Draft Final
Ecological Risk Assessment Methodology

Technical Memorandum No. 3
Ecological Chemicals of Concern (ECOCs)
Screening Methodology

U S Department of Energy
Rocky Flats Environmental Technology Site
Golden, Colorado

April 1995

TABLE OF CONTENTS

TABLE OF CONTENTS
(continued)

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ACRONYMS AND ABBREVIATIONS

AQUIRE	Aquatic Information Retrieval
AWQC	Ambient Water Quality Criteria
bw	body weight
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CDPHE	Colorado Department of Public Health and Environment
CMS/FS	Corrective Measures Studies/Feasibility Studies
COC	chemical of concern
CWQCC	Colorado Water Quality Control Commission
DQO	data quality objective
DOE	U S Department of Energy
DTPA	diethylenetriaminepentacetic acid
ECOC	ecological chemical of concern
EEC	environmental effects concentration
EG&G	EG&G Rocky Flats, Inc
EPA	U S Environmental Protection Agency
ERA	ecological risk assessment
HHRA	Human Health Risk Assessment
HI	hazard index
HQ	hazard quotient
IAEA	International Atomic Energy Agency
IHSS	individual hazardous substance site
IRIS	Integrated Risk Information System
NOAEL	no-observed-adverse-effects level
ORNL	Oak Ridge National Laboratory
OU	operable unit
PCOC	potential chemical of concern
QA/QC	quality assurance/quality control
QAPjP	Quality Assurance Project Plan
RCRA	Resource Conservation and Recovery Act
RFETS	Rocky Flats Environmental Technology Site
RFI	RCRA Facility Investigation
RI	Remedial Investigation
SCM	Site Conceptual Model

LIST OF ACRONYMS AND ABBREVIATIONS
(continued)

SUF	site use factor
TM	Technical Memorandum
UCL	upper confidence limit
UTL	upper tolerance limit

EXECUTIVE SUMMARY

Technical Memorandum No 3 (TM3), Ecological Chemicals of Concern (ECOCs) Screening Methodology, is one of three technical memoranda that summarize the general approach and methods used in ecological risk assessments (ERAs) at the U S Department of Energy (DOE) Rocky Flats Environmental Technology Site (RFETS) near Golden, Colorado (Figure 1-1) TM1, Assessment Endpoints, describes the general technical approach and scope of the ERAs and presents the assessment endpoints (Suter 1989, USEPA 1994), which are the focus of data collection and analysis for ERAs at RFETS TM2, Sitewide Conceptual Model, presents general descriptions of the abiotic and biotic aspects of the environment at RFETS, the primary contaminant source areas and types, and the species selected for conducting the exposure assessment portion of the ERA

TM3 describes the methodology for identifying ECOCs for use in ERAs associated with environmental investigations at RFETS A screening-level evaluation of contaminants is needed to focus the ERAs on contaminants present at concentrations that may represent a risk to ecological receptors and minimize evaluation of contaminants that do not present a hazard

ECOC screening is part of the problem formulation phase of performing ERAs at Superfund sites (USEPA 1992, 1994) Other components of the problem formulation include development of a site conceptual model (SCM) to characterize exposure pathways, development of risk characterization objectives, and identification of specific data-quality objectives needed to complete the ERA The problem formulation phase of each ERA performed at RFETS will be documented in a Problem Formulation TM which will be provided to the U S Environmental Protection Agency and Colorado Department of Public Health and Environment for review prior to completion of the ERA analysis

The ECOC screening method evaluates data on chemical distribution in biotic and abiotic media associated with potential contaminant source areas The primary source areas at RFETS are the individual hazardous substance sites included in each of the 16 operable units (OUs) designated in interagency agreements (Figure 1-2) Risk evaluation based on source areas is important because design of the primary Resource Conservation and Recovery Act (RCRA) and Comprehensive Environmental Response, Compensation and Liability Act activities, RCRA Facility Investigations/Remedial Investigations (RFI/RI), and Corrective Measures Studies/ Feasibility Studies is based on the OU designations, and remedial action and risk management decisions will be OU-specific Therefore, it is important that the results of the ERAs be useful in making decisions regarding remedial actions associated with an OU, basing the ECOC screen on primary source areas will facilitate decisions on what areas should (or can) be remediated to reduce the overall ecological risk to acceptable levels

The ECOC screening methodology is based on a phased approach with analyses conducted in three tiers (Figure 2-1) Tier 1 is intended to identify site-specific contaminants for each ERA The analysis may include statistical analyses and/or professional judgment The result is a list of potential chemicals of concern (PCOCs) that is then used to determine the contaminants of concern for the Human Health Risk Assessment and the ERA, the two components of the RFI/RI Baseline Risk Assessment

The potential ecotoxicity of PCOCs is evaluated in Tier 2 and Tier 3 The evaluations are conducted only for complete exposure pathways and require development of an SCM to identify contaminant sources, exposure points, potential exposure pathways, and receptor types The Tier 2 and Tier 3 screens each require estimates for exposure of representative or key receptors to site contaminants Key receptors to be used at RFETS were identified as part of the RFETS sitewide ERA methodology and are listed in TM2 Representative species of birds, small mammals, large mammals, and fish were selected based on their abundance at RFETS, special legal status, and position in local food webs Information on life history, body size, diet, and other parameters needed to estimate exposure is also presented in TM2

The Tier 2 screen provides an efficient and conservative mechanism to identify Tier 1 PCOCs that are present at potentially ecotoxic concentrations Estimation of exposure and comparison to benchmarks for this tier requires minimal effort in manipulating large data sets and involves a limited number of species The screen is conservative in that it assumes that receptors are continuously exposed to the highest concentrations detected and evaluates potential toxicity to individuals and not effects to populations or communities The Tier 2 screen is equivalent to preliminary exposure and risk calculations included in Step 2 of the most recent ERA (draft) guidance from EPA (1994)

ECOCs identified in Tier 2 are carried into Tier 3 Tier 3 is considered a screening step but includes a more accurate method for estimating exposure than Tier 2 because it incorporates the distribution of chemicals in the environment and spatial and temporal aspects of receptor behavior Factors such as diet, home-range size, seasonal migration, and body size affect the frequency, duration, and intensity of contact with contaminated media Adjustment of exposure parameters to account for these factors is important in obtaining more objective estimates

Potential ecotoxicity of contaminants is evaluated by comparing site-specific exposures to ecotoxicological benchmarks developed for various receptor species from established databases or scientific literature The comparison is expressed as a hazard quotient (HQ) or the ratio of a site-specific exposure estimate to the benchmark (USEPA 1994)

Eq ES-1

$$HQ = \frac{estimated\ exposure}{benchmark\ exposure}$$

Benchmarks are usually selected so that significant ecological effects are not expected when exposures are lower than the benchmarks (HQ < 1) Concentrations or exposures exceeding benchmarks (HQ > 1) do not necessarily indicate significant risk but do indicate that the contaminant should be further evaluated in the ERA

Ecotoxicological benchmark values are based on a database developed at Oak Ridge National Laboratory (ORNL) (ORNL 1994) In most cases benchmarks were derived from data on the toxicity to laboratory test animals and extrapolated to wildlife species by scaling to body size and applying uncertainty factors to account for variability among species and data types (ORNL 1994) The ORNL method is used to develop benchmarks for key receptor species at RFETS Benchmarks and accompanying documentation are included as appendices to this document

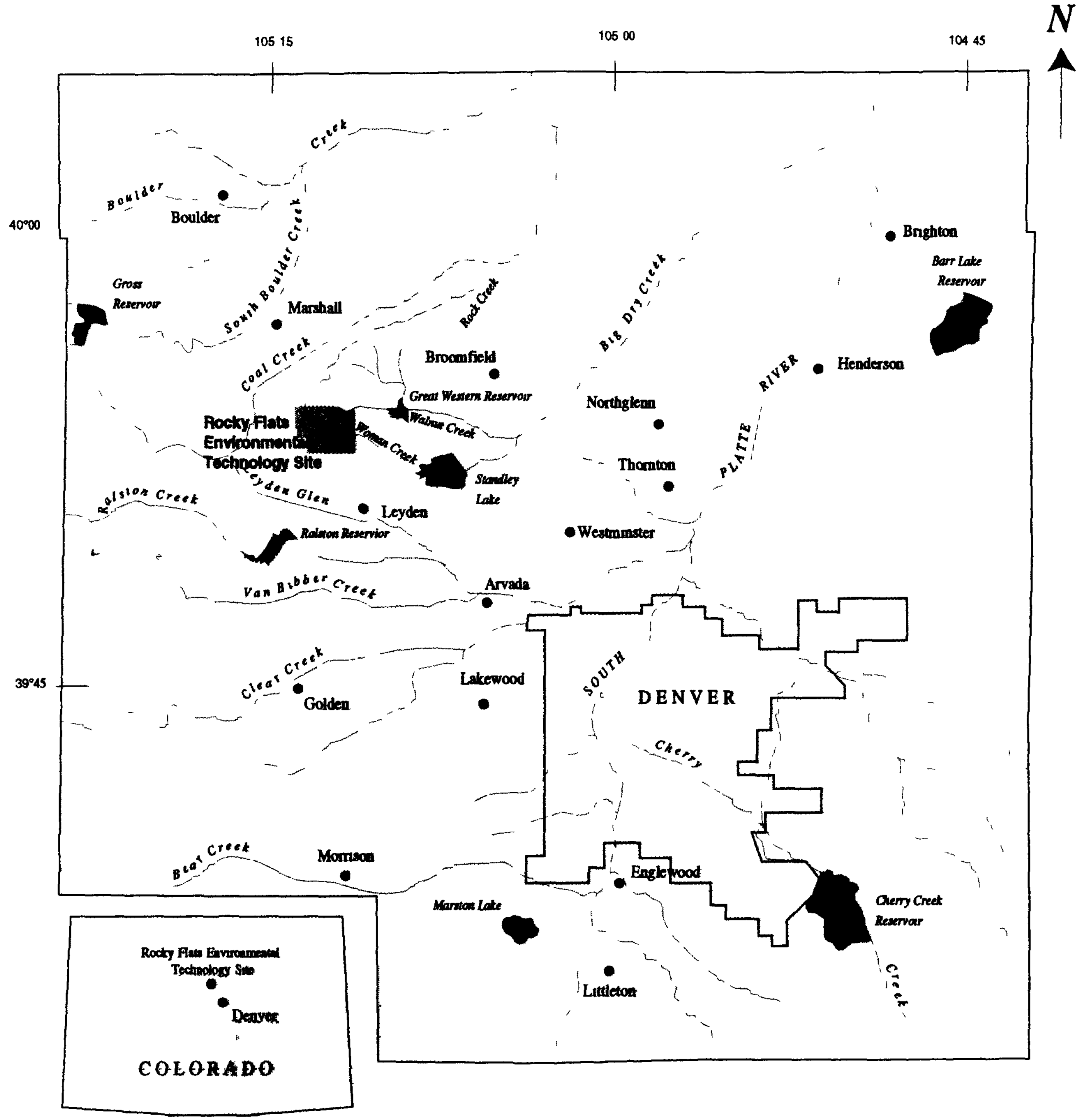
1 0 INTRODUCTION

1 1 Background

Technical Memorandum No 3 (TM3), Ecological Chemicals of Concern (ECOCs) Screening Methodology, is one of three technical memoranda that summarize the general approach and methods used in ecological risk assessments (ERAs) at the U S Department of Energy (DOE) Rocky Flats Environmental Technology Site (RFETS) near Golden, Colorado (Figure 1-1) TM1, Assessment Endpoints, describes the general technical approach and scope of the ERAs and presents the general goals for ecological assessments at RFETS These goals are used to develop specific assessment endpoints, which are the focus of data collection and analysis for ERAs at RFETS TM2, Sitewide Conceptual Model, presents general descriptions of the abiotic and biotic aspects of the environment at RFETS, the primary contaminant source areas and types, and the species selected for conducting the exposure assessment portion of the ERA

