Appendix G

PROPOSED PLAN AND CAD/ROD SCHEDULE

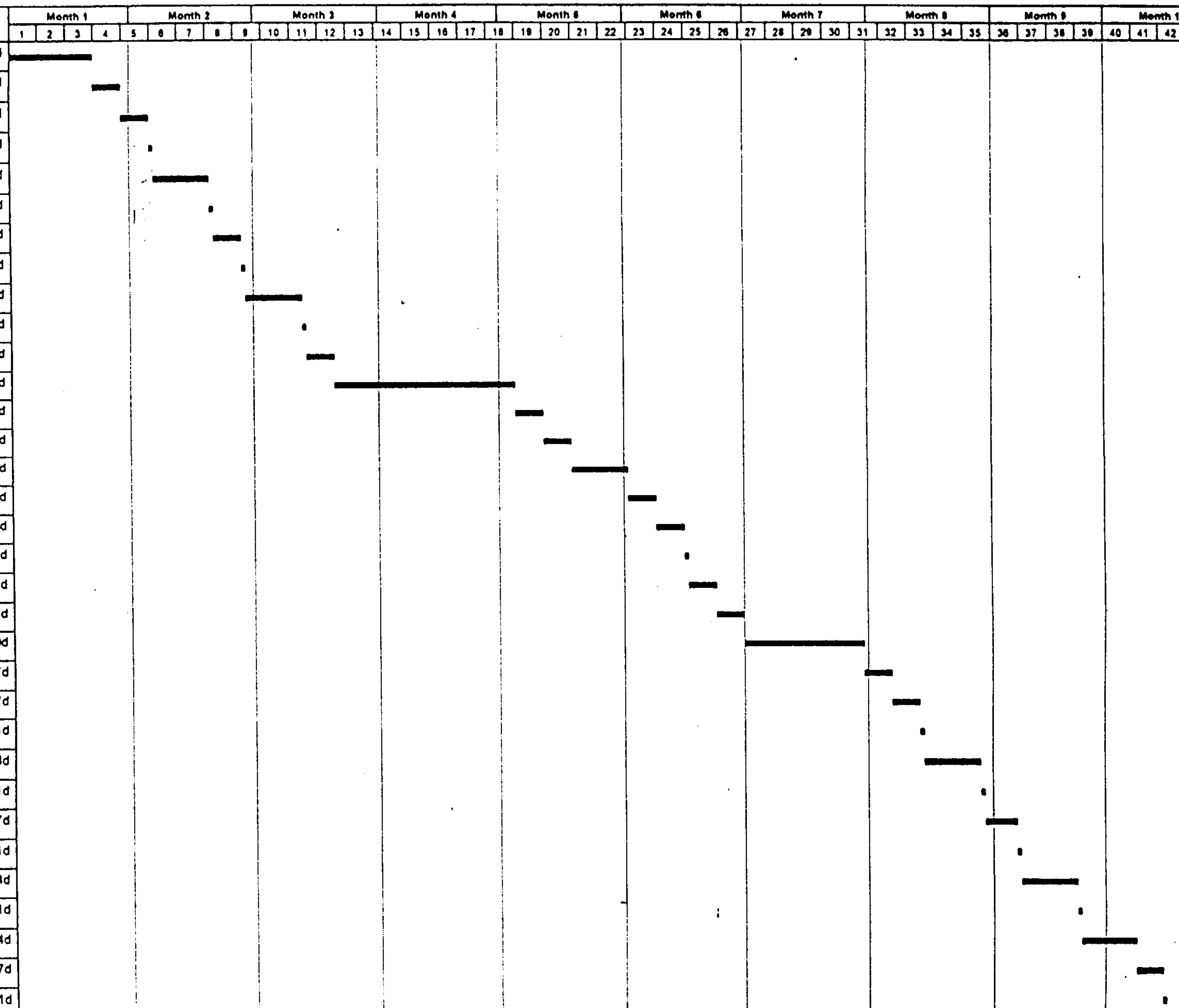
APPENDIX G

1.0 PROPOSED PLAN AND CAD/ROD SCHEDULE

Appendix F includes a generic schedule for the development of a PP/CAD/ROD. While actual activity durations may vary according to the complexity of the IHSS. This schedule may be used for planning purposes.

