon-14		0.049							7.20E-23
Cesium-134		0.164	1.555	0.05	0.085	0.0123	0.03	0.12	4.47E-17
Cesium-137		0.187							3.94E-21
Cobalt-57		0.019	0.125	0.06	0.0079	0.012	0.04	0.15	2.66E-18
Cobalt-60		0.097	2.504	0.04	0.008	0.01	0.03	0.11	7.25E-17
Curium-242	6.102	0.01	0.002	0.94	0.63	0.79	0.94	0.94	9.07E-22
Curium-243	5.797	0.138	0.134	0.06	0.008	0.0105	0.04	0.15	3.02E-18
Curium-244	5.795	0.009	0.002	0.94	0.63	0.79	0.94	0.94	6.74E-22
Europium-152		0.139	1.155	0.05	0.085	0.0123	0.03	0.12	3.75E-17
Europium-154		0.292	1.242	0.05	0.085	0.0123	0.03	0.12	4.11E-17
Europium-155		0.063	0.061	0.09	0.012	0.017	0.06	0.2	9.75E-19
Iodine-129		0.064	0.025	0.21	0.09	0.126	0.16	0.36	6.93E-20
Lead-212		0.176	0.148	0.06	0.0082	0.011	0.04	0.15	3.62E-18
Lead-214		0.293	0.25	0.06	0.009	0.01	0.04	0.14	6.70E-18
Neptunium-237	4.769	0.07	0.035	0.15	0.027	0.04	0.11	0.29	4.16E-19
Plutonium-238	5.487	0.011	0.002	0.94	0.63	0.79	0.94	0.94	8.07E-22
Plutonium-239	5.148	0.007		0.94	0.63	0.79	0.94	0.94	1.52E-21
Plutonium-239/40	5.148	0.007	0.002	0.94	0.63	0.79	0.94	0.94	1.52E-21
Plutonium-240	5.156	0.011	0.002	0.94	0.63	0.79	0.94	0.94	7.84E-22
Polonium-210		0.038	0.005	0.94	0.63	0.79	0.94	0.94	2.45E-22
Polonium-211	7.442		0.008	0.94	0.63	0.79	0.94	0.94	2.24E-19
Polonium-212	8.785								3.62E-18
Polonium-214	7.687								2.40E-21
Polonium-216	6.779								4.87E-22
Polonium-218	6.001								2.63E-22
Potassium-40		0.523	0.156	0.06	0.008	0.0115	0.04	0.14	4.57E-18
Protactinium-233		0.196	0.204	0.06	0.009	0.01	0.04	0.14	5.16E-18
Protactinium-234		0.494	1.919	0.05	0.085	0.0123	0.03	0.12	5.38E-17
Protactinium-234m		0.822	0.012	0.93	0.55	0.63	0.93	0.93	4.20E-19
Radium-223	5.667	0.076	0.134	0.06	0.008	0.0105	0.04	0.15	3.10E-18
Radium-224	5.674	0.002	0.01	0.35	0.63	0.79	0.29	0.52	2.62E-19

Table 9.2 (continued)

Radionuclide	Average energy of decay[a]			Absorbed fractions (gamma)[b]					DFgrd 0-15 (Sv m3/s Bq)[c]
	alpha	beta	gamma	A	B	C	D	E	
Radium-226	4.774	0.004	0.007	0.94	0.63	0.79	0.94	0.94	1.65E-19
Radium-228		0.017							0.00E+00
Radon-220	6.288								1.10E-20
Radon-222	5.489								1.14E-20
Sodium-22		0.194	2.193	0.05	0.085	0.0123	0.03	0.12	6.31E-17
Strontium-90		0.196							3.72E-21
Technetium-99		0.101							6.70E-22
Thallium-207		0.493	0.002	0.94	0.63	0.79	0.94	0.94	9.48E-20
Thallium-208		0.598	3.375	0.04	0.008	0.01	0.03	0.11	9.68E-17
Thorium-228	5.4	0.021	0.003	0.94	0.63	0.79	0.94	0.94	4.17E-20
Thorium-230	4.671	0.015	0.002	0.94	0.63	0.79	0.94	0.94	6.39E-21
Thorium-231		0.165	0.026	0.21	0.09	0.126	0.16	0.36	1.94E-19
Thorium-232	3.996	0.012	0.001	0.94	0.63	0.79	0.94	0.94	2.78E-21
Thorium-234		0.06	0.009	0.94	0.63	0.79	0.94	0.94	1.29E-19
Tin-126		0.172	0.057	0.09	0.012	0.017	0.06	0.2	7.90E-19
Tritium		0.006							0
Uranium-232	5.302	0.017	0.002	0.94	0.63	0.79	0.94	0.94	4.83E-21
Uranium-233	4.817	0.006	0.001	0.94	0.63	0.79	0.94	0.94	7.24E-21
Uranium-233/234	4.817	0.006	0.001	0.94	0.63	0.79	0.94	0.94	7.24E-21
Uranium-234	4.758	0.013	0.002	0.94	0.63	0.79	0.94	0.94	2.14E-21
Uranium-235	4.396	0.049	0.156	0.06	0.008	0.0115	0.04	0.14	3.75E-18
Uranium-235/236	4.396	0.049	0.156	0.06	0.008	0.0115	0.04	0.14	3.75E-18
Uranium-236	4.396	0.049	0.156	0.06	0.008	0.0115	0.04	0.14	3.75E-18
Uranium-238	4.187	0.01	0.001	0.94	0.63	0.79	0.94	0.94	5.52E-22
Yttrium-90		0.935							1.20E-19
Zirconium-89		0.101	1.165	0.05	0.085	0.0123	0.03	0.12	3.85E-17

[a] Values were obtained from ICRP (1983)

[b] Absorbed fractions for worms, plants, and mouse were derived from data in Blaylock et al. (1993). Absorbed fraction for other receptors were derived following methodology of Cristy and Eckerman (1987). Absorbed fractions for beta radiation were 100% for all radinoclides listed.

[c] DFgrad is the dose coefficient for soil 0-15 cm in depth (Eckerman and Ryman, 1993).

A = Fox, Turkey, Heron, Otter

B = Worms, Plants

C = Shrew, Mouse

D = Mink, Hawk, Kingfisher, Osprey

E = Deer

Table 9.3a. Average energy of decay and absorbed fractions for radionuclides detected in surface water used to evaluate exposures for aquatic organisms in the WOCW

	BCF (L/kg)[a]		Energies (MeV/nt)[b]			Gamma Absorption[c]	
Radionuclide	Fish	Inverts	alpha	beta	gamma	B	D
Actinium-225	25	25	5.787	0.022	0.018	0.33	0.75
Actinium-228	25	25		0.475	0.971	0.01	0.1
Americium-237	30	1000	0.002	0.077	0.37	0.01	0.09
Americium-241	30	1000	5.479	0.052	0.033	0.04	0.4
Americium-242	30	1000		0.179	0.018	0.33	0.75
Americium-243	30	1000	5.27	0.022	0.056	0.0125	0.15
Antimony-125	1	10		0.1	0.431	0.01	0.1
Antimony-122	1	10		0.565	0.441	0.01	0.1
Antimony-126	100	100		0.283	2.834	0.0081	0.08
Antimony-126m	100	100		0.591	1.548	0.009	0.08
Astatine-217			7.067				
Astatine-218			6.697	0.04	0.007	0.63	0.94
Barium-137m	4	200		0.065	0.597	0.011	0.11
Bismuth-210	20	100000		0.389			
Bismuth-212	20	100000	2.174	0.472	0.186	0.0085	0.12
Bismuth-213	20	100000	0.126	0.442	0.133	0.008	0.12
Bismuth-214	20	100000		0.659	1.508	0.01	0.08
Cadmium-109	2000	2000		0.083	0.026	0.14	0.58
Calcium-45	40	40		0.077			
Carbon-14	4550	3640		0.049			
Cerium-139	30	30		0.036	0.16	0.008	0.12
Cerium-141	30	1000		0.171	0.076	0.009	0.12
Cerium-143	30	1000		0.433	0.282	0.01	0.08
Cerium-144	30	1000		0.092	0.021	0.14	0.58
Cesium-134	2000	1000		0.164	1.555	0.009	0.08
Cesium-137	2000	1000		0.187			
Cobalt-57	300	10000		0.019	0.125	0.0079	0.11
Cobalt-58	300	10000		0.034	0.976	0.01	0.1
Cobalt-60	300	10000		0.097	2.504	0.0081	0.08
Curium-242	30	1000	6.102	0.01	0.002	0.63	0.94
Curium-242/243	30	1000					
Curium-243	30	1000	5.797	0.138	0.134	0.008	0.12
Curium-244	30	1000	5.795	0.009	0.002	0.63	0.94
Curium243/244	30	1000					
Europium-152	50	50		0.139	1.155	0.01	0.08
Europium-154	50	50		0.292	1.242	0.01	0.08
Europium-155	50	50		0.063	0.061	0.01	0.1
Francium-221			6.304	0.01	0.031	0.045	0.42
Holmium-166				0.695	0.029	0.063	0.58
Iodine-123	40	400		0.028	0.172	0.008	0.12
Iodine-125	40	400		0.019	0.042	0.0149	0.2
Iodine-129	40	400		0.064	0.025	0.11	0.58
Iron-55	100	3000		0.004	0.002	0.63	0.94
Lead-205	300	100		0.007	0.002	0.63	0.94
Lead-209	300	100		0.198			

Table 9.3a. (Continued)

Radionuclide	BCF (L/kg)[a] Fish	Inverts	Energies (MeV/nt)[b] alpha	beta	gamma	Gamma Absorption[c] B	D
Lead-210	300	100		0.038	0.005	0.63	0.94
Lead-212	300	100		0.176	0.148	0.0082	0.12
Lead-214	300	100		0.293	0.25	0.009	0.09
Neptunium-233	10	400		0.014	0.091	0.0079	0.06
Neptunium-237	10	400	4.769	0.07	0.035	0.027	0.3
Neptunium-239	10	400		0.26	0.173	0.008	0.12
Niobium-95	300	300		0.044	0.766	0.01	0.1
Niobium-95	300	300		0.166	0.068	0.01	0.1
Nickel-63	100	100		0.017			
Plutonium-237	4	100		0.016	0.052	0.0125	0.16
Plutonium-238	4	100	5.487	0.011	0.002	0.63	0.94
Plutonium-239	4	100	5.148	0.007			
Plutonium-239/40	4	100		0.007			
Plutonium-240	4	100	5.156	0.011	0.002	0.63	0.94
Plutonium-241	4	100		0.005			
Plutonium-242	4	100	4.891	0.009	0.001	0.63	0.94
Polonium-210	50	20000	5.297				
Polonium-212	50	20000	8.785				
Polonium-213	50	20000	8.376				
Polonium-214	50	20000	7.687				
Polonium-216	50	20000	6.779				
Polonium-218	50	20000	6.001				
Potassium-40				0.523	0.156	0.008	0.12
Praseodymium-143	100	100		0.314			
Praseodymium-144	100	100		1.208	0.032	0.04	0.35
Praseodymium-144	100	100		0.047	0.013	0.39	0.925
Promethium-145	30	3000		0.014	0.031	0.04	0.35
Promethium-147	30	3000		0.062			
Protactinium-233	10	100		0.196	0.204	0.009	0.09
Protactinium-234	10	100		0.494	1.919	0.085	0.08
Protactinium-234m	10	100		0.822	0.012	0.55	0.93
Protactinium-234m	10	100		0.822	0.012	0.55	0.93
Radium-224	50	300	5.674	0.002	0.01	0.63	0.94
Radium-225	50	300		0.107	0.014	0.39	0.925
Radium-226	50	300	4.774	0.004	0.007	0.63	0.94
Radium-228	50	300		0.017			
Radon-219	410	410	6.757	0.006	0.056	0.0125	0.15
Radon-220	410	410	6.288				
Radon-222	410	410	5.489				
Rhodium-103m	10	10		0.038	0.002	0.63	0.94
Rhodium-106	10	10		1.413	0.205	0.009	0.09
Ruthenium-103	10	300		0.075	0.469	0.01	0.1
Ruthenium-106	10	300		0.01			
Samarium-153	25	25		0.273	0.062	0.01	0.1
Sodium-22	20	20		0.194	2.193	0.0082	0.08
Strontium-89	60	300		0.583			

Table 9.3a. (Continued)

Radionuclide	BCF (L/kg)[a] Fish	BCF (L/kg)[a] Inverts	Energies (MeV/nt)[b] alpha	beta	gamma	Gamma Absorption[c] B	D
Strontium-90	60	300		0.196			
Technetium-99	20	5		0.101			
Tellurium-123	400	6000		0.006	0.02	0.156	0.58
Tellurium-123m	400	6000		0.099	0.148	0.0082	0.12
Tellurium-125m	400	6000		0.109	0.036	0.026	0.28
Thallium-208	10000	10000		0.598	3.375	0.008	0.08
Thallium-209	10000	10000		0.688	2.032	0.0082	0.08
Thorium-228	30	500	5.4	0.021	0.003	0.63	0.94
Thorium-229	30	500	4.873	0.116	0.096	0.0079	0.09
Thorium-230	30	500	4.671	0.015	0.002	0.63	0.94
Thorium-231	30	500		0.165	0.026	0.09	0.58
Thorium-232	30	500	3.996	0.012	0.001	0.63	0.94
Thorium-234	30	500		0.06	0.009	0.63	0.94
Tin-119m	3000	3000		0.078	0.011	0.58	0.94
Tin-121	3000	3000		0.114			
Tin-121m	3000	3000		0.035	0.005	0.63	0.94
Tritium	1	1		0.006			
Uranium-232	10	100	5.302	0.017	0.002	0.63	0.94
Uranium-232/233	10	100	5.302	0.017	0.002	0.63	0.94
Uranium-233	10	100	4.817	0.006	0.001	0.63	0.94
Uranium-233/234	10	100	4.817	0.006	0.001	0.63	0.94
Uranium-234	10	100	4.758	0.013	0.002	0.63	0.94
Uranium-234/235	10	100	4.758	0.013	0.002	0.63	0.94
Uranium-235	10	100	4.396	0.049	0.156	0.008	0.12
Uranium-235/236	10	100	4.396	0.049	0.156	0.008	0.12
Uranium-236	10	100	4.505	0.011	0.002	0.63	0.94
Uranium-237	10	100		0.196	0.143	0.0081	0.12
Uranium-238	10	100	4.187	0.01	0.001	0.63	0.94
Yttrium-90	30	1000		0.935			
Zinc-65	100	100		0.007	0.584	0.01	0.1
Zirconium-95	300	300		0.116	0.739	0.01	0.1

[a] BCF, bioconcentration factor, obtained from IAEA (1982) and Blaylock et al . (1993).

[b] Energies were obtained from Eckerman and Rayman (1993).

[c] Gamma absorption factors were derived from Blaylock et al. (1993).

B = Large insect

D = Large fish

MeV/nt = million electronvolts/disintegration

Table 9.3b Average energy of decay and absorbed fractions for radionuclides detected surface water used to evaluate piscivore exposures in the WOCW

	Energies (MeV/nt)[a]			Gamma Absorption[b]				
Radionuclide	alpha	beta	gamma	A	B	DFwat (Sv m3/s Bq)[c]	Fish BCF (L/kg)[d]	BAFs Mammal Food-to-tissue
Actinium-228		0.475	0.971	0.06	0.04	1.04E-16	25	0.000025
Americium-241	5.479	0.052	0.033	0.16	0.12	1.88E-18	30	0.002
Antimony-126		0.283	2.834	0.04	0.03	2.99E-16	100	
Antimony-126m		0.591	1.548	0.05	0.03	1.63E-16	100	
Astatine-218	6.697	0.04	0.007	0.94	0.94	2.75E-19		
Barium-137m		0.065	0.597	0.06	0.04	6.26E-17	4	
Beryllium-7			0.049	0.09	0.06	5.15E-18		
Bismuth-210		0.389				6.33E-20	20	0.02
Bismuth-211	6.55	0.01	0.047	0.13	0.11	4.85E-18	20	0.02
Bismuth-212	2.174	0.472	0.186	0.06	0.04	2.00E-17	20	0.02
Bismuth-214		0.659	1.508	0.05	0.03	1.66E-16	20	0.02
Cadmium-109		0.083	0.026	0.21	0.16	6.77E-19	2000	
Calcium-45		0.077				1.68E-21	40	0.1
Carbon-14		0.049				4.39E-22	4550	1
Cesium-134		0.164	1.555	0.05	0.03	1.64E-16	2000	2.5
Cesium-137		0.187				1.49E-20	2000	2.5
Cobalt-57		0.019	0.125	0.06	0.04	1.25E-17	300	1.5
Cobalt-60		0.097	2.504	0.04	0.03	2.74E-16	300	1.5
Curium-242	6.102	0.01	0.002	0.94	0.94	1.33E-20	30	0.001
Curium-243	5.797	0.138	0.134	0.06	0.04	1.30E-17	30	0.001
Curium-244	5.795	0.009	0.002	0.94	0.94	1.15E-20	30	0.001
Europium-152		0.139	1.155	0.05	0.03	1.23E-16	50	0.25
Europium-154		0.292	1.242	0.05	0.03	1.33E-16	50	0.25
Europium-155		0.063	0.061	0.09	0.06	5.61E-18	50	0.25
Europium-156		0.423	1.329	0.05	0.03	1.46E-16	50	0.25
Iodine-129		0.064	0.025	0.21	0.16	8.91E-19	40	2
Lead-212		0.176	0.148	0.06	0.04	1.52E-17	300	0.02
Lead-214		0.293	0.25	0.06	0.04	2.59E-17	300	0.02
Neptunium-237	4.769	0.07	0.035	0.15	0.11	2.32E-18	10	0.00384
Plutonium-238	5.487	0.011	0.002	0.94	0.94	1.14E-20	4	0.0005
Plutonium-239	5.148	0.007		0.94	0.94	9.60E-21	4	0.0005
Plutonium-239/40	5.148	0.007	0.002	0.94	0.94	1.04E-20	4	0.0005
Plutonium-240	5.156	0.011	0.002	0.94	0.94	1.11E-20	4	0.0005
Polonium-210		0.038	0.005	0.94	0.94	9.03E-22	50	
Polonium-211	7.442		0.008	0.94	0.94		50	
Polonium-212	8.785					0	50	
Polonium-214	7.687					8.85E-21	50	
Polonium-216	6.779					1.80E-21	50	
Polonium-218	6.001					9.71E-22	50	
Potassium-40		0.523	0.156	0.06	0.04	1.74E-17		1
Protactinium-233		0.196	0.204	0.06	0.04	2.05E-17	10	0.05
Protactinium-234		0.494	1.919	0.05	0.03	2.03E-16	10	0.05
Protactinium-234m		0.822	0.012	0.93	0.93	1.52E-18	10	0.05
Radium-223	5.667	0.076	0.134	0.06	0.04	1.35E-17	50	0.045

Table 9.3b (Continued)

Radionuclide	Energies (MeV/nt)[a] alpha	beta	gamma	Gamma Absorption[b] A	B	DFwat (Sv m3/s Bq)[c]	Fish BCF (L/kg)[d]	BAFs Mammal Food-to-tissue
Radium-224	5.674	0.002	0.01	0.35	0.29	1.03E-18	50	0.045
Radium-226	4.774	0.004	0.007	0.94	0.94	6.95E-19	50	0.045
Radium-228		0.017				0	50	0.045
Radon-220	6.288					4.03E-20	410	
Radon-222	5.489					4.16E-20	410	
Sodium-22		0.194	2.193	0.05	0.03	2.35E-16	20	4
Strontium-90		0.196				1.46E-20	60	0.4
Technetium-99		0.101				3.14E-21	20	0.0005
Thallium-207		0.493	0.002	0.94	0.94	3.38E-19	10000	2
Thallium-208		0.598	3.375	0.04	0.03	3.84E-16	10000	2
Thorium-228	5.4	0.021	0.003	0.94	0.94	2.05E-19	30	0.005
Thorium-230	4.671	0.015	0.002	0.94	0.94	3.94E-20	30	0.005
Thorium-231		0.165	0.026	0.21	0.16	1.18E-18	30	0.005
Thorium-232	3.996	0.012	0.001	0.94	0.94	1.99E-20	30	0.005
Thorium-234		0.06	0.009	0.94	0.94	7.64E-19	30	0.005
Tin-126		0.172	0.057	0.09	0.06	4.76E-18	3000	0.01
Tritium		0.006				0.00E+00	1	1
Uranium-232	5.302	0.017	0.002	0.94	0.94	3.22E-20	10	0.015
Uranium-233	4.817	0.006	0.001	0.94	0.94	3.64E-20	10	0.015
Uranium-233/234	4.817	0.006	0.001	0.94	0.94	2.695E-20	10	0.015
Uranium-234	4.758	0.013	0.002	0.94	0.94	1.75E-20	10	0.015
Uranium-235	4.396	0.049	0.156	0.06	0.04	1.59E-17	10	0.015
Uranium-235/236	4.396	0.049	0.156	0.06	0.04	1.59E-17	10	0.015
Uranium-236	4.396	0.049	0.156	0.06	0.04	1.16E-20	10	0.015
Uranium-238	4.187	0.01	0.001	0.94	0.94	7.95E-21	10	0.015
Yttrium-90		0.935				3.63E-19	30	
Zirconium-89		0.101	1.165	0.05	0.03	7.82E-17	300	

[a] Energies were obtained from Eckerman and Rayman (1993).

[b] Gamma absorption factors were derived from Blaylock et al. (1993).

[c] Dfwater is dose coefficient for external exposure to water (Ecferman and Rayman (1993).

[d] BCF, bioconcentration factor, obtained from IAEA (1982) and Blaylock et al . (1993).

A = Heron, Otter.

B = Mink, Kingfisher, Osprey.

Table 9.4 Soil-to-tissue and food-to-tissue radionuclide uptake factors used in food chain models

Radionuclide	Soil to Plant BTF* (wet wt.)	Ref	Soil to Worm BTF* (wet wt.)	Ref	BAFs for Mammal Soil-to-Tissue	Ref	BAFs for Mammal Food-to-tissue	Ref	BAFs for Bird Food-to-tissue	Ref
Actinium-228	0.0009		0.0009				0.000025		0.000025	
Americium-241	2.489	b	3.644	a	2.777	a	0.002	k	0.0042	k,m
Bismuth-212	0.00875	l,m	0.02	s			0.02	l	0.02	w
Bismuth-214	0.00875	l,m	0.02	s			0.02	l	0.02	w
Carbon-14	1						1		1	
Calcium-45	3.867	b,m	1.896	a,m	9.378	a,m	0.1	k	0.028	k,m
Curium-242	1.09		0.886		2.331		0.001		0.001	
Curium-243	1.09		0.886		2.331		0.001		0.001	
Curium-244	1.093	b	0.886	a	2.693	a	0.001	r	0.001	w
Cobalt-57	0.012	b,m	0.291	a,m	0.01	a,m	1.5	r	1.4	k,m
Cobalt-60	0.012	b,m	0.291	a,m	0.01	a,m	1.5	r	1.4	k,m
Cesium-134	0.011	t	0.015	a,n			2.5	k,m	7	k,m
Cesium-137	0.011	t	0.015	a			2.5	k,m	7	k,m
Europium-152	0.0105	t	0.25	s			0.25	l	0.25	w
Europium-154	0.0105	t	0.25	s			0.25	l	0.25	w
Europium-155	0.0105	t	0.25	s			0.25	l	0.25	w
Iodine-129	0.00034	t	2	s			2	k,m	0.007	k,m
Potassium-40	9.236	b,m	0.269	a	5.112	a,m	1	k	1	w
Lead-210	0.00019	t	0.078	a,m	0.045	a,m	0.02	k	0.02	w
Lead-212	0.00019	t	0.078	a,m	0.045	a,m	0.02	k	0.02	w
Lead-214	0.00019	t	0.078	a,m	0.045	a,m	0.02	k	0.02	w
Sodium-22	0.618	b,m	64.503	a,m	10.223	a,m	4	k	4	w
Neptunium-237	0.009	t	0.009	s			0.00384	i,m	0.00384	w
Protactinium-234m	0.000625	l,m	0.05	s			0.05	l	0.05	w
Plutonium-238	0.0003	t	2.5	a,n	6.467	a,n	0.0005	r	0.0021	k,m
Plutonium-239	0.0003	t	0.00912	j	6.467	a,n	0.0005	r	0.0021	k,m
Plutonium-239/40	5.2	b	2.5	a	6.467	a	0.0005	r	0.0021	k,m
Radium-223	0.00375	l,m	0.075	s			0.045	k	0.045	w
Radium-224	0.00375	l,m	0.075	s			0.045	k	0.045	w
Radium-226	0.00375	l,m	0.075	s			0.045	k	0.045	w
Radium-228	0.00375	l,m	0.075	s			0.045	k	0.045	w
Radon-219										

Table 9.4 (Continued)

Radionuclide	Soil to Plant BTF* (wet wt.)	Ref	Soil to Worm BTF* (wet wt.)	Ref	BAFs for Mammal Soil-to-Tissue	Ref	BAFs for Mammal Food-to-tissue	Ref	BAFs for Bird Food-to-tissue	Ref
Strontium-90	0.495	t	0.278	a,m	0.026	a,m	0.4	k	0.4	w
Technetium-99	76		76				0.0005		0.0005	
Thorium-228	0.0009	t	0.005	s	0.000032	c	0.005	r	0.005	w
Thorium-230	0.0009	t	0.005	s	0.000032	c	0.005	r	0.005	w
Thorium-232	0.0009	t	0.005	s	0.000032	c	0.005	r	0.005	w
Thorium-234	0.0009	t	0.005	s	0.000032	c	0.005	r	0.005	w
Thallium-208	0.001	l,m	2	s			2	l	2	w
Tin-126	0.3		0.3				0.01		0.01	
Tritium	1		1				1		1	
Uranium-232	1.965	t	0.063	a,m	0.00032	c	0.015	k	0.7	k,m
Uranium-233	1.965	t	0.063	a,m	0.00032	c	0.015	k	0.7	k,m
Uranium-233/234	1.965	t	0.063	a,m	0.00032	c	0.015	k	0.7	k,m
Uranium-234	1.965	t	0.063	a,m	0.00032	c	0.015	k	0.7	k,m
Uranium-234/235	1.965	t	0.063	a,m	0.00032	c	0.015	k	0.7	k,m
Uranium-235	1.965	t	0.063	a,m	0.00032	c	0.015	k	0.7	k,m
Uranium-235/236	1.965	t	0.063	a,m	0.00032	c	0.015	k	0.7	k,m
Uranium-238	1.965	t	0.063	a,m	0.00032	c	0.015	k	0.7	k,m

* Biotransfer factor

a = Sample et al. (1996b)

b = Efroymson et al. (1996b)

c = Garten et at., 1987

i = Trabalka and Garten, 1983

j = Garten and Dahlman, 1978

k = IAEA 1994

l = Baes et al., 1984

m = Elemental form of the Analyte was used for isotope.

r = NCRP 1989

s = Uptake factor for earthworms was unavailable. Used the larger of the plant BAFs and small mammal values.

t = surrogate maximum plant value was used

u = EPA 1990

w = surrogate mammal BAF was used

Ref = Source

Table 9.5. Equations for estimation of internal and external dose rates for aquatic organisms (Blaylock et al. 1993).

Estimation of internal dose rate:

	Radiation Type		
Receptor Type	α	β	γ
Small insects	$D_\alpha = 5.76*10^{-4}E_\alpha C_o$	$D_\beta = 5.76*10^{-4}E_\beta \Phi C_o$	$D_\gamma = 5.76*10^{-4}E_\gamma \Phi C_o$
Large insects	"	"	"
Small fish	"	"	"
Large fish	"	$D_\beta = 5.76*10^{-4}E_\beta C_o$	"

Estimation of external dose rate from water:

Receptor Type	α	β	γ
Small insects	ns	$D_\beta = 5.76*10^{-4}E_\beta(1-\Phi)C_w$	$D_\gamma = 5.76*10^{-4}E_\gamma(1-\Phi)C_w$
Large insects	ns	"	"
Small fish	ns	"	"
Large fish	ns	ns	"

Estimation of external dose rate from sediment:

Receptor Type	α	β	γ
Small insects	ns	$D_\beta = 2.88*10^{-4}E_\beta(1-\Phi)C_s R$	$D_\gamma = 2.88*10^{-4}E_\gamma(1-\Phi)C_s R$
Large insects	ns	"	"
Small fish	ns	"	"
Large fish	ns	ns	"

D_α = Dose rate for α-radiation (uGy/h) from radionuclide i.
D_β = Dose rate for β-radiation (uGy/h) from radionuclide i.
D_γ = Dose rate for γ-radiation (uGy/h) from radionuclide i.
E_α = Average energy of decay (MeV) for alpha particles from radionuclide I. Obtained from ICRP (1983).
E_β = Average energy of decay (MeV) for beta particles from radionuclide i. Obtained from ICRP (1983).
E_γ = Average energy of decay (MeV) for gamma particles from radionuclide i. Obtained from ICRP (1983).
Φ = Absorbed fraction of photon energy emitted by the source (unitless). Obtained from Blaylock et al. (1993).
C_o = Concentration of radionuclide in the organism (Bq/kg wet weight). Estimated by multiplying bioconcentration factors provided in Blaylock et al. (1993) by radionuclide activity in water.
C_w = Concentration of radionuclide in water (Bq/L)
C_s = Concentration of radionuclide in sediment (Bq/kg wet weight)
R = Fraction of time the organism spends at the sediment-water interface. Assumed 1 for small and large aquatic insects; assumed 0.5 for small and large fish.
ns = Exposure of organism to radiation of this type is not considered significant

Table 9.6a. Estimated radiation doses (mrad/d) from surface soil for soil invertebrates, plants, and short-tailed shrew at WOC

Radionuclide[a]	Soil Activity[b] (pCi/g)	Soil invertebrates			Plants			Short-tailed shrew		
		Internal	External	Total	Internal	External	Total	Internal	External	Total
East Seep										
Actinium-228	7.80E-01	1.74E-05	6.06E-02	6.07E-02	1.74E-05	7.72E-03	7.73E-03	4.69E-07	2.18E-02	2.18E-02
Bismuth-214	7.90E-01	1.25E-01	9.20E-02	2.17E-01	5.47E-02	1.23E-02	6.70E-02	1.89E-02	3.45E-02	5.34E-02
Cesium-137	7.00E+05	1.37E+02	3.07E+04	3.08E+04	1.01E+02	4.08E+03	4.18E+03	3.34E+03	1.15E+04	1.48E+04
Cobalt-60	9.28E+00	1.62E-02	1.30E+00	1.31E+00	6.67E-04	2.41E-01	2.42E-01	5.81E-04	6.74E-01	6.75E-01
Lead-212	7.05E+00	4.41E+00	9.14E-01	5.33E+00	1.08E-02	1.17E-01	1.27E-01	2.55E+00	3.22E-01	2.87E+00
Lead-214	8.80E-01	3.80E-03	1.28E-01	1.32E-01	9.27E-06	1.59E-02	1.59E-02	2.12E-03	4.46E-02	4.67E-02
Plutonium-238	1.40E-02	1.97E-01	9.78E-06	1.97E-01	2.36E-05	4.05E-09	2.36E-05	5.09E-01	6.07E-09	5.09E-01
Plutonium-239/40	4.40E-02	5.80E-01	2.13E-05	5.80E-01	1.21E+00	2.40E-08	1.21E+00	1.50E+00	3.60E-08	1.50E+00
Potassium-40	2.53E+01	1.83E-01	9.24E-01	1.11E+00	6.27E+00	4.14E-02	6.31E+00	3.48E+00	1.15E-01	3.59E+00
Strontium-90	4.32E+01	6.95E-01	2.63E+00	3.32E+00	1.24E+00	1.92E-03	1.24E+00	6.51E-02	2.87E-03	6.80E-02
Thallium-208	2.16E+00	1.38E-01	4.61E-01	6.00E-01	6.91E-05	7.49E-02	7.50E-02	2.98E-01	2.10E-01	5.08E-01
Thorium-228	9.60E+00	1.57E+00	1.26E+00	2.84E+00	2.83E-01	1.60E-01	4.43E-01	1.66E-02	4.41E-01	4.58E-01
Thorium-230	8.30E-01	1.99E-02	7.59E-04	2.06E-02	3.57E-03	1.90E-06	3.58E-03	2.10E-04	2.85E-06	2.13E-04
Thorium-232	8.10E-01	1.67E-02	6.43E-02	8.10E-02	3.00E-03	8.01E-03	1.10E-02	1.76E-04	2.26E-02	2.28E-02
Thorium-234	3.45E+00	6.83E+01	1.02E-01	6.84E+01	2.13E+03	7.18E-04	2.13E+03	3.70E-01	1.08E-03	3.71E-01
Uranium-232	1.08E+01	3.69E+00	1.10E-02	3.71E+00	1.15E+02	1.87E-05	1.15E+02	2.00E-02	2.80E-05	2.00E-02
Uranium-233/234	2.08E+02	6.46E+01	7.83E-02	6.47E+01	2.02E+03	5.40E-04	2.02E+03	3.50E-01	8.10E-04	3.51E-01
Uranium-235	2.51E+00	7.12E-01	2.77E-02	7.40E-01	2.22E+01	3.37E-03	2.22E+01	3.85E-03	1.03E-02	1.42E-02
Uranium-238	1.05E+01	2.87E+00	5.19E-01	3.39E+00	8.94E+01	2.47E-03	8.94E+01	1.55E-02	5.94E-03	2.15E-02
Total		2.85E+02	3.07E+04	3.10E+04	4.48E+03	4.08E+03	8.56E+03	3.35E+03	1.15E+04	1.48E+04
Haw Ridge										
Cobalt-60	4.70E+00	8.20E-03	6.57E-01	6.65E-01	3.38E-04	1.22E-01	1.22E-01	2.94E-04	3.41E-01	3.42E-01
Cesium-137	2.00E+03	3.92E-01	8.77E+01	8.81E+01	2.87E-01	1.16E+01	1.19E+01	9.55E+00	3.27E+01	4.23E+01
Potassium-40	1.60E+01	1.16E-01	5.84E-01	7.00E-01	3.97E+00	2.62E-02	3.99E+00	2.20E+00	7.29E-02	2.27E+00
Total		5.15E-01	8.90E+01	8.95E+01	4.25E+00	1.18E+01	1.60E+01	1.17E+01	3.31E+01	4.49E+01
HF-2										
Cobalt-60	1.94E+02	3.38E-01	2.71E+01	2.75E+01	1.39E-02	5.04E+00	5.05E+00	1.21E-02	1.41E+01	1.41E+01

Table 9.6a. (continued)

Radionuclide[a]	Soil Activity[b] (pCi/g)	Soil invertebrates			Plants			Short-tailed shrew		
		Internal	External	Total	Internal	External	Total	Internal	External	Total
Strontium-90	7.40E-02	1.19E-03	4.50E-03	5.69E-03	2.12E-03	3.28E-06	2.12E-03	1.12E-04	4.92E-06	1.16E-04
Thorium-228	1.40E+00	2.29E-01	1.84E-01	4.14E-01	4.13E-02	2.33E-02	6.46E-02	2.42E-03	6.43E-02	6.67E-02
Thorium-230	1.30E+00	3.11E-02	1.19E-03	3.23E-02	5.60E-03	2.98E-06	5.60E-03	3.29E-04	4.47E-06	3.33E-04
Thorium-232	1.40E+00	2.88E-02	1.11E-01	1.40E-01	5.19E-03	1.38E-02	1.90E-02	3.05E-04	3.90E-02	3.93E-02
Uranium-233/234	1.10E+00	3.42E-01	4.14E-04	3.42E-01	1.07E+01	2.85E-06	1.07E+01	1.85E-03	4.28E-06	1.85E-03
Uranium-235	1.10E-01	3.12E-02	1.21E-03	3.24E-02	9.74E-01	1.48E-04	9.74E-01	1.69E-04	4.52E-04	6.21E-04
Uranium-238	8.70E-01	2.38E-01	4.30E-02	2.81E-01	7.41E+00	2.05E-04	7.41E+00	1.29E-03	4.93E-04	1.78E-03
Total		1.24E+00	2.75E+01	2.87E+01	1.91E+01	5.08E+00	2.42E+01	1.86E-02	1.42E+01	1.42E+01
HFIR										
Cobalt-60	4.64E+00	8.09E-03	6.49E-01	6.57E-01	3.34E-04	1.21E-01	1.21E-01	2.91E-04	3.37E-01	3.37E-01
Cesium-137	5.07E+01	9.93E-03	2.22E+00	2.23E+00	7.28E-03	2.95E-01	3.03E-01	2.42E-01	8.29E-01	1.07E+00
Potassium-40	1.95E+01	1.41E-01	7.12E-01	8.53E-01	4.83E+00	3.19E-02	4.87E+00	2.68E+00	8.88E-02	2.77E+00
Strontium-90	2.50E+04	4.02E+02	1.52E+03	1.92E+03	7.17E+02	1.11E+00	7.18E+02	3.77E+01	1.66E+00	3.93E+01
Thorium-228	6.50E+01	1.06E+01	8.56E+00	1.92E+01	1.92E+00	1.08E+00	3.00E+00	1.12E-01	2.99E+00	3.10E+00
Uranium-234	3.50E+00	1.07E+00	2.82E-03	1.08E+00	3.35E+01	2.68E-06	3.35E+01	5.81E-03	4.03E-06	5.82E-03
Uranium-238	2.10E+00	5.73E-01	1.04E-01	6.77E-01	1.79E+01	4.95E-04	1.79E+01	3.10E-03	1.19E-03	4.29E-03
Total		4.15E+02	1.53E+03	1.95E+03	7.75E+02	2.64E+00	7.77E+02	4.07E+01	5.90E+00	4.66E+01
HFIR East										
Potassium-40	2.00E+01	1.44E-01	7.30E-01	8.74E-01	4.96E+00	3.28E-02	4.99E+00	2.75E+00	9.11E-02	2.84E+00
Total		1.44E-01	7.30E-01	8.74E-01	4.96E+00	3.28E-02	4.99E+00	2.75E+00	9.11E-02	2.84E+00
HRE										
Actinium-228	1.27E+00	2.84E-05	9.87E-02	9.88E-02	2.84E-05	1.26E-02	1.26E-02	7.64E-07	3.54E-02	3.54E-02
Bismuth-214	7.41E-01	1.17E-01	8.63E-02	2.04E-01	5.13E-02	1.16E-02	6.29E-02	1.77E-02	3.24E-02	5.01E-02
Cesium-137	3.84E+03	7.52E-01	1.68E+02	1.69E+02	5.51E-01	2.24E+01	2.29E+01	1.83E+01	6.28E+01	8.12E+01
Cobalt-60	4.35E-01	7.59E-04	6.08E-02	6.16E-02	3.13E-05	1.13E-02	1.13E-02	2.72E-05	3.16E-02	3.16E-02
Europium-154	1.25E+00	6.36E-03	1.03E-01	1.09E-01	2.67E-04	1.84E-02	1.87E-02	1.87E-03	4.85E-02	5.04E-02
Potassium-40	1.82E+01	1.31E-01	6.64E-01	7.96E-01	4.51E+00	2.98E-02	4.54E+00	2.50E+00	8.29E-02	2.58E+00

Table 9.6a. (continued)

Radionuclide[a]	Soil Activity[b] (pCi/g)	Soil invertebrates			Plants			Short-tailed shrew		
		Internal	External	Total	Internal	External	Total	Internal	External	Total
Radium-226	1.03E+00	1.90E+00	1.51E-01	2.05E+00	9.50E-02	1.86E-02	1.14E-01	2.34E-01	5.23E-02	2.86E-01
Radium-228	1.37E+00	8.94E-05	1.25E-03	1.34E-03	4.47E-06		4.47E-06	1.10E-05		1.10E-05
Strontium-90	2.03E+02	3.27E+00	1.23E+01	1.56E+01	5.82E+00	9.00E-03	5.83E+00	3.06E-01	1.35E-02	3.19E-01
Thallium-208	4.39E-01	2.81E-02	9.38E-02	1.22E-01	1.40E-05	1.52E-02	1.52E-02	6.05E-02	4.28E-02	1.03E-01
Thorium-228	5.50E-01	9.01E-02	7.24E-02	1.62E-01	1.62E-02	9.16E-03	2.54E-02	9.52E-04	2.53E-02	2.62E-02
Thorium-230	1.30E-01	3.11E-03	1.19E-04	3.23E-03	5.60E-04	2.98E-07	5.60E-04	3.29E-05	4.47E-07	3.33E-05
Thorium-232	1.50E+00	3.09E-02	1.19E-01	1.50E-01	5.56E-03	1.48E-02	2.04E-02	3.26E-04	4.18E-02	4.22E-02
Thorium-234	2.56E+00	7.71E+00	2.48E-02	7.73E+00	2.40E+02	9.27E-04	2.40E+02	4.17E-02	2.55E-03	4.43E-02
Uranium-233/234	2.43E+01	7.55E+00	9.14E-03	7.56E+00	2.36E+02	6.31E-05	2.36E+02	4.09E-02	9.46E-05	4.10E-02
Uranium-235	5.55E-01	1.57E-01	6.12E-03	1.64E-01	4.91E+00	7.46E-04	4.91E+00	8.52E-04	2.28E-03	3.13E-03
Uranium-238	1.29E+00	3.52E-01	6.37E-02	4.16E-01	1.10E+01	3.04E-04	1.10E+01	1.91E-03	7.30E-04	2.64E-03
Total		2.21E+01	1.82E+02	2.04E+02	5.03E+02	2.25E+01	5.25E+02	2.15E+01	6.32E+01	8.48E+01
Intermediate Pond										
Americium-241	3.06E+01	6.26E+02	1.40E-01	6.26E+02	4.28E+02	2.57E-03	4.28E+02	4.77E+02	1.74E-02	4.77E+02
Curium-244	5.72E+00	3.01E+01	3.38E-03	3.01E+01	3.71E+01	1.38E-06	3.71E+01	9.14E+01	2.07E-06	9.14E+01
Cobalt-60	1.31E+01	2.28E-02	1.83E+00	1.85E+00	9.42E-04	3.40E-01	3.41E-01	8.20E-04	9.51E-01	9.52E-01
Cesium-137	6.35E+03	1.24E+00	2.79E+02	2.80E+02	9.12E-01	3.70E+01	3.79E+01	3.03E+01	1.04E+02	1.34E+02
Plutonium-238	2.20E+00	3.09E+01	1.54E-03	3.09E+01	3.71E-03	6.36E-07	3.71E-03	7.99E+01	9.54E-07	7.99E+01
Plutonium-239/40	9.49E+01	1.25E+03	4.59E-02	1.25E+03	2.60E+03	5.17E-05	2.60E+03	3.24E+03	7.75E-05	3.24E+03
Strontium-90	2.48E+02	3.99E+00	1.51E+01	1.91E+01	7.11E+00	1.10E-02	7.12E+00	3.74E-01	1.65E-02	3.90E-01
Technetium-99	4.66E+00	1.83E+00	2.53E-02	1.86E+00	1.83E+00	1.12E-06	1.83E+00	9.18E-04	1.68E-06	9.19E-04
Thorium-228	5.08E+00	8.32E-01	6.69E-01	1.50E+00	1.50E-01	8.46E-02	2.34E-01	8.79E-03	2.33E-01	2.42E-01
Thorium-230	1.86E+01	4.45E-01	1.70E-02	4.62E-01	8.01E-02	4.26E-05	8.01E-02	4.70E-03	6.39E-05	4.77E-03
Thorium-232	5.28E+00	1.09E-01	4.19E-01	5.28E-01	1.96E-02	5.22E-02	7.18E-02	1.15E-03	1.47E-01	1.48E-01
Uranium-233/234	3.89E+01	1.21E+01	1.46E-02	1.21E+01	3.77E+02	1.01E-04	3.77E+02	6.54E-02	1.51E-04	6.56E-02
Uranium-235	5.29E+00	1.50E+00	5.83E-02	1.56E+00	4.68E+01	7.11E-03	4.68E+01	8.12E-03	2.18E-02	2.99E-02
Uranium-238	1.24E+01	3.39E+00	6.13E-01	4.00E+00	1.06E+02	2.92E-03	1.06E+02	1.83E-02	7.02E-03	2.53E-02
Total		1.96E+03	2.97E+02	2.26E+03	3.61E+03	3.75E+01	3.64E+03	3.91E+03	1.05E+02	4.02E+03

Table 9.6a. (continued)

Radionuclide[a]	Soil Activity[b] (pCi/g)	Soil invertebrates			Plants			Short-tailed shrew		
		Internal	External	Total	Internal	External	Total	Internal	External	Total
Lower WOC										
Americium-241	6.38E+00	1.31E+02	2.92E-02	1.31E+02	8.91E+01	5.35E-04	8.91E+01	9.95E+01	3.63E-03	9.95E+01
Curium-244	2.28E+00	1.20E+01	1.35E-03	1.20E+01	1.48E+01	5.51E-07	1.48E+01	3.64E+01	8.26E-07	3.64E+01
Cobalt-60	1.55E+01	2.70E-02	2.17E+00	2.19E+00	1.11E-03	4.03E-01	4.04E-01	9.71E-04	1.13E+00	1.13E+00
Cesium-137	8.68E+02	1.70E-01	3.81E+01	3.82E+01	1.25E-01	5.05E+00	5.18E+00	4.14E+00	1.42E+01	1.83E+01
Plutonium-238	1.14E+00	1.60E+01	7.97E-04	1.60E+01	1.92E-03	3.30E-07	1.92E-03	4.14E+01	4.95E-07	4.14E+01
Plutonium-239/40	4.51E+01	5.94E+02	2.18E-02	5.94E+02	1.24E+03	2.46E-05	1.24E+03	1.54E+03	3.69E-05	1.54E+03
Strontium-90	3.10E+01	4.99E-01	1.88E+00	2.38E+00	8.89E-01	1.37E-03	8.90E-01	4.67E-02	2.06E-03	4.88E-02
Technetium-99	1.47E+01	5.78E+00	7.98E-02	5.86E+00	5.78E+00	3.53E-06	5.78E+00	2.90E-03	5.29E-06	2.90E-03
Thorium-228	3.80E+00	6.22E-01	5.00E-01	1.12E+00	1.12E-01	6.33E-02	1.75E-01	6.58E-03	1.75E-01	1.81E-01
Thorium-230	4.84E+00	1.16E-01	4.42E-03	1.20E-01	2.08E-02	1.11E-05	2.08E-02	1.22E-03	1.66E-05	1.24E-03
Thorium-232	1.80E+00	3.71E-02	1.43E-01	1.80E-01	6.67E-03	1.78E-02	2.45E-02	3.92E-04	5.02E-02	5.06E-02
Uranium-233/234	4.94E+00	1.54E+00	1.86E-03	1.54E+00	4.79E+01	1.28E-05	4.79E+01	8.31E-03	1.92E-05	8.32E-03
Uranium-235	6.15E-01	1.75E-01	6.78E-03	1.81E-01	5.44E+00	8.27E-04	5.44E+00	9.44E-04	2.53E-03	3.47E-03
Uranium-238	2.10E+00	5.73E-01	1.04E-01	6.77E-01	1.79E+01	4.95E-04	1.79E+01	3.10E-03	1.19E-03	4.29E-03
Total		7.62E+02	4.30E+01	8.05E+02	1.42E+03	5.54E+00	1.42E+03	1.72E+03	1.56E+01	1.73E+03
MB-15										
Cobalt-60	4.20E+04	7.32E+01	5.87E+03	5.95E+03	3.02E+00	1.09E+03	1.09E+03	2.63E+00	3.05E+03	3.05E+03
Cesium-137	3.80E+02	7.44E-02	1.67E+01	1.67E+01	5.46E-02	2.21E+00	2.27E+00	1.81E+00	6.22E+00	8.03E+00
Total		7.33E+01	5.89E+03	5.96E+03	3.07E+00	1.09E+03	1.10E+03	4.44E+00	3.06E+03	3.06E+03
MV Drive										
Carbon-14	1.80E-01		4.74E-04	4.74E-04	4.52E-04	4.64E-09	4.52E-04	5.87E-05	6.97E-09	5.87E-05
Cobalt-60	1.20E+00	2.09E-03	1.68E-01	1.70E-01	8.63E-05	3.12E-02	3.13E-02	7.51E-05	8.72E-02	8.72E-02
Cesium-137	3.20E+02	6.27E-02	1.40E+01	1.41E+01	4.60E-02	1.86E+00	1.91E+00	1.53E+00	5.23E+00	6.76E+00
Potassium-40	1.20E+01	8.66E-02	4.38E-01	5.25E-01	2.97E+00	1.97E-02	2.99E+00	1.65E+00	5.46E-02	1.70E+00
Tritium	8.50E+00	2.61E-03	2.74E-03	5.35E-03	2.61E-03		2.61E-03	2.95E-03		2.95E-03
Total		1.54E-01	1.46E+01	1.48E+01	3.02E+00	1.91E+00	4.94E+00	3.18E+00	5.38E+00	8.56E+00

Table 9.6a. (continued)

Radionuclide[a]	Soil Activity[b] (pCi/g)	Soil invertebrates			Plants			Short-tailed shrew		
		Internal	External	Total	Internal	External	Total	Internal	External	Total
NHF										
Americium-241	1.10E-01	2.25E+00	5.03E-04	2.25E+00	1.54E+00	9.23E-06	1.54E+00	1.71E+00	6.26E-05	1.71E+00
Carbon-14	2.07E+00		5.45E-03	5.45E-03	5.19E-03	5.34E-08	5.19E-03	6.75E-04	8.01E-08	6.75E-04
Cesium-137	1.40E-01	2.74E-05	6.14E-03	6.17E-03	2.01E-05	8.15E-04	8.35E-04	6.68E-04	2.29E-03	2.96E-03
Potassium-40	2.66E+01	1.92E-01	9.71E-01	1.16E+00	6.59E+00	4.36E-02	6.64E+00	3.65E+00	1.21E-01	3.77E+00
Plutonium-238	2.60E-01	3.65E+00	1.82E-04	3.65E+00	4.38E-04	7.52E-08	4.38E-04	9.45E+00	1.13E-07	9.45E+00
Plutonium-239/40	5.00E-02	6.59E-01	2.42E-05	6.59E-01	1.37E+00	2.72E-08	1.37E+00	1.70E+00	4.09E-08	1.70E+00
Radium-226	9.50E-01	1.75E+00	1.39E-01	1.89E+00	8.76E-02	1.72E-02	1.05E-01	2.16E-01	4.82E-02	2.64E-01
Radium-228	1.70E+00	1.11E-04	1.55E-03	1.66E-03	5.55E-06		5.55E-06	1.37E-05		1.37E-05
Strontium-90	9.10E-01	1.46E-02	5.53E-02	7.00E-02	2.61E-02	4.04E-05	2.61E-02	1.37E-03	6.05E-05	1.43E-03
Thorium-228	2.42E+00	3.96E-01	3.19E-01	7.15E-01	7.13E-02	4.03E-02	1.12E-01	4.19E-03	1.11E-01	1.15E-01
Thorium-230	1.28E+00	3.06E-02	1.17E-03	3.18E-02	5.51E-03	2.93E-06	5.51E-03	3.24E-04	4.40E-06	3.28E-04
Thorium-232	1.55E+00	3.19E-02	1.23E-01	1.55E-01	5.74E-03	1.53E-02	2.11E-02	3.37E-04	4.32E-02	4.36E-02
Tritium	7.99E+00	2.45E-03	2.58E-03	5.03E-03	2.45E-03		2.45E-03	2.77E-03		2.77E-03
Uranium-233/234	9.70E-01	3.01E-01	3.65E-04	3.02E-01	9.40E+00	2.52E-06	9.40E+00	1.63E-03	3.78E-06	1.63E-03
Uranium-235/236	8.00E-02	2.87E-01	1.46E-03	2.89E-01	8.97E+00	1.08E-04	8.97E+00	1.56E-03	3.29E-04	1.88E-03
Uranium-238	9.80E-01	2.68E-01	4.84E-02	3.16E-01	8.35E+00	2.31E-04	8.35E+00	1.45E-03	5.55E-04	2.00E-03
Total		9.84E+00	1.67E+00	1.15E+01	3.64E+01	1.18E-01	3.65E+01	1.68E+01	3.27E-01	1.71E+01
Pit 4 South										
Americium-241	1.10E-01	2.25E+00	5.03E-04	2.25E+00	1.54E+00	9.23E-06	1.54E+00	1.71E+00	6.26E-05	1.71E+00
Cobalt-60	2.34E+02	4.08E-01	3.27E+01	3.31E+01	1.68E-02	6.08E+00	6.10E+00	1.47E-02	1.70E+01	1.70E+01
Cesium-137	1.34E+01	2.62E-03	5.88E-01	5.90E-01	1.92E-03	7.80E-02	8.00E-02	6.40E-02	2.19E-01	2.83E-01
Plutonium-238	6.70E-03	9.41E-02	4.68E-06	9.41E-02	1.13E-05	1.94E-09	1.13E-05	2.43E-01	2.91E-09	2.43E-01
Plutonium-239/40	2.90E-02	3.82E-01	1.40E-05	3.82E-01	7.95E-01	1.58E-08	7.95E-01	9.89E-01	2.37E-08	9.89E-01
Strontium-90	1.00E+00	1.61E-02	6.08E-02	7.69E-02	2.87E-02	4.43E-05	2.87E-02	1.51E-03	6.65E-05	1.57E-03
Thorium-228	6.40E+00	1.05E+00	8.42E-01	1.89E+00	1.89E-01	1.07E-01	2.95E-01	1.11E-02	2.94E-01	3.05E-01
Thorium-230	1.20E+00	2.87E-02	1.10E-03	2.98E-02	5.17E-03	2.75E-06	5.17E-03	3.03E-04	4.12E-06	3.07E-04
Thorium-232	1.50E+00	3.09E-02	1.19E-01	1.50E-01	5.56E-03	1.48E-02	2.04E-02	3.26E-04	4.18E-02	4.22E-02
Uranium-233/234	8.50E+00	2.64E+00	3.20E-03	2.64E+00	8.24E+01	2.21E-05	8.24E+01	1.43E-02	3.31E-05	1.43E-02

Table 9.6a. (continued)

Radionuclide[a]	Soil Activity[b] (pCi/g)	Soil invertebrates			Plants			Short-tailed shrew		
		Internal	External	Total	Internal	External	Total	Internal	External	Total
Uranium-235	9.80E-02	2.78E-02	1.08E-03	2.89E-02	8.67E-01	1.32E-04	8.67E-01	1.50E-04	4.03E-04	5.53E-04
Uranium-238	3.10E-01	8.46E-02	1.53E-02	1.00E-01	2.64E+00	7.30E-05	2.64E+00	4.58E-04	1.76E-04	6.33E-04
Total		7.01E+00	3.44E+01	4.14E+01	8.85E+01	6.28E+00	9.48E+01	3.05E+00	1.76E+01	2.06E+01
SWSA 5 Seep A										
Actinium-228	1.90E+00	4.24E-05	1.48E-01	1.48E-01	4.24E-05	1.88E-02	1.88E-02	1.14E-06	5.30E-02	5.30E-02
Americium-241	1.24E+00	2.54E+01	5.67E-03	2.54E+01	1.73E+01	1.04E-04	1.73E+01	1.93E+01	7.06E-04	1.93E+01
Bismuth-214	6.90E-01	1.09E-01	8.04E-02	1.90E-01	4.78E-02	1.08E-02	5.86E-02	1.65E-02	3.02E-02	4.66E-02
Calcium-45	3.00E+01	2.24E-01	1.24E-01	3.48E-01	4.57E-01	3.60E-06	4.57E-01	1.11E+00	5.40E-06	1.11E+00
Carbon-14	1.51E+00		3.98E-03	3.98E-03	3.79E-03	3.90E-08	3.79E-03	4.93E-04	5.84E-08	4.93E-04
Cesium-137	3.15E+00	6.17E-04	1.38E-01	1.39E-01	4.52E-04	1.83E-02	1.88E-02	1.50E-02	5.15E-02	6.66E-02
Iodine-129	3.40E+00	2.31E-02	1.63E-02	3.93E-02	3.92E-06	8.44E-05	8.84E-05	4.98E-02	1.27E-03	5.11E-02
Lead-212	1.90E+00	1.19E+00	2.46E-01	1.44E+00	2.90E-03	3.14E-02	3.43E-02	6.87E-01	8.67E-02	7.73E-01
Lead-214	9.80E-01	6.06E-01	1.43E-01	7.49E-01	1.48E-03	1.77E-02	1.91E-02	3.49E-01	4.97E-02	3.99E-01
Potassium-40	2.19E+01	1.58E-01	7.99E-01	9.58E-01	5.43E+00	3.59E-02	5.47E+00	3.01E+00	9.97E-02	3.11E+00
Plutonium-238	3.20E-01	4.50E+00	2.24E-04	4.50E+00	5.39E-04	9.26E-08	5.40E-04	1.16E+01	1.39E-07	1.16E+01
Plutonium-239/40	1.77E+00	2.33E+01	8.56E-04	2.33E+01	4.85E+01	9.64E-07	4.85E+01	6.03E+01	1.45E-06	6.03E+01
Radium-223	5.70E-01	2.48E-01	6.44E-03	2.55E-01	1.24E-02	6.33E-04	1.30E-02	3.06E-02	1.98E-03	3.26E-02
Radium-224	3.40E+00	6.94E+00	4.43E-01	7.38E+00	3.47E-01	5.66E-02	4.04E-01	8.56E-01	1.56E-01	1.01E+00
Radium-226	1.01E+00	1.86E+00	1.48E-01	2.01E+00	9.31E-02	1.83E-02	1.11E-01	2.30E-01	5.13E-02	2.81E-01
Radium-228	1.65E+00	1.08E-04	1.51E-03	1.62E-03	5.39E-06		5.39E-06	1.33E-05		1.33E-05
Radon-219	7.30E-01									
Strontium-90	1.33E+02	2.14E+00	8.09E+00	1.02E+01	3.81E+00	5.90E-03	3.82E+00	2.00E-01	8.85E-03	2.09E-01
Thorium-228	1.54E+00	2.52E-01	2.03E-01	4.55E-01	4.54E-02	2.56E-02	7.10E-02	2.66E-03	7.07E-02	7.34E-02
Thorium-230	1.65E+00	3.95E-02	1.51E-03	4.10E-02	7.10E-03	3.78E-06	7.11E-03	4.17E-04	5.67E-06	4.23E-04
Thorium-232	1.59E+00	3.27E-02	1.26E-01	1.59E-01	5.89E-03	1.57E-02	2.16E-02	3.46E-04	4.43E-02	4.47E-02
Thallium-208	1.40E+00	8.96E-02	2.99E-01	3.89E-01	4.48E-05	4.86E-02	4.86E-02	1.93E-01	1.36E-01	3.29E-01
Tin-126	1.80E-01	4.77E-04	2.22E-03	2.69E-03	4.77E-04	5.10E-05	5.28E-04	6.89E-06	2.14E-04	2.21E-04
Tritium	2.95E+02	9.06E-02	9.52E-02	1.86E-01	9.06E-02		9.06E-02	1.02E-01		1.02E-01
Uranium-232	1.50E-01	5.13E-02	1.53E-04	5.15E-02	1.60E+00	2.60E-07	1.60E+00	2.78E-04	3.89E-07	2.78E-04

Table 9.6a. (continued)

Radionuclide[a]	Soil Activity[b] (pCi/g)	Soil invertebrates			Plants			Short-tailed shrew		
		Internal	External	Total	Internal	External	Total	Internal	External	Total
Uranium-233/234	5.65E+00	1.76E+00	2.13E-03	1.76E+00	5.48E+01	1.47E-05	5.48E+01	9.50E-03	2.20E-05	9.52E-03
Uranium-238	1.02E+00	2.78E-01	5.04E-02	3.29E-01	8.69E+00	2.40E-04	8.69E+00	1.51E-03	5.77E-04	2.08E-03
Total		6.93E+01	1.12E+01	8.05E+01	1.41E+02	3.05E-01	1.42E+02	9.82E+01	8.43E-01	9.90E+01
SWSA 5 Seep B West										
Americium-241	6.78E+00	1.39E+02	3.10E-02	1.39E+02	9.47E+01	5.69E-04	9.47E+01	1.06E+02	3.86E-03	1.06E+02
Carbon-14	2.77E+01		7.30E-02	7.30E-02	6.95E-02	7.15E-07	6.95E-02	9.04E-03	1.07E-06	9.04E-03
Curium-244	3.56E+01	1.87E+02	2.11E-02	1.87E+02	2.31E+02	8.60E-06	2.31E+02	5.69E+02	1.29E-05	5.69E+02
Cobalt-60	2.24E+02	3.91E-01	3.13E+01	3.17E+01	1.61E-02	5.82E+00	5.84E+00	1.40E-02	1.63E+01	1.63E+01
Cesium-137	1.37E+01	2.68E-03	6.01E-01	6.04E-01	1.97E-03	7.98E-02	8.18E-02	6.54E-02	2.24E-01	2.90E-01
Potassium-40	3.20E+01	2.31E-01	1.17E+00	1.40E+00	7.93E+00	5.24E-02	7.99E+00	4.40E+00	1.46E-01	4.54E+00
Plutonium-238	8.90E-01	1.25E+01	6.22E-04	1.25E+01	1.50E-03	2.57E-07	1.50E-03	3.23E+01	3.86E-07	3.23E+01
Plutonium-239/40	1.46E+00	1.92E+01	7.06E-04	1.92E+01	4.00E+01	7.95E-07	4.00E+01	4.98E+01	1.19E-06	4.98E+01
Radium-226	3.50E+00	6.45E+00	5.12E-01	6.97E+00	3.23E-01	6.33E-02	3.86E-01	7.95E-01	1.78E-01	9.73E-01
Radium-228	8.60E+00	5.61E-04	7.86E-03	8.42E-03	2.81E-05		2.81E-05	6.92E-05		6.92E-05
Strontium-90	1.03E+04	1.66E+02	6.26E+02	7.92E+02	2.95E+02	4.57E-01	2.96E+02	1.55E+01	6.85E-01	1.62E+01
Thorium-228	1.91E+00	3.13E-01	2.51E-01	5.64E-01	5.63E-02	3.18E-02	8.81E-02	3.30E-03	8.77E-02	9.10E-02
Thorium-230	1.23E+01	2.94E-01	1.12E-02	3.05E-01	5.30E-02	2.82E-05	5.30E-02	3.11E-03	4.23E-05	3.15E-03
Thorium-232	1.55E+00	3.19E-02	1.23E-01	1.55E-01	5.74E-03	1.53E-02	2.11E-02	3.37E-04	4.32E-02	4.36E-02
Tritium	1.90E+03	5.84E-01	6.13E-01	1.20E+00	5.84E-01		5.84E-01	6.60E-01		6.60E-01
Uranium-232	5.30E-01	1.81E-01	5.41E-04	1.82E-01	5.66E+00	9.17E-07	5.66E+00	9.81E-04	1.38E-06	9.82E-04
Uranium-233	1.05E+01	3.26E+00	3.95E-03	3.27E+00	1.02E+02	2.72E-05	1.02E+02	1.77E-02	4.09E-05	1.77E-02
Uranium-238	9.60E-01	2.62E-01	4.74E-02	3.10E-01	8.18E+00	2.26E-04	8.18E+00	1.42E-03	5.44E-04	1.96E-03
Total		5.35E+02	6.61E+02	1.20E+03	7.86E+02	6.52E+00	7.92E+02	7.78E+02	1.76E+01	7.96E+02
SWSA 5 Seep B East										
Actinium-228	1.10E+00	2.46E-05	8.55E-02	8.55E-02	2.46E-05	1.09E-02	1.09E-02	6.62E-07	3.07E-02	3.07E-02
Carbon-14	2.05E+00		5.40E-03	5.40E-03	5.14E-03	5.29E-08	5.14E-03	6.69E-04	7.93E-08	6.69E-04
Cesium-137	6.53E+03	1.28E+00	2.86E+02	2.88E+02	9.38E-01	3.80E+01	3.90E+01	3.12E+01	1.07E+02	1.38E+02
Barium-137m	6.20E+03	3.41E-01	2.21E+02	2.21E+02	2.50E-01	3.80E+01	3.83E+01	8.52E+00	1.07E+02	1.15E+02

Table 9.6a. (continued)

Radionuclide[a]	Soil Activity[b] (pCi/g)	Soil invertebrates			Plants			Short-tailed shrew		
		Internal	External	Total	Internal	External	Total	Internal	External	Total
Lead-212	1.40E+00	8.77E-01	1.82E-01	1.06E+00	2.14E-03	2.32E-02	2.53E-02	5.06E-01	6.39E-02	5.70E-01
Lead-214	9.10E-01	5.63E-01	1.33E-01	6.95E-01	1.37E-03	1.64E-02	1.78E-02	3.24E-01	4.61E-02	3.70E-01
Potassium-40	1.95E+01	1.41E-01	7.12E-01	8.53E-01	4.83E+00	3.19E-02	4.87E+00	2.68E+00	8.88E-02	2.77E+00
Radium-226	1.10E+00	2.03E+00	1.61E-01	2.19E+00	1.01E-01	1.99E-02	1.21E-01	2.50E-01	5.59E-02	3.06E-01
Radium-228	1.10E+00	7.18E-05	1.01E-03	1.08E-03	3.59E-06		3.59E-06	8.85E-06		8.85E-06
Strontium-90	2.80E+01	4.51E-01	1.70E+00	2.15E+00	8.03E-01	1.24E-03	8.04E-01	4.22E-02	1.86E-03	4.41E-02
Thorium-228	1.50E+00	2.46E-01	1.97E-01	4.43E-01	4.42E-02	2.50E-02	6.92E-02	2.60E-03	6.89E-02	7.15E-02
Thorium-232	1.10E+00	2.27E-02	8.73E-02	1.10E-01	4.08E-03	1.09E-02	1.50E-02	2.39E-04	3.07E-02	3.09E-02
Thallium-208	1.40E+00	8.96E-02	2.99E-01	3.89E-01	4.48E-05	4.86E-02	4.86E-02	1.93E-01	1.36E-01	3.29E-01
Tritium	5.28E+01	1.62E-02	1.70E-02	3.33E-02	1.62E-02		1.62E-02	1.83E-02		1.83E-02
Total		6.05E+00	5.11E+02	5.17E+02	7.00E+00	7.62E+01	8.32E+01	4.37E+01	2.14E+02	2.58E+02
SWSA 5 Seep C										
Americium-241	1.10E+00	2.25E+01	5.03E-03	2.25E+01	1.54E+01	9.23E-05	1.54E+01	1.71E+01	6.26E-04	1.71E+01
Calcium-45	5.30E+02	3.96E+00	2.19E+00	6.16E+00	8.08E+00	6.36E-05	8.08E+00	1.96E+01	9.55E-05	1.96E+01
Carbon-14	4.55E+01		1.20E-01	1.20E-01	1.14E-01	1.17E-06	1.14E-01	1.48E-02	1.76E-06	1.48E-02
Curium-244	5.65E+00	2.97E+01	3.34E-03	2.97E+01	3.66E+01	1.36E-06	3.66E+01	9.03E+01	2.05E-06	9.03E+01
Cobalt-60	2.75E+00	4.80E-03	3.85E-01	3.89E-01	1.98E-04	7.15E-02	7.17E-02	1.72E-04	2.00E-01	2.00E-01
Cesium-137	4.30E+02	8.42E-02	1.89E+01	1.89E+01	6.18E-02	2.50E+00	2.57E+00	2.05E+00	7.03E+00	9.09E+00
Lead-212	3.81E-01	2.39E-01	4.94E-02	2.88E-01	5.81E-04	6.30E-03	6.88E-03	1.38E-01	1.74E-02	1.55E-01
Potassium-40	1.90E+01	1.37E-01	6.94E-01	8.31E-01	4.71E+00	3.11E-02	4.74E+00	2.61E+00	8.65E-02	2.70E+00
Plutonium-238	6.73E-01	9.45E+00	4.70E-04	9.45E+00	1.13E-03	1.95E-07	1.13E-03	2.45E+01	2.92E-07	2.45E+01
Plutonium-239/40	1.91E-01	2.52E+00	9.24E-05	2.52E+00	5.24E+00	1.04E-07	5.24E+00	6.51E+00	1.56E-07	6.51E+00
Radium-226	1.29E+00	2.38E+00	1.89E-01	2.57E+00	1.19E-01	2.33E-02	1.42E-01	2.93E-01	6.55E-02	3.59E-01
Radium-228	1.58E+00	1.03E-04	1.44E-03	1.55E-03	5.16E-06		5.16E-06	1.27E-05		1.27E-05
Strontium-90	1.58E+03	2.54E+01	9.61E+01	1.22E+02	4.53E+01	7.01E-02	4.54E+01	2.38E+00	1.05E-01	2.49E+00
Technetium-99	4.17E+00	1.64E+00	2.26E-02	1.66E+00	1.64E+00	1.00E-06	1.64E+00	8.21E-04	1.50E-06	8.23E-04
Thorium-228	1.88E+00	3.08E-01	2.47E-01	5.55E-01	5.54E-02	3.13E-02	8.67E-02	3.25E-03	8.63E-02	8.96E-02
Thorium-230	2.45E+00	5.86E-02	2.24E-03	6.08E-02	1.05E-02	5.61E-06	1.06E-02	6.19E-04	8.42E-06	6.28E-04
Thorium-232	1.73E+00	3.56E-02	1.37E-01	1.73E-01	6.41E-03	1.71E-02	2.35E-02	3.76E-04	4.82E-02	4.86E-02

Table 9.6a. (continued)

Radionuclide[a]	Soil Activity[b] (pCi/g)	Soil invertebrates			Plants			Short-tailed shrew		
		Internal	External	Total	Internal	External	Total	Internal	External	Total
Tritium	5.52E+02	1.70E-01	1.78E-01	3.48E-01	1.70E-01		1.70E-01	1.92E-01		1.92E-01
Uranium-233/234	2.11E+00	6.56E-01	7.94E-04	6.57E-01	2.05E+01	5.48E-06	2.05E+01	3.55E-03	8.21E-06	3.56E-03
Uranium-235	1.80E-01	5.11E-02	1.98E-03	5.31E-02	1.59E+00	2.42E-04	1.59E+00	2.76E-04	7.40E-04	1.02E-03
Uranium-235/236	6.29E-02	4.96E-01	1.74E-03	4.98E-01	1.55E+01	8.49E-05	1.55E+01	2.68E-03	2.59E-04	2.94E-03
Uranium-238	1.77E+00	4.83E-01	8.74E-02	5.71E-01	1.51E+01	4.17E-04	1.51E+01	2.61E-03	1.00E-03	3.62E-03
Total		1.00E+02	1.19E+02	2.20E+02	1.70E+02	2.76E+00	1.73E+02	1.66E+02	7.65E+00	1.73E+02
SWSA 5 Trib 1										
Actinium-228	2.17E+00	4.85E-05	1.69E-01	1.69E-01	4.85E-05	2.15E-02	2.15E-02	1.31E-06	6.05E-02	6.05E-02
Americium-241	4.95E-01	1.01E+01	2.26E-03	1.01E+01	6.92E+00	4.15E-05	6.92E+00	7.72E+00	2.82E-04	7.72E+00
Bismuth-212	2.60E+00	1.17E-01	9.20E-02	2.09E-01	5.12E-02	4.99E-03	5.62E-02	1.77E-02	1.40E-02	3.17E-02
Bismuth-214	9.40E-01	1.49E-01	1.10E-01	2.58E-01	6.51E-02	1.47E-02	7.98E-02	2.25E-02	4.11E-02	6.35E-02
Carbon-14	8.00E-01		2.11E-03	2.11E-03	2.01E-03	2.06E-08	2.01E-03	2.61E-04	3.10E-08	2.61E-04
Cesium-134	4.00E-02	9.10E-06	3.70E-03	3.71E-03	6.67E-06	6.41E-04	6.47E-04	1.36E-04	1.80E-03	1.93E-03
Cobalt-60	9.11E+01	1.59E-01	1.27E+01	1.29E+01	6.55E-03	2.37E+00	2.37E+00	5.70E-03	6.62E+00	6.62E+00
Cesium-137	3.27E+03	6.40E-01	1.43E+02	1.44E+02	4.70E-01	1.90E+01	1.95E+01	1.56E+01	5.35E+01	6.91E+01
Curium-243	1.80E-01	9.48E-01	2.63E-03	9.50E-01	1.17E+00	1.95E-04	1.17E+00	2.49E+00	6.16E-04	2.49E+00
Iodine-129	5.70E+00	3.87E-02	2.73E-02	6.59E-02	6.57E-06	1.42E-04	1.48E-04	8.35E-02	2.13E-03	8.56E-02
Lead-212	1.24E+00	7.77E-01	1.61E-01	9.37E-01	1.89E-03	2.05E-02	2.24E-02	4.48E-01	5.66E-02	5.05E-01
Lead-214	1.13E+00	6.99E-01	1.65E-01	8.63E-01	1.70E-03	2.04E-02	2.21E-02	4.03E-01	5.73E-02	4.60E-01
Potassium-40	2.39E+01	1.73E-01	8.72E-01	1.04E+00	5.93E+00	3.91E-02	5.96E+00	3.28E+00	1.09E-01	3.39E+00
Plutonium-238	3.50E+00	4.92E+01	2.45E-03	4.92E+01	5.90E-03	1.01E-06	5.90E-03	1.27E+02	1.52E-06	1.27E+02
Radium-223	5.60E-01	2.44E-01	6.32E-03	2.50E-01	1.22E-02	6.22E-04	1.28E-02	3.01E-02	1.94E-03	3.20E-02
Radium-226	1.43E+00	2.64E+00	2.09E-01	2.85E+00	1.32E-01	2.59E-02	1.58E-01	3.25E-01	7.26E-02	3.98E-01
Radium-228	1.70E+00	1.11E-04	1.55E-03	1.66E-03	5.55E-06		5.55E-06	1.37E-05		1.37E-05
Strontium-90	2.60E+01	4.19E-01	1.58E+00	2.00E+00	7.45E-01	1.15E-03	7.46E-01	3.92E-02	1.73E-03	4.09E-02
Thorium-228	1.66E+00	2.72E-01	2.18E-01	4.90E-01	4.89E-02	2.76E-02	7.66E-02	2.87E-03	7.62E-02	7.91E-02
Thorium-230	9.36E-01	2.24E-02	8.55E-04	2.32E-02	4.03E-03	2.14E-06	4.03E-03	2.37E-04	3.22E-06	2.40E-04
Thorium-232	1.79E+00	3.69E-02	1.42E-01	1.79E-01	6.63E-03	1.77E-02	2.43E-02	3.89E-04	4.99E-02	5.03E-02
Thallium-208	1.50E+00	9.60E-02	3.20E-01	4.16E-01	4.80E-05	5.20E-02	5.21E-02	2.07E-01	1.46E-01	3.53E-01

Table 9.6a. (continued)

Radionuclide[a]	Soil Activity[b] (pCi/g)	Soil invertebrates			Plants			Short-tailed shrew		
		Internal	External	Total	Internal	External	Total	Internal	External	Total
Thorium-234	7.30E+00	6.45E-03	8.56E-02	9.21E-02	6.35E-03	7.79E-03	1.41E-02	8.10E-05	2.16E-02	2.17E-02
Tin-126	4.60E-01	1.22E-03	5.66E-03	6.88E-03	1.22E-03	1.30E-04	1.35E-03	1.76E-05	5.48E-04	5.65E-04
Tritium	4.82E+00	1.48E-03	1.55E-03	3.04E-03	1.48E-03		1.48E-03	1.67E-03		1.67E-03
Uranium-233/234	4.00E+00	1.24E+00	1.51E-03	1.24E+00	3.88E+01	1.04E-05	3.88E+01	6.73E-03	1.56E-05	6.74E-03
Uranium-238	3.87E+00	1.06E+00	1.91E-01	1.25E+00	3.30E+01	9.11E-04	3.30E+01	5.72E-03	2.19E-03	7.91E-03
Total		6.90E+01	1.61E+02	2.30E+02	8.73E+01	2.17E+01	1.09E+02	1.58E+02	6.08E+01	2.19E+02
SWSA 5 WOC										
Actinium-228	1.80E+00	4.02E-05	1.40E-01	1.40E-01	4.02E-05	1.78E-02	1.78E-02	1.08E-06	5.02E-02	5.02E-02
Americium-241	1.58E-01	3.23E+00	7.22E-04	3.23E+00	2.21E+00	1.33E-05	2.21E+00	2.46E+00	9.00E-05	2.46E+00
Carbon-14	1.99E+00		5.24E-03	5.24E-03	4.99E-03	5.14E-08	4.99E-03	6.49E-04	7.70E-08	6.49E-04
Curium-244	1.51E-01	7.94E-01	8.93E-05	7.94E-01	9.79E-01	3.65E-08	9.79E-01	2.41E+00	5.47E-08	2.41E+00
Cobalt-60	5.34E+00	9.31E-03	7.47E-01	7.56E-01	3.84E-04	1.39E-01	1.39E-01	3.34E-04	3.88E-01	3.88E-01
Cobalt-57	2.30E+00	6.85E-04	1.78E-02	1.85E-02	2.82E-05	2.19E-03	2.22E-03	2.42E-05	7.15E-03	7.18E-03
Cesium-137	4.91E+02	9.62E-02	2.15E+01	2.16E+01	7.05E-02	2.86E+00	2.93E+00	2.34E+00	8.03E+00	1.04E+01
Curium-242	1.78E-02	9.86E-02	1.15E-05	9.86E-02	1.21E-01	5.79E-09	1.21E-01	2.59E-01	8.68E-09	2.59E-01
Lead-212	5.84E-01	3.66E-01	7.57E-02	4.41E-01	8.91E-04	9.66E-03	1.05E-02	2.11E-01	2.66E-02	2.38E-01
Lead-214	1.12E+00	6.92E-01	1.63E-01	8.56E-01	1.69E-03	2.02E-02	2.19E-02	3.99E-01	5.67E-02	4.56E-01
Potassium-40	1.57E+01	1.13E-01	5.73E-01	6.86E-01	3.89E+00	2.57E-02	3.92E+00	2.16E+00	7.15E-02	2.23E+00
Plutonium-238	2.90E-01	4.07E+00	2.03E-04	4.07E+00	4.89E-04	8.39E-08	4.89E-04	1.05E+01	1.26E-07	1.05E+01
Plutonium-239/40	2.22E-02	2.93E-01	1.07E-05	2.93E-01	6.09E-01	1.21E-08	6.09E-01	7.57E-01	1.81E-08	7.57E-01
Radium-226	1.21E+00	2.23E+00	1.77E-01	2.41E+00	1.12E-01	2.19E-02	1.33E-01	2.75E-01	6.14E-02	3.36E-01
Radium-228	2.10E+00	1.37E-04	1.92E-03	2.06E-03	6.85E-06		6.85E-06	1.69E-05		1.69E-05
Sodium-22	1.50E+00	1.88E+00	1.92E-01	2.08E+00	1.81E-02	3.39E-02	5.20E-02	1.73E-01	9.51E-02	2.69E-01
Strontium-90	6.69E+02	1.08E+01	4.07E+01	5.14E+01	1.92E+01	2.97E-02	1.92E+01	1.01E+00	4.45E-02	1.05E+00
Technetium-99	1.90E-01	7.47E-02	1.03E-03	7.57E-02	7.47E-02	4.56E-08	7.47E-02	3.74E-05	6.84E-08	3.75E-05
Thorium-228	1.50E+00	2.46E-01	1.97E-01	4.43E-01	4.42E-02	2.50E-02	6.92E-02	2.60E-03	6.89E-02	7.15E-02
Thorium-230	1.33E+00	3.18E-02	1.22E-03	3.30E-02	5.73E-03	3.05E-06	5.73E-03	3.36E-04	4.57E-06	3.41E-04
Thorium-232	1.30E+00	2.68E-02	1.03E-01	1.30E-01	4.82E-03	1.29E-02	1.77E-02	2.83E-04	3.63E-02	3.65E-02
Thallium-208	2.00E+00	1.28E-01	4.27E-01	5.55E-01	6.40E-05	6.94E-02	6.95E-02	2.76E-01	1.95E-01	4.70E-01

Table 9.6a. (continued)