ECOC screening is part of the problem formulation phase of performing ERAs at Superfund sites (USEPA 1992, 1994) Other components of the problem formulation include development of a site conceptual model (SCM) to characterize exposure pathways, development of risk characterization objectives, and identification of specific data-quality objectives needed to complete the ERA The problem formulation phase of each ERA performed on a watershed basis at RFETS will be documented in a Problem Formulation TM which will be provided to the U S Environmental Protection Agency (EPA) and Colorado Department of Public Health and Environment (CDPHE) for review prior to completion of the ERA analysis

EPA has drafted a guidance document to expand on the "Framework for Ecological Risk Assessment" (USEPA 1992) The guidance document (USEPA 1994) is currently in a review draft format that has not been formally released but is available The ECOC screening process described in TM3 is based, in part, on this draft guidance Specifically, assumptions used in the Tier 2 ECOC screen are consistent with the Preliminary Risk Calculation (Step 2) section Prior to preparation of this TM, EPA ecotoxicologists were informally consulted in the proper use and citation of the guidance document in its current form The methodology and assumptions used in the ECOC screening are also consistent with previous EPA guidance (USEPA 1989, 1992) and DOE guidance on incorporating ecological risk assessment into Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) investigations (DOE 1994)



U S DEPARTMENT OF ENERGY
Rocky Flats Environmental Technology Site
Golden, Colorado

Draft Final
Ecological Risk Assessment Methodology
Technical Memorandum No 3
Ecological Chemicals of Concern Screening Methodology

Location of Rocky Flats Environmental Technology Site

April 1995	Figure 1-1

1.2 Purpose

A screening-level evaluation of contaminants is needed for at least two reasons First, ERAs at RFETS are generally "source-driven" (Suter 1993), potential source areas are known, but exposures and toxic effects are largely unknown or uncharacterized Screening methods based on ecotoxicity are needed to identify contaminants present at potentially hazardous concentrations Second, investigations associated with CERCLA, the Resource Conservation and Recovery Act (RCRA), and other programs at RFETS are generally broad in scope and generate large amounts of data on the nature and extent of potential contamination Screening these data is necessary to focus the ERAs on contaminants present at potentially ecotoxic concentrations and minimize evaluation of those that present negligible, or *de minimus*, risk (Suter 1993)

This document describes the methodology for identifying ECOCs for use in ERAs associated with CERCLA investigations at RFETS EPA (1992, 1994) identifies three main categories of environmental stressors physical, chemical, and biological Although physical and biological stressors may occur at RFETS, the focus of baseline ERAs at the site is on chemical stressors Two main reasons for this are

- Chemical stressors are usually of greatest concern for ERAs conducted as part of CERCLA investigations (USEPA 1994) OSWER Directive 9285 7-17 states that the overall objectives of baseline ERAs for CERCLA are to identify and characterize the current and potential threats to the environment from a hazardous substance release and establish cleanup levels that will protect natural resources

- The motivation for ERAs conducted for the RFI/RI process at RFETS is generally "source-driven " A primary focus of baseline ERAs is to evaluate contaminant transport, estimate current and potential exposure of receptors to site contaminants, and evaluate the potential ecotoxicity resulting from the exposures

This document should also be used to aid in the development of data quality objectives (DQOs) for the baseline ERA In most cases, much of the data used in the ECOC screen will have been collected for purposes other than use in an ERA The process described in this document is intended to help use these data to focus the ERA on contaminants that may pose a threat to ecological receptors The results of the ECOC screen should be used to develop DQOs for further analysis of available data or for additional data collection and analysis The goals, methods, and DQOs for further evaluation of exposures and ecological risk should be presented in the Problem Formulation TM

1.3 Scope

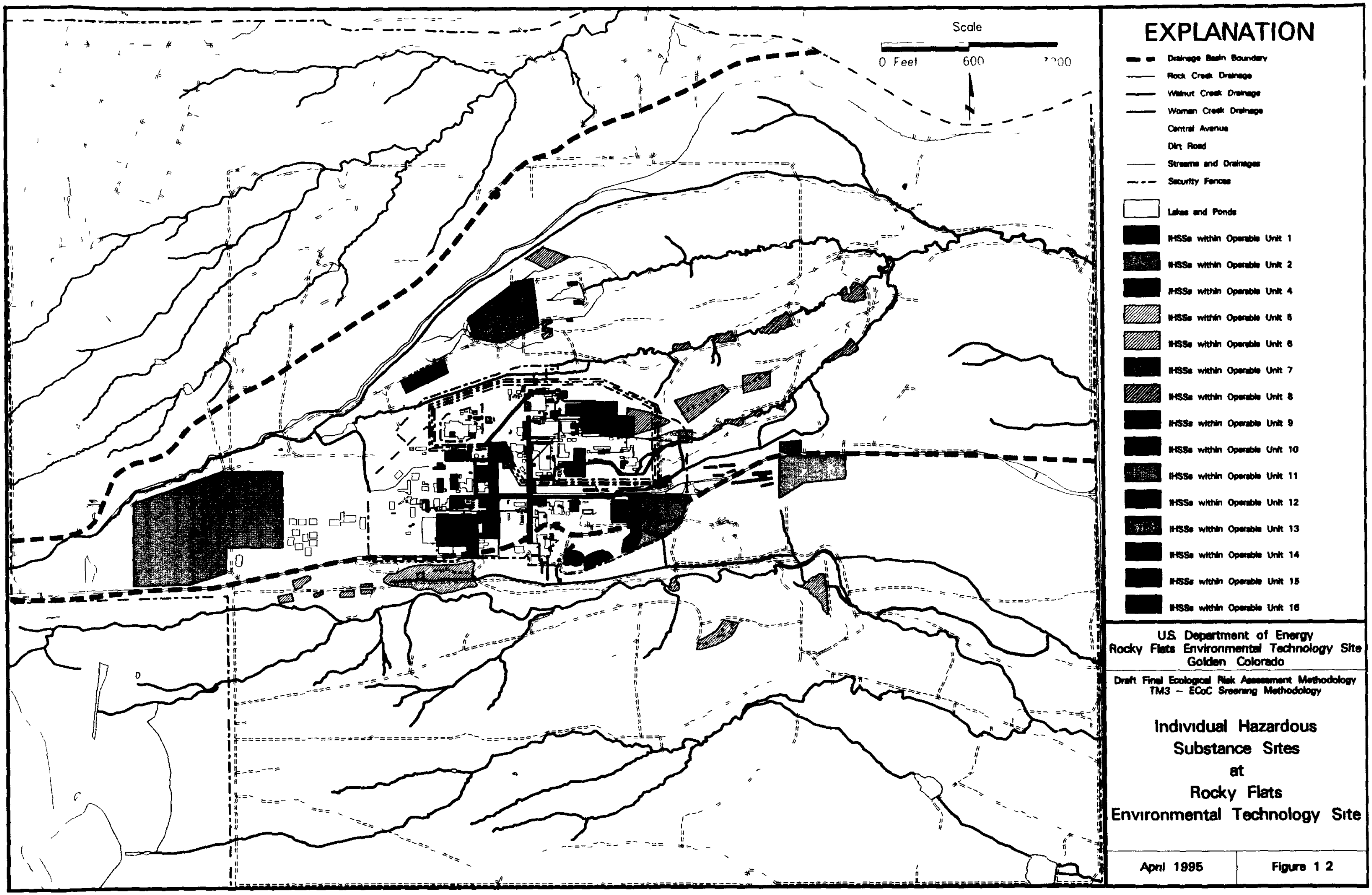
This document describes methods for screening data on chemical distribution in biotic and abiotic media associated with potential contaminant source areas The primary contaminant source areas at RFETS are the individual hazardous substance sites (IHSSs) included in each of the 16 operable units (OUs) designated in interagency agreements (Figure 1-2) Risk evaluation based on source areas is important because design of the primary RCRA/CERCLA activities, RCRA Facility Investigation/Remedial Investigation (RFI/RI), and Corrective Measures Studies/Feasibility Studies (CMS/FS) are based on the OU designations, and remedial action and risk management decisions will be OU-specific However, as a result of recent discussions among EG&G Rocky Flats (EG&G), DOE, EPA, and CDPHE, the design of ERAs, previously based on OUs, is now based on more ecologically relevant units such as the drainages associated with the streams that cross the site Now, an ERA conducted at RFETS may include multiple OUs and some or all of the IHSSs associated with each OU Therefore, it is important that the results of the ERAs be useful in making decisions regarding remedial actions associated with an OU, basing the ECOC screen on source areas relative to drainages or other ecologically relevant units will facilitate decisions on what areas should (or can) be remediated to reduce the overall ecological risk to acceptable levels

The ECOC screening method is a phased approach that includes three tiers The end result of the process is a list of ECOCs for which risks will be assessed in greater detail in the ERA report Although the intent is to identify ECOCs for use in the detailed risk assessment, the screening procedure itself includes a relatively extensive assessment of exposure and toxicity Considerable effort may be required in acquisition and manipulation of data This approach is meant to standardize and facilitate the identification of contaminants for which detailed analysis is required

The second- and third-tier screens include evaluation of toxicological hazards based on the concentration and potential ecotoxicity of contaminants at the site The estimation of exposure and toxicity included in this evaluation is based on effects to individuals, even though evaluation of ecological risk is best judged from effects on populations, communities, or ecosystems (Barnthouse 1993) The approach based on individuals is the most efficient for this evaluation because the best toxicological information on environmental contaminants is usually based on studies that address effects on individual organisms (Suter 1993) Extrapolation of such information to population-, community-, or ecosystem-level effects requires site-specific data acquisition and analysis and is a much more extensive effort The individual-based approach is also consistent with the assumptions of Step 2 of (draft) EPA risk assessment guidance (USEPA 1994) for screening site contaminants