GENERIC CAD/ROD SCHEDULE

ID	Task Name	Duration
1	Develop Draft Proprosed Plan	21d
2	Internal Review	7d
3	Revision of Draft	7d
4	Submit Draft PP to Agencies	1d
5	Agency Review	14d
6	Receive Agency Comments	1d
7	Develop Comment Responses	7d
8	Comment Resolution Meeting	1d
9	Revise Draft PP	14d
10	Submit Final PP to Agencies	1d
11	Agency Review and Approval	7d
12	Open Public Comment Period	45d
13	Compile Public Comments	7d
14	Agree on Public Comments	7d
15	Develop Comment Resposes	14d
16	Prepare Responsiveness Summary	7d
17	Document Production	7d
18	Submit Responsiveness Summary	1d
19	Agency Review	7d
20	Incorporate Comments and Finalize	7d
21	Develop Preliminary Draft ROD	30d
22	Internal Review and QA	7d
23	Final Revision and Document Production	7d
24	Submit Draft CAD/ROD for Agency Review	1d
25	Agency Review	14d
26	Recieve Agency Comments	1d
27	Develop Comment Resposes	7d
28	Comment Resolution Meeting	1d
29	Revision	14d
30	Submit to Agencies for Review	1d
31	Agency Approval for Release	14d
32	Incorporate Final Agency Comments	7d
33	Release CAD/ROD to Public	1d



Project: Generic CAD/ROD Schedule | Task | Progress

Appendix H

GENERIC RCRA FACILITY INVESTIGATION/REMEDIAL INVESTIGATION SCHEDULE

APPENDIX H

1.0 GENERIC RCRA FACILITY INVESTIGATION/REMEDIAL INVESTIGATION SCHEDULE

Contents

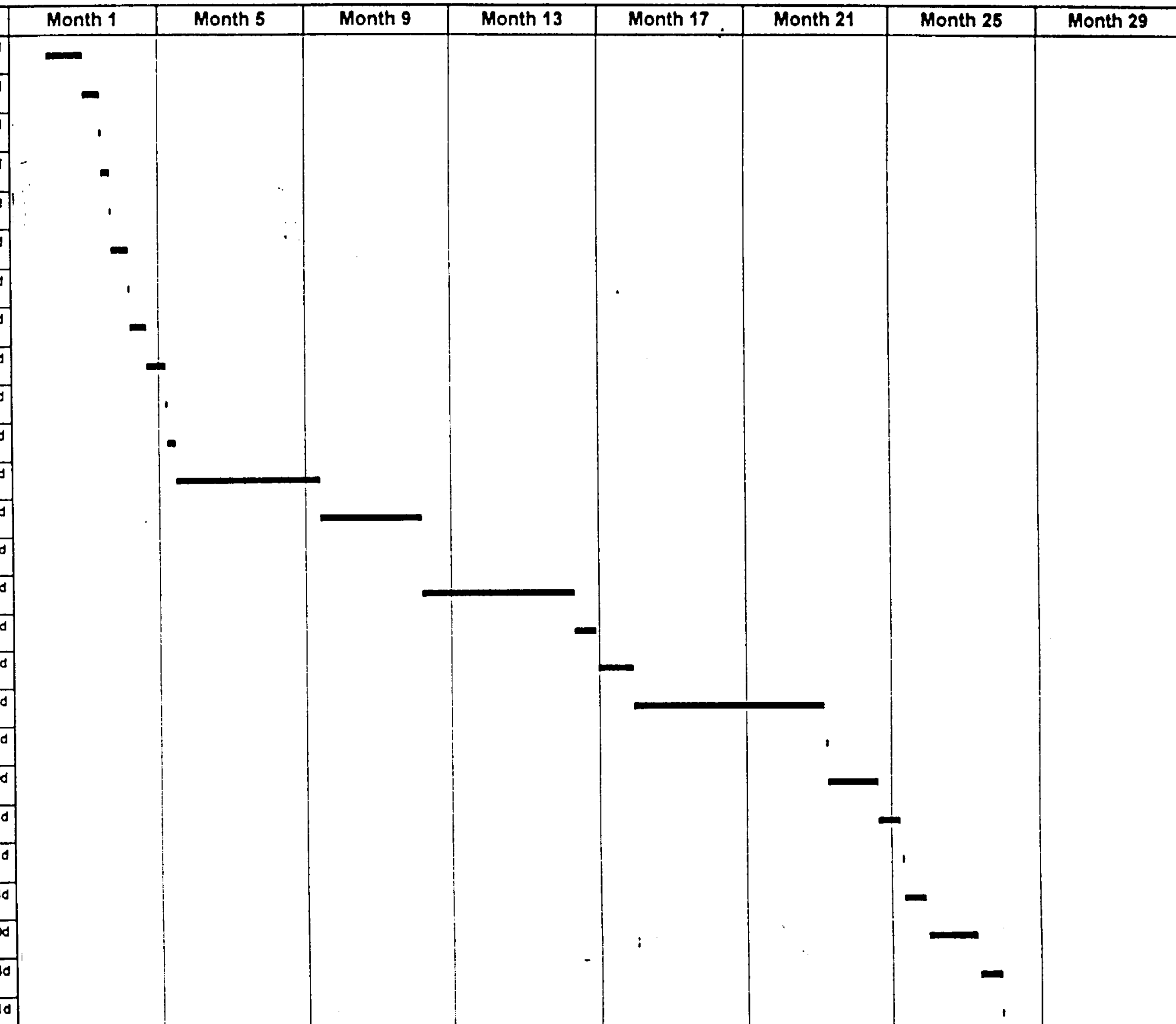
The contents of an RFI/RI Report may include, but is not limited to the following:

- Description of the IHSS
- A summary of all field activities
- Presentation of all field data
- Location and characteristics and source(s) of contamination
- Definition on nature, extent, fate, and transport of contaminants
- Identification of sources which impact surface water
- Evaluation of risks

A generic schedule for the development of an RFI/RI Report is included. While actual activity durations may vary according to the complexity of the IHSSs, this schedule may be used for planning purposes.

GENERIC RFI/RI SCHEDULE

ID	Task Name	Duration
1	Develop RFI/RI Work Plan	30d
2	Internal Review	14d
3	Recieve Comments	1d
4	Revise Workplan	7d
5	Submit to Agencies for Review and Comment	1d
6	Agency Review	14d
7	Recieve Agency Comments	1d
8	Resolve Agency Comments	14d
9	Revise Workplan	14d
10	Submit Workplan for Approval	1d
11	Agency Review and Approval	7d
12	Prepare for Fieldwork	90d
13	Perform Fieldwork	60d
14	Recieve Analytical Results	0d
15	Develop RFI/RI Report and HHRA	90d
16	Preliminary Review RFI/RI Report	14d
17	Revise Preliminary Draft	21d
18	Document Production	114d
19	Submit RFI/RI Report for Agency Review	1d
20	Agency Review	30d
21	Develop Comment Responses	14d
22	Submit Comment Responses to Agencies	1d
23	Agency Review of Comment Responses	14d
24	Revise RFI/RI Report	30d
25	Document Production	14d
26	Submit Final RFI/RI to Agencies	1d



Project: Generic RFI/RI Schedule | Task | Progress

Appendix I

OUTLINE OF SAMPLING AND ANALYSIS PLAN

APPENDIX I

1.0 OUTLINE OF SAMPLING AND ANALYSIS PLAN

The following SAP outline is based on *Guidance for Conducting Remedial Investigation and Feasibility Studies Under CERCLA* (EPA, 1988a) and reflects current RFETS usage. Each SAP will vary, however, depending on the data and sample requirements; SAPs will generally include information on the following topics:

- Background information
- Sampling rationale
- DQOs
- Sampling activities and methodology
- Data management
- Project organization
- Health and Safety Plan
- Quality Assurance
- Schedule

These outline topics are described in the following sections.

2.0 INTRODUCTION

The introduction will provide a brief project background and description including:

- Purpose/objectives of the SAP
- History of the site to be sampled (identify IHSSs, PACs or RCRA units in the area)
- Summary of existing data with an assessment of its adequacy
- Description of the Project including planned field activities
- Hydrogeologic setting (if appropriate to the project).

3.0 BACKGROUND INFORMATION AND SAMPLING RATIONALE

This section will discuss the reasons and justification used to develop sampling factors such as number of samples, location, depths, frequency, COCs, and analytical methods. Conditions of the physical setting which influence these factors can also be discussed.
This section should typically include a brief conceptual model to identify and document the potential field conditions, factors that may impact sampling results, and potential for free product to be present. The conceptual model is intended to show how the site works physically and chemically in terms of expected conditions. The model may be presented as cross-section of the contaminant distribution and potential transport mechanisms or items, structures, and physical conditions that may impact the project (e.g., presence of drums, depth to bedrock, depth to groundwater, steep slopes, location of surface water).