Radionuclide[a]	Soil Activity[b] (pCi/g)	Soil invertebrates			Plants			Short-tailed shrew		
		Internal	External	Total	Internal	External	Total	Internal	External	Total
Tritium	1.28E+01	3.93E-03	4.13E-03	8.06E-03	3.93E-03		3.93E-03	4.44E-03		4.44E-03
Uranium-233/234	9.76E-01	3.03E-01	3.67E-04	3.04E-01	9.46E+00	2.53E-06	9.46E+00	1.64E-03	3.80E-06	1.64E-03
Uranium-235	4.39E-02	1.25E-02	4.84E-04	1.29E-02	3.89E-01	5.90E-05	3.89E-01	6.74E-05	1.81E-04	2.48E-04
Uranium-235/236	1.11E-01	2.90E-01	1.79E-03	2.92E-01	9.05E+00	1.49E-04	9.05E+00	1.57E-03	4.57E-04	2.03E-03
Uranium-238	9.57E-01	2.61E-01	4.73E-02	3.09E-01	8.15E+00	2.25E-04	8.15E+00	1.41E-03	5.42E-04	1.96E-03
Total		2.60E+01	6.51E+01	9.11E+01	5.44E+01	3.27E+00	5.76E+01	2.33E+01	9.13E+00	3.24E+01
SWSA 4 Main										
Cesium-137	8.80E+04	1.72E+01	3.86E+03	3.88E+03	1.26E+01	5.12E+02	5.25E+02	4.20E+02	1.44E+03	1.86E+03
Potassium-40	1.30E+01	9.39E-02	4.75E-01	5.68E-01	3.22E+00	2.13E-02	3.24E+00	1.79E+00	5.92E-02	1.84E+00
Strontium-90	1.10E+04	1.77E+02	6.69E+02	8.46E+02	3.15E+02	4.88E-01	3.16E+02	1.66E+01	7.32E-01	1.73E+01
Tritium	6.70E+02	2.06E-01	2.16E-01	4.22E-01	2.06E-01		2.06E-01	2.33E-01		2.33E-01
Total		1.95E+02	4.53E+03	4.72E+03	3.31E+02	5.13E+02	8.44E+02	4.39E+02	1.44E+03	1.88E+03
SWSA 5 N WOC										
Actinium-228	2.10E+00	4.69E-05	1.63E-01	1.63E-01	4.69E-05	2.08E-02	2.08E-02	1.26E-06	5.86E-02	5.86E-02
Bismuth-212	1.90E+00	8.55E-02	6.72E-02	1.53E-01	3.74E-02	3.65E-03	4.11E-02	1.29E-02	1.02E-02	2.31E-02
Bismuth-214	8.10E-01	1.28E-01	9.44E-02	2.23E-01	5.61E-02	1.27E-02	6.87E-02	1.93E-02	3.54E-02	5.47E-02
Carbon-14	4.01E-01		1.06E-03	1.06E-03	1.01E-03	1.03E-08	1.01E-03	1.31E-04	1.55E-08	1.31E-04
Iodine-129	4.40E+00	2.98E-02	2.11E-02	5.09E-02	5.07E-06	1.09E-04	1.14E-04	6.44E-02	1.64E-03	6.61E-02
Lead-212	1.60E+00	1.00E+00	2.07E-01	1.21E+00	2.44E-03	2.65E-02	2.89E-02	5.78E-01	7.30E-02	6.51E-01
Lead-214	1.07E+00	6.62E-01	1.56E-01	8.17E-01	1.61E-03	1.93E-02	2.09E-02	3.81E-01	5.42E-02	4.36E-01
Potassium-40	3.08E+01	2.22E-01	1.12E+00	1.35E+00	7.64E+00	5.04E-02	7.69E+00	4.23E+00	1.40E-01	4.37E+00
Radium-226	9.50E-01	1.75E+00	1.39E-01	1.89E+00	8.76E-02	1.72E-02	1.05E-01	2.16E-01	4.82E-02	2.64E-01
Radium-228	2.10E+00	1.37E-04	1.92E-03	2.06E-03	6.85E-06		6.85E-06	1.69E-05		1.69E-05
Strontium-90	3.13E-01	5.04E-03	1.90E-02	2.41E-02	8.97E-03	1.39E-05	8.99E-03	4.72E-04	2.08E-05	4.92E-04
Thorium-228	2.00E+00	3.28E-01	2.63E-01	5.91E-01	5.90E-02	3.33E-02	9.23E-02	3.46E-03	9.19E-02	9.53E-02
Thorium-232	2.10E+00	4.32E-02	1.67E-01	2.10E-01	7.78E-03	2.08E-02	2.86E-02	4.57E-04	5.86E-02	5.90E-02
Thallium-208	1.80E+00	1.15E-01	3.84E-01	5.00E-01	5.76E-05	6.24E-02	6.25E-02	2.48E-01	1.75E-01	4.23E-01
Thorium-234	1.90E+00	4.71E-03	5.03E-02	5.50E-02	4.68E-03	5.59E-03	1.03E-02	5.92E-05	1.57E-02	1.58E-02

Table 9.6a. (continued)

Radionuclide[a]	Soil Activity[b] (pCi/g)	Soil invertebrates			Plants			Short-tailed shrew		
		Internal	External	Total	Internal	External	Total	Internal	External	Total
Tin-126	3.40E-01	9.02E-04	4.19E-03	5.09E-03	9.02E-04	9.63E-05	9.98E-04	1.30E-05	4.05E-04	4.18E-04
Tritium	1.06E+01	3.26E-03	3.42E-03	6.68E-03	3.26E-03		3.26E-03	3.68E-03		3.68E-03
Total		4.38E+00	2.87E+00	7.25E+00	7.91E+00	2.73E-01	8.18E+00	5.76E+00	7.63E-01	6.52E+00
SWSA 6 East										
Cobalt-60	5.33E+01	9.29E-02	7.45E+00	7.55E+00	3.83E-03	1.38E+00	1.39E+00	3.34E-03	3.87E+00	3.87E+00
Cesium-137	2.14E+00	4.19E-04	9.39E-02	9.43E-02	3.07E-04	1.25E-02	1.28E-02	1.02E-02	3.50E-02	4.52E-02
Potassium-40	2.57E+01	1.86E-01	9.38E-01	1.12E+00	6.37E+00	4.21E-02	6.41E+00	3.53E+00	1.17E-01	3.65E+00
Radium-224	1.52E+00	3.10E+00	1.98E-01	3.30E+00	1.55E-01	2.53E-02	1.80E-01	3.83E-01	6.98E-02	4.52E-01
Radium-226	8.00E-01	1.48E+00	1.17E-01	1.59E+00	7.38E-02	1.45E-02	8.82E-02	1.82E-01	4.06E-02	2.22E-01
Radium-228	1.52E+00	9.92E-05	1.39E-03	1.49E-03	4.96E-06		4.96E-06	1.22E-05		1.22E-05
Strontium-90	6.22E+00	1.00E-01	3.78E-01	4.78E-01	1.78E-01	2.76E-04	1.79E-01	9.37E-03	4.14E-04	9.79E-03
Thorium-228	1.45E+00	2.37E-01	1.91E-01	4.28E-01	4.27E-02	2.41E-02	6.69E-02	2.51E-03	6.66E-02	6.91E-02
Thorium-230	1.27E+00	3.04E-02	1.16E-03	3.15E-02	5.47E-03	2.91E-06	5.47E-03	3.21E-04	4.36E-06	3.25E-04
Thorium-232	1.11E+00	2.29E-02	8.81E-02	1.11E-01	4.11E-03	1.10E-02	1.51E-02	2.42E-04	3.10E-02	3.12E-02
Thorium-234	3.96E-01	2.28E-01	2.49E-02	2.52E-01	6.44E+00	1.88E-05	6.44E+00	2.58E-02	2.82E-05	2.58E-02
Tritium	7.10E+01	2.18E-02	2.29E-02	4.47E-02	2.18E-02		2.18E-02	2.46E-02		2.46E-02
Uranium-234	6.70E-01	2.06E-01	5.40E-04	2.06E-01	6.42E+00	5.14E-07	6.42E+00	1.11E-03	7.71E-07	1.11E-03
Uranium-235/236	6.00E-01	3.74E-01	7.06E-03	3.81E-01	1.17E+01	8.07E-04	1.17E+01	2.02E-03	2.47E-03	4.49E-03
Uranium-238	7.54E-01	2.06E-01	3.72E-02	2.43E-01	6.42E+00	1.78E-04	6.42E+00	1.11E-03	4.27E-04	1.54E-03
Total		6.28E+00	9.55E+00	1.58E+01	3.78E+01	1.52E+00	3.93E+01	4.18E+00	4.23E+00	8.41E+00
SWSA 6 South										
Americium-241	6.00E-01	1.23E+01	2.74E-03	1.23E+01	8.38E+00	5.03E-05	8.38E+00	9.35E+00	3.42E-04	9.35E+00
Potassium-40	1.81E+01	1.31E-01	6.61E-01	7.91E-01	4.49E+00	2.96E-02	4.52E+00	2.49E+00	8.24E-02	2.57E+00
Plutonium-238	6.00E-01	8.43E+00	4.19E-04	8.43E+00	1.01E-03	1.74E-07	1.01E-03	2.18E+01	2.60E-07	2.18E+01
Plutonium-239/40	6.00E-01	7.91E+00	2.90E-04	7.91E+00	1.64E+01	3.27E-07	1.64E+01	2.05E+01	4.90E-07	2.05E+01
Radium-224	1.40E+00	2.86E+00	1.82E-01	3.04E+00	1.43E-01	2.33E-02	1.66E-01	3.52E-01	6.43E-02	4.17E-01
Radium-226	8.30E-01	1.53E+00	1.21E-01	1.65E+00	7.65E-02	1.50E-02	9.15E-02	1.89E-01	4.21E-02	2.31E-01
Radium-228	1.46E+00	9.53E-05	1.33E-03	1.43E-03	4.77E-06		4.77E-06	1.17E-05		1.17E-05

Table 9.6a. (continued)

Radionuclide[a]	Soil Activity[b] (pCi/g)	Soil invertebrates			Plants			Short-tailed shrew		
		Internal	External	Total	Internal	External	Total	Internal	External	Total
Thorium-228	1.04E+00	1.70E-01	1.37E-01	3.07E-01	3.07E-02	1.73E-02	4.80E-02	1.80E-03	4.78E-02	4.96E-02
Thorium-230	1.00E+00	2.39E-02	9.14E-04	2.48E-02	4.31E-03	2.29E-06	4.31E-03	2.53E-04	3.44E-06	2.56E-04
Thorium-232	1.07E+00	2.20E-02	8.49E-02	1.07E-01	3.97E-03	1.06E-02	1.46E-02	2.33E-04	2.98E-02	3.01E-02
Thorium-234	1.12E+00	4.07E-01	1.14E-02	4.18E-01	1.27E+01	8.59E-04	1.27E+01	2.20E-03	2.55E-03	4.75E-03
Uranium-234	7.70E-01	2.36E-01	6.21E-04	2.37E-01	7.37E+00	5.91E-07	7.37E+00	1.28E-03	8.86E-07	1.28E-03
Uranium-235/236	6.00E-01	3.97E-01	7.11E-03	4.04E-01	1.24E+01	8.07E-04	1.24E+01	2.15E-03	2.47E-03	4.62E-03
Uranium-238	8.40E-01	2.29E-01	4.15E-02	2.71E-01	7.15E+00	1.98E-04	7.15E+00	1.24E-03	4.76E-04	1.72E-03
Total		3.46E+01	1.25E+00	3.59E+01	6.92E+01	9.78E-02	6.93E+01	5.46E+01	2.72E-01	5.49E+01
W6MS3										
Americium-241	8.90E-01	1.82E+01	4.07E-03	1.82E+01	1.24E+01	7.46E-05	1.24E+01	1.39E+01	5.07E-04	1.39E+01
Curium-244	6.00E-01	3.15E+00	3.55E-04	3.16E+00	3.89E+00	1.45E-07	3.89E+00	9.59E+00	2.17E-07	9.59E+00
Cobalt-60	1.06E-01	1.85E-04	1.48E-02	1.50E-02	7.62E-06	2.75E-03	2.76E-03	6.64E-06	7.70E-03	7.71E-03
Cesium-137	6.01E-01	1.18E-04	2.64E-02	2.65E-02	8.63E-05	3.50E-03	3.59E-03	2.87E-03	9.83E-03	1.27E-02
Curium-242	6.00E-01	3.32E+00	3.87E-04	3.32E+00	4.09E+00	1.95E-07	4.09E+00	8.74E+00	2.93E-07	8.74E+00
Potassium-40	2.39E+01	1.73E-01	8.72E-01	1.04E+00	5.93E+00	3.91E-02	5.96E+00	3.28E+00	1.09E-01	3.39E+00
Plutonium-238	6.00E-01	8.43E+00	4.19E-04	8.43E+00	1.01E-03	1.74E-07	1.01E-03	2.18E+01	2.60E-07	2.18E+01
Plutonium-239/40	6.00E-01	7.91E+00	2.90E-04	7.91E+00	1.64E+01	3.27E-07	1.64E+01	2.05E+01	4.90E-07	2.05E+01
Radium-224	1.27E+00	2.59E+00	1.66E-01	2.76E+00	1.30E-01	2.11E-02	1.51E-01	3.20E-01	5.83E-02	3.78E-01
Radium-226	8.21E-01	1.51E+00	1.20E-01	1.63E+00	7.57E-02	1.49E-02	9.05E-02	1.87E-01	4.17E-02	2.28E-01
Radium-228	1.34E+00	8.75E-05	1.22E-03	1.31E-03	4.37E-06		4.37E-06	1.08E-05		1.08E-05
Strontium-90	2.55E+01	4.11E-01	1.55E+00	1.96E+00	7.31E-01	1.13E-03	7.32E-01	3.84E-02	1.70E-03	4.01E-02
Technetium-99	9.00E-01	3.54E-01	4.89E-03	3.59E-01	3.54E-01	2.16E-07	3.54E-01	1.77E-04	3.24E-07	1.78E-04
Thorium-228	1.25E+00	2.05E-01	1.65E-01	3.69E-01	3.68E-02	2.08E-02	5.77E-02	2.16E-03	5.74E-02	5.96E-02
Thorium-230	1.59E+00	3.80E-02	1.45E-03	3.95E-02	6.85E-03	3.64E-06	6.85E-03	4.02E-04	5.46E-06	4.07E-04
Thorium-232	9.37E-01	1.93E-02	7.44E-02	9.36E-02	3.47E-03	9.27E-03	1.27E-02	2.04E-04	2.61E-02	2.63E-02
Thorium-234	1.50E+00	7.85E-01	1.73E-01	9.58E-01	1.97E+01	7.09E-05	1.97E+01	1.82E-01	1.06E-04	1.82E-01
Tritium	5.15E+02	1.58E-01	1.66E-01	3.24E-01	1.58E-01		1.58E-01	1.79E-01		1.79E-01
Uranium-234	2.04E+00	6.26E-01	1.65E-03	6.28E-01	1.95E+01	1.56E-06	1.95E+01	3.39E-03	2.35E-06	3.39E-03
Uranium-235/236	6.00E-01	4.54E-01	7.23E-03	4.61E-01	1.42E+01	8.07E-04	1.42E+01	2.46E-03	2.47E-03	4.92E-03

Table 9.6a. (continued)

Radionuclide[a]	Soil Activity[b] (pCi/g)	Soil invertebrates			Plants			Short-tailed shrew		
		Internal	External	Total	Internal	External	Total	Internal	External	Total
Uranium-238	1.05E+00	2.87E-01	5.19E-02	3.39E-01	8.94E+00	2.47E-04	8.94E+00	1.55E-03	5.94E-04	2.15E-03
Total		4.86E+01	3.40E+00	5.20E+01	1.07E+02	1.14E-01	1.07E+02	7.87E+01	3.15E-01	7.90E+01
W6MS1										
Americium-241	6.00E-01	1.23E+01	2.74E-03	1.23E+01	8.38E+00	5.03E-05	8.38E+00	9.35E+00	3.42E-04	9.35E+00
Cobalt-60	1.80E-01	3.14E-04	2.52E-02	2.55E-02	1.29E-05	4.68E-03	4.69E-03	1.13E-05	1.31E-02	1.31E-02
Cesium-137	6.48E-01	1.27E-04	2.84E-02	2.85E-02	9.31E-05	3.77E-03	3.87E-03	3.09E-03	1.06E-02	1.37E-02
Potassium-40	2.65E+01	1.91E-01	9.67E-01	1.16E+00	6.57E+00	4.34E-02	6.61E+00	3.64E+00	1.21E-01	3.76E+00
Plutonium-238	6.00E-01	8.43E+00	4.19E-04	8.43E+00	1.01E-03	1.74E-07	1.01E-03	2.18E+01	2.60E-07	2.18E+01
Plutonium-239/40	6.00E-01	7.91E+00	2.90E-04	7.91E+00	1.64E+01	3.27E-07	1.64E+01	2.05E+01	4.90E-07	2.05E+01
Radium-224	1.32E+00	2.69E+00	1.72E-01	2.87E+00	1.35E-01	2.20E-02	1.57E-01	3.32E-01	6.06E-02	3.93E-01
Radium-226	8.27E-01	1.52E+00	1.21E-01	1.65E+00	7.62E-02	1.50E-02	9.12E-02	1.88E-01	4.20E-02	2.30E-01
Radium-228	1.33E+00	8.68E-05	1.22E-03	1.30E-03	4.34E-06		4.34E-06	1.07E-05		1.07E-05
Thorium-228	1.13E+00	1.85E-01	1.49E-01	3.34E-01	3.33E-02	1.88E-02	5.21E-02	1.96E-03	5.19E-02	5.39E-02
Thorium-230	8.40E-01	2.01E-02	7.68E-04	2.09E-02	3.62E-03	1.92E-06	3.62E-03	2.12E-04	2.89E-06	2.15E-04
Thorium-232	7.40E-01	1.52E-02	5.87E-02	7.40E-02	2.74E-03	7.32E-03	1.01E-02	1.61E-04	2.06E-02	2.08E-02
Thorium-234	1.52E+00	4.19E-01	1.40E-01	5.59E-01	9.22E+00	7.10E-05	9.22E+00	1.45E-01	1.07E-04	1.45E-01
Tritium	4.14E+02	1.27E-01	1.34E-01	2.61E-01	1.27E-01		1.27E-01	1.44E-01		1.44E-01
Uranium-234	9.50E-01	2.92E-01	7.66E-04	2.92E-01	9.10E+00	7.29E-07	9.10E+00	1.58E-03	1.09E-06	1.58E-03
Uranium-235/236	6.00E-01	4.27E-01	7.17E-03	4.34E-01	1.33E+01	8.07E-04	1.33E+01	2.31E-03	2.47E-03	4.78E-03
Uranium-238	9.50E-01	2.59E-01	4.69E-02	3.06E-01	8.09E+00	2.24E-04	8.09E+00	1.40E-03	5.38E-04	1.94E-03
Total		3.48E+01	1.86E+00	3.66E+01	7.15E+01	1.16E-01	7.16E+01	5.61E+01	3.23E-01	5.64E+01
WCTRIB-1										
Cobalt-60	3.00E+02	5.23E-01	4.19E+01	4.25E+01	2.16E-02	7.80E+00	7.82E+00	1.88E-02	2.18E+01	2.18E+01
Cesium-137	8.50E+03	1.66E+00	3.73E+02	3.74E+02	1.22E+00	4.95E+01	5.07E+01	4.06E+01	1.39E+02	1.80E+02
Strontium-90	6.80E+02	1.09E+01	4.13E+01	5.23E+01	1.95E+01	3.02E-02	1.95E+01	1.02E+00	4.52E-02	1.07E+00
Total		1.31E+01	4.56E+02	4.69E+02	2.07E+01	5.73E+01	7.81E+01	4.16E+01	1.61E+02	2.03E+02
West Seep										

Table 9.6a. (continued)

Radionuclide[a]	Soil Activity[b] (pCi/g)	Soil invertebrates			Plants			Short-tailed shrew		
		Internal	External	Total	Internal	External	Total	Internal	External	Total
Actinium-228	1.19E+00	2.66E-05	9.25E-02	9.25E-02	2.66E-05	1.18E-02	1.18E-02	7.16E-07	3.32E-02	3.32E-02
Americium-241	8.39E-01	1.72E+01	3.83E-03	1.72E+01	1.17E+01	7.04E-05	1.17E+01	1.31E+01	4.78E-04	1.31E+01
Bismuth-214	6.40E-01	1.01E-01	7.46E-02	1.76E-01	4.43E-02	1.00E-02	5.43E-02	1.53E-02	2.80E-02	4.33E-02
Cesium-137	4.34E+02	8.50E-02	1.90E+01	1.91E+01	6.23E-02	2.53E+00	2.59E+00	2.07E+00	7.10E+00	9.17E+00
Curium-243/244	2.40E-02	1.26E-01	3.51E-04	1.27E-01	1.55E-01	2.60E-05	1.56E-01	3.32E-01	8.22E-05	3.33E-01
Curium-245/246	3.35E-02	1.63E-01	2.90E-04	1.63E-01	2.01E-01	2.16E-05	2.01E-01	4.29E-01	7.56E-05	4.29E-01
Cobalt-57	2.00E-02	5.96E-06	1.55E-04	1.61E-04	2.46E-07	1.91E-05	1.93E-05	2.10E-07	6.22E-05	6.24E-05
Cobalt-60	7.20E+04	1.26E+02	1.01E+04	1.02E+04	5.18E+00	1.87E+03	1.88E+03	4.51E+00	5.23E+03	5.23E+03
Europium-152	-6.30E-02	-1.91E-04	-4.38E-03	-4.57E-03	-8.03E-06	-8.47E-04	-8.55E-04	-4.70E-05	-2.25E-03	-2.29E-03
Lead-212	1.34E+00	8.39E-01	1.74E-01	1.01E+00	2.04E-03	2.22E-02	2.42E-02	4.84E-01	6.11E-02	5.45E-01
Lead-214	7.50E-01	3.24E-03	1.09E-01	1.13E-01	7.90E-06	1.35E-02	1.35E-02	1.81E-03	3.80E-02	3.98E-02
Plutonium-238	8.13E-02	1.14E+00	5.68E-05	1.14E+00	1.37E-04	2.35E-08	1.37E-04	2.95E+00	3.53E-08	2.95E+00
Plutonium-239/40	1.10E+00	1.45E+01	5.32E-04	1.45E+01	3.02E+01	5.99E-07	3.02E+01	3.75E+01	8.99E-07	3.75E+01
Potassium-40	2.12E+01	1.53E-01	7.74E-01	9.27E-01	5.26E+00	3.47E-02	5.29E+00	2.91E+00	9.65E-02	3.01E+00
Radium-224	2.46E+00	5.02E+00	3.21E-01	5.34E+00	2.51E-01	4.09E-02	2.92E-01	6.19E-01	1.13E-01	7.32E-01
Radium-226	7.87E-01	1.45E+00	1.15E-01	1.57E+00	7.26E-02	1.42E-02	8.68E-02	1.79E-01	4.00E-02	2.19E-01
Radium-228	1.40E+00	9.14E-05	1.28E-03	1.37E-03	4.57E-06		4.57E-06	1.13E-05		1.13E-05
Strontium-90	1.88E+02	3.03E+00	1.14E+01	1.45E+01	5.39E+00	8.34E-03	5.40E+00	2.83E-01	1.25E-02	2.96E-01
Thallium-208	4.60E-01	2.94E-02	9.83E-02	1.28E-01	1.47E-05	1.60E-02	1.60E-02	6.34E-02	4.48E-02	1.08E-01
Thorium-228	1.39E+00	2.28E-01	1.83E-01	4.11E-01	4.10E-02	2.31E-02	6.41E-02	2.41E-03	6.38E-02	6.62E-02
Thorium-230	9.81E-01	2.35E-02	8.97E-04	2.44E-02	4.22E-03	2.25E-06	4.23E-03	2.48E-04	3.37E-06	2.51E-04
Thorium-232	1.20E+00	2.47E-02	9.52E-02	1.20E-01	4.45E-03	1.19E-02	1.63E-02	2.61E-04	3.35E-02	3.37E-02
Thorium-234	1.55E+00	9.05E-02	3.70E-02	1.27E-01	1.93E+00	7.20E-05	1.93E+00	3.37E-02	1.08E-04	3.38E-02
Tritium	9.62E+01	2.96E-02	3.10E-02	6.06E-02	2.96E-02		2.96E-02	3.34E-02		3.34E-02
Uranium-232	1.78E-01	6.09E-02	1.82E-04	6.11E-02	1.90E+00	3.08E-07	1.90E+00	3.29E-04	4.62E-07	3.30E-04
Uranium-233/234	4.51E+00	1.40E+00	1.70E-03	1.40E+00	4.37E+01	1.17E-05	4.37E+01	7.58E-03	1.76E-05	7.60E-03
Uranium-234	1.19E+00	3.65E-01	9.60E-04	3.66E-01	1.14E+01	9.13E-07	1.14E+01	1.98E-03	1.37E-06	1.98E-03
Uranium-235	3.80E-01	1.08E-01	4.19E-03	1.12E-01	3.36E+00	5.11E-04	3.36E+00	5.83E-04	1.56E-03	2.15E-03
Uranium-238	1.82E+00	4.97E-01	8.99E-02	5.87E-01	1.55E+01	4.29E-04	1.55E+01	2.69E-03	1.03E-03	3.72E-03
Total		1.72E+02	1.01E+04	1.03E+04	1.36E+02	1.87E+03	2.01E+03	6.55E+01	5.24E+03	5.30E+03

Table 9.6a. (continued)

Radionuclide[a]	Soil Activity[b] (pCi/g)	Soil invertebrates			Plants			Short-tailed shrew		
		Internal	External	Total	Internal	External	Total	Internal	External	Total
SWSA 5 Drainage D-2										
Actinium-228	2.30E+00	5.14E-05	1.79E-01	1.79E-01	5.14E-05	2.28E-02	2.28E-02	1.38E-06	6.41E-02	6.41E-02
Bismuth-214	8.20E-01	1.30E-01	9.55E-02	2.25E-01	5.68E-02	1.28E-02	6.96E-02	1.96E-02	3.58E-02	5.54E-02
Calcium-45	1.30E+01	9.72E-02	5.38E-02	1.51E-01	1.98E-01	1.56E-06	1.98E-01	4.81E-01	2.34E-06	4.81E-01
Carbon-14	4.60E-01		1.21E-03	1.21E-03	1.15E-03	1.19E-08	1.15E-03	1.50E-04	1.78E-08	1.50E-04
Cesium-137	1.99E+01	3.90E-03	8.73E-01	8.77E-01	2.86E-03	1.16E-01	1.19E-01	9.50E-02	3.26E-01	4.21E-01
Iodine-129	3.30E+00	2.24E-02	1.58E-02	3.82E-02	3.81E-06	8.20E-05	8.58E-05	4.83E-02	1.23E-03	4.96E-02
Lead-210	6.10E+00									
Lead-212	9.23E-01	5.78E-01	1.20E-01	6.98E-01	1.41E-03	1.53E-02	1.67E-02	3.34E-01	4.21E-02	3.76E-01
Lead-214	1.40E+00	8.66E-01	2.04E-01	1.07E+00	2.11E-03	2.52E-02	2.73E-02	4.99E-01	7.09E-02	5.70E-01
Potassium-40	2.01E+01	1.45E-01	7.34E-01	8.79E-01	4.98E+00	3.29E-02	5.02E+00	2.76E+00	9.15E-02	2.85E+00
Radium-226	7.90E-01	1.46E+00	1.16E-01	1.57E+00	7.28E-02	1.43E-02	8.71E-02	1.80E-01	4.01E-02	2.20E-01
Radium-228	1.88E+00	1.23E-04	1.72E-03	1.84E-03	6.14E-06		6.14E-06	1.51E-05		1.51E-05
Strontium-90	1.28E+02	2.06E+00	7.78E+00	9.84E+00	3.67E+00	5.68E-03	3.67E+00	1.93E-01	8.51E-03	2.01E-01
Technetium-99	1.18E+00	4.64E-01	6.41E-03	4.70E-01	4.64E-01	2.83E-07	4.64E-01	2.32E-04	4.25E-07	2.33E-04
Thorium-228	1.50E+00	2.46E-01	1.97E-01	4.43E-01	4.42E-02	2.50E-02	6.92E-02	2.60E-03	6.89E-02	7.15E-02
Thorium-232	2.15E+00	4.43E-02	1.71E-01	2.15E-01	7.97E-03	2.13E-02	2.92E-02	4.68E-04	6.00E-02	6.04E-02
Thallium-208	1.40E+00	8.96E-02	2.99E-01	3.89E-01	4.48E-05	4.86E-02	4.86E-02	1.93E-01	1.36E-01	3.29E-01
Tritium	2.29E+01	7.03E-03	7.39E-03	1.44E-02	7.03E-03		7.03E-03	7.95E-03		7.95E-03
Total		6.21E+00	1.09E+01	1.71E+01	9.51E+00	3.40E-01	9.85E+00	4.81E+00	9.45E-01	5.76E+00
WAG 7 WOC										
Actinium-228	1.09E+00	2.43E-05	8.47E-02	8.48E-02	2.43E-05	1.08E-02	1.08E-02	6.56E-07	3.04E-02	3.04E-02
Americium-241	1.11E-01	2.27E+00	5.07E-04	2.27E+00	1.55E+00	9.31E-06	1.55E+00	1.73E+00	6.32E-05	1.73E+00
Bismuth-214	6.50E-01	1.03E-01	7.57E-02	1.79E-01	4.50E-02	1.02E-02	5.52E-02	1.55E-02	2.84E-02	4.39E-02
Cesium-137	5.62E+03	1.10E+00	2.57E+02	2.58E+02	8.07E-01	3.45E+01	3.53E+01	2.68E+01	9.68E+01	1.24E+02
Curium-243/244	1.08E+00	5.69E+00	1.58E-02	5.70E+00	7.00E+00	1.17E-03	7.00E+00	1.50E+01	3.70E-03	1.50E+01
Cobalt-57	9.00E-02	2.68E-05	6.97E-04	7.24E-04	1.11E-06	8.58E-05	8.69E-05	9.47E-07	2.80E-04	2.81E-04
Cobalt-60	2.02E-01	3.52E-04	2.82E-02	2.86E-02	1.45E-05	5.25E-03	5.26E-03	1.26E-05	1.47E-02	1.47E-02

Table 9.6a. (continued)

Radionuclide[a]	Soil Activity[b] (pCi/g)	Soil invertebrates			Plants			Short-tailed shrew		
		Internal	External	Total	Internal	External	Total	Internal	External	Total
Plutonium-238	2.42E-01	3.40E+00	1.69E-04	3.40E+00	4.08E-04	7.00E-08	4.08E-04	8.79E+00	1.05E-07	8.79E+00
Plutonium-239/40	5.10E-02	6.72E-01	2.47E-05	6.72E-01	1.40E+00	2.78E-08	1.40E+00	1.74E+00	4.17E-08	1.74E+00
Potassium-40	2.60E+01	1.88E-01	9.49E-01	1.14E+00	6.45E+00	4.26E-02	6.49E+00	3.57E+00	1.18E-01	3.69E+00
Thorium-228	5.00E-01	8.19E-02	6.58E-02	1.48E-01	1.47E-02	8.33E-03	2.31E-02	8.65E-04	2.30E-02	2.38E-02
Thorium-230	4.10E-01	9.81E-03	3.75E-04	1.02E-02	1.77E-03	9.39E-07	1.77E-03	1.04E-04	1.41E-06	1.05E-04
Thorium-232	4.00E-01	8.24E-03	3.17E-02	4.00E-02	1.48E-03	3.96E-03	5.44E-03	8.70E-05	1.12E-02	1.12E-02
Uranium-233/234	1.10E+00	3.42E-01	4.14E-04	3.42E-01	1.07E+01	2.85E-06	1.07E+01	1.85E-03	4.28E-06	1.85E-03
Uranium-235	8.30E-02	2.36E-02	9.15E-04	2.45E-02	7.35E-01	1.12E-04	7.35E-01	1.27E-04	3.41E-04	4.69E-04
Uranium-238	1.23E+00	3.36E-01	6.08E-02	3.97E-01	1.05E+01	2.90E-04	1.05E+01	1.82E-03	6.96E-04	2.51E-03
Total		1.42E+01	2.58E+02	2.72E+02	3.91E+01	3.45E+01	7.37E+01	5.77E+01	9.70E+01	1.55E+02
WOC										
Americium-241	2.86E+00	5.85E+01	1.31E-02	5.85E+01	4.00E+01	2.40E-04	4.00E+01	4.46E+01	1.63E-03	4.46E+01
Curium-244	3.22E+00	1.69E+01	1.90E-03	1.69E+01	2.09E+01	7.78E-07	2.09E+01	5.15E+01	1.17E-06	5.15E+01
Cobalt-60	4.56E+00	7.95E-03	6.38E-01	6.46E-01	3.28E-04	1.18E-01	1.19E-01	2.86E-04	3.31E-01	3.31E-01
Cesium-137	3.57E+02	6.99E-02	1.57E+01	1.57E+01	5.13E-02	2.08E+00	2.13E+00	1.70E+00	5.84E+00	7.54E+00
Plutonium-238	1.04E+00	1.46E+01	7.27E-04	1.46E+01	1.75E-03	3.01E-07	1.75E-03	3.78E+01	4.51E-07	3.78E+01
Plutonium-239/40	8.07E+00	1.06E+02	3.90E-03	1.06E+02	2.21E+02	4.40E-06	2.21E+02	2.75E+02	6.59E-06	2.75E+02
Strontium-90	2.16E+01	3.48E-01	1.31E+00	1.66E+00	6.19E-01	9.58E-04	6.20E-01	3.25E-02	1.44E-03	3.40E-02
Technetium-99	3.94E+00	1.55E+00	2.14E-02	1.57E+00	1.55E+00	9.46E-07	1.55E+00	7.76E-04	1.42E-06	7.77E-04
Thorium-228	2.81E+00	4.60E-01	3.70E-01	8.30E-01	8.28E-02	4.68E-02	1.30E-01	4.86E-03	1.29E-01	1.34E-01
Thorium-230	5.50E+00	1.32E-01	5.03E-03	1.37E-01	2.37E-02	1.26E-05	2.37E-02	1.39E-03	1.89E-05	1.41E-03
Thorium-232	1.80E+00	3.71E-02	1.43E-01	1.80E-01	6.67E-03	1.78E-02	2.45E-02	3.92E-04	5.02E-02	5.06E-02
Uranium-233/234	3.24E+00	1.01E+00	1.22E-03	1.01E+00	3.14E+01	8.41E-06	3.14E+01	5.45E-03	1.26E-05	5.46E-03
Uranium-235	2.49E-01	7.07E-02	2.74E-03	7.34E-02	2.20E+00	3.35E-04	2.20E+00	3.82E-04	1.02E-03	1.41E-03
Uranium-238	2.97E+00	8.11E-01	1.47E-01	9.58E-01	2.53E+01	7.00E-04	2.53E+01	4.39E-03	1.68E-03	6.07E-03
Total		2.01E+02	1.83E+01	2.19E+02	3.43E+02	2.26E+00	3.46E+02	4.11E+02	6.36E+00	4.17E+02

[a] Dose from each radionuclide includes all short-lived daughter products

[b] Representative concentration is the minimum of the UCL95 and the maximum detect.

Table 9.6b. Estimated radiation doses (mrad/d) from surface soil for white-footed mouse, red fox, and white-tailed deer at WOC

Radionuclide[a]	Soil Activity[b] (pCi/g)	White-footed mouse			Red Fox			White-tailed Deer		
		Internal	External	Total	Internal	External	Total	Internal	External	Total
East Seep										
Actinium-228	7.80E-01	4.16E-07	2.18E-02	2.18E-02	4.59E-07	1.60E-02	1.60E-02	1.27E-08	7.72E-03	7.72E-03
Bismuth-214	7.90E-01	4.42E-03	3.45E-02	3.90E-02	4.03E-03	2.53E-02	2.93E-02	3.60E-03	1.23E-02	1.59E-02
Cesium-137	7.00E+05	7.61E+02	1.15E+04	1.22E+04	2.46E+03	8.39E+03	1.09E+04	9.27E+02	4.08E+03	5.00E+03
Cobalt-60	9.28E+00	5.81E-04	6.74E-01	6.75E-01	3.69E-02	4.93E-01	5.30E-01	8.49E-03	2.41E-01	2.50E-01
Lead-212	7.05E+00	2.55E+00	3.22E-01	2.87E+00	4.18E-02	2.34E-01	2.76E-01	2.29E-02	1.17E-01	1.39E-01
Lead-214	8.80E-01	2.12E-03	4.46E-02	4.67E-02	1.79E-04	3.27E-02	3.29E-02	2.12E-05	1.59E-02	1.59E-02
Plutonium-238	1.40E-02	5.09E-01	6.07E-09	5.09E-01	1.14E-05	3.04E-09	1.14E-05	7.99E-07	4.05E-09	8.03E-07
Plutonium-239/40	4.40E-02	1.50E+00	3.60E-08	1.50E+00	9.65E-05	1.80E-08	9.65E-05	6.05E-04	2.40E-08	6.05E-04
Potassium-40	2.53E+01	3.48E+00	1.15E-01	3.59E+00	3.36E+00	8.41E-02	3.44E+00	6.53E+00	4.14E-02	6.57E+00
Strontium-90	4.32E+01	6.51E-02	2.87E-03	6.80E-02	2.36E-01	1.44E-03	2.37E-01	5.15E-01	1.92E-03	5.17E-01
Thallium-208	2.16E+00	1.43E-01	2.10E-01	3.53E-01	3.00E-01	1.54E-01	4.55E-01	4.50E-03	7.49E-02	7.94E-02
Thorium-228	9.60E+00	1.66E-02	4.41E-01	4.58E-01	5.16E-02	3.21E-01	3.73E-01	3.29E-02	1.60E-01	1.93E-01
Thorium-230	8.30E-01	2.10E-04	2.85E-06	2.13E-04	6.51E-04	1.43E-06	6.52E-04	4.15E-04	1.90E-06	4.17E-04
Thorium-232	8.10E-01	1.76E-04	2.26E-02	2.28E-02	5.47E-04	1.66E-02	1.71E-02	3.49E-04	8.01E-03	8.36E-03
Thorium-234	3.45E+00	3.70E-01	1.08E-03	3.71E-01	4.10E+00	5.38E-04	4.10E+00	3.23E+01	7.18E-04	3.23E+01
Uranium-232	1.08E+01	2.00E-02	2.80E-05	2.00E-02	2.22E-01	1.40E-05	2.22E-01	1.75E+00	1.87E-05	1.75E+00
Uranium-233/234	2.08E+02	3.50E-01	8.10E-04	3.51E-01	3.88E+00	4.05E-04	3.88E+00	3.06E+01	5.40E-04	3.06E+01
Uranium-235	2.51E+00	3.85E-03	1.03E-02	1.42E-02	4.27E-02	7.79E-03	5.05E-02	3.37E-01	3.37E-03	3.40E-01
Uranium-238	1.05E+01	1.55E-02	5.94E-03	2.15E-02	1.72E-01	4.09E-03	1.76E-01	1.36E+00	2.47E-03	1.36E+00
Total		7.70E+02	1.15E+04	1.22E+04	2.47E+03	8.39E+03	1.09E+04	1.00E+03	4.08E+03	5.08E+03
Haw Ridge										
Cobalt-60	4.70E+00	2.94E-04	3.41E-01	3.42E-01	1.87E-02	2.50E-01	2.68E-01	4.30E-03	1.22E-01	1.26E-01
Cesium-137	2.00E+03	2.17E+00	3.27E+01	3.49E+01	7.03E+00	2.40E+01	3.10E+01	2.65E+00	1.16E+01	1.43E+01
Potassium-40	1.60E+01	2.20E+00	7.29E-02	2.27E+00	2.12E+00	5.32E-02	2.18E+00	4.13E+00	2.62E-02	4.16E+00
Total		4.37E+00	3.31E+01	3.75E+01	9.17E+00	2.43E+01	3.35E+01	6.78E+00	1.18E+01	1.86E+01
HF-2										
Cobalt-60	1.94E+02	1.21E-02	1.41E+01	1.41E+01	7.72E-01	1.03E+01	1.11E+01	1.78E-01	5.04E+00	5.22E+00

Table 9.6b. (continued)

Radionuclide[a]	Soil Activity[b] (pCi/g)	White-footed mouse			Red Fox			White-tailed Deer		
		Internal	External	Total	Internal	External	Total	Internal	External	Total
Strontium-90	7.40E-02	1.12E-04	4.92E-06	1.16E-04	4.03E-04	2.46E-06	4.06E-04	8.83E-04	3.28E-06	8.86E-04
Thorium-228	1.40E+00	2.42E-03	6.43E-02	6.67E-02	7.52E-03	4.68E-02	5.43E-02	4.79E-03	2.33E-02	2.81E-02
Thorium-230	1.30E+00	3.29E-04	4.47E-06	3.33E-04	1.02E-03	2.23E-06	1.02E-03	6.50E-04	2.98E-06	6.53E-04
Thorium-232	1.40E+00	3.05E-04	3.90E-02	3.93E-02	9.46E-04	2.87E-02	2.96E-02	6.03E-04	1.38E-02	1.45E-02
Uranium-233/234	1.10E+00	1.85E-03	4.28E-06	1.85E-03	2.05E-02	2.14E-06	2.05E-02	1.62E-01	2.85E-06	1.62E-01
Uranium-235	1.10E-01	1.69E-04	4.52E-04	6.21E-04	1.87E-03	3.42E-04	2.21E-03	1.48E-02	1.48E-04	1.49E-02
Uranium-238	8.70E-01	1.29E-03	4.93E-04	1.78E-03	1.42E-02	3.39E-04	1.46E-02	1.12E-01	2.05E-04	1.12E-01
Total		1.86E-02	1.42E+01	1.42E+01	8.18E-01	1.04E+01	1.12E+01	4.73E-01	5.08E+00	5.55E+00
HFIR										
Cobalt-60	4.64E+00	2.91E-04	3.37E-01	3.37E-01	1.85E-02	2.47E-01	2.65E-01	4.25E-03	1.21E-01	1.25E-01
Cesium-137	5.07E+01	5.51E-02	8.29E-01	8.84E-01	1.78E-01	6.08E-01	7.86E-01	6.72E-02	2.95E-01	3.62E-01
Potassium-40	1.95E+01	2.68E+00	8.88E-02	2.77E+00	2.59E+00	6.48E-02	2.65E+00	5.03E+00	3.19E-02	5.07E+00
Strontium-90	2.50E+04	3.77E+01	1.66E+00	3.93E+01	1.36E+02	8.31E-01	1.37E+02	2.98E+02	1.11E+00	2.99E+02
Thorium-228	6.50E+01	1.12E-01	2.99E+00	3.10E+00	3.49E-01	2.17E+00	2.52E+00	2.23E-01	1.08E+00	1.30E+00
Uranium-234	3.50E+00	5.81E-03	4.03E-06	5.82E-03	6.44E-02	2.01E-06	6.44E-02	5.08E-01	2.68E-06	5.08E-01
Uranium-238	2.10E+00	3.10E-03	1.19E-03	4.29E-03	3.44E-02	8.18E-04	3.52E-02	2.71E-01	4.95E-04	2.72E-01
Total		4.05E+01	5.90E+00	4.64E+01	1.40E+02	3.93E+00	1.43E+02	3.04E+02	2.64E+00	3.07E+02
HFIR East										
Potassium-40	2.00E+01	2.75E+00	9.11E-02	2.84E+00	2.65E+00	6.65E-02	2.72E+00	5.16E+00	3.28E-02	5.20E+00
Total		2.75E+00	9.11E-02	2.84E+00	2.65E+00	6.65E-02	2.72E+00	5.16E+00	3.28E-02	5.20E+00
HRE										
Actinium-228	1.27E+00	6.77E-07	3.54E-02	3.54E-02	7.47E-07	2.60E-02	2.60E-02	2.08E-08	1.26E-02	1.26E-02
Bismuth-214	7.41E-01	4.15E-03	3.24E-02	3.65E-02	3.78E-03	2.37E-02	2.75E-02	3.37E-03	1.16E-02	1.50E-02
Cesium-137	3.84E+03	4.17E+00	6.28E+01	6.70E+01	1.35E+01	4.60E+01	5.95E+01	5.09E+00	2.24E+01	2.74E+01
Cobalt-60	4.35E-01	2.72E-05	3.16E-02	3.16E-02	1.73E-03	2.31E-02	2.48E-02	3.98E-04	1.13E-02	1.17E-02
Europium-154	1.25E+00	7.39E-04	4.85E-02	4.92E-02	4.62E-04	3.47E-02	3.51E-02	2.15E-04	1.84E-02	1.86E-02
Potassium-40	1.82E+01	2.50E+00	8.29E-02	2.58E+00	2.42E+00	6.05E-02	2.48E+00	4.70E+00	2.98E-02	4.73E+00

Table 9.6b. (continued)

Radionuclide[a]	Soil Activity[b] (pCi/g)	White-footed mouse			Red Fox			White-tailed Deer		
		Internal	External	Total	Internal	External	Total	Internal	External	Total
Radium-226	1.03E+00	6.82E-02	5.23E-02	1.20E-01	4.29E-02	3.83E-02	8.12E-02	2.71E-02	1.86E-02	4.57E-02
Radium-228	1.37E+00	3.21E-06		3.21E-06	2.02E-06		2.02E-06	1.27E-06		1.27E-06
Strontium-90	2.03E+02	3.06E-01	1.35E-02	3.19E-01	1.11E+00	6.75E-03	1.11E+00	2.42E+00	9.00E-03	2.43E+00
Thallium-208	4.39E-01	2.90E-02	4.28E-02	7.17E-02	6.11E-02	3.13E-02	9.24E-02	9.15E-04	1.52E-02	1.61E-02
Thorium-228	5.50E-01	9.52E-04	2.53E-02	2.62E-02	2.95E-03	1.84E-02	2.13E-02	1.88E-03	9.16E-03	1.10E-02
Thorium-230	1.30E-01	3.29E-05	4.47E-07	3.33E-05	1.02E-04	2.23E-07	1.02E-04	6.50E-05	2.98E-07	6.53E-05
Thorium-232	1.50E+00	3.26E-04	4.18E-02	4.22E-02	1.01E-03	3.07E-02	3.17E-02	6.47E-04	1.48E-02	1.55E-02
Thorium-234	2.56E+00	4.17E-02	2.55E-03	4.43E-02	4.62E-01	1.86E-03	4.64E-01	3.64E+00	9.27E-04	3.64E+00
Uranium-233/234	2.43E+01	4.09E-02	9.46E-05	4.10E-02	4.53E-01	4.73E-05	4.53E-01	3.57E+00	6.31E-05	3.57E+00
Uranium-235	5.55E-01	8.52E-04	2.28E-03	3.13E-03	9.44E-03	1.72E-03	1.12E-02	7.44E-02	7.46E-04	7.52E-02
Uranium-238	1.29E+00	1.91E-03	7.30E-04	2.64E-03	2.11E-02	5.02E-04	2.16E-02	1.66E-01	3.04E-04	1.67E-01
Total		7.17E+00	6.32E+01	7.04E+01	1.81E+01	4.63E+01	6.44E+01	1.97E+01	2.25E+01	4.22E+01
Intermediate Pond										
Americium-241	3.06E+01	4.77E+02	1.74E-02	4.77E+02	2.14E-01	1.55E-02	2.29E-01	8.62E-01	2.57E-03	8.65E-01
Curium-244	5.72E+00	9.14E+01	2.07E-06	9.14E+01	8.19E-03	1.04E-06	8.19E-03	3.78E-02	1.38E-06	3.78E-02
Cobalt-60	1.31E+01	8.20E-04	9.51E-01	9.52E-01	5.21E-02	6.96E-01	7.48E-01	1.20E-02	3.40E-01	3.52E-01
Cesium-137	6.35E+03	6.90E+00	1.04E+02	1.11E+02	2.23E+01	7.61E+01	9.85E+01	8.41E+00	3.70E+01	4.54E+01
Plutonium-238	2.20E+00	7.99E+01	9.54E-07	7.99E+01	1.79E-03	4.77E-07	1.79E-03	1.25E-04	6.36E-07	1.26E-04
Plutonium-239/40	9.49E+01	3.24E+03	7.75E-05	3.24E+03	2.08E-01	3.88E-05	2.08E-01	1.31E+00	5.17E-05	1.31E+00
Strontium-90	2.48E+02	3.74E-01	1.65E-02	3.90E-01	1.35E+00	8.25E-03	1.36E+00	2.96E+00	1.10E-02	2.97E+00
Technetium-99	4.66E+00	9.16E-04	1.68E-06	9.18E-04	1.77E-04	8.39E-07	1.78E-04	9.16E-04	1.12E-06	9.17E-04
Thorium-228	5.08E+00	8.79E-03	2.33E-01	2.42E-01	2.73E-02	1.70E-01	1.97E-01	1.74E-02	8.46E-02	1.02E-01
Thorium-230	1.86E+01	4.70E-03	6.39E-05	4.77E-03	1.46E-02	3.19E-05	1.46E-02	9.30E-03	4.26E-05	9.34E-03
Thorium-232	5.28E+00	1.15E-03	1.47E-01	1.48E-01	3.57E-03	1.08E-01	1.12E-01	2.28E-03	5.22E-02	5.45E-02
Uranium-233/234	3.89E+01	6.54E-02	1.51E-04	6.56E-02	7.25E-01	7.57E-05	7.25E-01	5.71E+00	1.01E-04	5.71E+00
Uranium-235	5.29E+00	8.12E-03	2.18E-02	2.99E-02	9.00E-02	1.64E-02	1.06E-01	7.10E-01	7.11E-03	7.17E-01
Uranium-238	1.24E+01	1.83E-02	7.02E-03	2.53E-02	2.03E-01	4.83E-03	2.08E-01	1.60E+00	2.92E-03	1.60E+00
Total		3.89E+03	1.05E+02	4.00E+03	2.52E+01	7.72E+01	1.02E+02	2.16E+01	3.75E+01	5.91E+01

Table 9.6b. (continued)

Radionuclide[a]	Soil Activity[b] (pCi/g)	White-footed mouse			Red Fox			White-tailed Deer		
		Internal	External	Total	Internal	External	Total	Internal	External	Total
Lower WOC										
Americium-241	6.38E+00	9.95E+01	3.63E-03	9.95E+01	4.46E-02	3.23E-03	4.78E-02	1.80E-01	5.35E-04	1.80E-01
Curium-244	2.28E+00	3.64E+01	8.26E-07	3.64E+01	3.26E-03	4.13E-07	3.27E-03	1.51E-02	5.51E-07	1.51E-02
Cobalt-60	1.55E+01	9.71E-04	1.13E+00	1.13E+00	6.17E-02	8.24E-01	8.85E-01	1.42E-02	4.03E-01	4.17E-01
Cesium-137	8.68E+02	9.43E-01	1.42E+01	1.51E+01	3.05E+00	1.04E+01	1.35E+01	1.15E+00	5.05E+00	6.20E+00
Plutonium-238	1.14E+00	4.14E+01	4.95E-07	4.14E+01	9.30E-04	2.47E-07	9.30E-04	6.50E-05	3.30E-07	6.54E-05
Plutonium-239/40	4.51E+01	1.54E+03	3.69E-05	1.54E+03	9.89E-02	1.84E-05	9.89E-02	6.21E-01	2.46E-05	6.21E-01
Strontium-90	3.10E+01	4.67E-02	2.06E-03	4.88E-02	1.69E-01	1.03E-03	1.70E-01	3.70E-01	1.37E-03	3.71E-01
Technetium-99	1.47E+01	2.89E-03	5.29E-06	2.90E-03	5.58E-04	2.65E-06	5.61E-04	2.89E-03	3.53E-06	2.89E-03
Thorium-228	3.80E+00	6.58E-03	1.75E-01	1.81E-01	2.04E-02	1.27E-01	1.47E-01	1.30E-02	6.33E-02	7.63E-02
Thorium-230	4.84E+00	1.22E-03	1.66E-05	1.24E-03	3.80E-03	8.31E-06	3.80E-03	2.42E-03	1.11E-05	2.43E-03
Thorium-232	1.80E+00	3.92E-04	5.02E-02	5.06E-02	1.22E-03	3.68E-02	3.81E-02	7.76E-04	1.78E-02	1.86E-02
Uranium-233/234	4.94E+00	8.31E-03	1.92E-05	8.32E-03	9.21E-02	9.61E-06	9.21E-02	7.26E-01	1.28E-05	7.26E-01
Uranium-235	6.15E-01	9.44E-04	2.53E-03	3.47E-03	1.05E-02	1.91E-03	1.24E-02	8.25E-02	8.27E-04	8.33E-02
Uranium-238	2.10E+00	3.10E-03	1.19E-03	4.29E-03	3.44E-02	8.18E-04	3.52E-02	2.71E-01	4.95E-04	2.72E-01
Total		1.72E+03	1.56E+01	1.73E+03	3.59E+00	1.14E+01	1.50E+01	3.45E+00	5.54E+00	8.99E+00
MB-15										
Cobalt-60	4.20E+04	2.63E+00	3.05E+03	3.05E+03	1.67E+02	2.23E+03	2.40E+03	3.84E+01	1.09E+03	1.13E+03
Cesium-137	3.80E+02	4.13E-01	6.22E+00	6.63E+00	1.34E+00	4.56E+00	5.89E+00	5.03E-01	2.21E+00	2.72E+00
Total		3.04E+00	3.06E+03	3.06E+03	1.68E+02	2.24E+03	2.40E+03	3.89E+01	1.09E+03	1.13E+03
MV Drive										
Carbon-14	1.80E-01	2.35E-04	6.97E-09	2.35E-04	2.49E-04	3.48E-09	2.49E-04	4.61E-04	4.64E-09	4.61E-04
Cobalt-60	1.20E+00	7.51E-05	8.72E-02	8.72E-02	4.77E-03	6.38E-02	6.85E-02	1.10E-03	3.12E-02	3.23E-02
Cesium-137	3.20E+02	3.48E-01	5.23E+00	5.58E+00	1.13E+00	3.84E+00	4.96E+00	4.24E-01	1.86E+00	2.29E+00
Potassium-40	1.20E+01	1.65E+00	5.46E-02	1.70E+00	1.59E+00	3.99E-02	1.63E+00	3.10E+00	1.97E-02	3.12E+00
Tritium	8.50E+00	2.66E-03		2.66E-03	2.73E-03		2.73E-03	2.66E-03		2.66E-03
Total		2.00E+00	5.38E+00	7.38E+00	2.73E+00	3.94E+00	6.67E+00	3.53E+00	1.91E+00	5.44E+00

Table 9.6b. (continued)

Radionuclide[a]	Soil Activity[b] (pCi/g)	White-footed mouse			Red Fox			White-tailed Deer		
		Internal	External	Total	Internal	External	Total	Internal	External	Total
NHF										
Americium-241	1.10E-01	1.71E+00	6.26E-05	1.71E+00	7.69E-04	5.57E-05	8.25E-04	3.10E-03	9.23E-06	3.11E-03
Carbon-14	2.07E+00	2.70E-03	8.01E-08	2.70E-03	2.87E-03	4.01E-08	2.87E-03	5.30E-03	5.34E-08	5.30E-03
Cesium-137	1.40E-01	1.52E-04	2.29E-03	2.44E-03	4.92E-04	1.68E-03	2.17E-03	1.85E-04	8.15E-04	1.00E-03
Potassium-40	2.66E+01	3.65E+00	1.21E-01	3.77E+00	3.53E+00	8.84E-02	3.62E+00	6.87E+00	4.36E-02	6.91E+00
Plutonium-238	2.60E-01	9.45E+00	1.13E-07	9.45E+00	2.12E-04	5.64E-08	2.12E-04	1.48E-05	7.52E-08	1.49E-05
Plutonium-239/40	5.00E-02	1.70E+00	4.09E-08	1.70E+00	1.10E-04	2.04E-08	1.10E-04	6.88E-04	2.72E-08	6.88E-04
Radium-226	9.50E-01	6.29E-02	4.82E-02	1.11E-01	3.95E-02	3.53E-02	7.49E-02	2.50E-02	1.72E-02	4.22E-02
Radium-228	1.70E+00	3.98E-06		3.98E-06	2.50E-06		2.50E-06	1.58E-06		1.58E-06
Strontium-90	9.10E-01	1.37E-03	6.05E-05	1.43E-03	4.96E-03	3.03E-05	4.99E-03	1.09E-02	4.04E-05	1.09E-02
Thorium-228	2.42E+00	4.19E-03	1.11E-01	1.15E-01	1.30E-02	8.09E-02	9.39E-02	8.28E-03	4.03E-02	4.86E-02
Thorium-230	1.28E+00	3.24E-04	4.40E-06	3.28E-04	1.00E-03	2.20E-06	1.01E-03	6.40E-04	2.93E-06	6.43E-04
Thorium-232	1.55E+00	3.37E-04	4.32E-02	4.36E-02	1.05E-03	3.17E-02	3.28E-02	6.68E-04	1.53E-02	1.60E-02
Tritium	7.99E+00	2.50E-03		2.50E-03	2.56E-03		2.56E-03	2.50E-03		2.50E-03
Uranium-233/234	9.70E-01	1.63E-03	3.78E-06	1.63E-03	1.81E-02	1.89E-06	1.81E-02	1.42E-01	2.52E-06	1.42E-01
Uranium-235/236	8.00E-02	1.56E-03	3.29E-04	1.88E-03	1.72E-02	2.49E-04	1.75E-02	1.36E-01	1.08E-04	1.36E-01
Uranium-238	9.80E-01	1.45E-03	5.55E-04	2.00E-03	1.60E-02	3.82E-04	1.64E-02	1.26E-01	2.31E-04	1.27E-01
Total		1.66E+01	3.27E-01	1.69E+01	3.65E+00	2.39E-01	3.89E+00	7.33E+00	1.18E-01	7.45E+00
Pit 4 South										
Americium-241	1.10E-01	1.71E+00	6.26E-05	1.71E+00	7.69E-04	5.57E-05	8.25E-04	3.10E-03	9.23E-06	3.11E-03
Cobalt-60	2.34E+02	1.47E-02	1.70E+01	1.70E+01	9.31E-01	1.24E+01	1.34E+01	2.14E-01	6.08E+00	6.29E+00
Cesium-137	1.34E+01	1.46E-02	2.19E-01	2.34E-01	4.71E-02	1.61E-01	2.08E-01	1.77E-02	7.80E-02	9.58E-02
Plutonium-238	6.70E-03	2.43E-01	2.91E-09	2.43E-01	5.46E-06	1.45E-09	5.46E-06	3.82E-07	1.94E-09	3.84E-07
Plutonium-239/40	2.90E-02	9.89E-01	2.37E-08	9.89E-01	6.36E-05	1.18E-08	6.36E-05	3.99E-04	1.58E-08	3.99E-04
Strontium-90	1.00E+00	1.51E-03	6.65E-05	1.57E-03	5.45E-03	3.33E-05	5.49E-03	1.19E-02	4.43E-05	1.20E-02
Thorium-228	6.40E+00	1.11E-02	2.94E-01	3.05E-01	3.44E-02	2.14E-01	2.48E-01	2.19E-02	1.07E-01	1.28E-01
Thorium-230	1.20E+00	3.03E-04	4.12E-06	3.07E-04	9.41E-04	2.06E-06	9.43E-04	6.00E-04	2.75E-06	6.03E-04
Thorium-232	1.50E+00	3.26E-04	4.18E-02	4.22E-02	1.01E-03	3.07E-02	3.17E-02	6.47E-04	1.48E-02	1.55E-02
Uranium-233/234	8.50E+00	1.43E-02	3.31E-05	1.43E-02	1.58E-01	1.65E-05	1.58E-01	1.25E+00	2.21E-05	1.25E+00

Table 9.6b. (continued)

Radionuclide[a]	Soil Activity[b] (pCi/g)	White-footed mouse			Red Fox			White-tailed Deer		
		Internal	External	Total	Internal	External	Total	Internal	External	Total
Uranium-235	9.80E-02	1.50E-04	4.03E-04	5.53E-04	1.67E-03	3.04E-04	1.97E-03	1.31E-02	1.32E-04	1.33E-02
Uranium-238	3.10E-01	4.58E-04	1.76E-04	6.33E-04	5.08E-03	1.21E-04	5.20E-03	4.00E-02	7.30E-05	4.01E-02
Total		3.00E+00	1.76E+01	2.06E+01	1.19E+00	1.28E+01	1.40E+01	1.57E+00	6.28E+00	7.85E+00
SWSA 5 Seep A										
Actinium-228	1.90E+00	1.01E-06	5.30E-02	5.30E-02	1.12E-06	3.89E-02	3.89E-02	3.11E-08	1.88E-02	1.88E-02
Americium-241	1.24E+00	1.93E+01	7.06E-04	1.93E+01	8.67E-03	6.28E-04	9.30E-03	3.49E-02	1.04E-04	3.50E-02
Bismuth-214	6.90E-01	3.86E-03	3.02E-02	3.40E-02	3.52E-03	2.21E-02	2.56E-02	3.14E-03	1.08E-02	1.39E-02
Calcium-45	3.00E+01	1.11E+00	5.40E-06	1.11E+00	9.84E-03	2.70E-06	9.84E-03	4.60E-02	3.60E-06	4.60E-02
Carbon-14	1.51E+00	1.97E-03	5.84E-08	1.97E-03	2.09E-03	2.92E-08	2.09E-03	3.86E-03	3.90E-08	3.86E-03
Cesium-137	3.15E+00	3.42E-03	5.15E-02	5.50E-02	1.11E-02	3.78E-02	4.88E-02	4.17E-03	1.83E-02	2.25E-02
Iodine-129	3.40E+00	2.39E-02	1.27E-03	2.51E-02	4.47E-02	1.21E-03	4.59E-02	5.17E-04	8.44E-05	6.01E-04
Lead-212	1.90E+00	6.87E-01	8.67E-02	7.73E-01	1.13E-02	6.31E-02	7.44E-02	6.17E-03	3.14E-02	3.76E-02
Lead-214	9.80E-01	3.49E-01	4.97E-02	3.99E-01	5.73E-03	3.64E-02	4.21E-02	3.14E-03	1.77E-02	2.08E-02
Potassium-40	2.19E+01	3.01E+00	9.97E-02	3.11E+00	2.91E+00	7.28E-02	2.98E+00	5.65E+00	3.59E-02	5.69E+00
Plutonium-238	3.20E-01	1.16E+01	1.39E-07	1.16E+01	2.61E-04	6.94E-08	2.61E-04	1.83E-05	9.26E-08	1.83E-05
Plutonium-239/40	1.77E+00	6.03E+01	1.45E-06	6.03E+01	3.88E-03	7.23E-07	3.88E-03	2.44E-02	9.64E-07	2.44E-02
Radium-223	5.70E-01	8.91E-03	1.98E-03	1.09E-02	5.60E-03	1.50E-03	7.10E-03	3.54E-03	6.33E-04	4.17E-03
Radium-224	3.40E+00	2.49E-01	1.56E-01	4.05E-01	1.57E-01	1.14E-01	2.70E-01	9.89E-02	5.66E-02	1.56E-01
Radium-226	1.01E+00	6.68E-02	5.13E-02	1.18E-01	4.20E-02	3.76E-02	7.96E-02	2.65E-02	1.83E-02	4.48E-02
Radium-228	1.65E+00	3.87E-06		3.87E-06	2.43E-06		2.43E-06	1.53E-06		1.53E-06
Radon-219	7.30E-01									
Strontium-90	1.33E+02	2.00E-01	8.85E-03	2.09E-01	7.25E-01	4.42E-03	7.30E-01	1.59E+00	5.90E-03	1.59E+00
Thorium-228	1.54E+00	2.66E-03	7.07E-02	7.34E-02	8.27E-03	5.15E-02	5.98E-02	5.27E-03	2.56E-02	3.09E-02
Thorium-230	1.65E+00	4.17E-04	5.67E-06	4.23E-04	1.29E-03	2.83E-06	1.30E-03	8.25E-04	3.78E-06	8.29E-04
Thorium-232	1.59E+00	3.46E-04	4.43E-02	4.47E-02	1.07E-03	3.25E-02	3.36E-02	6.85E-04	1.57E-02	1.64E-02
Thallium-208	1.40E+00	9.24E-02	1.36E-01	2.29E-01	1.95E-01	9.99E-02	2.95E-01	2.92E-03	4.86E-02	5.15E-02
Tin-126	1.80E-01	5.13E-06	2.14E-04	2.19E-04	1.47E-06	1.76E-04	1.78E-04	5.41E-06	5.10E-05	5.64E-05
Tritium	2.95E+02	9.24E-02		9.24E-02	9.46E-02		9.46E-02	9.24E-02		9.24E-02
Uranium-232	1.50E-01	2.78E-04	3.89E-07	2.78E-04	3.08E-03	1.95E-07	3.08E-03	2.43E-02	2.60E-07	2.43E-02

Table 9.6b. (continued)

Radionuclide[a]	Soil Activity[b] (pCi/g)	White-footed mouse			Red Fox			White-tailed Deer		
		Internal	External	Total	Internal	External	Total	Internal	External	Total
Uranium-233/234	5.65E+00	9.50E-03	2.20E-05	9.52E-03	1.05E-01	1.10E-05	1.05E-01	8.30E-01	1.47E-05	8.30E-01
Uranium-238	1.02E+00	1.51E-03	5.77E-04	2.08E-03	1.67E-02	3.97E-04	1.71E-02	1.32E-01	2.40E-04	1.32E-01
Total		9.72E+01	8.43E-01	9.81E+01	4.36E+00	6.15E-01	4.98E+00	8.58E+00	3.05E-01	8.89E+00
SWSA 5 Seep B West										
Americium-241	6.78E+00	1.06E+02	3.86E-03	1.06E+02	4.74E-02	3.43E-03	5.08E-02	1.91E-01	5.69E-04	1.92E-01
Carbon-14	2.77E+01	3.61E-02	1.07E-06	3.61E-02	3.84E-02	5.36E-07	3.84E-02	7.09E-02	7.15E-07	7.09E-02
Curium-244	3.56E+01	5.69E+02	1.29E-05	5.69E+02	5.10E-02	6.45E-06	5.10E-02	2.35E-01	8.60E-06	2.35E-01
Cobalt-60	2.24E+02	1.40E-02	1.63E+01	1.63E+01	8.91E-01	1.19E+01	1.28E+01	2.05E-01	5.82E+00	6.03E+00
Cesium-137	1.37E+01	1.49E-02	2.24E-01	2.39E-01	4.82E-02	1.64E-01	2.12E-01	1.81E-02	7.98E-02	9.79E-02
Potassium-40	3.20E+01	4.40E+00	1.46E-01	4.54E+00	4.25E+00	1.06E-01	4.35E+00	8.26E+00	5.24E-02	8.31E+00
Plutonium-238	8.90E-01	3.23E+01	3.86E-07	3.23E+01	7.26E-04	1.93E-07	7.26E-04	5.08E-05	2.57E-07	5.10E-05
Plutonium-239/40	1.46E+00	4.98E+01	1.19E-06	4.98E+01	3.20E-03	5.97E-07	3.20E-03	2.01E-02	7.95E-07	2.01E-02
Radium-226	3.50E+00	2.32E-01	1.78E-01	4.09E-01	1.46E-01	1.30E-01	2.76E-01	9.20E-02	6.33E-02	1.55E-01
Radium-228	8.60E+00	2.02E-05		2.02E-05	1.27E-05		1.27E-05	8.00E-06		8.00E-06
Strontium-90	1.03E+04	1.55E+01	6.85E-01	1.62E+01	5.62E+01	3.43E-01	5.65E+01	1.23E+02	4.57E-01	1.23E+02
Thorium-228	1.91E+00	3.30E-03	8.77E-02	9.10E-02	1.03E-02	6.39E-02	7.41E-02	6.54E-03	3.18E-02	3.83E-02
Thorium-230	1.23E+01	3.11E-03	4.23E-05	3.15E-03	9.65E-03	2.11E-05	9.67E-03	6.15E-03	2.82E-05	6.18E-03
Thorium-232	1.55E+00	3.37E-04	4.32E-02	4.36E-02	1.05E-03	3.17E-02	3.28E-02	6.68E-04	1.53E-02	1.60E-02
Tritium	1.90E+03	5.95E-01		5.95E-01	6.09E-01		6.09E-01	5.95E-01		5.95E-01
Uranium-232	5.30E-01	9.81E-04	1.38E-06	9.82E-04	1.09E-02	6.88E-07	1.09E-02	8.57E-02	9.17E-07	8.57E-02
Uranium-233	1.05E+01	1.77E-02	4.09E-05	1.77E-02	1.96E-01	2.04E-05	1.96E-01	1.54E+00	2.72E-05	1.54E+00
Uranium-238	9.60E-01	1.42E-03	5.44E-04	1.96E-03	1.57E-02	3.74E-04	1.61E-02	1.24E-01	2.26E-04	1.24E-01
Total		7.78E+02	1.76E+01	7.95E+02	6.25E+01	1.27E+01	7.52E+01	1.34E+02	6.52E+00	1.41E+02
SWSA 5 Seep B East										
Actinium-228	1.10E+00	5.86E-07	3.07E-02	3.07E-02	6.47E-07	2.25E-02	2.25E-02	1.80E-08	1.09E-02	1.09E-02
Carbon-14	2.05E+00	2.67E-03	7.93E-08	2.67E-03	2.84E-03	3.97E-08	2.84E-03	5.25E-03	5.29E-08	5.25E-03
Cesium-137	6.53E+03	7.10E+00	1.07E+02	1.14E+02	2.30E+01	7.83E+01	1.01E+02	8.65E+00	3.80E+01	4.67E+01
Barium-137m	6.20E+03	1.94E+00	1.07E+02	1.09E+02	7.78E+00	7.83E+01	8.61E+01	3.80E+00	3.80E+01	4.18E+01

Table 9.6b. (continued)

Radionuclide[a]	Soil Activity[b] (pCi/g)	White-footed mouse			Red Fox			White-tailed Deer		
		Internal	External	Total	Internal	External	Total	Internal	External	Total
Lead-212	1.40E+00	5.06E-01	6.39E-02	5.70E-01	8.29E-03	4.65E-02	5.48E-02	4.54E-03	2.32E-02	2.77E-02
Lead-214	9.10E-01	3.24E-01	4.61E-02	3.70E-01	5.17E-03	3.38E-02	3.90E-02	2.91E-03	1.64E-02	1.93E-02
Potassium-40	1.95E+01	2.68E+00	8.88E-02	2.77E+00	2.59E+00	6.48E-02	2.65E+00	5.03E+00	3.19E-02	5.07E+00
Radium-226	1.10E+00	7.28E-02	5.59E-02	1.29E-01	4.58E-02	4.09E-02	8.67E-02	2.89E-02	1.99E-02	4.88E-02
Radium-228	1.10E+00	2.58E-06		2.58E-06	1.62E-06		1.62E-06	1.02E-06		1.02E-06
Strontium-90	2.80E+01	4.22E-02	1.86E-03	4.41E-02	1.53E-01	9.31E-04	1.54E-01	3.34E-01	1.24E-03	3.35E-01
Thorium-228	1.50E+00	2.60E-03	6.89E-02	7.15E-02	8.06E-03	5.02E-02	5.82E-02	5.13E-03	2.50E-02	3.01E-02
Thorium-232	1.10E+00	2.39E-04	3.07E-02	3.09E-02	7.43E-04	2.25E-02	2.33E-02	4.74E-04	1.09E-02	1.14E-02
Thallium-208	1.40E+00	9.24E-02	1.36E-01	2.29E-01	1.95E-01	9.99E-02	2.95E-01	2.92E-03	4.86E-02	5.15E-02
Tritium	5.28E+01	1.65E-02		1.65E-02	1.69E-02		1.69E-02	1.65E-02		1.65E-02
Total		1.28E+01	2.14E+02	2.27E+02	3.38E+01	1.57E+02	1.91E+02	1.79E+01	7.62E+01	9.41E+01
SWSA 5 Seep C										
Americium-241	1.10E+00	1.71E+01	6.26E-04	1.71E+01	7.69E-03	5.57E-04	8.25E-03	3.10E-02	9.23E-05	3.11E-02
Calcium-45	5.30E+02	1.96E+01	9.55E-05	1.96E+01	1.74E-01	4.77E-05	1.74E-01	8.12E-01	6.36E-05	8.12E-01
Carbon-14	4.55E+01	5.94E-02	1.76E-06	5.94E-02	6.30E-02	8.81E-07	6.30E-02	1.16E-01	1.17E-06	1.16E-01
Curium-244	5.65E+00	9.03E+01	2.05E-06	9.03E+01	8.09E-03	1.02E-06	8.09E-03	3.73E-02	1.36E-06	3.73E-02
Cobalt-60	2.75E+00	1.72E-04	2.00E-01	2.00E-01	1.09E-02	1.46E-01	1.57E-01	2.52E-03	7.15E-02	7.40E-02
Cesium-137	4.30E+02	4.67E-01	7.03E+00	7.50E+00	1.51E+00	5.16E+00	6.67E+00	5.70E-01	2.50E+00	3.07E+00
Lead-212	3.81E-01	1.38E-01	1.74E-02	1.55E-01	2.26E-03	1.27E-02	1.49E-02	1.24E-03	6.30E-03	7.54E-03
Potassium-40	1.90E+01	2.61E+00	8.65E-02	2.70E+00	2.52E+00	6.32E-02	2.58E+00	4.91E+00	3.11E-02	4.94E+00
Plutonium-238	6.73E-01	2.45E+01	2.92E-07	2.45E+01	5.49E-04	1.46E-07	5.49E-04	3.84E-05	1.95E-07	3.86E-05
Plutonium-239/40	1.91E-01	6.51E+00	1.56E-07	6.51E+00	4.19E-04	7.80E-08	4.19E-04	2.63E-03	1.04E-07	2.63E-03
Radium-226	1.29E+00	8.54E-02	6.55E-02	1.51E-01	5.37E-02	4.80E-02	1.02E-01	3.39E-02	2.33E-02	5.72E-02
Radium-228	1.58E+00	3.70E-06		3.70E-06	2.33E-06		2.33E-06	1.47E-06		1.47E-06
Strontium-90	1.58E+03	2.38E+00	1.05E-01	2.49E+00	8.61E+00	5.25E-02	8.67E+00	1.88E+01	7.01E-02	1.89E+01
Technetium-99	4.17E+00	8.20E-04	1.50E-06	8.22E-04	1.58E-04	7.51E-07	1.59E-04	8.20E-04	1.00E-06	8.21E-04
Thorium-228	1.88E+00	3.25E-03	8.63E-02	8.96E-02	1.01E-02	6.29E-02	7.30E-02	6.44E-03	3.13E-02	3.77E-02
Thorium-230	2.45E+00	6.19E-04	8.42E-06	6.28E-04	1.92E-03	4.21E-06	1.93E-03	1.22E-03	5.61E-06	1.23E-03
Thorium-232	1.73E+00	3.76E-04	4.82E-02	4.86E-02	1.17E-03	3.54E-02	3.66E-02	7.46E-04	1.71E-02	1.79E-02

Table 9.6b. (continued)

Radionuclide[a]	Soil Activity[b] (pCi/g)	White-footed mouse			Red Fox			White-tailed Deer		
		Internal	External	Total	Internal	External	Total	Internal	External	Total
Tritium	5.52E+02	1.73E-01		1.73E-01	1.77E-01		1.77E-01	1.73E-01		1.73E-01
Uranium-233/234	2.11E+00	3.55E-03	8.21E-06	3.56E-03	3.93E-02	4.11E-06	3.93E-02	3.10E-01	5.48E-06	3.10E-01
Uranium-235	1.80E-01	2.76E-04	7.40E-04	1.02E-03	3.06E-03	5.59E-04	3.62E-03	2.41E-02	2.42E-04	2.44E-02
Uranium-235/236	6.29E-02	2.68E-03	2.59E-04	2.94E-03	2.97E-02	1.96E-04	2.99E-02	2.34E-01	8.49E-05	2.35E-01
Uranium-238	1.77E+00	2.61E-03	1.00E-03	3.62E-03	2.90E-02	6.89E-04	2.97E-02	2.28E-01	4.17E-04	2.29E-01
Total		1.64E+02	7.65E+00	1.72E+02	1.33E+01	5.58E+00	1.88E+01	2.63E+01	2.76E+00	2.91E+01
SWSA 5 Trib 1										
Actinium-228	2.17E+00	1.16E-06	6.05E-02	6.05E-02	1.28E-06	4.44E-02	4.44E-02	3.55E-08	2.15E-02	2.15E-02
Americium-241	4.95E-01	7.72E+00	2.82E-04	7.72E+00	3.46E-03	2.51E-04	3.71E-03	1.39E-02	4.15E-05	1.40E-02
Bismuth-212	2.60E+00	4.14E-03	1.40E-02	1.81E-02	3.78E-03	1.02E-02	1.40E-02	3.37E-03	4.99E-03	8.36E-03
Bismuth-214	9.40E-01	5.26E-03	4.11E-02	4.63E-02	4.80E-03	3.01E-02	3.49E-02	4.28E-03	1.47E-02	1.90E-02
Carbon-14	8.00E-01	1.04E-03	3.10E-08	1.04E-03	1.11E-03	1.55E-08	1.11E-03	2.05E-03	2.06E-08	2.05E-03
Cesium-134	4.00E-02	3.09E-05	1.80E-03	1.83E-03	1.20E-04	1.32E-03	1.44E-03	5.56E-05	6.41E-04	6.96E-04
Cobalt-60	9.11E+01	5.70E-03	6.62E+00	6.62E+00	3.62E-01	4.84E+00	5.20E+00	8.34E-02	2.37E+00	2.45E+00
Cesium-137	3.27E+03	3.55E+00	5.35E+01	5.70E+01	1.15E+01	3.92E+01	5.07E+01	4.33E+00	1.90E+01	2.34E+01
Curium-243	1.80E-01	2.49E+00	6.16E-04	2.49E+00	2.58E-04	4.70E-04	7.28E-04	1.19E-03	1.95E-04	1.38E-03
Iodine-129	5.70E+00	4.00E-02	2.13E-03	4.21E-02	7.49E-02	2.02E-03	7.69E-02	8.67E-04	1.42E-04	1.01E-03
Lead-212	1.24E+00	4.48E-01	5.66E-02	5.05E-01	7.35E-03	4.12E-02	4.85E-02	4.02E-03	2.05E-02	2.45E-02
Lead-214	1.13E+00	4.03E-01	5.73E-02	4.60E-01	6.42E-03	4.20E-02	4.84E-02	3.62E-03	2.04E-02	2.40E-02
Potassium-40	2.39E+01	3.28E+00	1.09E-01	3.39E+00	3.17E+00	7.95E-02	3.25E+00	6.17E+00	3.91E-02	6.21E+00
Plutonium-238	3.50E+00	1.27E+02	1.52E-06	1.27E+02	2.85E-03	7.59E-07	2.85E-03	2.00E-04	1.01E-06	2.01E-04
Radium-223	5.60E-01	8.76E-03	1.94E-03	1.07E-02	5.50E-03	1.48E-03	6.98E-03	3.48E-03	6.22E-04	4.10E-03
Radium-226	1.43E+00	9.46E-02	7.26E-02	1.67E-01	5.95E-02	5.32E-02	1.13E-01	3.76E-02	2.59E-02	6.35E-02
Radium-228	1.70E+00	3.98E-06		3.98E-06	2.50E-06		2.50E-06	1.58E-06		1.58E-06
Strontium-90	2.60E+01	3.92E-02	1.73E-03	4.09E-02	1.42E-01	8.65E-04	1.43E-01	3.10E-01	1.15E-03	3.11E-01
Thorium-228	1.66E+00	2.87E-03	7.62E-02	7.91E-02	8.91E-03	5.55E-02	6.44E-02	5.68E-03	2.76E-02	3.33E-02
Thorium-230	9.36E-01	2.37E-04	3.22E-06	2.40E-04	7.34E-04	1.61E-06	7.36E-04	4.68E-04	2.14E-06	4.70E-04
Thorium-232	1.79E+00	3.89E-04	4.99E-02	5.03E-02	1.21E-03	3.66E-02	3.79E-02	7.72E-04	1.77E-02	1.85E-02
Thallium-208	1.50E+00	9.90E-02	1.46E-01	2.45E-01	2.09E-01	1.07E-01	3.16E-01	3.13E-03	5.20E-02	5.52E-02