Approaches to ERAs vary greatly with site-specific conditions and objectives and no standard methods or assumptions exist for performing ERAs This document is intended to provide an ECOC screening framework that is flexible enough to accommodate specific needs of ERAs conducted at RFETS TM3 is also intended to be revised as needed to address changing needs of the ERA process at RFETS In particular, Appendices A through D will be revised to incorporate new information on the toxicity of chemical and radionuclide contaminants found at RFETS

Many steps in the ECOC screening process require professional judgment in deciding what methods, assumptions, and data are used The ERA process at RFETS is intended to be a cooperative effort aimed at gaining consensus among DOE, EPA, and CDPHE on key decisions Such cooperation requires frequent contact, substantive interaction, and complete documentation of decisions and assumptions


Scale
0 Feet
600
1200
EXPLANATION
Drainage Basin Boundary
Rock Creek Drainage
Walnut Creek Drainage
Woman Creek Drainage
Central Avenue
Dirt Road
Streams and Drainages
Security Fences
Lakes and Ponds
IHSSs within Operable Unit 1
IHSSs within Operable Unit 2
IHSSs within Operable Unit 4
IHSSs within Operable Unit 5
IHSSs within Operable Unit 6
IHSSs within Operable Unit 7
IHSSs within Operable Unit 8
IHSSs within Operable Unit 9
IHSSs within Operable Unit 10
IHSSs within Operable Unit 11
IHSSs within Operable Unit 12
IHSSs within Operable Unit 13
IHSSs within Operable Unit 14
IHSSs within Operable Unit 15
IHSSs within Operable Unit 16
U.S. Department of Energy
Rocky Flats Environmental Technology Site
Golden Colorado
Draft Final Ecological Risk Assessment Methodology
TM3 – ECoC Screening Methodology
Individual Hazardous
Substance Sites
at
Rocky Flats
Environmental Technology Site
April 1995
Figure 1 2

2.0 ECOC SCREENING METHODOLOGY

2 1 Overview

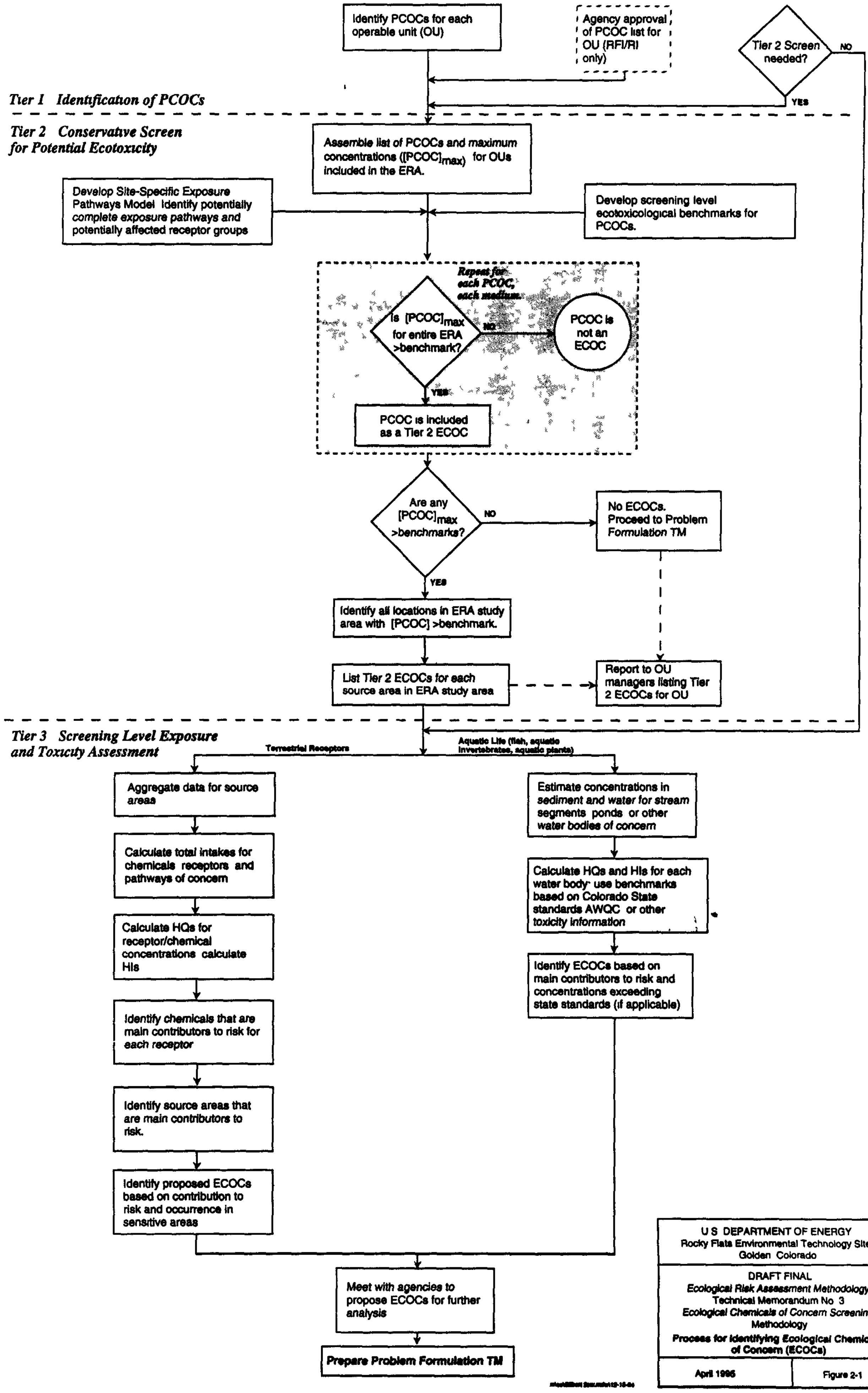
2 1 1 Tiered Approach

The ECOC screening methodology is based on a phased approach with analyses conducted in three tiers (Figure 2-1) The approach is designed for screening data on large numbers of chemicals to identify contaminants that are present at potentially ecotoxic concentrations The approach is based on conservative assumptions that minimize the chance of excluding chemicals that may represent ecological risk Analyses conducted in Tier 1 are intended to identify site-specific contaminants based on distribution of chemicals in abiotic media Tier 2 and Tier 3 include analysis of data from abiotic media and biological tissue and provide a preliminary evaluation of the potential ecotoxicity of contaminants at the site (Table 2-1)

Table 2-1
Summary of Ecological Chemical of Concern Screening Methodology Used in Ecological Risk Assessments at RFETS

Scope/Activity	Tier 1	Tier 2	Tier 3
Background Considered?	yes	no	yes
Exposure Pathways Considered?	no	yes	yes
Ecotoxicity Considered?	no	yes	yes
Data Used	RFI/RI data from chemical analysis of abiotic media	RFI/RI data from abiotic media and data from biological tissue analyses	RFI/RI data from abiotic media and data from biological tissue analyses
Spatial Distribution of Chemical Considered?	no	no[1]	yes
Aggregation of Data	OU-wide for RFI/RI, may be watershed/OU/source area for other ERAs	IHSS for RFI/RI, may be watershed or source area for other ERAs	IHSS for RFI/RI, may be watershed or source area for other ERAs
Receptor Behavior Considered?	no	no	yes
Results Known As	Potential Chemicals of Concern (PCOCs)	Tier 2 Ecological Chemicals of Concern (ECOCs)	Final ECOCs
Use in Ecological Risk Assessment	Used as input for Tier 2	Used as input for Tier 3	Final ECOCs used in detailed risk analysis

[1]Tier 2 screens assume receptor is exposed to maximum concentration 100 percent of time



U S DEPARTMENT OF ENERGY
Rocky Flats Environmental Technology Site
Golden Colorado

DRAFT FINAL
Ecological Risk Assessment Methodology
Technical Memorandum No 3
Ecological Chemicals of Concern Screening Methodology

Process for Identifying Ecological Chemicals of Concern (ECOCs)

April 1996	Figure 2-1

The purpose of Tier 1 is to identify the site-specific contaminants (potential chemicals of concern [PCOCs]) that are the focus of the ERA Tier 1 screening for RFI/RI activities combines statistical comparisons to site background conditions, frequency of detection, and professional judgment The process for identifying PCOCs was developed by DOE for RFETS in cooperation with EPA and CDPHE The result is a list of PCOCs that is then used to determine the chemicals of concern (COCs) for the Human Health Risk Assessment (HHRA) and the ERA, the two components of the RFI/RI Baseline Risk Assessment The PCOCs and the process used in identifying them are detailed in COC TMs prepared for each HHRA EPA and CDPHE must review and approve each of the COC TMs

The potential ecotoxicity of site contaminants is evaluated in Tier 2 and Tier 3 The evaluations are conducted only for complete exposure pathways and require development of an SCM to identify contaminant sources, exposure points, potential exposure pathways, and receptor types The Tier 2 and Tier 3 screens each require estimates for exposure of representative or key receptors to site contaminants Key receptors to be used at RFETS were identified as part of the RFETS sitewide ERA methodology and are listed in TM2 Representative species of birds, small mammals, large mammals, and fish were selected based on their abundance at RFETS, special legal status, and position in local food webs Information on life history, body size, diet, and other parameters needed to estimate exposure is also presented in TM2

Tier 2 screening is conducted using the PCOCs resulting from Tier 1 analysis Tier 2 screening includes the most conservative estimate of exposure because it assumes that each receptor spends all of its time in areas containing the maximum contamination and that 100 percent of a contaminant is absorbed from environmental media These assumptions probably overestimate exposure under most conditions and minimize the chance that a potentially ecotoxic contaminant will be eliminated from further risk evaluation The Tier 2 screen is also consistent with the methods recommended for preliminary risk calculations included in Step 2 of the most recent (draft) EPA guidance on conducting ERAs at Superfund sites (USEPA 1994)

ECOCs identified in Tier 2 are carried into Tier 3 Tier 3 is considered a screening step but includes a more accurate method for estimating exposure than Tier 2 because it incorporates the distribution of chemicals in the environment and spatial and temporal aspects of receptor behavior Factors such as diet, home-range size, seasonal migration, and body size affect the frequency, duration, and intensity of contact with contaminated media Adjustment of exposure parameters to account for these factors is important in obtaining more objective estimates