4.0 DATA QUALITY OBJECTIVES

The DQO process, as described in Section 3.2, is a structured decision-making process that requires the identification of and agreement on decisions for which data are required. The process results in the full set of specifications needed to develop a protective and compliance sampling program (i.e., qualitative and quantitative statements that specify the type, quality, and quantity of the data required to support decision making). The formal DQO process is documented in two EPA documents (EPA, 1993; EPA, 1994). Specific steps in the DQO process include:

- Identify and define problem(s) to be solved
- Identify decision(s) to be made relative to the problem
- Identify inputs to the decision (data needed to make decision)
- Define study boundaries/scope of problem and decision
- Develop decision rule(s) [IF/THEN action statement(s)]
- Specify limits on decision errors (acceptable types and degrees of uncertainty)
- Develop and optimize design for obtaining data

These steps are described below.

4.1 The Problem

Implementation of a sampling plan requires identification and disposition of contaminated media, materials, and equipment that were produced in past processes, especially relative to free release (of materials) or management of particular waste types or streams. Adequate samples must be taken to properly characterize and manage the materials and/or equipment, whether it is waste or not.

Other decisions or subdecisions that support final project actions may be put forth in the form of following questions, provided that the answers or conclusions relate directly to project decisions, e.g:

- Why perform this characterization
- What is the final disposition of the material, equipment, facility, or structure (free release, restricted use, low level waste, etc.)

4.2 The Decisions

The critical technical decisions for a typical project are as follows, understanding that decisions may vary relative to goals of the project:

- What materials (e.g., paint, concrete, pipe insulation, etc), media (e.g., soil, water, oil, solid, sludge, etc), or equipment within the facility or area are contaminated or, conversely, not contaminated
- What are the generic classification categories by which the materials, equipment, and/or media will be managed, relative to an eventual assignment as contaminated (hazardous, radiological, or mixed) or not contaminated (nonhazardous)? In other words, what are the categories of waste streams that will result from the activity? What are the ultimate dispositions (i.e., waste classifications and treatment, storage, and disposal [TSD] facilities) of the waste streams, including quantities (e.g., a completed summary table)

4.3 Inputs to the Decisions

Inputs to the decisions are data, both qualitative and quantitative. Qualitative information will typically consist of nominal data (e.g., paint color, texture, or equipment type, etc) derived from visual observation of the building's equipment and materials. Quantitative data may be produced from analytical, radiochemistry, radiation surveys or petrographic analysis (asbestos) of samples. Waste Acceptance Criteria (WAC) are typically the drivers for decision inputs where data will be used to characterize waste streams destined for a particular TSD facility (e.g., NTS, Envirocare or USA waste). Inputs to the decisions are COC-specific.

Inputs to the decision must also include, directly or in other subsections, the following:

- Analytical/radiochemistry results
- Radiation survey results
- Method-specific sensitivities (detection limits or minimum detectable activities)
- Error tolerances associated with the measurements (e.g., accuracy and precision)
- Action levels (regulatory thresholds)

Although professional judgment is instrumental, sampling must err to the conservative (i.e., collecting more samples) if there is any doubt regarding homogeneity of the materials sampled.

Other decisions or subdecisions that support final project actions may be put forth in the form of following questions, provided that the answers or conclusions relate directly to project decisions:

- What information is required to make this decision
- What source(s) can be used to obtain the information
- Can the desired analysis be done at RFETS or will the samples be shipped off-site for analysis
- What types and kind of sampling measurements are required
- What type of instrumentation is required
- Has facility structural data been reviewed
- What suspect materials have been identified
- What are the required instrumentation sensitivities
- What method will be used to obtain the desired information
- What Quality Assurance (QA) program requirements are there for these samples (i.e., blanks, duplicates)
- What number of samples/measurements will provide the desired certainty
- Have data quantity and quality control requirements for sampling been reviewed

4.4 Project Boundaries

Project boundaries describe the geographic, three-dimensional areas, and temporal boundaries of the characterization activity. Other decisions or subdecisions that support final project actions may be put forth in the form of following questions, provided that the answers or conclusions relate directly to project decisions:

- What is the sample population of interest
- Are there any constraints on data collection

4.5 Decision Rules and Error Limits

Decision rules must be based on objective, reproducible, and verifiable, measurable criteria. If the decision is statistically based, decision error must address both the producer's (alpha) error and the consumer's (beta) error. "False Positive" error is usually equivalent to the alpha error while the "false negative" is equivalent with beta error, although this determination hinges on the way in which the hypothesis test is setup. Alpha and beta error typically range from 1% to 10% (i.e., confidences from 99% to 90%, respectively), based on standard statistical practice and historical acceptance by the regulators (public, CDPHE, and EPA Region VIII).

Decisions may also be based directly on protocols promulgated by the regulators, for example determination of asbestos. Other decisions or subdecisions that support final project actions may be put forth in the form of the following questions, provided that the answers or conclusions relate directly to project decisions.

- What is the basis for the decision
- Are there any regulatory and statistical drivers for sampling frequency
- What action levels are applicable to the discussion or parameter of interest
- Define the discussions using "If ... then ..." statements (e.g.. if paint containing >50 ppm PCBs is identified then all resulting waste material will be handled as TSCA waste)

4.6 Optimization of Design

Modifications to the DQOs are typically based on visual observations, new information revealing data gaps as the project progresses, and professional judgement, all of which are documented and are discussed in the Data Quality Analysis section of the final report.

Acquisition of a sample directly depends on the sampling team's observations of the material, equipment, equipment components, or media of interest. If data gaps are identified subsequent to the characterization sampling and decisions described herein (i.e., the decision can not be made with confidence), additional sampling of source materials and/or waste streams will be conducted.

Analytical data collected in support of specific projects will be evaluated using the guidance established by the Rocky Flats Administrative Procedure 2-G32-ER-ADM-08.02, *Evaluation of ERM Data for Usability in Final Reports (RMRS 1994e)*. This procedure establishes the guidelines for evaluating analytical data with respect to PARCC parameters. Data validation will be performed according to the RFETS, Analytical Services Division (ASD) procedures and will be done after the data are used for their intended purpose.

5.0 SAMPLING ACTIVITIES AND METHODOLOGY

This section describes what information sampling methodology and the locations. Figures may be provided in the SAP for clarity, and available information may be presented about the samples, including:

- Number of samples in each media
- Grid spacing or sample location
- Sample depths
- Criteria for selection of additional samples
- Sample numbering
- Type and frequency of QA/QC samples
- Sample analysis (method numbers)

For each medium, describe the above information in the text and, as appropriate, provide a table enumerating the samples to be collected, rationale for each sample, analysis method (and method number), amount and types of QC samples, the type of container, preservative, and holding time. These tables should include project requirements and collection locations, where appropriate. The overall QA/QC requirements including field duplicates and blank samples analytical detection limits, and standards for accuracy and completeness are provided in the IMP. Sample handling, including chain-of-custody and packaging procedures, should be performed according to ER procedure 4-B29-ER-OPS-FO.13 *Containerization, Preserving, Handling and Shipping of Soil and Water Samples* (RMRS, 1994c).

This section should briefly describe of how samples will be numbered and labeled in the field. Sample numbers are assigned by the SWD or ASD. It is strongly recommended that sample numbers be obtained from SWD and included in the SAP. Numbers from the assigned block of samples will be assigned if additional samples are needed. If only field-screening data will be collected, describe a systematic method that will be used to number sample locations, depths and analytical results.

6.0 DATA MANAGEMENT

A project field logbook should be created and maintained by the project manager or designee in accordance with site Procedures 2-S47 ER-ADM-05.14, *Use of Field Logbooks and Forms (RMRS 1995b)* and 4-B29-ER-OPS-FO.14 *Field Data Management* (RMRS, 1994d). The logbook should include time and date of all field activities, sketch maps of sample locations, or any additional information not specifically required by the SAP. The originator should legibly sign and date each completed original hard copy of data. Appropriate field data forms should also be utilized when required by operating procedures that govern the field activity. Sample designations will appear in the logbook and on the field data forms. A peer reviewer should examine each completed original hard copy of data Any modifications will be indicated in ink, and initialed and dated by the reviewer. Logbooks will be controlled through RMRS Document Control.