Table 9.6b. (continued)

Radionuclide[a]	Soil Activity[b] (pCi/g)	White-footed mouse			Red Fox			White-tailed Deer		
		Internal	External	Total	Internal	External	Total	Internal	External	Total
Thorium-234	7.30E+00	6.07E-05	2.16E-02	2.17E-02	2.22E-05	1.58E-02	1.58E-02	7.50E-05	7.79E-03	7.86E-03
Tin-126	4.60E-01	1.31E-05	5.48E-04	5.61E-04	3.77E-06	4.50E-04	4.54E-04	1.38E-05	1.30E-04	1.44E-04
Tritium	4.82E+00	1.51E-03		1.51E-03	1.55E-03		1.55E-03	1.51E-03		1.51E-03
Uranium-233/234	4.00E+00	6.73E-03	1.56E-05	6.74E-03	7.45E-02	7.78E-06	7.45E-02	5.88E-01	1.04E-05	5.88E-01
Uranium-238	3.87E+00	5.72E-03	2.19E-03	7.91E-03	6.34E-02	1.51E-03	6.49E-02	4.99E-01	9.11E-04	5.00E-01
Total		1.45E+02	6.08E+01	2.06E+02	1.57E+01	4.46E+01	6.03E+01	1.21E+01	2.17E+01	3.37E+01
SWSA 5 WOC										
Actinium-228	1.80E+00	9.59E-07	5.02E-02	5.02E-02	1.06E-06	3.68E-02	3.68E-02	2.94E-08	1.78E-02	1.78E-02
Americium-241	1.58E-01	2.46E+00	9.00E-05	2.46E+00	1.10E-03	8.00E-05	1.18E-03	4.45E-03	1.33E-05	4.46E-03
Carbon-14	1.99E+00	2.60E-03	7.70E-08	2.60E-03	2.76E-03	3.85E-08	2.76E-03	5.09E-03	5.14E-08	5.09E-03
Curium-244	1.51E-01	2.41E+00	5.47E-08	2.41E+00	2.16E-04	2.74E-08	2.16E-04	9.97E-04	3.65E-08	9.97E-04
Cobalt-60	5.34E+00	3.34E-04	3.88E-01	3.88E-01	2.12E-02	2.84E-01	3.05E-01	4.89E-03	1.39E-01	1.44E-01
Cobalt-57	2.30E+00	2.42E-05	7.15E-03	7.18E-03	1.23E-03	5.51E-03	6.74E-03	2.13E-04	2.19E-03	2.41E-03
Cesium-137	4.91E+02	5.34E-01	8.03E+00	8.57E+00	1.73E+00	5.89E+00	7.61E+00	6.50E-01	2.86E+00	3.51E+00
Curium-242	1.78E-02	2.59E-01	8.68E-09	2.59E-01	2.68E-05	4.34E-09	2.68E-05	1.23E-04	5.79E-09	1.23E-04
Lead-212	5.84E-01	2.11E-01	2.66E-02	2.38E-01	3.46E-03	1.94E-02	2.29E-02	1.90E-03	9.66E-03	1.16E-02
Lead-214	1.12E+00	3.99E-01	5.67E-02	4.56E-01	6.36E-03	4.16E-02	4.80E-02	3.59E-03	2.02E-02	2.38E-02
Potassium-40	1.57E+01	2.16E+00	7.15E-02	2.23E+00	2.08E+00	5.22E-02	2.14E+00	4.05E+00	2.57E-02	4.08E+00
Plutonium-238	2.90E-01	1.05E+01	1.26E-07	1.05E+01	2.36E-04	6.29E-08	2.37E-04	1.65E-05	8.39E-08	1.66E-05
Plutonium-239/40	2.22E-02	7.57E-01	1.81E-08	7.57E-01	4.87E-05	9.07E-09	4.87E-05	3.05E-04	1.21E-08	3.05E-04
Radium-226	1.21E+00	8.01E-02	6.14E-02	1.42E-01	5.03E-02	4.50E-02	9.54E-02	3.18E-02	2.19E-02	5.37E-02
Radium-228	2.10E+00	4.92E-06		4.92E-06	3.09E-06		3.09E-06	1.95E-06		1.95E-06
Sodium-22	1.50E+00	1.73E-01	9.51E-02	2.69E-01	1.04E+01	6.97E-02	1.04E+01	8.96E-02	3.39E-02	1.24E-01
Strontium-90	6.69E+02	1.01E+00	4.45E-02	1.05E+00	3.65E+00	2.22E-02	3.67E+00	7.98E+00	2.97E-02	8.01E+00
Technetium-99	1.90E-01	3.74E-05	6.84E-08	3.74E-05	7.22E-06	3.42E-08	7.25E-06	3.73E-05	4.56E-08	3.74E-05
Thorium-228	1.50E+00	2.60E-03	6.89E-02	7.15E-02	8.06E-03	5.02E-02	5.82E-02	5.13E-03	2.50E-02	3.01E-02
Thorium-230	1.33E+00	3.36E-04	4.57E-06	3.41E-04	1.04E-03	2.28E-06	1.05E-03	6.65E-04	3.05E-06	6.68E-04
Thorium-232	1.30E+00	2.83E-04	3.63E-02	3.65E-02	8.78E-04	2.66E-02	2.75E-02	5.60E-04	1.29E-02	1.34E-02
Thallium-208	2.00E+00	1.32E-01	1.95E-01	3.27E-01	2.78E-01	1.43E-01	4.21E-01	4.17E-03	6.94E-02	7.36E-02

Table 9.6b. (continued)

Radionuclide[a]	Soil Activity[b] (pCi/g)	White-footed mouse			Red Fox			White-tailed Deer		
		Internal	External	Total	Internal	External	Total	Internal	External	Total
Tritium	1.28E+01	4.01E-03		4.01E-03	4.11E-03		4.11E-03	4.01E-03		4.01E-03
Uranium-233/234	9.76E-01	1.64E-03	3.80E-06	1.64E-03	1.82E-02	1.90E-06	1.82E-02	1.43E-01	2.53E-06	1.43E-01
Uranium-235	4.39E-02	6.74E-05	1.81E-04	2.48E-04	7.47E-04	1.36E-04	8.83E-04	5.89E-03	5.90E-05	5.95E-03
Uranium-235/236	1.11E-01	1.57E-03	4.57E-04	2.03E-03	1.74E-02	3.45E-04	1.77E-02	1.37E-01	1.49E-04	1.37E-01
Uranium-238	9.57E-01	1.41E-03	5.42E-04	1.96E-03	1.57E-02	3.73E-04	1.60E-02	1.24E-01	2.25E-04	1.24E-01
Total		2.11E+01	9.13E+00	3.03E+01	1.82E+01	6.68E+00	2.49E+01	1.33E+01	3.27E+00	1.65E+01
SWSA 4 Main										
Cesium-137	8.80E+04	9.56E+01	1.44E+03	1.54E+03	3.09E+02	1.06E+03	1.36E+03	1.17E+02	5.12E+02	6.29E+02
Potassium-40	1.30E+01	1.79E+00	5.92E-02	1.84E+00	1.73E+00	4.32E-02	1.77E+00	3.36E+00	2.13E-02	3.38E+00
Strontium-90	1.10E+04	1.66E+01	7.32E-01	1.73E+01	6.00E+01	3.66E-01	6.03E+01	1.31E+02	4.88E-01	1.32E+02
Tritium	6.70E+02	2.10E-01		2.10E-01	2.15E-01		2.15E-01	2.10E-01		2.10E-01
Total		1.14E+02	1.44E+03	1.55E+03	3.71E+02	1.06E+03	1.43E+03	2.51E+02	5.13E+02	7.64E+02
SWSA 5 N WOC										
Actinium-228	2.10E+00	1.12E-06	5.86E-02	5.86E-02	1.23E-06	4.30E-02	4.30E-02	3.43E-08	2.08E-02	2.08E-02
Bismuth-212	1.90E+00	3.03E-03	1.02E-02	1.33E-02	2.76E-03	7.49E-03	1.02E-02	2.46E-03	3.65E-03	6.11E-03
Bismuth-214	8.10E-01	4.54E-03	3.54E-02	3.99E-02	4.13E-03	2.59E-02	3.00E-02	3.69E-03	1.27E-02	1.63E-02
Carbon-14	4.01E-01	5.23E-04	1.55E-08	5.23E-04	5.56E-04	7.76E-09	5.56E-04	1.03E-03	1.03E-08	1.03E-03
Iodine-129	4.40E+00	3.09E-02	1.64E-03	3.25E-02	5.78E-02	1.56E-03	5.94E-02	6.69E-04	1.09E-04	7.78E-04
Lead-212	1.60E+00	5.78E-01	7.30E-02	6.51E-01	9.48E-03	5.32E-02	6.26E-02	5.19E-03	2.65E-02	3.17E-02
Lead-214	1.07E+00	3.81E-01	5.42E-02	4.36E-01	6.08E-03	3.97E-02	4.58E-02	3.43E-03	1.93E-02	2.27E-02
Potassium-40	3.08E+01	4.23E+00	1.40E-01	4.37E+00	4.09E+00	1.02E-01	4.19E+00	7.95E+00	5.04E-02	8.00E+00
Radium-226	9.50E-01	6.29E-02	4.82E-02	1.11E-01	3.95E-02	3.53E-02	7.49E-02	2.50E-02	1.72E-02	4.22E-02
Radium-228	2.10E+00	4.92E-06		4.92E-06	3.09E-06		3.09E-06	1.95E-06		1.95E-06
Strontium-90	3.13E-01	4.72E-04	2.08E-05	4.92E-04	1.71E-03	1.04E-05	1.72E-03	3.73E-03	1.39E-05	3.75E-03
Thorium-228	2.00E+00	3.46E-03	9.19E-02	9.53E-02	1.07E-02	6.69E-02	7.76E-02	6.85E-03	3.33E-02	4.01E-02
Thorium-232	2.10E+00	4.57E-04	5.86E-02	5.90E-02	1.42E-03	4.30E-02	4.44E-02	9.05E-04	2.08E-02	2.17E-02
Thallium-208	1.80E+00	1.19E-01	1.75E-01	2.94E-01	2.50E-01	1.28E-01	3.79E-01	3.75E-03	6.24E-02	6.62E-02
Thorium-234	1.90E+00	4.42E-05	1.57E-02	1.58E-02	1.44E-05	1.15E-02	1.15E-02	5.42E-05	5.59E-03	5.65E-03

Table 9.6b. (continued)

Radionuclide[a]	Soil Activity[b] (pCi/g)	White-footed mouse			Red Fox			White-tailed Deer		
		Internal	External	Total	Internal	External	Total	Internal	External	Total
Tin-126	3.40E-01	9.70E-06	4.05E-04	4.15E-04	2.78E-06	3.33E-04	3.35E-04	1.02E-05	9.63E-05	1.06E-04
Tritium	1.06E+01	3.32E-03		3.32E-03	3.40E-03		3.40E-03	3.32E-03		3.32E-03
Total		5.42E+00	7.63E-01	6.18E+00	4.48E+00	5.59E-01	5.03E+00	8.01E+00	2.73E-01	8.29E+00
SWSA 6 East										
Cobalt-60	5.33E+01	3.34E-03	3.87E+00	3.87E+00	2.12E-01	2.83E+00	3.04E+00	4.88E-02	1.38E+00	1.43E+00
Cesium-137	2.14E+00	2.33E-03	3.50E-02	3.73E-02	7.52E-03	2.57E-02	3.32E-02	2.83E-03	1.25E-02	1.53E-02
Potassium-40	2.57E+01	3.53E+00	1.17E-01	3.65E+00	3.41E+00	8.55E-02	3.50E+00	6.64E+00	4.21E-02	6.68E+00
Radium-224	1.52E+00	1.11E-01	6.98E-02	1.81E-01	7.00E-02	5.08E-02	1.21E-01	4.42E-02	2.53E-02	6.95E-02
Radium-226	8.00E-01	5.29E-02	4.06E-02	9.36E-02	3.33E-02	2.98E-02	6.30E-02	2.10E-02	1.45E-02	3.55E-02
Radium-228	1.52E+00	3.56E-06		3.56E-06	2.24E-06		2.24E-06	1.41E-06		1.41E-06
Strontium-90	6.22E+00	9.37E-03	4.14E-04	9.79E-03	3.39E-02	2.07E-04	3.41E-02	7.42E-02	2.76E-04	7.45E-02
Thorium-228	1.45E+00	2.51E-03	6.66E-02	6.91E-02	7.79E-03	4.85E-02	5.63E-02	4.96E-03	2.41E-02	2.91E-02
Thorium-230	1.27E+00	3.21E-04	4.36E-06	3.25E-04	9.96E-04	2.18E-06	9.98E-04	6.35E-04	2.91E-06	6.38E-04
Thorium-232	1.11E+00	2.42E-04	3.10E-02	3.12E-02	7.50E-04	2.27E-02	2.35E-02	4.78E-04	1.10E-02	1.15E-02
Thorium-234	3.96E-01	2.34E-02	2.82E-05	2.34E-02	3.51E-02	1.41E-05	3.51E-02	1.19E-01	1.88E-05	1.19E-01
Tritium	7.10E+01	2.22E-02		2.22E-02	2.28E-02		2.28E-02	2.22E-02		2.22E-02
Uranium-234	6.70E-01	1.11E-03	7.71E-07	1.11E-03	1.23E-02	3.85E-07	1.23E-02	9.72E-02	5.14E-07	9.72E-02
Uranium-235/236	6.00E-01	2.02E-03	2.47E-03	4.49E-03	2.24E-02	1.86E-03	2.43E-02	1.77E-01	8.07E-04	1.78E-01
Uranium-238	7.54E-01	1.11E-03	4.27E-04	1.54E-03	1.23E-02	2.94E-04	1.26E-02	9.73E-02	1.78E-04	9.75E-02
Total		3.76E+00	4.23E+00	8.00E+00	3.88E+00	3.10E+00	6.98E+00	7.35E+00	1.52E+00	8.86E+00
SWSA 6 South										
Americium-241	6.00E-01	9.35E+00	3.42E-04	9.35E+00	4.20E-03	3.04E-04	4.50E-03	1.69E-02	5.03E-05	1.70E-02
Potassium-40	1.81E+01	2.49E+00	8.24E-02	2.57E+00	2.40E+00	6.02E-02	2.46E+00	4.67E+00	2.96E-02	4.70E+00
Plutonium-238	6.00E-01	2.18E+01	2.60E-07	2.18E+01	4.89E-04	1.30E-07	4.89E-04	3.42E-05	1.74E-07	3.44E-05
Plutonium-239/40	6.00E-01	2.05E+01	4.90E-07	2.05E+01	1.32E-03	2.45E-07	1.32E-03	8.26E-03	3.27E-07	8.26E-03
Radium-224	1.40E+00	1.03E-01	6.43E-02	1.67E-01	6.45E-02	4.68E-02	1.11E-01	4.07E-02	2.33E-02	6.40E-02
Radium-226	8.30E-01	5.49E-02	4.21E-02	9.71E-02	3.45E-02	3.09E-02	6.54E-02	2.18E-02	1.50E-02	3.68E-02
Radium-228	1.46E+00	3.42E-06		3.42E-06	2.15E-06		2.15E-06	1.36E-06		1.36E-06

Table 9.6b. (continued)

Radionuclide[a]	Soil Activity[b] (pCi/g)	White-footed mouse			Red Fox			White-tailed Deer		
		Internal	External	Total	Internal	External	Total	Internal	External	Total
Thorium-228	1.04E+00	1.80E-03	4.78E-02	4.96E-02	5.59E-03	3.48E-02	4.04E-02	3.56E-03	1.73E-02	2.09E-02
Thorium-230	1.00E+00	2.53E-04	3.44E-06	2.56E-04	7.84E-04	1.72E-06	7.86E-04	5.00E-04	2.29E-06	5.02E-04
Thorium-232	1.07E+00	2.33E-04	2.98E-02	3.01E-02	7.23E-04	2.19E-02	2.26E-02	4.61E-04	1.06E-02	1.10E-02
Thorium-234	1.12E+00	2.20E-03	2.55E-03	4.75E-03	2.44E-02	1.90E-03	2.63E-02	1.92E-01	8.59E-04	1.93E-01
Uranium-234	7.70E-01	1.28E-03	8.86E-07	1.28E-03	1.42E-02	4.43E-07	1.42E-02	1.12E-01	5.91E-07	1.12E-01
Uranium-235/236	6.00E-01	2.15E-03	2.47E-03	4.62E-03	2.38E-02	1.86E-03	2.57E-02	1.88E-01	8.07E-04	1.89E-01
Uranium-238	8.40E-01	1.24E-03	4.76E-04	1.72E-03	1.38E-02	3.27E-04	1.41E-02	1.08E-01	1.98E-04	1.09E-01
Total		5.43E+01	2.72E-01	5.45E+01	2.59E+00	1.99E-01	2.79E+00	5.37E+00	9.78E-02	5.46E+00
W6MS3										
Americium-241	8.90E-01	1.39E+01	5.07E-04	1.39E+01	6.22E-03	4.51E-04	6.67E-03	2.51E-02	7.46E-05	2.51E-02
Curium-244	6.00E-01	9.59E+00	2.17E-07	9.59E+00	8.59E-04	1.09E-07	8.59E-04	3.96E-03	1.45E-07	3.96E-03
Cobalt-60	1.06E-01	6.64E-06	7.70E-03	7.71E-03	4.22E-04	5.63E-03	6.05E-03	9.70E-05	2.75E-03	2.85E-03
Cesium-137	6.01E-01	6.53E-04	9.83E-03	1.05E-02	2.11E-03	7.21E-03	9.32E-03	7.96E-04	3.50E-03	4.30E-03
Curium-242	6.00E-01	8.74E+00	2.93E-07	8.74E+00	9.04E-04	1.46E-07	9.04E-04	4.16E-03	1.95E-07	4.16E-03
Potassium-40	2.39E+01	3.28E+00	1.09E-01	3.39E+00	3.17E+00	7.95E-02	3.25E+00	6.17E+00	3.91E-02	6.21E+00
Plutonium-238	6.00E-01	2.18E+01	2.60E-07	2.18E+01	4.89E-04	1.30E-07	4.89E-04	3.42E-05	1.74E-07	3.44E-05
Plutonium-239/40	6.00E-01	2.05E+01	4.90E-07	2.05E+01	1.32E-03	2.45E-07	1.32E-03	8.26E-03	3.27E-07	8.26E-03
Radium-224	1.27E+00	9.31E-02	5.83E-02	1.51E-01	5.85E-02	4.25E-02	1.01E-01	3.70E-02	2.11E-02	5.81E-02
Radium-226	8.21E-01	5.43E-02	4.17E-02	9.60E-02	3.42E-02	3.05E-02	6.47E-02	2.16E-02	1.49E-02	3.64E-02
Radium-228	1.34E+00	3.14E-06		3.14E-06	1.97E-06		1.97E-06	1.25E-06		1.25E-06
Strontium-90	2.55E+01	3.84E-02	1.70E-03	4.01E-02	1.39E-01	8.48E-04	1.40E-01	3.04E-01	1.13E-03	3.05E-01
Technetium-99	9.00E-01	1.77E-04	3.24E-07	1.77E-04	3.42E-05	1.62E-07	3.44E-05	1.77E-04	2.16E-07	1.77E-04
Thorium-228	1.25E+00	2.16E-03	5.74E-02	5.96E-02	6.71E-03	4.18E-02	4.85E-02	4.28E-03	2.08E-02	2.51E-02
Thorium-230	1.59E+00	4.02E-04	5.46E-06	4.07E-04	1.25E-03	2.73E-06	1.25E-03	7.95E-04	3.64E-06	7.99E-04
Thorium-232	9.37E-01	2.04E-04	2.61E-02	2.63E-02	6.33E-04	1.92E-02	1.98E-02	4.04E-04	9.27E-03	9.67E-03
Thorium-234	1.50E+00	1.65E-01	1.06E-04	1.65E-01	2.03E-01	5.32E-05	2.03E-01	4.57E-01	7.09E-05	4.57E-01
Tritium	5.15E+02	1.61E-01		1.61E-01	1.65E-01		1.65E-01	1.61E-01		1.61E-01
Uranium-234	2.04E+00	3.39E-03	2.35E-06	3.39E-03	3.76E-02	1.17E-06	3.76E-02	2.96E-01	1.56E-06	2.96E-01
Uranium-235/236	6.00E-01	2.46E-03	2.47E-03	4.92E-03	2.72E-02	1.86E-03	2.91E-02	2.15E-01	8.07E-04	2.15E-01

Table 9.6b. (continued)

Radionuclide[a]	Soil Activity[b] (pCi/g)	White-footed mouse			Red Fox			White-tailed Deer		
		Internal	External	Total	Internal	External	Total	Internal	External	Total
Uranium-238	1.05E+00	1.55E-03	5.94E-04	2.15E-03	1.72E-02	4.09E-04	1.76E-02	1.36E-01	2.47E-04	1.36E-01
Total		7.83E+01	3.15E-01	7.86E+01	3.87E+00	2.30E-01	4.10E+00	7.85E+00	1.14E-01	7.96E+00
W6MS1										
Americium-241	6.00E-01	9.35E+00	3.42E-04	9.35E+00	4.20E-03	3.04E-04	4.50E-03	1.69E-02	5.03E-05	1.70E-02
Cobalt-60	1.80E-01	1.13E-05	1.31E-02	1.31E-02	7.16E-04	9.57E-03	1.03E-02	1.65E-04	4.68E-03	4.84E-03
Cesium-137	6.48E-01	7.04E-04	1.06E-02	1.13E-02	2.28E-03	7.77E-03	1.00E-02	8.58E-04	3.77E-03	4.63E-03
Potassium-40	2.65E+01	3.64E+00	1.21E-01	3.76E+00	3.52E+00	8.81E-02	3.60E+00	6.84E+00	4.34E-02	6.89E+00
Plutonium-238	6.00E-01	2.18E+01	2.60E-07	2.18E+01	4.89E-04	1.30E-07	4.89E-04	3.42E-05	1.74E-07	3.44E-05
Plutonium-239/40	6.00E-01	2.05E+01	4.90E-07	2.05E+01	1.32E-03	2.45E-07	1.32E-03	8.26E-03	3.27E-07	8.26E-03
Radium-224	1.32E+00	9.67E-02	6.06E-02	1.57E-01	6.08E-02	4.41E-02	1.05E-01	3.84E-02	2.20E-02	6.04E-02
Radium-226	8.27E-01	5.47E-02	4.20E-02	9.67E-02	3.44E-02	3.08E-02	6.52E-02	2.17E-02	1.50E-02	3.67E-02
Radium-228	1.33E+00	3.12E-06		3.12E-06	1.96E-06		1.96E-06	1.24E-06		1.24E-06
Thorium-228	1.13E+00	1.96E-03	5.19E-02	5.39E-02	6.07E-03	3.78E-02	4.39E-02	3.87E-03	1.88E-02	2.27E-02
Thorium-230	8.40E-01	2.12E-04	2.89E-06	2.15E-04	6.59E-04	1.44E-06	6.60E-04	4.20E-04	1.92E-06	4.22E-04
Thorium-232	7.40E-01	1.61E-04	2.06E-02	2.08E-02	5.00E-04	1.51E-02	1.56E-02	3.19E-04	7.32E-03	7.64E-03
Thorium-234	1.52E+00	1.31E-01	1.07E-04	1.31E-01	1.50E-01	5.33E-05	1.50E-01	2.68E-01	7.10E-05	2.68E-01
Tritium	4.14E+02	1.30E-01		1.30E-01	1.33E-01		1.33E-01	1.30E-01		1.30E-01
Uranium-234	9.50E-01	1.58E-03	1.09E-06	1.58E-03	1.75E-02	5.46E-07	1.75E-02	1.38E-01	7.29E-07	1.38E-01
Uranium-235/236	6.00E-01	2.31E-03	2.47E-03	4.78E-03	2.56E-02	1.86E-03	2.75E-02	2.02E-01	8.07E-04	2.03E-01
Uranium-238	9.50E-01	1.40E-03	5.38E-04	1.94E-03	1.56E-02	3.70E-04	1.59E-02	1.23E-01	2.24E-04	1.23E-01
Total		5.57E+01	3.23E-01	5.60E+01	3.97E+00	2.36E-01	4.21E+00	7.79E+00	1.16E-01	7.91E+00
WCTRIB-1										
Cobalt-60	3.00E+02	1.88E-02	2.18E+01	2.18E+01	1.19E+00	1.59E+01	1.71E+01	2.75E-01	7.80E+00	8.07E+00
Cesium-137	8.50E+03	9.24E+00	1.39E+02	1.48E+02	2.99E+01	1.02E+02	1.32E+02	1.13E+01	4.95E+01	6.08E+01
Strontium-90	6.80E+02	1.02E+00	4.52E-02	1.07E+00	3.71E+00	2.26E-02	3.73E+00	8.11E+00	3.02E-02	8.14E+00
Total		1.03E+01	1.61E+02	1.71E+02	3.48E+01	1.18E+02	1.53E+02	1.96E+01	5.73E+01	7.70E+01
West Seep										

Table 9.6b. (continued)

Radionuclide[a]	Soil Activity[b] (pCi/g)	White-footed mouse			Red Fox			White-tailed Deer		
		Internal	External	Total	Internal	External	Total	Internal	External	Total
Actinium-228	1.19E+00	6.34E-07	3.32E-02	3.32E-02	7.00E-07	2.44E-02	2.44E-02	1.94E-08	1.18E-02	1.18E-02
Americium-241	8.39E-01	1.31E+01	4.78E-04	1.31E+01	5.87E-03	4.25E-04	6.29E-03	2.36E-02	7.04E-05	2.37E-02
Bismuth-214	6.40E-01	3.58E-03	2.80E-02	3.16E-02	3.27E-03	2.05E-02	2.37E-02	2.91E-03	1.00E-02	1.29E-02
Cesium-137	4.34E+02	4.72E-01	7.10E+00	7.57E+00	1.53E+00	5.20E+00	6.73E+00	5.75E-01	2.53E+00	3.10E+00
Curium-243/244	2.40E-02	3.32E-01	8.22E-05	3.33E-01	3.44E-05	6.27E-05	9.71E-05	1.58E-04	2.60E-05	1.84E-04
Curium-245/246	3.35E-02	4.29E-01	7.56E-05	4.29E-01	4.44E-05	5.94E-05	1.04E-04	2.04E-04	2.16E-05	2.26E-04
Cobalt-57	2.00E-02	2.10E-07	6.22E-05	6.24E-05	1.07E-05	4.79E-05	5.86E-05	1.86E-06	1.91E-05	2.09E-05
Cobalt-60	7.20E+04	4.51E+00	5.23E+03	5.23E+03	2.86E+02	3.83E+03	4.11E+03	6.59E+01	1.87E+03	1.94E+03
Europium-152	-6.30E-02	-1.86E-05	-2.25E-03	-2.27E-03	-1.29E-05	-1.61E-03	-1.63E-03	-6.83E-06	-8.47E-04	-8.54E-04
Lead-212	1.34E+00	4.84E-01	6.11E-02	5.45E-01	7.94E-03	4.45E-02	5.25E-02	4.35E-03	2.22E-02	2.65E-02
Lead-214	7.50E-01	1.81E-03	3.80E-02	3.98E-02	1.53E-04	2.79E-02	2.80E-02	1.81E-05	1.35E-02	1.35E-02
Plutonium-238	8.13E-02	2.95E+00	3.53E-08	2.95E+00	6.63E-05	1.76E-08	6.63E-05	4.64E-06	2.35E-08	4.66E-06
Plutonium-239/40	1.10E+00	3.75E+01	8.99E-07	3.75E+01	2.41E-03	4.49E-07	2.41E-03	1.51E-02	5.99E-07	1.51E-02
Potassium-40	2.12E+01	2.91E+00	9.65E-02	3.01E+00	2.81E+00	7.05E-02	2.88E+00	5.47E+00	3.47E-02	5.51E+00
Radium-224	2.46E+00	1.80E-01	1.13E-01	2.93E-01	1.13E-01	8.22E-02	1.96E-01	7.16E-02	4.09E-02	1.13E-01
Radium-226	7.87E-01	5.21E-02	4.00E-02	9.20E-02	3.27E-02	2.93E-02	6.20E-02	2.07E-02	1.42E-02	3.49E-02
Radium-228	1.40E+00	3.28E-06		3.28E-06	2.06E-06		2.06E-06	1.30E-06		1.30E-06
Strontium-90	1.88E+02	2.83E-01	1.25E-02	2.96E-01	1.02E+00	6.25E-03	1.03E+00	2.24E+00	8.34E-03	2.25E+00
Thallium-208	4.60E-01	3.04E-02	4.48E-02	7.52E-02	6.40E-02	3.28E-02	9.68E-02	9.59E-04	1.60E-02	1.69E-02
Thorium-228	1.39E+00	2.41E-03	6.38E-02	6.62E-02	7.46E-03	4.65E-02	5.39E-02	4.76E-03	2.31E-02	2.79E-02
Thorium-230	9.81E-01	2.48E-04	3.37E-06	2.51E-04	7.69E-04	1.68E-06	7.71E-04	4.90E-04	2.25E-06	4.93E-04
Thorium-232	1.20E+00	2.61E-04	3.35E-02	3.37E-02	8.11E-04	2.46E-02	2.54E-02	5.17E-04	1.19E-02	1.24E-02
Thorium-234	1.55E+00	3.05E-02	1.08E-04	3.06E-02	3.45E-02	5.40E-05	3.46E-02	5.89E-02	7.20E-05	5.90E-02
Tritium	9.62E+01	3.01E-02		3.01E-02	3.09E-02		3.09E-02	3.01E-02		3.01E-02
Uranium-232	1.78E-01	3.29E-04	4.62E-07	3.30E-04	3.65E-03	2.31E-07	3.65E-03	2.88E-02	3.08E-07	2.88E-02
Uranium-233/234	4.51E+00	7.58E-03	1.76E-05	7.60E-03	8.40E-02	8.78E-06	8.40E-02	6.62E-01	1.17E-05	6.62E-01
Uranium-234	1.19E+00	1.98E-03	1.37E-06	1.98E-03	2.19E-02	6.85E-07	2.19E-02	1.73E-01	9.13E-07	1.73E-01
Uranium-235	3.80E-01	5.83E-04	1.56E-03	2.15E-03	6.47E-03	1.18E-03	7.65E-03	5.10E-02	5.11E-04	5.15E-02
Uranium-238	1.82E+00	2.69E-03	1.03E-03	3.72E-03	2.98E-02	7.09E-04	3.05E-02	2.35E-01	4.29E-04	2.35E-01
Total		6.33E+01	5.24E+03	5.30E+03	2.92E+02	3.83E+03	4.12E+03	7.56E+01	1.87E+03	1.95E+03

Table 9.6b. (continued)

Radionuclide[a]	Soil Activity[b] (pCi/g)	White-footed mouse			Red Fox			White-tailed Deer		
		Internal	External	Total	Internal	External	Total	Internal	External	Total
SWSA 5 Drainage D-2										
Actinium-228	2.30E+00	1.23E-06	6.41E-02	6.41E-02	1.35E-06	4.71E-02	4.71E-02	3.76E-08	2.28E-02	2.28E-02
Bismuth-214	8.20E-01	4.59E-03	3.58E-02	4.04E-02	4.19E-03	2.62E-02	3.04E-02	3.73E-03	1.28E-02	1.65E-02
Calcium-45	1.30E+01	4.81E-01	2.34E-06	4.81E-01	4.26E-03	1.17E-06	4.26E-03	1.99E-02	1.56E-06	1.99E-02
Carbon-14	4.60E-01	6.00E-04	1.78E-08	6.00E-04	6.37E-04	8.90E-09	6.37E-04	1.18E-03	1.19E-08	1.18E-03
Cesium-137	1.99E+01	2.16E-02	3.26E-01	3.47E-01	7.00E-02	2.39E-01	3.09E-01	2.64E-02	1.16E-01	1.42E-01
Iodine-129	3.30E+00	2.31E-02	1.23E-03	2.44E-02	4.34E-02	1.17E-03	4.45E-02	5.02E-04	8.20E-05	5.84E-04
Lead-210	6.10E+00									
Lead-212	9.23E-01	3.34E-01	4.21E-02	3.76E-01	5.47E-03	3.07E-02	3.61E-02	3.00E-03	1.53E-02	1.83E-02
Lead-214	1.40E+00	4.99E-01	7.09E-02	5.70E-01	7.95E-03	5.20E-02	6.00E-02	4.48E-03	2.52E-02	2.97E-02
Potassium-40	2.01E+01	2.76E+00	9.15E-02	2.85E+00	2.67E+00	6.68E-02	2.73E+00	5.19E+00	3.29E-02	5.22E+00
Radium-226	7.90E-01	5.23E-02	4.01E-02	9.24E-02	3.29E-02	2.94E-02	6.23E-02	2.08E-02	1.43E-02	3.51E-02
Radium-228	1.88E+00	4.41E-06		4.41E-06	2.77E-06		2.77E-06	1.75E-06		1.75E-06
Strontium-90	1.28E+02	1.93E-01	8.51E-03	2.01E-01	6.98E-01	4.26E-03	7.02E-01	1.53E+00	5.68E-03	1.53E+00
Technetium-99	1.18E+00	2.32E-04	4.25E-07	2.32E-04	4.48E-05	2.13E-07	4.50E-05	2.32E-04	2.83E-07	2.32E-04
Thorium-228	1.50E+00	2.60E-03	6.89E-02	7.15E-02	8.06E-03	5.02E-02	5.82E-02	5.13E-03	2.50E-02	3.01E-02
Thorium-232	2.15E+00	4.68E-04	6.00E-02	6.04E-02	1.45E-03	4.40E-02	4.55E-02	9.27E-04	2.13E-02	2.22E-02
Thallium-208	1.40E+00	9.24E-02	1.36E-01	2.29E-01	1.95E-01	9.99E-02	2.95E-01	2.92E-03	4.86E-02	5.15E-02
Tritium	2.29E+01	7.18E-03		7.18E-03	7.35E-03		7.35E-03	7.18E-03		7.18E-03
Total		4.47E+00	9.45E-01	5.42E+00	3.75E+00	6.90E-01	4.44E+00	6.81E+00	3.40E-01	7.15E+00
WAG 7 WOC										
Actinium-228	1.09E+00	5.81E-07	3.04E-02	3.04E-02	6.41E-07	2.23E-02	2.23E-02	1.78E-08	1.08E-02	1.08E-02
Americium-241	1.11E-01	1.73E+00	6.32E-05	1.73E+00	7.76E-04	5.62E-05	8.32E-04	3.13E-03	9.31E-06	3.14E-03
Bismuth-214	6.50E-01	3.64E-03	2.84E-02	3.21E-02	3.32E-03	2.08E-02	2.41E-02	2.96E-03	1.02E-02	1.31E-02
Cesium-137	5.62E+03	6.11E+00	9.68E+01	1.03E+02	1.98E+01	7.09E+01	9.07E+01	7.44E+00	3.45E+01	4.19E+01
Curium-243/244	1.08E+00	1.50E+01	3.70E-03	1.50E+01	1.55E-03	2.82E-03	4.37E-03	7.13E-03	1.17E-03	8.29E-03
Cobalt-57	9.00E-02	9.47E-07	2.80E-04	2.81E-04	4.81E-05	2.16E-04	2.64E-04	8.35E-06	8.58E-05	9.42E-05
Cobalt-60	2.02E-01	1.26E-05	1.47E-02	1.47E-02	8.04E-04	1.07E-02	1.15E-02	1.85E-04	5.25E-03	5.43E-03

Table 9.6b. (continued)

Radionuclide[a]	Soil Activity[b] (pCi/g)	White-footed mouse			Red Fox			White-tailed Deer		
		Internal	External	Total	Internal	External	Total	Internal	External	Total
Plutonium-238	2.42E-01	8.79E+00	1.05E-07	8.79E+00	1.97E-04	5.25E-08	1.97E-04	1.38E-05	7.00E-08	1.39E-05
Plutonium-239/40	5.10E-02	1.74E+00	4.17E-08	1.74E+00	1.12E-04	2.08E-08	1.12E-04	7.02E-04	2.78E-08	7.02E-04
Potassium-40	2.60E+01	3.57E+00	1.18E-01	3.69E+00	3.45E+00	8.65E-02	3.54E+00	6.71E+00	4.26E-02	6.76E+00
Thorium-228	5.00E-01	8.65E-04	2.30E-02	2.38E-02	2.69E-03	1.67E-02	1.94E-02	1.71E-03	8.33E-03	1.00E-02
Thorium-230	4.10E-01	1.04E-04	1.41E-06	1.05E-04	3.22E-04	7.04E-07	3.22E-04	2.05E-04	9.39E-07	2.06E-04
Thorium-232	4.00E-01	8.70E-05	1.12E-02	1.12E-02	2.70E-04	8.19E-03	8.46E-03	1.72E-04	3.96E-03	4.13E-03
Uranium-233/234	1.10E+00	1.85E-03	4.28E-06	1.85E-03	2.05E-02	2.14E-06	2.05E-02	1.62E-01	2.85E-06	1.62E-01
Uranium-235	8.30E-02	1.27E-04	3.41E-04	4.69E-04	1.41E-03	2.58E-04	1.67E-03	1.11E-02	1.12E-04	1.12E-02
Uranium-238	1.23E+00	1.82E-03	6.96E-04	2.51E-03	2.01E-02	4.79E-04	2.06E-02	1.59E-01	2.90E-04	1.59E-01
Total		3.69E+01	9.70E+01	1.34E+02	2.33E+01	7.11E+01	9.44E+01	1.45E+01	3.45E+01	4.90E+01
WOC										
Americium-241	2.86E+00	4.46E+01	1.63E-03	4.46E+01	2.00E-02	1.45E-03	2.14E-02	8.06E-02	2.40E-04	8.08E-02
Curium-244	3.22E+00	5.15E+01	1.17E-06	5.15E+01	4.61E-03	5.83E-07	4.61E-03	2.13E-02	7.78E-07	2.13E-02
Cobalt-60	4.56E+00	2.86E-04	3.31E-01	3.31E-01	1.81E-02	2.42E-01	2.60E-01	4.17E-03	1.18E-01	1.23E-01
Cesium-137	3.57E+02	3.88E-01	5.84E+00	6.23E+00	1.26E+00	4.28E+00	5.54E+00	4.73E-01	2.08E+00	2.55E+00
Plutonium-238	1.04E+00	3.78E+01	4.51E-07	3.78E+01	8.48E-04	2.26E-07	8.48E-04	5.93E-05	3.01E-07	5.96E-05
Plutonium-239/40	8.07E+00	2.75E+02	6.59E-06	2.75E+02	1.77E-02	3.30E-06	1.77E-02	1.11E-01	4.40E-06	1.11E-01
Strontium-90	2.16E+01	3.25E-02	1.44E-03	3.40E-02	1.18E-01	7.18E-04	1.18E-01	2.58E-01	9.58E-04	2.59E-01
Technetium-99	3.94E+00	7.75E-04	1.42E-06	7.76E-04	1.50E-04	7.10E-07	1.50E-04	7.74E-04	9.46E-07	7.75E-04
Thorium-228	2.81E+00	4.86E-03	1.29E-01	1.34E-01	1.51E-02	9.40E-02	1.09E-01	9.62E-03	4.68E-02	5.64E-02
Thorium-230	5.50E+00	1.39E-03	1.89E-05	1.41E-03	4.31E-03	9.45E-06	4.32E-03	2.75E-03	1.26E-05	2.76E-03
Thorium-232	1.80E+00	3.92E-04	5.02E-02	5.06E-02	1.22E-03	3.68E-02	3.81E-02	7.76E-04	1.78E-02	1.86E-02
Uranium-233/234	3.24E+00	5.45E-03	1.26E-05	5.46E-03	6.04E-02	6.31E-06	6.04E-02	4.76E-01	8.41E-06	4.76E-01
Uranium-235	2.49E-01	3.82E-04	1.02E-03	1.41E-03	4.24E-03	7.73E-04	5.01E-03	3.34E-02	3.35E-04	3.37E-02
Uranium-238	2.97E+00	4.39E-03	1.68E-03	6.07E-03	4.86E-02	1.16E-03	4.98E-02	3.83E-01	7.00E-04	3.84E-01
Total		4.09E+02	6.36E+00	4.16E+02	1.57E+00	4.66E+00	6.23E+00	1.85E+00	2.26E+00	4.12E+00

[a] Dose from each radionuclide includes all short-lived daughter products

[b] Representative concentration is the minimum of the UCL95 and the maximum detect.

Table 9.6c. Estimated radiation doses (mrad/d) from surface soil for red-tailed hawk, wild turkey, and mink at WOC

Radionuclide[a]	Soil Activity[b] (pCi/g)	Red-tailed Hawk			Wild Turkey			Mink		
		Internal	External	Total	Internal	External	Total	Internal	External	Total
East Seep										
Actinium-228	7.80E-01	2.68E-13	7.72E-04	7.72E-04	5.00E-08	7.72E-03	7.72E-03	3.42E-07	1.59E-02	1.59E-02
Bismuth-214	7.90E-01	8.59E-05	1.23E-03	1.32E-03	1.29E-02	1.23E-02	2.52E-02	1.43E-04	2.52E-02	2.53E-02
Cesium-137	7.00E+05	5.62E+03	4.08E+02	6.03E+03	7.41E+03	4.08E+03	1.15E+04	9.11E+02	8.35E+03	9.26E+03
Cobalt-60	9.28E+00	2.95E-02	2.41E-02	5.36E-02	1.73E-02	2.41E-01	2.58E-01	1.43E-02	4.91E-01	5.05E-01
Lead-212	7.05E+00	1.34E-03	1.17E-02	1.30E-02	1.14E-01	1.17E-01	2.31E-01	1.55E-03	2.34E-01	2.36E-01
Lead-214	8.80E-01	1.07E-06	1.59E-03	1.59E-03	9.46E-05	1.59E-02	1.60E-02	1.17E-04	3.25E-02	3.26E-02
Plutonium-238	1.40E-02	1.05E-07	4.05E-10	1.05E-07	5.55E-05	4.05E-09	5.55E-05	1.32E-06	4.05E-09	1.33E-06
Plutonium-239/40	4.40E-02	9.43E-07	2.40E-09	9.45E-07	2.45E-03	2.40E-08	2.45E-03	3.97E-06	2.40E-08	3.99E-06
Potassium-40	2.53E+01	3.27E+00	4.14E-03	3.28E+00	5.83E+00	4.14E-02	5.87E+00	1.49E+00	8.39E-02	1.57E+00
Strontium-90	4.32E+01	1.63E-01	1.92E-04	1.63E-01	5.67E-01	1.92E-03	5.69E-01	7.39E-02	1.92E-03	7.58E-02
Thallium-208	2.16E+00	3.16E-01	7.49E-03	3.23E-01	4.67E-02	7.49E-02	1.22E-01	1.43E-01	1.53E-01	2.97E-01
Thorium-228	9.60E+00	1.80E-04	1.60E-02	1.62E-02	1.48E-01	1.60E-01	3.08E-01	5.32E-03	3.21E-01	3.26E-01
Thorium-230	8.30E-01	2.28E-06	1.90E-07	2.47E-06	1.87E-03	1.90E-06	1.87E-03	6.72E-05	1.90E-06	6.91E-05
Thorium-232	8.10E-01	1.91E-06	8.01E-04	8.03E-04	1.57E-03	8.01E-03	9.59E-03	5.65E-05	1.65E-02	1.65E-02
Thorium-234	3.45E+00	1.18E+01	7.18E-05	1.18E+01	1.42E+03	7.18E-04	1.42E+03	1.33E-01	7.18E-04	1.33E-01
Uranium-232	1.08E+01	6.37E-01	1.87E-06	6.37E-01	7.69E+01	1.87E-05	7.69E+01	7.17E-03	1.87E-05	7.19E-03
Uranium-233/234	2.08E+02	1.11E+01	5.40E-05	1.11E+01	1.35E+03	5.40E-04	1.35E+03	1.25E-01	5.40E-04	1.26E-01
Uranium-235	2.51E+00	1.23E-01	3.37E-04	1.23E-01	1.48E+01	3.37E-03	1.48E+01	1.38E-03	7.58E-03	8.97E-03
Uranium-238	1.05E+01	4.94E-01	2.47E-04	4.94E-01	5.76E+01	2.47E-03	5.76E+01	5.57E-03	4.26E-03	9.83E-03
Total		5.65E+03	4.08E+02	6.05E+03	1.03E+04	4.08E+03	1.44E+04	9.13E+02	8.35E+03	9.26E+03
Haw Ridge										
Cobalt-60	4.70E+00	1.49E-02	1.22E-02	2.71E-02	4.45E-03	1.22E-01	1.27E-01	7.26E-03	2.49E-01	2.56E-01
Cesium-137	2.00E+03	1.61E+01	1.16E+00	1.72E+01	7.98E+00	1.16E+01	1.96E+01	2.60E+00	2.38E+01	2.64E+01
Potassium-40	1.60E+01	2.07E+00	2.62E-03	2.07E+00	3.66E+00	2.62E-02	3.69E+00	9.39E-01	5.30E-02	9.92E-01
Total		1.81E+01	1.18E+00	1.93E+01	1.16E+01	1.18E+01	2.34E+01	3.55E+00	2.41E+01	2.77E+01
HF-2										
Cobalt-60	1.94E+02	6.16E-01	5.04E-01	1.12E+00	1.84E-01	5.04E+00	5.22E+00	3.00E-01	1.03E+01	1.06E+01

Table 9.6c. (continued)

Radionuclide[a]	Soil Activity[b] (pCi/g)	Red-tailed Hawk Internal	Red-tailed Hawk External	Red-tailed Hawk Total	Wild Turkey Internal	Wild Turkey External	Wild Turkey Total	Mink Internal	Mink External	Mink Total
Strontium-90	7.40E-02	2.79E-04	3.28E-07	2.79E-04	8.60E-04	3.28E-06	8.64E-04	1.27E-04	3.28E-06	1.30E-04
Thorium-228	1.40E+00	2.63E-05	2.33E-03	2.36E-03	6.72E-03	2.33E-02	3.00E-02	7.76E-04	4.68E-02	4.76E-02
Thorium-230	1.30E+00	3.57E-06	2.98E-07	3.87E-06	9.11E-04	2.98E-06	9.14E-04	1.05E-04	2.98E-06	1.08E-04
Thorium-232	1.40E+00	3.31E-06	1.38E-03	1.39E-03	8.45E-04	1.38E-02	1.47E-02	9.76E-05	2.85E-02	2.86E-02
Uranium-233/234	1.10E+00	5.89E-02	2.85E-07	5.89E-02	6.87E+00	2.85E-06	6.87E+00	6.64E-04	2.85E-06	6.66E-04
Uranium-235	1.10E-01	5.38E-03	1.48E-05	5.39E-03	6.27E-01	1.48E-04	6.27E-01	6.06E-05	3.32E-04	3.93E-04
Uranium-238	8.70E-01	4.09E-02	2.05E-05	4.10E-02	4.77E+00	2.05E-04	4.77E+00	4.61E-04	3.53E-04	8.14E-04
Total		7.21E-01	5.08E-01	1.23E+00	1.25E+01	5.08E+00	1.75E+01	3.02E-01	1.03E+01	1.06E+01
HFIR										
Cobalt-60	4.64E+00	1.47E-02	1.21E-02	2.68E-02	4.40E-03	1.21E-01	1.25E-01	7.16E-03	2.45E-01	2.53E-01
Cesium-137	5.07E+01	4.07E-01	2.95E-02	4.36E-01	2.02E-01	2.95E-01	4.98E-01	6.60E-02	6.04E-01	6.70E-01
Potassium-40	1.95E+01	2.52E+00	3.19E-03	2.52E+00	4.46E+00	3.19E-02	4.49E+00	1.14E+00	6.46E-02	1.21E+00
Strontium-90	2.50E+04	9.42E+01	1.11E-01	9.43E+01	2.91E+02	1.11E+00	2.92E+02	4.28E+01	1.11E+00	4.39E+01
Thorium-228	6.50E+01	1.22E-03	1.08E-01	1.09E-01	3.12E-01	1.08E+00	1.39E+00	3.60E-02	2.17E+00	2.21E+00
Uranium-234	3.50E+00	1.85E-01	2.68E-07	1.85E-01	2.16E+01	2.68E-06	2.16E+01	2.09E-03	2.68E-06	2.09E-03
Uranium-238	2.10E+00	9.88E-02	4.95E-05	9.89E-02	1.15E+01	4.95E-04	1.15E+01	1.11E-03	8.52E-04	1.97E-03
Total		9.74E+01	2.64E-01	9.76E+01	3.29E+02	2.64E+00	3.31E+02	4.40E+01	4.20E+00	4.82E+01
HFIR East										
Potassium-40	2.00E+01	2.59E+00	3.28E-03	2.59E+00	4.58E+00	3.28E-02	4.61E+00	1.17E+00	6.63E-02	1.24E+00
Total		2.59E+00	3.28E-03	2.59E+00	4.58E+00	3.28E-02	4.61E+00	1.17E+00	6.63E-02	1.24E+00
HRE										
Actinium-228	1.27E+00	4.36E-13	1.26E-03	1.26E-03	8.14E-08	1.26E-02	1.26E-02	5.57E-07	2.58E-02	2.58E-02
Bismuth-214	7.41E-01	8.06E-05	1.16E-03	1.24E-03	1.21E-02	1.16E-02	2.36E-02	1.34E-04	2.36E-02	2.37E-02
Cesium-137	3.84E+03	3.08E+01	2.24E+00	3.31E+01	4.06E+01	2.24E+01	6.30E+01	5.00E+00	4.58E+01	5.08E+01
Cobalt-60	4.35E-01	1.38E-03	1.13E-03	2.51E-03	8.12E-04	1.13E-02	1.21E-02	6.72E-04	2.30E-02	2.37E-02
Europium-154	1.25E+00	1.98E-04	1.84E-03	2.04E-03	7.18E-04	1.84E-02	1.91E-02	9.02E-05	3.51E-02	3.52E-02
Potassium-40	1.82E+01	2.35E+00	2.98E-03	2.36E+00	4.20E+00	2.98E-02	4.23E+00	1.07E+00	6.03E-02	1.13E+00

Table 9.6c. (continued)

Radionuclide[a]	Soil Activity[b] (pCi/g)	Red-tailed Hawk Internal	Red-tailed Hawk External	Red-tailed Hawk Total	Wild Turkey Internal	Wild Turkey External	Wild Turkey Total	Mink Internal	Mink External	Mink Total
Radium-226	1.03E+00	3.04E-03	1.86E-03	4.91E-03	1.18E-01	1.86E-02	1.37E-01	1.80E-03	3.81E-02	3.99E-02
Radium-228	1.37E+00	1.43E-07		1.43E-07	5.56E-06		5.56E-06	8.50E-08		8.50E-08
Strontium-90	2.03E+02	7.65E-01	9.00E-04	7.65E-01	2.67E+00	9.00E-03	2.67E+00	3.47E-01	9.00E-03	3.56E-01
Thallium-208	4.39E-01	6.42E-02	1.52E-03	6.57E-02	9.49E-03	1.52E-02	2.47E-02	2.91E-02	3.12E-02	6.03E-02
Thorium-228	5.50E-01	1.03E-05	9.16E-04	9.26E-04	8.49E-03	9.16E-03	1.77E-02	3.05E-04	1.84E-02	1.87E-02
Thorium-230	1.30E-01	3.57E-07	2.98E-08	3.87E-07	2.93E-04	2.98E-07	2.94E-04	1.05E-05	2.98E-07	1.08E-05
Thorium-232	1.50E+00	3.55E-06	1.48E-03	1.49E-03	2.91E-03	1.48E-02	1.78E-02	1.05E-04	3.05E-02	3.06E-02
Thorium-234	2.56E+00	1.33E+00	9.27E-05	1.33E+00	1.60E+02	9.27E-04	1.60E+02	1.50E-02	1.86E-03	1.68E-02
Uranium-233/234	2.43E+01	1.30E+00	6.31E-06	1.30E+00	1.57E+02	6.31E-05	1.57E+02	1.47E-02	6.31E-05	1.47E-02
Uranium-235	5.55E-01	2.71E-02	7.46E-05	2.72E-02	3.28E+00	7.46E-04	3.28E+00	3.06E-04	1.68E-03	1.98E-03
Uranium-238	1.29E+00	6.07E-02	3.04E-05	6.07E-02	7.08E+00	3.04E-04	7.08E+00	6.84E-04	5.23E-04	1.21E-03
Total		3.67E+01	2.25E+00	3.90E+01	3.76E+02	2.25E+01	3.98E+02	6.48E+00	4.61E+01	5.26E+01
Intermediate Pond										
Americium-241	3.06E+01	4.45E-03	2.57E-04	4.71E-03	1.90E+00	2.57E-03	1.90E+00	3.83E-03	1.34E-02	1.72E-02
Curium-244	5.72E+00	3.43E-05	1.38E-07	3.44E-05	3.74E-02	1.38E-06	3.74E-02	5.81E-04	1.38E-06	5.83E-04
Cobalt-60	1.31E+01	4.16E-02	3.40E-02	7.56E-02	1.24E-02	3.40E-01	3.53E-01	2.02E-02	6.93E-01	7.13E-01
Cesium-137	6.35E+03	5.10E+01	3.70E+00	5.47E+01	2.53E+01	3.70E+01	6.23E+01	8.26E+00	7.57E+01	8.40E+01
Plutonium-238	2.20E+00	1.65E-05	6.36E-08	1.66E-05	7.03E-03	6.36E-07	7.03E-03	2.08E-04	6.36E-07	2.08E-04
Plutonium-239/40	9.49E+01	2.03E-03	5.17E-06	2.04E-03	5.22E+00	5.17E-05	5.22E+00	8.56E-03	5.17E-05	8.61E-03
Strontium-90	2.48E+02	9.34E-01	1.10E-03	9.35E-01	2.88E+00	1.10E-02	2.89E+00	4.24E-01	1.10E-02	4.35E-01
Technetium-99	4.66E+00	4.58E-07	1.12E-07	5.70E-07	9.16E-04	1.12E-06	9.17E-04	6.10E-07	1.12E-06	1.73E-06
Thorium-228	5.08E+00	9.55E-05	8.46E-03	8.55E-03	2.44E-02	8.46E-02	1.09E-01	2.82E-03	1.70E-01	1.73E-01
Thorium-230	1.86E+01	5.11E-05	4.26E-06	5.53E-05	1.30E-02	4.26E-05	1.31E-02	1.51E-03	4.26E-05	1.55E-03
Thorium-232	5.28E+00	1.25E-05	5.22E-03	5.24E-03	3.19E-03	5.22E-02	5.54E-02	3.68E-04	1.07E-01	1.08E-01
Uranium-233/234	3.89E+01	2.08E+00	1.01E-05	2.08E+00	2.43E+02	1.01E-04	2.43E+02	2.35E-02	1.01E-04	2.36E-02
Uranium-235	5.29E+00	2.59E-01	7.11E-04	2.59E-01	3.02E+01	7.11E-03	3.02E+01	2.91E-03	1.60E-02	1.89E-02
Uranium-238	1.24E+01	5.84E-01	2.92E-04	5.84E-01	6.80E+01	2.92E-03	6.80E+01	6.57E-03	5.03E-03	1.16E-02
Total		5.49E+01	3.75E+00	5.86E+01	3.77E+02	3.75E+01	4.14E+02	8.76E+00	7.67E+01	8.55E+01

Table 9.6c. (continued)

Radionuclide[a]	Soil Activity[b] (pCi/g)	Red-tailed Hawk Internal	Red-tailed Hawk External	Red-tailed Hawk Total	Wild Turkey Internal	Wild Turkey External	Wild Turkey Total	Mink Internal	Mink External	Mink Total
Lower WOC										
Americium-241	6.38E+00	9.29E-04	5.35E-05	9.82E-04	3.95E-01	5.35E-04	3.96E-01	7.98E-04	2.80E-03	3.60E-03
Curium-244	2.28E+00	1.37E-05	5.51E-08	1.37E-05	1.49E-02	5.51E-07	1.49E-02	2.32E-04	5.51E-07	2.32E-04
Cobalt-60	1.55E+01	4.92E-02	4.03E-02	8.95E-02	1.47E-02	4.03E-01	4.17E-01	2.39E-02	8.20E-01	8.44E-01
Cesium-137	8.68E+02	6.97E+00	5.05E-01	7.47E+00	3.46E+00	5.05E+00	8.52E+00	1.13E+00	1.03E+01	1.15E+01
Plutonium-238	1.14E+00	8.54E-06	3.30E-08	8.58E-06	3.64E-03	3.30E-07	3.64E-03	1.08E-04	3.30E-07	1.08E-04
Plutonium-239/40	4.51E+01	9.66E-04	2.46E-06	9.69E-04	2.48E+00	2.46E-05	2.48E+00	4.07E-03	2.46E-05	4.09E-03
Strontium-90	3.10E+01	1.17E-01	1.37E-04	1.17E-01	3.60E-01	1.37E-03	3.62E-01	5.30E-02	1.37E-03	5.44E-02
Technetium-99	1.47E+01	1.44E-06	3.53E-07	1.80E-06	2.89E-03	3.53E-06	2.89E-03	1.92E-06	3.53E-06	5.45E-06
Thorium-228	3.80E+00	7.14E-05	6.33E-03	6.40E-03	1.82E-02	6.33E-02	8.15E-02	2.11E-03	1.27E-01	1.29E-01
Thorium-230	4.84E+00	1.33E-05	1.11E-06	1.44E-05	3.39E-03	1.11E-05	3.40E-03	3.92E-04	1.11E-05	4.03E-04
Thorium-232	1.80E+00	4.25E-06	1.78E-03	1.78E-03	1.09E-03	1.78E-02	1.89E-02	1.26E-04	3.66E-02	3.67E-02
Uranium-233/234	4.94E+00	2.65E-01	1.28E-06	2.65E-01	3.08E+01	1.28E-05	3.08E+01	2.98E-03	1.28E-05	2.99E-03
Uranium-235	6.15E-01	3.01E-02	8.27E-05	3.02E-02	3.51E+00	8.27E-04	3.51E+00	3.39E-04	1.86E-03	2.20E-03
Uranium-238	2.10E+00	9.88E-02	4.95E-05	9.89E-02	1.15E+01	4.95E-04	1.15E+01	1.11E-03	8.52E-04	1.97E-03
Total		7.53E+00	5.54E-01	8.08E+00	5.26E+01	5.54E+00	5.82E+01	1.22E+00	1.13E+01	1.26E+01
MB-15										
Cobalt-60	4.20E+04	1.33E+02	1.09E+02	2.42E+02	3.98E+01	1.09E+03	1.13E+03	6.48E+01	2.22E+03	2.29E+03
Cesium-137	3.80E+02	3.05E+00	2.21E-01	3.27E+00	1.52E+00	2.21E+00	3.73E+00	4.95E-01	4.53E+00	5.02E+00
Total		1.36E+02	1.09E+02	2.46E+02	4.13E+01	1.09E+03	1.13E+03	6.53E+01	2.23E+03	2.29E+03
MV Drive										
Carbon-14	1.80E-01	2.35E-04	4.64E-10	2.35E-04	4.20E-04	4.64E-09	4.20E-04	1.07E-04	4.64E-09	1.07E-04
Cobalt-60	1.20E+00	3.81E-03	3.12E-03	6.93E-03	1.14E-03	3.12E-02	3.23E-02	1.85E-03	6.35E-02	6.53E-02
Cesium-137	3.20E+02	2.57E+00	1.86E-01	2.75E+00	1.28E+00	1.86E+00	3.14E+00	4.16E-01	3.81E+00	4.23E+00
Potassium-40	1.20E+01	1.55E+00	1.97E-03	1.55E+00	2.75E+00	1.97E-02	2.77E+00	7.05E-01	3.98E-02	7.44E-01
Tritium	8.50E+00	2.66E-03		2.66E-03	2.68E-03		2.68E-03	1.21E-03		1.21E-03
Total		4.13E+00	1.91E-01	4.32E+00	4.03E+00	1.91E+00	5.94E+00	1.12E+00	3.92E+00	5.04E+00

Table 9.6c. (continued)

Radionuclide[a]	Soil Activity[b] (pCi/g)	Red-tailed Hawk			Wild Turkey			Mink		
		Internal	External	Total	Internal	External	Total	Internal	External	Total
NHF										
Americium-241	1.10E-01	1.60E-05	9.23E-07	1.69E-05	6.82E-03	9.23E-06	6.83E-03	1.38E-05	4.83E-05	6.20E-05
Carbon-14	2.07E+00	2.70E-03	5.34E-09	2.70E-03	4.83E-03	5.34E-08	4.83E-03	1.23E-03	5.34E-08	1.23E-03
Cesium-137	1.40E-01	1.12E-03	8.15E-05	1.21E-03	5.59E-04	8.15E-04	1.37E-03	1.82E-04	1.67E-03	1.85E-03
Potassium-40	2.66E+01	3.44E+00	4.36E-03	3.44E+00	6.09E+00	4.36E-02	6.13E+00	1.56E+00	8.82E-02	1.65E+00
Plutonium-238	2.60E-01	1.95E-06	7.52E-09	1.96E-06	8.31E-04	7.52E-08	8.31E-04	2.46E-05	7.52E-08	2.46E-05
Plutonium-239/40	5.00E-02	1.07E-06	2.72E-09	1.07E-06	2.75E-03	2.72E-08	2.75E-03	4.51E-06	2.72E-08	4.54E-06
Radium-226	9.50E-01	2.81E-03	1.72E-03	4.53E-03	4.06E-02	1.72E-02	5.78E-02	1.66E-03	3.52E-02	3.68E-02
Radium-228	1.70E+00	1.78E-07		1.78E-07	2.57E-06		2.57E-06	1.05E-07		1.05E-07
Strontium-90	9.10E-01	3.43E-03	4.04E-06	3.43E-03	1.06E-02	4.04E-05	1.06E-02	1.56E-03	4.04E-05	1.60E-03
Thorium-228	2.42E+00	4.55E-05	4.03E-03	4.08E-03	1.16E-02	4.03E-02	5.19E-02	1.34E-03	8.09E-02	8.22E-02
Thorium-230	1.28E+00	3.51E-06	2.93E-07	3.81E-06	8.97E-04	2.93E-06	9.00E-04	1.04E-04	2.93E-06	1.07E-04
Thorium-232	1.55E+00	3.66E-06	1.53E-03	1.54E-03	9.36E-04	1.53E-02	1.63E-02	1.08E-04	3.15E-02	3.16E-02
Tritium	7.99E+00	2.50E-03		2.50E-03	2.52E-03		2.52E-03	1.14E-03		1.14E-03
Uranium-233/234	9.70E-01	5.20E-02	2.52E-07	5.20E-02	6.06E+00	2.52E-06	6.06E+00	5.85E-04	2.52E-06	5.88E-04
Uranium-235/236	8.00E-02	4.95E-02	1.08E-05	4.95E-02	5.78E+00	1.08E-04	5.78E+00	5.58E-04	2.42E-04	8.00E-04
Uranium-238	9.80E-01	4.61E-02	2.31E-05	4.61E-02	5.38E+00	2.31E-04	5.38E+00	5.19E-04	3.98E-04	9.17E-04
Total		3.60E+00	1.18E-02	3.61E+00	2.34E+01	1.18E-01	2.35E+01	1.57E+00	2.38E-01	1.81E+00
Pit 4 South										
Americium-241	1.10E-01	1.60E-05	9.23E-07	1.69E-05	6.82E-03	9.23E-06	6.83E-03	1.38E-05	4.83E-05	6.20E-05
Cobalt-60	2.34E+02	7.43E-01	6.08E-01	1.35E+00	2.22E-01	6.08E+00	6.30E+00	3.61E-01	1.24E+01	1.27E+01
Cesium-137	1.34E+01	1.08E-01	7.80E-03	1.15E-01	5.35E-02	7.80E-02	1.32E-01	1.74E-02	1.60E-01	1.77E-01
Plutonium-238	6.70E-03	5.02E-08	1.94E-10	5.04E-08	2.14E-05	1.94E-09	2.14E-05	6.33E-07	1.94E-09	6.35E-07
Plutonium-239/40	2.90E-02	6.21E-07	1.58E-09	6.23E-07	1.59E-03	1.58E-08	1.59E-03	2.62E-06	1.58E-08	2.63E-06
Strontium-90	1.00E+00	3.77E-03	4.43E-06	3.77E-03	1.16E-02	4.43E-05	1.17E-02	1.71E-03	4.43E-05	1.76E-03
Thorium-228	6.40E+00	1.20E-04	1.07E-02	1.08E-02	3.07E-02	1.07E-01	1.37E-01	3.55E-03	2.14E-01	2.17E-01
Thorium-230	1.20E+00	3.29E-06	2.75E-07	3.57E-06	8.41E-04	2.75E-06	8.44E-04	9.72E-05	2.75E-06	9.99E-05
Thorium-232	1.50E+00	3.55E-06	1.48E-03	1.49E-03	9.05E-04	1.48E-02	1.57E-02	1.05E-04	3.05E-02	3.06E-02
Uranium-233/234	8.50E+00	4.55E-01	2.21E-06	4.55E-01	5.31E+01	2.21E-05	5.31E+01	5.13E-03	2.21E-05	5.15E-03

Table 9.6c. (continued)

Radionuclide[a]	Soil Activity[b] (pCi/g)	Red-tailed Hawk			Wild Turkey			Mink		
		Internal	External	Total	Internal	External	Total	Internal	External	Total
Uranium-235	9.80E-02	4.79E-03	1.32E-05	4.81E-03	5.59E-01	1.32E-04	5.59E-01	5.40E-05	2.96E-04	3.50E-04
Uranium-238	3.10E-01	1.46E-02	7.30E-06	1.46E-02	1.70E+00	7.30E-05	1.70E+00	1.64E-04	1.26E-04	2.90E-04
Total		1.33E+00	6.28E-01	1.96E+00	5.57E+01	6.28E+00	6.19E+01	3.90E-01	1.28E+01	1.32E+01
SWSA 5 Seep A										
Actinium-228	1.90E+00	6.53E-13	1.88E-03	1.88E-03	3.75E-08	1.88E-02	1.88E-02	8.33E-07	3.86E-02	3.86E-02
Americium-241	1.24E+00	1.80E-04	1.04E-05	1.91E-04	7.69E-02	1.04E-04	7.70E-02	1.55E-04	5.44E-04	6.99E-04
Bismuth-214	6.90E-01	7.50E-05	1.08E-03	1.15E-03	4.13E-03	1.08E-02	1.49E-02	1.25E-04	2.20E-02	2.21E-02
Calcium-45	3.00E+01	9.61E-04	3.60E-07	9.61E-04	1.23E-02	3.60E-06	1.23E-02	1.56E-03	3.60E-06	1.56E-03
Carbon-14	1.51E+00	1.97E-03	3.90E-09	1.97E-03	3.53E-03	3.90E-08	3.53E-03	8.94E-04	3.90E-08	8.94E-04
Cesium-137	3.15E+00	2.53E-02	1.83E-03	2.71E-02	1.26E-02	1.83E-02	3.09E-02	4.10E-03	3.76E-02	4.17E-02
Iodine-129	3.40E+00	1.69E-04	8.44E-06	1.78E-04	1.88E-05	8.44E-05	1.03E-04	2.19E-02	9.98E-04	2.29E-02
Lead-212	1.90E+00	3.61E-04	3.14E-03	3.50E-03	1.09E-02	3.14E-02	4.23E-02	4.18E-04	6.31E-02	6.35E-02
Lead-214	9.80E-01	1.84E-04	1.77E-03	1.95E-03	5.55E-03	1.77E-02	2.32E-02	2.13E-04	3.62E-02	3.64E-02
Potassium-40	2.19E+01	2.83E+00	3.59E-03	2.84E+00	5.01E+00	3.59E-02	5.05E+00	1.29E+00	7.26E-02	1.36E+00
Plutonium-238	3.20E-01	2.40E-06	9.26E-09	2.41E-06	1.02E-03	9.26E-08	1.02E-03	3.02E-05	9.26E-08	3.03E-05
Plutonium-239/40	1.77E+00	3.79E-05	9.64E-08	3.80E-05	9.73E-02	9.64E-07	9.73E-02	1.60E-04	9.64E-07	1.61E-04
Radium-223	5.70E-01	3.98E-04	6.33E-05	4.61E-04	5.76E-03	6.33E-04	6.39E-03	2.36E-04	1.45E-03	1.69E-03
Radium-224	3.40E+00	1.11E-02	5.66E-03	1.68E-02	1.61E-01	5.66E-02	2.18E-01	6.59E-03	1.14E-01	1.20E-01
Radium-226	1.01E+00	2.99E-03	1.83E-03	4.81E-03	4.32E-02	1.83E-02	6.15E-02	1.77E-03	3.74E-02	3.91E-02
Radium-228	1.65E+00	1.73E-07		1.73E-07	2.50E-06		2.50E-06	1.02E-07		1.02E-07
Radon-219	7.30E-01									
Strontium-90	1.33E+02	5.01E-01	5.90E-04	5.02E-01	1.55E+00	5.90E-03	1.55E+00	2.28E-01	5.90E-03	2.33E-01
Thorium-228	1.54E+00	2.89E-05	2.56E-03	2.59E-03	7.39E-03	2.56E-02	3.30E-02	8.54E-04	5.15E-02	5.23E-02
Thorium-230	1.65E+00	4.53E-06	3.78E-07	4.91E-06	1.16E-03	3.78E-06	1.16E-03	1.34E-04	3.78E-06	1.37E-04
Thorium-232	1.59E+00	3.76E-06	1.57E-03	1.58E-03	9.60E-04	1.57E-02	1.67E-02	1.11E-04	3.23E-02	3.24E-02
Thallium-208	1.40E+00	2.05E-01	4.86E-03	2.09E-01	2.34E-02	4.86E-02	7.20E-02	9.29E-02	9.94E-02	1.92E-01
Tin-126	1.80E-01	5.17E-08	5.10E-06	5.15E-06	5.35E-06	5.10E-05	5.63E-05	5.04E-08	1.61E-04	1.61E-04
Tritium	2.95E+02	9.24E-02		9.24E-02	9.32E-02		9.32E-02	4.20E-02		4.20E-02
Uranium-232	1.50E-01	8.84E-03	2.60E-08	8.84E-03	1.03E+00	2.60E-07	1.03E+00	9.96E-05	2.60E-07	9.99E-05

Table 9.6c. (continued)

Radionuclide[a]	Soil Activity[b] (pCi/g)	Red-tailed Hawk Internal	Red-tailed Hawk External	Red-tailed Hawk Total	Wild Turkey Internal	Wild Turkey External	Wild Turkey Total	Mink Internal	Mink External	Mink Total
Uranium-233/234	5.65E+00	3.03E-01	1.47E-06	3.03E-01	3.53E+01	1.47E-05	3.53E+01	3.41E-03	1.47E-05	3.42E-03
Uranium-238	1.02E+00	4.80E-02	2.40E-05	4.80E-02	5.60E+00	2.40E-04	5.60E+00	5.41E-04	4.14E-04	9.55E-04
Total		4.03E+00	3.05E-02	4.06E+00	4.90E+01	3.05E-01	4.93E+01	1.69E+00	6.14E-01	2.31E+00
SWSA 5 Seep B West										
Americium-241	6.78E+00	9.87E-04	5.69E-05	1.04E-03	4.20E-01	5.69E-04	4.21E-01	8.48E-04	2.97E-03	3.82E-03
Carbon-14	2.77E+01	3.61E-02	7.15E-08	3.61E-02	6.47E-02	7.15E-07	6.47E-02	1.64E-02	7.15E-07	1.64E-02
Curium-244	3.56E+01	2.13E-04	8.60E-07	2.14E-04	2.33E-01	8.60E-06	2.33E-01	3.62E-03	8.60E-06	3.63E-03
Cobalt-60	2.24E+02	7.11E-01	5.82E-01	1.29E+00	2.12E-01	5.82E+00	6.03E+00	3.46E-01	1.19E+01	1.22E+01
Cesium-137	1.37E+01	1.10E-01	7.98E-03	1.18E-01	5.47E-02	7.98E-02	1.34E-01	1.78E-02	1.63E-01	1.81E-01
Potassium-40	3.20E+01	4.14E+00	5.24E-03	4.14E+00	7.32E+00	5.24E-02	7.37E+00	1.88E+00	1.06E-01	1.98E+00
Plutonium-238	8.90E-01	6.67E-06	2.57E-08	6.70E-06	2.84E-03	2.57E-07	2.84E-03	8.41E-05	2.57E-07	8.43E-05
Plutonium-239/40	1.46E+00	3.13E-05	7.95E-08	3.14E-05	8.03E-02	7.95E-07	8.03E-02	1.32E-04	7.95E-07	1.32E-04
Radium-226	3.50E+00	1.03E-02	6.33E-03	1.67E-02	1.50E-01	6.33E-02	2.13E-01	6.13E-03	1.30E-01	1.36E-01
Radium-228	8.60E+00	9.00E-07		9.00E-07	1.30E-05		1.30E-05	5.33E-07		5.33E-07
Strontium-90	1.03E+04	3.88E+01	4.57E-02	3.88E+01	1.20E+02	4.57E-01	1.20E+02	1.76E+01	4.57E-01	1.81E+01
Thorium-228	1.91E+00	3.59E-05	3.18E-03	3.22E-03	9.16E-03	3.18E-02	4.10E-02	1.06E-03	6.38E-02	6.49E-02
Thorium-230	1.23E+01	3.38E-05	2.82E-06	3.66E-05	8.62E-03	2.82E-05	8.65E-03	9.96E-04	2.82E-05	1.02E-03
Thorium-232	1.55E+00	3.66E-06	1.53E-03	1.54E-03	9.36E-04	1.53E-02	1.63E-02	1.08E-04	3.15E-02	3.16E-02
Tritium	1.90E+03	5.95E-01		5.95E-01	6.00E-01		6.00E-01	2.70E-01		2.70E-01
Uranium-232	5.30E-01	3.12E-02	9.17E-08	3.12E-02	3.64E+00	9.17E-07	3.64E+00	3.52E-04	9.17E-07	3.53E-04
Uranium-233	1.05E+01	5.62E-01	2.72E-06	5.62E-01	6.56E+01	2.72E-05	6.56E+01	6.33E-03	2.72E-05	6.36E-03
Uranium-238	9.60E-01	4.52E-02	2.26E-05	4.52E-02	5.27E+00	2.26E-04	5.27E+00	5.09E-04	3.90E-04	8.98E-04
Total		4.50E+01	6.52E-01	4.57E+01	2.03E+02	6.52E+00	2.10E+02	2.02E+01	1.28E+01	3.30E+01
SWSA 5 Seep B East										
Actinium-228	1.10E+00	3.78E-13	1.09E-03	1.09E-03	2.17E-08	1.09E-02	1.09E-02	4.82E-07	2.24E-02	2.24E-02
Carbon-14	2.05E+00	2.67E-03	5.29E-09	2.67E-03	4.79E-03	5.29E-08	4.79E-03	1.21E-03	5.29E-08	1.21E-03
Cesium-137	6.53E+03	5.24E+01	3.80E+00	5.62E+01	2.61E+01	3.80E+01	6.41E+01	8.50E+00	7.78E+01	8.63E+01
Barium-137m	6.20E+03	1.63E+01	3.80E+00	2.01E+01	8.83E+00	3.80E+01	4.68E+01	2.64E+00	7.78E+01	8.05E+01

Table 9.6c. (continued)

Radionuclide[a]	Soil Activity[b] (pCi/g)	Red-tailed Hawk Internal	Red-tailed Hawk External	Red-tailed Hawk Total	Wild Turkey Internal	Wild Turkey External	Wild Turkey Total	Mink Internal	Mink External	Mink Total
Lead-212	1.40E+00	2.66E-04	2.32E-03	2.58E-03	8.04E-03	2.32E-02	3.12E-02	3.08E-04	4.65E-02	4.68E-02
Lead-214	9.10E-01	1.70E-04	1.64E-03	1.81E-03	5.15E-03	1.64E-02	2.16E-02	7.82E-05	3.36E-02	3.37E-02
Potassium-40	1.95E+01	2.52E+00	3.19E-03	2.52E+00	4.46E+00	3.19E-02	4.49E+00	1.14E+00	6.46E-02	1.21E+00
Radium-226	1.10E+00	3.25E-03	1.99E-03	5.24E-03	4.70E-02	1.99E-02	6.69E-02	1.93E-03	4.07E-02	4.26E-02
Radium-228	1.10E+00	1.15E-07		1.15E-07	1.67E-06		1.67E-06	6.82E-08		6.82E-08
Strontium-90	2.80E+01	1.05E-01	1.24E-04	1.06E-01	3.26E-01	1.24E-03	3.27E-01	4.79E-02	1.24E-03	4.91E-02
Thorium-228	1.50E+00	2.82E-05	2.50E-03	2.53E-03	7.20E-03	2.50E-02	3.22E-02	8.32E-04	5.01E-02	5.10E-02
Thorium-232	1.10E+00	2.60E-06	1.09E-03	1.09E-03	6.64E-04	1.09E-02	1.15E-02	7.67E-05	2.24E-02	2.24E-02
Thallium-208	1.40E+00	2.05E-01	4.86E-03	2.09E-01	2.34E-02	4.86E-02	7.20E-02	9.29E-02	9.94E-02	1.92E-01
Tritium	5.28E+01	1.65E-02		1.65E-02	1.67E-02		1.67E-02	7.51E-03		7.51E-03
Total		7.16E+01	7.62E+00	7.92E+01	3.98E+01	7.62E+01	1.16E+02	1.24E+01	1.56E+02	1.69E+02
SWSA 5 Seep C										
Americium-241	1.10E+00	1.60E-04	9.23E-06	1.69E-04	6.82E-02	9.23E-05	6.83E-02	1.38E-04	4.83E-04	6.20E-04
Calcium-45	5.30E+02	1.70E-02	6.36E-06	1.70E-02	2.17E-01	6.36E-05	2.17E-01	2.76E-02	6.36E-05	2.76E-02
Carbon-14	4.55E+01	5.94E-02	1.17E-07	5.94E-02	1.06E-01	1.17E-06	1.06E-01	2.70E-02	1.17E-06	2.70E-02
Curium-244	5.65E+00	3.38E-05	1.36E-07	3.40E-05	3.69E-02	1.36E-06	3.69E-02	5.74E-04	1.36E-06	5.76E-04
Cobalt-60	2.75E+00	8.73E-03	7.15E-03	1.59E-02	2.61E-03	7.15E-02	7.41E-02	4.25E-03	1.45E-01	1.50E-01
Cesium-137	4.30E+02	3.45E+00	2.50E-01	3.70E+00	1.72E+00	2.50E+00	4.22E+00	5.60E-01	5.13E+00	5.69E+00
Lead-212	3.81E-01	7.23E-05	6.30E-04	7.02E-04	2.19E-03	6.30E-03	8.49E-03	8.38E-05	1.26E-02	1.27E-02
Potassium-40	1.90E+01	2.46E+00	3.11E-03	2.46E+00	4.35E+00	3.11E-02	4.38E+00	1.12E+00	6.30E-02	1.18E+00
Plutonium-238	6.73E-01	5.04E-06	1.95E-08	5.06E-06	2.15E-03	1.95E-07	2.15E-03	6.36E-05	1.95E-07	6.38E-05
Plutonium-239/40	1.91E-01	4.09E-06	1.04E-08	4.10E-06	1.05E-02	1.04E-07	1.05E-02	1.72E-05	1.04E-07	1.73E-05
Radium-226	1.29E+00	3.81E-03	2.33E-03	6.15E-03	5.52E-02	2.33E-02	7.85E-02	2.26E-03	4.77E-02	5.00E-02
Radium-228	1.58E+00	1.65E-07		1.65E-07	2.39E-06		2.39E-06	9.80E-08		9.80E-08
Strontium-90	1.58E+03	5.95E+00	7.01E-03	5.96E+00	1.84E+01	7.01E-02	1.84E+01	2.70E+00	7.01E-02	2.77E+00
Technetium-99	4.17E+00	4.10E-07	1.00E-07	5.10E-07	8.20E-04	1.00E-06	8.21E-04	5.45E-07	1.00E-06	1.55E-06
Thorium-228	1.88E+00	3.53E-05	3.13E-03	3.17E-03	9.02E-03	3.13E-02	4.03E-02	1.04E-03	6.28E-02	6.39E-02
Thorium-230	2.45E+00	6.72E-06	5.61E-07	7.29E-06	1.72E-03	5.61E-06	1.72E-03	1.98E-04	5.61E-06	2.04E-04
Thorium-232	1.73E+00	4.09E-06	1.71E-03	1.72E-03	1.04E-03	1.71E-02	1.82E-02	1.21E-04	3.52E-02	3.53E-02