Tier 3 ECOCs may not require further evaluation if the estimation in Tier 3 is adequate to characterize exposure ECOCs present at concentrations that are clearly hazardous (*de manifestus* risk) also may not require further analysis for exposure In these cases, information on effects from the site, such as results of toxicity tests or community data, are likely to reflect impacts Further characterization may be needed when toxicity is not clearly indicated or for development of remediation criteria Details of further analyses are presented in the Problem Formulation TM

Details of screening methods and use of ecotoxicological benchmarks are presented the following sections Tier 1 is briefly described in Section 2 2 More detailed treatments of this process are included in the technical memoranda associated with specific RFI/RI reports Section 2 3 and Section 2 4 describe the methods for Tier 2 and Tier 3 ECOC screens, including assumptions for identifying exposure pathways and receptor types and calculating exposure point concentrations

Evaluation of ecotoxicity in Tier 2 and Tier 3 requires development of an SCM to identify the receptors of concern, potentially complete exposure pathways, and the data needed to estimate exposure point concentrations Information on the distribution of PCOCs in environmental media are used in conjunction with ecological information in TM2 to develop the SCM for the ERA study area or each contaminant source area. This information is used in the ECOC screen and more detailed exposure estimates to characterize risk from toxic exposure

2 1 2 Estimation of Risk

Potential ecotoxicity of contaminants is evaluated by comparing site-specific exposures to ecotoxicological benchmarks developed for various receptor species from established databases or scientific literature The comparison is expressed as a hazard quotient (HQ), the ratio of a site-specific exposure estimate to the benchmark (USEPA 1994)

Eq 2-1

$$HQ = \frac{estimated\ exposure}{benchmark\ exposure}$$

Benchmarks are usually selected so that significant ecological effects are not expected when exposures are lower than the benchmarks (HQ $<$ 1) Concentrations or exposures exceeding benchmarks (HQ > 1) do not necessarily indicate significant risk but do indicate that the contaminant should be evaluated further in the ERA

Information for developing ecotoxicological benchmarks is available from various sources, including

- EPA-supported databases such as the Integrated Risk Information System (IRIS) and Aquatic Information Retrieval (AQUIRE)

- EPA Ambient Water Quality Criteria

- U S Fish and Wildlife Service Contaminant Hazard Reviews

- Oak Ridge National Laboratory (ORNL) database of toxicological benchmarks (for wildlife, aquatic life, and plants)

- The open scientific literature

Selection of ecotoxicological benchmarks from these and other sources is discussed in Section 2 5

2 1 3 Sources for Data

Data on PCOC concentrations in media and/or biological tissues may be used in the ECOC screens Data on contaminant concentrations may be obtained from any source approved for use by EG&G, DOE, EPA, and CDPHE Review of data quality should be undertaken to determine its usability and limitations Data use and analysis in ECOC screening or in ERA reports should conform to Rocky Flats quality assurance/quality control (QA/QC) guidelines described in the Environmental Restoration Sitewide Quality Assurance Project Plan (QAPjP) (EG&G 1990), EMD Operating Procedures (Manual 5-21000, Volumes I through VI) for sample collection and handling methods (EG&G undated), and EMD Administrative Procedures Manual (Manual 2-11000-ER-ADM) (EG&G undated) for report preparation and data use In particular, the following procedures and QA/QC guidelines should be consulted

- QAPjP Section 3 0, Design and Control of Scientific Investigations

- QAPjP Appendix A, Data Quality Objective Development Process

- Administrative Procedure for Evaluation of ERM Data for Usability in Final Reports (Manual 2-G32-ER-ADM-8 02)

- Environmental Restoration Operating Procedures Volume V Ecology (Manual 5-21200 OPS-EE)

Data used to estimate exposure point concentrations should be appropriate for the exposure pathways and receptor species of concern In general, use of data on abiotic media is appropriate when evaluating exposure to receptors that have direct contact with soil, sediment, or water When available, data from biological tissue analysis should be used when evaluating exposure to species in upper trophic levels Measurements are based on total chemical content in media For example, exposure to metals in soil or sediment should be based on measurement of the total recoverable metal content of the sample, not measurement of bioavailable fractions such as diethylenetriaminepentacetic acid (DTPA) or other weak acid extraction techniques

Data used to estimate exposure to contaminants in water should be consistent with application of state water quality standards Total recoverable (not filtered) chemical concentrations in water should be used when estimating exposure of wildlife to contaminants in drinking water The dissolved fraction (sample passed through a filter with 0 45 micron pore size) is appropriate when evaluating direct exposure of aquatic species to contaminants in surface water

If biological tissue data are not available, appropriate assumptions about bioaccumulation is appropriate incorporated into the exposure estimate Bioaccumulation properties vary among chemicals and among the media in which contaminants are found For example, non-ionic organic compounds generally have a greater potential for bioaccumulation than metals and ionic organic compounds Many metals tend to bioconcentrate in aquatic systems but not in terrestrial habitats Bioaccumulation factors for typical chemicals can be found in ORNL (1994) (see Appendix A), the EPA database AQUIRE, and primary sources in the ecotoxicological literature Use of bioaccumulation factors in estimating exposures in ECOC screening characterization should be well documented in the Problem Formulation TM Prior approval from EPA and/or CDPHE may be required

2 1 4 Treatment of Uncertainty

Many sources of uncertainty are associated with ecological risk assessments or other environmental investigations The term "risk" itself implies uncertainty about the outcome of the process under study Suter *et al* (1987) identify three main categories of uncertainty sources

- The fundamentally stochastic (random) nature of the environment
- Incomplete knowledge of the system under study
- Uncertainty associated with execution of the study

The stochastic variability of nature can be quantified and characterized but not reduced because it is a fundamental property of the system Variability within a data set can be reduced by narrowing the scope of sampling to include items of similar qualities, such as collecting only female mice of a certain age and weight However, the general applicability of the results is proportionately narrowed

The second source of uncertainty refers to scientific ignorance of the system under study This source is theoretically reducible but only at increased cost of sampling or experimental manipulation However, the goal of the RFI/RI and associated risk assessments is not to eliminate uncertainty but to characterize it in a way that allows it to be used in making informed risk management decisions (USEPA 1987)

The third source of uncertainty involves execution of data collection and analysis This source of uncertainty includes inappropriate sampling locations, inaccurate or inconsistent sample collection methods, and data recording errors This type of uncertainty can be controlled by development of and strict adherence to comprehensive quality assurance plans However, the amount of this error should be assessed for each sampling and analysis step

Uncertainty in risk assessments has traditionally been accomplished through application of conservative assumptions about exposure parameters However, this practice can lead to inconsistent estimation of risk, take accurate estimates of uncertainty out of the decision process, and generate "false positives" that may lead to unnecessary, costly, and possibly damaging remedial actions (Paustenbauch 1990)

As noted, the purpose of the ECOC screen is to identify site-specific contaminants that are present at potentially ecotoxic concentrations while minimizing the chance of underestimating risk of toxicological exposure It is not necessary to fully characterize uncertainty to accomplish this purpose Conservative assumptions that minimize the chance of excluding a chemical contaminant from further evaluation when it is present at potentially ecotoxic levels The degree of conservativeness decreases with successive tiers of the screening process resulting in more accurate risk estimates

2.2 Tier 1—Determination of PCOCs

2 2 1 General

The purpose of Tier 1 is to identify site-specific contaminants (i e , PCOCs) based on data collected from abiotic media in the ERA study area The primary focus of RFI/RI ERAs is on risk resulting from the presence of site-specific contaminants The most detailed exposure and toxicity analyses will be performed for the PCOCs

PCOCs may be identified using qualitative or quantitative methods PCOC identification for RFI/RIs at RFETS is usually based on a method developed specially for use at the site This method, sometimes referred to as the "Gilbert Toolbox," is described in Section 2 2 2 Less quantitative means may also be used to identify PCOCs For example, PCOCs may be identified based on knowledge of industrial processes, waste storage, or known contaminant releases Adequate knowledge of chemical releases may be used to significantly reduce the scope and effort involved in performing the ERA

In most cases, the regulatory agencies must approve the PCOCs addressed in risk assessments Thus, the regulatory agencies may add or delete chemicals based on professional judgment Agency approval of the selection process, the data used in selection, and the final list of PCOCs should be obtained early in the risk assessment process, preferably prior to completion of problem formulation

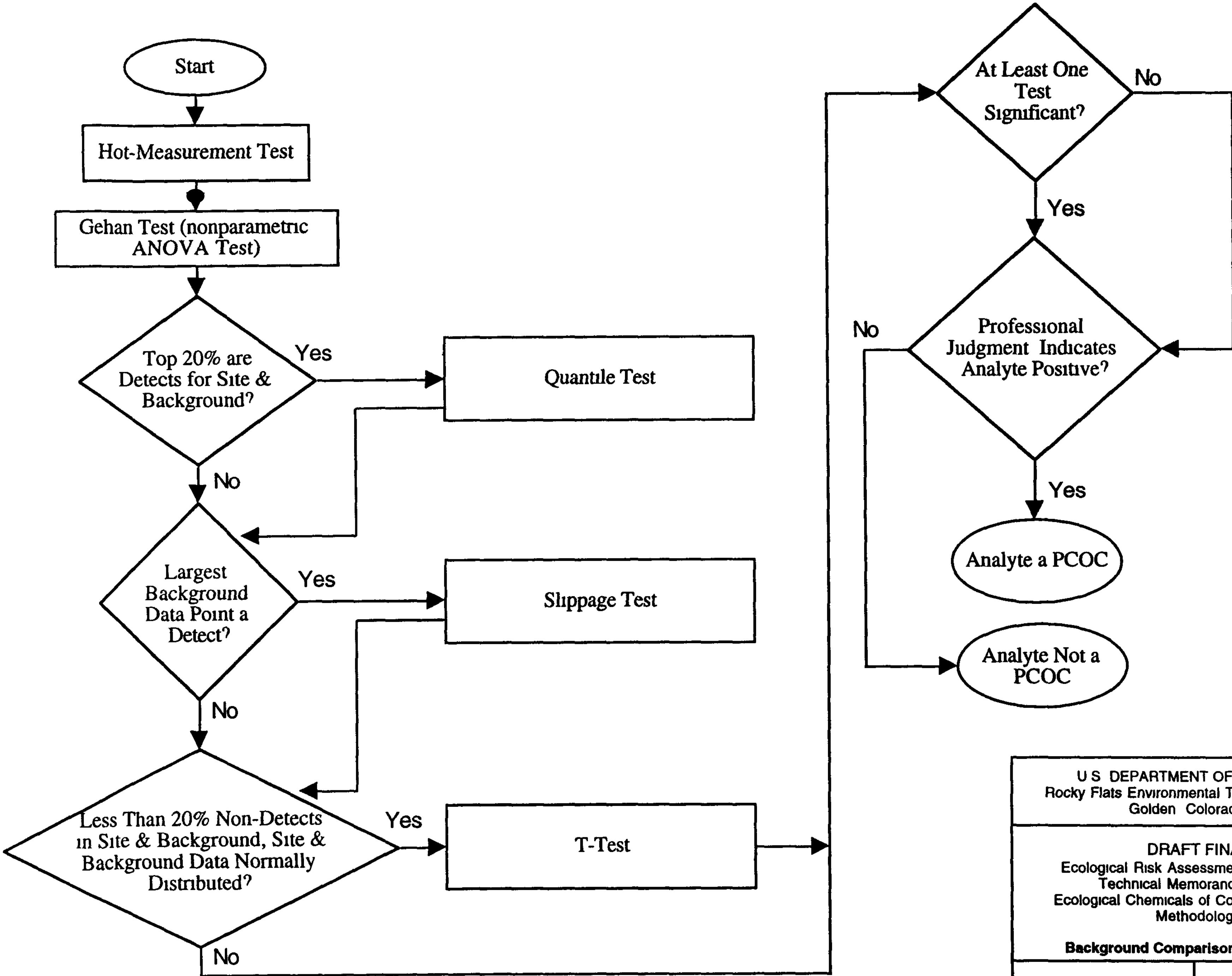
2 2 2 Statistical Analysis Procedures for PCOC Identification Associated with RFI/RI Activities