Analytical data record storage for this project will be performed by ASD. Sample analytical results will be delivered directly from the laboratory to the APO in an Electronic Data Deliverable (EDD) format and archived in the SWD. Hard copy records of laboratory results will be obtained from the APO in the event that the analytical data is unavailable in EDD or SWD at the time of report preparation. Analytical results will be compiled into a sampling and analysis results report. Additional data management discussion is provided in Section 3.4 of the main text.

7.0 PROJECT ORGANIZATION

If the SAP is not part of a document which already includes a project organization section, it should be described here. An organization chart should be included, at a minimum, that will include the project manager, sample team lead, and the appropriate quality assurance and safety personnel.

8.0 HEALTH AND SAFETY PLAN

The HASP used to control work should be referenced. In addition to the site-wide HASP, a project-specific HASP will usually have been developed for the PAM or IM/IRA being implemented. If only sampling activities are to be performed, a separate HASP may be needed to cover the activity.

9.0 QUALITY ASSURANCE

This section is based on implementing the site-wide Quality Assurance Project Plan to address the project-specific quality requirements, including the following elements:

- The 10 DOE quality criteria (Per DOE Order 5700.6C or 10 CFR 830.120) and including relevant parts of ANSI/ASQC E4 as applicable
- Sampling method, including specialized or specific equipment or instrumentation
- Collecting Decision logic for fewer or greater numbers of samples than those specified in the SAP
- QC sample types and quantities
- Specific analytical and/or radiochemistry methods and method numbers (e.g., SW-846, ASTM, (ANSI) American National Standards Institute, (ASQC) American Society of Quality Control, (ASTM) American Society of Testing and Material, etc)
- Sample management requirements, including preservation, chain of custody, and shipping
- Data management and reduction requirements, including hardcopies and digital data (See Appendix F, Environmental Data Management.)
- Modeling of software/hardware verification/validation

10.0 REFERENCES

Provide the references used to generate the SAP, if appropriate. This will include documents used to develop the background and site descriptions.

Appendix J

CORRECTIVE MEASURES STUDY/FEASIBILITY STUDY PREPARATION

APPENDIX J

1.0 CORRECTIVE MEASURES STUDY/FEASIBILITY STUDY PREPARATION

The CMS/FS report summarizes the results of the RFI/RI and the baseline risk assessment. Based upon that summary, risk and ARARs-based narrative remedial action objectives and where appropriate numeric remedial action goals are developed. Based upon the statement of objectives and goals, technologies are identified and evaluated for feasibility, screened against the criteria enumerated in the NCP, and ultimately compared one against another.

A suggested outline for the development of the CMS/FS is discussed in the following sections. It must be understood that the remedial action objectives control the types of technologies and process options considered.

The sections of a CMS/FS include:

- Executive Summary
- Introduction
- Site Characteristics
- Corrective/Remedial Action Objectives
- Identification and Screening of Alternatives
- Detailed Analysis of Alternatives
- Selected Alternative (Optional)

1.1 EXECUTIVE SUMMARY

The Executive Summary outlines the site characteristic, risk factors, and ARARs considerations essential to developing the remedial action objectives and then clearly presents the remedial action objectives. The processes and factors that proved crucial to identifying and framing alternatives are then highlighted and followed by a comparison of each alternative to the nine criteria. The selected alternative may then be presented with further discussion of relevant factors that demonstrate satisfaction of the criteria.

1.2 INTRODUCTION

The introduction provides information as to the framework to which the CMS/FS is being prepared, a list of acronyms and an outline of each section of the report.

1.3 SITE CHARACTERISTICS

This section describes the nature and history of the contamination source(s).

1.4 CORRECTIVE/REMEDIAL ACTION OBJECTIVES

This section summarizes the risk assessment, provides an overview of location and action specific ARARs, and defines chemical specific ARARs. The risk assessment results and ARARs are then used to develop narrative remedial action objectives, and, where appropriate, numeric remedial action goals.

1.5 IDENTIFICATION AND SCREENING OF ALTERNATIVES

Based upon the narrative remedial action objectives and numeric remedial action goals, remedial technologies and process options are first identified and screened. The remedial technologies and process options are then assembled into alternatives, and screened as to effectiveness, implementability, and relative cost.