Table 9.6c. (continued)

Radionuclide[a]	Soil Activity[b] (pCi/g)	Red-tailed Hawk			Wild Turkey			Mink		
		Internal	External	Total	Internal	External	Total	Internal	External	Total
Tritium	5.52E+02	1.73E-01		1.73E-01	1.74E-01		1.74E-01	7.85E-02		7.85E-02
Uranium-233/234	2.11E+00	1.13E-01	5.48E-07	1.13E-01	1.32E+01	5.48E-06	1.32E+01	1.27E-03	5.48E-06	1.28E-03
Uranium-235	1.80E-01	8.80E-03	2.42E-05	8.83E-03	1.03E+00	2.42E-04	1.03E+00	9.92E-05	5.44E-04	6.43E-04
Uranium-235/236	6.29E-02	8.55E-02	8.49E-06	8.55E-02	9.97E+00	8.49E-05	9.97E+00	9.63E-04	1.90E-04	1.15E-03
Uranium-238	1.77E+00	8.33E-02	4.17E-05	8.33E-02	9.71E+00	4.17E-04	9.71E+00	9.38E-04	7.18E-04	1.66E-03
Total		1.24E+01	2.76E-01	1.27E+01	5.90E+01	2.76E+00	6.18E+01	4.52E+00	5.57E+00	1.01E+01
SWSA 5 Trib 1										
Actinium-228	2.17E+00	7.46E-13	2.15E-03	2.15E-03	4.28E-08	2.15E-02	2.15E-02	9.51E-07	4.41E-02	4.41E-02
Americium-241	4.95E-01	7.20E-05	4.15E-06	7.62E-05	3.07E-02	4.15E-05	3.07E-02	6.19E-05	2.17E-04	2.79E-04
Bismuth-212	2.60E+00	8.05E-05	4.99E-04	5.80E-04	4.43E-03	4.99E-03	9.42E-03	1.34E-04	1.02E-02	1.03E-02
Bismuth-214	9.40E-01	1.02E-04	1.47E-03	1.57E-03	5.63E-03	1.47E-02	2.03E-02	1.70E-04	2.99E-02	3.01E-02
Carbon-14	8.00E-01	1.04E-03	2.06E-09	1.04E-03	1.87E-03	2.06E-08	1.87E-03	4.74E-04	2.06E-08	4.74E-04
Cesium-134	4.00E-02	2.49E-04	6.41E-05	3.13E-04	1.37E-04	6.41E-04	7.77E-04	4.04E-05	1.31E-03	1.35E-03
Cobalt-60	9.11E+01	2.89E-01	2.37E-01	5.26E-01	8.63E-02	2.37E+00	2.45E+00	1.41E-01	4.82E+00	4.96E+00
Cesium-137	3.27E+03	2.62E+01	1.90E+00	2.81E+01	1.31E+01	1.90E+01	3.21E+01	4.26E+00	3.90E+01	4.32E+01
Curium-243	1.80E-01	1.08E-06	1.95E-05	2.06E-05	1.17E-03	1.95E-04	1.37E-03	1.83E-05	4.54E-04	4.72E-04
Iodine-129	5.70E+00	2.83E-04	1.42E-05	2.98E-04	3.14E-05	1.42E-04	1.73E-04	3.68E-02	1.67E-03	3.84E-02
Lead-212	1.24E+00	2.35E-04	2.05E-03	2.29E-03	7.12E-03	2.05E-02	2.76E-02	2.73E-04	4.12E-02	4.14E-02
Lead-214	1.13E+00	2.12E-04	2.04E-03	2.25E-03	6.40E-03	2.04E-02	2.68E-02	9.71E-05	4.17E-02	4.18E-02
Potassium-40	2.39E+01	3.09E+00	3.91E-03	3.09E+00	5.47E+00	3.91E-02	5.51E+00	1.40E+00	7.92E-02	1.48E+00
Plutonium-238	3.50E+00	2.62E-05	1.01E-07	2.63E-05	1.12E-02	1.01E-06	1.12E-02	3.31E-04	1.01E-06	3.32E-04
Radium-223	5.60E-01	3.91E-04	6.22E-05	4.53E-04	5.66E-03	6.22E-04	6.28E-03	2.32E-04	1.43E-03	1.66E-03
Radium-226	1.43E+00	4.23E-03	2.59E-03	6.81E-03	6.12E-02	2.59E-02	8.70E-02	2.50E-03	5.29E-02	5.54E-02
Radium-228	1.70E+00	1.78E-07		1.78E-07	2.57E-06		2.57E-06	1.05E-07		1.05E-07
Strontium-90	2.60E+01	9.79E-02	1.15E-04	9.80E-02	3.02E-01	1.15E-03	3.03E-01	4.45E-02	1.15E-03	4.56E-02
Thorium-228	1.66E+00	3.12E-05	2.76E-03	2.80E-03	7.96E-03	2.76E-02	3.56E-02	9.20E-04	5.55E-02	5.64E-02
Thorium-230	9.36E-01	2.57E-06	2.14E-07	2.78E-06	6.56E-04	2.14E-06	6.58E-04	7.58E-05	2.14E-06	7.79E-05
Thorium-232	1.79E+00	4.23E-06	1.77E-03	1.78E-03	1.08E-03	1.77E-02	1.88E-02	1.25E-04	3.64E-02	3.65E-02
Thallium-208	1.50E+00	2.19E-01	5.20E-03	2.24E-01	2.51E-02	5.20E-02	7.71E-02	9.95E-02	1.06E-01	2.06E-01

Table 9.6c. (continued)

Radionuclide[a]	Soil Activity[b] (pCi/g)	Red-tailed Hawk Internal	Red-tailed Hawk External	Red-tailed Hawk Total	Wild Turkey Internal	Wild Turkey External	Wild Turkey Total	Mink Internal	Mink External	Mink Total
Thorium-234	7.30E+00	6.27E-07	7.79E-04	7.79E-04	6.91E-05	7.79E-03	7.86E-03	1.03E-06	1.57E-02	1.57E-02
Tin-126	4.60E-01	1.32E-07	1.30E-05	1.32E-05	1.37E-05	1.30E-04	1.44E-04	1.29E-07	4.12E-04	4.12E-04
Tritium	4.82E+00	1.51E-03		1.51E-03	1.52E-03		1.52E-03	6.86E-04		6.86E-04
Uranium-233/234	4.00E+00	2.14E-01	1.04E-06	2.14E-01	2.50E+01	1.04E-05	2.50E+01	2.41E-03	1.04E-05	2.42E-03
Uranium-238	3.87E+00	1.82E-01	9.11E-05	1.82E-01	2.12E+01	9.11E-04	2.12E+01	2.05E-03	1.57E-03	3.62E-03
Total		3.03E+01	2.17E+00	3.25E+01	6.53E+01	2.17E+01	8.70E+01	5.99E+00	4.43E+01	5.03E+01
SWSA 5 WOC										
Actinium-228	1.80E+00	6.19E-13	1.78E-03	1.78E-03	3.55E-08	1.78E-02	1.78E-02	7.89E-07	3.66E-02	3.66E-02
Americium-241	1.58E-01	2.30E-05	1.33E-06	2.43E-05	9.79E-03	1.33E-05	9.81E-03	1.98E-05	6.93E-05	8.91E-05
Carbon-14	1.99E+00	2.60E-03	5.14E-09	2.60E-03	4.65E-03	5.14E-08	4.65E-03	1.18E-03	5.14E-08	1.18E-03
Curium-244	1.51E-01	9.05E-07	3.65E-09	9.08E-07	9.87E-04	3.65E-08	9.87E-04	1.53E-05	3.65E-08	1.54E-05
Cobalt-60	5.34E+00	1.69E-02	1.39E-02	3.08E-02	5.06E-03	1.39E-01	1.44E-01	8.24E-03	2.83E-01	2.91E-01
Cobalt-57	2.30E+00	1.02E-03	2.19E-04	1.24E-03	2.93E-04	2.19E-03	2.49E-03	4.95E-04	5.28E-03	5.78E-03
Cesium-137	4.91E+02	3.94E+00	2.86E-01	4.23E+00	1.96E+00	2.86E+00	4.82E+00	6.39E-01	5.85E+00	6.49E+00
Curium-242	1.78E-02	1.12E-07	5.79E-10	1.13E-07	1.22E-04	5.79E-09	1.22E-04	1.90E-06	5.79E-09	1.91E-06
Lead-212	5.84E-01	1.11E-04	9.66E-04	1.08E-03	3.35E-03	9.66E-03	1.30E-02	1.28E-04	1.94E-02	1.95E-02
Lead-214	1.12E+00	2.10E-04	2.02E-03	2.23E-03	6.34E-03	2.02E-02	2.65E-02	9.62E-05	4.14E-02	4.15E-02
Potassium-40	1.57E+01	2.03E+00	2.57E-03	2.03E+00	3.59E+00	2.57E-02	3.62E+00	9.22E-01	5.20E-02	9.74E-01
Plutonium-238	2.90E-01	2.17E-06	8.39E-09	2.18E-06	9.27E-04	8.39E-08	9.27E-04	2.74E-05	8.39E-08	2.75E-05
Plutonium-239/40	2.22E-02	4.76E-07	1.21E-09	4.77E-07	1.22E-03	1.21E-08	1.22E-03	2.00E-06	1.21E-08	2.01E-06
Radium-226	1.21E+00	3.58E-03	2.19E-03	5.77E-03	5.17E-02	2.19E-02	7.36E-02	2.12E-03	4.48E-02	4.69E-02
Radium-228	2.10E+00	2.20E-07		2.20E-07	3.18E-06		3.18E-06	1.30E-07		1.30E-07
Sodium-22	1.50E+00	1.04E+01	3.39E-03	1.04E+01	6.38E-01	3.39E-02	6.72E-01	4.72E+00	6.93E-02	4.79E+00
Strontium-90	6.69E+02	2.52E+00	2.97E-03	2.52E+00	7.78E+00	2.97E-02	7.81E+00	1.14E+00	2.97E-02	1.17E+00
Technetium-99	1.90E-01	1.87E-08	4.56E-09	2.32E-08	3.73E-05	4.56E-08	3.74E-05	2.49E-08	4.56E-08	7.05E-08
Thorium-228	1.50E+00	2.82E-05	2.50E-03	2.53E-03	7.20E-03	2.50E-02	3.22E-02	8.32E-04	5.01E-02	5.10E-02
Thorium-230	1.33E+00	3.65E-06	3.05E-07	3.96E-06	9.32E-04	3.05E-06	9.35E-04	1.08E-04	3.05E-06	1.11E-04
Thorium-232	1.30E+00	3.07E-06	1.29E-03	1.29E-03	7.85E-04	1.29E-02	1.36E-02	9.07E-05	2.64E-02	2.65E-02
Thallium-208	2.00E+00	2.92E-01	6.94E-03	2.99E-01	3.35E-02	6.94E-02	1.03E-01	1.33E-01	1.42E-01	2.75E-01

Table 9.6c. (continued)

Radionuclide[a]	Soil Activity[b] (pCi/g)	Red-tailed Hawk			Wild Turkey			Mink		
		Internal	External	Total	Internal	External	Total	Internal	External	Total
Tritium	1.28E+01	4.01E-03		4.01E-03	4.04E-03		4.04E-03	1.82E-03		1.82E-03
Uranium-233/234	9.76E-01	5.23E-02	2.53E-07	5.23E-02	6.10E+00	2.53E-06	6.10E+00	5.89E-04	2.53E-06	5.91E-04
Uranium-235	4.39E-02	2.15E-03	5.90E-06	2.15E-03	2.50E-01	5.90E-05	2.50E-01	2.42E-05	1.33E-04	1.57E-04
Uranium-235/236	1.11E-01	5.00E-02	1.49E-05	5.00E-02	5.83E+00	1.49E-04	5.83E+00	5.63E-04	3.36E-04	8.99E-04
Uranium-238	9.57E-01	4.50E-02	2.25E-05	4.51E-02	5.25E+00	2.25E-04	5.25E+00	5.07E-04	3.88E-04	8.96E-04
Total		1.94E+01	3.27E-01	1.97E+01	3.15E+01	3.27E+00	3.48E+01	7.58E+00	6.65E+00	1.42E+01
SWSA 4 Main										
Cesium-137	8.80E+04	7.06E+02	5.12E+01	7.58E+02	9.31E+02	5.12E+02	1.44E+03	1.15E+02	1.05E+03	1.16E+03
Potassium-40	1.30E+01	1.68E+00	2.13E-03	1.68E+00	3.00E+00	2.13E-02	3.02E+00	7.63E-01	4.31E-02	8.06E-01
Strontium-90	1.10E+04	4.14E+01	4.88E-02	4.15E+01	1.44E+02	4.88E-01	1.45E+02	1.88E+01	4.88E-01	1.93E+01
Tritium	6.70E+02	2.10E-01		2.10E-01	2.25E-01		2.25E-01	9.53E-02		9.53E-02
Total		7.50E+02	5.13E+01	8.01E+02	1.08E+03	5.13E+02	1.59E+03	1.34E+02	1.05E+03	1.18E+03
SWSA 5 N WOC										
Actinium-228	2.10E+00	7.22E-13	2.08E-03	2.08E-03	4.14E-08	2.08E-02	2.08E-02	9.21E-07	4.27E-02	4.27E-02
Bismuth-212	1.90E+00	5.88E-05	3.65E-04	4.24E-04	3.24E-03	3.65E-03	6.89E-03	9.80E-05	7.45E-03	7.55E-03
Bismuth-214	8.10E-01	8.81E-05	1.27E-03	1.35E-03	4.85E-03	1.27E-02	1.75E-02	1.47E-04	2.58E-02	2.59E-02
Carbon-14	4.01E-01	5.23E-04	1.03E-09	5.23E-04	9.37E-04	1.03E-08	9.37E-04	2.38E-04	1.03E-08	2.38E-04
Iodine-129	4.40E+00	2.19E-04	1.09E-05	2.30E-04	2.43E-05	1.09E-04	1.34E-04	2.84E-02	1.29E-03	2.97E-02
Lead-212	1.60E+00	3.04E-04	2.65E-03	2.95E-03	9.18E-03	2.65E-02	3.56E-02	3.52E-04	5.31E-02	5.35E-02
Lead-214	1.07E+00	2.00E-04	1.93E-03	2.13E-03	6.06E-03	1.93E-02	2.54E-02	9.19E-05	3.95E-02	3.96E-02
Potassium-40	3.08E+01	3.98E+00	5.04E-03	3.99E+00	7.05E+00	5.04E-02	7.10E+00	1.81E+00	1.02E-01	1.91E+00
Radium-226	9.50E-01	2.81E-03	1.72E-03	4.53E-03	4.06E-02	1.72E-02	5.78E-02	1.66E-03	3.52E-02	3.68E-02
Radium-228	2.10E+00	2.20E-07		2.20E-07	3.18E-06		3.18E-06	1.30E-07		1.30E-07
Strontium-90	3.13E-01	1.18E-03	1.39E-06	1.18E-03	3.64E-03	1.39E-05	3.65E-03	5.35E-04	1.39E-05	5.49E-04
Thorium-228	2.00E+00	3.76E-05	3.33E-03	3.37E-03	9.60E-03	3.33E-02	4.29E-02	1.11E-03	6.68E-02	6.79E-02
Thorium-232	2.10E+00	4.96E-06	2.08E-03	2.08E-03	1.27E-03	2.08E-02	2.20E-02	1.46E-04	4.27E-02	4.28E-02
Thallium-208	1.80E+00	2.63E-01	6.24E-03	2.69E-01	3.01E-02	6.24E-02	9.26E-02	1.19E-01	1.28E-01	2.47E-01
Thorium-234	1.90E+00	4.57E-07	5.59E-04	5.60E-04	4.93E-05	5.59E-03	5.64E-03	5.54E-07	1.15E-02	1.15E-02

Table 9.6c. (continued)

Radionuclide[a]	Soil Activity[b] (pCi/g)	Red-tailed Hawk			Wild Turkey			Mink		
		Internal	External	Total	Internal	External	Total	Internal	External	Total
Tin-126	3.40E-01	9.77E-08	9.63E-06	9.72E-06	1.01E-05	9.63E-05	1.06E-04	9.53E-08	3.05E-04	3.05E-04
Tritium	1.06E+01	3.32E-03		3.32E-03	3.35E-03		3.35E-03	1.51E-03		1.51E-03
Total		4.25E+00	2.73E-02	4.28E+00	7.16E+00	2.73E-01	7.43E+00	1.96E+00	5.56E-01	2.52E+00
SWSA 6 East										
Cobalt-60	5.33E+01	1.69E-01	1.38E-01	3.08E-01	5.05E-02	1.38E+00	1.44E+00	8.23E-02	2.82E+00	2.90E+00
Cesium-137	2.14E+00	1.72E-02	1.25E-03	1.84E-02	8.54E-03	1.25E-02	2.10E-02	2.79E-03	2.55E-02	2.83E-02
Potassium-40	2.57E+01	3.32E+00	4.21E-03	3.33E+00	5.88E+00	4.21E-02	5.92E+00	1.51E+00	8.52E-02	1.59E+00
Radium-224	1.52E+00	4.97E-03	2.53E-03	7.50E-03	7.20E-02	2.53E-02	9.73E-02	2.95E-03	5.08E-02	5.37E-02
Radium-226	8.00E-01	2.36E-03	1.45E-03	3.81E-03	3.42E-02	1.45E-02	4.87E-02	1.40E-03	2.96E-02	3.10E-02
Radium-228	1.52E+00	1.59E-07		1.59E-07	2.30E-06		2.30E-06	9.43E-08		9.43E-08
Strontium-90	6.22E+00	2.34E-02	2.76E-05	2.35E-02	7.23E-02	2.76E-04	7.26E-02	1.06E-02	2.76E-04	1.09E-02
Thorium-228	1.45E+00	2.72E-05	2.41E-03	2.44E-03	6.96E-03	2.41E-02	3.11E-02	8.04E-04	4.84E-02	4.93E-02
Thorium-230	1.27E+00	3.49E-06	2.91E-07	3.78E-06	8.90E-04	2.91E-06	8.93E-04	1.03E-04	2.91E-06	1.06E-04
Thorium-232	1.11E+00	2.62E-06	1.10E-03	1.10E-03	6.70E-04	1.10E-02	1.17E-02	7.74E-05	2.26E-02	2.26E-02
Thorium-234	3.96E-01	5.77E-02	1.88E-06	5.77E-02	4.16E+00	1.88E-05	4.16E+00	1.05E-02	1.88E-05	1.05E-02
Tritium	7.10E+01	2.22E-02		2.22E-02	2.24E-02		2.24E-02	1.01E-02		1.01E-02
Uranium-234	6.70E-01	3.54E-02	5.14E-08	3.54E-02	4.13E+00	5.14E-07	4.13E+00	3.99E-04	5.14E-07	4.00E-04
Uranium-235/236	6.00E-01	6.44E-02	8.07E-05	6.45E-02	7.51E+00	8.07E-04	7.52E+00	7.26E-04	1.81E-03	2.54E-03
Uranium-238	7.54E-01	3.55E-02	1.78E-05	3.55E-02	4.14E+00	1.78E-04	4.14E+00	4.00E-04	3.06E-04	7.06E-04
Total		3.76E+00	1.52E-01	3.91E+00	2.61E+01	1.52E+00	2.76E+01	1.63E+00	3.08E+00	4.72E+00
SWSA 6 South										
Americium-241	6.00E-01	8.73E-05	5.03E-06	9.24E-05	3.72E-02	5.03E-05	3.72E-02	7.50E-05	2.63E-04	3.38E-04
Potassium-40	1.81E+01	2.34E+00	2.96E-03	2.34E+00	4.14E+00	2.96E-02	4.17E+00	1.06E+00	6.00E-02	1.12E+00
Plutonium-238	6.00E-01	4.50E-06	1.74E-08	4.51E-06	1.92E-03	1.74E-07	1.92E-03	5.67E-05	1.74E-07	5.69E-05
Plutonium-239/40	6.00E-01	1.29E-05	3.27E-08	1.29E-05	3.30E-02	3.27E-07	3.30E-02	5.41E-05	3.27E-07	5.44E-05
Radium-224	1.40E+00	4.58E-03	2.33E-03	6.91E-03	6.63E-02	2.33E-02	8.96E-02	2.72E-03	4.68E-02	4.95E-02
Radium-226	8.30E-01	2.45E-03	1.50E-03	3.95E-03	3.55E-02	1.50E-02	5.05E-02	1.45E-03	3.07E-02	3.22E-02
Radium-228	1.46E+00	1.53E-07		1.53E-07	2.21E-06		2.21E-06	9.05E-08		9.05E-08

Table 9.6c. (continued)

Radionuclide[a]	Soil Activity[b] (pCi/g)	Red-tailed Hawk Internal	Red-tailed Hawk External	Red-tailed Hawk Total	Wild Turkey Internal	Wild Turkey External	Wild Turkey Total	Mink Internal	Mink External	Mink Total
Thorium-228	1.04E+00	1.95E-05	1.73E-03	1.75E-03	4.99E-03	1.73E-02	2.23E-02	5.77E-04	3.48E-02	3.53E-02
Thorium-230	1.00E+00	2.74E-06	2.29E-07	2.97E-06	7.01E-04	2.29E-06	7.03E-04	8.10E-05	2.29E-06	8.33E-05
Thorium-232	1.07E+00	2.53E-06	1.06E-03	1.06E-03	6.46E-04	1.06E-02	1.12E-02	7.46E-05	2.18E-02	2.18E-02
Thorium-234	1.12E+00	7.01E-02	8.59E-05	7.02E-02	8.17E+00	8.59E-04	8.17E+00	7.89E-04	1.87E-03	2.65E-03
Uranium-234	7.70E-01	4.07E-02	5.91E-08	4.07E-02	4.75E+00	5.91E-07	4.75E+00	4.59E-04	5.91E-07	4.59E-04
Uranium-235/236	6.00E-01	6.84E-02	8.07E-05	6.85E-02	7.98E+00	8.07E-04	7.98E+00	7.71E-04	1.81E-03	2.58E-03
Uranium-238	8.40E-01	3.95E-02	1.98E-05	3.95E-02	4.61E+00	1.98E-04	4.61E+00	4.45E-04	3.41E-04	7.86E-04
Total		2.57E+00	9.78E-03	2.58E+00	2.98E+01	9.78E-02	2.99E+01	1.07E+00	1.98E-01	1.27E+00
W6MS3										
Americium-241	8.90E-01	1.30E-04	7.46E-06	1.37E-04	5.52E-02	7.46E-05	5.52E-02	1.11E-04	3.90E-04	5.02E-04
Curium-244	6.00E-01	3.59E-06	1.45E-08	3.61E-06	3.92E-03	1.45E-07	3.92E-03	6.10E-05	1.45E-07	6.11E-05
Cobalt-60	1.06E-01	3.36E-04	2.75E-04	6.12E-04	1.00E-04	2.75E-03	2.85E-03	1.64E-04	5.61E-03	5.77E-03
Cesium-137	6.01E-01	4.82E-03	3.50E-04	5.17E-03	2.40E-03	3.50E-03	5.90E-03	7.82E-04	7.16E-03	7.95E-03
Curium-242	6.00E-01	3.78E-06	1.95E-08	3.80E-06	4.12E-03	1.95E-07	4.12E-03	6.42E-05	1.95E-07	6.44E-05
Potassium-40	2.39E+01	3.09E+00	3.91E-03	3.09E+00	5.47E+00	3.91E-02	5.51E+00	1.40E+00	7.92E-02	1.48E+00
Plutonium-238	6.00E-01	4.50E-06	1.74E-08	4.51E-06	1.92E-03	1.74E-07	1.92E-03	5.67E-05	1.74E-07	5.69E-05
Plutonium-239/40	6.00E-01	1.29E-05	3.27E-08	1.29E-05	3.30E-02	3.27E-07	3.30E-02	5.41E-05	3.27E-07	5.44E-05
Radium-224	1.27E+00	4.16E-03	2.11E-03	6.27E-03	6.01E-02	2.11E-02	8.13E-02	2.46E-03	4.24E-02	4.49E-02
Radium-226	8.21E-01	2.43E-03	1.49E-03	3.91E-03	3.51E-02	1.49E-02	5.00E-02	1.44E-03	3.04E-02	3.18E-02
Radium-228	1.34E+00	1.40E-07		1.40E-07	2.03E-06		2.03E-06	8.31E-08		8.31E-08
Strontium-90	2.55E+01	9.60E-02	1.13E-04	9.62E-02	2.96E-01	1.13E-03	2.98E-01	4.36E-02	1.13E-03	4.48E-02
Technetium-99	9.00E-01	8.85E-08	2.16E-08	1.10E-07	1.77E-04	2.16E-07	1.77E-04	1.18E-07	2.16E-07	3.34E-07
Thorium-228	1.25E+00	2.35E-05	2.08E-03	2.10E-03	6.00E-03	2.08E-02	2.68E-02	6.93E-04	4.18E-02	4.25E-02
Thorium-230	1.59E+00	4.36E-06	3.64E-07	4.73E-06	1.11E-03	3.64E-06	1.12E-03	1.29E-04	3.64E-06	1.32E-04
Thorium-232	9.37E-01	2.21E-06	9.27E-04	9.29E-04	5.66E-04	9.27E-03	9.84E-03	6.53E-05	1.91E-02	1.91E-02
Thorium-234	1.50E+00	2.69E-01	7.09E-06	2.69E-01	1.27E+01	7.09E-05	1.27E+01	7.45E-02	7.09E-05	7.46E-02
Tritium	5.15E+02	1.61E-01		1.61E-01	1.63E-01		1.63E-01	7.33E-02		7.33E-02
Uranium-234	2.04E+00	1.08E-01	1.56E-07	1.08E-01	1.26E+01	1.56E-06	1.26E+01	1.22E-03	1.56E-06	1.22E-03
Uranium-235/236	6.00E-01	7.82E-02	8.07E-05	7.83E-02	9.12E+00	8.07E-04	9.12E+00	8.81E-04	1.81E-03	2.69E-03

Table 9.6c. (continued)

Radionuclide[a]	Soil Activity[b] (pCi/g)	Red-tailed Hawk Internal	Red-tailed Hawk External	Red-tailed Hawk Total	Wild Turkey Internal	Wild Turkey External	Wild Turkey Total	Mink Internal	Mink External	Mink Total
Uranium-238	1.05E+00	4.94E-02	2.47E-05	4.94E-02	5.76E+00	2.47E-04	5.76E+00	5.57E-04	4.26E-04	9.83E-04
Total		3.86E+00	1.14E-02	3.88E+00	4.63E+01	1.14E-01	4.65E+01	1.60E+00	2.29E-01	1.83E+00
W6MS1										
Americium-241	6.00E-01	8.73E-05	5.03E-06	9.24E-05	3.72E-02	5.03E-05	3.72E-02	7.50E-05	2.63E-04	3.38E-04
Cobalt-60	1.80E-01	5.71E-04	4.68E-04	1.04E-03	1.71E-04	4.68E-03	4.85E-03	2.78E-04	9.52E-03	9.80E-03
Cesium-137	6.48E-01	5.20E-03	3.77E-04	5.58E-03	2.59E-03	3.77E-03	6.36E-03	8.43E-04	7.73E-03	8.57E-03
Potassium-40	2.65E+01	3.43E+00	4.34E-03	3.43E+00	6.06E+00	4.34E-02	6.11E+00	1.56E+00	8.79E-02	1.64E+00
Plutonium-238	6.00E-01	4.50E-06	1.74E-08	4.51E-06	1.92E-03	1.74E-07	1.92E-03	5.67E-05	1.74E-07	5.69E-05
Plutonium-239/40	6.00E-01	1.29E-05	3.27E-08	1.29E-05	3.30E-02	3.27E-07	3.30E-02	5.41E-05	3.27E-07	5.44E-05
Radium-224	1.32E+00	4.32E-03	2.20E-03	6.52E-03	6.25E-02	2.20E-02	8.45E-02	2.56E-03	4.41E-02	4.66E-02
Radium-226	8.27E-01	2.44E-03	1.50E-03	3.94E-03	3.54E-02	1.50E-02	5.03E-02	1.45E-03	3.06E-02	3.20E-02
Radium-228	1.33E+00	1.39E-07		1.39E-07	2.01E-06		2.01E-06	8.25E-08		8.25E-08
Thorium-228	1.13E+00	2.12E-05	1.88E-03	1.90E-03	5.42E-03	1.88E-02	2.42E-02	6.26E-04	3.78E-02	3.84E-02
Thorium-230	8.40E-01	2.31E-06	1.92E-07	2.50E-06	5.89E-04	1.92E-06	5.91E-04	6.80E-05	1.92E-06	6.99E-05
Thorium-232	7.40E-01	1.75E-06	7.32E-04	7.34E-04	4.47E-04	7.32E-03	7.77E-03	5.16E-05	1.50E-02	1.51E-02
Thorium-234	1.52E+00	1.80E-01	7.10E-06	1.80E-01	5.99E+00	7.10E-05	5.99E+00	5.95E-02	7.10E-05	5.95E-02
Tritium	4.14E+02	1.30E-01		1.30E-01	1.31E-01		1.31E-01	5.89E-02		5.89E-02
Uranium-234	9.50E-01	5.03E-02	7.29E-08	5.03E-02	5.86E+00	7.29E-07	5.86E+00	5.66E-04	7.29E-07	5.67E-04
Uranium-235/236	6.00E-01	7.36E-02	8.07E-05	7.37E-02	8.58E+00	8.07E-04	8.58E+00	8.29E-04	1.81E-03	2.64E-03
Uranium-238	9.50E-01	4.47E-02	2.24E-05	4.47E-02	5.21E+00	2.24E-04	5.21E+00	5.04E-04	3.86E-04	8.89E-04
Total		3.92E+00	1.16E-02	3.93E+00	3.20E+01	1.16E-01	3.21E+01	1.68E+00	2.35E-01	1.92E+00
WCTRIB-1										
Cobalt-60	3.00E+02	9.52E-01	7.80E-01	1.73E+00	2.84E-01	7.80E+00	8.08E+00	4.63E-01	1.59E+01	1.63E+01
Cesium-137	8.50E+03	6.82E+01	4.95E+00	7.32E+01	3.39E+01	4.95E+01	8.34E+01	1.11E+01	1.01E+02	1.12E+02
Strontium-90	6.80E+02	2.56E+00	3.02E-03	2.56E+00	7.91E+00	3.02E-02	7.94E+00	1.16E+00	3.02E-02	1.19E+00
Total		7.17E+01	5.73E+00	7.75E+01	4.21E+01	5.73E+01	9.94E+01	1.27E+01	1.17E+02	1.30E+02
West Seep										

Table 9.6c. (continued)

Radionuclide[a]	Soil Activity[b] (pCi/g)	Red-tailed Hawk			Wild Turkey			Mink		
		Internal	External	Total	Internal	External	Total	Internal	External	Total
Actinium-228	1.19E+00	4.09E-13	1.18E-03	1.18E-03	7.63E-08	1.18E-02	1.18E-02	5.22E-07	2.42E-02	2.42E-02
Americium-241	8.39E-01	1.22E-04	7.04E-06	1.29E-04	5.33E-02	7.04E-05	5.34E-02	1.05E-04	3.68E-04	4.73E-04
Bismuth-214	6.40E-01	6.96E-05	1.00E-03	1.07E-03	1.04E-02	1.00E-02	2.04E-02	1.16E-04	2.04E-02	2.05E-02
Cesium-137	4.34E+02	3.48E+00	2.53E-01	3.74E+00	4.59E+00	2.53E+00	7.12E+00	5.65E-01	5.17E+00	5.74E+00
Curium-243/244	2.40E-02	1.44E-07	2.60E-06	2.74E-06	1.66E-04	2.60E-05	1.92E-04	2.44E-06	6.06E-05	6.30E-05
Curium-245/246	3.35E-02	1.86E-07	2.16E-06	2.35E-06	2.14E-04	2.16E-05	2.36E-04	3.15E-06	5.62E-05	5.93E-05
Cobalt-57	2.00E-02	8.85E-06	1.91E-06	1.08E-05	5.02E-06	1.91E-05	2.41E-05	4.31E-06	4.59E-05	5.03E-05
Cobalt-60	7.20E+04	2.29E+02	1.87E+02	4.16E+02	1.34E+02	1.87E+03	2.01E+03	1.11E+02	3.81E+03	3.92E+03
Europium-152	-6.30E-02	-5.26E-06	-8.47E-05	-8.99E-05	-2.01E-05	-8.47E-04	-8.67E-04	-2.40E-06	-1.63E-03	-1.63E-03
Lead-212	1.34E+00	2.54E-04	2.22E-03	2.47E-03	2.17E-02	2.22E-02	4.38E-02	2.95E-04	4.45E-02	4.48E-02
Lead-214	7.50E-01	9.14E-07	1.35E-03	1.35E-03	8.06E-05	1.35E-02	1.36E-02	9.95E-05	2.77E-02	2.78E-02
Plutonium-238	8.13E-02	6.09E-07	2.35E-09	6.12E-07	3.22E-04	2.35E-08	3.22E-04	7.68E-06	2.35E-08	7.70E-06
Plutonium-239/40	1.10E+00	2.36E-05	5.99E-08	2.36E-05	6.13E-02	5.99E-07	6.13E-02	9.92E-05	5.99E-07	9.98E-05
Potassium-40	2.12E+01	2.74E+00	3.47E-03	2.75E+00	4.89E+00	3.47E-02	4.92E+00	1.24E+00	7.03E-02	1.31E+00
Radium-224	2.46E+00	8.05E-03	4.09E-03	1.21E-02	3.12E-01	4.09E-02	3.53E-01	4.77E-03	8.22E-02	8.69E-02
Radium-226	7.87E-01	2.33E-03	1.42E-03	3.75E-03	9.02E-02	1.42E-02	1.04E-01	1.38E-03	2.91E-02	3.05E-02
Radium-228	1.40E+00	1.47E-07		1.47E-07	5.68E-06		5.68E-06	8.68E-08		8.68E-08
Strontium-90	1.88E+02	7.08E-01	8.34E-04	7.09E-01	2.47E+00	8.34E-03	2.48E+00	3.22E-01	8.34E-03	3.30E-01
Thallium-208	4.60E-01	6.72E-02	1.60E-03	6.88E-02	9.94E-03	1.60E-02	2.59E-02	3.05E-02	3.27E-02	6.32E-02
Thorium-228	1.39E+00	2.61E-05	2.31E-03	2.34E-03	2.15E-02	2.31E-02	4.46E-02	7.71E-04	4.64E-02	4.72E-02
Thorium-230	9.81E-01	2.69E-06	2.25E-07	2.92E-06	2.21E-03	2.25E-06	2.21E-03	7.94E-05	2.25E-06	8.17E-05
Thorium-232	1.20E+00	2.84E-06	1.19E-03	1.19E-03	2.33E-03	1.19E-02	1.42E-02	8.37E-05	2.44E-02	2.45E-02
Thorium-234	1.55E+00	4.06E-02	7.20E-06	4.06E-02	1.30E+00	7.20E-05	1.30E+00	1.38E-02	7.20E-05	1.39E-02
Tritium	9.62E+01	3.01E-02		3.01E-02	3.23E-02		3.23E-02	1.37E-02		1.37E-02
Uranium-232	1.78E-01	1.05E-02	3.08E-08	1.05E-02	1.27E+00	3.08E-07	1.27E+00	1.18E-04	3.08E-07	1.19E-04
Uranium-233/234	4.51E+00	2.42E-01	1.17E-06	2.42E-01	2.92E+01	1.17E-05	2.92E+01	2.72E-03	1.17E-05	2.73E-03
Uranium-234	1.19E+00	6.30E-02	9.13E-08	6.30E-02	7.60E+00	9.13E-07	7.60E+00	7.09E-04	9.13E-07	7.10E-04
Uranium-235	3.80E-01	1.86E-02	5.11E-05	1.86E-02	2.24E+00	5.11E-04	2.25E+00	2.09E-04	1.15E-03	1.36E-03
Uranium-238	1.82E+00	8.56E-02	4.29E-05	8.57E-02	9.99E+00	4.29E-04	9.99E+00	9.65E-04	7.39E-04	1.70E-03
Total		2.36E+02	1.87E+02	4.23E+02	1.99E+02	1.87E+03	2.07E+03	1.13E+02	3.81E+03	3.93E+03

Table 9.6c. (continued)

Radionuclide[a]	Soil Activity[b] (pCi/g)	Red-tailed Hawk Internal	Red-tailed Hawk External	Red-tailed Hawk Total	Wild Turkey Internal	Wild Turkey External	Wild Turkey Total	Mink Internal	Mink External	Mink Total
SWSA 5 Drainage D-2										
Actinium-228	2.30E+00	7.90E-13	2.28E-03	2.28E-03	4.54E-08	2.28E-02	2.28E-02	1.01E-06	4.68E-02	4.68E-02
Bismuth-214	8.20E-01	8.92E-05	1.28E-03	1.37E-03	4.91E-03	1.28E-02	1.77E-02	1.49E-04	2.61E-02	2.63E-02
Calcium-45	1.30E+01	4.16E-04	1.56E-07	4.17E-04	5.32E-03	1.56E-06	5.32E-03	6.76E-04	1.56E-06	6.78E-04
Carbon-14	4.60E-01	6.00E-04	1.19E-09	6.00E-04	1.07E-03	1.19E-08	1.07E-03	2.72E-04	1.19E-08	2.72E-04
Cesium-137	1.99E+01	1.60E-01	1.16E-02	1.71E-01	7.94E-02	1.16E-01	1.95E-01	2.59E-02	2.37E-01	2.63E-01
Iodine-129	3.30E+00	1.64E-04	8.20E-06	1.72E-04	1.82E-05	8.20E-05	1.00E-04	2.13E-02	9.69E-04	2.23E-02
Lead-210	6.10E+00									
Lead-212	9.23E-01	1.75E-04	1.53E-03	1.70E-03	5.30E-03	1.53E-02	2.06E-02	2.03E-04	3.06E-02	3.08E-02
Lead-214	1.40E+00	2.62E-04	2.52E-03	2.79E-03	7.93E-03	2.52E-02	3.32E-02	1.20E-04	5.17E-02	5.18E-02
Potassium-40	2.01E+01	2.60E+00	3.29E-03	2.60E+00	4.60E+00	3.29E-02	4.63E+00	1.18E+00	6.66E-02	1.25E+00
Radium-226	7.90E-01	2.33E-03	1.43E-03	3.76E-03	3.38E-02	1.43E-02	4.81E-02	1.38E-03	2.92E-02	3.06E-02
Radium-228	1.88E+00	1.97E-07		1.97E-07	2.85E-06		2.85E-06	1.17E-07		1.17E-07
Strontium-90	1.28E+02	4.82E-01	5.68E-04	4.83E-01	1.49E+00	5.68E-03	1.49E+00	2.19E-01	5.68E-03	2.25E-01
Technetium-99	1.18E+00	1.16E-07	2.83E-08	1.44E-07	2.32E-04	2.83E-07	2.32E-04	1.54E-07	2.83E-07	4.38E-07
Thorium-228	1.50E+00	2.82E-05	2.50E-03	2.53E-03	7.20E-03	2.50E-02	3.22E-02	8.32E-04	5.01E-02	5.10E-02
Thorium-232	2.15E+00	5.08E-06	2.13E-03	2.13E-03	1.30E-03	2.13E-02	2.26E-02	1.50E-04	4.37E-02	4.39E-02
Thallium-208	1.40E+00	2.05E-01	4.86E-03	2.09E-01	2.34E-02	4.86E-02	7.20E-02	9.29E-02	9.94E-02	1.92E-01
Tritium	2.29E+01	7.18E-03		7.18E-03	7.23E-03		7.23E-03	3.26E-03		3.26E-03
Total		3.46E+00	3.40E-02	3.49E+00	6.26E+00	3.40E-01	6.60E+00	1.55E+00	6.88E-01	2.23E+00
WAG 7 WOC										
Actinium-228	1.09E+00	3.75E-13	1.08E-03	1.08E-03	6.99E-08	1.08E-02	1.08E-02	4.78E-07	2.22E-02	2.22E-02
Americium-241	1.11E-01	1.62E-05	9.31E-07	1.71E-05	7.05E-03	9.31E-06	7.06E-03	1.39E-05	4.87E-05	6.26E-05
Bismuth-214	6.50E-01	7.07E-05	1.02E-03	1.09E-03	1.06E-02	1.02E-02	2.07E-02	1.18E-04	2.07E-02	2.08E-02
Cesium-137	5.62E+03	4.51E+01	3.45E+00	4.86E+01	5.95E+01	3.45E+01	9.39E+01	7.31E+00	7.05E+01	7.78E+01
Curium-243/244	1.08E+00	6.47E-06	1.17E-04	1.23E-04	7.47E-03	1.17E-03	8.64E-03	1.10E-04	2.72E-03	2.83E-03
Cobalt-57	9.00E-02	3.98E-05	8.58E-06	4.84E-05	2.26E-05	8.58E-05	1.08E-04	1.94E-05	2.07E-04	2.26E-04
Cobalt-60	2.02E-01	6.41E-04	5.25E-04	1.17E-03	3.77E-04	5.25E-03	5.63E-03	3.12E-04	1.07E-02	1.10E-02

Table 9.6c. (continued)

Radionuclide[a]	Soil Activity[b] (pCi/g)	Red-tailed Hawk Internal	Red-tailed Hawk External	Red-tailed Hawk Total	Wild Turkey Internal	Wild Turkey External	Wild Turkey Total	Mink Internal	Mink External	Mink Total
Plutonium-238	2.42E-01	1.81E-06	7.00E-09	1.82E-06	9.59E-04	7.00E-08	9.59E-04	2.29E-05	7.00E-08	2.29E-05
Plutonium-239/40	5.10E-02	1.09E-06	2.78E-09	1.10E-06	2.84E-03	2.78E-08	2.84E-03	4.60E-06	2.78E-08	4.63E-06
Potassium-40	2.60E+01	3.36E+00	4.26E-03	3.37E+00	5.99E+00	4.26E-02	6.04E+00	1.53E+00	8.62E-02	1.61E+00
Thorium-228	5.00E-01	9.40E-06	8.33E-04	8.42E-04	7.72E-03	8.33E-03	1.60E-02	2.77E-04	1.67E-02	1.70E-02
Thorium-230	4.10E-01	1.13E-06	9.39E-08	1.22E-06	9.25E-04	9.39E-07	9.26E-04	3.32E-05	9.39E-07	3.41E-05
Thorium-232	4.00E-01	9.45E-07	3.96E-04	3.97E-04	7.77E-04	3.96E-03	4.73E-03	2.79E-05	8.13E-03	8.16E-03
Uranium-233/234	1.10E+00	5.89E-02	2.85E-07	5.89E-02	7.12E+00	2.85E-06	7.12E+00	6.64E-04	2.85E-06	6.66E-04
Uranium-235	8.30E-02	4.06E-03	1.12E-05	4.07E-03	4.90E-01	1.12E-04	4.90E-01	4.57E-05	2.51E-04	2.96E-04
Uranium-238	1.23E+00	5.79E-02	2.90E-05	5.79E-02	6.75E+00	2.90E-04	6.75E+00	6.52E-04	4.99E-04	1.15E-03
Total		4.86E+01	3.45E+00	5.20E+01	7.98E+01	3.45E+01	1.14E+02	8.84E+00	7.07E+01	7.95E+01
WOC										
Americium-241	2.86E+00	4.16E-04	2.40E-05	4.40E-04	1.77E-01	2.40E-04	1.78E-01	3.58E-04	1.25E-03	1.61E-03
Curium-244	3.22E+00	1.93E-05	7.78E-08	1.94E-05	2.10E-02	7.78E-07	2.10E-02	3.27E-04	7.78E-07	3.28E-04
Cobalt-60	4.56E+00	1.45E-02	1.18E-02	2.63E-02	4.32E-03	1.18E-01	1.23E-01	7.04E-03	2.41E-01	2.48E-01
Cesium-137	3.57E+02	2.87E+00	2.08E-01	3.07E+00	1.43E+00	2.08E+00	3.50E+00	4.65E-01	4.26E+00	4.72E+00
Plutonium-238	1.04E+00	7.79E-06	3.01E-08	7.82E-06	3.32E-03	3.01E-07	3.32E-03	9.82E-05	3.01E-07	9.85E-05
Plutonium-239/40	8.07E+00	1.73E-04	4.40E-07	1.73E-04	4.44E-01	4.40E-06	4.44E-01	7.28E-04	4.40E-06	7.32E-04
Strontium-90	2.16E+01	8.14E-02	9.58E-05	8.14E-02	2.51E-01	9.58E-04	2.52E-01	3.70E-02	9.58E-04	3.79E-02
Technetium-99	3.94E+00	3.87E-07	9.46E-08	4.82E-07	7.75E-04	9.46E-07	7.75E-04	5.15E-07	9.46E-07	1.46E-06
Thorium-228	2.81E+00	5.28E-05	4.68E-03	4.73E-03	1.35E-02	4.68E-02	6.03E-02	1.56E-03	9.39E-02	9.55E-02
Thorium-230	5.50E+00	1.51E-05	1.26E-06	1.64E-05	3.85E-03	1.26E-05	3.87E-03	4.45E-04	1.26E-05	4.58E-04
Thorium-232	1.80E+00	4.25E-06	1.78E-03	1.78E-03	1.09E-03	1.78E-02	1.89E-02	1.26E-04	3.66E-02	3.67E-02
Uranium-233/234	3.24E+00	1.74E-01	8.41E-07	1.74E-01	2.02E+01	8.41E-06	2.02E+01	1.95E-03	8.41E-06	1.96E-03
Uranium-235	2.49E-01	1.22E-02	3.35E-05	1.22E-02	1.42E+00	3.35E-04	1.42E+00	1.37E-04	7.52E-04	8.89E-04
Uranium-238	2.97E+00	1.40E-01	7.00E-05	1.40E-01	1.63E+01	7.00E-04	1.63E+01	1.57E-03	1.21E-03	2.78E-03
Total		3.29E+00	2.26E-01	3.51E+00	4.03E+01	2.26E+00	4.26E+01	5.16E-01	4.63E+00	5.15E+00

[a] Dose from each radionuclide includes all short-lived daughter products

[b] Representative concentration is the minimum of the UCL95 and the maximum detect.

Table 9.7 Estimated radiation doses (mrad/d) to piscivorous wildlife exposed to radionuclides in surfacewater at WOC

Radionuclide[a]	Soil Activity[b] (pCi/L)	Mink			Otter			Kingfisher			Heron			Osprey		
		Internal	External	Total	Internal	External	Total	Internal	External	Total	Internal	External	Total	Internal	External	Total
HF-2																
Cobalt-60	7.90E+00	1.72E-02	1.39E-04	1.73E-02	3.60E-02	2.60E-04	3.63E-02	3.14E-02	1.14E-04	3.15E-02	3.60E-02	2.60E-04	3.63E-02	3.14E-02	3.46E-05	3.15E-02
Cesium-137	5.04E+00	1.91E-01	1.92E-05	1.91E-01	3.65E-01	3.60E-05	3.65E-01	3.50E-01	1.58E-05	3.50E-01	3.65E-01	3.60E-05	3.65E-01	3.50E-01	4.80E-06	3.50E-01
Strontium-90	4.64E+00	3.63E-03	1.12E-07	3.63E-03	6.56E-03	2.10E-07	6.56E-03	6.56E-03	9.25E-08	6.56E-03	6.56E-03	2.10E-07	6.56E-03	6.56E-03	2.80E-08	6.56E-03
Tritium	1.39E+04	6.60E-03		6.60E-03	8.54E-03		8.54E-03	8.54E-03		8.54E-03	8.54E-03		8.54E-03	8.54E-03		8.54E-03
Total		2.19E-01	1.58E-04	2.19E-01	4.16E-01	2.96E-04	4.16E-01	3.97E-01	1.30E-04	3.97E-01	4.16E-01	2.96E-04	4.16E-01	3.97E-01	3.95E-05	3.97E-01
HFIR South																
Strontium-90	2.00E+00	1.56E-03	4.83E-08	1.56E-03	2.83E-03	9.06E-08	2.83E-03	2.83E-03	3.99E-08	2.83E-03	2.83E-03	9.06E-08	2.83E-03	2.83E-03	1.21E-08	2.83E-03
Tritium	3.20E+04	1.52E-02		1.52E-02	1.97E-02		1.97E-02	1.97E-02		1.97E-02	1.97E-02		1.97E-02	1.97E-02		1.97E-02
Total		1.68E-02	4.83E-08	1.68E-02	2.25E-02	9.06E-08	2.25E-02	2.25E-02	3.99E-08	2.25E-02	2.25E-02	9.06E-08	2.25E-02	2.25E-02	1.21E-08	2.25E-02
HRE																
Strontium-90	1.22E+03	9.54E-01	2.95E-05	9.54E-01	1.72E+00	5.53E-05	1.72E+00	1.72E+00	2.43E-05	1.72E+00	1.72E+00	5.53E-05	1.72E+00	1.72E+00	7.37E-06	1.72E+00
Tritium	1.00E+03	4.75E-04		4.75E-04	6.14E-04		6.14E-04	6.14E-04		6.14E-04	6.14E-04		6.14E-04	6.14E-04		6.14E-04
Total		9.54E-01	2.95E-05	9.55E-01	1.72E+00	5.53E-05	1.72E+00	1.72E+00	2.43E-05	1.72E+00	1.72E+00	5.53E-05	1.72E+00	1.72E+00	7.37E-06	1.72E+00
Intermediate Pond																
Cobalt-60	4.97E+00	1.08E-02	8.72E-05	1.09E-02	2.27E-02	1.63E-04	2.28E-02	1.98E-02	7.19E-05	1.98E-02	2.27E-02	1.63E-04	2.28E-02	1.98E-02	2.18E-05	1.98E-02
Cesium-137	1.10E+02	4.18E+00	4.19E-04	4.18E+00	7.97E+00	7.85E-04	7.97E+00	7.65E+00	3.45E-04	7.65E+00	7.97E+00	7.85E-04	7.97E+00	7.65E+00	1.05E-04	7.65E+00
Strontium-90	9.40E+01	7.35E-02	2.27E-06	7.35E-02	1.33E-01	4.26E-06	1.33E-01	1.33E-01	1.87E-06	1.33E-01	1.33E-01	4.26E-06	1.33E-01	1.33E-01	5.68E-07	1.33E-01
Tritium	7.73E+03	3.67E-03		3.67E-03	4.75E-03		4.75E-03	4.75E-03		4.75E-03	4.75E-03		4.75E-03	4.75E-03		4.75E-03
Total		4.27E+00	5.08E-04	4.27E+00	8.13E+00	9.53E-04	8.13E+00	7.80E+00	4.19E-04	7.81E+00	8.13E+00	9.53E-04	8.13E+00	7.80E+00	1.27E-04	7.80E+00
Little No-Name																
Strontium-90	2.38E+01	1.86E-02	5.75E-07	1.86E-02	3.36E-02	1.08E-06	3.36E-02	3.36E-02	4.75E-07	3.36E-02	3.36E-02	1.08E-06	3.36E-02	3.36E-02	1.44E-07	3.36E-02
Tritium	1.15E+03	5.46E-04		5.46E-04	7.07E-04		7.07E-04	7.07E-04		7.07E-04	7.07E-04		7.07E-04	7.07E-04		7.07E-04
Total		1.92E-02	5.75E-07	1.92E-02	3.43E-02	1.08E-06	3.43E-02	3.43E-02	4.75E-07	3.43E-02	3.43E-02	1.08E-06	3.43E-02	3.43E-02	1.44E-07	3.43E-02
Lower WOC																
Cobalt-60	6.12E+00	1.33E-02	1.07E-04	1.34E-02	2.79E-02	2.01E-04	2.81E-02	2.44E-02	8.85E-05	2.44E-02	2.79E-02	2.01E-04	2.81E-02	2.44E-02	2.68E-05	2.44E-02
Cesium-137	5.12E+01	1.94E+00	1.95E-04	1.94E+00	3.71E+00	3.65E-04	3.71E+00	3.56E+00	1.61E-04	3.56E+00	3.71E+00	3.65E-04	3.71E+00	3.56E+00	4.87E-05	3.56E+00
Plutonium-238	2.00E-01	1.79E-06	1.46E-10	1.79E-06	2.81E-06	2.74E-10	2.81E-06	2.81E-06	1.20E-10	2.81E-06	2.81E-06	2.74E-10	2.81E-06	2.81E-06	3.65E-11	2.81E-06
Strontium-90	3.89E+02	3.04E-01	9.40E-06	3.04E-01	5.50E-01	1.76E-05	5.50E-01	5.50E-01	7.76E-06	5.50E-01	5.50E-01	1.76E-05	5.50E-01	5.50E-01	2.35E-06	5.50E-01

Table 9.7 (continued)

Radionuclide[a]	Soil Activity[b] (pCi/L)	Mink Internal	Mink External	Mink Total	Otter Internal	Otter External	Otter Total	Kingfisher Internal	Kingfisher External	Kingfisher Total	Heron Internal	Heron External	Heron Total	Osprey Internal	Osprey External	Osprey Total
Thorium-228	1.30E+00	3.70E-03	1.45E-05	3.71E-03	6.60E-03	2.73E-05	6.63E-03	6.60E-03	1.20E-05	6.61E-03	6.60E-03	2.73E-05	6.63E-03	6.60E-03	3.63E-06	6.60E-03
Thorium-230	2.20E-01	9.15E-05	5.55E-10	9.15E-05	1.63E-04	1.04E-09	1.63E-04	1.63E-04	4.58E-10	1.63E-04	1.63E-04	1.04E-09	1.63E-04	1.63E-04	1.39E-10	1.63E-04
Tritium	4.93E+05	2.34E-01		2.34E-01	3.03E-01		3.03E-01	3.03E-01		3.03E-01	3.03E-01		3.03E-01	3.03E-01		3.03E-01
Uranium-234	1.59E+00	7.51E-04	1.78E-09	7.51E-04	1.28E-03	3.34E-09	1.28E-03	1.28E-03	1.47E-09	1.28E-03	1.28E-03	3.34E-09	1.28E-03	1.28E-03	4.45E-10	1.28E-03
Uranium-238	6.50E-01	2.73E-04	1.12E-07	2.73E-04	4.65E-04	2.10E-07	4.65E-04	4.65E-04	9.26E-08	4.65E-04	4.65E-04	2.10E-07	4.65E-04	4.65E-04	2.81E-08	4.65E-04
Total		2.50E+00	3.26E-04	2.50E+00	4.60E+00	6.12E-04	4.60E+00	4.44E+00	2.69E-04	4.45E+00	4.60E+00	6.12E-04	4.60E+00	4.44E+00	8.16E-05	4.45E+00
MB-15																
Cobalt-60	4.90E+02	1.07E+00	8.59E-03	1.08E+00	2.23E+00	1.61E-02	2.25E+00	1.95E+00	7.09E-03	1.96E+00	2.23E+00	1.61E-02	2.25E+00	1.95E+00	2.15E-03	1.95E+00
Strontium-90	2.60E+01	2.03E-02	6.28E-07	2.03E-02	3.67E-02	1.18E-06	3.67E-02	3.67E-02	5.18E-07	3.67E-02	3.67E-02	1.18E-06	3.67E-02	3.67E-02	1.57E-07	3.67E-02
Tritium	6.23E+04	2.96E-02		2.96E-02	3.83E-02		3.83E-02	3.83E-02		3.83E-02	3.83E-02		3.83E-02	3.83E-02		3.83E-02
Total		1.12E+00	8.59E-03	1.13E+00	2.31E+00	1.61E-02	2.32E+00	2.02E+00	7.09E-03	2.03E+00	2.31E+00	1.61E-02	2.32E+00	2.02E+00	2.15E-03	2.03E+00
SWSA 5 Seep A																
Strontium-90	1.32E+03	1.03E+00	3.19E-05	1.03E+00	1.87E+00	5.98E-05	1.87E+00	1.87E+00	2.63E-05	1.87E+00	1.87E+00	5.98E-05	1.87E+00	1.87E+00	7.97E-06	1.87E+00
Tritium	1.10E+06	5.22E-01		5.22E-01	6.76E-01		6.76E-01	6.76E-01		6.76E-01	6.76E-01		6.76E-01	6.76E-01		6.76E-01
Total		1.55E+00	3.19E-05	1.55E+00	2.54E+00	5.98E-05	2.54E+00	2.54E+00	2.63E-05	2.54E+00	2.54E+00	5.98E-05	2.54E+00	2.54E+00	7.97E-06	2.54E+00
SWSA 5 Seep B West																
Strontium-90	1.91E+02	1.49E-01	4.62E-06	1.49E-01	2.70E-01	8.65E-06	2.70E-01	2.70E-01	3.81E-06	2.70E-01	2.70E-01	8.65E-06	2.70E-01	2.70E-01	1.15E-06	2.70E-01
Tritium	6.23E+05	2.96E-01		2.96E-01	3.83E-01		3.83E-01	3.83E-01		3.83E-01	3.83E-01		3.83E-01	3.83E-01		3.83E-01
Total		4.45E-01	4.62E-06	4.45E-01	6.53E-01	8.65E-06	6.53E-01	6.53E-01	3.81E-06	6.53E-01	6.53E-01	8.65E-06	6.53E-01	6.53E-01	1.15E-06	6.53E-01
SWSA 5 Seep B East																
Strontium-90	1.09E+03	8.52E-01	2.63E-05	8.52E-01	1.54E+00	4.94E-05	1.54E+00	1.54E+00	2.17E-05	1.54E+00	1.54E+00	4.94E-05	1.54E+00	1.54E+00	6.59E-06	1.54E+00
Tritium	1.52E+06	7.22E-01		7.22E-01	9.34E-01		9.34E-01	9.34E-01		9.34E-01	9.34E-01		9.34E-01	9.34E-01		9.34E-01
Total		1.57E+00	2.63E-05	1.57E+00	2.47E+00	4.94E-05	2.47E+00	2.47E+00	2.17E-05	2.47E+00	2.47E+00	4.94E-05	2.47E+00	2.47E+00	6.59E-06	2.47E+00
SWSA 5 Seep C																
Strontium-90	4.33E+02	3.39E-01	1.05E-05	3.39E-01	6.12E-01	1.96E-05	6.12E-01	6.12E-01	8.63E-06	6.12E-01	6.12E-01	1.96E-05	6.12E-01	6.12E-01	2.62E-06	6.12E-01
Tritium	1.14E+06	5.41E-01		5.41E-01	7.00E-01		7.00E-01	7.00E-01		7.00E-01	7.00E-01		7.00E-01	7.00E-01		7.00E-01
Total		8.80E-01	1.05E-05	8.80E-01	1.31E+00	1.96E-05	1.31E+00	1.31E+00	8.63E-06	1.31E+00	1.31E+00	1.96E-05	1.31E+00	1.31E+00	2.62E-06	1.31E+00

Table 9.7 (continued)

Radionuclide[a]	Soil Activity[b] (pCi/L)	Mink			Otter			Kingfisher			Heron			Osprey		
		Internal	External	Total	Internal	External	Total	Internal	External	Total	Internal	External	Total	Internal	External	Total
SWSA 5 Trib 1																
Americium-241	5.00E-01	9.76E-05	6.02E-08	9.76E-05	1.74E-04	1.13E-07	1.74E-04	1.74E-04	4.96E-08	1.74E-04	1.74E-04	1.13E-07	1.74E-04	1.74E-04	1.50E-08	1.74E-04
Carbon-14	5.18E+03		1.46E-07	1.46E-07		2.73E-07	2.73E-07		1.20E-07	1.20E-07		2.73E-07	2.73E-07		3.64E-08	3.64E-08
Curium-244	5.10E+00	5.26E-04	3.75E-09	5.26E-04	9.38E-04	7.04E-09	9.38E-04	9.38E-04	3.10E-09	9.38E-04	9.38E-04	7.04E-09	9.38E-04	9.38E-04	9.38E-10	9.38E-04
Cobalt-60	1.27E+02	2.77E-01	2.23E-03	2.79E-01	5.79E-01	4.18E-03	5.83E-01	5.05E-01	1.84E-03	5.07E-01	5.79E-01	4.18E-03	5.83E-01	5.05E-01	5.57E-04	5.06E-01
Cesium-137	4.94E+01	1.88E+00	1.88E-04	1.88E+00	3.58E+00	3.53E-04	3.58E+00	3.43E+00	1.55E-04	3.43E+00	3.58E+00	3.53E-04	3.58E+00	3.43E+00	4.70E-05	3.43E+00
Plutonium-238	2.10E-01	1.88E-06	1.53E-10	1.88E-06	2.95E-06	2.87E-10	2.95E-06	2.95E-06	1.26E-10	2.95E-06	2.95E-06	2.87E-10	2.95E-06	2.95E-06	3.83E-11	2.95E-06
Strontium-90	5.98E+03	4.68E+00	1.45E-04	4.68E+00	8.45E+00	2.71E-04	8.45E+00	8.45E+00	1.19E-04	8.45E+00	8.45E+00	2.71E-04	8.45E+00	8.45E+00	3.61E-05	8.45E+00
Tritium	1.23E+04	5.84E-03		5.84E-03	7.56E-03		7.56E-03	7.56E-03		7.56E-03	7.56E-03		7.56E-03	7.56E-03		7.56E-03
Uranium-232	2.18E+01	1.15E-02	4.49E-08	1.15E-02	1.95E-02	8.42E-08	1.95E-02	1.95E-02	3.71E-08	1.95E-02	1.95E-02	8.42E-08	1.95E-02	1.95E-02	1.12E-08	1.95E-02
Uranium-233/234	2.62E+02	1.25E-01	4.52E-07	1.25E-01	2.13E-01	8.47E-07	2.13E-01	2.13E-01	3.73E-07	2.13E-01	2.13E-01	8.47E-07	2.13E-01	2.13E-01	1.13E-07	2.13E-01
Uranium-238	4.82E+00	2.02E-03	8.32E-07	2.03E-03	3.45E-03	1.56E-06	3.45E-03	3.45E-03	6.87E-07	3.45E-03	3.45E-03	1.56E-06	3.45E-03	3.45E-03	2.08E-07	3.45E-03
Total		6.97E+00	2.56E-03	6.98E+00	1.29E+01	4.80E-03	1.29E+01	1.26E+01	2.11E-03	1.26E+01	1.29E+01	4.80E-03	1.29E+01	1.26E+01	6.40E-04	1.26E+01
SWSA 5 WOC																
Americium-241	3.90E-01	7.61E-05	4.69E-08	7.61E-05	1.36E-04	8.80E-08	1.36E-04	1.36E-04	3.87E-08	1.36E-04	1.36E-04	8.80E-08	1.36E-04	1.36E-04	1.17E-08	1.36E-04
Carbon-14	9.65E+04		2.71E-06	2.71E-06		5.08E-06	5.08E-06		2.24E-06	2.24E-06		5.08E-06	5.08E-06		6.78E-07	6.78E-07
Curium-244	1.62E+01	1.67E-03	1.19E-08	1.67E-03	2.98E-03	2.24E-08	2.98E-03	2.98E-03	9.84E-09	2.98E-03	2.98E-03	2.24E-08	2.98E-03	2.98E-03	2.98E-09	2.98E-03
Cobalt-60	1.54E+02	3.35E-01	2.70E-03	3.38E-01	7.02E-01	5.06E-03	7.07E-01	6.13E-01	2.23E-03	6.15E-01	7.02E-01	5.06E-03	7.07E-01	6.13E-01	6.75E-04	6.13E-01
Cesium-137	3.16E+04	1.20E+03	1.20E-01	1.20E+03	2.29E+03	2.26E-01	2.29E+03	2.20E+03	9.92E-02	2.20E+03	2.29E+03	2.26E-01	2.29E+03	2.20E+03	3.01E-02	2.20E+03
Potassium-40	6.22E+01	1.69E-03	6.93E-05	1.75E-03	1.70E-03	1.30E-04	1.83E-03	1.69E-03	5.71E-05	1.74E-03	1.70E-03	1.30E-04	1.83E-03	1.69E-03	1.73E-05	1.70E-03
Plutonium-238	7.00E-01	6.26E-06	5.11E-10	6.26E-06	9.83E-06	9.58E-10	9.83E-06	9.83E-06	4.21E-10	9.83E-06	9.83E-06	9.58E-10	9.83E-06	9.83E-06	1.28E-10	9.83E-06
Radium-228	2.00E+01	2.22E-05		2.22E-05	4.00E-05		4.00E-05	4.00E-05		4.00E-05	4.00E-05		4.00E-05	4.00E-05		4.00E-05
Strontium-90	9.36E+04	7.32E+01	2.26E-03	7.32E+01	1.32E+02	4.24E-03	1.32E+02	1.32E+02	1.87E-03	1.32E+02	1.32E+02	4.24E-03	1.32E+02	1.32E+02	5.65E-04	1.32E+02
Technetium-99	4.32E+01	1.33E-06	8.68E-09	1.34E-06	2.35E-06	1.63E-08	2.36E-06	2.35E-06	7.16E-09	2.35E-06	2.35E-06	1.63E-08	2.36E-06	2.35E-06	2.17E-09	2.35E-06
Thorium-228	1.07E+00	3.05E-03	1.20E-05	3.06E-03	5.43E-03	2.24E-05	5.45E-03	5.43E-03	9.87E-06	5.44E-03	5.43E-03	2.24E-05	5.45E-03	5.43E-03	2.99E-06	5.43E-03
Thorium-230	4.94E-01	2.05E-04	1.25E-09	2.05E-04	3.66E-04	2.34E-09	3.66E-04	3.66E-04	1.03E-09	3.66E-04	3.66E-04	2.34E-09	3.66E-04	3.66E-04	3.11E-10	3.66E-04
Tritium	3.50E+04	1.66E-02		1.66E-02	2.15E-02		2.15E-02	2.15E-02		2.15E-02	2.15E-02		2.15E-02	2.15E-02		2.15E-02
Uranium-232	3.70E+00	1.95E-03	7.62E-09	1.95E-03	3.32E-03	1.43E-08	3.32E-03	3.32E-03	6.29E-09	3.32E-03	3.32E-03	1.43E-08	3.32E-03	3.32E-03	1.91E-09	3.32E-03
Uranium-233/234	1.02E+02	4.88E-02	1.76E-07	4.88E-02	8.30E-02	3.30E-07	8.30E-02	8.30E-02	1.45E-07	8.30E-02	8.30E-02	3.30E-07	8.30E-02	8.30E-02	4.40E-08	8.30E-02
Uranium-235/236	3.80E-01	5.56E-04	3.87E-07	5.57E-04	9.48E-04	7.26E-07	9.48E-04	9.47E-04	3.19E-07	9.48E-04	9.48E-04	7.26E-07	9.48E-04	9.47E-04	9.68E-08	9.48E-04
Uranium-238	9.40E-01	3.95E-04	1.62E-07	3.95E-04	6.72E-04	3.04E-07	6.73E-04	6.72E-04	1.34E-07	6.72E-04	6.72E-04	3.04E-07	6.73E-04	6.72E-04	4.06E-08	6.72E-04
Total		1.27E+03	1.25E-01	1.27E+03	2.42E+03	2.35E-01	2.42E+03	2.33E+03	1.03E-01	2.33E+03	2.42E+03	2.35E-01	2.42E+03	2.33E+03	3.13E-02	2.33E+03

Table 9.7 (continued)

Radionuclide[a]	Soil Activity[b] (pCi/L)	Mink			Otter			Kingfisher			Heron			Osprey		
		Internal	External	Total	Internal	External	Total	Internal	External	Total	Internal	External	Total	Internal	External	Total
SWSA 5 N WOC																
Strontium-90	1.18E+02	9.23E-02	2.85E-06	9.23E-02	1.67E-01	5.35E-06	1.67E-01	1.67E-01	2.35E-06	1.67E-01	1.67E-01	5.35E-06	1.67E-01	1.67E-01	7.13E-07	1.67E-01
Tritium	1.25E+04	5.94E-03		5.94E-03	7.68E-03		7.68E-03	7.68E-03		7.68E-03	7.68E-03		7.68E-03	7.68E-03		7.68E-03
Total		9.82E-02	2.85E-06	9.82E-02	1.74E-01	5.35E-06	1.74E-01	1.74E-01	2.35E-06	1.74E-01	1.74E-01	5.35E-06	1.74E-01	1.74E-01	7.13E-07	1.74E-01
SWSA 6 East																
Cobalt-60	5.50E+02	1.20E+00	9.64E-03	1.21E+00	2.51E+00	1.81E-02	2.52E+00	2.19E+00	7.96E-03	2.20E+00	2.51E+00	1.81E-02	2.52E+00	2.19E+00	2.41E-03	2.19E+00
Cesium-137	1.12E+01	4.25E-01	4.26E-05	4.25E-01	8.11E-01	7.99E-05	8.11E-01	7.79E-01	3.52E-05	7.79E-01	8.11E-01	7.99E-05	8.11E-01	7.79E-01	1.07E-05	7.79E-01
Tritium	1.90E+05	9.02E-02		9.02E-02	1.17E-01		1.17E-01	1.17E-01		1.17E-01	1.17E-01		1.17E-01	1.17E-01		1.17E-01
Total		1.71E+00	9.69E-03	1.72E+00	3.43E+00	1.82E-02	3.45E+00	3.08E+00	7.99E-03	3.09E+00	3.43E+00	1.82E-02	3.45E+00	3.08E+00	2.42E-03	3.09E+00
W6MS3																
Americium-241	1.76E+00	3.43E-04	2.12E-07	3.44E-04	6.13E-04	3.97E-07	6.13E-04	6.13E-04	1.75E-07	6.13E-04	6.13E-04	3.97E-07	6.13E-04	6.13E-04	5.29E-08	6.13E-04
Curium-244	1.35E+02	1.39E-02	9.94E-08	1.39E-02	2.48E-02	1.86E-07	2.48E-02	2.48E-02	8.20E-08	2.48E-02	2.48E-02	1.86E-07	2.48E-02	2.48E-02	2.48E-08	2.48E-02
Cobalt-60	3.49E+00	7.60E-03	6.12E-05	7.66E-03	1.59E-02	1.15E-04	1.60E-02	1.39E-02	5.05E-05	1.39E-02	1.59E-02	1.15E-04	1.60E-02	1.39E-02	1.53E-05	1.39E-02
Cesium-137	3.65E+00	1.39E-01	1.39E-05	1.39E-01	2.64E-01	2.61E-05	2.64E-01	2.54E-01	1.15E-05	2.54E-01	2.64E-01	2.61E-05	2.64E-01	2.54E-01	3.47E-06	2.54E-01
Curium-242	7.88E+00	8.56E-04	6.71E-09	8.56E-04	1.53E-03	1.26E-08	1.53E-03	1.53E-03	5.53E-09	1.53E-03	1.53E-03	1.26E-08	1.53E-03	1.53E-03	1.68E-09	1.53E-03
Europium-152	2.78E+01	1.75E-03	2.19E-04	1.97E-03	3.57E-03	4.10E-04	3.98E-03	3.15E-03	1.81E-04	3.33E-03	3.57E-03	4.10E-04	3.98E-03	3.15E-03	5.47E-05	3.21E-03
Europium-154	5.74E+00	6.85E-04	4.89E-05	7.33E-04	1.33E-03	9.16E-05	1.42E-03	1.23E-03	4.03E-05	1.27E-03	1.33E-03	9.16E-05	1.42E-03	1.23E-03	1.22E-05	1.25E-03
Europium-155	1.15E+01	2.78E-04	4.13E-06	2.82E-04	5.14E-04	7.74E-06	5.22E-04	5.00E-04	3.41E-06	5.04E-04	5.14E-04	7.74E-06	5.22E-04	5.00E-04	1.03E-06	5.01E-04
Europium-156	2.89E+02	4.85E-02	2.70E-03	5.12E-02	9.23E-02	5.06E-03	9.74E-02	8.73E-02	2.23E-03	8.96E-02	9.23E-02	5.06E-03	9.74E-02	8.73E-02	6.75E-04	8.80E-02
Potassium-40	2.53E+02	6.86E-03	2.82E-04	7.14E-03	6.90E-03	5.28E-04	7.42E-03	6.86E-03	2.32E-04	7.09E-03	6.90E-03	5.28E-04	7.42E-03	6.86E-03	7.04E-05	6.93E-03
Plutonium-238	1.08E+00	9.66E-06	7.88E-10	9.66E-06	1.52E-05	1.48E-09	1.52E-05	1.52E-05	6.50E-10	1.52E-05	1.52E-05	1.48E-09	1.52E-05	1.52E-05	1.97E-10	1.52E-05
Radium-224	2.10E+01	7.28E-01	2.35E-04	7.28E-01	1.31E+00	4.40E-04	1.31E+00	1.31E+00	1.93E-04	1.31E+00	1.31E+00	4.40E-04	1.31E+00	1.31E+00	5.86E-05	1.31E+00
Radium-228	2.09E+01	2.32E-05		2.32E-05	4.17E-05		4.17E-05	4.17E-05		4.17E-05	4.17E-05		4.17E-05	4.17E-05		4.17E-05
Strontium-90	5.26E+02	4.11E-01	1.27E-05	4.11E-01	7.43E-01	2.38E-05	7.43E-01	7.43E-01	1.05E-05	7.43E-01	7.43E-01	2.38E-05	7.43E-01	7.43E-01	3.18E-06	7.43E-01
Thorium-228	9.03E-01	2.57E-03	1.01E-05	2.58E-03	4.58E-03	1.89E-05	4.60E-03	4.58E-03	8.33E-06	4.59E-03	4.58E-03	1.89E-05	4.60E-03	4.58E-03	2.52E-06	4.59E-03
Thorium-230	7.07E-01	2.94E-04	1.78E-09	2.94E-04	5.24E-04	3.34E-09	5.24E-04	5.24E-04	1.47E-09	5.24E-04	5.24E-04	3.34E-09	5.24E-04	5.24E-04	4.46E-10	5.24E-04
Thorium-232	5.69E-01	2.04E-04	3.79E-06	2.07E-04	3.63E-04	7.10E-06	3.71E-04	3.63E-04	3.13E-06	3.66E-04	3.63E-04	7.10E-06	3.71E-04	3.63E-04	9.47E-07	3.64E-04
Thorium-234	2.66E+02	1.09E+00	1.30E-05	1.09E+00	1.41E+00	2.44E-05	1.41E+00	1.41E+00	1.07E-05	1.41E+00	1.41E+00	2.44E-05	1.41E+00	1.41E+00	3.25E-06	1.41E+00
Tritium	2.30E+06	1.09E+00		1.09E+00	1.41E+00		1.41E+00	1.41E+00		1.41E+00	1.41E+00		1.41E+00	1.41E+00		1.41E+00
Uranium-234	6.62E-01	3.13E-04	7.41E-10	3.13E-04	5.32E-04	1.39E-09	5.32E-04	5.32E-04	6.12E-10	5.32E-04	5.32E-04	1.39E-09	5.32E-04	5.32E-04	1.85E-10	5.32E-04
Total		3.55E+00	3.60E-03	3.55E+00	5.30E+00	6.76E-03	5.31E+00	5.28E+00	2.97E-03	5.28E+00	5.30E+00	6.76E-03	5.31E+00	5.28E+00	9.01E-04	5.28E+00

Table 9.7 (continued)

Radionuclide[a]	Soil Activity[b] (pCi/L)	Mink			Otter			Kingfisher			Heron			Osprey		
		Internal	External	Total	Internal	External	Total	Internal	External	Total	Internal	External	Total	Internal	External	Total
W6MS1																
Cesium-137	3.45E+00	1.31E-01	1.31E-05	1.31E-01	2.50E-01	2.46E-05	2.50E-01	2.40E-01	1.08E-05	2.40E-01	2.50E-01	2.46E-05	2.50E-01	2.40E-01	3.28E-06	2.40E-01
Europium-154	3.42E+00	4.08E-04	2.91E-05	4.37E-04	7.91E-04	5.46E-05	8.45E-04	7.35E-04	2.40E-05	7.59E-04	7.91E-04	5.46E-05	8.45E-04	7.35E-04	7.28E-06	7.42E-04
Radium-224	1.83E+01	6.34E-01	2.04E-04	6.35E-01	1.14E+00	3.83E-04	1.14E+00	1.14E+00	1.69E-04	1.14E+00	1.14E+00	3.83E-04	1.14E+00	1.14E+00	5.11E-05	1.14E+00
Strontium-90	3.30E+00	2.58E-03	7.97E-08	2.58E-03	4.66E-03	1.50E-07	4.66E-03	4.66E-03	6.58E-08	4.66E-03	4.66E-03	1.50E-07	4.66E-03	4.66E-03	1.99E-08	4.66E-03
Tritium	5.57E+05	2.65E-01		2.65E-01	3.42E-01		3.42E-01	3.42E-01		3.42E-01	3.42E-01		3.42E-01	3.42E-01		3.42E-01
Total		1.03E+00	2.47E-04	1.03E+00	1.74E+00	4.63E-04	1.74E+00	1.73E+00	2.04E-04	1.73E+00	1.74E+00	4.63E-04	1.74E+00	1.73E+00	6.17E-05	1.73E+00
WOC																
Cobalt-60	2.35E+00	5.12E-03	4.12E-05	5.16E-03	1.07E-02	7.73E-05	1.08E-02	9.35E-03	3.40E-05	9.38E-03	1.07E-02	7.73E-05	1.08E-02	9.35E-03	1.03E-05	9.36E-03
Cesium-137	1.01E+02	3.84E+00	3.85E-04	3.84E+00	7.32E+00	7.21E-04	7.32E+00	7.02E+00	3.17E-04	7.02E+00	7.32E+00	7.21E-04	7.32E+00	7.02E+00	9.61E-05	7.02E+00
Strontium-90	1.31E+02	1.02E-01	3.17E-06	1.02E-01	1.85E-01	5.94E-06	1.85E-01	1.85E-01	2.61E-06	1.85E-01	1.85E-01	5.94E-06	1.85E-01	1.85E-01	7.91E-07	1.85E-01
Tritium	5.28E+04	2.51E-02		2.51E-02	3.24E-02		3.24E-02	3.24E-02		3.24E-02	3.24E-02		3.24E-02	3.24E-02		3.24E-02
Total		3.97E+00	4.29E-04	3.97E+00	7.54E+00	8.04E-04	7.54E+00	7.25E+00	3.54E-04	7.25E+00	7.54E+00	8.04E-04	7.54E+00	7.25E+00	1.07E-04	7.25E+00
WOCE																
Cobalt-60	4.66E+00	1.02E-02	8.17E-05	1.02E-02	2.12E-02	1.53E-04	2.14E-02	1.85E-02	6.74E-05	1.86E-02	2.12E-02	1.53E-04	2.14E-02	1.85E-02	2.04E-05	1.86E-02
Cesium-137	6.10E+01	2.32E+00	2.32E-04	2.32E+00	4.42E+00	4.35E-04	4.42E+00	4.24E+00	1.92E-04	4.24E+00	4.42E+00	4.35E-04	4.42E+00	4.24E+00	5.81E-05	4.24E+00
Strontium-90	4.27E+01	3.34E-02	1.03E-06	3.34E-02	6.03E-02	1.93E-06	6.03E-02	6.03E-02	8.51E-07	6.03E-02	6.03E-02	1.93E-06	6.03E-02	6.03E-02	2.58E-07	6.03E-02
Tritium	6.38E+04	3.03E-02		3.03E-02	3.92E-02		3.92E-02	3.92E-02		3.92E-02	3.92E-02		3.92E-02	3.92E-02		3.92E-02
Total		2.39E+00	3.15E-04	2.39E+00	4.54E+00	5.91E-04	4.54E+00	4.36E+00	2.60E-04	4.36E+00	4.54E+00	5.91E-04	4.54E+00	4.36E+00	7.87E-05	4.36E+00
West Seep																
Strontium-90	5.10E+00	3.99E-03	1.23E-07	3.99E-03	7.21E-03	2.31E-07	7.21E-03	7.21E-03	1.02E-07	7.21E-03	7.21E-03	2.31E-07	7.21E-03	7.21E-03	3.08E-08	7.21E-03
Tritium	1.69E+05	8.03E-02		8.03E-02	1.04E-01		1.04E-01	1.04E-01		1.04E-01	1.04E-01		1.04E-01	1.04E-01		1.04E-01
Total		8.43E-02	1.23E-07	8.43E-02	1.11E-01	2.31E-07	1.11E-01	1.11E-01	1.02E-07	1.11E-01	1.11E-01	2.31E-07	1.11E-01	1.11E-01	3.08E-08	1.11E-01

[a] Dose from each radionuclide includes all short-lived daughter products

[b] Representative concentration is the minimum of the UCL95 and the maximum detect.