The flow chart presented in Figure 2-2 illustrates the process for identifying PCOCs The statistical methodology for site-to-background comparisons for inorganic analytes and radionuclides is outlined in Statistical Comparisons of Site-to-Background Data in Support of RFI/RI Investigations (EG&G 1994) The PCOC identification process consists of the following steps (1) a hot-measurement test, (2) the Gehan test, (3) the Quantile test, (4) the Slippage test, (5) the t-test, and (6) professional judgment Analytes having concentrations elevated relative to background concentrations, as indicated by the hot-measurement test or any one of the inferential statistical tests (Gehan, Quantile, Slippage, and t-test), are considered PCOCs The five comparison tests are described below

Chemical data are evaluated using a hot-measurement test, which compares each measurement with an upper tolerance limit (UTL) value for the corresponding analyte in the background data The hot-measurement test is useful as a screening tool to ensure that unusually large measurements are adequately evaluated regardless of the output of the more formal inferential statistical tests The UTL concentration used during comparison of site to background data was the $UTL_{99/99}$ value in accordance with Rocky Flats guidance on statistical comparisons (EG&G 1994) This UTL represents a value for which there is 99-percent confidence that the UTL is equal to or greater than the true 99th percentile of the background population The UTL values for background data are reported in the Background Geochemical Characterization Report (EG&G 1993)

Statistical inference tests (Gehan, Quantile, Slippage, and t-test) are used to compare the means and medians of site data to background populations Inferential tests include both nonparametric (distribution-free) and more traditional parametric types Nonparametric tests are generally more appropriate for use with environmental data because of the relatively rigid assumptions of parametric tests (Gilbert 1987)

The nonparametric Gehan test (Gehan 1965, Palachek *et al* 1993) can be used to evaluate data sets with multiple detection limits, and nondetects and can be used regardless of the distribution of the data The Gehan test is a generalization of the more common nonparametric ANOVA Wilcoxon Rank Sum test The Gehan test is performed for all analytes The parametric ANOVA t-test is used only when background and site data contain less than 20-percent nondetects and normality, as assessed using the Shapiro-Wilk test (Gilbert 1987), is satisfied



U S DEPARTMENT OF ENERGY Rocky Flats Environmental Technology Site Golden Colorado
DRAFT FINAL Ecological Risk Assessment Methodology Technical Memorandum No 3 Ecological Chemicals of Concern Screening Methodology **Background Comparison Methodology**
April 1995 / Figure 2 2

G95\ES\Background Comp 2509 flw

Other nonparametric tests used to compare background and site data include the Quantile and Slippage tests The Slippage test consists of counting the number of OU measurements that exceed the maximum background measurement If the number of measurements exceeding the maximum background measurement is greater than a critical value obtained from tables in Rosenbaum (1954), then the analyte is considered a PCOC

The Quantile test is similar to the Slippage test and is performed by listing the combined background and OU measurements from smallest to largest The test counts the number of measurements from the OU that are among the largest measurements of the combined data sets If the number of measurements is greater than a critical value, the analyte is considered a PCOC The largest measurement and critical values are determined from tables in Gilbert and Simpson (1992)

The inferential statistical tests (Gehan, Slippage, Quantile, and t-test) compare background and OU concentration distributions The hot-measurement test compares each measurement to a corresponding $UTL_{99/99}$ value The difference in the two methods is that the inferential tests compare differences between population distributions and the hot-measurement test compares individual measurement to a single value The hot-measurement test is not considered a formal statistical test because false positive and power requirements are not explicitly stated

The final identification of PCOCs is subject to professional review of the test results and graphic presentation of the data The professional judgment of the analyst is required to consider other factors such as the spatial and temporal distribution of analytes, historic information regarding past operations at the site, inter-element correlations, mass-balance calculations, and knowledge of the hydrology, geochemistry, and geology of the site

2.3 Tier 2—Conservative Screen for Potential Ecotoxicity

The purpose of the Tier 2 screen is to provide an efficient and conservative mechanism to screen a large number of Tier 1 PCOCs to determine which are present at potentially ecotoxic concentrations Estimation of exposure and comparison to benchmarks for this tier requires minimal effort in manipulating large data sets and involves a limited number of species The Tier 2 screen may be omitted if a small or pre-defined area or set of chemicals is to be assessed The screen is conservative in that it assumes that receptors are continuously exposed to the highest concentrations detected and evaluates potential toxicity to individuals and not effects to populations or communities The Tier 2 screen is equivalent to preliminary exposure and risk calculations included in Step 2 of the most recent ERA (draft) guidance from EPA (1994)

2 3 1 Estimation of Exposure Point Concentrations

2 3 1 1 Spatial Aggregation of Data

The concentration of a PCOC at an exposure point is assumed to be equal to the maximum concentration detected for the medium This includes all source areas within the ERA study area For example, if the ERA is being conducted for a drainage basin, the maximum concentration detected among all the potential source areas is used to represent exposures throughout the drainage Although using the maximum concentration overestimates exposure for the study area, it is an efficient way to identify chemicals for further detailed analysis

2 3 1 2 Data Used

Data on PCOC concentrations in abiotic and/or biotic media may be used Data on contaminant concentrations may be obtained from any source provided that it has been approved for use in CERCLA and RCRA investigations at RFETS If data on biological tissue burdens are not available, the exposure point concentration for food is assumed to be equal to that of the maximum concentration in the abiotic medium to which the prey or forage species are exposed

2 3 1 3 Bioavailability

Bioavailability is assumed to be 100 percent for all chemicals in all food and abiotic media Therefore, no adjustment for bioavailability is made when calculating exposures using the measurements described in the previous section This is a conservative assumption that overestimates exposure in most cases but is consistent with Step 2 of the (draft) guidance for conducting ERAs at Superfund sites (USEPA 1994)

2 3 2 Exposure Estimation Procedure

2 3 2 1 Receptors

The screen is conducted using pathway/receptor groups with the lowest benchmark values for a given chemical Using only the most sensitive endpoints ensures that the risk estimate is conservative and minimizes the effort needed to complete the screen As noted previously, only potentially complete exposure pathways are included in the screen The exposure is estimated for individuals of each receptor group considered No extrapolation to population exposures or effects is used

2 3 2 2 Site Use Factors

The exposure estimate assumes continuous exposure to the maximum concentrations for a given PCOC ($[PCOC]_{max}$) in the ERA study area Individual receptors are assumed to spend all of their time in the areas of highest contaminant concentration (site use factor [SUF] = 1 0)

2 3 2 3 Exposure Estimate

The $[PCOC]_{max}$ will be used when comparing site contaminant concentrations to environmental effects concentrations (EECs) When benchmarks are in the form of ingestion rates that result in the no-observed-adverse-effects level (NOAEL), exposure is calculated as

Eq 2-2

$$Exposure = ([PCOC]_{max}) * (IR)$$

Where IR is the ingestion rate for food and/or water for a given receptor species

2 3 4 Risk Estimation

The ecotoxicological risk is calculated as

Eq 2-3

$$HQ = \frac{[PCOC]_{max}}{EEC}$$

when assessing exposure using benchmarks in the form of EECs Equation 2-4 will be used when benchmarks are in the form of ingestion rates

Eq 2-4

$$HQ = \frac{([PCOC]_{max}) * (IR)}{NOAEL}$$

The result of the screen is a list of contaminants, called Tier 2 ECOCs, for which concentrations exceed benchmark values in samples from at least one location in the ERA study area For each Tier 2 ECOC, an inventory is made of all sample locations at which concentrations exceed toxic benchmarks, and the correspondence to IHSSs is noted and reported to RFI/RI project managers for use in preliminary steps of the CMS/FS These sample locations are mapped to help determine whether they represent additional sources outside the IHSS designations

If no ECOCs are identified, the Tier 1 screen should be documented in the Problem Formulation TM The results are used in combination with data on ecological effects, such as community composition and results of toxicity testing, in a weight-of-evidence approach to evaluating risk at the site This analysis includes evaluation of the need for further information on contaminant concentrations and distribution at the site(s) under consideration A screen that results in a lack of ECOCs at a site must be well supported with documentation of the screen, the data used to perform it, and the uncertainty associated with the results

2 4 Tier 3—Exposure Screening Methodology

Tier 3 screening is conducted for chemicals carried through from previous tiers The Tier 3 analysis is also a screening-level evaluation and includes conservative assumptions about bioavailability of contaminants and the use of screening benchmarks However, Tier 3 includes a much more comprehensive evaluation of exposure pathways and more accurate methods for estimating exposure than Tier 2 The Tier 3 exposure estimation includes methods that account for factors that modify the frequency, duration, and intensity of contact between a receptor and the contaminated media These include behavioral factors such as home-range size, seasonal inactivity (hibernation/torpor), and seasonal migration away from or to RFETS In addition, exposure point concentrations are averaged over larger areas to more accurately represent the concentrations to which a mobile receptor species or plant communities are exposed

The more intensive level of screening included in Tier 3 is particularly appropriate in source-driven (Suter 1993) ERAs in which source areas may contain several potential contaminants, but the effects of contaminant exposure are not apparent The Tier 3 analysis is equivalent to a screening-level risk assessment that may be conducted on such sites Use of screening methods that incorporate toxicological benchmarks is an important component in the weight-of-evidence approach to ERAs (Suter 1993) The analysis differs from a more complete ERA in that conservative assumptions are used to estimate exposure, conservative benchmarks are used to characterize risk, and the potential toxicity to individuals, not to populations, is the focus Estimation of risks to populations or communities is conducted for chemicals selected as ECOCs