Table 9.8 Estimated radiation doses (mrad/d) to aquatic organisms exposed to radionuclides in surfacewater at WOC

Radionuclide[a]	Soil Activity[b] (pCi/L)	Large invertebrates			Large fish		
		Internal	External	Total	Internal	External	Total
East Seep							
Americium-241	9.40E-01	2.77E-04	1.59E-09	2.77E-04	8.33E-06	9.92E-10	8.33E-06
Cesium-137	9.59E+00	1.30E-04	2.87E-07	1.31E-04	3.18E-04	2.58E-07	3.18E-04
Cobalt-60	5.75E+02	3.59E-02	7.61E-05	3.60E-02	2.73E-03	7.06E-05	2.80E-03
Curium-243	2.82E+00	8.92E-04	2.00E-08	8.92E-04	2.68E-05	1.77E-08	2.69E-05
Plutonium-238	5.00E-02	1.47E-06	1.97E-12	1.47E-06	5.86E-08	3.20E-13	5.86E-08
Strontium-90	4.96E+01	8.97E-04		8.97E-04	1.79E-04		1.79E-04
Thorium-228	1.10E+00	9.63E-04	9.04E-08	9.63E-04	5.80E-05	8.28E-08	5.81E-05
Thorium-230	1.50E-01	1.87E-05	5.92E-12	1.87E-05	1.12E-06	9.59E-13	1.12E-06
Thorium-232	3.00E-02	3.61E-06	1.54E-09	3.61E-06	2.21E-07	1.40E-09	2.22E-07
Tritium	3.01E+04	9.63E-06		9.63E-06	9.63E-06		9.63E-06
Uranium-232	2.25E+02	6.38E-03	8.87E-09	6.38E-03	6.38E-04	1.44E-09	6.38E-04
Uranium-234	4.14E+03	1.05E-01	1.63E-07	1.05E-01	1.05E-02	2.65E-08	1.05E-02
Uranium-235	1.50E+01	3.69E-04	1.43E-07	3.69E-04	3.71E-05	1.18E-07	3.72E-05
Uranium-238	1.01E+02	2.74E-03	6.79E-08	2.74E-03	2.75E-04	2.68E-08	2.75E-04
Total		1.54E-01	7.69E-05	1.54E-01	1.48E-02	7.11E-05	1.49E-02
HF-2							
Americium-241	8.12E-02	2.39E-05	1.37E-10	2.39E-05	7.20E-07	8.57E-11	7.20E-07
Carbon-14	2.36E+02	2.24E-03		2.24E-03	2.80E-03		2.80E-03
Cesium-137	5.31E+00	7.22E-05	1.59E-07	7.23E-05	1.76E-04	1.43E-07	1.76E-04
Cobalt-60	7.96E+00	4.98E-04	1.05E-06	4.99E-04	3.78E-05	9.77E-07	3.88E-05
Iodine-129	9.60E+02	1.37E-03	1.14E-06	1.37E-03	1.61E-04	5.37E-07	1.61E-04
Radium-228	1.52E+01	4.13E-06		4.13E-06	6.89E-07		6.89E-07
Strontium-90	2.15E+01	3.89E-04		3.89E-04	7.78E-05		7.78E-05
Technetium-99	6.23E+00	1.68E-07		1.68E-07	6.71E-07		6.71E-07
Thorium-228	8.24E-01	7.21E-04	6.77E-08	7.21E-04	4.34E-05	6.20E-08	4.35E-05
Thorium-230	3.57E+00	4.46E-04	1.41E-10	4.46E-04	2.68E-05	2.28E-11	2.68E-05
Thorium-232	1.34E+00	1.61E-04	6.87E-08	1.61E-04	9.85E-06	6.24E-08	9.91E-06
Tritium	1.32E+04	4.22E-06		4.22E-06	4.22E-06		4.22E-06
Uranium-233/234	8.12E-01	2.09E-05	1.60E-11	2.09E-05	2.09E-06	2.60E-12	2.09E-06
Uranium-238	7.39E-01	2.01E-05	4.97E-10	2.01E-05	2.01E-06	1.96E-10	2.01E-06
Total		5.97E-03	2.49E-06	5.97E-03	3.35E-03	1.78E-06	3.35E-03
HFIR East							
Strontium-90	7.00E+00	1.27E-04		1.27E-04	2.53E-05		2.53E-05
Tritium	2.00E+03	6.40E-07		6.40E-07	6.40E-07		6.40E-07
Total		1.27E-04	0.00E+00	1.27E-04	2.60E-05	0.00E+00	2.60E-05
HRE							
Americium-241	3.03E+00	8.93E-04	5.12E-09	8.93E-04	2.69E-05	3.20E-09	2.69E-05
Calcium-45	9.90E+02	1.63E-04		1.63E-04	1.63E-04		1.63E-04
Carbon-14	4.61E+02	4.38E-03		4.38E-03	5.48E-03		5.48E-03

Table 9.8 (continued)

Radionuclide[a]	Soil Activity[b] (pCi/L)	Large invertebrates			Large fish		
		Internal	External	Total	Internal	External	Total
Curium-244	5.76E-01	1.78E-04	2.27E-11	1.78E-04	5.35E-06	3.68E-12	5.35E-06
Strontium-90	1.87E+03	3.38E-02		3.38E-02	6.76E-03		6.76E-03
Technetium-99	1.25E+01	3.36E-07		3.36E-07	1.35E-06		1.35E-06
Thorium-228	1.39E+00	1.22E-03	1.14E-07	1.22E-03	7.33E-05	1.05E-07	7.34E-05
Thorium-230	3.27E+00	4.08E-04	1.29E-10	4.08E-04	2.45E-05	2.09E-11	2.45E-05
Thorium-232	2.87E+00	3.45E-04	1.47E-07	3.45E-04	2.11E-05	1.34E-07	2.12E-05
Tritium	1.26E+03	4.03E-07		4.03E-07	4.03E-07		4.03E-07
Uranium-233/234	1.37E-01	3.52E-06	2.70E-12	3.52E-06	3.52E-07	4.38E-13	3.52E-07
Total		4.14E-02	2.67E-07	4.14E-02	1.26E-02	2.42E-07	1.26E-02
Intermediate Pond							
Cesium-137	1.09E+02	1.48E-03	3.26E-06	1.48E-03	3.62E-03	2.93E-06	3.62E-03
Cobalt-60	4.58E+00	2.86E-04	6.06E-07	2.87E-04	2.18E-05	5.62E-07	2.23E-05
Strontium-90	1.36E+03	2.46E-02		2.46E-02	4.92E-03		4.92E-03
Tritium	1.08E+06	3.45E-04		3.45E-04	3.45E-04		3.45E-04
Total		2.67E-02	3.87E-06	2.67E-02	8.90E-03	3.49E-06	8.90E-03
Lower WOC							
Carbon-14	5.26E+04	5.00E-01		5.00E-01	6.25E-01		6.25E-01
Cesium-137	4.88E+01	6.63E-04	1.46E-06	6.65E-04	1.62E-03	1.31E-06	1.62E-03
Cobalt-60	8.08E+01	5.05E-03	1.07E-05	5.06E-03	3.84E-04	9.92E-06	3.94E-04
Plutonium-238	2.00E-01	5.86E-06	7.89E-12	5.86E-06	2.35E-07	1.28E-12	2.35E-07
Strontium-90	1.62E+04	2.93E-01		2.93E-01	5.86E-02		5.86E-02
Thorium-228	1.30E+00	1.14E-03	1.07E-07	1.14E-03	6.85E-05	9.79E-08	6.86E-05
Thorium-230	2.20E-01	2.75E-05	8.68E-12	2.75E-05	1.65E-06	1.41E-12	1.65E-06
Tritium	1.29E+06	4.13E-04		4.13E-04	4.13E-04		4.13E-04
Uranium-234	1.59E+00	4.04E-05	6.27E-11	4.04E-05	4.04E-06	1.02E-11	4.04E-06
Uranium-238	6.50E-01	1.76E-05	4.37E-10	1.76E-05	1.77E-06	1.72E-10	1.77E-06
Total		8.00E-01	1.23E-05	8.00E-01	6.86E-01	1.13E-05	6.86E-01
MB-15							
Cesium-137	2.70E+01	3.67E-04	8.07E-07	3.68E-04	8.96E-04	7.26E-07	8.96E-04
Cobalt-60	4.90E+02	3.06E-02	6.49E-05	3.07E-02	2.33E-03	6.02E-05	2.39E-03
Strontium-90	2.72E+01	4.92E-04		4.92E-04	9.84E-05		9.84E-05
Tritium	7.68E+04	2.46E-05		2.46E-05	2.46E-05		2.46E-05
Total		3.15E-02	6.57E-05	3.16E-02	3.35E-03	6.09E-05	3.41E-03
MV Drive							
Strontium-90	1.80E+01	3.26E-04		3.26E-04	6.51E-05		6.51E-05
Tritium	2.00E+03	6.40E-07		6.40E-07	6.40E-07		6.40E-07
Total		3.26E-04	0.00E+00	3.26E-04	6.57E-05	0.00E+00	6.57E-05
Pit 4 South							
Cesium-137	5.66E+00	7.69E-05	1.69E-07	7.71E-05	1.88E-04	1.52E-07	1.88E-04
Cobalt-60	1.80E+02	1.13E-02	2.38E-05	1.13E-02	8.56E-04	2.21E-05	8.78E-04

Table 9.8 (continued)

Radionuclide[a]	Soil Activity[b] (pCi/L)	Large invertebrates			Large fish		
		Internal	External	Total	Internal	External	Total
Strontium-90	3.43E+03	6.20E-02		6.20E-02	1.24E-02		1.24E-02
Tritium	3.00E+04	9.59E-06		9.59E-06	9.59E-06		9.59E-06
Total		7.34E-02	2.40E-05	7.34E-02	1.35E-02	2.23E-05	1.35E-02
SWSA 5 Seep A							
Americium-241	1.37E+00	4.04E-04	2.31E-09	4.04E-04	1.21E-05	1.45E-09	1.21E-05
Calcium-45	4.60E+01	7.55E-06		7.55E-06	7.55E-06		7.55E-06
Carbon-14	4.73E+04	4.50E-01		4.50E-01	5.62E-01		5.62E-01
Cesium-137	5.66E+00	7.69E-05	1.69E-07	7.71E-05	1.88E-04	1.52E-07	1.88E-04
Curium-244	3.20E+00	9.90E-04	1.26E-10	9.90E-04	2.97E-05	2.05E-11	2.97E-05
Plutonium-238	3.70E-01	1.08E-05	1.46E-11	1.08E-05	4.34E-07	2.37E-12	4.34E-07
Potassium-40	1.33E+02		1.10E-06	1.10E-06		9.73E-07	9.73E-07
Radium-226	1.48E-01	5.90E-05	1.38E-08	5.90E-05	9.88E-06	1.27E-08	9.90E-06
Radium-228	1.34E+01	3.64E-06		3.64E-06	6.07E-07		6.07E-07
Strontium-90	3.43E+03	6.20E-02		6.20E-02	1.24E-02		1.24E-02
Technetium-99	1.15E+02	3.10E-06		3.10E-06	1.24E-05		1.24E-05
Thorium-228	3.32E-01	2.91E-04	2.73E-08	2.91E-04	1.75E-05	2.50E-08	1.75E-05
Thorium-230	7.39E-01	9.23E-05	2.91E-11	9.23E-05	5.54E-06	4.73E-12	5.54E-06
Thorium-232	5.03E+00	6.05E-04	2.58E-07	6.05E-04	3.70E-05	2.34E-07	3.72E-05
Thorium-234	5.99E+02	1.30E-03	1.11E-07	1.30E-03	3.34E-04	1.79E-08	3.34E-04
Tin-119	1.90E+01						
Tin-119m	1.90E+01	2.56E-04	4.68E-09	2.56E-04	2.68E-04	6.68E-10	2.68E-04
Tritium	3.00E+04	9.59E-06		9.59E-06	9.59E-06		9.59E-06
Uranium-233/234	2.03E-01	5.22E-06	4.00E-12	5.22E-06	5.22E-07	6.49E-13	5.22E-07
Uranium-238	1.70E-01	4.61E-06	1.14E-10	4.62E-06	4.62E-07	4.50E-11	4.62E-07
Total		5.16E-01	1.68E-06	5.16E-01	5.75E-01	1.42E-06	5.75E-01
SWSA 5 Seep B West							
Calcium-45	1.50E+04	2.46E-03		2.46E-03	2.46E-03		2.46E-03
Carbon-14	5.66E+05	5.38E+00		5.38E+00	6.73E+00		6.73E+00
Strontium-90	7.10E+03	1.28E-01		1.28E-01	2.57E-02		2.57E-02
Technetium-99	1.58E+03	4.25E-05		4.25E-05	1.70E-04		1.70E-04
Thorium-228	2.90E-01	2.54E-04	2.38E-08	2.54E-04	1.53E-05	2.18E-08	1.53E-05
Tritium	1.12E+07	3.58E-03		3.58E-03	3.58E-03		3.58E-03
Uranium-233/234	5.28E+02	1.36E-02	1.04E-08	1.36E-02	1.36E-03	1.69E-09	1.36E-03
Uranium-238	1.82E+00	4.94E-05	1.22E-09	4.94E-05	4.95E-06	4.82E-10	4.95E-06
Total		5.53E+00	3.55E-08	5.53E+00	6.76E+00	2.40E-08	6.76E+00
SWSA 5 Seep B East							
Strontium-90	1.14E+03	2.06E-02		2.06E-02	4.12E-03		4.12E-03
Tritium	2.62E+06	8.38E-04		8.38E-04	8.38E-04		8.38E-04
Total		2.15E-02	0.00E+00	2.15E-02	4.96E-03	0.00E+00	4.96E-03
SWSA 5 Seep C							
Americium-241	2.08E+00	6.13E-04	3.51E-09	6.13E-04	1.84E-05	2.20E-09	1.84E-05

Table 9.8 (continued)

Radionuclide[a]	Soil Activity[b] (pCi/L)	Large invertebrates			Large fish		
		Internal	External	Total	Internal	External	Total
Calcium-45	7.11E+03	1.17E-03		1.17E-03	1.17E-03		1.17E-03
Carbon-14	2.49E+06	2.37E+01		2.37E+01	2.96E+01		2.96E+01
Cesium-137	2.20E+00	2.99E-05	6.58E-08	3.00E-05	7.30E-05	5.92E-08	7.30E-05
Curium-243	1.51E+01	4.78E-03	1.07E-07	4.78E-03	1.44E-04	9.49E-08	1.44E-04
Plutonium-238	4.50E-01	1.32E-05	1.77E-11	1.32E-05	5.28E-07	2.88E-12	5.28E-07
Potassium-40	1.50E+02		1.24E-06	1.24E-06		1.10E-06	1.10E-06
Strontium-90	1.19E+05	2.15E+00		2.15E+00	4.30E-01		4.30E-01
Technetium-99	1.64E+03	4.41E-05		4.41E-05	1.77E-04		1.77E-04
Thorium-228	6.80E-01	5.95E-04	5.59E-08	5.95E-04	3.59E-05	5.12E-08	3.59E-05
Thorium-230	8.00E-02	9.99E-06	3.16E-12	9.99E-06	6.00E-07	5.12E-13	6.00E-07
Thorium-232	3.25E-02	3.91E-06	1.67E-09	3.91E-06	2.39E-07	1.51E-09	2.40E-07
Tritium	3.52E+06	1.13E-03		1.13E-03	1.13E-03		1.13E-03
Uranium-233/234	7.90E-01	2.03E-05	1.56E-11	2.03E-05	2.03E-06	2.53E-12	2.03E-06
Uranium-234	3.00E-02	7.63E-07	1.18E-12	7.63E-07	7.63E-08	1.92E-13	7.63E-08
Uranium-235	1.00E-02	2.46E-07	9.51E-11	2.46E-07	2.48E-08	7.90E-11	2.48E-08
Uranium-238	3.82E-01	1.04E-05	2.57E-10	1.04E-05	1.04E-06	1.01E-10	1.04E-06
Total		2.58E+01	1.47E-06	2.58E+01	3.00E+01	1.31E-06	3.00E+01
SWSA 5 Trib 1							
Americium-241	1.20E-01	3.54E-05	2.03E-10	3.54E-05	1.06E-06	1.27E-10	1.06E-06
Carbon-14	4.42E+03	4.20E-02		4.20E-02	5.25E-02		5.25E-02
Cesium-137	1.54E+01	2.09E-04	4.60E-07	2.10E-04	5.11E-04	4.14E-07	5.11E-04
Cobalt-60	1.27E+02	7.94E-03	1.68E-05	7.96E-03	6.04E-04	1.56E-05	6.19E-04
Curium-244	1.86E+00	5.76E-04	7.34E-11	5.76E-04	1.73E-05	1.19E-11	1.73E-05
Lead-212	2.12E+01	9.80E-04	1.74E-06	9.82E-04	2.98E-03	1.60E-06	2.98E-03
Plutonium-238	9.31E-01	2.73E-05	3.67E-11	2.73E-05	1.09E-06	5.95E-12	1.09E-06
Potassium-40	1.31E+02		1.08E-06	1.08E-06		9.59E-07	9.59E-07
Radium-226	2.77E-01	1.10E-04	2.57E-08	1.10E-04	1.85E-05	2.39E-08	1.85E-05
Radium-228	5.66E+01	1.54E-05		1.54E-05	2.56E-06		2.56E-06
Ruthenium-103	2.60E+01	3.31E-05	6.43E-07	3.38E-05	1.69E-06	5.85E-07	2.27E-06
Strontium-90	1.77E+02	3.20E-03		3.20E-03	6.40E-04		6.40E-04
Technetium-99	2.21E+01	5.95E-07		5.95E-07	2.38E-06		2.38E-06
Thorium-228	5.26E-01	4.60E-04	4.32E-08	4.60E-04	2.77E-05	3.96E-08	2.78E-05
Thorium-232	2.76E-01	3.32E-05	1.41E-08	3.32E-05	2.03E-06	1.29E-08	2.04E-06
Thorium-234	1.60E+03	3.54E-03	2.98E-07	3.54E-03	9.52E-04	4.80E-08	9.52E-04
Tin-119	5.50E+01						
Tin-119m	5.50E+01	7.42E-04	1.35E-08	7.42E-04	7.77E-04	1.93E-09	7.77E-04
Tritium	1.36E+05	4.35E-05		4.35E-05	4.35E-05		4.35E-05
Uranium-232	1.36E+01	3.86E-04	5.36E-10	3.86E-04	3.86E-05	8.70E-11	3.86E-05
Uranium-233/234	2.99E+02	7.69E-03	5.90E-09	7.69E-03	7.69E-04	9.56E-10	7.69E-04
Uranium-235	1.49E+01	3.66E-04	1.42E-07	3.67E-04	3.69E-05	1.18E-07	3.70E-05
Uranium-235/236	3.20E+00	7.58E-05	2.64E-08	7.59E-05	7.61E-06	2.34E-08	7.64E-06
Uranium-238	1.10E+03	2.99E-02	7.39E-07	2.99E-02	2.99E-03	2.91E-07	2.99E-03
Total		9.83E-02	2.20E-05	9.84E-02	6.29E-02	1.97E-05	6.30E-02

Table 9.8 (continued)

Radionuclide[a]	Soil Activity[b] (pCi/L)	Large invertebrates			Large fish		
		Internal	External	Total	Internal	External	Total
SWSA 5 WOC							
Americium-241	3.90E-01	1.15E-04	6.59E-10	1.15E-04	3.46E-06	4.12E-10	3.46E-06
Carbon-14	5.90E+03	5.61E-02		5.61E-02	7.01E-02		7.01E-02
Cesium-137	3.16E+04	4.29E-01	9.45E-04	4.30E-01	1.05E+00	8.50E-04	1.05E+00
Cobalt-60	1.54E+02	9.63E-03	2.04E-05	9.65E-03	7.32E-04	1.89E-05	7.51E-04
Curium-244	1.62E+01	5.01E-03	6.39E-10	5.01E-03	1.50E-04	1.04E-10	1.50E-04
Plutonium-238	7.00E-01	2.05E-05	2.76E-11	2.05E-05	8.21E-07	4.48E-12	8.21E-07
Potassium-40	6.22E+01		5.13E-07	5.13E-07		4.55E-07	4.55E-07
Radium-228	2.70E+01	7.34E-06		7.34E-06	1.22E-06		1.22E-06
Strontium-90	2.57E+02	4.65E-03		4.65E-03	9.30E-04		9.30E-04
Technetium-99	3.95E+01	1.06E-06		1.06E-06	4.25E-06		4.25E-06
Thorium-228	8.92E-01	7.81E-04	7.33E-08	7.81E-04	4.70E-05	6.72E-08	4.71E-05
Thorium-230	5.10E-01	6.37E-05	2.01E-11	6.37E-05	3.82E-06	3.26E-12	3.82E-06
Tritium	3.10E+04	9.91E-06		9.91E-06	9.91E-06		9.91E-06
Uranium-232	3.70E+00	1.05E-04	1.46E-10	1.05E-04	1.05E-05	2.37E-11	1.05E-05
Uranium-233/234	9.32E+01	2.40E-03	1.84E-09	2.40E-03	2.40E-04	2.98E-10	2.40E-04
Uranium-235/236	3.80E-01	9.01E-06	3.13E-09	9.01E-06	9.04E-07	2.78E-09	9.07E-07
Uranium-238	8.90E-01	2.42E-05	5.98E-10	2.42E-05	2.42E-06	2.36E-10	2.42E-06
Total		5.08E-01	9.66E-04	5.09E-01	1.12E+00	8.70E-04	1.12E+00
SWSA 4 Main							
Carbon-14	2.64E+04	2.51E-01		2.51E-01	3.14E-01		3.14E-01
Cesium-137	2.85E+02	3.87E-03	8.52E-06	3.88E-03	9.45E-03	7.67E-06	9.46E-03
Lead-214	5.95E+03	2.75E-01	5.52E-04	2.75E-01	8.36E-01	5.12E-04	8.36E-01
Plutonium-238	1.60E-01	4.69E-06	6.31E-12	4.69E-06	1.88E-07	1.02E-12	1.88E-07
Strontium-90	1.24E+04	2.24E-01		2.24E-01	4.49E-02		4.49E-02
Thorium-228	3.21E+00	2.81E-03	2.64E-07	2.81E-03	1.69E-04	2.42E-07	1.69E-04
Thorium-230	2.77E-01	3.46E-05	1.09E-11	3.46E-05	2.08E-06	1.77E-12	2.08E-06
Thorium-232	4.00E-02	4.81E-06	2.05E-09	4.81E-06	2.94E-07	1.86E-09	2.96E-07
Tritium	1.09E+07	3.49E-03		3.49E-03	3.49E-03		3.49E-03
Uranium-232	3.08E+00	8.73E-05	1.21E-10	8.73E-05	8.73E-06	1.97E-11	8.73E-06
Uranium-234	1.60E+02	4.07E-03	6.31E-09	4.07E-03	4.07E-04	1.02E-09	4.07E-04
Uranium-235	5.16E+00	1.27E-04	4.91E-08	1.27E-04	1.28E-05	4.08E-08	1.28E-05
Uranium-238	8.23E+01	2.23E-03	5.53E-08	2.23E-03	2.24E-04	2.18E-08	2.24E-04
Total		7.66E-01	5.61E-04	7.67E-01	1.21E+00	5.20E-04	1.21E+00
SWSA 5 N WOC							
Carbon-14	2.74E+02	2.60E-03		2.60E-03	3.26E-03		3.26E-03
Cesium-137	1.08E+01	1.47E-04	3.23E-07	1.47E-04	3.58E-04	2.91E-07	3.58E-04
Potassium-40	8.12E+01		6.70E-07	6.70E-07		5.94E-07	5.94E-07
Strontium-90	8.37E+01	1.51E-03		1.51E-03	3.03E-04		3.03E-04
Thorium-232	2.91E+01	3.50E-03	1.49E-06	3.50E-03	2.14E-04	1.36E-06	2.15E-04
Tritium	7.59E+03	2.43E-06		2.43E-06	2.43E-06		2.43E-06
Uranium-238	9.21E-01	2.50E-05	6.19E-10	2.50E-05	2.50E-06	2.44E-10	2.50E-06
Total		7.79E-03	2.48E-06	7.79E-03	4.14E-03	2.24E-06	4.14E-03

Table 9.8 (continued)

Radionuclide[a]	Soil Activity[b] (pCi/L)	Large invertebrates			Large fish		
		Internal	External	Total	Internal	External	Total
SWSA 6 East							
Americium-241	1.00E+00	2.95E-04	1.69E-09	2.95E-04	8.87E-06	1.06E-09	8.87E-06
Cesium-137	1.62E+01	2.20E-04	4.84E-07	2.21E-04	5.37E-04	4.36E-07	5.38E-04
Cobalt-60	5.50E+02	3.44E-02	7.28E-05	3.45E-02	2.61E-03	6.75E-05	2.68E-03
Plutonium-238	1.00E+00	2.93E-05	3.94E-11	2.93E-05	1.17E-06	6.40E-12	1.17E-06
Strontium-90	5.00E+00	9.04E-05		9.04E-05	1.81E-05		1.81E-05
Thorium-228	1.00E+00	8.75E-04	8.22E-08	8.75E-04	5.27E-05	7.53E-08	5.28E-05
Thorium-230	1.00E+00	1.25E-04	3.94E-11	1.25E-04	7.50E-06	6.40E-12	7.50E-06
Thorium-232	1.00E+00	1.20E-04	5.13E-08	1.20E-04	7.35E-06	4.66E-08	7.40E-06
Tritium	1.90E+05	6.08E-05		6.08E-05	6.08E-05		6.08E-05
Uranium-234	1.00E+00	2.54E-05	3.94E-11	2.54E-05	2.54E-06	6.40E-12	2.54E-06
Uranium-235/236	1.00E+00	2.37E-05	8.25E-09	2.37E-05	2.38E-06	7.32E-09	2.39E-06
Uranium-238	1.00E+00	2.71E-05	6.72E-10	2.71E-05	2.72E-06	2.65E-10	2.72E-06
Total		3.63E-02	7.34E-05	3.63E-02	3.32E-03	6.81E-05	3.38E-03
W6MS3							
Americium-241	1.23E+00	3.63E-04	2.08E-09	3.63E-04	1.09E-05	1.30E-09	1.09E-05
Cesium-137	1.44E+01	1.96E-04	4.31E-07	1.96E-04	4.78E-04	3.87E-07	4.78E-04
Cobalt-60	1.71E+00	1.07E-04	2.26E-07	1.07E-04	8.13E-06	2.10E-07	8.34E-06
Curium-242	7.88E+00	2.57E-03	3.11E-10	2.57E-03	7.70E-05	5.04E-11	7.70E-05
Curium-244	1.35E+02	4.18E-02	5.32E-09	4.18E-02	1.25E-03	8.63E-10	1.25E-03
Europium-152	2.78E+01	1.12E-05	1.69E-06	1.28E-05	1.71E-05	1.57E-06	1.87E-05
Europium-154	5.74E+00	4.66E-06	3.76E-07	5.03E-06	5.99E-06	3.50E-07	6.34E-06
Europium-155	1.15E+01	1.95E-06	3.70E-08	1.99E-06	2.12E-06	3.37E-08	2.15E-06
Europium-156	2.89E+02						
Plutonium-238	1.47E+00	4.31E-05	5.80E-11	4.31E-05	1.72E-06	9.40E-12	1.72E-06
Potassium-40	2.52E+02		2.08E-06	2.08E-06		1.84E-06	1.84E-06
Radium-224	2.10E+01	9.21E-03	1.72E-06	9.21E-03	1.54E-03	1.58E-06	1.54E-03
Radium-226	1.00E+00	3.99E-04	9.29E-08	3.99E-04	6.68E-05	8.61E-08	6.69E-05
Radium-228	2.18E+01	5.93E-06		5.93E-06	9.88E-07		9.88E-07
Strontium-90	4.70E+02	8.50E-03		8.50E-03	1.70E-03		1.70E-03
Thorium-228	1.19E+00	1.04E-03	9.78E-08	1.04E-03	6.27E-05	8.96E-08	6.28E-05
Thorium-230	1.13E+00	1.41E-04	4.46E-11	1.41E-04	8.47E-06	7.23E-12	8.47E-06
Thorium-232	1.02E+00	1.23E-04	5.23E-08	1.23E-04	7.50E-06	4.75E-08	7.55E-06
Thorium-234	2.66E+02	7.88E-03	4.73E-08	7.88E-03	7.42E-03	7.66E-09	7.42E-03
Tritium	2.31E+07	7.39E-03		7.39E-03	7.39E-03		7.39E-03
Uranium-234	1.11E+00	2.82E-05	4.38E-11	2.82E-05	2.82E-06	7.10E-12	2.82E-06
Uranium-235/236	1.00E+00	2.37E-05	8.25E-09	2.37E-05	2.38E-06	7.32E-09	2.39E-06
Uranium-238	1.00E+00	2.71E-05	6.72E-10	2.71E-05	2.72E-06	2.65E-10	2.72E-06
Total		7.98E-02	6.87E-06	7.98E-02	2.01E-02	6.22E-06	2.01E-02
W6MS1							
Americium-241	1.00E+00	2.95E-04	1.69E-09	2.95E-04	8.87E-06	1.06E-09	8.87E-06
Cesium-137	6.15E+00	8.36E-05	1.84E-07	8.38E-05	2.04E-04	1.65E-07	2.04E-04

Table 9.8 (continued)

Radionuclide[a]	Soil Activity[b] (pCi/L)	Large invertebrates Internal	External	Total	Large fish Internal	External	Total
Cobalt-60	1.35E+00	8.44E-05	1.79E-07	8.46E-05	6.42E-06	1.66E-07	6.58E-06
Europium-154	3.42E+00	2.77E-06	2.24E-07	3.00E-06	3.57E-06	2.08E-07	3.78E-06
Plutonium-238	1.00E+00	2.93E-05	3.94E-11	2.93E-05	1.17E-06	6.40E-12	1.17E-06
Radium-224	1.83E+01	8.02E-03	1.50E-06	8.03E-03	1.34E-03	1.38E-06	1.34E-03
Radium-226	1.00E+00	3.99E-04	9.29E-08	3.99E-04	6.68E-05	8.61E-08	6.69E-05
Radium-228	3.00E+00	8.15E-07		8.15E-07	1.36E-07		1.36E-07
Strontium-90	7.09E+00	1.28E-04		1.28E-04	2.56E-05		2.56E-05
Thorium-228	1.00E+00	8.75E-04	8.22E-08	8.75E-04	5.27E-05	7.53E-08	5.28E-05
Thorium-230	1.00E+00	1.25E-04	3.94E-11	1.25E-04	7.50E-06	6.40E-12	7.50E-06
Thorium-232	1.00E+00	1.20E-04	5.13E-08	1.20E-04	7.35E-06	4.66E-08	7.40E-06
Tritium	2.07E+06	6.62E-04		6.62E-04	6.62E-04		6.62E-04
Uranium-234	1.00E+00	2.54E-05	3.94E-11	2.54E-05	2.54E-06	6.40E-12	2.54E-06
Uranium-235/236	1.00E+00	2.37E-05	8.25E-09	2.37E-05	2.38E-06	7.32E-09	2.39E-06
Uranium-238	1.00E+00	2.71E-05	6.72E-10	2.71E-05	2.72E-06	2.65E-10	2.72E-06
Total		1.09E-02	2.33E-06	1.09E-02	2.40E-03	2.13E-06	2.40E-03
WAG 7 WOC							
Cesium-137	3.38E+02	4.59E-03	1.01E-05	4.60E-03	1.12E-02	9.09E-06	1.12E-02
Strontium-90	1.15E+03	2.08E-02		2.08E-02	4.16E-03		4.16E-03
Tritium	3.00E+03	9.59E-07		9.59E-07	9.59E-07		9.59E-07
Total		2.54E-02	1.01E-05	2.54E-02	1.54E-02	9.09E-06	1.54E-02
West Seep							
Americium-241	1.09E+01	3.21E-03	1.84E-08	3.21E-03	9.66E-05	1.15E-08	9.66E-05
Cesium-137	1.40E+01	1.90E-04	4.19E-07	1.91E-04	4.64E-04	3.77E-07	4.65E-04
Cobalt-60	5.99E+02	3.74E-02	7.93E-05	3.75E-02	2.85E-03	7.35E-05	2.92E-03
Curium-243	5.06E+01	1.60E-02	3.59E-07	1.60E-02	4.81E-04	3.18E-07	4.82E-04
Plutonium-238	9.60E-01	2.81E-05	3.79E-11	2.81E-05	1.13E-06	6.14E-12	1.13E-06
Radium-226	1.00E+00	3.99E-04	9.29E-08	3.99E-04	6.68E-05	8.61E-08	6.69E-05
Radium-228	3.00E+00	8.15E-07		8.15E-07	1.36E-07		1.36E-07
Strontium-90	8.76E+02	1.58E-02		1.58E-02	3.17E-03		3.17E-03
Thorium-228	1.00E+00	8.75E-04	8.22E-08	8.75E-04	5.27E-05	7.53E-08	5.28E-05
Thorium-230	1.00E+00	1.25E-04	3.94E-11	1.25E-04	7.50E-06	6.40E-12	7.50E-06
Thorium-232	1.00E+00	1.20E-04	5.13E-08	1.20E-04	7.35E-06	4.66E-08	7.40E-06
Tritium	1.36E+05	4.35E-05		4.35E-05	4.35E-05		4.35E-05
Uranium-232	7.15E+01	2.03E-03	2.82E-09	2.03E-03	2.03E-04	4.57E-10	2.03E-04
Uranium-234	7.65E+02	1.95E-02	3.02E-08	1.95E-02	1.95E-03	4.89E-09	1.95E-03
Uranium-235	6.22E+00	1.53E-04	5.91E-08	1.53E-04	1.54E-05	4.91E-08	1.54E-05
Uranium-235/236	1.00E+00	2.37E-05	8.25E-09	2.37E-05	2.38E-06	7.32E-09	2.39E-06
Uranium-238	3.33E+01	9.04E-04	2.24E-08	9.04E-04	9.05E-05	8.82E-09	9.05E-05
Total		9.69E-02	8.04E-05	9.69E-02	9.49E-03	7.45E-05	9.57E-03
SWSA 5 Drainage D-2							
Americium-241	9.74E+00	2.87E-03	1.64E-08	2.87E-03	8.63E-05	1.03E-08	8.64E-05
Carbon-14	1.48E+03	1.41E-02		1.41E-02	1.76E-02		1.76E-02

Table 9.8 (continued)

Radionuclide[a]	Soil Activity[b] (pCi/L)	Large invertebrates			Large fish		
		Internal	External	Total	Internal	External	Total
Cesium-137	7.00E-01	9.51E-06	2.09E-08	9.53E-06	2.32E-05	1.88E-08	2.32E-05
Plutonium-238	1.77E+01	5.19E-04	6.98E-10	5.19E-04	2.08E-05	1.13E-10	2.08E-05
Radium-226	1.30E-01	5.18E-05	1.21E-08	5.18E-05	8.68E-06	1.12E-08	8.69E-06
Radium-228	1.52E+03	4.13E-04		4.13E-04	6.89E-05		6.89E-05
Strontium-90	1.98E+03	3.58E-02		3.58E-02	7.16E-03		7.16E-03
Technetium-99	5.90E+01	1.59E-06		1.59E-06	6.35E-06		6.35E-06
Thorium-228	6.97E-01	6.10E-04	5.73E-08	6.10E-04	3.67E-05	5.25E-08	3.68E-05
Thorium-230	1.09E+00	1.36E-04	4.30E-11	1.36E-04	8.17E-06	6.97E-12	8.17E-06
Thorium-232	1.73E-01	2.08E-05	8.87E-09	2.08E-05	1.27E-06	8.06E-09	1.28E-06
Tritium	8.47E+06	2.71E-03		2.71E-03	2.71E-03		2.71E-03
Uranium-232	1.41E-01	4.00E-06	5.56E-12	4.00E-06	4.00E-07	9.02E-13	4.00E-07
Uranium-233/234	4.13E+00	1.06E-04	8.14E-11	1.06E-04	1.06E-05	1.32E-11	1.06E-05
Uranium-238	6.65E-01	1.81E-05	4.47E-10	1.81E-05	1.81E-06	1.76E-10	1.81E-06
Total		5.73E-02	1.17E-07	5.73E-02	2.77E-02	1.01E-07	2.77E-02
WOC							
Cesium-137	9.27E+01	1.26E-03	2.77E-06	1.26E-03	3.07E-03	2.49E-06	3.08E-03
Cobalt-60	2.27E+00	1.42E-04	3.01E-07	1.42E-04	1.08E-05	2.79E-07	1.11E-05
Strontium-90	1.54E+02	2.79E-03		2.79E-03	5.57E-04		5.57E-04
Tritium	0.00E+00						
Total		4.19E-03	3.07E-06	4.19E-03	3.64E-03	2.77E-06	3.65E-03
WOCE							
Cesium-137	6.10E+01	8.29E-04	1.82E-06	8.31E-04	2.02E-03	1.64E-06	2.02E-03
Cobalt-60	4.66E+00	2.91E-04	6.17E-07	2.92E-04	2.22E-05	5.72E-07	2.27E-05
Strontium-90	4.27E+01	7.72E-04		7.72E-04	1.54E-04		1.54E-04
Tritium	6.38E+04	2.04E-05		2.04E-05	2.04E-05		2.04E-05
Total		1.91E-03	2.44E-06	1.92E-03	2.22E-03	2.21E-06	2.22E-03

[a] Dose from each radionuclide includes all short-lived daughter products

[b] Representative concentration is the minimum of the UCL95 and the maximum detect.

Table 9.9 Estimated radiation doses (mrad/d) to aquatic organisms exposed to radionuclides in sediment at WOC

Radionuclide[a]	Soil Activity[b] (pCi/g)	Large invertebrates	Large fish
Intermediate Pond			
Cobalt-60	3.20E+01	2.12E+00	9.83E-01
Cesium-137	3.44E+03	5.15E+01	2.32E+01
Total		5.36E+01	2.41E+01
Lower WOC			
Cobalt-60	5.50E+02	3.64E+01	1.69E+01
Cesium-137	5.41E+03	8.09E+01	3.64E+01
Total		1.17E+02	5.33E+01
Pit 4 South			
Cobalt-60	1.89E+02	1.25E+01	5.81E+00
Total		1.25E+01	5.81E+00
SWSA 5 Seep A			
Actinium-228	1.50E+00	3.85E-02	1.75E-02
Bismuth-214	9.10E-01	3.62E-02	1.68E-02
Carbon-14	4.50E-01		
Cesium-137	3.90E-01	5.83E-03	2.62E-03
Iodine-129	1.30E+00	7.71E-04	1.82E-04
Lead-210	2.70E+00	1.33E-04	1.08E-05
Lead-212	1.40E+00	5.74E-02	2.64E-02
Lead-214	1.00E+00	4.64E-02	2.15E-02
Potassium-40	1.30E+01	5.36E-02	2.38E-02
Radium-226	8.80E-01	4.09E-02	1.90E-02
Radium-228	1.50E+00		
Strontium-90	1.00E+00		
Thorium-228	1.20E+00	4.93E-02	2.26E-02
Thorium-232	1.50E+00	3.85E-02	1.75E-02
Thallium-208	1.10E+00	9.82E-02	4.55E-02
Thorium-234	1.80E+00	7.93E-03	3.62E-03
Tin-126	1.90E-01		
Tritium	1.14E+01		
Total		4.74E-01	2.17E-01
	0.00E+00		
SWSA 5 Seep C			
Cobalt-60	1.34E+03	8.88E+01	4.12E+01
Cesium-137	5.93E+02	8.87E+00	3.99E+00
Total		9.76E+01	4.51E+01
SWSA 5 Trib 1			
Americium-241	5.55E+02	4.69E-01	1.47E-01
Actinium-228	1.40E+00	3.59E-02	1.63E-02
Bismuth-212	1.50E+00	7.38E-03	3.27E-03
Bismuth-214	8.60E-01	3.42E-02	1.59E-02

Table 9.9 (continued)

Radionuclide[a]	Soil Activity[b] (pCi/g)	Large invertebrates	Large fish
Curium-244	1.00E+03	1.97E-02	1.60E-03
Carbon-14	5.94E+01		
Cobalt-60	3.90E+03	2.58E+02	1.20E+02
Cesium-137	1.28E+04	1.91E+02	8.61E+01
Curium-242	3.50E-01	6.91E-06	5.60E-07
Europium-152	9.61E+02	2.93E+01	1.36E+01
Europium-154	5.79E+02	1.90E+01	8.82E+00
Europium-155	1.50E-01	2.42E-04	1.10E-04
Lead-212	8.14E-01	3.34E-02	1.53E-02
Lead-214	9.30E-01	4.32E-02	2.00E-02
Plutonium-238	1.11E+02	2.19E-03	1.78E-04
Plutonium-239/40	1.11E+02		
Potassium-40	2.40E+01	9.90E-02	4.39E-02
Radium-223	3.70E-01		
Radium-224	1.60E+00	6.57E-02	3.01E-02
Radium-226	4.89E+01	2.27E+00	1.05E+00
Radium-228	1.16E+02		
Radon-219	4.70E-01	7.68E-04	2.98E-04
Strontium-90	9.59E+04		
Technetium-99	2.80E+00		
Thorium-228	2.94E+02	1.21E+01	5.54E+00
Thorium-230	4.30E+01	8.49E-04	6.88E-05
Thorium-231	5.30E-01	3.34E-04	7.72E-05
Thorium-232	3.51E+00	9.00E-02	4.09E-02
Thorium-234	1.10E+01	1.24E-02	5.40E-03
Tin-126	2.80E-01		
Tritium	8.30E+02		
Uranium-232	3.21E+02	6.33E-03	5.14E-04
Uranium-233	4.13E+03	4.07E-02	3.30E-03
Uranium-233/234	9.06E+00	8.94E-05	7.25E-06
Uranium-235	3.61E-01	1.49E-03	6.61E-04
Uranium-235/236	1.47E+01	6.18E-02	2.70E-02
Uranium-238	1.17E+02	3.93E-02	7.75E-03
Total		5.13E+02	2.35E+02
SWSA 5 WOC			
Americium-241	9.58E+02	8.09E-01	2.53E-01
Curium-244	2.77E+04	5.47E-01	4.43E-02
Carbon-14	8.08E+03		
Cobalt-60	4.00E+04	2.65E+03	1.23E+03
Cesium-137	1.33E+07	1.99E+05	8.95E+04
Plutonium-238	1.24E+03	2.45E-02	1.98E-03
Plutonium-239/40	6.39E+02		
Radium-226	3.00E+03	1.39E+02	6.46E+01
Radium-228	3.90E+03		
Strontium-90	7.40E+05		

Table 9.9 (continued)

Radionuclide[a]	Soil Activity[b] (pCi/g)	Large invertebrates	Large fish
Thorium-228	1.74E+02	7.15E+00	3.28E+00
Thorium-230	3.09E+02	6.10E-03	4.94E-04
Thorium-232	5.28E+01	1.35E+00	6.15E-01
Tritium	2.97E+01		
Uranium-232	3.76E+01	7.42E-04	6.02E-05
Uranium-233	1.58E+03	1.56E-02	1.26E-03
Uranium-238	1.53E+01	5.15E-03	1.01E-03
Total		2.02E+05	9.08E+04
SWSA 4 Main			
Cobalt-60	1.34E+03	8.88E+01	4.12E+01
Cesium-137	6.88E+02	1.03E+01	4.63E+00
Total		9.90E+01	4.58E+01
SWSA 5 Drainage D-2			
Americium-241	6.20E-01	5.24E-04	1.64E-04
Actinium-228	2.30E+00	5.90E-02	2.68E-02
Bismuth-212	1.70E+00	8.36E-03	3.71E-03
Bismuth-214	1.20E+00	4.78E-02	2.22E-02
Curium-244	5.52E+00	1.09E-04	8.83E-06
Calcium-45	9.20E+01		
Carbon-14	6.18E+01		
Cobalt-60	6.30E-01	4.17E-02	1.94E-02
Cesium-137	6.48E+00	9.69E-02	4.36E-02
Iodine-129	1.40E+01	8.31E-03	1.96E-03
Lead-212	1.70E+00	6.97E-02	3.20E-02
Lead-214	1.20E+00	5.57E-02	2.58E-02
Plutonium-238	3.13E+01	6.18E-04	5.01E-05
Plutonium-239/40	2.60E-01		
Potassium-40	1.18E+01	4.87E-02	2.16E-02
Radium-223	9.10E-01		
Radium-224	4.90E+00	2.01E-01	9.23E-02
Radium-226	2.73E+00	1.27E-01	5.88E-02
Radium-228	2.30E+00		
Radon-219	1.20E+00	1.96E-03	7.62E-04
Strontium-90	1.36E+03		
Technetium-99	1.10E+01		
Thorium-228	2.50E+00	1.03E-01	4.71E-02
Thorium-230	1.30E+00	2.57E-05	2.08E-06
Thorium-232	2.25E+00	5.77E-02	2.62E-02
Thallium-208	1.40E+00	1.25E-01	5.80E-02
Tritium	1.84E+03		
Uranium-233/234	1.60E+01	1.58E-04	1.28E-05
Uranium-235	4.10E-01	1.69E-03	7.50E-04
Uranium-238	2.40E+00	8.07E-04	1.59E-04
Total		1.06E+00	4.81E-01

Table 9.9 (continued)

Radionuclide[a]	Soil Activity[b] (pCi/g)	Large invertebrates	Large fish
WOC			
Americium-241	2.70E+00	2.28E-03	7.13E-04
Curium-244	4.80E+00	9.47E-05	7.68E-06
Cobalt-60	8.84E+02	5.85E+01	2.72E+01
Cesium-137	1.45E+03	2.17E+01	9.76E+00
Plutonium-238	8.10E-01	1.60E-05	1.30E-06
Plutonium-239/40	5.00E+00		
Strontium-90	1.80E+01		
Thorium-228	1.50E+00	6.17E-02	2.82E-02
Thorium-230	8.80E-01	1.74E-05	1.41E-06
Thorium-232	1.10E+00	2.82E-02	1.28E-02
Uranium-233/234	5.50E+00	5.43E-05	4.40E-06
Uranium-235	1.10E-01	4.54E-04	2.01E-04
Uranium-238	1.80E+00	6.05E-04	1.19E-04
Total		8.03E+01	3.70E+01
WOCE			
Cobalt-60	1.47E+03	9.74E+01	4.52E+01
Cesium-137	2.57E+03	3.84E+01	1.73E+01
Total		1.36E+02	6.24E+01

[a] Dose from each radionuclide includes all short-lived daughter products

[b] Representative concentration is the minimum of the UCL95 and the maximum detect.

Table 9.10. Summary of risk to terrestrial biota from exposure to radionuclides in White Oak Creek watershed soil.

Subbasin	Receptor	HI: rads	Risk Drivers[a]									
			^{241}Am	^{244}Cm	^{60}Co	^{137}Cs	^{238}Pu	$^{239/240}Pu$	^{90}Sr	^{234}Th	$^{233/234}U$	^{238}U
East Seep	shrew	148.0				147.9						
East Seep	turkey	144.1				114.8				14.2	13.5	
East Seep	mouse	122.2				122.1						
East Seep	fox	108.7				108.5						
East Seep	mink	92.6				92.6						
East Seep	hawk	60.5				60.3						
East Seep	deer	50.8				50						
East Seep	inverts	31.0				30.8						
East Seep	plants	8.6				4.2				2.1	2	
WestSeep	shrew	53.0			52.3							
WestSeep	mouse	53.0			52.3							
WestSeep	fox	41.2			41.1							
WestSeep	mink	39.3			39.2							
WestSeep	turkey	20.7			20.1							
WestSeep	deer	19.5			19.4							
WestSeep	inverts	10.3			10.2							
WestSeep	hawk	4.2			4.2							
WestSeep	plants	2.0			1.9							
IntermediatePond	shrew	40.2	4.8			1.3		32.3				
IntermediatePond	mouse	40.0	4.8			1.1		32.3				
IntermediatePond	turkey	4.7				1					2.5	0.7
IntermediatePond	plants	3.6	0.4					2.6				
IntermediatePond	inverts	2.3	0.6					1.2				
IntermediatePond	fox	1.0				1						
MB-15	shrew	30.6			30.5							
MB-15	mouse	30.6			30.5							
MB-15	fox	24.0			24							
MB-15	mink	22.9			22.9							

Table 9.10. (continued)

Subbasin	Receptor	HI: rads	Risk Drivers[a]									
			^{241}Am	^{244}Cm	^{60}Co	^{137}Cs	^{238}Pu	$^{239/240}Pu$	^{90}Sr	^{234}Th	$^{233/234}U$	^{238}U
MB-15	inverts	6.0			6							
MB-15	hawk	2.5			2.4							
MB-15	plants	1.1			1.1							
SWSA 4 Main	shrew	18.8				18.6						
SWSA 4 Main	turkey	15.9				14.4			1.4			
SWSA 4 Main	mouse	15.6				15.4						
SWSA 4 Main	fox	14.3				13.6						
SWSA 4 Main	mink	11.8				11.6						
SWSA 4 Main	hawk	8.0				7.6						
SWSA 4 Main	deer	7.6				6.3			1.3			
SWSA 4 Main	inverts	4.7				3.9						
LowerWOC	shrew	17.4	1					15.4				
LowerWOC	mouse	17.3	1					15.4				
LowerWOC	plants	1.4						1.2				
SWSA 5 Seep B West	shrew	8.0	1.1	5.7								
SWSA 5 Seep B West	mouse	8.0	1.1	5.7								
SWSA 5 Seep B West	turkey	2.3							1.4			
SWSA 5 Seep B West	deer	1.4							1.2			
SWSA 5 Seep B West	inverts	1.2							0.8			
WOC	shrew	4.2	0.4	0.5				2.8				
WOC	mouse	4.2	0.4	0.5				2.8				
HRE	turkey	4.0								1.6	1.6	
HFIR	turkey	3.7							3.3			
HFIR	deer	3.1							3			
HFIR	inverts	2.0							1.9			
HFIR	fox	1.4							1.4			
HFIR	hawk	1.0							0.9			
SWSA 5 Seep B East	shrew	2.6				2.5						
SWSA 5 Seep B East	mouse	2.3				2.2						
SWSA 5 Seep B East	fox	1.9				1.9						

Table 9.10. (continued)

Subbasin	Receptor	HI: rads	Risk Drivers[a]									
			^{241}Am	^{244}Cm	^{60}Co	^{137}Cs	^{238}Pu	$^{239/240}Pu$	^{90}Sr	^{234}Th	$^{233/234}U$	^{238}U
SWSA 5 Seep B East	turkey	1.7				1.7						
Seep B East	mink	1.7				1.7						
SWSA5Trib-1	shrew	2.2					1.3					
SWSA5Trib-1	mouse	2.1					1.3					
SWSA5Trib-1	turkey	1.1										
WCTrib1	shrew	2.0				1.8						
WCTrib1	mouse	1.7				1.5						
WCTrib1	turkey	1.6				1.4						
WCTrib1	fox	1.5				1.3						
WCTrib1	mink	1.3				1.1						
SWSA 5 SeepC	shrew	1.7		0.9								
SWSA 5 SeepC	mouse	1.7		0.9								
WAG 7 WOC	shrew	1.5				1.2						
WAG 7 WOC	mouse	1.3				1.0						
WAG 7 WOC	turkey	1.1				0.9						
SWSA 5 SeepA	shrew	1.0						0.6				
SWSA 5 SeepA	mouse	1.0						0.6				

[a] HI = Hazard Index for radionuclides, calculated as estimated dose rate divided by recommended dose limit.

Am - 241= Americium-241, Cm-244 = Curium-244, Co-60 = Cobalt-60, Cs-137 = Cesium-137, Pu-238= Plutonium-238, Pu-239/240 = Plutonium-239/240, Sr-90 = Strontium-90, Th-234 = Thorium-234, U-233/234 = Uranium-233/234, U-238 = Uranium-238

No risks were identified at the HFIR East, HF-2, SWSA 5 Drainage D-2, MVDrive, SWSA 5 WOC, SWSA 5 N WOC, Haw Ridge, W6MS3, W6MS1, SWSA 6 South, SWSA 6 East, Pit 4 South, or NHF subbasins.

Table 9.11. Summary of estimated risks to piscivorous wildlife from food chain exposures to radionuclides in White Oak Creek watershed surface water

Subbasin	HI[a]	Receptor	Risk Driver ^{137}Cs
SWSA5/WOC	12.7	Mink	12.0
	24.2	River otter	22.9
	23.3	Belted kingfisher	22.0
	24.2	Great blue heron	22.9
	23.3	Osprey	22.0

Note: No other subbasins resulted in risks to piscivorous wildlife.
[a] The Hazard Index (HI) is the overall dose rate from all radionuclides detected in the subbasin divided by the recommended dose rate limit of 100 mrad/d.

Table 9.12. Summary of estimated risks to aquatic biota from exposures to radionuclides in White Oak Creek watershed surface water and sediment

					SW Risk drivers[b]		SD Risk drivers[b]	
Subbasin	Overall HI[a]	Water HI[a]	Sediment HI[a]	Receptor	^{137}Cs	^{90}Sr	^{137}Cs	^{60}Co
SWSA5/ WOC	202.1	0.4	201.7	Aquatic invertebrate	0.4		199.0	2.6
	92.3	1.0	90.8	Large fish	1.0		89.5	1.2
Seep C	2.2	2.2	0.1	Aquatic invertebrate		2.2		
	0.4	0.4	0.0	Large fish		0.4		

Note: No other subbasins resulted in risks to aquatic organisms.
[a] The Overall Hazard Index (HI) is the combined dose rate from all radionuclides detected in surface water and sediment in the subbasin divided by the recommended dose rate limit of 1 rad/d. The water and sediment HIs represent exposures from single media only.
[b] Risk driving radionuclides are those that account for the largest fraction of the dose rate. The value entered is the dose rate from individual radionuclides divided by the recommended dose rate limit.

10. SUMMARY OF ECOLOGICAL RISKS WITHIN THE WHITE OAK CREEK WATERSHED

10.1 SOIL EXPOSURES

Ecological risks were evaluated for plants, soil invertebrates, and terrestrial wildlife exposed to radionuclide and nonradionuclide contaminants in surface soil within each subbasin in the watershed for which surface soil data were available. Nonradiological data were available from 22 subbasins; radiological data were available from 28 subbasins. Only one formal line of evidence, single chemical toxicity data, was available to evaluate potential risks for terrestrial flora and fauna.

Potential risks to terrestrial plants from nonradionuclide soil-related exposures were identified for 19 subbasins for plants, 10 for soil invertebrates, 20 for short-tailed shrews, 9 for white-footed mice, 10 for red fox, 3 for white-tailed deer, 6 for red-tailed hawks, 4 for wild turkeys, and 5 for mink (Tables 5.2, 6.2, and 7.17 through 7.23). The Intermediate Pond resulted in the highest risks for all receptors due to high soil mercury concentrations. Radionuclide exposures resulted in potential risks to terrestrial biota at 16 subbasins (Table 9.10). Radionuclide risks were highest in the East Seep subbasin with Cs-137 driving risks for all receptors.

Potential nonradionuclide risks to plants were identified in at least one subbasin from exposure to maximum concentrations of antimony, arsenic, barium, cadmium, chromium, cobalt, copper, mercury, molybdenum, nickel, selenium, silver, thallium, tin, and zinc (Table 6.2). Hazard quotients were generally low (<3.8) with the exception of mercury, nickel, silver, and zinc at the Intermediate Pond; chromium and zinc at HF-2; chromium, mercury, and zinc at Lower WOC/WOL; zinc, mercury, and silver at WOC; mercury at SWSA 5 Trib-1 and Seep B; nickel at SWSA 4 Main; chromium at HRE; and zinc and selenium at Seep A. Potential risks to plants from exposure to radionuclides were identified in 5 subbasins. Cesium-137 was the risk driver in East Seep soils. Plutonium-239/240 was the primary risk driver at the Intermediate Pond and Lower WOC/WOL subbasins, and Co-60 was the risk driver at MB-15 and West Seep.

Potential nonradionuclide risks to soil invertebrates were identified in at least one subbasin from exposure to maximum concentrations of chromium, copper, mercury, nickel, and zinc (Table 5.2). Hazard quotients were generally low (<4.5) with the exception of mercury at the Intermediate Pond, WOC, SWSA5 Trib-1, Seep B West, and SWSA5/WOC; chromium at HF-2 and HRE; and chromium and mercury at Lower WOC; and nickel at SWSA 4 Main. Potential risks to soil invertebrates from exposure to radionuclides in surface soil were identified in 7 subbasins. Cesium-137 was the risk driver in East Seep and SWSA 4 Main. Cobalt-60 was the primary risk driver at MB-15 and West Seep, and Plutonium-239/240 was the primary risk driver at the Intermediate Pond. Strontium-90 was the risk driver at the HFIR and Seep B West subbasins.

LOAELs for at least one wildlife receptor (short-tailed shrew, white-footed mouse, red fox, white-tailed deer, red-tailed hawk, wild turkey, or mink) were exceeded in at least one subbasin as a result of arsenic, barium, cadmium, chromium, copper, mercury, molybdenum, nickel, selenium, thallium, zinc, and PCB-1260 (Tables 7.17 through 7.23). However, only mercury, molybdenum, nickel, selenium, and PCB-1260 for the shrew and mercury for the fox resulted in potential watershed-wide effects. Fewer than 20% of the individuals in populations within the watershed were likely to exceed LOAELs for all other receptor-contaminant combinations. The Intermediate Pond was the primary contributor to mercury exposures; the average mercury concentration there was an order of magnitude higher than in any other subbasin. The White Oak Creek, Lower White Oak

Creek/White Oak Lake, and Seep B West subbasins were also major contributors to high mercury exposures. The SWSA 5 Drainage D-2 was the primary contributor to PCB-1260 exposures, followed by the Intermediate Pond. Seep C subbasin was the most significant contributor to molybdenum exposures. Selenium exposures were highest in the Seep A, Pit 4 South, and SWSA 5 N/WOC subbasins. Nickel risks were driven by a single location (WAG 4 Seep 6) in SWSA 4 Main.

Potential risks from exposure to radionuclides in surface soil were identified for at least one wildlife receptor at 16 subbasins (Table 9.10). Shrews and mice generally received the highest dose rates. Cs-137 was the primary risk driver in East Seep, SWSA 4 Main, Seep B East, WAG 7 WOC, and WC Trib-1 soils. Plutonium-239/240 was the primary risk driver at the Intermediate Pond, Lower WOC/WOL, WOC, and Seep A. Cobalt-60 contributed the highest dose rate at MB-15 and West Seep. Curium-244 was the risk driver at Seep B West and Seep C and was a significant contributor at WOC. Strontium-90 was a risk driver at the HFIR subbasin and at Seep B West. Plutonium-238 was the primary risk driver at SWSA 5 Trib-1.

10.2 SURFACE WATER EXPOSURES

Ecological risks were evaluated for aquatic organisms and piscivorous wildlife exposed to nonradiological contaminants in unfiltered surface water within each subbasin in the watershed for which surface water data were available. Evaluations were restricted to unfiltered surface water samples from mainstem streams and large tributaries potentially providing suitable habitat for fish. Risks were estimated by subbasin by comparing the distribution of observed concentrations to different types of aquatic benchmarks. Chemicals were considered to present significant risks if at least 20% of the concentrations exceeded probably effects benchmarks. In addition, risks to terrestrial plants were evaluated based on exposure to surface water at identified seeps. Nonradiological data were available from 19 subbasins for the fish evaluation and 21 for the plant-seep evaluation. Potential risks from exposure to radionuclides were evaluated for aquatic organisms across all 25 subbasins for which surface water and sediment radionuclide data were available. Only one formal line of evidence, single chemical toxicity data, was available to evaluate potential risks for plants. For piscivorous wildlife, three lines of evidence (limited biological survey data, media toxicity data, and single chemical toxicity data) were available. For fish, biological survey data, biological indicators data, media toxicity data, and single chemical toxicity data were available.

Significant or potential risks were identified for aquatic organisms exposed to nonradionuclides in mainstem surface water in 14 subbasins (Tables 3.2 and 3.4). Thirteen inorganics, ammonia, BEHP, and PCBs potentially present significant risks to aquatic organisms in the watershed. Evaluation of the HIs suggests that the HF-2 and SWSA 6 East subbasins present the highest risks although only 5 and 3 inorganics, respectively, were identified as COECs. PCBs present significant risks in the Lower WOC/WOL and WOC subbasins. Mercury presents significant risks at SWSA 6 East, W6MS3, and W6MS1. Copper, aluminum, and iron potentially present significant risks at 10, 9, and 8 subbasins, respectively. However, use of unfiltered water samples may result in overestimates of risks for metals that are significantly associated with the particulate fraction as they may not be bioavailable.

Significant risks indicated by surface water chemical concentrations were corroborated by the biological data for four subbasins: Intermediate Pond, WOC, Lower WOC/WOL, and WOCE. The weight of evidence is strongest for the subbasins upstream of WOD. The fish community is less species rich relative to the community observed here in the 1950s, redbreast sunfish have

experienced reproductive failures, and the water has been lethal to Medaka embryos and larvae. The total number of macroinvertebrate species and the number of sensitive species are significantly lower than the upstream and pooled reference communities.

In Seep C, the biological data contradicts the chemical data. The water in the Seep C subbasin does not appear to pose a significant risk to fish. Although copper and nickel appear to present a significant risk and were identified as COECs, the water has not been toxic in the standard toxicity tests.

Potential risks to aquatic organisms exposed to radionuclides in surface water within the watershed were identified for only two subbasins: SWSA5/WOC and Seep C. The dose rate to large fish in the SWSA5/WOC subbasin marginally exceeded the recommended dose rate limit (HI = 1.1) as a result of high ^{137}Cs activity. This dose was associated with the 05.OHF station at the OHF Pond and does not represent a widespread problem. The dose rate for large insects at Seep C also marginally exceeded the dose limit (HI = 2.2) but was a result of ^{90}Sr, which contributed >99% of the dose. No aquatic receptors received doses above the dose rate limit in any of the other subbasins.

Potential risks were evaluated for 5 species of piscivorous wildlife: mink, river otter, belted kingfisher, great blue heron, and osprey. Evaluation of available single chemical toxicity data, toxicity test data, and field surveys suggest that the WOCW populations of mink, great blue heron, and osprey are not at risk. However, if present, individual river otter (listed as threatened by TWRA) may be at risk from exposure to mercury, primarily at the Lower WOC/WOL and WOC subbasins, and kingfisher populations may be at risk from exposure to mercury and selenium.

Risks from exposure of piscivorous wildlife to radionuclides are not anticipated in the White Oak Creek watershed. Exposure of piscivorous wildlife to radionuclides were modeled using available surface water data and measured fish body burden data. Potential risks were identified in only one subbasin: SWSA5/WOC. As noted above, the sample from this subbasin was associated with the OHF Pond and does not represent a widespread problem. Estimated exposures were below recommended dose rate limits for all receptors in all other subbasins.

Potential risks to plants assumed to be exposed to seep water in soil solution were identified for seeps in most subbasins from which data were available (Table 6.3). The primary risk drivers were aluminum and/or thallium in most seeps. The aluminum and thallium benchmarks appear to be conservative as both analytes exceeded benchmarks at numerous seeps across the whole watershed, and the aluminum benchmark is below background. There is low confidence in the arsenic benchmark as it was derived from limited data on root length reduction (Will and Suter 1995b). Other analytes marginally exceeding benchmarks at at least one station in the watershed included boron, chromium, cobalt, copper, fluoride, iron, lead, manganese, and nickel (HQs generally <5). Use of unfiltered water samples may result in overestimates of risks for metals that are significantly associated with the particulate fraction, which is largely unavailable to plants. Because of the uncertainty associated with the benchmarks and analyte bioavailability, it is unclear whether significant risks are present.

10.3 SEDIMENT EXPOSURES

Ecological risks were evaluated for benthic invertebrates exposed to nonradiological contaminants in sediment within each subbasin in the watershed for which sediment data were available. Nonradiological data were available from 21 subbasins. Potential risks from exposure

to radionuclides were evaluated for aquatic organisms across all 25 subbasins for which surface water and sediment radionuclide data were available. Two lines of evidence, biological survey data and single chemical toxicity data, were used in evaluating potential risks to benthic invertebrates.

Significant or potential risks were identified for benthic invertebrates exposed to nonradionuclides in sediment in 21 subbasins (Tables 4.2 and 4.3), based on the comparison of sediment concentration to benchmarks. Eleven inorganics and 15 organic analytes potentially present significant risks to aquatic organisms in the watershed. Evaluation of the average HIs suggests that the WOC Embayment and SWSA5 Trib 1 subbasins appeared to present the highest risks with 5 and 11 COECs, respectively. PCBs present significant risks in the WOC Embayment, SWSA 5 Trib 1, Lower WOC/WOL, WOC, SWSA5/WOC, Intermediate Pond, and HRE subbasins. Mercury presents significant risks at the WOC Embayment, SWSA5 Trib 1, WOC, SWSA5/WOC, and Intermediate Pond subbasins. Several polyaromatic hydrocarbons present significant risks at the WOC and Intermediate Pond subbasins. Manganese, silver, and zinc potentially present significant risks at 8, 7, and 5 subbasins, respectively.

Significant risks indicated by sediment chemical concentrations were not refuted by the community survey data in the Lower WOC/WOL subbasin. That is, eight sediment COECs were identified in this subbasin and the sediment community surveys were inconclusive. The relative importance of habitat and contamination could not be determined because a good reference was not available. However, the community survey suggests that sediment in subbasin WOC does not pose a significant risk to benthic invertebrates. Chironomid taxa richness was slightly lower than in the reference pools, but total taxonomic richness of the sediment community was similar to the reference sites. Hence, all of the eleven COECs appear to be credible contributors to toxicity, but the community does not appear to be degraded.

Potential risks to aquatic organisms exposed to radionuclides in sediment within the watershed were identified for just one subbasins: SWSA5/WOC. The dose rate to large invertebrates and fish in the SWSA5/WOC subbasin greatly exceeded the recommended dose rate limit (HI = 202 and 91) as a result of high Cs-137 activity. This dose was associated with the 05.OHF station at the OHF Pond and does not represent a widespread ecological problem. Sediment did not contribute significantly to the dose to large insects at Seep C (see surface water discussion). No aquatic receptors received doses above the dose rate limit in any of the other subbasins.

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ATTACHMENT

TOXICITY PROFILES FOR CONTAMINANTS OF CONCERN

TOXICITY TO AQUATIC ORGANISMS

ORGANICS

ALUMINUM

Aluminum (Al), the third most abundant element, is found in the earth's crust at approximately 8 mg/kg (Krueger et al., 1984). Its natural occurrence is restricted to highly insoluble complex minerals (Freeman and Everhart, 1971). Upon contact with acidic water, aluminum becomes more soluble and available to local flora and fauna (Havas, 1985) by complexing with hydroxide, fluoride and organic ligands (Baker and Schofield, 1982). It can be highly toxic to aquatic biota under some circumstances, but its toxicity is strongly dependent on pH, hardness, and organic matter content. In general, the more sensitive an organism is to a low pH, the stronger the toxic response to Al concentrations with falling pH levels (Baker and Schofield, 1982). Aluminum is amphoteric, i.e., it is more soluble in both acidic and basic solutions than in approximately neutral solutions, with its highest toxicity occurring around pH 5.5 (Freeman and Everhart, 1971, Baker and Schofield, 1982). EPA's water quality criteria for aluminum (EPA, 1988-Al) 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 dissolved 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+}). The aquatic toxicity tests discussed below and used to calculate the "National Ambient Water Quality Criteria "(NAWQC) for aluminum is relevant to situations in which an acidic solution of aluminum is neutralized in ambient water forming the hydroxide flocs reported to occur in the tests. This might be the case for an acidic waste or an acidified tributary entering a well-buffered stream or lake. Their relevance to other situations is questionable.

Acute Toxicity. Between pH 6.5 and 9.0, acute toxicities of aluminum reported by EPA (1988-Al) ranged between 1.8 mg/L for *Ceriodaphnia elegans* and >79.9 mg/L for midge larvae (*Tanytarsus dissimilis*). Acute toxicities for fish ranged from 3.6 mg/L to >50.0 mg/L. Acute toxicity tests of aluminum on the nematode, *Caenorhabditis elegans*, ranged from 1.8 to 79 mg/L (Williams and Dusenbery, 1990). At pH 4.5, Freda et al. (1990) found that the 96h LC50 for *Bufo americanus* tadpoles is 0.63 mg/L. Dissolved organic compounds (5.7 mg/L) raised the LC50 of *Rana pipens* tadpoles from 0.47 mg/L Al to >0.98mg/L (Freda et al., 1990). Sublethal stress in three-week old *Rana pipens* tadpoles exposed to 0.5-1.0 mg/L Al (pH 4.8) include lowered body sodium concentration, down 26-34% of initial concentration (Freda and McDonald, 1990). The 96h LC50 for the *R. pipens* tadpole was found to be slightly greater than 1.0 mg/L Al. At pH 4.4, *R. temporaria* exhibited a 96h LC50 of 1.6 mg/L Al (Cummins, 1986)(Table 1).

Chronic Toxicity. Chronic values for aluminum in circumneutral water reported by EPA (1988-Al) ranged from 0.742 to 3.29 mg/L for aquatic organisms. In one such study, rainbow trout exposed for 45 days to 0.5 and 5.1mg/L Al (nominal pH 7.0) averaged 32.5 and 24.1% of the control weight, respectively (Freeman and Everhart, 1971). However, if acidified water is present (pH<6.5) the following results should be considered. At pH 4.5 and 5.5 aluminum (0.3 mg/L for 67d) induced fatal behavioral development in brook trout; decreased swimming response, ability to feed and ability to evade predators. Mortality of brook trout eggs was not influenced by the aluminum concentration (0.3 mg/L) at pH between 5.5 and 7.2. However, at pH 4.5, 54.4 $\pm$ 17.2% of the eggs did not survive (0.3 mg/L Al) after 67d (Cleveland et al., 1986). Baker and Schofield (1982) found that Al (0.1-0.5 mg/L) in acidic solutions (pH 4.6-7.06) decreased survival and growth of white sucker larvae after 13d exposure. In contrast, 95% of all post larval brook trout survived at pH 4.2-5.5 when no Al was added.

Toxicity to Aquatic Plants. Aluminum inhibited the growth of the diatom, *Cyclotella meneghiniana*, at 0.810 mg/L and caused mortality at 6.48 mg/L (Rao and Subramanian, 1982, cited in EPA, 1988-Al). Concentrations of aluminum ranging from 0.40 to 0.90 mg/L were chronically toxic to the green algae, *Selenastrum capricornutum*. At concentrations ranging from 0.02 to 0.20 mg/L Al^{3+} the growth and activity of acid photophase of *S. capricornutum* were significantly inhibited. The activity of G6PDH was decreased at Al^{3+} levels higher than 0.02 mg/L (Kong and Chen, 1995).

Bioaccumulation. Estimated steady state bioconcentration factors for aluminum in brook trout, which were inversely related to pH, were 215 at pH 5.3, 123 at pH 6.1 and 36 at pH 7.2 (Cleveland et. al., 1991). Bioaccumulation was pH dependent, with a maximum at pH 6.5 and minimum at pH 4.5. Al was found at 350, 3,000, and 11, 000μg/g BW at exposure concentrations of 0.02, 0.32 and 1.02mg/L (pH6.5) in *D. magna* (Havas, 1985). Based on body dry weight, Pynnonen (1990) found a bioconcentration factor ranging from 166.8 to 414.3 in freshwater clams, *Unio pictorum*. After a three week exposure to 0.3 mg/L Al, high accumulation of aluminum in the kidney suggest that it is the final target organ, while low level presence of Al on the gills identifies the presence of metals in the sample area.

Aquatic Mode of Action. The exact mechanisms of aluminum's physiological effects are still under investigation and not completely understood. Mortality of fish exposed to aluminum and low pH may be the result of respiratory stress caused by gill damage, mucous clogging of the gill membrane, to the loss of sodium and chloride ions (Brumbaugh and Kane, 1985) and to the adsorption and nucleation of aluminum polymers at surface interfaces (Baker and Schofield, 1982). Aluminum may hamper the activity of calmodulin which is active in numerous biochemical processes (Siegel and Haug, 1983 cited in Lewis et al. 1990). It has been shown that trace-metals, such as aluminum, compete with H^+ for exchange sites on the gill surface (Pagenkopf, 1983 cited in Havas, 1985). Muniz and Levistad (1980 cited in Lewis et al. 1990) found that the presence of aluminum increased the loss of chloride from plasma and decreased blood oxygen tension in the brown trout. The fact that aluminum uptake and mortality increase with higher pH levels may indicate that the Al ion may bind or precipitate on biological membranes (Freda and McDonald, 1990). Verbost et al. (1992) showed that the inhibition of calcium uptake by the common carp is time and doseage dependent (>0.1 mg/L Al). In highly acidic waters, aluminum decreases RNA syntheses which may be due to disruption or deactivation of metabolic pathways (Cleveland et al., 1986). Observable effects include coughing response, hyperventilation and excessive mucus clogging of gills. Sublethal concentrations of aluminum have been shown to cause histopathological changes in the liver, kidney, skin, muscle, and gills and interfere with reproductive physiology in trout. Many studies have shown that aluminum may inhibit or render useless the hatching enzyme that digests the vitelline membrane in *Rana pipens* embryos (Katagiri, 1976, Yoshizaki, 1978, Freda and Dunson, 1984, Clark and LaZerte, 1985). In *Daphnia magna*, it has been shown that aluminum interferes with salt regulation and leads to death when sodium and chlorine concentrations are reduced (Havas, 1985).

Water Quality Criteria. NAWQC indicated that freshwater aquatic organisms and their uses should not be affected unacceptably, when the pH is between 6.5 and 9.0, if the four-day average concentration of aluminum does not exceed 0.087 mg/L more than once every three years on the average and if the one-hour average concentration does not exceed 0.750 mg/L more than once every three years on the average (EPA-Al, 1988).

Table 1. Toxicity of aluminum to aquatic organisms in circumneutral water (EPA, 1988-Al)*.

Conc.* (mg/L)	Effect
>79.9	Midge larvae (*Tanytarsus dissimilis*) LC50
79.0	Nematode (*Caenorhabditis elegans*) 24hr LC50
>50.0	Green sunfish (*Lepomis cyanellus*) LC50
>49.8	Yellow perch (*Perca flavescens*) LC50
>47.9	Channel catfish (*Ictalurus punctatus*) LC50
40.0	Chinook salmon (*Oncorhynchus tshawytsca*) LC50
38.2	Water flea (*Daphnia magna*) EC50
36.9	Water flea (*Ceriodaphnia sp*) 48h LC50 (Call et al. 1984)
35.0	Fathead minnow (*Pimephales promelas*) LC50
30.6	Snail (*Physa sp.*) LC50
>23.0	Planaria (*Dugasia tigrina*) LC50
>22.6	Stonefly (*Acroneuria sp.*) LC50
22.0	Amphipod (*Gammarus pseudolimnaeus*) LC50
10.4	Rainbow trout (*Oncorhynchus mykiss*) 24h LC50
8.60	Rainbow trout (*Oncorhynchus mykiss*) 96h LC50 (Call et al.1984)
3.69	Water flea (*Ceriodaphnia sp.*) EC50
3.60	Brook trout (*Salvelinus fontinalis*) LC50
3.29	Fathead minnow (*Pimephales promelas*) CV
>3.00	Rotifer (*Brachionus calyciforus*) 24h LC50 (Snell et al. 1991)
2.00	Nematode (*Caenorhabditis elegans*) 48hr LC50
1.91	Water flea (*Ceriodaphnia dubia*) CV
1.90	Water flea (*Ceriodaphnia dubia*) EC50
1.90	Nematode (*Caenorhabditis elegans*) 72hr LC50
1.80	Nematode (*Caenorhabditis elegans*) 96hr LC50
0.75	Acute NAWQ
0.74	Water flea (*Daphnia magna*) CV
0.09	Chronic NAWQ

*unless otherwise cited
*- concentrations given as Al, not the compound

BARIUM

Barium (Ba) is found in the more common mineral forms barite ($BaSO_4$) and witherite ($BaCO_3$) (Oehme, 1979). Barium fluorosilicate and carbonate are forms often used as pesticides. Approximately 400 mg/kg of barium is found in the earth's crust. Some plants accumulate barium from the soil. Barium has industrial applications in areas such as paper manufacturing, fabric printing and dyeing, synthetic rubber production, and drilling fluids. Barium in groundwater has been found to range from 0 to over 20 mg/L (Gilkeson et al., 1983)

Acute Toxicity. There is relatively little information of the aquatic toxicity of barium. Acute values range from a 96h LC50 for the mosquitofish *(Gambusia affinis)* (Wallen et al, 1957) to a 48h EC50 for *D. magna* (Biesinger and Christensen, 1972) (Table 2).

Toxicity to Aquatic Plants. The calculated 50% inhibition concentration was 25mg/L for duckweed (pH 6.32-8.32) in various ambient waters. The magnitude of barium's toxicity towards aquatic plants was shown to be highly dependent upon site-specific water quality characteristics and doseage (Wang, 1988). Barium inhibited calcification of the freshwater green alga *Goeotaenium* at 50.0 mg/L (Prasad, 1984).

Bioaccumulation. Barium is bioconcentrated from water by algae and vascular plants at levels dependent upon the particular species. However, Ba is not bioaccumulated through food chains and barium levels in higher species rarely exceeds 10mg/kg (Moore, 1991).

Water Quality Criteria. The state of Illinois has a water quality standard for indigenous aquatic life of 5.0 mg/L (Wang, 1988). Calculated Tier II values are SAV- 113.6 and SCV- 4.0 (Suter and Tsao, 1996).

Table 2. Toxicity of barium to aquatic organisms.

Compound	Conc.[a] (mg/L)	Species	Effect	Reference
$BaCO_3$	6950.0	Mosquitofish *(Gambusia affinis)*	96h LC50	Wallen et al. 1957
$BaCl_2$	3980.0	Scud *(Gammarus pulex)*	24h LC50	Vincent et al 1986
$BaCl_2$	1080.0	Mosquitofish *(Gambusia affinis)*	96h LC50	Wallen et al. 1957
$BaCl_2$	150.0	Brown trout *(Salmo trutta)*	96h LC50	Woodiwiss and Fretwell 1974
$BaCl_2$	122.0	Scud *(Echinogammarus berilloni)*	96h LC50	Vincent et al 1986
	113.6		SAV	Suter and Tsao, 1996
$BaCl_2$	78.0	Crayfish *(Orconectes)*	96h LC50	Boutet and Chaisemartin 1973
$BaCl_2$	46.0	Crayfish *(Austropotamobius pallipes)*	96h LC50	Boutet and Chaisemartin 1973
$BaSO_4$	33.7	Tubificid worm *(Tubifex tubifex)*	48h EC50	Khangrot 1991
$BaSO_4$	32.0	Water flea *(Daphnia magna)*	48h EC50	Khangarot and Ray 1989
$BaCl_2$	25.0	Duckweed *(Lemna minor)*	96h EC50	Wang 1988
$BaCl_2$	14.5	Water flea *(Daphnia magna)*	48h EC50	Biesinger and Christensen 1972
	4.0		SCV	Suter and Tsao, 1996

BERYLLIUM

Beryllium (Be), an alkaline earth metal, is experimentally used as a missile propellant, in high-performance aerospace craft, the nuclear industry and other industrial purposes (Finch et al, 1990; Oehme, 1979). The emphasis of beryllium toxicity has recently shifted from purely industrial exposures to concern for general environmental contamination as a result of new uses. Be speciation is pH dependent, with Be concentration increasing as the pH declines (Jagoe et al., 1993).