The Tier 3 analysis results in a list of contaminants that will be subjected to more detailed analysis in the ERA ECOCs, exposure pathways, and receptor types are identified for each IHSS or other source area so that results can be used by managers of OU-based investigations such as RFI/RIs

2 4 1 Estimation of Exposure Point Concentrations

2 4 1 1 Spatial Aggregation of Data

Aggregation of data for the Tier 3 screen depends upon the specific objectives of the analysis, the receptor species under consideration, and the size of the source area(s) relative to the receptor species' home range For example, exposure of individual deer mice may be estimated for each source area in the ERA study area, whereas exposure of coyotes may be averaged over all source areas Alternatively, the contribution from each source area to coyote exposure may be estimated and the aggregate exposure calculated by weighting each area according to proportion of the overall site use Specific objectives and assumptions for each species and group of source areas should be clearly stated in the ECOC screen portion of the Problem Formulation TM

2 4 1 2 Data Used

Data on ECOC concentrations in abiotic and/or biotic media may be used Data may be obtained from any source provided that sampling methods and analysis are well documented and the data are acceptable for use in CERCLA or RCRA investigations If data are not available to estimate biological tissue burdens or uptake ratios, the exposure point concentration for food is assumed to be equal to that of the maximum concentration for the abiotic medium from which the chemical may acquired (e g , soil, water, sediment) and within the area of interest (e g , ERA source area, OU, watershed) Data sources and data quality used in calculating exposure point concentrations must be well documented

Summary statistics used to estimate exposure point concentrations may vary with the objectives of the ERA In some cases, the arithmetic or geometric mean may be the most appropriate measure However, in most cases a more conservative estimate of exposure such as the upper

95 percent confidence on the mean (UCL_{95}) is appropriate If exposure is to be averaged over several source areas, calculation of the mean and UCL_{95} should be weighted in proportion to the site use For terrestrial resources, weighting should be based on the area of the source or habitats within the source relative to the total area under assessment For use of aquatic habitats by terrestrial species, weighting should be based on the amount of aquatic habitat in a source area relative to the total available habitat in all source areas Procedures for calculating weighted means and UCLs are presented in Gilbert (1987)

2 4 1 3 Bioavailability

Bioavailability of contaminants from food and water is assumed to be 100 percent unless data are available to estimate site-specific uptake ratios

2 4 2 Exposure Estimation Procedure

2 4 2 1 Receptors/Exposure Pathways

The screen is conducted for all receptors and exposure routes for which potentially complete exposure pathways exist The exposure is estimated for individuals of each receptor group considered No extrapolation to population exposures or effects is conducted

2 4 2 2 Site Use Factors

The exposure estimate assumes that exposure of individual receptors is proportional to the amount of time spent in the source area The SUF has two main components the proportion of time spent in the source area while at RFETS (proportion of home range) and the proportion of total time spent on RFETS The primary component of the SUF is the proportion of a receptor's home range that is represented by the IHSS or source area under consideration For example, if a given source area represents one-tenth of a coyote home range, the coyote is assumed to spend one-tenth of its time in the area engaged in activities that result in exposure (e g , foraging) In some cases, seasonal migration patterns or inactivity (e g , hibernation) may be considered in combination with home-range size For example, a migratory bird may spend six months per year at RFETS and forage in an area that includes an IHSS that comprises 10 percent of its home range In this case the SUF may be calculated as 0 5 * 0 1 = 0 05 Caution must be exercised when seasonal-use patterns are included in exposure estimations Exposure to a toxin for a period of several months may easily be adequate to elicit a toxic response, particularly if the exposure occurs at critical times of year such as during breeding or gestation

Use of Colorado water quality standards in evaluating risk to aquatic species implies an SUF of 1 0 This exposure scenario is appropriate since obligate aquatic species are restricted to small bodies of water and are continuously exposed to contaminants in surface water and sediment

2 4 2 3 Exposure Estimate

As with Tier 2, benchmarks used to characterize risk may be in the form of EECs in environmental media or expressed as an intake rate The media concentration will be used as the exposure estimate when a concentration is compared against an EEC When the benchmark is in the form of an intake rate, the exposure is calculated from intake of all media (e g , soil, water, food) for which exposure is being estimated Intakes are calculated for each chemical separately For a given species, intake is estimated from Eq 2-5

Eq 2-5

$$Total\ Intake = [C_{soil} * IR_{soil} * SUF_{soil}] + [C_{water} * IR_{water} * SUF_{water}] + [C_{prey} * IR_{prey} * SUF_{prey}] + [C_{forage} * IR_{forage} * SUF_{forage}]$$

Where

C_{medium} = concentration of chemical in environmental medium (i e , soil, water, prey, forage)
IR_{medium} = intake rate for environmental medium
SUF_{medium} = site use factor for medium

Eq 2-5 can be used when estimating intake from a given source area or when data from several source areas is combined to estimate exposure over the ERA study area Alternatively, total intake may be estimated by summing the intakes from several individual source areas within the ERA study area Intakes from individual areas are calculated using Eq 2-5, then summed

Eq 2-6

$$Total\ Intake = \sum_{i=1}^{n} Intake_{area_i} = Intake_{area_1} + Intake_{area_2} + \quad Intake_{area_n}$$

The SUF applied in Eq 2-5 serves to weight intakes proportionate to the expected level of use

2 4 3 Risk Estimation

As with the Tier 2 methods, risk is characterized by comparing exposure estimates to benchmarks using an HQ approach The HQ is calculated using Eq 2-7 when the benchmark is in the form of an EEC and Eq 2-8 when the benchmark is in the form of an intake rate

Eq 2-7

$$HQ = \frac{Exposure\ Point\ Concentration}{EEC}$$

Eq 2-8

$$HQ = \frac{Total\ Intake}{NOAEL}$$

The result of the risk estimation is an HQ for each chemical/receptor/source area combination analyzed Cumulative risk of exposure to multiple contaminants is evaluated using the hazard index (HI) approach (USEPA 1994) The HI assumes that the effects of exposure to multiple chemicals is an additive function of the effects of individual chemicals The HI is calculated as the sum of HQs for individual chemicals Thus, an HI greater than 1 0 indicates potentially significant risk, even if no single HQ is greater than 1 0 HIs will be calculated in Tier 3 by summing the HQs for individual chemicals When the HI for a given area is greater than 1 0, risk estimation will be evaluated to determine which of the contaminants are the main contributors of risk

Identification of final ECOCs from HIs is based on professional judgment, including relative ecotoxicity, potential for bioaccumulation, and presence in areas that are sensitive or used intensively by wildlife The proportion of chemicals included in the final ECOCs may vary among investigations An example process for intake calculations and ranking the relative contribution of ECOCs to total risk is presented in Table 2-2 and Figure 2-3

2.5 Ecotoxicological Benchmarks

The ecotoxicological benchmarks used in estimating risk of toxic exposure may be taken from any source provided they meet the objectives of the study being conducted As noted previously, the benchmarks used in screening ECOCs are conservatively low to avoid underestimating risk of toxicity Benchmarks proposed for use at Rocky Flats are presented in Appendices A through D These appendices will be updated as benchmarks become available or require revision

Table 2-2 Example of Tier 3 ECOC Screen Results Rocky Flats Environmental Technology Site[1]

	Exposure Point															
	Small Mammals				Vegetation				Soil				Surface Water			
ECOC	Conc in Small Mammals[1] (mg/kg)	Ingestion Rate (kg/kg/day)	Fraction Ingested	Intake from Sm Mammals (mg/kg bw/day)	Conc in Vegetation[1] (mg/kg)	Ingestion Rate (kg/kg/day)	Fraction Ingested	Intake from Vegetation (mg/kg bw/day)	Conc in Soil[1] (mg/kg)	Ingestion Rate (kg/kg/day)	Fraction Ingested	Intake from Soil (mg/kg bw/day)	Conc in Water[1] (mg/kg)[2]	Ingestion Rate (kg/kg/day)	Fraction Ingested	Intake from Surface Water (mg/kg bw/day)
Aluminum	111	0 042	1	4 66E+00	656	0 005	1	3 28E+00	20839	0 0013	1	2 71E+01	1100	0 077	1	8 47E+01
Antimony	13 4	0 042	1	5 63E-01	4 9	0 005	1	2 45E 02	50	0 0013	1	6 50E-02	42	0 077	1	3 23E+00
Mercury	0 88	0 042	1	3 70E-02	0 28	0 005	1	1 40E-03	0 2	0 0013	1	2 60E 04	1 4	0 077	1	1 08E-01
Selenium	7 3	0 042	1	3 07E-01	1 5	0 005	1	7 50E-03	1 4	0 0013	1	1 82E-03	2	0 077	1	1 54E-01
Vanadium	1 5	0 042	1	6 30E-02	1 4	0 005	1	7 00E-03	55 6	0 0013	1	7 23E-02	18 2	0 077	1	1 40E+00
Cadmium	3 3	0 042	1	1 39E-01	3 5	0 005	1	1 75E-02	5	0 0013	1	6 50E-03	5	0 077	1	3 85E-01
Arsenic	2 5	0 042	1	1 05E-01	0 85	0 005	1	4 25E-03	12 9	0 0013	1	1 68E-02	2 9	0 077	1	2 23E-01
Barium	10	0 042	1	4 20E-01	211	0 005	1	1 06E+00	371	0 0013	1	4 82E 01	116	0 077	1	8 93E+00
Manganese	10 5	0 042	1	4 41E-01	614	0 005	1	3 07E+00	1675	0 0013	1	2 18E+00	687 4	0 077	1	5 29E+01
Beryllium	0 22	0 042	1	9 24E-03	0 13	0 005	1	6 50E-04	5 2	0 0013	1	6 76E-03	4 8	0 077	1	3 70E-01
Lead	4 1	0 042	1	1 72E-01	5 1	0 005	1	2 55E-02	61 4	0 0013	1	7 98E-02	21	0 077	1	1 62E+00
Copper	42 8	0 042	1	1 80E+00	91	0 005	1	4 55E-01	27 3	0 0013	1	3 55E 02	22 7	0 077	1	1 75E+00
Zinc	157	0 042	1	6 59E+00	80 4	0 005	1	4 02E-01	86 6	0 0013	1	1 13E 01	221 5	0 077	1	1 71E+01
Cobalt	2 1	0 042	1	8 82E 02	0 94	0 005	1	4 70E 03	24 8	0 0013	1	3 22E-02	7 5	0 077	1	5 78E 01
Lithium	2 9	0 042	1	1.22E-01	1 1	0 005	1	5 50E-03	41 9	0 0013	1	5 45E-02	12 1	0 077	1	9 32E 01
Strontium	16 3	0 042	1	6 85E-01	131	0 005	1	6 55E-01	90 1	0 0013	1	1 17E-01	364 3	0 077	1	2 81E+01
Nickel	12 1	0 042	1	5 08E-01	15 1	0 005	1	7 55E-02	26 9	0 0013	1	3 50E-02	16 9	0 077	1	1 30E+00
Chromium	19 9	0 042	1	8 36E-01	5 4	0 005	1	2 70E-02	24 8	0 0013	1	3 22E-02	18 9	0 077	1	1 46E+00