Acute Toxicity. Morphological changes were observed (96h) in European perch *(Perca fluviatilis)* at concentrations as low as 0.01 mg/L (pH 5.5) including swelling of epithelial cell and reductions in microridges on cell surfaces. Fatal abnormalities such as the shortening of the secondary lamellae were observed at 0.05 mg/L, leading to a decrease in the surface area available for gas exchange. Be at pH 4.5 damaged epithelial cells causing a disruption in the ion and osmoregulatory systems (Jagoe et al, 1993). Be is more acidic and 100 times more toxic to guppies in soft water than hard water. In hard circumneutral water, guppies *(Lebistes reticulatis)* exhibited a 96h LC50 of 27.0 mg/L (Slonim, 1973) (Table 3).

Aquatic Mode of Action. Due to their similar chemical characteristics, it is believed that the toxicity mechanism of beryllium is similar to that of aluminum. Physiological processes of the gills such as ion regulation and gas exchange are affected, indicated by changes in chloride cell surface morphology and shortened secondary lamellae (Jagoe et al, 1993).

Water Quality Criteria. National ambient water quality criteria are not available. Calculated Tier II values are SAV- 35 and SCV-0.66 (Suter and Tsao, 1996).

Table 3. Acute toxicity of beryllium to aquatic organisms.

Compound	Conc[a] (mg/L)	Species	Effect	Reference
$Be(NO_3)_2$	20.00	Fathead minnow *(Pimephales promelas)*	96h LC50[b]	Tarzwell and Henderson 1960
$Be(NO_3)_2$	0.15	Fathead minnow *(Pimephales promelas)*	96h LC50[a]	Tarzwell and Henderson 1960
$BeCl_2$	>100.00	Fathead minnow *(Pimephales promelas)*	96h LC50	Ewell et al. 1986
$BeCl_2$	>100.00	Flatworm *(Dugesia tigrina)*	96h LC50	Ewell et al. 1986
$BeCl_2$	>100.00	Oligochaete *(Lumbriculus variegatus)*	96h LC50	Ewell et al. 1986
$BeCl_2$	>100.00	Ramshorn snail *(Heliosoma trivolvis)*	96h LC50	Ewell et al. 1986
$BeCl_2$	100.00	Aquatic sowbug *(Asellus intermedius)*	96h LC50	Ewell et al. 1986
$BeCl_2$	11.00	Fathead minnow *(Pimephales promelas)*	96h LC50[b]	Tarzwell and Henderson 1960
$BeCl_2$	1.90	Water flea *(Daphnia magna)*	24h LC50	LeBlanc 1980
$BeCl_2$	0.70	Scud *(Gammarus fasciatus)*	96h LC50	Ewell et al. 1986
$BeCl_2$	0.20	Fathead minnow *(Pimephales promelas)*	96h LC50[a]	Tarzwell and Henderson 1960
$BeCl_2$	0.05	Water flea *(Daphnia magna)*	96h LC50	Ewell et al. 1986
$BeSO_4$	259.70	Tubificid worm *(Tubiflex tubiflex)*	24h EC50[i]	Khangarot 1991

Compound	Conc[a] (mg/L)	Species	Effect	Reference
$BeSO_4$	102.50	Tubificid worm *(Tubiflex tubiflex)*	96h EC50[i]	Khangarot 1991
$BeSO_4$	55.90	Goldfish *(Carassius auratus)*	96h LC50	Cardwell et al. 1976a
$BeSO_4$	41.10	Flagfish *(Jordanella floridae)*	96h LC50	Cardwell et al. 1976a
$BeSO_4$	40.00	Nematode *(Caenorhabditis elegans)*	24h LC50	Williams and Dusenberry 1990
$BeSO_4$	31.50	Salamander *(Ambystoma opacum)*	24h LC50[h]	Slonim and Ray 1975
$BeSO_4$	23.70	Salamander *(Ambystoma opacum)*	24h LC50[s]	Slonim and Ray 1975
$BeSO_4$	23.60	Salamander *(Ambystoma maculatum)*	24h LC50[h]	Slonim and Ray 1975
$BeSO_4$	22.60	Salamander *(Ambystoma maculatum)*	96h LC50[h]	Slonim and Ray 1975
$BeSO_4$	22.00	Guppy *(Lebistis reticulatis)*	96h LC50[h]	Slonim and Slonim 1973
$BeSO_4$	17.70	Fathead minnow *(Pimephales promelas)*	96h LC50	Kimbal 1978
$BeSO_4$	12.00	Bluegill *(Lepomis macrochirus)*	96h LC50[h]	Tarzwell and Henderson 1960
$BeSO_4$	11.00	Fathead minnow *(Pimephales promelas)*	96h LC50[h]	Tarzwell and Henderson 1960
$BeSO_4$	8.94	Salamander *(Ambystoma maculatum)*	24h LC50[s]	Slonim and Ray 1975
$BeSO_4$	6.49	Salamander *(Ambystoma maculatum)*	96h LC50[s]	Slonim and Ray 1975
$BeSO_4$	4.64	Water flea *(Daphnia magna)*	24h EC50[i]	Khangarot and Ray 1989
$BeSO_4$	3.15	Salamander *(Ambystoma opacum)*	96h LC50[s]	Slonim and Ray 1975
$BeSO_4$	2.00	Guppy *(Lebistis reticulatis)*	24h LC50[s]	Slonim and Slonim 1973
$BeSO_4$	1.30	Bluegill *(Lepomis macrochirus)*	96h LC50[s]	Tarzwell and Henderson 1960
$BeSO_4$	0.20	Fathead minnow *(Pimephales promelas)*	96h LC50[s]	Tarzwell and Henderson 1960
$BeSO_4$	0.16	Guppy *(Lebistis reticulatis)*	96h LC50[s]	Slonim and Slonim 1973
$BeSO_4$	0.14	Nematode *(Caenorhabditis elegans)*	96h LC50	Williams and Dusenberry 1990
$BeSO_4$	0.07	Perch *(Perca fluviatilis)*	72h CV[p]	Jagoe et al. 1993
$BeSO_4$	0.07	Roach *(Rutilus rutilus)*	72h CV[p]	Jagoe et al. 1993
$BeSO_4$	0.005	Water flea *(Daphnia magna)*	24h CV[r]	Kimbal 1978

[a]- all concentrations are given as Be, not the compound
[h]- hard water(>400mg/L Ca)
[i]- immobilization
[p]- pH 5.5
[r]- reproduction
[s]- soft water (20-25 mg/L Ca)

BORON

Boron (B) is found in the earth's crust at an average concentration of 16 mg/kg (Oehme, 1979). Borax ($Na_2B_4O_7$), is used in soldering and welding to remove oxide film, for softening water, in soaps, and in glass, pottery, and enamels. Boron has medicinal properties as sodium borate and borax is used as a common cleaner (Dixon et al., 1976). Agricultural run off from the application of boric acid as an insecticide and non-selective herbicide acts as a non-point source that severly affects the ecology of wetlands (Sander et al., 1991; Smith and Anders, 1989). Boron is found in natural water supplies at levels lower than 1.0 mg/L, in soils of the Western U.S. at 10-300 mg/kg and is essential to plants (Smith and Anders, 1989). Boron can also be found in vegetables, fruits, cereals and breads (Valdes-Dapena and Arey, 1962).

Boron is released by weathering processes, existing in sediments as borosilicates, an inert compound with regard to metabolism of living animals (Butterwick et al., 1989). Boron speciation is dependent on water quality parameters such as boron concentration and pH (Maier and Knight, 1991). Boric acid, $B(OH)_3$ and $B(OH)^{4-}$ are the active forms of boron and are highly soluble and stable, however, it is not certain which form of the metal is most toxic. Unlike a number of other metals, boron toxicity is not affected by water hardness (Butterwick et al., 1989).

Acute Toxicity. Relatively little aquatic toxicity information is available for boron. The only standard data are LC50s and CVs for *Daphnia magna* exposed to boric acid in relatively hard water. Lewis and Valentine (1981) reported a 48h LC50 of 226 mg/L for *Daphnia magna.* The lethal threshold concentration was <200 mg/L of boron. Gersich (1984) reported a LC50 of 133 mg/L. Neonate stages of *D. magna* had a slightly higher 48h LC50 of 141 mg/L. Fourth instar, *Chironomus decorus* exhibited a 48h LC50 of 1376.0 mg/L B (Maier and Knight, 1991). Early life stages of rainbow trout *(Oncorhynchus mykiss)* are more sensitive than later stages with a LOEC of 0.1 mg/L B (Birge and Black, 1981). Hamilton and Buhl (1990) found that Chinook salmon *(Oncorhynchus tshawytscha)* have a higher LC50, 725.0 mg/L than do Coho salmon *(O. kisutch)*, 447.0 mg/L. The 24h LC50s for both species were greater than 1000.0mg/L, the highest concentration tested.

Chronic Toxicity. Gersich (1984) reported a CV of 9.33 mg/L for *D. magna* while Lewis and Valentine (1981) reported a slightly lower CV of 8.83 mg/L for the same species. Chronic exposures to sodium tetraborate significantly inhibited midge larvae growth at 20.0 mg/L (Maier and Knight, 1991). McKee and Wolf (1963) saw NOEC and LOEC values for *D. magna* to be 6.0 and 13.0 mg/L B.

Toxicity to Aquatic Plants. Root growth of *Myriophyllum spicatum* was inhibited by 50% after a 32d test at 40.3mg/L B as tetraborate salt (Butterwick et al., 1989).

Bioaccumulation. Boron can be bioaccumulated at higher concentrations but there is no biomagnification up the trophic levels (Ohlendorf et al., 1986). Coho salmon, *Oncorhynchus kisutch,* have a BCF of 22.4-2.7 (Thompson et al., 1976). Due to its polarity, boron does not bioaccumulate in fat tissue (Moseman, 1994). Instead, the target areas include the brain, spinal cord and liver (Whitworth et al. 1991). In the San Joaquin Valley of California an area of high boron run-off from agricultural fields, boron was found at concentrations of 371, 501 and 1860 mg/L in the wigeon grass, algae and grass seeds, respectively (Whitworth et al., 1991). Boron levels in aquatic vegetation seed have been as high as 3500.0 mg/kg, a concentration sufficient to adversely affect birds that feed upon it (Schuler, 1987).

Water Quality Criteria. No water quality criteria data are available. Calculated Tier II values are SAV- 29.65; SCV- 1.6 (Suter and Tsao, 1996).

CADMIUM

Cadmium (Cd) occurs predominately in the form of free divalent cations in most well oxygenated, low organic matter, fresh waters (EPA 1985-Cd). However, both particulate matter and dissolved organic matter can bind cadmium in biologically unavailable forms. There is no evidence that cadmium is a biologically essential or beneficial element (Eisler, 1985a). Cd toxicity is related to water hardness, with a reduction in toxicity associated with increased water hardness (EPA, 1985-Cd). Therefore, the cadmium toxicity values presented in Table 2 that are not from tests conducted in waters of moderate hardness are normalized to 100 mg/L using the slopes calculated by the EPA (1985-Cd).

Acute toxicity. See Table 4.

Chronic Toxicity. Fertilized eggs of the goldfish, leopard frog, and largemouth bass were placed in natural stream sediment spiked with cadmium (Francis et al., 1984) and maintained until four days posthatching, which resulted in a total exposure duration of six to seven days. Sediments with 1000 mg/kg cadmium were not toxic to goldfish or leopard frog but resulted in 25% mortality 4 days posthatching for largemouth bass. A sediment concentration of 100 mg/kg cadmium was not toxic to the largemouth bass. Organic matter content of the sediment was 2.3%.

Spiked sediment toxicity tests were performed 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, in which 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 2 and 13 mg/kg resulted in between 47 and 63% mortality relative to controls. A concentration of 121 mg/kg resulted in 89% mortality (Birge et al., 1979a).

Sauter et al. (1976; cited in Suter and Tsao, 1996) reported a CV of 0.0017 mg/L for fish and Chapman et al. (n.d; cited in Suter and Tsao, 1996) reported a CV of 0.00015 mg/L for Daphnids.

Bioaccumulation. Aquatic organisms are able to bioconcentrate Cd, although there is evidence that only the lower trophic levels can biomagnify this element.

Water Quality Criteria. NAWQ criteria values for Cd are 0.0039 and 0.0011mg/L for the acute and chronic toxicity of cadmium (Suter and Tsao, 1996).

Table 4. Toxicity of cadmium to aquatic organisms (EPA, 1985- Cd).

Concentration (mg/L)[a]		Effect
100 mg/L hardness	200 mg/L hardness	
24.6	72.8	Goldfish (*Carassius auratus*) LC50
18	18	Stonefly (Plecoptera) LC50[b]
17.7	38.7	Mayfly (*Ephemerella grandis*) LC50
17.3	37.8	Tubificid worm (*Rhyacodrilus montana*) LC50
16.8	36.7	Mosquitofish ((*Gambusia affinis*) LC50
16.5	36	White perch (*Morone americana*) LC50
15.1	33	Tubificid worm (*Stylodrilus heringlanus*) LC50
12.7	23.2	Bluegill (*Lepomis macrochirus*) LC50

Concentration (mg/L)[a]		Effect
100 mg/L hardness	200 mg/L hardness	
12.5	27.3	Channel catfish (*Ictalurus punctatus*) LC50
12.4	27	Tubificid worm (*Spirosperma nikolskyl*) LC50
10.9	23.8	Threespine stickleback (*Gasterosteus aculeatus*) LC50
10.4	22.8	Tubificid worm (*Varichaeta pacifica*) LC50
9.62	21.02	Tubificid worm (*Spirosperma ferox*) LC50
8.79	19.22	Tubificid worm (*Quistadrilus multisetosus*) LC50
8.79	19.22	Tubificid worm (*Tubifex tubifex*) LC50
8.3	18.15	Snail (*Amicola* sp.) LC50
7.8	17.5	Guppy (*Poecilla reticulata*) LC50
7.68	16.79	White sucker (*Catostomus commersoni*) LC50
7.43	16.24	Caddisfly (Trichoptera)LC50
6.86	12.85	Green sunfish (*Lepomis cyanellus*) LC50
6.59	14.41	Tubificid worm (*Branchiura sowerbyl*) LC50
6.31	13.79	Flagfish (*Jordanella floridae*) LC50
5.24	11.46	Northern squawfish (*Ptychochellus oregonensis*) LC50
5.05	11.04	Mayfly (*Paraleptophlebia praepedita*) LC50
4.67	10.21	Tubificid worm (*Limnodrilus hoffmelsterl*) LC50
3.71	8.12	Worm (*Nais* sp.) LC50
2.94	6.43	Pumpkinseed (*Lepomus gibbosus*) LC50
2.62	5.73	Midge (*Chironomus* sp.) LC50
1.61	3.52	American eel (*Anguilla rostrata*) LC50
0.875	1.913	Isopod (*Asellus bicrenata*) LC50
0.705	1.542	Crayfish (*Orconectes limosus*) LC50
0.484	1.06	Bryozoan (*Plumatella emarginata*) LC50
0.471	1.03	Common carp (*Cyprinus carpio*) LC50
0.448	0.979	Amphipod (*Hyalella azteca*) LC50
0.343	0.749	Snail (*Physa gyrina*) LC50
0.311	0.681	Bryozoan (*Pectinatella magnifica*) LC50
0.227	0.497	Snail (*Aplexa hypnorum*) LC50
0.216	0.472	Banded killifish (*Fundulus diaphanus*) LC50
0.181	0.397	Water flea (*Ceriodaphnia reticulata*) EC50
0.153	0.334	Amphipod (*Gammarus* sp.) LC50
0.132	0.288	Amphipod (*Gammarus pseudolimnaeus*) LC50
0.122	0.266	Water flea (*Daphnia pulex*) EC50
0.1	0.219	Cladoceran (*Simocephalus serralatus*) EC50
0.0935	0.2044	Isopod (*Lirceus alabamae*) LC50
0.0891	0.1948	Cladoceran (*Molina macrocopa*) EC50
0.072	0.1699	Fathead minnow (*Pimephales promelas*) LC50
0.0667	0.1459	Bryozoan (*Lophopodella carteri*) LC50
0.0281	0.0485	Bluegill (*Lepomis macrochirus*) CV
0.0266	0.0582	Water flea (*Daphnia magna*) EC50
0.0262	0.0452	Fathead minnow (*Pimephales promelas*) CV
0.0141	0.0243	Atlantic salmon (*Salmo salar*) CV
0.0141	0.0243	Smallmouth bass (*Micropterus dolomieui*) CV

Concentration (mg/L)[a]		Effect
100 mg/L hardness	200 mg/L hardness	
0.014	0.0242	Northern pike (*Esox lucius*) CV
0.014	0.0242	Lake trout (*Salvelinus namaycush*) CV
0.0135	0.0233	White sucker (*Catostomas commersoni*) CV
0.0129	0.0282	Coho salmon (*Oncorhynchus kisutch*) LC50
0.0127	0.0219	Brown trout (*Salmo trutta*) CV
0.0093	0.02032	Chinook salmon (*Oncorhynchus tshawytscha*) LC50
0.0092	0.01586	Flagfish (*Jordanella floridae*) CV
0.00834	0.01438	Snail (*Aplexa hypnorum*) CV
0.00784	0.01714	Rainbow trout (*Oncorhynchus mykiss*) LC50
0.00739	0.01274	Coho salmon (*Oncorhynchus kisutch*) CV
0.00678	0.01168	Cladoceran (*Ceriodaphnia reticulata*) CV
0.00464	0.008	Chinook salmon (*Oncorhynchus kisutch*) CV
0.00407	0.00701	Brook trout (*Salvelinus fontinalis*) CV
0.0039	0.0086	Acute NAWQC
0.00358	0.00782	Brown trout (*Salmo trutta*) LC50
0.0011	0.002	Chronic NAWQC
0.00033	0.00057	Cladoceran (*Molna macrocopa*) CV
0.000233	0.000401	Water flea (*Daphnia magna*) CV

[a] concentrations given as Cd, not the compound.
[b] the stonefly acute test did not specify the hardness of the water

COBALT

Cobalt (Co), a hard, silvery white metal, is strategically important in the production of high-temperature alloys and permanent magnets (Brobst et al., 1973). Cobalt salts are utilized in the production of pigments and in paint dryers as catalysts (Lustigman et al., 1995). It is found in the earth's crust at an average concentration of 20 mg/kg. Cobalt is an essential element making up approximately one-half of the contents of vitamin B12, which is necessary in the prevention of pernicious anemia (Oehme, 1979). Comparatively little is known about the toxicity of cobalt.

Acute Toxicity. Acute toxicity values for cobalt ranged from 3.46 mg/L for fathead minnows to 139.32 mg/L for a tubificid worm (Table 5). Biesinger and Christensen (1972) reported 48h LC50s of 1.11 and 1.62 mg/L with and without food added, respectively. 16% reproductive impairment was seen at an exposure of 0.01 mg/L for 64h.

Chronic Toxicity. Chronic toxicity values (CVs) ranged from 5.1 mg/L for *D. magna* to 286.20 mg/L for the fathead minnow. Zebrafish embryos and larvae, *Brachydanio rerio*, were exposed to $CoCl_2$ for 16 days. NOECs of 0.06 and 3.84 mg/L were found for survival and hatching times, respectively (Dave and Xiu, 1991).

Toxicity to Aquatic Plants. 21d chronic tests using the unicellular alga, *Chlamydomonas reinhardtii*, exposed lethal toxic effects of cobalt (II) as $Co(NO_3)_2$ at 10-50 mg/L. Growth impairment starting at 10mg/L increased to the highest concentration tested (50 mg/L) and proved to be time and dose dependent. All cells at 50 mg/L were degraded and bleached, indicative of the inhibition of chlorophyll synthesis (Lustigman et al., 1995).

Aquatic Mode of Action. Mechanism for cobalt toxicity in aquatic plants may be linked to cobalt's competition with iron for active sites on the chlorophyll molecule (Lustigman et al., 1995).

Table 5. Toxicity of cobalt to aquatic organisms.

Conc. (mg/L)*	Species	Endpoint	Reference
286.20	Fathead minnow *(Pimephales promelas)*	CV	Kimball, 1978
139.32	Tubificid worm *(Tubifex tubifex)*	EC50	Khangarot, 1991
>100.00	Scud *(Gammarus fasciatus)*	LC50	Ewell et al., 1986
>100.00	Ramshorn snail *(Heliosoma trivolvis)*	LC50	Ewell et al., 1986
>100.00	Oligochaete *(Lumbriculus variegatus)*	LC50	Ewell et al., 1986
100.00	Aquatic sowbug *(Asellus intermedius)*	LC50	Ewell et al., 1986
25.00	Flatworm *(Dugesia tigrina)*	LC50	Ewell et al., 1986
23.00		SCV	Suter and Tsao, 1996
22.00	Fathead minnow *(Pimephales promelas)*	LC50	Ewell et al., 1986
17.59	Frog *(Rana hexadactyla)*	LC50	Khangarot et al., 1985
6.83	Water flea *(Daphnia magna)*	EC50	Kimball, 1978
5.15	Water flea *(Daphnia magna)*	EC50	Kimball, 1978

Conc. (mg/L)[a]	Species	Endpoint	Reference
5.10	Water flea *(Daphnia magna)*	CV	Kimball, 1978
3.75	Fathead minnow *(Pimephales promelas)*	LC50	Kimball, 1978
3.46	Fathead minnow *(Pimephales promelas)*	LC50	Kimball, 1978
1.48		SAV	Suter and Tsao, 1996

[a]- concentrations given as Co, not the compound

COPPER

Copper (Cu) occurs in natural waters primarily as the divalent cupric ion in free and complexed forms (EPA 1985-Cu). Copper is a minor nutrient for both plants and animals at low concentrations, but is toxic to aquatic life at concentrations only slightly higher. Concentrations of 0.001 to 0.010 mg/L are usually reported for unpolluted surface waters in the United States. Common copper salts, such as the sulfate, carbonate, cyanide, oxide, and sulfide are used as fungicides, as components of ceramics and pyrotechnics, for electroplating, and for numerous other industrial applications (ACGIH, 1986). The largest anthropogenic releases of copper to the environment result from mining operations, agriculture, solid waste, and sludge from sewage treatment plants.

Acute Toxicity. Toxicity of copper appears to be a function of calcium hardness and associated carbonate alkalinity. Therefore, the concentrations in Table 6 are corrected for hardness of 100 and 200 mg/L.

Bioaccumulation. Copper is not known to be appreciably bioaccumulated by fish, but some algae and bivalve molluscs do bioconcentrate or bioaccumulate copper by factors of over 1000 (EPA 1985-Cu).

Aquatic Mode of Action. The toxicity of copper to aquatic life is related primarily to activity of the cupric (Cu^{2+}) ion, and possibly to the hydroxy complexes. The cupric ion is highly reactive, forms moderate to strong complexes and precipitates with inorganic and organic constituents (e.g., carbonate, phosphate, amino acids), and is readily sorbed onto surfaces of suspended solids. The proportion of free cupric ion may be less than 1 percent in eutrophic waters where complexation predominates. These complexes appear to be much less toxic than free cupric ions, thus reducing toxicity. Hence, even dissolved copper measurements may overestimate copper exposure relative to laboratory test waters due to dissolved organic and inorganic ligands (EPA 1985-Cu; Benson et al., 1994).

Water Quality Criteria

The NAWQC for copper are fuctions of water hardness. The equations are $e^{(0.8545[\ln(\text{hardness})]-1.465)}$ for the chronic value and $e^{(0.9422[\ln(\text{hardness})]-1.464)}$ for the acute value (Suter and Tsao, 1996).

Table 6. Toxicity of copper to aquatic organisms (EPA-Cu, 1985).

Concentration (mg/L)[a]		Effect
100 mg/L hardness	200 mg/L hardness	
19.6757	37.8060	Stonefly (*Acroneuria lycorias*) LC50
11.2597	21.6351	White perch (*Morone americana*) LC50
8.2719	15.8940	American eel (*Anguilla rostrata*) LC50
3.8237	7.3471	Crayfish (*Procambarus clarkil*) LC50
3.6066	6.9299	Snail (*Campeloma decisum*) LC50
2.6843	5.1577	Crayfish (*Orconectes limosus*) LC50
1.7293	3.3228	Snail (*Amnicola*) LC50
1.6653	3.1999	Blacknose dace (*Rhinichthys atratulus*) LC50

Concentration (mg/L)[a]		Effect
100 mg/L hardness	200 mg/L hardness	
1.6653	3.1999	Rainbow darter (*Etheostoma caeruleum*) LC50
1.6134	3.1002	Creek chub (*Semotilus atromaculatus*) LC50
1.7434	2.9887	Bluegill (*Lepomis macrochirus*) LC50
1.5191	2.9189	Banded killifish (*Fundulus diaphanus*) LC50
1.3414	2.5774	Brown bullhead (*Ictalurus nebulosus*) LC50
1.3149	2.5264	Mozambique tilapia (*Tilapia mossambica*) LC50
1.2315	2.3662	Pumpkinseed (*Lepomis gibbosus*) LC50
0.6375	1.2250	Striped shiner (*Notropis chrysocephalus*) LC50
0.4663	0.8960	Worm (*Lumbriculus variegatus*) LC50
0.4492	0.8632	Sockeye salmon (*Oncorhynchus nerka*) LC50
0.4423	0.8499	Orangethroat darter (*Etheostoma spectabile*) LC50
0.3207	0.8254	Guppy (*Poecilia reticulata*) LC50
0.3789	0.7281	Midge (*Chironomus tentans*) LC50
0.3778	0.7258	Atlantic salmon (*Salmo salar*) LC50
0.3768	0.7240	Mosquitofish (*Gambusia affinis*) LC50
0.3217	0.6180	Northern squawfish (*Ptychocheilus oregonensis*) LC50
0.3193	0.6136	Snail (*Goniobasis livescens*) LC50
0.2644	0.6053	Fathead minnow (*Pimephales promelas*) LC50
0.3019	0.5800	Goldfish (*Carassius auratus*) LC50
0.3013	0.5789	Common carp (*Cyprinus carpio*) LC50
0.2594	0.4984	Bryozoan (*Pectinatella magnifica*) LC50
0.2556	0.4910	Chiselmouth (*Acrocheilus alutaceus*) LC50
0.2121	0.4076	Brook trout (*Salvelinus fontinalis*) LC50
0.1729	0.3323	Worm (*Nais sp.*) LC50
0.1509	0.2900	Central stoneroller (*Campostoma anomalum*) LC50
0.1387	0.2664	Bluntnose minnow (*Pimephales notatus*) LC50
0.1350	0.2594	Coho salmon (*Oncorhynchus kisutch*) LC50
0.1270	0.2441	Northern pike (*Esox lucius*) CV
0.1217	0.2234	Cutthroat trout (*Salmo clarki*) LC50
0.1080	0.2075	Snail (*Gyraulus circumstriatus*) LC50
0.1020	0.1960	Tubifed worm (*Limnodrilius hoffmeisteri*) LC50
0.0828	0.1590	Snail (*Physa integra*) LC50
0.0787	0.1457	Rainbow trout (*Oncorhynchus mykiss*) LC50
0.0712	0.1368	Bryozoan (*Lophodella carteri*) LC50
0.0712	0.1368	Bryozoan (*Plumatella emarginata*) LC50

Concentration (mg/L)[a]		Effect
100 mg/L hardness	200 mg/L hardness	
0.0690	0.1326	Snail (*Physa heterostropha*) LC50
0.0656	0.1260	Brook trout (*Salvelinus fontinalis*) CV
0.0649	0.1247	Brown trout (*Salmo trutta*) CV
0.0642	0.1234	Lake trout (*Salvelinus namaycush*) CV
0.0615	0.1182	Bluegill (*Lepomis macrochirus*) CV
0.0576	0.1108	Midge (*Chironomus*) LC50
0.0553	0.1063	Amphipod (*Gammarus pulex*) LC50
0.0645	0.0983	Chinook salmon (*Oncorhynchus tshawytscha*) LC50
0.0488	0.0939	Water flea (*Ceriodaphnia pulex*) EC50
0.0436	0.0900	Water flea (*Ceriodaphnia magna*) EC50
0.0439	0.0844	White sucker (*Catostomus commersoni*) CV
0.0434	0.0835	Fathead minnow (*Pimephales promelas*) CV
0.0424	0.0816	Amphipod (*Gammarus pseudolimnaeus*) LC50
0.0400	0.0769	Rainbow trout *(Oncorhynchus mykiss)* CV
0.0393	0.0756	Fathead minnow (*Pimephales promelas*) CV
0.0370	0.0710	Caddisfly (*Clistornia magnifica*) CV
0.0361	0.0693	Water flea(*Ceriodaphnia reticulata*) EC50
0.0296	0.0568	Chinook salmon (*Oncorhynchus tshawytscha*) CV
0.0273	0.0524	Brook trout (*Salvelinus fontinalis*) CV
0.0236	0.0454	Snail (*Campeloma decisum*) CV
0.0236	0.0454	Snail (*Physa integra*) CV
0.0039	0.0086	NAWQC Acute Value
0.0144	0.0277	Fathead minnow (*Pimephales promelas*) CV
0.0296	0.0249	Water flea(*Daphnia magna*) CV
0.0129	0.0247	Amphipod (*Gammarus pseudolimnaeus*) CV
0.0150	0.0243	Water flea (*Ceriodaphnia pulicaria*) EC50
0.0183	0.0219	Fathead minnow (*Pimephales promelas*) CV
0.0011	0.002	NAWQC Chronic Value
0.0098	0.0188	Brook trout (*Salvelinus fontinalis*) CV
0.0115	0.0097	Water flea(*Daphnia magna*) CV
0.0115	0.0097	Water flea(*Daphnia magna*) CV
0.0047	0.0091	Bluntnose minnow (*Pimephales notatus*) CV

[a]- concentrations are given as Cu, not the compound

IRON

Because iron (Fe) is the fourth most abundant element in the earth's crust, it commonly occurs at high concentrations in whole water analyses. Dissolved concentrations in water and soil are dependent upon redox conditions and pH. Fe typically occurs in water between 0.01 and 1.4 mg/L (Jorgensen et al., 1991; as cited in Gerhardt, 1994) with occurrence increasing in the presence of humic acids (Gerhardt, 1993). At lower concentrations, iron is an essential trace metal in both the plant and animal kingdoms because of its role in oxygen and energy transport. Iron occurs in the +1,+2 and +3 valence states and speciation from the +2 to the +3 state has been known to occur between pH 4.5 and 7. However, increased toxicity of iron at in acidic conditions may be a result of the photoreduction from +3 to the +2 state, or the destabilization of weaker iron complexes (Gerhardt, 1994). The most common dissolved inorganic form of iron is $Fe(OH)_2^+$ (Dave 1984). Toxicity of iron to aquatic organisms has received little attention because it is observed in unusual circumstances such as acid mine drainage or discharge of acidic metal working wastes.

Acute Toxicity. Iron is acutely toxic to freshwater fish and invertebrates at concentrations ranging from 0.300 mg/L to 2.0 mg/L (Train, 1979; cited in Dave, 1984). Survival of brown trout alevin (swim-up fry) and eyed-eggs was reduced at an average iron concentration of 5.170 mg/L (Geertz-Hansen and Mortensen 1983).

Uptake of and survival to iron was dose dependent in mayflys (*Leptophlebia marginata* L.) when exposed to 10-500 mg/L Fe. pH had little effect on the rate of uptake, but played an important role in survivability of the mayfly to Fe exposure. The 96h LC50 obtained during this study were 106.3 and 89.5 mg/L at pH 7 and 4.5, respectively. EC50s for escape behavior were 70 and 63.9 mg/L at pH 7 and 4.5, respectively (Gerhardt, 1994).

The common carp *(Cyprinus carpio)* had a LC50 of 1200 mg/L Fe as iron ammonium alum while the guppy had an LC50 of 1125 mg/L (Yarzhombek et al., 1991). Mullick and Konar (1991) found the 48h LC50 of a copepod *(Diaptomus forbesi)* to be 86.5 mg/L Fe as iron sulfate.

Chronic Toxicity. After 30d exposure to Fe at 10, 20 or 50 mg/L Fe as FeSO4, Gerhardt (1992a) observed decreased activity and food consumption by the mayfly *(Leptophlebia marginata)* at all concentrations tested (pH 4.5).

Reproduction of *Daphnia magna* was stimulated at concentrations up to 0.001 mg/L, and reproduction and survival were inhibited by iron at 0.158 mg/L and 0.256 mg/L, respectively (Dave, 1984). This is considerably lower than the 4.380 mg/L concentration causing 16% reproductive decrement in a 3 week 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."

Toxicity to Aquatic Plants. Wang (1986) found the 96h growth EC50 for duckweed *(Lemna minor)* to be 3.7 mg/L.

Bioaccumulation. Following acute (72h) exposure, the banded tilapia *(Tilapia sparrmanii)* exhibited a bioconcentration order of liver-ovary-heart-muscle-testis-brain, with the highest concentration being found in the liver (du Preez et al., 1993).

Aquatic Mode of Action. Excess Fe^{3+} in the liver of the banded tilapia *(Tilapia sparrmanii)* caused the excess formation of iron protein complexes such as hemoglobin, ferritin, and transferritin (Morgan, 1974; as cited in du Preez, et al., 1993). Fe stress is more detrimental to younger and female fish, as they invest more energy in reproduction than do males (Maltby and Naylor, 1991; as cited in Gerhardt, 1993).

LEAD

Lead (Pb), a comparatively rare metal, averages 16 mg/kg in the earth's crust, and 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). Although lead occurs in a variety of forms in the aquatic environment, the relative toxicities of these forms are not well defined (EPA, 1985-Pb).

Acute Toxicity. Acute and chronic lead toxicity increases as hardness decreases (EPA, 1985-Pb). Therefore, the lead toxicities values to aquatic life, listed in Table 1, are normalized to 100 and 200 mg/L hardness using the slopes calculated by the EPA (1985-Pb). Acute toxicities of lead, normalized to 100 mg/L, range from 0.3446 to 570.201 mg/L and acute toxicities, normalized to 200 mg/L, range from 0.8328 to 1377.968 mg/L. Biesinger and Christensen (1972) reported a 48-hr LC50 of 0.45 mg/L without food added for the toxicity of lead to *Daphnia magna* (Table 7).

Chronic Toxicity. Chronic toxicities, normalized to 100 mg/L, range from 0.0167 to 0.3874 mg/L and chronic toxicities, normalized to 200 mg/L, range from 0.0405 to 0.9362 mg/L. In general, invertebrates are more sensitive to lead than fish. Biesinger and Christensen (1972) reported a 3-week CV of 0.030 mg/L with food added for the toxicity of lead to *Daphnia magna* which caused 16% reproductive impairment.

Toxicity to Aquatic Plants. Monahan (1976; as cited in EPA, 1985-Pb) exposed three species of alga to various concentrations of lead chloride. 0.5 mg/L Pb proved to inhibit growth by 53, 35 and 52% in *Chlorella* sp., *Scenedesmus* sp., and *Selenastrum* sp., respectively. 32d chronic exposure to Eurasian watermilfoil *(Myriophyllum spicatum)*, yielded an EC50 for root growth of 363 mg/L (Stanley, 1974; as cited in EPA, 1985-Pb). Investigating the effects of lead shot on rooted aquatic plants, Behan et al. (1979) found that the bioavailability of powdered lead is much higher than that of lead shot. Depuration of accumulated lead is comparatively rapid; 10% of the Pb absorbed during the first hour of exposure by *Elodea canadensis* remained in the shoot tissue 14d after transfer to clean water (Everard and Denny, 1985; as cited in Eisler, 1988).

Bioaccumulation. Biomagnification of lead does not occur in aquatic food chains as evidenced by its relatively high concentrations in aquatic plants and invertebrates and low concentrations in fish (Eisler, 1988). Bioconcentration factors range from 1700 for a snail *(Lymnaea palustris)* to 42 for the brook trout *(Salvelinus fontinalis)* (Borgman et al., 1978; Holcombe et al., 1976).

Water Quality Criteria. The acute and chronic NAWQ criteria for lead are 0.082 and 0.0032 mg/L at a hardness of 100 mg/L as $CaCO_3$ (EPA, 1985- Pb).

Table 7. Toxicity of lead to aquatic organisms (EPA 1985- Pb).

Concentration (mg/L)		Effect
100 mg hardness	200 mg hardness	
570.201	1377.968	Midge (*Tanytarsus dissimilis*) LC50
244.399	590.623	Goldfish (*Carassius auratus*) LC50

Concentration (mg/L)		Effect
100 mg hardness	200 mg hardness	
159.829	386.249	Guppy (*Poecilia reticulata*) LC50
71.706	202.114	Fathead minnow (*Pimephales promelas*) LC50
105.421	212.455	Bluegill (*Lepomis macrochirus*) LC50
13.610	75.668	Rainbow trout (*Oncorhynchus mykiss*) LC50
11.659	28.176	Brook trout (*Salvelinus fontinalis*) LC50
2.514	6.076	Snail (*Aplexa hypnorum*) LC50
0.9087	1.8441	Water flea (*Daphnia magna*) EC50
0.3874	0.9362	Rainbow trout (*Oncorhynchus mykiss*) CV
0.3446	0.8328	Amphipod (*Gammarus pseudolimnaeus*) LC50
0.2363	0.5709	Brook trout (*Salvelinus fontinalis*) CV
0.1134	0.5696	Water flea (*Daphnia magna*) CV
0.0562	0.2821	Water flea (*Daphnia magna*) CV
0.0491	0.2464	Water flea (*Daphnia magna*) CV
0.0954	0.2307	Rainbow trout (*Oncorhynchus mykiss*) CV
0.0167	0.0405	Snail (*Lymnaea palustris*) CV
0.082	0.197	NAWQC acute value
0.0032	0.0077	NAWQC chronic value

LITHIUM

The concentration of lithium (Li)found in the earth's crust is 30 mg/kg. Metallic lithium does not occur in nature, it occurs as salts and complexes. Lithium is not considered a heavy metal or an essential element (Oehme, 1979).

Acute Toxicity. The striped bass 96 hr LC50 in a static test of lithium was >105 mg/L (Dwyer et al., 1992). Survival of the striped bass increased as the hardness of the water was increased. Recent studies conducted at Oak Ridge National Laboratory have revealed that the toxicity of lithium decreases as the concentration of sodium increases (Kszos, 1996). Survival of *Ceriodaphnia dubia* exposed to lithium concentrations ranging from 1-4 mg/L increased as sodium concentrations were increased. The feeding rate for *Elimia clavaeformis* was reduced by 25% at 0.11 mg/L, the growth of *Pimephales promelas* was reduced by 25% at 0.42 mg/L, and the reproduction of *Ceriodaphnia dubia* was reduced by 25% at 0.46 mg/L in 7 day tests. Studies of three species of fish by Hamilton (1995) showed lithium to be more toxic to fry than juveniles (Table 8). Lithium was found to have an EC50 (50% immobilization response) for tubificid worms (*Tubifex tubifex)* of 44.77 mg/L at the 24 hr, 11.22 mg/L at the 48 hr, and 9.34 mg/L at the 96 hr (Khangarot, 1991).

Toxicity to Aquatic Plants. Lithium as LiCl gradually decreased cell growth of the alga, *Chlamydomonas reinhardii* between 13.9 and 138.8 mg/L over a 6 day period (Gamboa et al., 1985). LiCl placed in the alga media caused loss of cell mobility and production of large amounts of extracellular mucus. This toxicity is due to the free cation.

Aquatic Mode of Action. The mode of action of lithium is unclear. However, lithium may interfere with or substitute for sodium, potassium, calcium, and magnesium (Klemfuss and Greene, 1991).

Table 8. Toxicity of lithium to aquatic organisms.

Conc. (mg/L)	Effect	Reference
186.00	Razorback sucker (2.0g-juvenile)LC50	Hamilton, 1995
138.80	Algae (*Chlamydomonas reinhardii*)75% growth inhibition	Gamboa et al., 1985
65.00	Bonytail (2.6g-juvenile)LC50	Hamilton, 1995
62.00	Bonytail (1.1g-juvenile) LC50	Hamilton, 1995
53.00	Razorback sucker (0.9g-juvenile) LC50	Hamilton, 1995
44.77	Tubificid worm (*Tubifex tubifex)*24hr EC50	Khangarot, 1991
41.00	Colorado squawfish (1.7g-juvenile) LC50	Hamilton, 1995
28.00	Colorado squawfish (0.4-1.1g-juvenile) LC50	Hamilton, 1995
25.00	Razorback sucker (swimup fry) LC50	Hamilton, 1995
2.00	Bonytail (swimup fry) LC50	Hamilton, 1995
17.00	Colorado squawfish (swimup fry) LC50	Hamilton, 1994

Conc. (mg/L)	Effect	Reference
13.90	Algae (*Chlamydomonas reinhardii*) 25% growth inhibition	Gamboa et al., 1985
11.22	Tubificid worm (*Tubifex tubifex*) 48hr EC50	Khangarot, 1991
9.34	Tubificid worm (*Tubifex tubifex*) 96hr EC50	Khangarot, 1991

[a]Concentration causing 25% reduction in test endpoints compared to control
[b]Nominal concentration
[c]Measured concentration

MANGANESE

Manganese (Mn) makes up about 0.10% of the earth's crust and is the 12th most abundant element (NAS, 1980). In soil, natural levels of manganese range from 0.6-0.9 mg/kg and its solubility increases with decreasing pH. In surface water, Mn is present at concentrations ranging from 0.001-0.04 mg/L (Rouleau et al., 1995). Manganese oxides and peroxides are used in industry as oxidizers, and elemental Mn is used for manufacturing metal alloys to increase hardness and corrosion resistance. Increasingly, Mn as a Mn carbonyl compound, is being utilized as an anti-knocking agent in engines and is released into the air as Mn_3O_4 following combustion (Brault et al., 1994). Manganese is also present in the air and water discharges from mining and smelting activities (Saric 1986). In living systems, manganese is an essential element that is found most often in the +2 valence state. 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). Manganese is one of the first metals to increase in concentration in acidified waters (Harvey 1983).

Acute Toxicity. Mn is not considered to be severe, acute threat to fish, as 96h LC50 values range much higher than concentrations that are found in surface waters. The 96h LC50 is 3,230 mg/L for the tropical perch *(Colisa fasciatus)* (Nath and Kumar, 1987), 1679.0 mg/L for *Oreochromis mossambicus* (Seymore et al., 1993), and 130.0 mg/L for the logfin dace *(Agosia chrysogaster)* (Lewis, 1978).

Acute and chronic toxicity tests using fathead minnows and *Daphnia magna* were conducted in relatively hard water. Acute toxicity values for manganese ranged from 19.4 mg/L for *D. magna* to 33.80 mg/L for fathead minnow (Kimball, 1978). Manganese toxicity was increased by the presence of food during the *D. magna* acute toxicity tests. Biesinger and Christensen (1972) reported an LC50 of 9.80 mg/L for *D. magna* without food added (Table 9).

Chronic Toxicity. Biesinger and Christensen (1972) reported an EC50 value for reproductive impairment of 5.2 mg/L and a 3-week LC50 of 5.7 mg/L. The CV of 4.10 mg/L based on a 3-week toxicity test resulted in 16% reproductive impairment of *D. magna.*

After a 30d exposure to Mn, brown trout showed a decrease in body calcium concentrations and impaired development in the two highest concentrations (0.36 and 1.08 mg/L) tested (Reader et al., 1988). The CV for this assay was calculated at 0.21 mg/L.

Bioaccumulation. Body concentrations of Mn in aquatic organisms is not dependent on the ambient concentration of the metal (Bendell-Young and Harvey, 1986). In young trout, Mn has been known to concentrate in newly forming fibrous or cartilaginous bone (Hibiya 1982), while in older fish, Mn targets the liver and gills (Rouleau et al., 1995). Studies on the bioaccumulation of Mn have found bioconcentration factors for brown trout, fathead minnow, and yellow perch to be 17.8, 22.6 and 12.0, respectively (Rouleau et al., 1995; Kwasnik et al., 1978; Kerns and Vetter, 1982).

Benthic invertebrates appear to play an important role in the transfer of Mn to fish. 70% of the whole body concentrations of Mn was present in the gut contents of *Tipula* (spp.), a detritus feeding aquatic insect (Elwood et al., 1976).

Aquatic Mode of Action. Manganese uptake to the brain occurs via the olfactory system which by its nature, enables the quick deposition of the metal in the olfactory bulb of the brain

(Rouleau et al., 1995). Body deposition occurs via the circulatory system targeting the liver, kidney, muscle and inorganic portions of the bone (Bendell-Young and Harvey, 1986).

Once transfered to the organs, manganese impairs calcium transport. Fish from lakes with high levels of manganese exhibit symptoms of impaired transport of calcium during oogenesis and altered calcium deposition in the skeleton (Beamish et al., 1975; Fraser and Harvey, 1982). Ca^{2+} - ATPase activity on the gill is inhibited and both net uptake and deposition of calcium were impaired by manganese (Reader et al., 1988).

Table 9. Toxicity of manganese to aquatic organisms.

Conc.[a] (mg/L)	Species	Effect	Reference
333000.0	aquatic sowbug *(Asellus aquaticus)*	96h EC50[i]	Martin and Holdich, 1986.
77100.0	aquatic sowbug *(Asellus aquaticus)*	48h EC50[i]	Martin and Holdich, 1986.
51000.0	crayfish *(Orconectes limosus)*	96h LC50	Boutet and Chaisemartin, 1973.
38700.0	rotifer *(Brachionus calyciflorus)*	24h LC50	Couillard et al., 1989.
28000.0	crayfish *(Austropotamobius pallipes)*	96h LC50	Boutet and Chaisemartin, 1973.
16620.0	frog *(Microhyla ornata)*	24h LC50	Rao and Madhyastha, 1987.
16030.0	frog *(Microhyla ornata)*	48h LC50	Rao and Madhyastha, 1987.
3230.0	tropical perch *(Colisa fasciatus)*	96h LC50	Nath and Kumar, 1987.
1679.0	*(Oreochromis mossambicus)*	96h LC50	Seymore et al., 1993
130.0	logfin dace *(Agosia chrysogaster)*	96h LC50	Lewis, 1978.
9.8	water flea *(Daphnia magna)*	LC50	Biesinger and Christensen, 1972.

[a]- concentrations given as Mn, not the compound
[i]- immobilization

MERCURY

Mercury (Hg) has no known biological function and is toxic to fish and wildlife. It is a mutagen and carcinogen that adversely affects the central nervous, renal, and reproductive systems of wildlife. Hg occurs in the environment as elemental mercury, Hg_2(II) and Hg(II), the latter of which is naturally oxidized from elemental mercury (Eisler, 1987). Mercury in ambient waters commonly occurs as mercury (II) or methylmercury. Mercury (II) can be methylated by both aerobic and anaerobic bacteria in the slime coat, liver, and intestines of fish, but methylation apparently does not occur in other tissues or in plants (EPA, 1985-Hg). From a toxicological standpoint, methylmercury (MeHg) poses a greater threat to biota due to its high stability and the ease with which it penetrates membranes in living organisms. Hg(II), however, is more prevalent in aquatic systems, bound up and unavailable in sediment layers. Biota bioconcentrate mercury compounds which can be further biomagnified through food chains (Wren, 1986). High concentrations of mercury in water are often associated with low alkalinity lakes and newly created bodies of water (Weiner and Stokes, 1990). Alkalinity, ascorbic acid, chloride, dissolved oxygen, hardness, organic complexing agents, pH, sediment, and temperature probably affect the acute and chronic toxicity and bioaccumulation of the various forms of mercury.

Anthropogenic sources of Hg include the combustion of fossil fuels, metal mining and processing plants, chloralkali plants, and disposal of batteries and fluorescent lamps (NAS 1978, and Das et al., 1982; as cited in Eisler, 1987).

Acute Toxicity. Acute toxicity values for mercuric chloride range from 0.001 mg/L for the toad, *Gastroqhyryne carolinensis* (Birge et al., 1979b) to 2.00 mg/L for the caddisfly, *Hydropsyche betteni* (EPA, 1985-Hg) (Table 10). Acute toxicty values for methylmercury include 96h LC50s of 0.065 and 0.024 mg/L for brook trout *(Salvelinus fontinalis)* (McKim et al., 1976) and rainbow trout *(Oncorhynchus mykiss)* (EPA, 1980) (Table 11).

As reported by Armstrong (1979; as cited in Eisler, 1987) symptoms of acute mercury poisoning include, "flaring of gill covers, increased frequency of respiratory movements, loss of equilibrium, and sluggishness."

Chronic Toxicity. Fathead minnows *(Pimephales promelas)* were exposed to 0.00026-0.00369 mg/L $HgCl_2$ for 41 weeks. Reproductive inhibition, including a decrease in egg production, occurred at all concentrations tested while spawning ceased at 0.001 mg/L and above. Significant growth retardation of males occurred at 0.00369 mg/L. During the second part of the assay, a 60d test, survival of the minnows was significantly reduced at 0.00451 mg/L. After 30d of testing, growth retardation was evident at and above 0.00127 mg/L. The 7d LC50 was calculated at 0.074 mg/L Hg (Snarski and Olson, 1982).

When comparing three mercury compounds, Biesinger et al., 1982 found that MeHg was more fatal to *Daphnia magna* than $HgCl_2$ and phenyl mercuric acetate (PMA) following a 3 week exposureii. At 0.004 mg/L MeHg, survival was 0% following an 8d exposure. PMA decreased survival by 26% at 0.005 mg/L and by 97% at 0.01 mg/L. $HgCl_2$ proved 100% fatal at 0.0136 mg/L and 40% fatal at 0.0068 mg/L.

Dave and Xiu (1991) ran 16d tests on the embryos and larvae of the zebrafish *(Brachydanio rerio)* exposing the fish to 0.001-0.512 mg/L Hg as HgCl2. At 0.032, hatching was completely inhibited and the CV was calculated at 0.002 mg/L. The 3-week CV for the toxicity of mercury to

D. magna is 0.0034 mg/L resulting in 16% reproductive impairment (Biesinger and Christensen, 1972) (Table 10).

As reported by Armstrong (1979; as cited in Eisler, 1987) symptoms of chronic mercury exposure in fish include, "emaciation (due to appetite loss), brain lesions, cataracts, diminished response to change in light intensity, inability to capture food, abnormal motor coordination, and various erratic behaviors."

Toxicity to Aquatic Plants. Toxicity values for mercuric chloride range from a 32d EC50 (root weight) of 3.4 mg/L for eurasian milfoil (Stanley, 1974) to an acute EC50 for the alga *(Anabaena flosaque)* of 0.053 mg/L (Thomas and Montes, 1978) (Table 1). *Pistia stratiotes* L. were exposed to 0.05-20.0 mg/L Hg as $HgCl_2$ for 7d. At 20.0 mg/L all plants died after 2d. No other deaths were reported in the remaining test groups (De et al., 1985).

Bioaccumulation. Uptake of MeHg by aquatic organisms may range from 8.5 to 16 times greater than that of Hg(II) (Olson et al., 1975; as cited in Snarski and Olson, 1982). Uptake and accumulation of mercury compounds by *Daphnia magna* was measured by Biesinger et al. (1982). MeHg yielded the highest tissue concentration of 184.5 mg/kg upon exposure to 0.00026 mg/L and $HgCl_2$ yielded a tissue concentration of 23.28 mg/kg upon exposure to 0.0027 mg/L.

Snarski and Olson (1982) exposed fathead minnows to 0.00031- 0.00451 mg/L Hg as $HgCl_2$. Whole body concentrations of mercury reflected water concentration ranging from 0.8 mg/kg at the lowest concentration tested to 4.18 mg/kg at the highest concentration tested.

Maximum accumulation of Hg(II) in *Pistia stratiotes* L. occurred in the roots and shoots during first day of exposure to 0.05-20.0 mg/L Hg(II) (De et al., 1985).

Hg has a biological half life in fish of 2-3 years. Depuration of mercury from aquatic organisms is considered extremely slow, and decreases in body concentration may be primarily due to dilution from tissue growth and development (EPA, 1985-Hg).

Aquatic Mode of Action. Mercury binds with sulfhydrl groups on proteins resulting in numerous sites and modes of action. Probably the most important is inhibition of cell division.

Water Quality Criteria. The NAWQ criteria for Hg(II) is 0.00244 mg/L and the final chronic value is 0.00130 mg/L (EPA, 1985- Hg). Calculated Tier II values for methylmercury are SAV- 0.000099 mg/L; SCV- 0.0000028 mg/L (Suter and Tsao, 1996).

Table 10. Toxicity of mercuric chloride to aquatic organisms.

Conc. (mg/L)[a]	Species	Effect[b]	Reference
3.400	eurasian milfoil *(Myrophyllum spicatum)*	32d EC50	Stanley, 1974
2.000	caddisfly *(Hydropsyche betteni)*	LC50	EPA, 1985-Hg
2.000	mayfly *(Ephemerella subvaria)*	LC50	EPA, 1985-Hg
2.000	stonefly *(Acroneuria lycorias)*	LC50	EPA, 1985-Hg
1.400	indian food fish *(Channa gachua)*	96h LC50	Hanumante and Kulkarni, 1979.

Conc. (mg/L)[a]	Species	Effect[b]	Reference
1.030	alga *(Chlorella vulgaris)*	33d EC50	Rosko and Rachlin, 1977
1.000	mozambique tilapia *(Tilapia mossambica)*	LC50	EPA, 1985-Hg
0.500	tubificid worm *(Spirosperma nikolskyi)*	LC50	EPA, 1985-Hg
0.440	fish *(Notopterus notopterus)*	96h LC50	Verma and Tonk, 1983
0.370	snail *(Aplexa hypnorum)*	96h LC50	Holcombe et al., 1983
0.330	tubificid worm *(Spirosperma ferox)*	LC50	EPA, 1985-Hg
0.250	tubificid worm *(Quistadrilus multisetosus)*	LC50	EPA, 1985-Hg
0.240	coho salmon *(Oncorhynchus kisutch)*	96h LC50	Lorz, 1978
0.240	tubificid worm *(Rhyacodrilus montana)*	LC50	EPA, 1985-Hg
0.180	tubificid worm *(Limnodrilus hoffmelsteri)*	LC50	EPA, 1985-Hg
0.168	fathead minnow *(Pimephales promelas)*	96h LC50	Snarski and Olson, 1982
0.160	bluegill *(Lepomis macrochirus)*	96h LC50	Holcombe et al., 1983
0.140	tubificid worm *(Stylodrilus heringianus)*	LC50	EPA- Hg, 1985
0.140	tubificid worm *(Tubifex tubifex)*	LC50	EPA- Hg, 1985
0.108	salamander *(Ambystoma opacum)*	96h LC50	Birge et al., 1979b
0.100	tubificid worm *(Varichaeta pacifica)*	LC50	EPA, 1985-Hg
0.080	tubificid worm *(Branchiura sowerbyi)*	LC50	EPA, 1985-Hg
0.074	fathead minnow *(Pimephales promelas)*	7d LC50	Snarski and Olson, 1982
0.063	frog *(Rana catesbeiana)*	96h LC50	McCrary, 1995
0.053	alga *(Anabaena flosaquae)*	EC50	Thomas and Montes, 1978
0.053	mosquitofish *(Gambusia affinis)*	96h LC50	McCrary, 1995
0.050	crayfish *(Orconectes limosus)*	LC50	EPA, 1985-Hg
0.044	aquatic oligochaete *(Lumbriculus variegatus)*	96h LC50	McCrary, 1995
0.030	guppy *(Poecilla reticulata)*	LC50	EPA, 1985-Hg
0.020	crayfish *(Faxonella clypeatus)*	LC50	EPA, 1985-Hg
0.017	fish *(Notemigonus crysoleucas)*	96h LC50	McCrary, 1995
0.015	frog *(Rana clamitans)*	96h LC50	McCrary, 1995
0.010	cricket frog *(Acris sp.)*	96h LC50	Birge et al., 1979
0.010	scud *(Gammarus pseudolimnaeus)*	96h LC50	EPA, 1980
0.007	leopard frog *(Rana pipens)*	96h LC50	Birge et al., 1979b
0.007	frog *(Rana sphenocephala)*	96h LC50	McCrary, 1995
0.005	water flea *(Daphnia magna)*	96h LC50	EPA, 1980

Conc. (mg/L)[a]	Species	Effect[b]	Reference
0.0034	water flea *(Daphnia magna)*	CV	Biesinger and Chistensen, 1972
0.003	water flea *(Daphnia magna)*	EC50	EPA, 1985-Hg
0.002	acute NAWQC		EPA, 1985-Hg
0.002	treefrog *(Hyla spp.)*	96h LC50	Birge et al., 1979b
0.002	water flea *(Daphnia pulex)*	EC50	EPA- Hg, 1985
0.002	crayfish *(Orconectes limosus)*	30d LC50	EPA, 1980
0.002	zebrafish *(Brachydanio rerio)*	CV	Dave and Xiu, 1991
0.001	final chronic value		EPA, 1985-Hg
0.001	toad *(Gastrophyryne carolinensis)*	96h LC50	Birge et al., 1979b
0.00023	fathead minnow *(Pimephales promelas)*	CV	EPA, 1985-Hg

[a]- concentrations given as Hg(II) not the compound
[b]- all endpoints are considered acute, unless otherwise noted

Table 11. Toxicity of methylmercury to aquatic organisms.

Conc. (mg/L)[a]	Species	Endpoint	References
0.50000	flatworm *(Dugesia dorotocephala)*	5d LC100	Best et al., 1981
0.06500	brook trout *(Salvelinus fontinalis)*	96h LC50	EPA, 1980
0.02400	rainbow trout *(Oncorhynchus mykiss)*	96h LC50	EPA, 1980
0.00600	alga *(Anabaena flosaquae)*	EC50	Thomas and Montes, 1978
0.00052	brook trout *(Salvelinus fontinalis)*	CV	McKim et al., 1976
0.00004	water flea *(Daphnia magna)*	CV	Biesinger et al., 1982

[a]- concentrations given as MeHg

NICKEL

Nickel is a naturally occuring element that may exist in various mineral forms. It forms 0.008% of the earth's crust (NAS, 1980). Soil and sediment are the primary receptacles for nickel, but mobilization may occur depending on physico-chemical characteristics of the soil (ATSDR, 1988; USAF, 1990). 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. Nickel occurs in nature in the nonionic and divalent states; other valence states occur very infrequently (Mastromatteo, 1986). Although nickel can exist in several oxidation states, the divalent cation state predominates and is generally considered the most toxic form (EPA 1986-Ni). As with many metals the toxicity of nickel increases as hardness decreases. Fish and invertebrates have approximately the same range of sensitivity.

Acute Toxicity. Acute toxicities of nickel to aquatic life, normalized to 100 and 200 mg/L of hardness, are presented in Table 12. Acute toxicities, normalized to 100 mg/L, range from 2.5 to 77.7 mg/L and while acute toxicities normalized to 200 mg/L range from 5.7 to 139.7 mg/L. Biesinger and Christensen (1972) reported 48-hr LC50 values for *D. magna* of 1.120 and 0.510 mg/L with and without food, respectively.

Chronic Toxicity. The chronic toxicity of nickel to aquatic life, normalized to 100 mg/L, range from 0.0106 to 0.502 mg/L while chronic toxicities normalized to 200 mg/L, range from 0.398 to 0.746 mg/L. In general, invertebrates are more sensitive to nickel than fish. Biesinger and Christensen (1972) reported a 3-week CV of 0.030 mg/L which caused 16% reproductive impairment in *D. magna.*

Table 12. Toxicity of nickel to aquatic organisms (EPA 1986-Ni).

Concentration (mg/L)		Effect
100 mg/L hardness	200 mg/L hardness	
77.7	139.7	banded killifish (*Fundulus diaphanus*) LC50
72.7	130.7	stonefly (*Acroneuria lycorias*) LC50
54.3	97.6	caddisfly LC50
38.3	68.9	goldfish (*Carassius auratus*) LC50
38.1	68.5	damselfly LC50
25.3	45.6	Worm *(Nais sp.)* LC50
24.1	43.2	rainbow trout (*Oncorhyncus mykiss*) LC50
23.4	42	amphipod (*Gammarus* sp.) LC50
23.3	41.8	white perch (*Morone americana*) LC50
23	41.3	snail (*Amnicola sp.*) LC50
21.9	39.4	American eel (*Anguilla rostrata*) LC50
19.4	31.4	bluegill (*Lepomis macrochirus*) LC50
17.6	31.7	common carp (*Cyprinus carpio*) LC50
17.4	31.2	guppy (*Poecilla reticulata*) LC50
14.3	25.3	fathead minnow (*Pimephales promelas*) LC50
13.6	24.4	pumpkinseed (*Lepomis gibbosus*) LC50
12.2	25.2	striped bass (*Morone saxatillis*) LC50
8.33	15	Mayfly (*Ephemerella subvaria*) LC50
7.75	13.9	rock bass (*Ambioplites rupestris*) LC50
3.67	6.6	*Daphnia pulicaria* EC50

Concentration (mg/L)		Effect
100 mg/L hardness	200 mg/L hardness	
2.5	5.7	*Daphnia magna* EC50
1.42	2.55	acute NAWQC
0.502	0.746	fathead minnow (*Pimephales promelas*) CV
0.231	0.415	Caddisfly (*Clistoronia magnifica*) CV
0.162	0.291	rainbow trout (*Oncorhynchus mykiss*) CV
0.158	0.283	chronic NAWQC
0.0809	0.398	*Daphnia magna* CV
0.0106		*Ceriodaphnia dubia* CV[a]

[a] Seven day test at 117 mg/L hardness from Kszos et al. (1992).

SELENIUM

Selenium (Se), is an essential nutrient for some plants and animals when present in trace amounts. However, at levels currently present in the environment, Se poses a significant toxic risk. Anthropogenic sources include the combustion of fossil fuels, municipal wastes, irrigation run-off and industrial effluents. Lechate from seleniferous soils also contributes to the presence of Se in the environment (Eisler, 1985b). 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. Plants have the ability to convert inorganic selenium to organic selenium compounds, thereby increasing their biological availability (Lo and Sandi, 1980).

Acute Toxicity. Acute toxicity values for Se(IV) are available for 23 freshwater fish and invertebrate species in 22 genera and range from 0.304 mg/L for the amphipod *Hyalella azteca* to 203.0 mg/L for the leech *Nephelopsis obscura.* The two most sensitive and resistant species were invertebrates. The species mean acute values were (0.8555 mg/L) for *Daphnia magna* and (1.601 mg/L) for the fathead minnow (EPA, 1987).

Acute toxicity values for Se(VI) are available for 12 freshwater animal species and range from 0.06538 mg/L for the amphipod *Gammarus pseudolimnaeus* to 442.0 mg/L for the leech *Nephelopsis obscura.* The species mean acute values were (1.450 mg/L) for *Daphnia magna* and (5.5 mg/L) for the fathead minnow (EPA, 1987) (Tables 13,14).

Chronic Toxicity. Chronic values for Se(IV) ranged from >0.047 mg/L for the rainbow trout *(Onchorhychus mykiss)* to 0.6928 mg/L for *D. magna.* Chronic values for Se(VI) ranged from 0.5655 mg/L for the fathead minnow *(Pimephales promelas)* to 2.891 mg/L for the rainbow trout *(Onchorhychus mykiss). Daphnia magna* had a chronic value of 1.99 mg/L (EPA, 1987) (Table 13, 14).

Toxicity to Aquatic Plants. Kumar and Prakash (1971) found the 96h LC50 for the algae *Anabaena variabilis* to be 15.0-17.0 mg/L Se(IV). In a similar study, the 48h LC50 for *Oedogonium cardiacum* was found to be less than 0.1 mg/L (Nassos et al., 1980; as cited in Eisler, 1985b). Blue-green algae appear to be more resistant to Se(VI) than green algae as the lowest concentration to affect growth of the former lies at 10.0 mg/L Se(VI) (Vocke et al., 1980; as cited in EPA, 1987).

Bioaccumulation. Se accumulation is quite variable and not known to be affected by water hardness and temperature (Lemley, 1982; as cited in EPA, 1987). Nassos et al. (1980; as cited in Eisler, 1985b) found short-term exposure yielded BCFs of 460 for the mosquitofish and 32,000 for the freshwater gastropod. Long-term studies yielded lower BCFs; 6 for the common carp after an 85d exposure to 1.0 mg/L Se. Target organs for the carp were the kidney and liver (Sato et al., 1980; as cited in Eisler, 1985b). Se(VI) bioaccumulation factors for the fathead minnows ranged from 21 to 52 (Bertram and Brooks, 1986; as cited in EPA, 1987). Adams (1976; as cited in EPA, 1987) looked at the uptake of Se(IV) by fathead minnows. Initially, concentrations in the tissue and whole

body increased rapidly, however, after 8d the rate fell off until steady state was approached, but never reached, at 96d.

Aquatic Mode of Action. Ellis et al. (1937; as cited in Eisler, 1985b) observed a number of symptoms typical of selenium toxicosisin fish: loss of equilibrium, lethargy, contraction of dermal chromatophores, loss of coordination, muscle spasms, protruding eyes, swollen abdomen, liver degeneration, reduction in blood hemoglobin and erythrocyte number, and increase in white blood cells.

Water Quality Criteria. The species of selenium are not differentiated in the water quality criteria. The acute and chronic NAWQ criteria for the protection of aquatic organisms are 0.02 and 0.005 mg/L, respectively (EPA, 1987).

Table 13. Toxicity of Se(IV) to aquatic organisms (EPA, 1987).

Conc. (mg/L)	Effect
203	Leech (*Nepheiopsis obscura*) LC50
42.5	Midge(*Tanytarsus dissimilis*) LC50
35	Common carp (*Cyprinus carpio*) LC50
34.91	Snail (*Aplexa hypnorum*) LC50
30.18	White sucker (*Cotostomus commersoni*) LC50
28.5	Bluegill (*Lepomis macrochirus*) LC50
26.1	Goldfish (*Carassius auratus*) LC50
25.93	Midge (*Chironomus plumosus*) LC50
24.1	Snail (*Physa sp.*) LC50
13.6	Channel catfish (*Ictalurus punctatus*) LC50
12.6	Mosquitofish (*Gambusia affinis*) LC50
11.7	Yellow perch (*Perca flavescens*) LC50
10.49	Rainbow trout (*Onchorhynchus mykiss*)LC50
10.2	Brook trout (*Salvelinus fontinalis*) LC50
6.5	Flagfish (*Jordonella floridae*) LC50
3.87	Water flea (*Daphnia pulex*) EC50
2.704	Amphipod (*Gammarus pseudolimnaeus*) LC50
1.783	Striped bass (*Morone saxatilis*) LC50
1.7	Hydra (*Hydra sp.*) LC50
1.601	Fathead minnow (*Pimephales promelas*) LC50
0.8558	Water flea (*Daphnia magna*) EC50
0.6928	Water flea (*Daphnia pulex*) CV
<0.6036	Water flea (*Ceriodaphnia affinis*) EC50
0.304	Amphipod (*Hyalella azteca*) LC50
0.1615	Water flea (*Daphnia magna*) CV

Conc. (mg/L)	Effect
0.1127	Fathead minnow (*Pimephales promelos*) CV
0.09165	Water flea (*Daphnia magna*) CV
0.0883	Rainbow trout *(Onchorhynchus mykiss)*CV

Table 14. Toxicity of selenium (VI) to aquatic organisms (EPA, 1987).

Conc. (mg/L)	Effect
442.0	Leech (*Nephelepsis obscura*) LC50
193.0	Snail (*Aplexa hypnorum*) LC50
66.0	Channel catfish (*Ictalurus punctatus*) LC50
63.0	Bluegill (*Lepomis macrochirus*) LC50
47.0	Rainbow trout (*Onchorhynchus mykiss)* LC50
20.0	Midge (*Paratanytarsus parthenogeneticus*) LC50
7.30	Hydra (*Hydra sp.*) LC50
5.50	Fathead minnow (*Pimephales promelas*) LC50
2.891	Rainbow trout (*Onchorhynchus mykiss)* CV
1.999	Water flea (*Daphnia magna*) CV
1.450	Water flea (*Daphnia magna*) EC50
0.760	Amphipod *(Hyalella azteca*) LC50
0.5655	Fathead minnow (*Pimephales promelas*) CV
0.246	Water flea (*Daphnia pulicaria*) EC50
0.06538	Amphipod (*Gammarus pseudolimnaeus*) LC50

SILVER

Silver (Ag), a basic element, occurs naturally in the environment as a soft, silver colored metal (ATSDR, 1989b). It also occurs in a powdery white or dark gray to black compound. Silver is found at an average of 0.1 mg/kg in the earth's crust and about 0.3 mg/kg in soils. Silver metals and silver compounds are used in the production of surgical protheses, fungicides, coinage, jewelry, and dental fillings (Fisher et al., 1984). The accumulation of silver in marine algae appears to result from adsorption rather than uptake; bioconcentration fators of 13,000 - 66,000 have been reported (Fisher et al., 1984; ATSDR, 1989b).

Acute Toxicity. Toxicity of silver to freshwater fish and invertebrates is dependent upon water hardness and chloride content, with silver being more toxic in soft and low chloride water (EPA 1980-Ag). Toxicity of silver is dependent upon the form of the element. In tests with fathead minnow, free silver ion is the form of silver most acutely toxic to fish, with a 96-h LC50 of 0.016 mg/L, followed by silver thiosulfate complex (280-360 mg/L), and silver sulfide (>240 mg/L).

Acute toxicity data are available for four invertebrate species (EPA 1980-Ag), with acute values ranging from 0.00683 mg/L for *Daphnia magna* to 52.4 mg/L for the scud *Gammarus pseudolimnaeus*, both of which were tested in Lake Superior water. Acute values for fish in a hardness of 100 mg/L Ca range from 0.309 mg/L for the bluegill *(Lepomis macrochirus)* to 0.0106 mg/L for the speckled dace (*Rhinichthys osculus*) (EPA, 1980-Ag) (Table 15).

Chronic Toxicity. Chronic values for rainbow trout listed in EPA (1980-Ag) are between 0.00009 and 0.0159 mg/L. One of these studies was an 18-month study to evaluate the effects on silver nitrate in soft water on survival and growth of rainbow trout was conducted by Davies et al., (1978). The exposure was initiated with eyed embryos which hatched after 26 days. The "no-effect" concentration was between 0.00009 and 0.00017 mg/L, based on mortality data. However, this concentration does not reflect possible effects of silver on spawning behavior or reproduction. From 3.5 months of exposure to the end of the experiment, significant decreases in growth occurred in fish exposed to 0.00069 mg/L Ag. Egg and sac-fry mortality was 52% in the 0.00069 mg/L concentration.

Results of exposing fathead minnow embryos and larvae to silver sulfide at 11 mg/L (total silver) resulted in no significant effects on average wet weight or total length of larvae after 30 days of continuous exposure. Exposures of silver thiosulfate complex at total silver concentrations greater than 35 mg/L caused significant effects in survival and total length. Concentrations of 140 mg/L total silver resulted in a significant reduction in egg hatch (LeBlanc et al., 1984).

Table 15. Toxicity of silver to aquatic organisms (EPA 1980- Ag).

Concentration (mg/L)		Effect
100 mg hardness	200 mg hardness	
15.9	52.4	scud (*Gammarus pseudolimnaeus*) LC50
15.2	50.1	rotifer (*Philodina acuticornis*) LC50
11.3	37.3	midge (*Tanytarsus dissimilis*) LC50
0.309	1.020	bluegill (*Lepomis macrochirus*) LC50

Concentration (mg/L)		Effect
100 mg hardness	200 mg hardness	
0.046	0.113	rainbow trout (*Oncorhynchus mykiss*) LC50
0.0339	0.1118	flagfish (*Jordanella floridae*) LC50
0.0271	0.0765	fathead minnow (*Pimephales promelas*) LC50
0.011	0.036	mottled sculpin (*Cottus bairdi*) LC50
0.0106	0.0350	speckled dace (*Rhinichthys osculus*) LC50
0.00791	0.00791	water flea (*Daphnia magna*) CV
0.00683	0.03484	water flea (*Daphnia magna*) EC50
0.0041	0.0134	NAWQC acute value
0.0012	0.0012	rainbow trout (*Oncorhynchus mykiss*) CV

[a] Acute effect levels were converted based on a 100 mg/L water hardness. Slopes used for the conversion were associated with individual species, where specified in the Criteria document. Otherwise, 1.72 was used. Chronic values were not converted based on water hardness, since no correlation was evident. A chronic NAWQC has not been determined.

[b] Acute effect levels were converted based on a 200 mg/L water hardness.

THALLIUM

Thallium (Tl) is a widely distributed metal, occurring at concentrations of approximately 1 mg/kg in the earth's crust (Kazantzis, 1979). Tl exists as Tl(II) or the more stable, and soluble, Tl(I) and is soluble over a wide range of pH (Kwan and Smith, 1991). Industrial uses of thallium include alloys, electronic devices, special glass and explosives (Zitko, 1975). Coal-fired power plants are major sources of Tl air pollution due to its presence in flyash (Wallwork-Barber et al., 1985). The international market for thallium is limited, therefore its removal from mining effluent is of low priority (Zitko et al., 1975). Thallium has been used since the 1920s as a rodenticide and is a major primary and secondary source of poisoning for raptors and other predatory mammals (Crabtree, 1962; Robinson, 1948: as cited in Bean and Hudson, 1976). Due to their high toxicity to larger mammals, their use against larger predatory animals was cancelled in 1972 (Zitko, 1975).

Chronic Toxicity. LeBlanc and Dean (1984) exposed fathead minnows (48h post fertilization) to Tl as thallium sulfate for 30d. At 0.72 mg/L none of the larvae hatched and at 0.35 mg/L none survived after 30d. 0.04 mg/L significantly reduced larval survivability and was considered the CV.

Bioaccumulation. Uptake of Tl by aquatic plants appears to be a metabolically mediated process due to its strong dependence on temperature and light conditions. Optimal conditions for uptake occur at pH 6 and temperatures above 12°C. Mechanisms of absorption in *Lemna minor* L. became saturated at concentrations above 204.4 mg/L after which, absorption ceased to occur, despite increased concentrations of Tl (Kwan and Smith, 1991).

Aquatic Mode of Action. Due to its low complexation ability the toxic action of Tl, unlike most metals, is not affected by the presence of humic acid or water hardness (O'Shea, 1972: as cited in Zitko et al., 1975; Zitko 1975). Hypertension in fish may be a reaction to the oxidation of Tl(I) to (III) inhibiting ATPase of amino storing granules, causing abnormalities in catecholamine metabolism (Burger and Starke, 1969: as cited in Zitko, 1975).

Water Quality Criteria. Suter and Tsao (1996) calculated SAV and SCV values for Tl(I) of 105.2 mg/L and 12 mg/L, respectively.

URANIUM

Uranium (U) is a silvery white metal consisting of three semistable radioactive isotopes; U238, U235, and U234 (Brobst and Pratt, 1973) making up approximately 3-4 mg/kg of the earth's crust (Merritt, 1971). Despite their radioactive properties, metallic uranium and particles of insoluble uranium compounds are biologically inert, its chemical toxicity being exerted only by its aqueous ions (Durbin and Wrenn, 1975). Aqueous ions have been identified for uranium (III), uranium (IV), uranium (V), and uranium (VI), but only uranium (IV) and uranium (VI) are stable in solution. In a solution of low acidity, uranium (IV) hydrolyzes to form insoluble hydroxides (Durbin and Wrenn, 1975). Uranyl nitrate and uranyl fluoride are 1.4–2 times more toxic than UCl_5, UCl_4, UO_3, or $NO_2U_2O_7$ and 3 times more toxic than $(NH_4)_2U_2O_7$ (Durbin and Wrenn, 1975). Uranium-235 is the most radioactive of the uranium isotopes. Other uranium isotopes including uranium-233, -234, and -238 have low specific activities, long half-lives, and have lower potential to cause radiation induced diseases (ATSDR, 1990).

In its radioactive elemental form, U fuels nuclear reactions, and is used in the manufacture of nuclear weapons and amunition. In its natural or depleted form U is used as counterweights in airplanes and as shielding material (Burkart, 1991)

Acute Toxicity. Relatively little aquatic toxicity data is available for uranium. The only standard data are LC50s for fathead minnow with values for various uranium salts ranging from 2.8 to 135 mg/L (Cushman et al., 1977). Toxic concentrations from nonstandard and poorly documented tests fall within this range.

ZINC

Zinc (Zn) is an essential trace element in all 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). Zinc phosphide is used as a rodenticide. Zinc makes up about 0.002% of the earth's crust (NAS, 1980) and occurs in many forms in natural waters and aquatic sediments.

In freshwater with pH >4 and <7, the dominant forms of dissolved zinc are the free ion (aquo ion complex) (98%) and zinc sulfate (2%) (Campbell and Stokes, 1985), whereas at pH 9.0, the dominant forms are the monohydroxide ion (78%), zinc carbonate (16%), and the free ion (6%) (EPA, 1987-Zn).

Zinc occurs in nature as a sulfide, oxide, or carbonate (Eisler, 1993). It is divalent in solution. 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 0.040 mg/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).

Toxicity to Aquatic Plants. Although freshwater plants are often more sensitive to zinc than freshwater animals, the range of toxicity values was much greater: growth of the algae *Selenastrum capricornutum* was inhibited by 0.030 mg/L whereas several other species of green algae had 96-hour EC50s that exceeded 200.0 mg/L (EPA, 1987-Zn).

INORGANICS

BENZENE

Toxicity to Aquatic Organisms. Suter and Tsao (1996) reported lowest chronic values for aquatic plants and daphnids of 525.0 and >98.0 mg/L, respectively. Tier II values include a SAV of 2.3 mg/L and a SCV of 0.13 mg/L. Out of the three invertebrate studies cited, LC50s range from 100.0 mg/L for *Chironomus thummi* to 620.0 mg/L for *D. Magna*. Out of the seven vertebrate studies cited, LC50s range from 4.63 mg/L for *Oncorhynchus gorbuscha* to 425.0 mg/L for *Ictalurus punctatus*.

BIS (2-ETHYLHEXL) PHTHALATE

Bis(2-ethylhexyl)phthalate (BEHP) or di(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. The wide-spread uses of bis(2-ethylhexyl)phthalate have made the compound, along with other phthalic acid esters, ubiquitous in the environment. It has been detected in ground water, surface water, drinking water, air, soil, plants, fish and animals (Sittig, 1985; Sandmeyer and Kirwin, 1978). While bioaccumulation factors for bis(2-ethylhexyl)phthalate at lower trophic levels are high, because it is rapidly metabolized, levels in higher trophic levels are generally lower than those observed at lower trophic levels (Peakall, 1975).

Toxicity to Aquatic Organisms. Suter and Tsao (1996) reported a lowest chronic value for daphnids of 0.912 mg/L. Tier II values include a SAV of 0.0266 mg/L and a SCV of 0.003 mg/L. Out of the four invertebrate studies cited, LC50s range from >32.0 for the amphipod *(Gammarus pseudolimnaeus)* to 0.133 mg/L for *D. pulex.* Out of the seven vertebrate studies cited, LC50s range from >0.16 mg/L for the fathead minnow *(Pimephales promelas)* to >770.0 mg/L for the bluegill *(Lepomis macrochirus).*

CARBON DISULFIDE

Toxicity to Aquatic Organisms. Suter and Tsao (1996) reported lowest chronic values for fish and daphnids of 9.538 and 0.244 mg/L, respectively. Tier II values include a SAV of 0.01653 mg/L and a SCV of 0.00092 mg/L. The only study available for carbon disulfide yielded a LC50 of 4.0 for the guppy *(Poecilia reticulata)* in circumneutral water.

CARBON TETRACHLORIDE

Toxicity to Aquatic Organisms. Suter and Tsao (1996) reported lowest chronic values for fish and daphnids of 1.97 and 5.58 mg/L, respectively. Tier II values include a SAV of 0.1757 mg/L and a SCV of 0.0098 mg/L. Fathead minnows *(Pimephales promelas)* are the only known test organisms yielding an LC50 between 41.4 and 43.3 mg/L.

ETHYLBENZENE

Toxicity to Aquatic Organisms. Suter and Tsao (1996) reported lowest chronic values for fish, daphnids, and aquatic plants of >0.44, 12.922, and >438.0 mg/L, respectively. Tier II values include a SAV of 0.13 mg/L and a SCV of 0.0073 mg/L. Known values include an EC50 of 8.45 mg/L for the fathead minnow and a LC50 of 9.6 mg/L for the guppy *(Poecilia reticulata)*.

NAPTHALENE

Naphthalene is a white solid substance used in the manufacture of dyes, resins and in mothballs. It is released to the air from the burning of coal and oil and from the use of mothballs containing naphthalene. Naphthalene may also be released into the air by coal tar production and wood preservation. In water and soil, naphthalene is either destroyed by bacteria or evaporated into the air within a few hours or days (ATSDR, 1989c). Naphthalene breaks down readily in the environment and is easily metabolized by various organisms (ATSDR, 1989c).

Toxicity to Aquatic Organisms. Suter and Tsao (1996) reported lowest chronic values for fish, daphnids, and aquatic plants of 0.62, 1.163, and 33.0 mg/L, respectively. Tier II values include a SAV of 0.186 mg/L and a SCV of 0.012 mg/L. Two daphnid invertebrate studies found EC50s of 2.194 and 4.663 mg/L for *D. magna* and *D. pulex*, respectively. Vertebrate LC50 values range from 1.6 mg/L for the rainbow trout *(Oncorhynchus mykiss)* to 7.9 mg/L for the fathead minnow. A chronic value of 0.619 mg/L was found for the fathead minnow.

POLYCHLORINATED BIPHENYLS

Polychlorinated biphenyls (PCB's) are a family of man-made chemicals consisting of 209 individual compounds with varying toxicity (ATSDR, 1989d). Aroclor is the trade name for PCB's made by Monsanto. Because of their insulating and nonflammable properties, PCB's were widely used in industrial applications such as coolants and lubricants in transformers, capacitors, and electrical equipment (ATSDR, 1989d). The United States stopped manufacturing PCB's in 1977 due to evidence that they accumulated in the environment. Although PCB's are no longer manufactured or used in the United States, they remain present and will continue to become a widespread environmental contaminant. The biodegradation of PCB's in soil is slow, especially in soils with high organic carbon content (ATSDR, 1993).

Table 1. Toxicity of PCBs to aquatic life (EPA, 1980).

Conc. (mg/L)	Effect
0.283	damselfly (*Ischnura verticalis*) LC50
0.046	Scud (*Gammarus pseudolimnaeus*) LC50
0.033	fathead minnow (*Pimephales promelas*) LC50
0.019	redear sunfish (*Lepomis microlophus*) LC50
0.010	Scud (*Gammarus fasciatus*) LC50
0.00514	cladoceran (*Daphnia magna*) CV
0.00402	Scud (*Gammarus pseudolimnaeus*) CV
0.0023	largemouth bass (*Micropterus salmoides*) LC50
0.0020	rainbow trout (*Oncorhynchus mykiss*) LC50
0.00186	fathead minnow (*Pimephales promelas*) CV
0.0010	brook trout (*Salvelinus fontinalis*) CV
0.00080	Midge (*Tanytarsus dissimilis*) CV

TOLUENE

Toxicity to Aquatic Organisms. Suter and Tsao (1996) reported lowest chronic values for fish, daphnids, and aquatic plants of 1.269, 25.229, and 245.0 mg/L, respectively. Tier II values include a SAV of 0.12 mg/L and a SCV of 0.0098 mg/L. Fathead minnows were the only test species found with LC50 values ranging from 18.0 to 36.2 mg/L.

XYLENE

Toxicity to Aquatic Organisms. Suter and Tsao (1996) reported a lowest chronic value for fish to be 62.308 mg/L. Tier II values include a SAV of 0.2323 mg/L and a SCV of 0.013 mg/L. Bluegills *(Lepomis macrochirus)* yielded a LC50 of 15.7 mg/L, while fathead minnows had EC50 values of 15.3 and 14.8 mg/L.

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TOXICITY TO BENTHIC INVERTEBRATES

ORGANICS

ANTIMONY

Antimony (Sb) 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, 1990). Antimony 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 parasiticides (Beliles, 1979).

Toxicity in Sediment to Benthic Invertebrates. Freshwater data for the toxicity of antimony in sediment is not available, however, Long and Morgan (1991) reported data for the toxicity of antimony in sediment for marine water. The data from Commencement Bay, Washington indicated that toxicity to both *Rhepoxynius abronius* and the larvae of the oyster *Crassostrea gigas* increased with increasing antimony concentrations in the sediment. Data collected from San Francisco Bay, however, showed no relation between toxicity to amphipods and antimony concentration. Sediments that were least toxic or not toxic had higher antimony concentrations than sediments that were most toxic or significantly toxic. The suggested Effects Range-Low (ER-L) and Effects Range-Medium (ER-M) values are 2.0 and 25 mg/kg, respectively.

ARSENIC

Arsenic (As) is a naturally-occuring metaloid found in air and all living organisms. It is present in the earth's crust at approximately 2 mg/kg and is sparingly soluble in water and body fluids. It occurs as two forms in ambient media, arsenic (III), usually the most toxic, and arsenic (V) (EPA, 1985-As) with its magnitude of bioavailability and toxicity dependent upon the oxidation state and temperature (McGeachy and Dixon, 1992). The state is dependent on environmental conditions, including Eh, pH, organic content, suspended solids and sediment. The relative toxicities of the various forms of arsenic apparently vary from species to species. Arsenic may be released into aquatic ecosystems by anthropogenic sources including the manufacture and use of arsenical defoliants and pesticides, electric generating stations, manufacturing companies, mineral or strip mines, steel production, fossil fuel combustion and smelting operations (Sorensen, 1991; McGeachy and Dixon, 1989; Ferguson and Gavis, 1972; NRCC, 1978) and natural leaching of the soils. Arsenic levels in a river ecosystem were found to be dependent upon the availability of arsenic, rain water dillution, extent of complexation with dissolved organic matter and possibly the metabolic activity of aquatic plants (Koranda et al. 1981). As soil clay concentration increases, arsenic adsorption into the soil increases as a function of soil pH, texture, iron, aluminum, organic matter and time (Woolson, 1977). Arsenic is known as one of the most toxic elements to fish with acute exposures resulting in immediate death (Sorensen, 1991).

Toxicity in Sediment to Benthic Invertebrates. Sediments of Waukegan Harbor, Wisconsin, which had more than 47 mg/kg arsenic caused 34% mortality in the amphipod *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 polychlorinated biphenyls (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).

Long et al., (1995) reported ER-L and ER-M values of 8.2 and 70 mg/kg, respectively. Only 11% of these documented studies 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 (Table 1).

Table 1. Arsenic toxicity to benthic invertebrates in saline water (MacDonald et al., 1994)

Conc. (mg/kg)	Endpoint	Species
1.88	14d LC100	sandworm *(Nereis virens)*
4.33	1h EC98 (fertilization)	sea urchin *(Arbacia punctulata)*
4.65	48h LC25	sea urchin *(Arbacia punctulata)*
8.25	Chronic Marine EqP Threshold	aquatic biota
10.10	LC33	mysid shrimp *(Mysidopsis bahia)*
10.20	10d LC16	amphipod *(Ampelisca abdita)*
12.00	10d LC55	amphipod *(Hyallela azteca)*
12.80	96h LC>50	shrimp *(Paleamonetes pugio)*
16.00	EPA Acute Marine EP Threshold	aquatic biota
20.00	10d LC20	amphipod *(Rhepoxynius abronius)*
22.10	48h EC59 (abnormality)	bivalve
22.40	15m EC50	microtox *(Photobacterium phosphoreum)*
43.00	20d LC37	polychaete *(Neanthes arenaceodentata)*
50.70	48h EC92 (abnormality)	bivalve
58.70	48h EC23 (abnormality)	oyster
91.80	48h LC50	mummichog *(Fundulus heteroclitus)*
91.80	48h LC50	spot *(Leiostomus xanthurus)*
690.00	48h EC45 (abnormality)	oyster
2257.00	10d LC79	amphipod *(Rhepoxynius abronius)*

CADMIUM

Cadmium (Cd) occurs predominately in the form of free divalent cations in most well oxygenated, low organic matter, fresh waters (EPA 1985-Cd). However, both particulate matter and dissolved organic matter can bind cadmium in biologically unavailable forms. There is no evidence that cadmium is a biologically essential or beneficial element (Eisler, 1985). Cd toxicity is related to water hardness, with a reduction in toxicity associated with increased water hardness (EPA, 1985-Cd).

Toxicity in Sediment to Benthic Invertebrates. An Illinois harbor sediment containing 2.5 mg/kg cadmium resulted in 34% mortality of *Hyalella azteca.* A concentration of 1.98 mg/kg caused 95% mortality to *Hyalella azteca* in a Washington lake sediment. Significant mortality to the prawn *Macrobrachium rosenbergii* resulted from 2.8 mg/kg cadmium in a Wisconsin river (studies cited in Long and Morgan, 1991).

Confidence in the Long and Morgan (1991) ER-L and ER-M is very high, because data are available from many approaches, from multiple methods for some approaches, and are relatively

consistent (Long and Morgan, 1991). The updated ER-L and ER-M (Long et al., 1995), which do not include freshwater data, also show good consistency. That is, 37% of the documented studies indicated biological effects at concentrations between the ER-L and ER-M, and 66% of the studies at concentrations above the ER-M indicated biological effects. However, resistance to cadmium is higher among marine species than among freshwater species (Eisler, 1985).

CHROMIUM

Chromium (Cr) occurs in the environment as either chromium (III) or chromium (VI). Trivalent chromium is an essential metal in animals, playing an important role in insulin metabolism (Larngard 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). Chromium (III), the predominant form in the environment, exhibits decreasing solubility with increasing pH, and is completely precipitated at a pH above 5.5. In most soils, chromium is primarily present as precipitated chromium (III), which is not bioavailable and has not been know to biomagnify through food chains in its inorganic form (Eisler, 1986). Chromium is released into the environment in the processing of chromate, electroplating, production at tanning and textile plants, pigment production, and cooling tower preservation. Cr is naturally released into the environment through the weathering of soils (Fishbein, 1976).

Toxicity in Sediment to Benthic Invertebrates. There is relatively little consistency in the effects data presented by NOAA (Long and Morgan, 1991). This may be due to the lack of chromium speciation data in the NOAA studies. All of the data were reported as total chromium, whereas the hexavalent form has been reported to be the most toxic. In Lake Union, Washington, a concentration of 20 mg/kg resulted in 95% mortality of *Hyalella azteca*. However, in the Dupage and Kishwaukee rivers in Illinois chromium levels of 34 and 29 mg/kg, respectively, had the highest number of benthic macroinvertebrate taxa, while concentrations of 60 and 43 mg/kg, respectively, has the lowest number of benthic macroinvertebrate taxa. In the Keweenaw Waterway of Michigan, 36 mg/kg of chromium was not toxic to *Daphnia magna,* but levels of 109 mg/kg were significantly toxic. In Torch Lake, Michigan, concentrations of 180 mg/kg of chromium resulted in significant mortality to *Daphnia magna* and *Hexagenia sp.* (studies cited in Long and Morgan, 1991). Long et al., (1995) reported ER-L and ER-M values of 81 and 370 mg/kg for chromium. The incidence of adverse effects was 95% in the probable-effects range for chromium, however, the incidence of effects in the probable-effects range was greatly influenced and exaggerated by data from multiple tests conducted in only two field surveys (Table 2).

Table 2. Chromium toxicity to benthic invertebrates in saline water (MacDonald et al., 1994).

Conc. (mg/kg)	Endpoint	Species
6.25	Chronic Marine EqP Threshold	aquatic biota
17.40	48h LC25	*Arbacia punctulata* (sea urchin)
31.30	10d LC83	*Leptocheirus plumulosus* (amphipod)
35.70	20d LC95	*Leptocheirus plumulosus* (amphipod)
48.30	10d LC55	*Hyalella azteca* (amphipod)
54.00	10d LC55	*Hyalella azteca* (amphipod)
57.90	1h EC98 (fertilization)	*Arbacia punctulata* (sea urchin)
59.90	48h EC85 (devlopment)	*Arbacia punctulata* (sea urchin)
60.00	48h Significant increase in burrowing time	*Macoma balthica* (bivalve)

Conc. (mg/kg)	Endpoint	Species
60.40	low density	echinodermata
61.20	low density	arthropods
62.00	low spec. richness	benthic
77.40	EC50	*Photobacterium phosphoreum* (Microtox)
87.30	Sediments Devoid of Feral Clams	*Macoma balthica* (bivalve)
90.00	24h - avoidance	*Macoma balthica* (bivalve)
93.70	10d LC32	*Ampelisca abdita* (amphipod)
108.00	20d EC<90 (emergence)	*Hyalella azteca* (amphipod)
108.00	10d LC29	*Lepidactylus dytiscus* (amphipod)
108.00	10d EC90 (reburial)	*Lepidactylus dytiscus* (amphipod)
108.00	20d EC<90 (emergence)	*Lepidactylus dytiscus* (amphipod)
110.00	48h EC77 (abnormality)	*Crassostrea gigas* (oyster)
146.00	low abundance	arthropods
157.00	low spec. richness	benthic
160.00	14d reduced growth rate	*Chromadorina germanice* (nematode)
197.00	low abundance	benthic
201.00	low abundance	echinoderm
211.00	low abundance	echinoderms
227.00	low abundance	phoxocephalids
227.00	low abundance	amphipods
260.00	Chemical Criteria	benthic
369.00	14d LC100	*Nereis virens* (sandworm)
383.00	low density	echinoderm
416.00	low spec. richness	benthic
523.00	low density	echinoderm
523.00	low density	*Foraminifera* (sponge)
523.00	low density	*Ophiuroidea* (brittle star)
527.00	low density	amphipod
527.00	low density	phoxocephalid
669.00	10d LC21	*Rhepoxynius abronius* (amphipod)
669.00	low density	mollusca
682.00	low density	crustacea
682.00	low density	phoxocephalid
682.00	low density	amphipod
682.00	low spec. richness	macro benthos
1646.00	48h LC50	*Leiostomus xanthurus* (spot)
1646.00	48h LC50	*Fundulus heteroclitus*(mummichog)

COPPER

Copper (Cu) occurs in natural waters primarily as the divalent cupric ion in free and complexed forms (EPA 1985-Cu). Copper is a minor nutrient for both plants and animals at low concentrations, but is toxic to aquatic life at concentrations only slightly higher. Concentrations of 0.001 to 0.010 mg/L are usually reported for unpolluted surface waters in the United States.

Common copper salts, such as the sulfate, carbonate, cyanide, oxide, and sulfide are used as fungicides, as components of ceramics and pyrotechnics, for electroplating, and for numerous other industrial applications (ACGIH, 1986). The largest anthropogenic releases of copper to the environment result from mining operations, agriculture, solid waste, and sludge from sewage treatment plants.

Toxicity in Sediment to Benthic Invertebrates. A concentration of 156 mg/kg Cu caused 95% mortality to *Hyalella azteca* at Lake Union, Washington. In Waukegan Harbor, Illinois, there was 34% mortality to the same species at a concentration of 19.5 mg/kg. In Illinois, a high number of benthic invertebrate taxa were found in one river with a sediment copper concentration of 62 mg/kg; although another Illinois river had a high number of taxa at 19.5 mg/kg and a low number of taxa at a concentration of 45 mg/kg (studies cited in Long and Morgan, 1991). Long et al., (1995) reported ER-L and ER-M values of 34 and 270 mg/kg for copper. Confidence in these values is high because 84% of the studies at concentrations above the ER-M indicated biological effects (Table 3).

Table 3. Copper toxicity to benthic invertebrates in sediments of saline waters (MacDonald et al., 1994).

Conc. (mg/kg)	Endpoint	Species
1.00	EC98 (moderate diversity)	benthic
3.78	48 h LC25	*Arbacia punctulata* (sea urchin)
8.08	10 d LC55	*Hyalella azteca* (ampipod)
10.70	low abundance	oligochaeta
11.30	low density	annelida
12.60	10 d LC46	*Lepidactylus dytiscus* (amphipod)
12.70	48 h EC85 (development)	*Arbacia punctulata* (sea urchin)
13.60	ET50 (burrowing time)	*Protothaca staminea* (littleneck clam)
14.00	low density	echinodermata
14.20	10 d EC90 (reburial)	*Lepidactylus dytiscus* (amphipod)
14.20	low density	arthropoda
14.20	20 d EC<90 (emergence)	*Lepidactylus dytiscus* (amphipod)
14.20	20 d EC<90 (emergence)	*Hyalella azteca* (ampipod)
14.20	10 d LC29	*Lepidactylus dytiscus* (amphipod)
14.50	low richness	benthic
16.80	20 d EC<90 (emergence)	*Hyalella azteca* (ampipod)
16.80	20 d EC<80 (emergence)	*Lepidactylus dytiscus* (amphipod)
16.80	10 d EC83 (reburial)	*Lepidactylus dytiscus* (amphipod)
16.80	10d growth	*Lepidactylus dytiscus* (amphipod)
23.40	ET50 - 69h (reburial)	*Protothaca staminea* (littleneck clam)
23.40	ET50 - 63h (reburial)	*Protothaca staminea* (littleneck clam)
30.00	10 d LC16	*Ampelisca abdita* (amphipod)
32.40	ET50 - 25h (burial)	*Protothaca staminea* (littleneck clam)
32.40	ET50 - 97h (reburial)	*Protothaca staminea* (littleneck clam)
32.40	ET50 - 300h (reburial)	*Protothaca staminea* (littleneck clam)
32.40	ET50 - 101h (burial)	*Protothaca staminea* (littleneck clam)
34.00	EPA Chronic Marine EP Threshold	aquatic biota

Conc. (mg/kg)	Endpoint	Species
34.00	Chronic Marine EqP Threshold	aquatic biota
38.20	48 d LC25	*Protothaca staminea* (littleneck clam)
38.20	48 d LC15	*Protothaca staminea* (littleneck clam)
43.00	20 d LC52	*Neanthes sp.* (polychaete)
43.80	1 h EC98 (fertilization)	*Arbacia punctulata* (sea urchin)
54.00	EPA Acute Marine EP Threshold	aquatic biota
67.00	48 h Significant increase in burrowing time	*Macoma balthica* (bivalve)
68.20	48 h EC56 (abnormal)	bivalve
71.00	low abundance	arthropods
72.00	EC50	*Photobacterium phosphoreum* (Microtox)
73.20	low richness	benthic
76.00	48 h EC59 (abnormal)	bivalve
84.60	10 d LC67	*Rhepoxynius abronius* (amphipod)
87.80	48 h EC92 (abnormal)	bivalve
96.70	low abundance	echinoderm
98.70	48 h LC92	mussel
103.00	10 d LC32	*Ampelisca abdita* (amphipod)
106.00	48 h EC23 (abnormal)	oyster
109.00	low abundance	echinoderms
114.00	48 h EC67 (abnormal)	mussel
117.00	10 d LC31	*Ampelisca abdita* (amphipod)
118.00	10 d LC26	*Rhepoxynius abronius* (amphipod)
121.00	low abundance	phoxocephalids
121.00	low abundance	amphipods
124.00	10 d LC83	*Leptocheirus plumulosus* (amphipod)
125.00	10 d EC31 (emergence)	*Rhepoxynius abronius* (amphipod)
125.00	EC23 (emergence)	*Corophium volutator* (amphipod)
130.00	10 d EC37 (avoidance)	amphipod
130.00	10 d LC95	amphipod
135.00	Sediments devoid of feral clams	*Macoma balthica* (bivalve)
147.00	96 h LC>50	*Palaemonetes pugio* (shrimp)
150.00	24h - avoidance	*Macoma balthica* (bivalve)
157.00	20 d LC95	*Leptocheirus plumulosus* (amphipod)
164.00	EC50	*Photobacterium phosphoreum* (Microtox)
181.00	10 d LC52	*Grandidierella japonica* (amphipod)
187.00	low density	echinoderm
192.00	10 d LC62	*Rhepoxynius abronius* (amphipod)
196.00	48 h LC52	*Mulinia lateralis* (bivalve)
202.00	0.25 h EC50 (extract)	*Photobacterium phosphoreum* (Microtox)
220.00	20 d EC60 (abnormal development)	*Dendraster excentricus* (echinoderm)
258.00	low richness	benthic
259.00	10 d LC81	*Rhepoxynius abronius* (amphipod)

Conc. (mg/kg)	Endpoint	Species
270.00	low density	phoxocephalid
270.00	low density	amphipod
337.00	20 d LC37	*Neanthes arenaceodentata* (polychaete)
361.00	10 d LC55	*Hyalella azteca* (ampipod)
412.00	low density	polychaeta
455.00	low density	*Foraminifera foraminifera* (sponge)
455.00	low density	*Ophiuroidea ophiuroidea* (brittle star)
455.00	low density	echinoderm
581.00	low density	phoxocephalid
581.00	low richness	macro benthos
581.00	low density	crustacea
581.00	low density	amphipod
592.00	10 d LC21	*Rhepoxynius abronius* (amphipod)
592.00	low density	mollusca
612.00	14 d LC100	*Nereis virens* (sandworm)
918.00	48 h EC45 (abnormal)	oyster
1071.00	48 h LC50	*Fundulus heteroclitus* (mummichog)
1071.00	48 h LC50	*Leiostomus xanthurus* (spot)
2820.00	10 d LC79	*Rhepoxynius abronius* (amphipod)

IRON

Because iron (Fe) is the fourth most abundant element in the earth's crust, it commonly occurs at high concentrations in whole water analyses. Dissolved concentrations in water and soil are dependent upon redox conditions and pH. Fe typically occurs in water between 0.01 and 1.4 mg/L (Jorgensen et al., 1991; as cited in Gerhardt, 1994) with occurrence increasing in the presence of humic acids (Gerhardt, 1993). At lower concentrations, iron is an essential trace metal in both the plant and animal kingdoms because of its role in oxygen and energy transport. Iron occurs in the +1,+2 and +3 valence states and speciation from the +2 to the +3 state has been known to occur between pH 4.5 and 7. However, increased toxicity of iron at in acidic conditions may be a result of the photoreduction from +3 to the +2 state, or the destabilization of weaker iron complexes (Gerhardt, 1994). The most common dissolved inorganic form of iron is $Fe(OH)_2^+$ (Dave 1984). Toxicity of iron to aquatic organisms has received little attention because it is observed in unusual circumstances such as acid mine drainage or discharge of acidic metal working wastes.

Toxicity in Sediment to Benthic Invertebrates. The Ontario Ministry of the Environment (MOE) 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 (Jones et al., 1996).

LEAD

Lead (Pb), a comparatively rare metal, averages 16 mg/kg in the earth's crust, and 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). Although lead occurs in a variety of forms in the aquatic environment, the relative toxicities of these forms are not well defined (EPA, 1985-Pb).

Toxicity in Sediment to Benthic Invertebrates. Although a relatively large amount of data exists for lead and measures of effects in sediments, there are no spiked sediment bioassays and a wide concentration range exists with the associated effects (Long and Morgan, 1991). Freshwater biota may be more sensitive to lead than marine species (Eisler, 1988).

Significant effects were observed in *Daphnia magna* exposed to Keweenaw Waterway sediments containing 27 mg/kg lead. Taxa richness of macroinvertebrate communities in the Kishwaukee River were reduced in sediments containing 31 mg/kg and taxa-rich in sediment containing 21 mg/kg. Significant toxicity to *D. magna* and *Hexagenia limbata* was observed at 110 mg/kg in sediments of Torch Lake, Michigan (studies cited in Long and Morgan, 1991). Long et al., (1995) reported ER-L and ER-M values of 46.7 and 218 mg/kg for lead. Confidence is high for these values because 90% of the studies at concentrations above the ER-M indicated biological effects (Table 4).

Table 4. Toxicity of lead to benthic invertebrates in sediment of saline water (MacDonald et al., 1994).

Conc. (mg/kg)	Endpoint	Species
10.00	1h EC55 (fertilization)	*Arbacia punctulata* (sea urchin)
12.30	moderate abundance	oligocheate worm
18.20	low abundance	oligocheate worm
20.80	low abundance	copepoda
23.00	10d EC90 (reburial)	*Lepidactylus dytiscus* (amphipod)
23.00	20d EC<90 (emergence)	*Hyalella azteca* (amphipod)
23.00	10d LC29	*Lepidactylus dytiscus* (amphipod)
23.00	20d EC<90 (emergence)	*Lepidactylus dytiscus* (amphipod)
24.20	10d LC46	*Lepidactylus dytiscus* (amphipod)
28.00	10d LC20	*Rhepoxynius abronius* (amphipod)
32.00	48h Significant Increase in burrowing time	*Macoma bathica* (bivalve)
33.00	Chronic Marine EqP	aquatic biota
33.00	EPA Chronic Marine EP	aquatic biota
37.80	20d EC<80 (emergence)	*Lepidactylus dytiscus* (amphipod)
37.80	20d EC<90 (emergence)	*Hyalella azteca* (amphipod)
37.80	10d EC83 (reburial)	*Lepidactylus dytiscus* (amphipod)
41.30	96h LC>50	Palaemonetes pugio
41.30	low density	annelida
41.60	low density	echinodermata
42.10	10d LC34	*Rhepoxynius abronius* (amphipod)

Conc. (mg/kg)	Endpoint	Species
42.40	low density	arthropods
43.10	low richness	benthic
48.00	low abundance	arthropods
51.00	low richness	benthic
58.90	48h EC56 (abnormal)	bivalve
63.40	48h EC59 (abnormal)	bivalve
64.00	low abundance	echinoderm
68.70	low abundance	echinoderm
73.60	1h EC98 (fertilization)	*Arbacia punctulata* (sea urchin)
74.00	24h - avoidance	*Macoma bathica* (bivalve)
74.80	low abundance	phoxocephalids
74.80	low abundance	amphipods
81.70	Sediments devoid of feral clams	*Macoma bathica* (bivalve)
89.60	14d LC100	*Nereis virens* (sandworm)
95.80	10d LC67	*Rhepoxynius abronius* (amphipod)
105.00	48h EC93 (abnormal)	bivalve
108.00	EC50	*Photobacterium phosphoreum* (Microtox)
108.00	EC50	*Photobacterium phosphoreum* (Microtox)
111.00	low density	echinoderm
113.00	48h EC23 (abnormal)	oyster
129.00	4wk EC95 (reproduction)	*Tignopus californicus* (bivalve)
129.00	48h LC93	mussel
131.00	10d LC25	*Pennaeus aztecus* (brown shrimp)
137.00	10d LC83	*Leptocheirus plumulsos* (amphipod)
143.00	low richness	benthic
149.00	EC50	*Photobacterium phosphoreum* (Microtox)
160.00	low density	amphipod
160.00	low density	phoxocephalid
167.00	10d LC32	*Ampelisca abdita* (amphipod)
168.00	0.25h EC50 (extract)	*Photobacterium phosphoreum* (Microtox)
169.00	48h EC67 (abnormal)	mussel
171.00	10d LC26	*Rhepoxynius abronius* (amphipod)
172.00	20d LC95	*Leptocheirus plumulsos* (amphipod)
223.00	10d EC63(avoidance)	amphipod
223.00	10d LC95	amphipod
229.00	10d LC62	*Rhepoxynius abronius* (amphipod)
233.00	low density	echinoderm
233.00	low density	*Foraminifera* (sponge)
233.00	low density	*Ophiuroidea* (brittle star)
255.00	10d EC77 (emergence)	*Corophium volutator* (amphipod)
255.00	10d EC69 (emergence)	*Rhepoxynius abronius* (amphipod)
297.00	low richness	macro benthos
297.00	low density	amphipod

Conc. (mg/kg)	Endpoint	Species
297.00	low density	crustacea
297.00	low density	phoxocephalid
312.00	10d LC21	*Rhepoxynius abronius* (amphipod)
312.00	low density	mullosca
314.00	10d LC55	*Hyalella azteca* (amphipod)
321.00	14d reduced growth rate	*Chromadorina germanica* (nematode)
344.00	20d LC37	*Neanthes arenaceodentata* (polychaete)
512.00	48h LC50	*Leiostomus xanthurus* (spot)
512.00	48h LC50	*Fundulus heretoclitus* (mummichog)
570.00	48h EC45 (abnormal)	oyster
613.00	10d LC79	*Rhepoxynius abronius* (amphipod)
840.00	EPA Acute Marine EP Threshold	aquatic biota

MANGANESE

Manganese (Mn) makes up about 0.10% of the earth's crust and is the 12th most abundant element (NAS, 1980). In soil, natural levels of manganese range from 0.6-0.9 mg/kg and its solubility increases with decreasing pH. In surface water, Mn is present at concentrations ranging from 0.001-0.04 mg/L (Rouleau et al., 1995). Manganese oxides and peroxides are used in industry as oxidizers, and elemental Mn is used for manufacturing metal alloys to increase hardness and corrosion resistance. Increasingly, Mn as a Mn carbonyl compound, is being utilized as an anti-knocking agent in engines and is released into the air as Mn_3O_4 following combustion (Brault et al., 1994). Manganese is also present in the air and water discharges from mining and smelting activities (Saric 1986). In living systems, manganese is an essential element that is found most often in the +2 valence state. 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). Manganese is one of the first metals to increase in concentration in acidified waters (Harvey 1983).

Toxicity in Sediment to Benthic Invertebrates. Very little sediment toxicity information is available for manganese. The Ontario Ministry of the Environment has estimated that most benthic organisms in that region will not be adversely affected by concentrations of 460 mg/kg, which is consistent with the Great Lakes pre-colonial sediments background level of 400 mg/kg. A concentration of 1,110 mg/kg manganese is estimated to be toxic to most benthic organisms (Persaud et al., 1990).

Body Mn levels for benthic invertebrates are correlated to the concentration of the metal in the surficial sediments (Bendell-Young and Harvey, 1986).

MERCURY

Mercury (Hg) has no known biological function and is toxic to fish and wildlife. It is a mutagen and carcinogen that adversely affects the central nervous, renal, and reproductive systems of wildlife. Hg occurs in the environment as elemental mercury, Hg_2(II) and Hg(II), the latter of which is naturally oxidized from elemental mercury (Eisler, 1987a). Mercury in ambient waters

commonly occurs as mercury (II) or methylmercury. Mercury (II) can be methylated by both aerobic and anaerobic bacteria in the slime coat, liver, and intestines of fish, but methylation apparently does not occur in other tissues or in plants (EPA, 1985-Hg). From a toxicological standpoint, methylmercury (MeHg) poses a greater threat to biota due to its high stability and the ease with which it penetrates membranes in living organisms. Hg(II), however, is more prevalent in aquatic systems, bound up and unavailable in sediment layers. Biota bioconcentrate mercury compounds which can be further biomagnified through food chains (Wren, 1986). High concentrations of mercury in water are often associated with low alkalinity lakes and newly created bodies of water (Weiner and Stokes, 1990). Alkalinity, ascorbic acid, chloride, dissolved oxygen, hardness, organic complexing agents, pH, sediment, and temperature probably affect the acute and chronic toxicity and bioaccumulation of the various forms of mercury.

Anthropogenic sources of Hg include the combustion of fossil fuels, metal mining and processing plants, chloralkali plants, and disposal of batteries and fluorescent lamps (NAS 1978, and Das et al., 1982; as cited in Eisler, 1987a).

Toxicity in Sediment to Benthic Invertebrates. 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). Long et al., (1995) reported ER-L and ER-M values 0.15 and 0.71 mg/kg. Biological effects were observed in only 42% of the documented studies with concentrations greater than the ER-M (Table 5).

Table 5. Toxicity of mercury to benthic invertebrates in sediment of saline waters (MacDonald et al., 1994).

Conc. (mg/kg)	Endpoint	Species
0.01	48h LC25	*Arbacia punctulata* (sea urchin)
0.01	EPA Chronic Marine EP Threshold	aquatic biota
0.01	10d LC28	*Mysidopsis bahia* (mysid)
0.01	10d LC30	*Streblospio benedicti* (polychaete worm)
0.02	10d LC55	*Hyalella azteca* (amphipod)
0.02	48h EC85 (normal development)	*Arbacia punctulata* (sea urchin)
0.04	96h LC16	*Mysidopsis bahia* (mysid)
0.08	10d LC100	*Corophium volutator* (amphipod)
0.08	10d LC100	*Rhepoxynius abronius* (amphipod)

Conc. (mg/kg)	Endpoint	Species
0.12	1h EC80 (fertilization)	*Arbacia punctulata* (sea urchin)
0.12	low density	annelida
0.14	low density	echinodermata
0.15	low density	arthropods
0.15	10d LC83	*Leptocheirus plumulosus* (amphipod)
0.15	low richness	benthic
0.15	EPA Acute Marine EP Threshold	aquatic biota
0.15	96h LC>50	*Palaemonetes pugio* (shrimp)
0.18	20d LC95	*Leptocheirus plumulosus* (amphipod)
0.18	48h significant increase in burrow time	*Macoma balthica* (bivalve)
0.20	Chronic Marine EqP Threshold	aquatic biota
0.29	10d LC55	*Hyalella azteca* (amphipod)
0.30	10d LC23	amphipod
0.40	20d LC52	*Neanthes sp.* (polychaete)
0.40	10d LC20	*Rhepoxynius abronius* (amphipod)
0.42	Sediments devoid of feral clams	*Mulinia lateralis* (bivalve)
0.46	24h - avoidance	*Mulinia lateralis* (bivalve)
0.47	EC50	*Photobacterium phosphoreum* (Microtox)
0.62	EC50	*Photobacterium phosphoreum* (Microtox)
0.71	48h LC92	mussel
0.89	48h EC68 (abnormal)	mussel
0.90	48h EC59 (abnormal)	bivalve
0.93	EC50	*Photobacterium phosphoreum* (Microtox)
0.95	10d LC67	*Rhepoxynius abronius* (amphipod)
1.09	10d LC62	*Rhepoxynius abronius* (amphipod)
1.44	2d EC60 (abnormal development)	*Dendraster excentricus* (echinoderm)
1.60	48h LC50	*Fundulus heteroclitus* (mummichog)
1.60	48h LC50	*Leiostomus xanthurus* (spot)
1.74	10d LC81	*Rhepoxynius abronius* (amphipod)
2.46	20d LC37	*Neanthes arenaceodentata* (polychaete
3.50	48h EC45 (abnormal)	oyster
11.20	10d LC79	*Rhepoxynius abronius* (amphipod)
11.40	LC10	*Rhepoxynius abronius* (amphipod)
13.10	LC50	*Rhepoxynius abronius* (amphipod)
138.00	1h EC98 (fertilization)	*Arbacia punctulata* (sea urchin)
205.00	EC50	*Photobacterium phosphoreum* (Microtox)
234.00	10d LC32	*Ampelisca abdita* (amphipod)

NICKEL

Nickel is a naturally occuring element that may exist in various mineral forms. It forms 0.008% of the earth's crust (NAS, 1980). Soil and sediment are the primary receptacles for nickel, but mobilization may occur depending on physico-chemical characteristics of the soil. 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. Nickel occurs in nature in the nonionic and divalent states; other valence states occur very infrequently (Mastromatteo, 1986). Although nickel can exist in several oxidation states, the divalent cation state predominates and is generally considered the most toxic form (EPA 1986-Ni). As with many metals the toxicity of nickel increases as hardness decreases. Fish and invertebrates have approximately the same range of sensitivity.

Toxicity in Sediment to Benthic Invertebrates. 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).

Long et al., (1995) reported ER-L and ER-M values 20.9 and 51.6 mg/kg. A relatively low percentage (17%) of these documented studies indicated an incidence of biological effects at concentrations greater than the ER-M.

SILVER

Silver (Ag), a basic element, occurs naturally in the environment as a soft, silver colored metal (ATSDR, 1989). It also occurs in a powdery white or dark gray to black compound. Silver is found at an average of 0.1 mg/kg in the earth's crust and about 0.3 mg/kg in soils. Silver metals and silver compounds are used in the production of surgical protheses, fungicides, coinage, jewelry, and dental fillings(Fisher et al., 1984). The accumulation of silver in marine algae appears to result from adsorption rather than uptake; bioconcentration fators of 13,000 - 66,000 have been reported (Fisher et al., 1984; ATSDR, 1989b).

Toxicity in Sediment to Benthic Invertebrates. 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 *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) (Table 6).

The 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., (1995) indicated occurence of biological effects at concentrations greater than the ER-M.

Table 6. Toxicity of silver to benthic invertebrates in sediment of saline waters (MacDonald et al., 1994).

Conc. (mg/kg)	Endpoint	Species
0.088	48h LC25	*Arbacia punctulata* (sea urchin)

Conc. (mg/kg)	Endpoint	Species
0.137	48h EC15 (development)	*Arbacia punctulata* (sea urchin)
0.172	1h EC55 (fertilization)	*Arbacia punctulata* (sea urchin)
0.220	LC08	*Mysidopsis bahia* (mysid shrimp)
0.457	1h EC98 (fertilization)	*Arbacia punctulata* (sea urchin)
0.666	EC50	*Photobacterium phosphoreum* (Microtox)
0.812	10d LC32	*Ampelisca abdita* (amphipod)
1.000	24h - avoidance	*Macoma balthica* (bivalve)
1.000	48h EC59 (abnormal)	Bivalve
1.130	0.25h EC50 (extract)	*Photobacterium phosphoreum* (Microtox)
1.700	48h EC56 (abnormal)	Bivalve
1.960	20d LC37	*Neanthes arenaceodentata* (polychaete)
2.100	Sediments devoid of feral clams	*Macoma balthica* (bivalve)
2.200	low abundance	Arthropods
2.250	EC50	*Photobacterium phosphoreum* (Microtox)
2.440	48h EC89 (development)	*Mulinia lateralis* (bivalve)
2.500	low richness	Benthic species
2.600	48h Significant increase in burrowing time	*Macoma balthica* (bivalve)
3.100	low abundance	Echinoderm
3.430	EC50	*Photobacterium phosphoreum* (Microtox)
6.900	48h EC92 (abnormal)	Bivalve
6.900	48h LC92	Mussel
6.900	4wk EC95 (reproduction)	*Tigriopus californicus* (copepod)
8.100	10d LC95	Amphipod
8.100	10d EC37 (avoidance)	Amphipod
8.350	48h EC67 (abnormal)	Mussel

ZINC

Zinc (Zn) is an essential trace element in all 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, 1989d). Zinc phosphide is used as a rodenticide. Zinc makes up about 0.002% of the earth's crust (NAS, 1980) and occurs in many forms in natural waters and aquatic sediments.

In freshwater with pH >4 and <7, the dominant forms of dissolved zinc are the free ion (aquo ion complex) (98%) and zinc sulfate (2%), whereas at pH 9.0, the dominant forms are the monohydroxide ion (78%), zinc carbonate (16%), and the free ion (6%) (Campbell and Stokes, 1985). Zinc occurs in nature as a sulfide, oxide, or carbonate and background concentrations seldom exceed 0.040 mg/L in water or 200 mg/kg in soil or sediment (Eisler, 1993). It is divalent in

solution. Zinc interacts with many chemicals, and it may diminish the toxic effects of cadmium and protect against lead toxicosis in terrestrial animals (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).

Toxicity in Sediment to Benthic Invertebrates. A concentration of 127 mg/kg caused 34% mortality to *Hyalella azteca* in Waukegan Harbor, Illinois. A concentration of 320 mg/kg in Lake Union, Washington, caused 95% mortality to *H. azteca*. In Torch Lake, Michigan, there was significant mortality of *Daphnia magna* and *Hexagenia limbata* associated with concentrations of 310 mg/kg. At 2 rivers in Illinois, the highest number of benthic macroinvertebrate taxa was associated with concentrations of 96 and 182 mg/kg zinc, while the lowest number of taxa was associated with concentrations of 107 and 327 mg/kg, respectively (studies cited in Long and Morgan, 1991). Long et al., (1995) reported ER-L and ER-M values of 150 and 410 mg/kg for zinc.

INORGANICS

ACENAPHTHENE

Acenaphthene is a polycyclic aromatic hydrocarbon (PAH) compound (EPA-Acen, 1993). Acenaphthene may occur naturally in coal tar or as a by product of various oil and coal tar manufacturing processes (Verschueren, 1983). It is also used in the production of dyes, plastics, insecticides and fungicides.

Toxicity in Sediment to Benthic Organisms. In studies used to calculate the NOAA ER-L, effects were usually observed in association with concentrations of 0.15 mg/kg or greater (Long and Morgan, 1991). The AET for Puget Sound sediments, derived from the Microtox© bioassay, the benthic community composition, oyster larvae bioassay, and *Rhepoxynius abronius* amphipod bioassay, were 0.5, 0.5, 0.5, and 0.63 mg/kg, respectively, in a 1986 study and 0.5, 0.73, 0.5, and 2.0 mg/kg, respectively, in a 1988 study (Long and Morgan, 1991). According to EPA (1993-Acen) benthic organisms represent both the most sensitive and most resistant organisms to acenaphthene in freshwater. The freshwater snail, *Aplexa hypnorum*, was the most resistant having an LC50 >2.04 mg/L and the stonefly, *Peltoperla maria*, was the most sensitive with an LC50 of 0.24 mg/L of acenaphthene. Long et al., (1995) reported ER-L and ER-M values of 16 and 500 mg/kg. The acute and chronic NAWQ criteria for acenaphthene in freshwater are 0.080 and 0.023 mg/L (Suter and Tsao, 1996).

The lowest chronic values for fish, daphnid, and non-daphnid invertebrates in sediment are 5.314, 477.222, and 16.3 mg/kg, respectively (assuming 1% TOC) (Jones et al., 1996).

ACETONE

Toxicity in Sediment to Benthic Organisms. The lowest chronic values (LCV) for fish and daphnids in water are estimated at 507.64 and 1.56 mg/L (Suter and Tsao, 1996) which are equivalent to fish and daphnid LCVs in sediment of 2.968 and 0.00912 mg/kg, respectively (assuming 1% TOC)(Jones et al., 1996).

ANTHRACENE

Anthracene is a member of the polycyclic aromatic hydrocarbons (PAHs) produced by incomplete combustion. Exposure may come from natural (coal tar, volcanoes, and forest fires) or anthropogenic (combustion of fossil fuels, wood burning stoves, furnaces, and power plants) sources.

Toxicity in Sediment to Benthic Invertebrates Long and Morgan (1991) reported an ER-L value of 0.085 mg/kg and an ER-M value of 0.96 mg/kg for the toxicity of anthracene. The ER-L degree of confidence is low because there is no consistency in the effects observed at lower concentrations. The AET for Puget Sound sediments, derived from the Microtox© bioassay, the benthic community composition, oyster larvae bioassay, and *Rhepoxynius abronius* amphipod bioassay, were 0.96, 1.3, 0.96, and 1.9 mg/kg, respectively, in a 1986 study and 0.96, 4.4, 0.96, and 13.0 mg/kg, respectively, in a 1988 study (Long and Morgan, 1991). Long et al., (1995) reported ER-L and ER-M values of 85.3 and 1100 mg/kg. There are no SQC or NAWQ criteria for anthracene, however, the SQB value derived using equilibrium partitioning, based on the Tier II SCV, and assuming 1% organic carbon is 0.0003 mg/kg (Jones et al., 1996). The freshwater SCV for anthracene is 0.218 mg/L (Suter and Tsao, 1996). The SQB derived from the LCV for fish is 0.023672 mg/kg.

BENZO(A)ANTHRACENE

Benzo(a)anthracene (B(a)A) is a polycyclic aromatic hydrocarbon (PAH) compound. B(a)A is found in smoke and soot from the burning of gasoline, garbage, or any animal or plant material (ATSDR, 1990b). It is also found in coal tar pitch that industries use to join electrical parts or in creosote, used to preserve wood. B(a)A is a known animal carcinogen (ATSDR, 1990b)

Toxicity in Sediment to Benthic Organisms In bioassays of the lower Columbia River sediments, no toxicity to *Hyalella azteca* was observed at concentrations of 2.2 mg/kg. However, these data were not used in the calculation of the ER-L (Long and Morgan, 1991). In the studies used to calculate the ER-L, no effects were observed at concentrations below 0.06 mg/kg. The overall AET from these data was 0.55 mg/kg, although AET values in the data base ranged from 1.3 to 5.1 mg/kg for Puget Sound to 0.06 to 1.1 mg/kg for San Francisco Bay. Long et al., (1995) reported ER-L and ER-M values of 261 and 1600 mg/kg. There are no SQC for benzo(a)anthracene, however, the SQB derived using equilibrium partitioning and assuming 1% organic carbon is 0.109 mg/kg and is based on the Tier II SCV (Jones et al., 1996). The freshwater SCV is 0.000027 mg/L (Suter and Tsao, 1996). The SQB derived from the LCV for Daphnids is 2.59 mg/kg.

BENZO(A)PYRENE

Benzo(a)pyrene (BaP) is a polycyclic aromatic hydrocarbon (PAH) consisting of 5 fused benzene rings. Despite their high lipid solubility, most PAH's show little tendency to biomagnify in food chains, probably because they are rapidly metabolized in most biota (Eisler, 1987b). PAH's are ubiquitous in nature, produced by forest fires, microbial synthesis, and anthropogenic activities. PAH's are teratogenic, mutagenic, and carcinogenic, with the higher molecular weight compounds being less toxic than lighter compounds (Eisler, 1987b).

Toxicity in Sediment to Benthic Organisms A study was found relating effects data in freshwater sediment to concentrations of benzo(a)pyrene: 220 mg/kg resulted in 95% mortality of *Hyallela azteca.* In the studies documented in Long et al. (1995), 63% indicated biological effects at concentrations between the ER-L (430 mg/kg) and ER-M (1600 mg/kg), and 80% of the studies at concentrations above the ER-M indicated biological effects. The freshwater SCV for benzo(a)pyrene is 0.000014 mg/L (Suter and Tsao, 1996). There are no SQC for benzo(a)pyrene, however, the SQB derived using equilibrium partitioning and assuming 1% organic carbon is 0.14 mg/kg and is based on the Tier II SCV (Jones et al., 1996) The SQB derived from the LCV for Daphnids is 3.0 mg/kg.

ALPHA-BHC

Toxicity in Sediment to Benthic Organisms. The lowest chronic values (LCV) for daphnids is estimated at 0.0095 and 1.56 mg/L (Suter and Tsao, 1996) which is equivalent to a daphnid LCV in sediment of 5.199 mg/kg (assuming 1% TOC) (Jones et al., 1996).

BIS(2-ETHYLHEXYL)PHTHALATE

Bis(2-ethylhexyl)phthalate (BEHP) or di(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. The wide-spread uses of bis(2-ethylhexyl)phthalate have made the compound, along with other phthalic acid esters, ubiquitous in the environment. It has been detected in ground water, surface water, drinking water, air, soil, plants, fish and animals (Sittig, 1985; Sandmeyer and Kirwin, 1978). While bioaccumulation factors for bis(2-ethylhexyl)phthalate at lower trophic levels are high, because it is rapidly metabolized, levels in higher trophic levels are generally lower than those observed at lower trophic levels (Peakall, 1975).

Toxicity in Sediment to Benthic Organisms There were no specific data found relating to the toxicity of BEHP to benthic organisms. There are no SQC available, however, the SQB derived using equilibrium partitioning, based on the Tier II SCV, and assuming 1% organic carbon is 8.9E+05 mg/kg. (Jones et al., 1996). The freshwater SCV for BEHP is 0.03 mg/L (Suter and Tsao, 1996). The SQB derived from the LCV for Daphnids is 82,626.861 mg/kg.

2- BUTANONE

The lowest chronic values (LCV) for fish and daphnids in water are estimated at 282.17 and 1,394.93 mg/L (Suter and Tsao, 1996) which are equivalent to fish and daphnid LCVs in sediment of 5.475 and 27.066 mg/kg, respectively (assuming 1% TOC)(Jones et al., 1996).

CARBON DISULFIDE

Toxicity in Water to Aquatic Life. The EC50 for *Daphnia magna* is 2.1 mg/L and the LC50 for mosquitofish is 135 mg/L (Van Leeuwen et al. 1985, AQUIRE). The secondary chronic value (Suter and Tsao, 1996) of 0.00092 mg/L is used as the water quality benchmark.

CHRYSENE

Chrysene is a polycyclic aromatic hydrocarbon (PAH) compound and like all other PAH compounds it is derived from both natural and man-made sources. The major sources of chrysene released into the environment are from the incomplete combustion of carbonaceous material, residential heating and open burning (ATSDR, 1990c). Chrysene is known to accumulate in aquatic biota, however, detected concentrations are low because many organisms metabolize and excrete PAH compounds rapidly (ATSDR, 1990c).

Toxicity in Sediment to Benthic Organisms. In freshwater systems, a concentration of 4.1 mg/kg was not toxic to *Hyalella azteca* in the Columbia River but a concentration of 170 mg/kg in Lake Union, Washington, resulted in 95% mortality to *Hyalella azteca.* In the studies used to calculate the ER-L, effects were almost always observed at concentrations exceeding 0.9 mg/kg, although the lowest Puget Sound and San Francisco Bay AET values were 1.4 and 1.7 mg/kg, respectively (studies cited in Long and Morgan, 1991). Long et al., (1995) reported ER-L and ER-M values of 384 and 2800 mg/kg. There are no SQC or SQB values available for chrysene.

DI-N-BUTYL PHTHALATE

Toxicity in Sediment to Benthic Organisms. The lowest chronic values (LCV) for fish and daphnids in water are calculated at 0.717 and 0.697 mg/L (Suter and Tsao, 1996) which are equivalent to LCVs in sediment of 254.442 and 238.596 mg/kg, respectively (assuming 1% TOC) (Jones et al., 1996).

DIBENZ(A,H)ANTHRACENE

Dibenz(a,h)anthracene (DB(a,h)A) is a polycyclic aromatic hydrocarbon (PAH) compound. Like all other PAH compounds, it is a product of combustion and it's major fate is most likely sorption and biodegradation (ATSDR, 1990d). The half-life of (DB(a,h)A) in soil is estimated at 750 days.

Toxicity in Sediment to Benthic Organisms In studies used to calculate the ER-L, effects in sediments were observed at concentrations as low as 0.042 mg/kg in marine systems (Long and Morgan, 1991). The safe sediment level based upon equilibrium partitioning and the acute NAWQ criteria is 240 mg/kg (Long and Morgan, 1991). Long et al., (1995) reported ER-L and ER-M values of 63.4 and 260 mg/kg. There are no SQC or SQB for dibenz(a,h)anthracene.

DIBENZOFURAN

Toxicity in Sediment to Benthic Organisms. The lowest chronic value (LCV) for daphnids is estimated at 1.003 mg/L (Suter and Tsao, 1996) which is equivalent to an LCV in sediment of 113.256 mg/kg (assuming 1% TOC) (Jones et al., 1996).

1,1- DICHLOROETHANE

Toxicity in Sediment to Benthic Organisms. The lowest chronic value (LCV) for fish is estimated at 14.68 mg/L (Suter and Tsao, 1996) which is equivalent to an LCV in sediment of 8.494 mg/kg (assuming 1% TOC) (Jones et al., 1996).

1,2- DICHLOROETHYLENE

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). DCE is the isomer most widely used in industry and, consequently, in aquatic toxicity tests. 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.

Toxicity in Sediment to Benthic Organisms. The lowest chronic value (LCV) for fish in water is estimated at 9.538 mg/L (Suter and Tsao, 1996) which is equivalent to an LCV in sediment of 6.466 mg/kg (assuming 1% TOC) (Jones et al., 1996).

DDT, Total

DDT (1,1,1-trichloro-2,2-bis(p-chlorophenyl)ethane) is an organochlorine insecticide that was banned from use in the United States in 1972. DDT, and its metabolites, DDE and DDD, are highly persistent man-made chemicals and are not known to occur naturally in the environment (ATSDR, 1992). The half-life of DDT in soil is reported to range from 2 to 15 years (ATSDR, 1993). DDT and it's metabolites are also highly lipophilic and have a high bioaccumulation potential. A bioconcentration factor for rainbow trout is reported to be 12000 (ATSDR, 1993). DDT's are transported from one medium to another by solubilization, adsorption, bioaccumulation, or volatilization (ATSDR, 1992).

4,4' - DDT

Toxicity in Sediment to Benthic Organisms Long et al., (1995) reported ER-L and ER-M values of 1.58 mg/kg and 46.1 mg/kg for total DDT. There are no SQC for DDT, however, the SQB derived using the equilibrium partitioning and assuming 1% carbon is 0.343 mg/kg and is based on the NAWQ criteria (Jones et al., 1996). The freshwater NAWQ criteria for DDT is 0.0011 mg/L (Suter and Tsao, 1996). The SQB derived from the LCV for plants is 5.58626 mg/kg.

DIETHYL PHTHALATE

Toxicity in Sediment to Benthic Organisms. The secondary chronic value (SCV) for fish in water is estimated at 0.21 mg/L (Suter and Tsao, 1996) which is equivalent to an SCV in sediment of 0.606 mg/kg (assuming 1% TOC) (Jones et al., 1996).

ENDOSULFAN

Toxicity in Sediment to Benthic Organisms. The secondary chronic value (SCV) for fish in water is estimated at 0.000051 mg/L (Suter and Tsao, 1996) which is equivalent to an SCV in sediment of 0.0055 mg/kg (assuming 1% TOC) (Jones et al., 1996).

FLUORANTHENE

Fluoranthene is a member of the polycyclic aromatic hydrocarbon (PAH) group of organic compounds. Sources of fluoranthene include crude oil, coal tar and motor oil or it may be produced by plants, algae and bacteria (Verschueren, 1983; as cited in EPA, 1993-Flu). Gradual increases in fossil fuel consumption in the United States will lead to increases in emissions of PAH's to the environment. The impact of PAH's is of environmental concern because they are known carcinogens and/or mutagens. Although fluoranthene bioaccumulates in aquatic biota, the associated health or ecological risks are unknown (EPA, 1993-Flu).

Toxicity in Sediment to Benthic Organisms In Lake Union, Washington, sediment with a concentration of 570 mg/kg caused 95% mortality to *Hyalella azteca.* Columbia River, Washington, sediment with 2.1 mg/kg fluoranthene was not toxic to *Hyalella azteca.* The lowest AET for Puget Sound and San Francisco Bay were 1.7 and 2.0 mg/kg, respectively. The confidence in the ER-L is high (Long and Morgan, 1991). The EPA freshwater SQC assuming 1% organic carbon is 6.2 mg/kg (EPA, 1993-Flu).

A freshwater sediment with approximately 0.5% organic carbon was spiked with fluoranthene to generate an EC50 for *Hyalella azteca* and *Chironomus tentans*, using organism

immobility as the endpoint (Suedel et al., 1993). The EC50 values were between 2.3 and 7.4 mg/kg for *H. azteca* and between 3.0 and 8.7 mg/kg for *C. tentans*. The SQC for fluoranthene derived using equilibrium partitioning and assuming 1% organic carbon is 6.2 mg/kg (EPA, 1993-Flu).

FLUORENE

Fluorene is a polycyclic aromatic hydrocarbon (PAH) compound. Like all other PAH compounds, fluorene is the result of the combustion of fossil fuels and remains persistent in the environment (Eisler, 1987). Fluorene compounds may be introduced into aquatic environments by sewage effluents, surface runoff, or petroleum spills. PAH compounds reach soil by direct deposition or by deposition on vegetation.

Toxicity in Sediment to Benthic Organisms In Lake Union, Washington, sediment with a concentration of 40 mg/kg fluorene caused 95% mortality in *Hyalella azteca*. The SQC calculated using equilibrium partitioning and the acute NAWQ criteria and 1% organic carbon yields a value of 7.0 mg/kg (Long and Morgan, 1991). Long et al, (1995) reported ER-L and ER-M values of 19 and 540 mg/kg for fluorene.

METHYLENE CHLORIDE

Toxicity in Sediment to Benthic Organisms. The lowest chronic values (LCV) for fish and daphnids in water are calculated at 108.0 and 42.667 mg/L (Suter and Tsao, 1996) which are equivalent to LCVs in sediment of 18.407 and 7.272 mg/kg, respectively (assuming 1% TOC) (Jones et al., 1996).

2-METHYLNAPHTHALENE

Toxicity in Sediment to Benthic Organisms. The lowest AET values for 2-methylnaphthalene in San Francisco Bay and Puget Sound were 0.000027 mg/kg and 0.000045 mg/kg, respectively. Sediment in Commencement Bay, WA was highly toxic to amphipods at 0.000546 mg/kg 2-methylnaphthalene (MacDonald et al., 1994).

4-METHYLPHENOL

Toxicity in Sediment to Benthic Organisms. The lowest chronic values (LCV) for fish and daphnids in water are estimated at 0.489 and 1.316 mg/L (Suter and Tsao, 1996) which are equivalent to LCVs in sediment of 0.445 and 1.197 mg/kg, respectively (assuming 1% TOC) (Jones et al., 1996).

NAPHTHALENE

Naphthalene is a white solid substance used in the manufacture of dyes, resins and in mothballs. It is released to the air from the burning of coal and oil and from the use of mothballs containing naphthalene. Naphthalene may also be released into the air by coal tar production and wood preservation. In water and soil, naphthalene is either destroyed by bacteria or evaporated into the air within a few hours or days (ATSDR, 1989a). Naphthalene breaks down readily in the environment and is easily metabolized by various organisms (ATSDR, 1989a).

Toxicity in Sediment to Benthic Organisms In Lake Union, Washington, sediments with 40 mg/kg naphthalene caused 95% mortality in *Hyalella azteca*. Effects were almost always observed at concentrations greater than 0.50 mg/kg in marine systems (Long and Morgan, 1991). The Puget Sound AET was 2.1 mg/kg. Long et al., (1995) reported ER-L and ER-M values of 160 and 2100 mg/kg. The SQB value is 0.242 mg/kg and is derived from equilibrium partitioning and assuming 1% organic carbon (Jones et al., 1996). The freshwater SCV is 0.012 mg/L (Suter and Tsao, 1996). The SQB derived from the LCV for fish is 10.77 mg/kg.

PAHs, TOTAL

Polycyclic aromatic hydrocarbons (PAH) are composed of two or more fused aromatic rings containing only carbon and hydrogen atoms (Hodgson, 1984). Anthropogenic combustion of fossil fuels is thought to be the primary source of PAH in the aquatic environment. Some PAH's are among the most potent carcinogens known to exist (Eisler, 1987b). Prior to 1900, the production and degradation of PAH's was balanced, however, the recent increase in industrial development and increased emphasis of fossil fuels as energy sources has disrupted that balance. PAH's reaching the sediment may be adsorbed or assimilated by plant leaves before entering the animal food chain. The fate of PAH's that accumulate in sediments is thought to biotransformation and biodegradation by benthic organisms (Eisler, 1987b). Long et al., (1995) reported ER-L and ER-M values of 4022 and 44792 mg/kg for total PAH.

PCBs

Polychlorinated biphenyls (PCB's) are a family of man-made chemicals consisting of 209 individual compounds with varying toxicity (ATSDR, 1989c). Aroclor is the trade name for PCB's made by Monsanto. Because of their insulating and nonflammable properties, PCB's were widely used in industrial applications such as coolants and lubricants in transformers, capacitors, and electrical equipment (ATSDR, 1989c). The United States stopped manufacturing PCB's in 1977 due to evidence that they accumulated in the environment. Although PCB's are no longer manufactured or used in the United States, they remain present and will continue to become a widespread environmental contaminant. The biodegradation of PCB's in soil is slow, especially in soils with high organic carbon content (ATSDR, 1993).

PCB-1248

Toxicity in Sediment to Benthic Organisms. The log K_{oc} for Aroclor 1248 is 7.02. The sediment quality benchmark (SQB) of 1.05 mg/kg is derived using the equilibrium partitioning approach based on 1% organic carbon. The secondary chronic value (Suter and Tsao, 1996) of 0.00008 mg/L is used as the water quality benchmark. The secondary chronic value implies a greater than 20% chance that the NAWQC, if its value were known, would be exceeded. For comparison, substitution of the lowest chronic value for daphnids results in a SQB of 450 mg/kg for Aroclor 1248.

PCB-1254

Toxicity in Sediment to Benthic Organisms The log K_{oc} for Aroclor 1254 is 5.93. There are no SQC for PCB-1254, however, the SQB derived from equilibrium partitioning and assuming

1% organic carbon is 0.814 mg/kg (Jones et al., 1996). The freshwater SCV is 0.000033 mg/kg (Suter and Tsao, 1996). The SQB derived from the LCV for plants is 0.85 mg/kg.

PCB-1260

Toxicity in Sediment to Benthic Organisms The log K_{oc} for Aroclor 1260 is 7.02. There are no SQC for PCB-1260, however, the SQB derived from the equilibrium partitioning and assuming 1% organic carbon is 4574 mg/kg (Jones et al., 1996). The freshwater SCV is 0.094 mg/L (Suter and Tsao, 1996). The SQB derived from the LCV for fish is 136.127 mg/kg.

PHENANTHRENE

Phenanthrene is a polycyclic aromatic hydrocarbon (PAH) compound. It is produced by fractional distillation of high-boiling coal-tar oil and purification of the crystalline solid (EPA, 1993-Phen). Phenanthrene may be used in the manufacturing of dye, drugs, and explosives. The fate of phenanthrene in sediment is highly influenced by sorption and biodegradation. Phenanthrene has the ability to bioaccumulate in aquatic biota. The acute toxicity of phenanthrene in freshwater ranges from 0.096 to >1.150 mg/L and 0.0219 to 0.6 mg/L for saltwater organisms.

Toxicity in Sediment to Benthic Organisms In Lake Union, Washington, sediments with 410 mg/kg phenanthrene caused 95% mortality among *Hyalella azteca.* Columbia River, Washington, sediments with 0.58 mg/kg phenanthrene were not toxic to the same species (studies cited in Long and Morgan, 1991). The EPA SQC for phenanthrene is 1.8 mg/kg assuming 1% organic carbon (EPA, 1993-Phen). Long et al., (1995) reported ER-L and ER-M values of 240 and 1500 mg/kg. The SQC for phenanthrene derived using equilibrium partitioning and assuming 1% organic carbon is 1.8 mg/kg (EPA, 1993-Phen).

PHENOL

Toxicity in Sediment to Benthic Organisms. The lowest chronic values (LCV) for fish and daphnids in water are calculated at <0.2 and 2.005 mg/L (Suter and Tsao, 1996) which are equivalent to LCVs in sediment of <0.0574 and 0.575 mg/kg, respectively (assuming 1% TOC) (Jones et al., 1996).

PYRENE

Pyrene is an polycyclic aromatic hydrocarbon (PAH) compound. The PAH are of environmental concern because they are known carcinogens and/or mutagens. Like all other PAH compounds, pyrene is a product of combustion and it's major fate is most likely biodegradation (ATSDR, 1990a).

Toxicity in Sediment to Benthic Organisms In Lake Union, Washington, sediments with 750 mg/kg pyrene caused 95% mortality among *Hyalella azteca.* A concentration of 2.5 mg/kg in Columbia River, Washington, sediments was not toxic to the same species (studies cited in Long and Morgan, 1991). The EPA interim SQC based on equilibrium partitioning and 1% organic carbon is 13.1 mg/kg (Long and Morgan, 1991). Long et al., (1995) reported ER-L and ER-M values of 665 and 2600 mg/kg.

TOLUENE

Toxicity in Sediment to Benthic Organisms. The lowest chronic values (LCV) for fish and daphnids in water are calculated at 1.269 and 25.229 mg/L (Suter and Tsao, 1996) which are equivalent to LCVs in sediment of 6.449 and 128.218 mg/kg, respectively (assuming 1% TOC) (Jones et al., 1996).

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TOXICITY TO HETEROTROPHIC PROCESSES AND SOIL AND LITTER INVERTEBRATES

ORGANICS

Chromium

Chromium (Cr) occurs in the environment as either chromium (III) or chromium (VI). Trivalent chromium is an essential metal in animals, playing an important role in insulin metabolism (Larngard 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). Chromium (III), the predominant form in the environment, exhibits decreasing solubility with increasing pH, and is completely precipitated at a pH above 5.5. In most soils, chromium is primarily present as precipitated chromium (III), which is not bioavailable and has not been know to biomagnify through food chains in its inorganic form (Eisler, 1986). Chromium is released into the environment in the processing of chromate, electroplating, production at tanning and textile plants, pigment production, and cooling tower preservation. Cr is naturally released into the environment through the weathering of soils (Fishbein, 1976).

Toxicity to Heterotrophic Processes and Soil and Litter Invertebrates. Liang and Tabatabai (1977) investigated the effects of various metals on N mineralization by native soil microflora in four soils. Chromium(III) at 260 ppm reduced N mineralization in the soil containing the highest organic matter content. The effects of Cr(III) on dehydrogenase activity of the native soil microflora in soil from the Rocky Mountain Arsenal was assessed by Rogers and Li (1985). After 6 days, a concentration of 30 ppm Cr (the lowest concentration tested) reduced dehydrogenase activity by 54%. Juma and Tabatabai (1977) evaluated the effect of Cr on soil acid and alkaline phosphatase activities in microbes. Acid and alkaline phosphatase activities were affected at 1635 ppm in all three soils to about the same degree, but greater inhibition of alkaline phosphatase activity occurred in the soil with the greatest content of organic matter and clay. Ross et al. (1981) evaluated the relative toxicities of forms of Cr to respiration of native soil microflora in a loam and a sandy loam soil. Cr (III), tested at only 100 ppm, caused reductions in both soils of 41 and 48%. A concentration of 10 ppm (the lowest concentration tested) Cr (VI) caused reductions in both soils (27 and 33%). Cr(VI) was more toxic than Cr(III) to soil respiration. Bhuiya and Cornfield (1976) investigated the effects of several metals on N mineralization and nitrification by native soil microflora in a sandy soil at different pH levels. At 6 weeks, mineralization and nitrification were reduced by 1000 ppm Cr at pH 7, but not at pH 6. After 12 weeks, neither mineralization nor nitrification was affected by Cr at either pH.

Haanstra and Doelman (1991) investigated short- and long-term effects of Cr on arylsulfatase activity, urease activity (Doelman and Haanstra, 1986), and total phosphatase activity (Doelman and Haanstra, 1989) by native soil microflora in five soils. The highest EC_{50}s were 3203, 5512, and 4470 ppm, respectively, for arylsulfatase, phosphatase, and urease activities found in different soils. The lowest was 17 ppm in the sand for arylsulfatase and 1170 and 490 ppm in the clay for phosphatase and urease. In an 18-month study, the highest EC_{50}s were 1798, 20020, and 1110 ppm Cr, respectively, for arylsulfatase, phosphatase, and urease activities found in different soils. The lowest were 12 and <1 ppm in the clay for arylsulfatase and urease activities and 2692 ppm in the sandy loam for phosphatase activity. The benchmark for Cr for microbes was established at 10 ppm because the 10th percentile lies between the EC_{50} values of 12 and 15 ppm from the work of Haanstra and Doelman (1991). Confidence in this benchmark is high because of the relatively large amount of data available for a variety of functional measures.

Abbasi and Soni (1983) assessed the effect of Cr(VI), added as $K_2Cr_2O_7$, on survival and reproduction of the earthworm *Octochaetus pattoni*. Survival was the most sensitive measure with a 75% decrease resulting from 2 ppm Cr, the lowest concentration tested. The number of cocoons

produced was not diminished until the concentration reached 20 ppm Cr (highest concentration tested); the number of juveniles produced was not affected. Soni and Abbasi, (1981) found no survival of *Pheretima posthuma* after 61 days in a paddy soil to which 10 ppm Cr(VI) (lowest concentration tested) was added. van Gestel et al. (1992), also found growth of *E. andrei* to be more sensitive to Cr than reproduction. 32 ppm Cr (III) reduced growth by 30% while cocoons/worm/week, percent fertile cocoons, and juveniles/worm/week were reduced 28, 22, and 51%, respectively, by 100 ppm Cr. Molnar et al. (1989) examined the effects of Cr(III) and Cr(VI) on growth and reproduction of *Eisenia fetida*. Reproduction after 8 weeks was the measure most sensitive to Cr(III) with a 55% decrease in the number of cocoons and hatchlings at 625 ppm Cr(III).

It is difficult to set a benchmark concentration for toxicity of Cr to earthworms. Survival may be more sensitive than reproduction to the metal when it is added to the earthworm substrate as a soluble salt. The relative toxicity of Cr(III) and Cr(VI) is not clear from these studies. Cr(VI) ions can pass through cell membranes with much greater ease than Cr(III) ions. However, it is thought that Cr(VI) is reduced to Cr(III) inside the cell (Molnar et al., 1989); this latter may be the final active form. Without a better understanding of Cr transformations in the soil, transport across earthworm cell membranes, and reactions within the cell, it is difficult to separate the effects of the two different forms. The 0.4 ppm benchmark for Cr is based on the work of Abbasi and Soni (1983). A safety factor of 5 was applied to the 2 ppm LOEC because it caused a 75% reduction in earthworm survival. Confidence in this benchmark is low because it is based on only five reported concentrations causing toxicity to earthworms (Table 4).

Copper

Copper (Cu) occurs in natural waters primarily as the divalent cupric ion in free and complexed forms (EPA 1985-Cu). Copper is a minor nutrient for both plants and animals at low concentrations, but is toxic to aquatic life at concentrations only slightly higher. Concentrations of 0.001 to 0.010 mg/L are usually reported for unpolluted surface waters in the United States. Common copper salts, such as the sulfate, carbonate, cyanide, oxide, and sulfide are used as fungicides, as components of ceramics and pyrotechnics, for electroplating, and for numerous other industrial applications (ACGIH, 1986). The largest anthropogenic releases of copper to the environment result from mining operations, agriculture, solid waste, and sludge from sewage treatment plants.

Toxicity to Heterotrophic Processes and Soil and Litter Invertebrates. Liang and Tabatabai (1977) investigated the effects of various metals on N mineralization by native soil microflora in four soils. Copper at 320 ppm severely reduced N mineralization in one soil. The effects of Cu on dehydrogenase activity of the native soil microflora in soil from the Rocky Mountain Arsenal was assessed by Rogers and Li (1985). A concentration of 30 ppm Cu (the lowest concentration tested) Cu reduced dehydrogenase activity by 28%. Bollag and Barabasz (1979) evaluated the effects of Cu on denitrification by three species of soil-dwelling *Pseudomonas* species of bacteria in autoclaved soil and by native soil microflora. In the autoclaved soil LOECs ranged from 10 (lowest concentration tested) to 250 ppm (highest concentration tested). Denitrification by the native soil population was reduced 44% by 250 ppm Cu. The effects of adding Cu, as $CuSO_4$, to a sandy loam adjusted to three pH levels on N mineralization during a 21-day incubation was assessed by Quraishi and Cornfield (1973). Mineralization was decreased by 1000 ppm Cu at all three pH levels (5.1, 5.9, and 7.3) with inhibitory effect increasing with decreasing pH from 39% to 100%.

Bhuiya and Cornfield (1972) assessed the effects of several metals on C mineralization by native microflora in a sandy soil, with or without added organic matter. After a further 12 weeks, soil respiration was reduced in the Cu-treated soil with amendment but not in the unamended soil. The influence of soil characteristics on effects of Cu on arylsulfatase activity was evaluated by Al-Khafaji and Tabatabai (1979). In the soil with the highest pH (7.6), Cu had no effect. Arylsulfatase activity in the other three soils was reduced by Cu at a concentration of 1590 ppm. Reductions were the least severe in the soil having the highest organic carbon and clay content. The effects of Cu (as $CuCl_2$) on carbon and nitrogen mineralization and nitrogen transformations in alfalfa-amended sieved soil were determined by Suter and Sharples (1984). At 10 days, respiration was reduced by 24% at 100 ppm, but significant reductions occurred at 500 ppm on days 3 and 14 and at 1000 ppm on all dates. Ammonia concentration was decreased significantly by 58% on days 4 and 11 at 10 ppm, but there was no increase of effects with concentration on those dates, and ammonia concentrations were unchanged or increased at those concentrations on later dates. Ammonia concentrations were significantly increased at 500 and 1000 ppm from day 18 to 53, and after day 18 there were regular patterns of increasing ammonia at increasing Cu levels. Nitrate levels were reduced by 21% on day 4 at a concentration of 10 ppm, but not on later dates. On day 11, nitrate concentrations were significantly reduced to 50–1000 ppm (but increased at 10 ppm), and on days 18 to 53, they were significantly reduced only at 500 and 1000 ppm Cu. These results suggest that nitrification is highly sensitive to Cu, relative to C and N mineralization. The benchmark for Cu has been established at 100 ppm, and confidence in this benchmark is high.

Neuhauser et al. (1984) evaluated the effects of soluble forms of copper on growth and reproduction *E. fetida*. After 6 weeks, both growth (weight) and cocoon production were decreased (75 and 85%) by 2000 ppm Cu, while 1000 ppm had no effect. Neuhauser et al. (1985) used the OECD artificial soil to estimate LC_{50} of Cu (added as Cu nitrate) for adult *E. fetida*. After 14 days, the LC_{50} was 643 ppm Cu. Spurgeon et al. (1994) kept adult *E. fetida* in contaminated OECD artificial soil for 8 weeks to test the effects of Cu (as $Cu(NO_3)_2$) on survival and growth of the earthworms. After 56 days, the calculated LC_{50} was 555 ppm, and the EC_{50} for cocoon production was 53.3 ppm. Bengtsson et al. (1986) looked at the effects of copper on *Dendrobaena rubida* at different acidities. After 4 months at pH 4.5, the number of cocoons produced per worm, hatchlings/cocoon, and total number of hatchlings were reduced 70, 64, and 74%, respectively, by 100 ppm Cu, the lowest concentration tested. The percent hatched cocoons was not affected. At pH 5.5, the number of cocoons produced per worm, hatchlings/cocoon, and percent hatched cocoons were reduced 96, 100, and 100%, respectively, by 500 ppm Cu, while 100 ppm had no effect. The total number of hatchlings was not affected. At pH 6.5, the number of cocoons produced per worm, hatchlings/cocoon, and percent hatched cocoons were reduced 90, 100, and 100%, respectively, by 500 ppm Cu, while 100 ppm had no effect. The total number of hatchlings was not affected.

In experiments by van Gestel et al. (1991) using Cu ($CuCl_2$) mixed homogeneously with the OECD substrate, growth of *E. fetida* was reduced 32% by 100 ppm (32 ppm had no effect). The EC_{50} for clitella development (sexual development) was >100 ppm Cu. In a study examining the effects of soil factors on Cu toxicity and uptake, Ma (1982) used a sandy loam soil spiked with $CuCl_2$ to determine the effects of Cu on survival of adult *Lumbricus rubellus*. After 12 weeks, 1000 ppm Cu caused an 82% decrease in survival while 150 ppm had no effect. The effect of soil organic carbon on toxicity of Cu ($CuSO_4$) to the earthworm *Octolasium cyaneum* was evaluated by Streit and Jaggy (1983). They determined the 14-day LC_{50} in a Brown soil, a Rendzina soil, and a peat soil containing 3.2, 14, and 43% organic carbon, respectively. The LC_{50} concentrations were 180, 850, and 2500 ppm, respectively. The relative sensitivity of several lumbricid earthworms to Cu ($CuCl_2$) added to a sandy soil was investigated by Ma (1988). EC_{50}s for cocoon production of *L. rubellus*, *Aporrectodea caliginosa*, and *Allolobophora chlorotica* were 122, 68, and 51 ppm Cu. The work

of Streit and Jaggy (1983) and others shows that the organic carbon content of the soil is a strong determinant of the bioavailability and toxicity of copper. From the studies cited, it appears that low pH has a compounding effect, with an increase in Cu availability resulting from more acid conditions. Overall, reproduction is more sensitive than mortality, and there is no consistent evidence that one genus of earthworms is any less tolerant to Cu under a given set of conditions than another genus. The benchmark for Cu was established at 50 ppm. Confidence in this benchmark is moderate.

The acute toxicity of Cu to the nematode *C. elegans* in four soils and in solution was evaluated by Donkin and Dusenbery (1993). A concentration of 105 ppm Cu in solution caused 50% mortality while at least 400 ppm (sandy loam soil) was required in soil. The highest LC_{50} (1061 ppm) was associated with the highest percentage organic matter in the loam soil. Parmalee et al. (1993) used a soil microcosm to test the effects of Cu on survival of nematodes and microarthropods feeding on native soil organic matter. There was an average reduction of approximately 70% in number of individuals of most categories of nematodes (fungivores, bactivores, herbivores, hatchlings) at 400 ppm total Cu, while 185 ppm had no effect. The number of individuals of the omnivores/predators category was reduced 85% by the lowest concentration of Cu tested, 72 ppm. Total microarthropod numbers were reduced about 50% by 400 ppm. Hopkin and Hames (1994) investigated the effects of Cu (as $CuNO_3$) in food on survival and reproduction of the terrestrial isopod *Porcellio scaber*. After 360 days, the number of juveniles produced was decreased 53% by 50 ppm Cu while 100 ppm of Cu was required to reduce total survival. The slug, *Arion ater*, was used as the test organism by Marigomez et al. (1986) to determine the effects of several pollutants on terrestrial mollusks. After 27 days, the animals experienced a 55% decrease in growth at 1000 ppm Cu, while 300 ppm had no effect. The studies of Donkin and Dusenbery (1993) and Parmalee et al. (1993) taken together show a higher concentration in soil than in solution is required to affect the survival of nematodes. Differences among groups of nematodes in sensitivity to Cu is shown by Parmalee et al. (1993). The application of soluble form of Cu to food material by Hopkin and Hames (1994) and Marigomez et al. (1986) show very distinct sensitivities of woodlice and slugs to Cu. The lowest toxic concentration reported in these two studies (72 ppm Cu) is higher than the benchmarks for earthworms (50 ppm) and microbes (30 ppm) (Table 4).

Mercury

Mercury (Hg) has no known biological function and is toxic to fish and wildlife. It is a mutagen and carcinogen that adversely affects the central nervous, renal, and reproductive systems of wildlife. Hg occurs in the environment as elemental mercury, Hg_2(II) and Hg(II), the latter of which is naturally oxidized from elemental mercury (Eisler, 1987). Mercury in ambient waters commonly occurs as mercury (II) or methylmercury. Mercury (II) can be methylated by both aerobic and anaerobic bacteria in the slime coat, liver, and intestines of fish, but methylation apparently does not occur in other tissues or in plants (EPA, 1985-Hg). From a toxicological standpoint, methylmercury (MeHg) poses a greater threat to biota due to its high stability and the ease with which it penetrates membranes in living organisms. Hg(II), however, is more prevalent in aquatic systems, bound up and unavailable in sediment layers. Biota bioconcentrate mercury compounds which can be further biomagnified through food chains (Wren, 1986). High concentrations of mercury in water are often associated with low alkalinity lakes and newly created bodies of water (Weiner and Stokes, 1990). Alkalinity, ascorbic acid, chloride, dissolved oxygen, hardness, organic complexing agents, pH, sediment, and temperature probably affect the acute and chronic toxicity and bioaccumulation of the various forms of mercury.

Anthropogenic sources of Hg include the combustion of fossil fuels, metal mining and processing plants, chloralkali plants, and disposal of batteries and fluorescent lamps (NAS 1978, and Das et al., 1982; as cited in Eisler, 1987).

Toxicity to Heterotrophic Processes and Soil and Litter Invertebrates. van Fanssen (1973) investigated the effects of an inorganic and an organic mercury compound on N mineralization and nitrification by native soil microflora in two alkaline soils. In the clay soil, both $HgCl_2$ and phenylmercury acetate reduced nitrification at 100 mg/kg Hg (10 mg/kg had no effect), but the organic form was more inhibitory than the inorganic form. Mineralization was not affected by the inorganic form but was decreased by phenylmercury acetate. In the dune sand, $HgCl_2$ severely reduced nitrification at 100 mg/kg (10 mg/kg had no effect) and phenylmercury acetate reduced nitrification at 10 mg/kg Hg (lowest concentration tested). Mineralization was not affected by the organic form but was decreased by $HgCl_2$ at 100 mg/kg Hg. This work indicates that the relative toxicity of various forms of Hg can be influenced by soil characteristics. Landa and Fang (1978) investigated the effects of mercuric chloride (up to 100 mg/kg Hg) on carbon mineralization by native soil microflora in five agricultural topsoils varying in pH and organic matter content. The magnitude of effects varied greatly among the soils and were not related to those two soil characteristics. Effects ranged from an 87% reduction at 0.1 mg/kg (the lowest concentration tested) in one of the soils to no effect at 100 mg/kg in another soil.