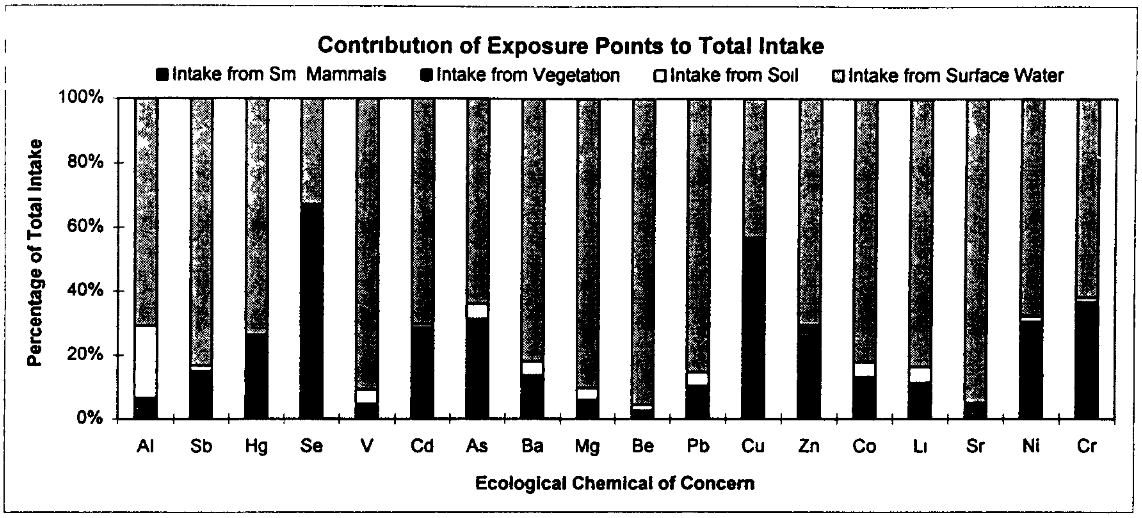
[1] Data are maximum concentrations from background areas of Rocky Flats Environmental Technology Site

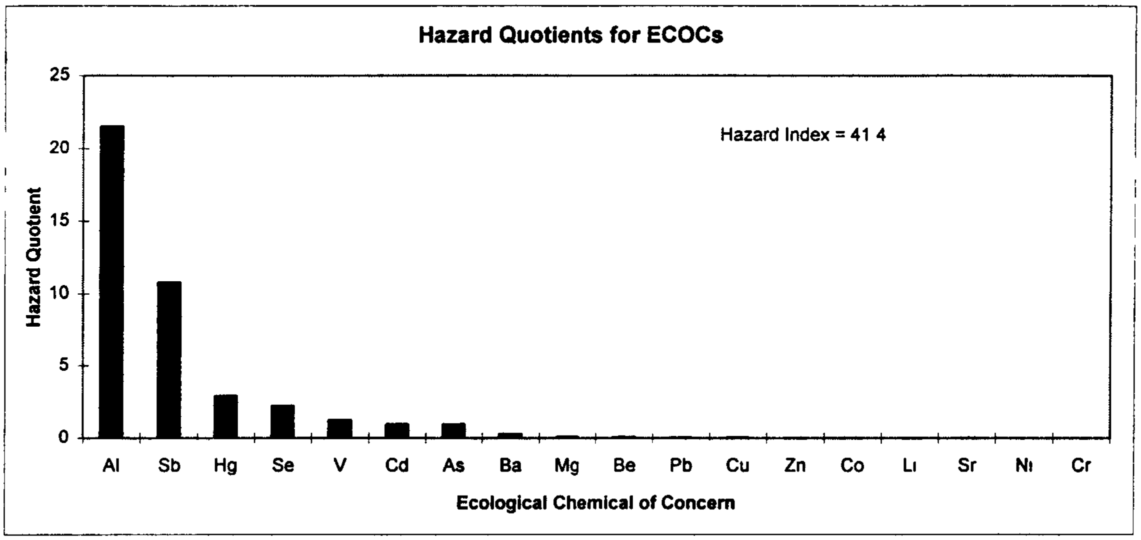
[2] 1 L water weighs 1 kg

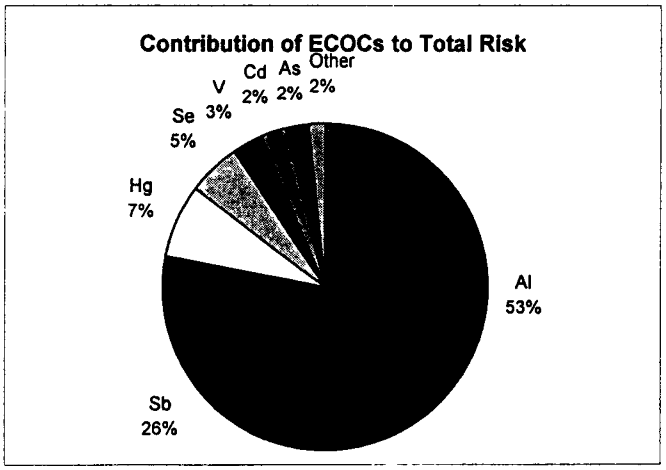
ECOC	Total Intake (mg/kg bw/day)	NOAEL (mg/kg bw/day)	Hazard Quotient	Proportion of Total Risk
Aluminum	1 20E+02	5 55	21 57	52 08%
Antimony	3 89E+00	0 36	10 8	26 08%
Mercury	1 46E-01	0 05	2 93	7 07%
Selenium	4 70E-01	0 21	2 24	5 41%
Vanadium	1 54E+00	1 23	1 26	3 04%
Cadmium	5 48E-01	0 56	0 98	2 37%
Arsenic	3 49E-01	0 36	0 97	2 34%
Barium	1 09E+01	35 2	0 31	0 75%
Manganese	5 86E+01	570	0 1	0 24%
Beryllium	3 86E-01	4 27	0 09	0 22%
Lead	1 89E+00	51 8	0 04	0 10%
Copper	4 04E+00	107	0 0377	0 09%
Zinc	2 42E+01	1037	0 0233	0 06%
Cobalt	7 03E-01	32 1	0 0219	0 05%
Lithium	1 11E+00	60 8	0 0183	0 04%
Strontium	2 95E+01	1704	0 0173	0 04%
Nickel	1 92E+00	259	0 0074	0 02%
Chromium	2 35E+00	17731	0 00013	0 00%

Hazard Index = 41 41603

Figure 2-3 Example of Tier 3 ECOC Screen Results Rocky Flats Environmental Technology Site[1]
Contaminant Intake and Risk for Coyotes







[1] Hazard quotients based on maximum concentrations of metals in samples from background areas of Rocky Flats Environmental Technology Site

Grass Chart COYBAK.XLS 4/7/95

Persons using benchmarks in ERAs should consult ecological risk assessment subject matter experts at Rocky Flats to ensure use of the most recent and appropriate data

2 5 1 Terrestrial Wildlife and Plants

No state or federal standards currently exist for regulating exposure of wildlife to anthropogenic chemical contaminants Risk evaluations and remediation decisions are based on risk-based criteria developed in site-specific ERAs A process for developing ecotoxicological benchmarks and a database for some chemicals and receptor types is presented in ORNL (1994) The benchmarks were derived to approximate NOAELs, which represent the greatest exposures at which no adverse effects are observed NOAELs (and benchmarks) may be expressed as a dose (e g , milligrams contaminant ingested/kilogram body weight [bw]/day) or EECs (e g , milligrams contaminant/liter water) Information on acquiring ORNL documents that describes the methods for developing benchmarks and list benchmarks for 17 wildlife species is listed in Appendix A

When benchmarks are not available, the ORNL methods will be used to develop them for species or chemicals not included in the database The benchmarks cited in ORNL (1994) or developed using similar methods will be used for screening purposes only As requested by EPA, any benchmarks used in detailed risk assessments or to develop remediation criteria require prior approval from EPA and CDPHE

As noted in Section 2 1, derivation of ecotoxicological benchmark values is based on a database developed at ORNL (ORNL 1994) In some cases, data were available for the wildlife species of concern However, in most cases benchmarks were derived from data on the toxicity to laboratory test animals and extrapolated to wildlife species by scaling to body size and applying uncertainty factors to account for variability among species and data types (ORNL 1994) The ORNL database includes information for 17 species of birds and mammals that are common in the eastern United States Where appropriate, the wildlife benchmarks developed by ORNL are adapted for use in ERAs at RFETS (Table 2-3) For each species, benchmarks were derived for many chemicals known to be potential contaminants at RFETS

Table 2-3
Correspondence Between Species Represented in ORNL Database and Representative Receptor Species Used in ERAs at RFETS

Species in ORNL Database[1]	RFETS Receptor Species[2]
White-footed mouse	Deer mouse Preble's jumping mouse
Meadow vole	Meadow vole Prairie vole
White-tailed deer	Mule deer
Red fox	Coyote Raccoon
Red-tailed hawk	Red-tailed hawk American kestrel Bald eagle
American woodcock	Mallard
Great blue heron	Great blue heron
Barred owl	Great horned owl

[1]ORNL (1994)
[2]Technical Memorandum No 2, Sitewide Conceptual Model

The database includes contaminants and representative species used in ERAs conducted at ORNL In many cases, the contaminants and species found at ORNL do not correspond to those at RFETS However, the representative species to be used at RFETS have similar ecology and feeding behaviors to those included in the ORNL database Thus, benchmarks for RFETS species may be extrapolated from those of similar species included in the ORNL database (Table 2-3) The methods for extrapolation will follow that recommended by ORNL (1994) and briefly descried below The reader is referred to the ORNL documentation for a more detailed treatment The following method will be used for extrapolating NOAEL values among similar species (Eq 4 in ORNL 1994)

Eq 2-9

$$NOAEL_b = NOAEL_a * \frac{(bw_a)^{1/3}}{bw_b}$$

$NOAEL_a$ = known NOAEL for a given species
$NOAEL_b$ = NOAEL for species at RFETS
bw_a = body weight for a given species
bw_b = body weight for species at RFETS

When the benchmark is to reflect the concentration of contaminant in food that would result in a dose equal to the NOAEL (EEC_{food}, mass chemical in food/body weight) the EEC was calculated as

Eq 2-10

$$EEC_{food} = \frac{NOAEL}{IR}$$

where

IR = mass-specific ingest rate for a given species (mass ingested/mass bw/day)

When evaluating a chemical contaminant not included in the ORNL database, information in the primary scientific literature will be used to derive benchmarks for RFETS species The approach to developing the benchmarks will be identical to that used by ORNL All benchmarks used in ECOC screening, whether they are taken directly from the ORNL database, extrapolated for similar species, or derived from primary literature benchmarks, are subject to review and approval by EPA and CDPHE

2 5 2 Aquatic Life

Screening-level evaluation of risk to aquatic biota is based primarily on Colorado State Water Quality Standards for protection of aquatic life (5 CCR 1002-8) or EPA Ambient Water Quality Criteria State-wide standards have been promulgated for some metals and water quality parameters but not for most organic compounds or radionuclides (5 CCR 1002-8, September 1993) (State Water Quality Standards are included in Appendix B) The Colorado Water Quality Control Commission (CWQCC) has classified segments of Woman Creek and Walnut Creek at Rocky Flats as Class 2 Aquatic Life Class 2 streams are not capable of sustaining a wide variety of aquatic fauna due to lack of physical habitat, sufficient flow, or to uncorrectable water-quality conditions (5 CCR 1002-8, April 1993) Aquatic standards for Class 2 stream segments are set on a site-specific basis

The CWQCC published site-specific standards for some organics and radionuclides for segment 5 of Big Dry Creek basin, which includes Rocky Flats (see 5 CCR 1002-8, April 1993) The specific standards include temporary modifications (effective through April 1, 1996) for carbon tetrachloride, tetrachloroethane, trichloroethylene, copper, iron, lead, zinc, manganese, and unionized ammonia Aquatic standards for radionuclides are available for segment 5 of the Big Dry Creek basin (5 CCR 1002-8, April 1993) but were established primarily for protection of human health The Colorado state standards and the federal Ambient Water Quality Criteria (AWQC) are subject to periodic revision and should be reviewed for each ERA

Colorado standards are based on EPA AWQC, which use available toxicological data from multiple studies and species to derive water-borne chemical concentrations that are not expected to result in toxicity to 95 percent of the species for which data are available Criteria and water-quality standards are available for evaluating acute and chronic exposures Because they are based on the AWQC, the Colorado standards can be considered risk-based

Aquatic benchmarks presented in ORNL (1994) may be used when neither state water quality standards nor AWQC are available The endpoints used in the ORNL document are based on effects at the population and community levels of biological organization and differ from those used in the AWQC The resulting ORNL benchmarks tend to be less stringent than Colorado standards ORNL benchmarks also may be used to supplement the Colorado standards in interpreting risks to aquatic biota

2 5 3 Radionuclide Benchmarks

Benchmarks for evaluation of radionuclide exposure were developed through a consortium of scientists at Rocky Flats, Los Alamos National Laboratory, Argonne National Laboratory, and the Oregon State University (Appendix C) The benchmarks were developed based on a limit for total radiological dose of 0 1 rad/day based on data presented by the International Atomic Energy Agency (IAEA) which indicates that there is no reason to expect ecological effects at exposures of this magnitude or less (IAEA 1992) Benchmarks for concentrations in soil, water, and sediment were developed for 12 radionuclides typically found in environmental media at Rocky Flats Benchmarks are in the form of EECs and expressed as picocuries (pCi)/per gram (soil and sediment) or pCi per liter (water) Specific benchmarks were developed for small mammals and aquatic life (in general) because these groups represent the upper bounding exposure scenarios for species at Rocky Flats

3 0 REFERENCES

Barnthouse, L 1993 Population-Level Effects In Suter, G W , II 1993 Ecological Risk Assessment Lewis Publishers Ann Arbor, Michigan p 247-274

CCR (Colorado Code of Regulations) 1993 Colorado Water Quality Standards 3 1 0 (5 CCR 1002-8) as amended September 7, 1993

EG&G 1990 Rocky Flats Plant Site-Wide Sitewide Quality Assurance Project Plan (QAPjP) for CERCLA Remedial Investigation/Feasibility Studies and RCRA Facility Investigations/Corrective Measure Studies EG&G Rocky Flats, Inc , Golden, CO

EG&G 1993 Background Geochemical Characterization Report for 1993, Rocky Flats Plant EG&G Rocky Flats, Inc , Golden, CO

EG&G 1994 Statistical Comparisons of Site-to-Background Data in Support of RFI/RI Investigations Rocky Flats Plant Guidance Document Draft B January

EG&G Undated Environmental Management Department Administrative Procedures Manual (Manual No 5-21000, Volumes I through VI) EG&G Rocky Flats, Inc , Rocky Flats Plant, Golden, CO

EG&G Undated Environmental Management Department Administrative Procedures Manual (Manual 2-11000-ER-ADM) EG&G Rocky Flats, Inc , Rocky Flats Plant, Golden, CO

Gehan, E A 1965 A Generalized Wilcoxon Test for Comparing Arbitrarily Singly-Censored Samples *Biometrika*, Volume 52, pp 203–223

Gilbert, R O 1987 Statistical Methods for Environmental Pollution Monitoring Van Nostrand Reinhold New York

Gilbert, R O , and J S Simpson 1992 Statistical Methods for Evaluating the Attainment of Cleanup Standards, Volume 3 Reference-Based Standards for Soils and Solid Media, PNL-7409, Vol 3, Rev 1 Pacific Northwest Laboratories Richland, WA December

IAEA (International Atomic Energy Agency) 1992 Effects of Ionizing Radiation on Plants and Animals at Level Implied by Current Radiation Protection Standards Technical Report Series No 332, Vienna, Austria

ORNL (Oak Ridge National Laboratory) 1994 Toxicological Benchmarks for Wildlife 1994 Revision ES/ER/TM-86/R1 September

Palachek, A D , D K Sullivan, and D R Weier 1993 Statistical Determination of Proposed Contaminants of Concern for the Pond Water Quality IM/IRA, SA-93-012 EG&G Statistical Applications Internal Report EG&G Rocky Flats, Inc , Rocky Flats Plant, Golden, CO June

Paustenbauch, D J 1990 The Risk Assessment of Environmental and Human Health Hazards A Textbook of Case Studies J Wiley & Sons, New York

Rosenbaum, S 1954 Tables for a Nonparametric Test of Location *Annals of Mathematical Statistics* Volume 25, pp 146–150

Suter, G W , II 1989 "Ecological Endpoints " In *Ecological Assessment of Hazardous Waste Sites A Field and Laboratory Reference Document*, Warren-Hicks, B R Parkhurst, and S S Baker, Jr , Editors Corvallis Environmental Research Laboratory, OR, EPA 600/3-89/013

Suter, G W , II, Editor 1993 *Ecological Risk Assessment* Lewis Publishers, Boca Raton, FL

USEPA (U S Environmental Protection Agency) 1987 Data Quality Objectives for Remedial Response Activities, U S Environmental Protection Agency, Washington, D C EPA 154-IG-871003, OSWER Directive 9355 0-7B March

USEPA (U S Environmental Protection Agency) 1992 Framework for Ecological Risk Assessment EPA/630/R-92/001 February

USEPA (U S Environmental Protection Agency) 1994 Ecological Risk Assessment Guidance for Superfund Process for Designing and Conducting Ecological Risk Assessments Review Draft September 26

Appendix A
Sources of Information for Developing Ecotoxicological Benchmarks

Radionuclides

IAEA (International Atomic Energy Agency) 1992 Effects of Ionizing Radiation on Plants and Animals at Level Implied by Current Radiation Protection Standards Technical Report Series No 332, Vienna, Austria

Higley, K and R Kuperman 1995 Radiological Benchmarks for Wildlife at Rocky Flats Environmental Technology Site Draft March 1995

Non-Radionuclide Chemicals

CIS (Chemical Information System) (updated periodically) Aquatic Information Retrieval (AQUIRE) *(data base management supported by EPA, Telephone (410)321-8448)*

CIS (Chemical Information System) (updated periodically) Phytotox *(data base management supported by EPA, Telephone (410)321-8448)*

CCR (Colorado Code of Regulations) 1993 Colorado Water Quality Standards 3 1 0 (5 CCR 1002-8) as amended September 7, 1993

EPA (U S Environmental Protection Agency) (updated quarterly) Integrated Risk Information System (IRIS) Health Criteria and Assessment Office, Cincinnati, Ohio

EPA (U S Environmental Protection Agency) Ambient Water Quality Criteria *(reviews of toxicity data for several metals and organic compounds)*

EPA (U S Environmental Protection Agency) 1991 Proposed Sediment Quality Criteria for the Protection of Benthic Organisms Phenanthrene Office of Science and Technology, Health and Ecological Criteria Division November

EPA (U S Environmental Protection Agency) 1991 Proposed Sediment Quality Criteria for the Protection of Benthic Organisms Fluoranthene Office of Science and Technology, Health and Ecological Criteria Division November

EPA (U S Environmental Protection Agency) 1992 Sediment Classification Methods Compendium Sediment Oversight Technical Committee EPA 823-R-92-006 September

FWS (U S Fish and Wildlife Service) Contaminant Hazard Reviews *(reviews available for several organic compounds and metals)*

ORNL (Oak Ridge National Laboratory) 1994 Toxicological Benchmarks for Wildlife 1994 Revision September ES/ER/TM-86/R1

ORNL (Oak Ridge National Laboratory) 1994 Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Terrestrial Plants 1994 Revision September ES/ER/TM-85/R1

ORNL (Oak Ridge National Laboratory) 1994 Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Aquatic Biota 1994 Revision September ES/ER/TM-96/R1

ORNL (Oak Ridge National Laboratory) 1994 Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Sediment-Associated Biota 1994 Revision September ES/ER/TM-95/R1

Appendix B

Ecotoxicological Benchmarks for Common Chemical (Non-Radionuclide) Contaminants at RFETS

This appendix will be amended with benchmarks when benchmarks have been finalized.

Appendix C

Ecotoxicological Benchmarks for Radionuclide Contaminants at RFETS

The document "Radiological Benchmarks for Wildlife at Rocky Flats Environmental Technology Site" is currently in draft form. The final document will be amended to this TM when it becomes available. Preliminary results of benchmark calculations for soil, surface water, and sediments are presented in the following tables. (4/11/95)

Appendix D

**Documentation for Ecotoxicological Benchmarks
Developed Specifically for
Ecological Risk Assessments at RFETS**

**Documentation for benchmark selection is in draft form.
This appendix will be amended when final reports are available.**