Liang and Tabatabai (1977) investigated the effects of Hg on N mineralization by native soil microflora in four soils. Mercury reduced N mineralization in all soils at 1003 mg/kg The greatest magnitude of the toxic effect was seen in the soil having the lowest pH and organic matter and clay contents. The influence of soil characteristics on effects of Hg on arylsulfatase activity was evaluated by Al-Khafaji and Tabatabai (1979). In two soils tested with a lowest concentration of 502 mg/kg, arylsulfatase activity was greatly reduced. In the two soils tested with a lowest concentration of 5015 mg/kg, arylsulfatase activity was inhibited almost totally. No clear differences between the soils with regard to effects on toxicity of Hg could be discerned.

Frankenberger and Tabatabai (1981) investigated the effect of Hg on amidase activity in three soils in shaker flask assays. After 2 1/2 hours, amidase activity was reduced in all three soils at 5015 mg/kg. The greatest reduction occurred in the soil with the lowest pH and organic matter and clay contents. Juma and Tabatabai (1977) evaluated the effect of Hg on soil acid and alkaline phosphatase activities. Acid and alkaline phosphatase activities were affected at 5015 mg/kg in all three soils to about the same degree. The benchmark of 30 mg/kg Hg is the 10th percentile of the 27 reported effective values. Confidence in this benchmark is high because of the relatively large amount of data available for a variety of functional measures.

Abbasi and Soni (1983) assessed the effect of Hg(II), added as $HgCl_2$, on survival and reproduction of *Octochaetus pattoni*. Survival and cocoon production were reduced 65 and 40% at 0.5 mg/kg Hg, the lowest concentration tested. The number of juveniles produced was not affected. The effect of methyl mercury on survival and segment regeneration of *Eisenia fetida* was investigated by Beyer et al. (1985). A concentration of 12.5 mg/kg Hg reduced survival by 21%, and the ability to regenerate excised segments was reduced by 69%. Methyl mercury at 2.5 mg/kg had no effect. It is not possible to evaluate the relative toxicity of forms of Hg based on these two studies which used different systems and evaluated two different families of earthworms. A benchmark of 0.1 mg/kg was established for Hg based on the work of Abbasi and Soni (1983). A safety factor of 5 was applied to the 0.5 mg/kg LOEC because it caused a 65% reduction in earthworm survival. Confidence in this benchmark is low because of the limited amount of data.

The slug, *Arion ater*, was used as the test organism by Marigomez et al. (1986) to determine the effect of mercury (as $HgCl_2$) on terrestrial mollusks. After 27 days on this diet, the animals experienced a 26% decrease in growth at 1000 mg/kg Hg, while 300 mg/kg had no effect.

Nickel

Nickel is a naturally occuring element that may exist in various mineral forms. It forms 0.008% of the earth's crust (NAS, 1980). Soil and sediment are the primary receptacles for nickel, but mobilization may occur depending on physico-chemical characteristics of the soil (ATSDR, 1988; USAF, 1990). 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. Nickel occurs in nature in the nonionic and divalent states; other valence states occur very infrequently (Mastromatteo, 1986). Although nickel can exist in several oxidation states, the divalent cation state predominates and is generally considered the most toxic form (EPA 1986-Ni). As with many metals the toxicity of nickel increases as hardness decreases. Fish and invertebrates have approximately the same range of sensitivity.

Toxicity to Heterotrophic Processes and Soil and Litter Invertebrates. The effects of Ni, as nickel sulfate, on dehydrogenase activity of the native soil microflora in soil from the Rocky Mountain Arsenal was assessed by Rogers and Li (1985). After 6 days, a concentration of 30 ppm (lowest concentration tested) Ni reduced dehydrogenase activity by 39%. Babich and Stotzky (1982) evaluated the effects of two forms of Ni on mycelial growth rate of a number of soil-dwelling fungi inoculated individually into autoclaved sandy loam soil. The concentrations at which growth was reduced ranged from 50 to 750 ppm for Ni (added in chloride or sulfate form). Giashuddin and Cornfield assessed the effect of Ni added in oxide (1979) and sulfate (1978) forms on N and C mineralization by native soil microflora in a sandy soil. After 42 days incubation, soil respiration (C mineralization) was reduced in soil containing 10 ppm Ni from Ni sulfate (lowest concentration tested), and N mineralization was affected at 100 ppm. Soil respiration was reduced in soil containing 50 ppm Ni from Ni oxide (lowest concentration tested), and N mineralization was affected at 1000 ppm. Because of the test concentrations used, it is difficult to assess the relative toxicity of these two forms of Ni to C mineralization. When the soil pH was raised to 6.9 (from its normal 5.9), soil respiration was reduced in soil containing 250 ppm Ni from Ni oxide (lowest concentration tested), and N mineralization was affected at 1000 ppm. The effect of Ni from Ni sulfate was not tested at the higher pH. Raising the pH appeared to affect soil respiration but not N mineralization. A benchmark of 90 ppm Ni was established based on the 56 reported effective values. Confidence in this benchmark is high because of the relatively large amount of data available for a variety of functional measures.

The effects of Ni (added to horse manure as Ni acetate) on *E. fetida* were investigated by Malecki et al. (1982). In the 8-week test, 300 ppm Ni caused a 41% decrease in cocoon production, while 200 ppm had no effect. In the 20-week test, 200 ppm Ni caused a 23% decrease in cocoon production, while 100 ppm had no effect. Neuhauser et al. (1985) used the OECD artificial soil to determine LC_{50} of Ni (added as Ni nitrate) for adult *E. fetida*. After 14 days, the LC_{50} was calculated to be 757 ppm Ni. Neuhauser et al. (1984) evaluated the effects of soluble forms of nickel on growth and reproduction *E. fetida*. After 6 weeks, cocoon production was decreased 33% by 250 ppm Ni, the lowest concentration tested. Growth was not affected until 500 ppm was added to the substrate. In a study examining the effects of soil factors on Ni toxicity and uptake, Ma (1982) used a sandy loam soil spiked with $NiCl_2$ to determine the effects of Ni on survival of adult *Lumbricus rubellus*. After 12 weeks, 1000 ppm Cd caused a 31% decrease in survival while 150 ppm had no effect. A

benchmark of 200 ppm has been established for Ni based on the work of Malecki et al. (1982) which showed inhibition of reproduction at this concentration. Confidence in this benchmark is low because of the limited amount of data.

Zinc

Zinc (Zn) is an essential trace element in all 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, 1989). Zinc phosphide is used as a rodenticide. Zinc makes up about 0.002% of the earth's crust (NAS, 1980) and occurs in many forms in natural waters and aquatic sediments.

In freshwater with pH >4 and <7, the dominant forms of dissolved zinc are the free ion (aquo ion complex) (98%) and zinc sulfate (2%) (Campbell and Stokes, 1985), whereas at pH 9.0, the dominant forms are the monohydroxide ion (78%), zinc carbonate (16%), and the free ion (6%) (EPA, 1987-Zn).

Zinc occurs in nature as a sulfide, oxide, or carbonate (Eisler, 1993). It is divalent in solution. 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 0.040 mg/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).

Toxicity to Heterotrophic Processes and Soil and Litter Invertebrates. Wilson (1977) evaluated the effect of Zn, as zinc sulfate solution, on nitrification by native soil microflora in three soils. After 49 days, nitrification was severely inhibited in all three soils (98 to 100%) by 1000 ppm Zn, while Zn at 100 ppm had no effect. Haanstra and Doelman (1991) investigated short- and long-term effects of Zn on arylsulfatase activity, urease activity (Doelman and Haanstra, 1986), and total phosphatase activity (Doelman and Haanstra, 1989) by native soil microflora in five soils. In the 6-week study the highest EC_{50}s were 5559, 3623, and 1780 ppm for arylsulfatase, phosphatase, and urease activities, all in the soil with the greatest content of clay. The lowest EC_{50}s of 909, 220, and 420 ppm Zn were all found in the sand. In the 18-month study, the highest EC_{50}s were 9679, 4872, and 290 ppm Zn in different soils. The lowest EC_{50}s were 375, 170, and 70 ppm in different soils. Bhuiya and Cornfield (1974) investigated the effects of 1000 ppm Zn added as Zn oxide to a sandy soil at three pH levels on nitrogen mineralization by native soil microflora. After 42 days, N mineralization was reduced in the pH 7.7 soil but not in soils at pH 6 and 7. The effects of Zn on dehydrogenase activity of the native soil microflora in soil from the Rocky Mountain Arsenal was assessed by Rogers and Li (1985). A concentration of 300 ppm Zn reduced dehydrogenase activity by 30%; Zn at 150 ppm had no effect. Laskowski et al. (1994) looked at the effects of several metals

at low to moderate levels of $CdCl_2$ (up to 250 ppm Cd), $Pb(NO_3)_2$ (up to 2500 ppm Pb), or $ZnCl_2$ on the respiration rate of acid-mixed forest litter. Only zinc had an effect at the concentrations tested. A concentration of 1000 ppm Zn reduced respiration by 26%; Zn at 200 ppm had no effect. The effect of Cd and Zn on respiration of soil microflora in field-collected black oak forest soil/litter microcosms was evaluated by Chaney et al. (1978). After 23 days, Cd at a concentration up to 6 ppm had no effect. Respiration was decreased 21% by Zn at 479 ppm; Zn at 47 ppm had no effect. The benchmark of 100 ppm Zn is the 10th percentile of the 46 reported effective values. Confidence in this benchmark is high because of the relatively large amount of data available for a variety of functional response factors.

van Gestel et al. (1993) evaluated the effect of zinc added as $ZnCl_2$ to OECD artificial soil (pH 6.2), on the growth and reproduction of *E. andrei*. The numbers of cocoons and juveniles produced were reduced 31 and 42% by 560 ppm, while 320 ppm had no effect. The percent fertile cocoons and number of juveniles per fertile cocoon were not affected until Zn was added to a concentration of 1000 ppm Zn, and percent growth of individuals increased with increasing Zn concentration. Spurgeon et al. (1994) test the effects of Zn (as $Zn(NO_3)_2$) on survival and growth of *E. fetida*. After 56 days, the calculated LC_{50} was 745 ppm, and the EC_{50} for cocoon production was 276 ppm. Neuhauser et al. (1985) used the OECD artificial soil (pH 6) to determine LC_{50} of Zn [added as Zn (NO_3)] for adult *E. fetida*. After 14 days, the LC_{50} was calculated to be 662 ppm Zn. van Rhee (1975) tested the effects of one concentration of Zn (1100 ppm) added to a polder soil on body weight, number of cocoons produced per week, mortality and sexual development of *Allolobophora caliginosa*. After 60 days, there was a 53% loss of body weight and a 22% increase in mortality; clitellum development and cocoon production were completely inhibited. Neuhauser et al. (1984) evaluated the effects of soluble forms of zinc on growth and reproduction *E. fetida*. After 6 weeks, cocoon production was decreased 50% by 2500 ppm Zn, while 1000 ppm had no effect. Growth was not affected until 5000 ppm was added to the substrate. The effects of Zn added to horse manure (as zinc acetate) on *E. fetida was* investigated by Malecki et al. (1982). In the 8-week test, 2000 ppm Zn caused a 36% decrease in cocoon production, while 1000 ppm had no effect. In the 20-week test, 5000 ppm Zn caused a 53% decrease in cocoon production, while 2500 ppm had no effect. The EC_{50} value of 276 (Spurgeon et al., 1994) was the lowest toxic concentration of the seven reported. Confidence in the benchmark of 200 ppm Zn is low because of the limited amount of data.

Hopkin and Hames (1994) investigated the effects of Zn (as $ZnNO_3$) in food on survival and reproduction of the terrestrial isopod *Porcellio scaber*. Survival and number of juveniles produced after 360 days were decreased 100% by 1000 ppm Zn while 500 ppm had no effect. Zinc (as ZnO) was added to litter from the O_2 layer under woodlands to evaluate the effects of that metal on *Porcellio scaber* (Beyer et al. 1984). The only concentration tested, 5000 ppm, caused a 26% decrease in survival. Beyer and Anderson (1985) also used *Porcellio scaber* in experiments to determine the effect of Zn, added ZnO to ground deciduous leaf litter, on several population parameters. The maximum number of individuals in generation 2 and the survival rate for generation 2 were decreased 22 and 27% by 1600 ppm Zn in the diet, while 800 ppm had no effect. The slug, *Arion ater*, was used as the test organism by Marigomez et al. (1986) to determine the effect of Zn (as $ZnCl_2$) on terrestrial mollusks. After 27 days on this diet the animals experienced a 38% decrease in growth at 10 ppm Zn, the lowest concentration tested. The experiments evaluating the toxicity of Zn to the woodlouse *Porcellio scaber* show a high tolerance to the metal when it is added to the food in soluble form. The work with *Arion ater* (Marigomez et al., 1986) indicates that this organism is more sensitive than *P. scaber* to Zn. On the other hand, growth of individual woodlice was not evaluated and may be more sensitive than survival and reproduction.

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TOXICITY TO PLANTS

INORGANICS

Antimony

Antimony (Sb) is a naturally occurring metalloid element (displaying both metallic and nonmetallic properties) existing in valence states of 3 and 5 (Budavari, 1989; ATSDR, 1990). Metallic antimony and a few trivalent antimony compounds are the most significant regarding exposure potential and toxicity (ATSDR, 1990). Antimony 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 parasiticides (Beliles, 1979).

Toxicity to Plants in Soil. Primary reference data for the toxicity of antimony to plants grown in soil was unavailable, however, the secondary reference data on the phytotoxicity of plants in soil noted undefined, qualitative phytotoxic effects on plants grown in surface soil (Kloke, 1979). Antimony is considered a nonessential metal and is easily taken up by plants if available in the soil in soluble forms (Kabata-Pendias and Pendias, 1984).

Arsenic

Arsenic (As) is a naturally-occuring metaloid found in air and all living organisms. It is present in the earth's crust at approximately 2 mg/kg and is sparingly soluble in water and body fluids. It occurs as two forms in ambient media, arsenic (III), usually the most toxic, and arsenic (V) (EPA, 1985-As) with its magnitude of bioavailability and toxicity dependent upon the oxidation state and temperature (McGeachy and Dixon, 1992). The state is dependent on environmental conditions, including Eh, pH, organic content, suspended solids and sediment. The relative toxicities of the various forms of arsenic apparently vary from species to species. Arsenic may be released into aquatic ecosystems by anthropogenic sources including the manufacture and use of arsenical defoliants and pesticides, electric generating stations, manufacturing companies, mineral or strip mines, steel production, fossil fuel combustion and smelting operations (Sorensen, 1991; McGeachy and Dixon, 1989; Ferguson and Gavis, 1972; NRCC, 1978) and natural leaching of the soils. Arsenic levels in a river ecosystem were found to be dependent upon the availability of arsenic, rain water dillution, extent of complexation with dissolved organic matter and possibly the metabolic activity of aquatic plants (Koranda et al. 1981). As soil clay concentration increases, arsenic adsorption into the soil increases as a function of soil pH, texture, iron, aluminum, organic matter and time (Woolson, 1977). Arsenic is known as one of the most toxic elements to fish with acute exposures resulting in immediate death (Sorensen, 1991).

Toxicity to Plants in Soil. The tolerance of spruce seedlings to As in soil was tested in field plots by Rosehart and Lee (1973). Three-yr old seedlings grown 335 d in soil to which 1000 mg/kg As was added as As(III) (lowest concentration tested) experienced a 50% reduction in height.

Soil type affected the toxicity of As(III) added to two soils on the shoot weight of cotton and soybeans grown from seed for 6 weeks (Deuel and Swoboda, 1972). In a sandy loam soil, shoot weights of both crops were reduced (cotton 22%; soybeans 45%) by 11 mg/kg As (the lowest concentration tested). Soybean growth in a clay soil was reduced 28% by 22.4 mg/kg As (lowest concentration tested). Cotton growth in this soil was reduced 29% by 89.6 mg/kg As.

The source of As(V) has been shown to influence the effect on corn grown from seed for 4 weeks in a loamy sand (pH 7.1). Plant weight reductions were almost 100% for NaH_2AsO_4, over

75% for $Al(H_2AsO_4)_3$, and about 65% for $Ca(H_2AsO_4)_2$ with the addition of 100 mg/kg As (Woolson et al., 1971).

Will and Suter (1995) reported soil NOEC and soil LOEC values for the effects of arsenic derived from experiments conducted in soil. The soil NOEC values ranged from 10 to 62.7 mg/kg and the soil LOEC values ranged from 2 mg/kg (barley) to 1000 mg/kg (spruce) for the phytotoxicity of arsenic.

Soil-plant uptake factors (concentration in plant/concentration in soil) for grass and herbs were calculated at 0.0166 and 0.0005, respectively (Efroymson et al., 1996).

Toxicity to Plants in Solution. Mhatre and Chaphekar (1982) found no effect of As(III) (As_2O_3), up to 1 mg/kg As, on germination of seeds of sorghum, alfalfa, mung bean, cluster bean, and radish. After 5d, reductions in root length occurred between 0.001 mg/kg As (29% reduction in cluster bean) and 1 mg/kg As (55 and 87% reductions in alfalfa and mung bean). The concentrations of As (V), from Na_2HAsO_4, required for a 50% reduction in seed germination and root length of mustard after 3d exposure in solution (pH 7.3), was reported by Fargasova (1994) to be 30 ppm. The EC50 for root length was 5.5 mg/kg As.

Will and Suter (1995) reported NOEC and LOEC values for the effects of arsenic in solution The NOEC's ranged from 0.001 to 0.1 mg/kg and the LOEC's ranged from 0.001 mg/kg (LCT for cluster bean) to 30 mg/kg (LC50 for mustard).

Phytotoxic Mode of Action. Arsenic is not essential for plant growth. It is taken up actively by roots, with arsenate being more easily absorbed than arsenite. Arsenic and phosphate ions are likely taken up by the same carrier (Asher and Reay, 1979). The phytotoxicity is strongly affected by the form in which it occurs in soils. Arsenite (III) is more toxic than arsenate (V), and both are considerably more toxic than organic forms (Peterson et al., 1981). In experiments with toxic levels of As, rice and legumes appear to be more sensitive than other plants. Symptoms include wilting of new-cycle leaves, retardation of root and top growth, violet coloration, root discoloration, cell plasmolysis, leaf necrosis and death (Aller et al., 1990). Arsenic is chemically similar to phosphorous, it is translocated in the plant in a similar manner and is able to replace P in many cell reactions. Arsenic (III) probably reacts with sulphydryl enzymes leading to membrane degradation and cell death. Arsenic (V) is known to uncouple phosphorylation and affect enzyme systems (Peterson et al., 1981).

Cadmium

Cadmium (Cd) occurs predominately in the form of free divalent cations in most well oxygenated, low organic matter, fresh waters (EPA 1985-Cd). However, both particulate matter and dissolved organic matter can bind cadmium in biologically unavailable forms. There is no evidence that cadmium is a biologically essential or beneficial element (Eisler, 1985). Cd toxicity is related to water hardness, with a reduction in toxicity associated with increased water hardness (EPA, 1985-Cd). Therefore, the cadmium toxicity values presented in Table 2 that are not from tests conducted in waters of moderate hardness are normalized to 100 mg/L using the slopes calculated by the EPA (1985-Cd).

Toxicity to Plants in Soil. A number of researchers have measured reductions in growth of a variety of plants in different soils with 10 mg/kg or less of Cd added to soil as soluble salts. Plants tested include sycamore and spruce trees, wild flowering plants, and crops and horticultural

plants (corn, lettuce, radish, wheat). Soils range from light sands to heavy silty clay loams in the acid to neutral pH range. There are no clear trends in responses indicating that any particular type of plant is more sensitive to Cd (reductions in growth range from 23 to 45%), or that growth conditions (pH and soil texture) consistently affected toxicity. Grasses appear to be generally less sensitive than several other plant groups with growth adversely affected at concentrations greater than 10 mg/kg (up to 160 mg/kg for oats) under a variety of growth conditions.

Will and Suter (1995) reported a large range of soil NOEC and LOEC values for the toxicity of cadmium in soil. The NOEC values ranged from 1 to 56.3 mg/kg and the LOEC values ranged from1 to 300 mg/kg.

Soil-plant uptake factors (concentration in plant/ concentration in the soil) for grass, herbs, and tree/shrubs were calculated at 0.2303, 0.0042, and 0.7837, respectively (Efroymson et al., 1996).

Toxicity to Plants in Solution. Will and Suter (1995) reported a large range of soil NOEC and LOEC values for the toxicity of cadmium in solution. The NOEC values ranged from 0.01 to 11.2 mg/L and the LOEC values ranged from 0.01 to 692 mg/L.

Phytotoxic Mode of Action. Cadmium is not essential for plant growth. If present in available form, it is readily taken up by the roots and translocated through the plant, and accumulated. Cadmium is chemically similar to Zn, an essential element. Competition between the two for organic ligands may explain some of the toxic effects of Cd, and the ameliorative effects of Zn on Cd toxicity. Cadmium depresses uptake of Fe, Mn, and probably Ca, Mg, and N (Wallace et al., 1977d; Iwai, et al. 1975). Cadmium is toxic at low concentrations. Symptoms resemble Fe chlorosis, and include necrosis, wilting, reduced Zn levels, and reduction in growth. The mechanisms of toxicity include reduced photosynthetic rate, poor root system development, reduced conductivity of stems, and ion interactions in the plant. Agronomic crops are more sensitive to Cd toxicity than trees (Adriano, 1986).

Chromium

Chromium (Cr) occurs in the environment as either chromium (III) or chromium (VI). Trivalent chromium is an essential metal in animals, playing an important role in insulin metabolism (Larngard 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). Chromium (III), the predominant form in the environment, exhibits decreasing solubility with increasing pH, and is completely precipitated at a pH above 5.5. In most soils, chromium is primarily present as precipitated chromium (III), which is not bioavailable and has not been know to biomagnify through food chains in its inorganic form (Eisler, 1986). Chromium is released into the environment in the processing of chromate, electroplating, production at tanning and textile plants, pigment production, and cooling tower preservation. Cr is naturally released into the environment through the weathering of soils (Fishbein, 1976).

Toxicity to Plants in Soil. It is believed that Cr(VI) is more toxic to plants and more mobile inside the plant than Cr(III). It has also been shown that valence of the Cr ion is more important in determining the distribution of the element than the specific species. There are, however, conflicting views on the uptake and metabolism of Cr(III) and Cr(VI). One argument is that Cr(VI) may be absorbed into roots while the other states that Cr(VI) is reduced to Cr(III) just before absorption into the roots (Smith et al., 1989).

Turner and Rust (1971) investigated the effect of Cr added as Cr(VI) on soybean seedlings grown 3 days in a loam soil. Fresh shoot weight was reduced 30% by 30 mg/L Cr, while 10 mg/kg had no effect. Adema and Henzen (1989) calculated EC50 concentrations for effects of Cr added as Cr(VI) on lettuce, tomato and oats grown in a growth chamber from seed for 14d. The EC50 for lettuce in a humic sand soil (pH 5.1, % organic matter 3.7) was greater than 11 mg/kg while in a loam soil (pH 7.4, % organic matter 1.4) it was 1.8 mg/kg Cr. The EC50 for tomato in the humic sand soil was 21 mg/kg, while in the loam soil it was 6.8 mg/kg Cr. The EC50 for oats in the humic sand soil was 31 mg/kg, while in the loam soil it was 7.4 mg/kg Cr. Results of these experiments show the ameliorating effects of organic matter on Cr (VI) toxicity.

Farasgova (1994) studied the effects of metals on the germination and root growth of *Sinapsis alba* seeds at various pHs. 72h LC50s for germination were 123.03 mg/kg at pH 2.46 and 100.0 mg/kg at pH 7.25. 72h LC50s for root growth inhibition were 5.01 mg/kg at pH 2.46 and 45.71 mg/kg at pH 7.25.

Will and Suter (1995) reported soil NOEC and soil LOEC values for the toxicity of chromium to plants in soil. The NOEC values ranged from 0.35 to 11 mg/kg and the LOEC values ranged from 1.8 to 31 mg/kg. A bioconcentration factor of 1000 was calculated for barley seedlings (Smith et al., 1989).

Soil-plant uptake factors (concentration in plant/ concentration in the soil) for grass, herbs, and tree/shrubs were calculated at 0.0663, 0.0007, and 0.0249, respectively (Efroymson et al., 1996).

Toxicity to Plants in Solution. Calculated EC50 concentrations for effects of Cr(VI) added as $K_2Cr_2O_7$ on lettuce, tomato and oats grown from seed for 14d ranged from 0.16 (lettuce) to 1.4 mg/kg Cr (oats) (Adema and Henzen, 1989). The concentration of Cr(VI), from $(NH_4)_2CrO_4$, required for a 50% reduction in seed germination and root length of mustard after 3d exposure in solution (pH 7.3), was reported by Farasgova (1994) to be 100 mg/kg. EC50 for root length was 46 mg/kg Cr. Using a 1:1 combination of Cr(III) ($CrCl_3$) and Cr(VI) (K_2CrO_7) in nutrient solution (pH 5), Hara et al. (1976) measured a 68% reduction in weight of cabbage with 10 mg/kg Cr (2 mg/kg had no effect).

Top weight of soybean seedlings grown for 5d in nutrient solution containing Cr(VI) was reduced 21% by 1 mg/kg Cr, while 0.5 mg/kg had no effect (Turner and Rust, 1971). Wallace et al. (1977a) measured a 30% reduction in leaf weight of bush beans grown 11d in nutrient solution containing 0.54 mg/kg Cr as (Cr VI).

Length of the longest root of rye grass was reduced 69% by exposure to 2.5 mg/kg Cr(VI) (lowest concentration tested) in nutrient solution (pH 7) for 14d (Wong and Bradshaw, 1982). Length of the longest shoot was not affected at this concentration. Breeze (1973) found little difference in the toxicity of Cr(III) [$Cr_2(SO_4)_3$] and Cr(VI) ($K_2Cr_2O_7$) to rye grass seed germination. Seed exposed to solutions containing 50 mg/kg Cr (III) or (VI) reduced germination 37 and 38% after 2.5d.

Nutrient solution containing 0.05 mg/kg Cr(III) [$Cr_2(SO_4)_3$] reduced leaf and stem weights of chrysanthemum seedlings exposed for 2 d by 31 and 36% (Patel et al., 1976). This was the lowest concentration tested and root weight was not affected.

Based on these experiments, there is an indication that the source of the Cr affects plant response and seed germination is not as sensitive as growth.

Will and Suter (1995) reported NOEC and LOEC values for the toxicity of chromium to plants in solution. The NOEC values ranged from 0.004 to 50 mg/L and the LOEC values ranged from 0.052 to 100 mg/L.

Phytotoxic Mode of Action. Chromium is not an essential element in plants. The (VI) form is more soluble and available to plants than the (III) form and is considered the more toxic form (Smith, et al., 1989). In soils within a normal Eh and pH range, Cr(VI), a strong oxidant, is likely to be reduced to the less available Cr(III) form, although the (III) form may be oxidized to the (VI) form in the presence of oxidized Mn (Bartlett and James, 1979). In nutrient solution, however, both forms are about equally taken up by plants and toxic to plants (McGrath, 1982). Cr(VI), as CrO_4^{2-}, may share a root membrane carrier with SO_4^{2-}. Cr(VI) is more mobile in plants than Cr(III) but translocation varies with plant type. After plant uptake, Cr generally remains in the roots because of the many binding sites in the cell wall capable of binding especially the Cr(III) ions (Smith et al., 1989). Within the plant Cr(VI) may be reduced to the +3 form and complexed as an anion with organic molecules. Symptoms of toxicity include stunted growth, poorly developed roots, and leaf curling. Chromium may interfere with C, N, P, Fe, and Mo metabolism, and enzyme reactions (Kabata-Pendias and Pendias, 1984).

Cobalt

Cobalt (Co), a hard, silvery white metal, is strategically important in the production of high-temperature alloys and permanent magnets (Brobst and Pratt, 1973). Cobalt salts are utilized in the production of pigments and in paint dryers as catalysts (Lustigman et al., 1995). It is found in the earth's crust at an average concentration of 20 mg/kg. Cobalt is an essential element making up approximately one-half of the contents of vitamin B12, which is necessary in the prevention of pernicious anemia (Oehme, 1979). Comparatively little is known about the toxicity of cobalt.

Toxicity to Plants in Soil. Linzon (1978) reported unspecified toxic effects on plants grown in a surface soil with the addition of 20 mg/kg Co.

Soil-plant uptake factors (concentration in plant/ concentration in the soil) for grass, herbs, and tree/shrubs were calculated at 0.0096, 0.0056, and 0.0026, respectively (Efroymson et al., 1996).

Toxicity to Plants in Solution. Wallace et al. (1977a) evaluated the effect of Co as $CoSO_4$ on bush beans grown for 21d in nutrient solution. Leaf dry weight was reduced 22% by the addition of 0.06 mg/kg Co, the lowest concentration tested. Root and stem weight were not affected at this concentration. Chrysanthemum seedling root weight was reduced 55% after 21d growth in nutrient solution containing the same concentration of Co as $CoSO_4$ (Patel et al., 1976). Leaf and stem weight were not affected at this concentration.

Will and Suter (1995) reported NOEC and LOEC values for the toxicity of cobalt to plants in solution. The NOEC values ranged from 1 to 50 mg/kg and the LOEC values ranged from 0.06 to 50 mg/kg.

Phytotoxic Mode of Action. Cobalt is not known to be essential to plants except legumes in symbiosis with N_2-fixing microorganisms. When translocated from roots it travels in the xylem as the Co(II) ion (Tiffin, 1967). 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).

Copper

Copper (Cu) occurs in natural waters primarily as the divalent cupric ion in free and complexed forms (EPA 1985-Cu). Copper is a minor nutrient for both plants and animals at low concentrations, but is toxic to aquatic life at concentrations only slightly higher. Concentrations of 0.001 to 0.010 mg/L are usually reported for unpolluted surface waters in the United States. Common copper salts, such as the sulfate, carbonate, cyanide, oxide, and sulfide are used as fungicides, as components of ceramics and pyrotechnics, for electroplating, and for numerous other industrial applications (ACGIH, 1986). The largest anthropogenic releases of copper to the environment result from mining operations, agriculture, solid waste, and sludge from sewage treatment plants.

Toxicity to Plants in Soil. Miles and Parker (1979) found approximately 68% reductions in root and shoot weights of little bluestem grown from seed for 12 weeks in a sandy soil (pH 7.8, % organic matter 2.5), with 100 mg/kg Cu as $CuSO_4$ added (only concentration tested). Growth was reduced in a second sandy soil (pH 4.8, % organic matter 1.9) by 86% with the addition of 100 mg/kg Cu (only concentration tested). Wallace et al. (1977c) evaluated the effects of Cu, added as $CuSO_4$ to a loam soil, on leaf and stem weights of bush beans grown from seed for 17 days. Leaf weight was reduced 26% by 200 mg/kg Cu, while 100 mg/kg had no effect.

Soil-plant uptake factors (concentration in plant/ concentration in the soil) for grass, herbs, and tree/shrubs were calculated at 0.1409, 0.0012, and 0.2439, respectively (Efroymson et al., 1996).

Toxicity to Plants in Solution. The effect of Cu on stem diameter increase and plant weight of red pine, maple, dogwood, and honeysuckle was examined by Heale and Ormrod (1982). All seedlings (90-d old) grown for 110 d in nutrient solution containing 4 mg/L Cu from $CuSO_4$ (lowest concentration tested) were affected. Reductions in rate of stem diameter increase and in plant weight were 41 and 50%, 79 and 67%, and 97 and 74% for maple, dogwood, and honeysuckle, respectively. Red pine experienced a 28% decrease in plant weight at 4 mg/L Cu but the stem diameter increase was unaffected up to 20 mg/L Cu (highest concentration tested).

Wong and Bradshaw (1982) measured a 71% reduction in length of longest root in rye grass grown for 14 d in nutrient solution (pH 7) to which 0.031 mg/L Cu as $CuSO_4$ was added (lowest concentration tested). After 4 d, root length of rice seedlings was reduced 64% by 64 ppm Cu (6.4 mg/L had no effect) added as $CuSO_4$ to nutrient solution (Gupta and Mukherji, 1977).

Maize seedlings germinated and grown for 10 d in solution containing $CuSO_4$ had a 40% reduction in total fresh weight in the 0.06 mg/L Cu treatment (lowest concentration tested) (Stiborova et al., 1986). This same concentration caused a 45% reduction in root weight of chrysanthemums grown for 21d in nutrient solution with $CuSO_4$ added (Patel et al., 1976).

Will and Suter (1995) reported NOEC and LOEC values for the toxicity of copper to plants in solution. The NOEC values ranged from 0.5 to 50 mg/L and the LOEC values ranged from 0.031 to 100 mg/L.

Phytotoxic Mode of Action. Copper is a micronutrient essential for plant nutrition. It is required as a co-factor for many enzymes and is an essential part of a copper protein involved in

photosynthesis. Copper occurs as part of enzymes and enzyme systems. Root absorption appears to be passive, perhaps in organo-copper complexes (Jarvis and Whitehead, 1983), and active through a specific carrier (Fernandes and Henriques, 1991). Copper may be deficient in low-copper soils because the metal is adsorbed to cells in the root system. The form in which it is taken into the root affects its binding there (Wallace and Romney, 1977c). Copper can be transported in the xylem and phloem of plants complexed with amino acids.

The most common toxicity symptoms include reduced growth, poorly developed root system, and leaf chlorosis (Wong and Bradshaw, 1982). The basic deleterious effect of Cu is related to the root system where it interferes with enzyme functioning (Mukherji and Das Gupta, 1972). It also strongly interferes with photosynthesis and fatty acid synthesis (Smith et al., 1985).

Mercury

Mercury (Hg) has no known biological function and is toxic to fish and wildlife. It is a mutagen and carcinogen that adversely affects the central nervous, renal, and reproductive systems of wildlife. Hg occurs in the environment as elemental mercury, Hg_2(II) and Hg(II), the latter of which is naturally oxidized from elemental mercury (Eisler, 1987). Mercury in ambient waters commonly occurs as mercury (II) or methylmercury. Mercury (II) can be methylated by both aerobic and anaerobic bacteria in the slime coat, liver, and intestines of fish, but methylation apparently does not occur in other tissues or in plants (EPA, 1985-Hg). From a toxicological standpoint, methylmercury (MeHg) poses a greater threat to biota due to its high stability and the ease with which it penetrates membranes in living organisms. Hg(II), however, is more prevalent in aquatic systems, bound up and unavailable in sediment layers. Biota bioconcentrate mercury compounds which can be further biomagnified through food chains (Wren, 1986). High concentrations of mercury in water are often associated with low alkalinity lakes and newly created bodies of water (Weiner and Stokes, 1990). Alkalinity, ascorbic acid, chloride, dissolved oxygen, hardness, organic complexing agents, pH, sediment, and temperature probably affect the acute and chronic toxicity and bioaccumulation of the various forms of mercury.

Anthropogenic sources of Hg include the combustion of fossil fuels, metal mining and processing plants, chloralkali plants, and disposal of batteries and fluorescent lamps (NAS 1978, and Das et al., 1982; as cited in Eisler, 1987).

Toxicity to Plants in Soil. There was no primary reference data describing toxicity of Hg to plants grown in soil. Kloke (1979) report unspecified toxic effects on plants grown in a surface soil with the addition of 0.3 mg/kg Hg.

Toxicity to Plants in Solution. Several authors have provided information on the relative phytotoxicity of forms of Hg. Results indicate that organic forms are more toxic than inorganic forms. The effect of Hg, as $HgCl_2$, on root elongation of 3-week old Norway spruce seedlings grown for 7d in nutrient solution (pH 4) was examined by Lamersdorf et al. (1991). The only concentration tested, 0.002 mg/L Hg, reduced root elongation by 31%. Methyl mercury (CH_3HgCl) completely stopped root elongation at a concentration of 0.0002 mg/L, the only concentration tested. Schlegel et al. (1987) investigated the effects of inorganic ($HgCl_2$) and organic (CH_3HgCl) Hg on needle chlorophyll content, transpiration rate, and CO_2 uptake of 2-week old spruce seedlings in nutrient solution (pH 4.3) for 35d. Methyl Hg at 0.002 mg/L Hg (lowest concentration tested) reduced transpiration rate, and CO_2 uptake by 49, and 73%. At 0.02 mg/L Hg (lowest concentration tested), both forms reduced needle chlorophyll content approximately 28%.

Mukhiya et al. (1983) compared the toxicity of different Hg compounds to barley growth in solution at concentrations of 1 to 50 mg/L, and found organic forms to be more toxic than inorganic forms. After 7d, mercury as $C_8H_8HgO_2$ (phenyl mercuric acetate) at 5 mg/L reduced growth approximately 25%. Mercuric acetate ($C_4H_6HgO_4$) at 10 mg/L Hg reduced root length and plant weight 23%. Mercurous chloride (Hg_2Cl_2) and mercuric chloride ($HgCl_2$) at 50 mg/L reduced growth approximately 25%.

Seeds of sorghum, alfalfa, mung bean, cluster bean , and radish were allowed to germinate and grow for 5d in solutions containing 0.001 to 1 mg/L Hg as $HgCl_2$ (Mhatre and Chaphekar, 1982). At 0.01 mg/L Hg, root length reductions ranged from 22 for radish to 52% for alfalfa, with Pennisetum, mustard, sorghum, and cluster bean having intermediate reductions. Shoot length of *Pennisetum*, alfalfa, and cluster bean were also reduced at this concentration 25, 37, and 26%, respectively. Root length of pea was reduced 40% by the addition of 0.1 mg/L. Root and shoot lengths of mung bean were reduced 28 and 50% at this concentration. The concentration of Hg, from $HgCl_2$, required for a 50% reduction in seed germination and root length of mustard after 3d exposure in solution (pH 7.4), was reported by Fargasova (1994) to be 129 mg/L. EC50 for root length was 9.3 mg/L Hg. After 14d, lengths of longest root and shoot of germinating rye grass seedlings were reduced 40 and 23% by 5 mg/L Hg (lowest concentration tested) added to nutrient solution (pH 7) as $HgCl_2$ (Wong and Bradshaw, 1982).

Plant Uptake. Organic forms of Hg may be translocated from roots to shoots to a greater degree than inorganic forms in some plants (Huckabee and Blaylock, 1973). Gay (1975) reports that pea plants form methylmercury as an intermediate product from Hg added to the soil in organic and inorganic forms.

Soil-plant uptake factors (concentration in plant/ concentration in the soil) for grass, and tree/shrubs on the Oak Ridge Reservation were calculated at 0.0339, and 0.0468, respectively (Efroymson et al., 1996).

Nickel

Nickel is a naturally occuring element that may exist in various mineral forms. It forms 0.008% of the earth's crust (NAS, 1980). Soil and sediment are the primary receptacles for nickel, but mobilization may occur depending on physico-chemical characteristics of the soil (ATSDR, 1988; USAF, 1990). 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. Nickel occurs in nature in the nonionic and divalent states; other valence states occur very infrequently (Mastromatteo, 1986). Although nickel can exist in several oxidation states, the divalent cation state predominates and is generally considered the most toxic form (EPA 1986-Ni). As with many metals the toxicity of nickel increases as hardness decreases. Fish and invertebrates have approximately the same range of sensitivity.

Toxicity to Plants in Soil. A limited number of studies have evaluated the effects of Ni on oak, rye grass, corn, cotton, and beans. Dixon (1988) measured a 30% weight reduction of red oak seedlings grown for 16 weeks in a sandy loam soil (pH 6, % organic matter 1.5) with addition of 50 mg/kg Ni ($NiCl_2$) (no effect at 20 mg/kg Ni).

Rye grass shoot weight was reduced 66% with the addition of 180 mg/kg Ni (as $NiSO_4$) to a loam soil (pH 4.7) in which the plants had been grown for 4 weeks from seed (90 mg/kg had no

effect) (Khalid and Tinsley, 1980). Oats grown from seed for 110 d in the presence of 50 mg/kg Ni (as $NiCl_2$) in soil (pH 6.1, % organic matter 1.4) had reductions of 38 and 63% in grain and straw weight (Halstead et al., 1969). In a second soil (pH 5.7, % organic matter 4.1) only straw weight was reduced (45%) by addition of 100 mg/kg Ni (50 mg/kg had no effect). Traynor and Knezek (1973) measured a 21% reduction in corn plant weight with the addition of 294 mg/kg Ni (as $NiCl_2$) to a sandy soil (pH 5, % organic matter 2) in which the plants had been grown for 5 weeks from seed. Addition of 220 mg/kg had no effect.

Wallace et al. (1977b) report the results of experiments on the effects of Ni (as $NiSO_4$) on seedlings of a variety of plants grown in a loam soil at several pH's. Corn grown in soil at pH 4.2, 5.6, and 7.5 experienced 74, 80, and 50% reductions in shoot weight after 14 days growth with the addition of 250 mg/kg Ni. Ni at 100 mg/kg had no effect. At pH 5.8, bush beans grown for 16 days had a 64% reduction in shoot weight with the addition of 100 mg/kg (lowest concentration tested). At pH 7.5, a 36% reduction in plant weight occurred with 250 mg/kg Ni, while 100 mg/kg had no effect. After 28 days growth in a loam soil at pH 5.8, bush bean leaf weight was reduced 45% by the addition of 100 mg/kg Ni, while 25 mg/kg had no effect. For barley under these same growth conditions, 25 mg/kg Ni (lowest concentration tested) reduced shoot weight 88%.

Two-week old cotton seedlings grown for 35 d in soil (pH 6.8) to which 100 mg/kg Ni was added (lowest concentration tested) experienced reductions in leaf and stem weights of approximately 45 to 60% (Rehab and Wallace, 1978).

Toxicity to Plants in Solution. The effect of Ni on stem diameter increase and plant weight of red pine, maple, dogwood, and honeysuckle was examined by Heale and Ormrod (1982). Seedlings (90-d from cutting) of red pine and honeysuckle grown for 110 d in nutrient solution containing 2 mg/L Cu from $NiSO_4$ (lowest concentration tested) had reductions in stem diameter increase and plant weight of 100, and 25%, and 84 and 65%, respectively.. Reductions in stem diameter increase in plant weight were 70% dogwood grown in solution containing 10 mg/L Ni, while 2 mg/L had no effect. Maple experienced a 48% decease in plant weight only at 10 mg/L Cu with the stem diameter increase remaining unaffected up to 20 mg/L Cu (highest concentration tested).

The effects of Ni on several horticultural and field crops have been evaluated. Wong and Bradshaw (1982) measured a 29% decrease in length of longest root of rye grass when germinated and grown for 14 d in nutrient solution (pH 7) with 0.13 mg/L Ni [$Ni(NH_4)_2(SO_4)_2$], the lowest concentration tested. Wallace (1979) measured 92 and 68% decreases in root and leaf weights of bush bean seedlings when grown for 21 d in nutrient solution (pH 5) with 1.2 mg/L Ni, the only concentration tested. The effects of 0.25 to 20 mg/L Ni, from $NiSO_4$, on germination and radicle length after 3 d growth in solution of radish, cabbage, turnip, lettuce, wheat, and millet were determined by Carlson et al. (1991b). There was no effect on seed germination up to 20 mg/L Ni. Effective concentrations ranged from 1 mg/L (25% reduction in radicle length of lettuce and turnip) to 12 mg/L (40% reduction in radicle length of millet). The effect of Ni, as $NiCl_2$, on plant weight of cotton grown in nutrient solution (pH 6) was evaluated by Rehab and Wallace (1978). Plant weight was reduced 92% by 5.9 mg/L Cd, while 0.59 mg/L had no effect.

Patel et al. (1976) found 26 and 27% decreases in leaf and stem weights of chrysanthemum seedlings when grown for 14 d in nutrient solution with 0.59 mg/L Ni ($NiSO_4$), while 0.006 mg/L had no effect. Root weight was not affected at 0.59 mg/L Ni.

Phytotoxic Mode of Action. 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). It is generally adsorbed as the Ni(II) ion and translocated in xylem and phloem with an organic chelate (Hutchinson, 1981). Nickel is fairly uniformly distributed between roots and shoots (Wallace and Romney, 1977b). 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.

Selenium

Selenium (Se), is an essential nutrient for some plants and animals when present in trace amounts. However, at levels currently present in the environment, Se poses a significant toxic risk. Anthropogenic sources include the combustion of fossil fuels, municipal wastes, irrigation run-off and industrial effluents. Lechate from seleniferous soils also contributes to the presence of Se in the environment (Eisler, 1985b). Selenium has a combination of attributes which make it an unusual pollutant (EPA, 1987-Se). 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. Plants have the ability to convert inorganic selenium to organic selenium compounds, thereby increasing their biological availability (Lo and Sandi, 1980).

Toxicity to Plants in Soil. Wan et al. (1988) investigated the effects of Se(VI), as Na_2SeO_4, on alfalfa grown from seed to 0.25 bloom stage in three soils. In the sandy loam soil (pH 6.7, % organic matter 13) and in the two clay loam soils (pH 5.6, % organic matter 15; pH 6.9, % organic matter 13), shoot weight was reduced 83, 33, and 56% by the addition of 1.5 mg/kg Se(VI), while 0.5 mg/kg had no effect. The effect of Se(VI) (Na_2SeO_4) on alfalfa grown from seed to bloom was examined in five silty clay loam soils, ranging in pH from 6.9 to 7.8, by Soltanpour and Workman (1980). Shoot weight was reduced by 2 mg/kg in 4 of the 5 soils (91, 74, 23, and 27% reductions), with the greatest reductions in soils with the lowest organic matter content (%'s organic matter 3.1, 3.7, 5, and 6.5, respectively).

Carlson et al. (1991a) investigated the effects of Se(VI) (as Na_2SeO_4) and Se (IV) (as Na_2SeO_3) on sorgrass (*Sorghum*) grown from seed for 42 days in several soils. In a loamy sand soil (% organic matter 19) at pH 5.5 and 6.0, there were 59 and 53% reductions in shoot weight with the addition of 1 mg/kg Se(VI), (lowest concentration tested). No reductions were observed with additions of up to 4 mg/kg Se(IV). In a sandy soil at pH 4.9, 1 mg/kg Se(VI) and 2 mg/kg Se(IV) caused 64 and 61% reductions in shoot weight. In this same sandy soil limed to pH 6.5, Se(IV) had no effect up to 4 mg/kg and Se(VI) reduced shoot weight 66% at 1 mg/kg.

Soil-plant uptake factors (concentration in plant/ concentration in soil) for herbs and tree/shrubs were calculated at 0.004 and 0.072, respectively (Efroymson et al. 1996). However, some plants are Se hyperaccumulators.

Toxicity to Plants in Solution. Martin (1937) evaluated the effect of Se (IV) from Na_2SeO_3 on root and shoot weight, and plant height of wheat and buckwheat seedlings growing in nutrient solution for 42d. Selenium at 1 mg/L (lowest concentration tested) reduced wheat root and shoot weight, and plant height 41, 40, and 23%. This concentration also reduced buckwheat root and shoot weight, and plant height 59, 75, and 44%. Selenium VI (Na_2SeO_4) at 0.79 mg/L (lowest concentration tested) caused a 21% reduction in root weight of bush bean seedlings grown in nutrient solution (pH 4.4) (Wallace et al., 1980).

Phytotoxic Mode of Action. Selenium is absorbed by plants as selenite (IV), selenate (VI) or in organic form and the selenate may be the more toxic. It is believed that selenate is taken up actively while selenite uptake is largely passive (Peterson et al., 1981). Selenium is translocated to all parts of the plant, including the seed, in low molecular weight compounds (Broyer et al., 1972). 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).

Silver

Silver (Ag), a basic element, occurs naturally in the environment as a soft, silver colored metal (ATSDR, 1989b). It also occurs in a powdery white or dark gray to black compound. Silver is found at an average of 0.1 mg/kg in the earth's crust and about 0.3 mg/kg in soils. Silver metals and silver compounds are used in the production of surgical protheses, fungicides, coinage, jewelry, and dental fillings (Fisher et al., 1984). The accumulation of silver in marine algae appears to result from adsorption rather than uptake; bioconcentration fators of 13,000 - 66,000 have been reported (Fisher et al., 1984; ATSDR, 1989b).

Toxicity to Plants in Soil. There was no primary reference data showing toxicity of Ag to plants grown in soil. Linzon (1978) reported unspecified toxic effects on plants grown in a surface soil with the addition of 2 mg/kg Ag.

Toxicity to Plants in Solution. Wallace (1979) examined the effect of Ag from $AgNO_3$ on shoot weight of bush bean seedlings grown in nutrient solution (pH 5) for 13 d. Silver at 0.16 mg/L reduced shoot weight 58% while 0.016 mg/L had no effect.

Phytotoxic Mode of Action. Silver taken up by plants remains in the root system precipitated with phosphate or chloride (Ward et al., 1979). 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).

Thallium

Thallium (Tl) is a widely distributed metal, occurring at concentrations of approximately 1 mg/kg in the earth's crust (Kazantzis, 1979). Tl exists as Tl(II) or the more stable, and soluble, Tl(I) and is soluble over a wide range of pH (Kwan and Smith, 1991). Industrial uses of thallium include alloys, electronic devices, special glass and explosives (Zitko, 1975). Coal-fired power plants are major sources of Tl air pollution due to its presence in flyash (Wallwork-Barber et al., 1985). The international market for thallium is limited, therefore its removal from mining effluent is of low priority (Zitko et al., 1975). Thallium has been used since the 1920s as a rodenticide and is a major primary and secondary source of poisoning for raptors and other predatory mammals

(Crabtree, 1962; Robinson, 1948: as cited in Bean and Hudson, 1976). Due to their high toxicity to larger mammals, their use against larger predatory animals was cancelled in 1972 (Zitko, 1975).

Toxicity to Plants in Soil. No primary data were found showing toxicity of Tl to plants grown in soil. Kloke (1979) reported unspecified toxic effects on plants grown in a surface soil with the addition of 1 mg/kg Tl.

Soil-plant uptake factors (concentration in plant/ concentration in soil) for grass and trees/shrubs were calculated at 0.0143 and 0.0038 (Efroymson et al., 1996).

Toxicity to Plants in Solution. The effect of Tl, as $TlCl_3$, on root elongation of 3-week old Norway spruce seedlings grown for 7d in nutrient solution (pH 4) was examined by Lamersdorf et al. (1991). The only concentration tested, 0.02 mg/kg Tl, reduced root elongation by 27%.

The effects of 0.5 to 40 mg/kg Tl, from Tl_2SO_4, on germination and radicle length after 3d growth in solution of radish, cabbage, turnip, lettuce, wheat, and millet were determined by Carlson et al. (1991b). There was no effect on seed germination up to 40 mg/kg Tl. Effective concentrations ranged from 0.5 mg/kg (65% decrease in lettuce radicle length) to 7.5 mg/kg Tl (23% decrease in cabbage radicle length). Carlson et al. (1975) measured 40 and 55% reductions in photosynthesis when corn and sunflower seedlings were grown in nutrient solution containing 1 mg/kg Tl ($TlCl_2$) (lowest concentration tested).

Phytotoxic Mode of Action. Thallium is not essential for plant growth. Soluble Tl is readily taken up by plants and translocated to aerial parts, probably because of its chemical similarity to K. Toxic effects on plants include impairment of chlorophyll synthesis and seed germination, reduced transpiration due to interference in stomatal processes, growth reduction, stunting of roots, and leaf chlorosis (Adriano, 1986).

Zinc

Zinc (Zn) is an essential trace element in all 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). Zinc phosphide is used as a rodenticide. Zinc makes up about 0.002% of the earth's crust (NAS, 1980) and occurs in many forms in natural waters and aquatic sediments.

In freshwater with pH >4 and <7, the dominant forms of dissolved zinc are the free ion (aquo ion complex) (98%) and zinc sulfate (2%) (Campbell and Stokes, 1985), whereas at pH 9.0, the dominant forms are the monohydroxide ion (78%), zinc carbonate (16%), and the free ion (6%) (EPA, 1987-Zn).

Zinc occurs in nature as a sulfide, oxide, or carbonate (Eisler, 1993). It is divalent in solution. 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 0.040 mg/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).

Toxicity to Plants in Soil. Muramoto et al. (1990) measured the effects of addition of Zn as ZnO to an alluvial soil (pH 6) on root and stem weights, stem length, and grain yield of wheat and rice grown from seed to maturity. Root weight of rice was reduced about 29% by 1000 mg/kg (lowest concentration tested). Wheat grain yield and plant weight were reduced 66 and 28% by 1000 mg/kg (lowest concentration tested).

The effect of Zn on soybean growth has been evaluated. Number of seeds produced per plant was decreased by 28% when plants were grown from seed to maturity in an average garden soil to which 25 mg/kg Zn was added as $ZnSO_4$ (Aery and Sakar, 1991). Zn at 10 mg/kg had no effect. The work of White et al. (1979) shows the ameliorating effect on Zn toxicity of increased pH in a sandy loam soil. Soybean leaf weight was reduced 30% by 131 mg/kg Zn at pH 5.5, while 115 mg/kg had no effect. At pH 6.5, leaf weight was reduced 33% by 393 mg/kg Zn, while 327 mg/kg had no effect.

Lata and Veer (1990) measured 45 and 22% reductions in plant weights of spinach and coriander after 60 days in soil with 87 mg/kg Zn.

Toxicity to Plants in Solution. Carroll and Loneragan (1968) measured effects of Zn on weight of 1-week old seedlings of barrel medic (*Medicago*), subterranean clover, and lucerne (*Medicago*) grown for 46 d in nutrient solution (pH 6). Zinc at 0.41 mg/L reduced weights 80, 40, and 37%, respectively, while 0.08 mg/L had no effect. Rye grass root growth was reduced 63% after 14 d growth in solution (pH 7) containing 1.85 mg/L Zn ($ZnSO_4$) (Wong and Bradshaw, 1982). After 16 d, weights bush bean plant weight was reduced approximately 40% by 6.6 mg/L Zn (as $ZnSO_4$), while 0.66 mg/L had no effect (Wallace et al., 1977c).

Patel et al. (1976) found a 30% decrease in root and stem weights of chrysanthemum seedlings when grown for 21 d in nutrient solution with 6.5 mg/L Zn (as $ZnSO_4$), while 0.65 mg/L had no effect.

Phytotoxic Mode of Action. Zinc is an essential element for plant growth. It has a part in many enzymes, and is involved in disease protection and metabolism of carbohydrates and proteins. Zinc is actively taken up by roots in ionic form, and less so in organically chelated form (Collins, 1981).It is fairly uniformly distributed between roots and shoots being transported in the xylem in ionic form (Wallace and Romney, 1977c). Transport in the phloem appears to be as an anionic complex (van Goor and Wiersma, 1976). Toxicity symptoms include chlorosis and depressed plant growth (Chapman, 1966). It acts to inhibit CO_2 fixation, phloem transport of carbohydrates, and alter membrane permeability (Collins, 1981).

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TOXICITY TO MAMMALS AND BIRDS

INORGANICS

Arsenic

Arsenic (As) is a naturally-occuring metaloid found in air and all living organisms. It is present in the earth's crust at approximately 2 mg/kg and is sparingly soluble in water and body fluids. It occurs as two forms in ambient media, arsenic (III), usually the most toxic, and arsenic (V) (EPA, 1985-As) with its magnitude of bioavailability and toxicity dependent upon the oxidation state and temperature (McGeachy and Dixon, 1992). The state is dependent on environmental conditions, including Eh, pH, organic content, suspended solids and sediment. The relative toxicities of the various forms of arsenic apparently vary from species to species. Arsenic may be released into aquatic ecosystems by anthropogenic sources including the manufacture and use of arsenical defoliants and pesticides, electric generating stations, manufacturing companies, mineral or strip mines, steel production, fossil fuel combustion and smelting operations (Sorensen, 1991; McGeachy and Dixon, 1989; Ferguson and Gavis, 1972; NRCC, 1978) and natural leaching of the soils. Arsenic levels in a river ecosystem were found to be dependent upon the availability of arsenic, rain water dillution, extent of complexation with dissolved organic matter and possibly the metabolic activity of aquatic plants (Koranda et al. 1981). As soil clay concentration increases, arsenic adsorption into the soil increases as a function of soil pH, texture, iron, aluminum, organic matter and time (Woolson, 1977). Arsenic is known as one of the most toxic elements to fish with acute exposures resulting in immediate death (Sorensen, 1991).

Toxicity to Mammals. Tissues of animals generally contain an average of <0.5 mg/kg (Venugopal and Luckey, 1978). Arsenic is a carcinogen and teratogen. Effects include reduced growth, hearing/sight loss, liver/kidney damage, and death (Eisler, 1988). Inorganic arsenic is usually more toxic than organic arsenic compounds. Arsenic may be a required micronutrient; growth, survival, and reproduction of goats is poor if the diet contains <0.05 mg/kg As (NAS, 1977). Wildlife mortality and malformations have been observed for chronic doses of 1-10 mg As/kg bw and dietary concentrations of 5-50 mg/kg (Eisler, 1988). Acute LD50s for mammals of 35–100 mg calcium arsenate/kg body weight and 10-50 mg lead arsenate/kg body weight have been reported (NRCC, 1978).

After a 14d exposure to arsine gas, mice had a significant decrease in red blood cells, haemoglobin, and hematocrit numbers. The spleen to body ration increased from 38 to 236% at 0.5 to 5.0 mg/L As (Hong et al., 1989). The solubility in organic solvents and relative nonpolarity of arsine gas allow it to transverse biologic membranes of stem cells and/or react with sulfhydryl groups of proteins necessary for osmotic balance within erythrocytes (Graham et al., 1946; Levinsky et al. 1970).

Schroeder and Mitchner (1971) exposed mice to 5 mg/kg sodium arsenite in drinking water for three generations. While mice exposed to arsenic survived well, litter size decreased in subsequent generations. A dose of 0.38 mg arsenic/kg over a lifetime was sufficient to cause a slight decrease in the median lifespan of laboratory mice (Schroeder and Balassa, 1967), but it had no effect on growth. As little as 3 mg arsenic trioxide/kg body weight or 1 mg sodium arsenite/kg body weight can be lethal (NAS, 1977).

Because metabolism of arsenic in rats is unlike that in other animals, results of toxicity studies using rats generally should not be extrapolated to other species (Eisler, 1988).

Soil-small mammal uptake factors for *Sigmodon hispidus, Peromyscus leucopus*, and *Oryzomys palustais* were calculated at 0.001, 0.004, and 0.010, respectively (Sample et al., 1996).

Toxicity to Birds. Among birds, LD50s for arsenic compounds range from 17.4 to 3300 mg/kg bw (Eisler, 1988). While no mortality was observed among mallard ducks fed a diet containing 100 mg/kg sodium arsenite for 128 days, 12% to 92% mortality was observed for ducks fed diets containing 250 to 1000 mg/kg arsenite (USFWS, 1964). Camardese et al. (1990) and Whitworth et al. (1991) fed mallards diets containing 30, 100, or 300 mg/kg sodium arsenate. While no effects were observed on behavior, growth was reduced for male ducks consuming 300 mg/kg arsenic and for female ducks at all exposure levels. Arsenic levels in the Dunlin (*Calidris alpina*) paralleled each other in the preegland and kidney which suggests that excretion of the toxicant is via the preegland (Goede and de Bruin, 1985). Swelling of the granular endoplasmic reticulum (GER) of the Coturnix quail suggest that ions accumulate in the interior of the GER with a subsequent influx of water due to a disruption of the normal osmotic balance across the GER membrane. ATP production is reduced through the binding of the citric acid enzymes, and in turn upsets the sodium pump which maintains normal osmotic balance (Bartik and Pisac, 1981; Buchanan, 1962;Clarke and Clarke, 1967; Nystrom, 1984).

Barium

Barium (Ba) is found in the more common mineral forms barite ($BaSO_4$) and witherite ($BaCO_3$) (Oehme, 1979). Barium fluorosilicate and carbonate are forms often used as pesticides. Approximately 400 mg/kg of barium is found in the earth's crust. Some plants accumulate barium from the soil. Barium has industrial applications in areas such as paper manufacturing, fabric printing and dyeing, synthetic rubber production, and drilling fluids. Barium in groundwater has been found to range from 0 to over 20 mg/L (Gilkeson et al., 1983)

Toxicity to Mammals. At low doses, barium acts as a muscle stimulant and at higher doses affects the nervous system of mammals eventually leading to paralysis. The LD50 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).

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 mg/kg 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 mg/kg dose group. Information on developmental and reproductive toxicity of barium to mammals is not available.

Uptake factors for the small mammals *Sigmodon hispidus* and *Oryzomys palustais* were calculated at 0.003 and 0.023, respectively (Sample et al., 1996).

Toxicity to Birds. The LD50 of barium to chickens is 623 mg/kg (Johnson et al., 1960). While chickens will tolerate 1000 mg/kg barium in their diet without adverse effects, 2000 mg/kg reduces growth, 8000 mg/kg produces 50% mortality in 4 weeks, and diets containing 16,000 or 32,000 mg/kg barium are 100% lethal.

Cadmium

Cadmium (Cd) occurs predominately in the form of free divalent cations in most well oxygenated, low organic matter, fresh waters (EPA 1985-Cd). However, both particulate matter and

dissolved organic matter can bind cadmium in biologically unavailable forms. There is no evidence that cadmium is a biologically essential or beneficial element (Eisler, 1985a). Cd toxicity is related to water hardness, with a reduction in toxicity associated with increased water hardness (EPA, 1985-Cd). Therefore, the cadmium toxicity values presented in Table 2 that are not from tests conducted in waters of moderate hardness are normalized to 100 mg/L using the slopes calculated by the EPA (1985-Cd).

Toxicity to Mammals. 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 bioaccumulation the liver and kidney, eventually acting as a cumulative toxin. Cd residues of 2 mg/kg whole body fresh weight are evidence of Cd contamination, and residues >5 mg/kg 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, 1980). Weigel et al., (1987) fed rats 0.24, 0.85, or 2.25 mg/kg Cd in diet for 8 weeks. Concentrations $\geq$0.85 mg/kg 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 mg/kg/day corresponded with critical renal metal loads of 120 mg/kg, a level indicative of adverse health effects. Rats on a diet with 5 mg/kg Cd suffered shortened lifespans (Schroeder et al. 1965). Cd at 50 mg/kg in the diet depleted iron from rat livers (Whanger, 1973). In a 3 generation reproductive study, the population of mice exposed to 1 mg/kg $CdCl_2$ 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).

Soil-small mammal uptake factors for *Sigmodon hispidus* and *Peromyscus leucopus* were calculated at 0.002 and 0.032, respectively (Sample et al., 1996).

Toxicity to Birds. No mortality was observed among adult mallard ducks fed diets containing 0, 2, 20, and 200 mg/kg 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 mg/kg Cd group atrophied and the spermatogenic process was disrupted (White et al., 1978). Among mallard ducklings, 20 mg/kg 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 mg/kg Cd (Heinz and Haseltine, 1983).

Chromium

Chromium (Cr) occurs in the environment as either chromium (III) or chromium (VI). Trivalent chromium is an essential metal in animals, playing an important role in insulin metabolism (Larngard 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). Chromium (III), the predominant form in the environment, exhibits decreasing solubility with increasing pH, and is completely precipitated at a pH above 5.5. In most soils, chromium is primarily present as precipitated chromium (III), which is not bioavailable and has not been know to biomagnify through food chains in its inorganic form (Eisler, 1986b). Chromium is released into the environment in the processing of chromate, electroplating, production at tanning and textile plants, pigment production, and cooling tower preservation. Cr is naturally released into the environment through the weathering of soils (Fishbein, 1976).

Toxicity to Mammals. At high concentrations, chromium is a mutagen, teratogen and carcinogen (Eisler, 1986b). The LD50 for chromium (III) in mice is 260 mg/kg bw and 5 mg/kg BW for chromium (VI). Rats fed Cr(VI) reached a toxic threshold at 1000 mg/kg (Steven et al., 1976). Similar results were observed among rats consuming water containing 25 mg/L Cr(VI) for 1 year (Mackenzie et al., 1958). Tissue accumulation of hexavalent Cr was nine times higher than trivalent chromium.

Soil-small mammal uptake factors for *Sigmodon hispidus, Peromyscus leucopus*, and *Oryzomys palustais* were calculated at 0.001, 0.030, and 0.121, respectively (Sample et al., 1996).

Toxicity to Birds. Chromium is of concern to aquatic birds due to its tendency to accumulate in the roots which are a highly selected food. Although weight gain, egg laying, fertility and embryonic mortality were unaffected at both concentrations tested (10 and 50 mg/kg Cr(III) for 10 months), black duck hens experienced higher mortality as reproductive season approached and those in the higher concentration group were unable to raise as large a proportion of their broods to 10 weeks of age (Haseltine et al., unpublished manuscript). While no malformations were observed among ducklings from treated birds, growth and survivorship was reduced. Physiological effects in the adult ducks included moderate to severe kidney damage in 33% of the ducks tested and mild nephrosis in 33%. Blood examination revealed alteration in packed cell volume and haemoglobin count, both proving to increase with increased doseage.

Heinz and Haseltine (1981) observed no effects on avoidance behavior from fright stimulus of black ducklings fed a diet containing 20 or 200 mg/kg Cr(III).

Copper

Copper (Cu) occurs in natural waters primarily as the divalent cupric ion in free and complexed forms (EPA 1985-Cu). Copper is a minor nutrient for both plants and animals at low concentrations, but is toxic to aquatic life at concentrations only slightly higher. Concentrations of 0.001 to 0.010 mg/L are usually reported for unpolluted surface waters in the United States. Common copper salts, such as the sulfate, carbonate, cyanide, oxide, and sulfide are used as fungicides, as components of ceramics and pyrotechnics, for electroplating, and for numerous other industrial applications (ACGIH, 1986). The largest anthropogenic releases of copper to the environment result from mining operations, agriculture, solid waste, and sludge from sewage treatment plants.

Toxicity to Mammals. Copper is a component of a number of metalloenzymes such as catalase, peroxidases, and cytochrome oxidase and is essential for the utilization of iron (Goyer, 1991; Stokinger, 1981). Although most copper salts occur in two valence states, as cuprous (Cu^{+}) or cupric (Cu^{2+}) ions, the biological availability and toxicity of copper is most likely associated with the divalent state (ATSDR, 1990). Copper sulfate is the most common copper salt. Copper is soluble in nitric acid and hot sulfuric acid, slightly soluble in hydrochloric acid and ammonia, and insoluble in water (Stokinger, 1981).

The metabolism of copper involves mainly its transfer to and from various organic ligands, most notably sulfhydryl and imidazole groups on amino acids and proteins (ATSDR, 1990). The liver is one of the main organs involved in the storage and metabolism of copper. Absorption of ingested copper occurs primarily in the upper gastrointestinal tract (EPA, 1987-Cu). Soluble copper compounds (oxides, hydroxides, citrates) are readily absorbed but water-insoluble compounds

(sulfides) are poorly absorbed (Venugopal and Luckey, 1978). Zinc, molybdenum, and other metals may decrease dietary copper absorption (USAF, 1990a).

In animal studies, oral exposure to copper caused hepatic and renal accumulation of copper, liver and kidney necrosis at doses of ≥100 mg/kg/day, and hematological effects at doses of 40 mg/kg/day (EPA, 1986-Cu; Haywood, 1985; Rana and Kumar, 1978; Gopinath et al., 1974; Kline et al., 1971). Oral or intravenous administration of copper sulfate can increase fetal mortality and developmental abnormalities in experimental animals (Lecyk, 1980; Ferm and Hanlon, 1974). Rat oral LD50 values for various copper compounds are 140 mg/kg for copper chloride ($CuCl_2$); 470 mg/kg for copper oxide (Cu_2O); 940 mg/kg for copper nitrate ($Cu(NO_3)_2 \cdot 3H_2O$); and 960 mg/kg for copper sulfate ($CuSO_4 \cdot 5\ H_2O$) (Stokinger, 1981). Deaths in animals given lethal doses of copper have been attributed to extensive hepatic centrilobular necrosis (USAF, 1990a).

In a 90-day subchronic study with copper cyanide (CuCN), high mortality, attributed to hemolytic anemia, was seen in both male and female rats receiving 50 mg/kg/day by gavage, but not in those receiving ≤5 mg/kg/day (EPA 1986-Cu). In general, male rats appeared to be more sensitive to the effects of CuCN than female rats. Rats receiving 500 mg/kg copper in their diet (about 5 mg/day) appeared normal, while rats receiving 1000 mg/kg exhibited depressed growth, those at 2000 mg/kg hardly grew at all, and those on a 4000 mg/kg diet lost weight rapidly and died (Boyden et al., 1938). Salt licks containing 5–9% copper sulfate caused anorexia, hemolytic anemia, icterus, and hemoglobinuria, followed by death within 2 days in sheep using the licks (Gopinath et al., 1974). The estimated ingested dose was 40–49 g over a 25- to 86-day period. Lecyk (1980) observed reduced litter size, decreased fetal weights, and skeletal abnormalities in the offspring of mice fed diets supplemented with 3000 or 4000 mg/kg copper sulfate (155 or 207 mg copper/kg/day, respectively) for one month prior to gestation and on days 0–19 of gestation.

Aulerich et al., (1982) reported an increased mortality rate in the offspring of minks fed a diet supplemented with >3 mg copper/kg/day as copper sulfate for 50 weeks. Although kit mortality was greater and litter mass was reduced relative to controls, reproductive performance of mink fed diets supplemented with up to 200 mg/kg copper for 357 days was within the normal range for the species (Aulerich et al., 1982). Lifetime exposure to 42.4 mg copper/kg/day (as copper gluconate) in drinking water caused a 12.8% decrease in the maximal lifespan in mice (Massie and Aiello, 1984).

Soil-small mammal uptake factors for *Sigmodon hispidus, Peromyscus leucopus*, and *Oryzomys palustais* were calculated at 0.001, 0.388, and 26.498, respectively (Sample et al., 1996).

Toxicity to Birds. Domestic chicks on diets ≥324 mg/kg copper grew slowly; mortality increased with dietary copper concentrations of 1270 mg/kg (Mayo et al., 1956). Arthur et al., (1958) observed no ill effects in chicks fed ≤500 mg/kg copper in diet up to 8 weeks of age. Dietary copper levels from 588–1176 mg/kg for 10 weeks exerted a toxic effect on chick growth; the minimum toxic level of copper appeared to be about 500 mg/kg (Mehring et al., 1960). Turkey poults tolerated 676 mg/kg copper in starter diets for 21 days with no deleterious effects, but copper was definitely toxic at levels >1620 mg/kg (Vohra and Kratzer, 1968). Chickens given a daily dose of >70 mg/kg of $CuCO_3$ died while those receiving <60 mg/kg exhibited slight symptoms of copper poisoning but survived (Pullar, 1940). No symptoms of copper poisoning were observed in domestic mallards ingesting ≤29 mg/kg/day of $CuCO_3$, but daily intakes ≥55 mg/kg/day were toxic (Pullar, 1940).

Mercury

Mercury (Hg) has no known biological function and is toxic to fish and wildlife. It is a mutagen and carcinogen that adversely affects the central nervous, renal, and reproductive systems of wildlife. Hg occurs in the environment as elemental mercury, Hg_2(II) and Hg(II), the latter of which is naturally oxidized from elemental mercury (Eisler, 1987). Mercury in ambient waters commonly occurs as mercury (II) or methylmercury. Mercury (II) can be methylated by both aerobic and anaerobic bacteria in the slime coat, liver, and intestines of fish, but methylation apparently does not occur in other tissues or in plants (EPA, 1985-Hg). From a toxicological standpoint, methylmercury (MeHg) poses a greater threat to biota due to its high stability and the ease with which it penetrates membranes in living organisms. Hg(II), however, is more prevalent in aquatic systems, bound up and unavailable in sediment layers. Biota bioconcentrate mercury compounds which can be further biomagnified through food chains (Wren, 1986). High concentrations of mercury in water are often associated with low alkalinity lakes and newly created bodies of water (Weiner and Stokes, 1990). Alkalinity, ascorbic acid, chloride, dissolved oxygen, hardness, organic complexing agents, pH, sediment, and temperature probably affect the acute and chronic toxicity and bioaccumulation of the various forms of mercury.

Anthropogenic sources of Hg include the combustion of fossil fuels, metal mining and processing plants, chloralkali plants, and disposal of batteries and fluorescent lamps (NAS 1978, and Das et al., 1982; as cited in Eisler, 1987).

Toxicity to Mammals. Daily doses of 0.1–0.5 mg/kg bw/day and dietary concentrations of 1.0–5.0 mg/kg are lethal to sensitive mammals (Eisler, 1987). Central nervous system toxicity, weight loss, and mortality were observed among rats fed a diet containing 250 mg/kg methyl mercury (MeHg) for 2 weeks (Verschuuren et al., 1976a). Rats consuming 2.5 mg/kg 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 mg/kg MeHg for three generations. While no effects were observed among rats fed 0.1 or 0.5 mg/kg MeHg, offspring viability was reduced among rats in the 2.5 mg/kg treatment. Among mink, 93-day consumption of diets containing 1.8 to 15.0 mg/kg MeHg produced mortality, ataxia, anorexia, and paralysis (Wobeser et al., 1976), with the highest exposures showing the greatest effects.

Soil-small mammal uptake factors for *Peromyscus leucopus*, and *Oryzomys palustais* on the Oak Ridge Reservation were calculated at 0.035, and 1.13, respectively (Sample et al., 1996).

Toxicity to Birds. The acute 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 mg/kg 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 mg/kg 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 produced slightly thinner eggshells. Young of MeHg-treated adults were less responsive to maternal calls and hyper-responsive to fright stimuli.

Nickel

Nickel is a naturally occuring element that may exist in various mineral forms. It forms 0.008% of the earth's crust (NAS, 1980). Soil and sediment are the primary receptacles for nickel,

but mobilization may occur depending on physico-chemical characteristics of the soil (ATSDR, 1988; USAF, 1990). Nickel is used in a wide variety of applications including metallurgical processes and electrical components, such as batteries (ATSDR, 1988; USAF, 1990b). There is some evidence that nickel may be an essential trace element for mammals. Nickel occurs in nature in the nonionic and divalent states; other valence states occur very infrequently (Mastromatteo, 1986). Although nickel can exist in several oxidation states, the divalent cation state predominates and is generally considered the most toxic form (EPA 1986-Ni). As with many metals the toxicity of nickel increases as hardness decreases. Fish and invertebrates have approximately the same range of sensitivity.

Toxicity to Mammals. The absorption of nickel is dependent on its physico-chemical form, with water soluble forms being more readily absorbed. Soluble nickel compounds tend to be more toxic than insoluble compounds (Goyer, 1991). 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.

Oral LD50 values for rats range from 67 mg nickel/kg (nickel sulfate hexahydrate) to >9000 mg nickel/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).

Inorganic nickel compounds are well-tolerated when taken orally by rodents in doses up to 500 mg/kg (Mastromatteo, 1986). Rats continually fed a 250 ppm nickel diet for 16 months suffered no deleterious effects and were considered in excellent condition (Phatak and Patwardhan, 1952). Progressive accumulation of nickel was not observed in the tissues assayed. In a three-generation study of rats, Ambrose et al. (1976) reported 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. Doses of 24.15 mg/kg-day administered as nickel sulfate in the diet had no adverse effects on reproduction of the rats. Growth in dogs was depressed by dietary concentrations of 2500 ppm nickel sulfate hexahydrate; in the rats, growth was depressed at dietary concentrations >1000 ppm (Ambrose et al., 1976).

Toxicity to Birds. Weber and Reid (1968) fed a basal diet of up to 1300 ppm nickel sulfate or nickel acetate to domestic chicks for 4 weeks. Growth of chicks was significantly depressed at 700 ppm nickel and above. Doses of 21.4 mg/kg-day administered as nickel sulfate in the diet had no adverse effects on weight gain after 4 weeks. Mallard ducklings on diets with ≥800 ppm nickel would be adversely affected (Cain and Pafford, 1981).

Selenium

Selenium (Se), is an essential nutrient for some plants and animals when present in trace amounts. However, at levels currently present in the environment, Se poses a significant toxic risk. Anthropogenic sources include the combustion of fossil fuels, municipal wastes, irrigation run-off and industrial effluents. Lechate from seleniferous soils also contributes to the presence of Se in the environment (Eisler, 1985b). Selenium has a combination of attributes which make it an unusual pollutant (EPA, 1987-Se). 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. Plants have the ability to convert inorganic selenium to organic selenium compounds, thereby increasing their biological availability (Lo and Sandi, 1980).

Toxicity to Mammals. While selenium is an essential nutrient that interacts with Vitamin E and maintains muscle integrity, it has a very narrow tolerance range (Eisler, 1985b). In mammals, chronic selenium poisoning is induced by diets containing 1–44 mg/kg 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 mg/L 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 mg/L selenate or selenite in water for a lifetime had no effect on mouse longevity and no tumorigenicity was observed (Schroeder and Mitchner, 1972).

Raccoons on the Kesterson National Wildlife Refuge in California 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.

Soil-small mammal uptake factors for *Peromyscus leucopus*, and *Oryzomys palustais* were calculated at 0.143 and 0.109, respectively (Sample et al., 1996). These factors are unitless quotients of concentration in the whole animal/ concnetration in soil, all on a dry weight basis.

Toxicity to Birds. 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 mg/kg selenite (Heinz et al., 1987) or 1, 2, 4, 8, or 16 mg/kg selenomethionine (Heinz et al., 1989) for about 10 weeks. Exposure to 1, 5, or 10 mg/kg selenite or 1, 2, or 4 mg/kg selenomethionine in the diet had no effect on survival, growth, or reproductive success of adults. The diet containing 100 mg/kg selenite killed 11 of 12 adults. While only one adult receiving the 25 mg/kg diet died, time to laying and the interval between eggs was increased, and duckling survivorship was reduced in this treatment (Heinz et al., 1987). Diets containing 8 and 16 mg/kg 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. Agricultural wastewater containing approximately 0.3 mg/L 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 mg/L (dry weight). As a result, reproductive success among water birds was poor, and the incidence of embryo mortality and developmental abnormalities was dramatically increased.

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 (Tl) is a widely distributed metal, occurring at concentrations of approximately 1 mg/kg in the earth's crust (Kazantzis, 1979). Tl exists as Tl(II) or the more stable, and soluble, Tl(I) and is soluble over a wide range of pH (Kwan and Smith, 1991). Industrial uses of thallium include alloys, electronic devices, special glass and explosives (Zitko, 1975). Coal-fired power plants are major sources of Tl air pollution due to its presence in flyash (Wallwork-Barber et al., 1985). The international market for thallium is limited, therefore its removal from mining effluent is of low priority (Zitko et al., 1975). Thallium has been used since the 1920s as a rodenticide and is a major primary and secondary source of poisoning for raptors and other predatory mammals (Crabtree, 1962; Robinson, 1948: as cited in Bean and Hudson, 1976). Due to their high toxicity to larger mammals, their use against larger predatory animals was cancelled in 1972 (Zitko, 1975).

Toxicity to Mammals. Thallium sulfate, which has been widely used as a rodenticide, has a rat acute oral LD50 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 mg/L Tl in drinking water for 2 mo accumulated Tl in testis and exhibited signs of testicular toxicity including reduced sperm motility (Formigli et al., 1986).

Being chemically isomorphic to potassium, Tl interferes with the potassium dependent activities of the cell (Cavanagh et al., 1974). For instance, Tl affinity to ATPase is ten times greater than that of K which puts the active transport systems at high risk to the presence of Tl (Gehring and Hammond, 1966).

Sample et al. (1996) calculated a soil-mammal uptake factor for *Peromyscus peucopus* at 0.027.

Toxicity to Birds. Bean and Hudson (1976) orally dosed 3 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 LD50 between the doses. Oral LD50s 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 (Zn) is an essential trace element in all 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). Zinc phosphide is used as a rodenticide. Zinc makes up about 0.002% of the earth's crust (NAS, 1980) and occurs in many forms in natural waters and aquatic sediments.

In freshwater with pH >4 and <7, the dominant forms of dissolved zinc are the free ion (aquo ion complex) (98%) and zinc sulfate (2%) (Campbell and Stokes, 1985), whereas at pH 9.0, the

dominant forms are the monohydroxide ion (78%), zinc carbonate (16%), and the free ion (6%) (EPA, 1987-Zn).

Zinc occurs in nature as a sulfide, oxide, or carbonate (Eisler, 1993). It is divalent in solution. 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 0.040 mg/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).

Toxicity to Mammals. 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, 1984). 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 CO_2 exchange (Stokinger, 1981).

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; 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.

Toxicity to Birds. 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 ≥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).

PCBs

Polychlorinated biphenyls (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.

Toxicity to Mammals. 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 1986a, 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 1980).

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