1.6 DETAILED ANALYSIS OF ALTERNATIVES

The alternatives which are retained following the screening are now further refined as to technical detail and cost. The refined alternatives are then evaluated against the nine evaluation criteria:

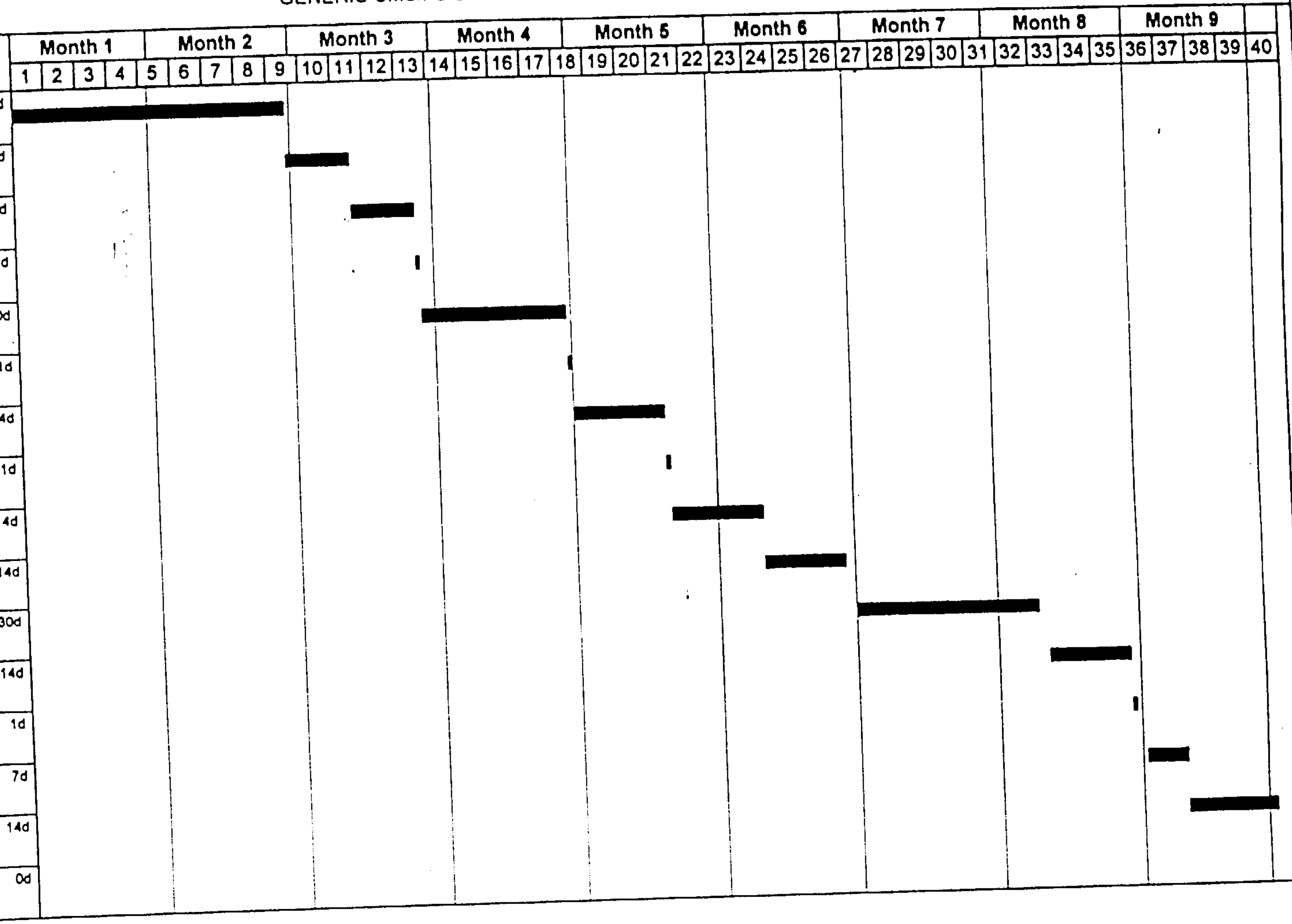
- Overall protection of human health and the environment
- Attainment of ARARs
- Long-term protectiveness
- Short-term effectiveness
- Implementability
- Cost
- State acceptance
- Community acceptance

1.7 SELECTED ALTERNATIVE

During project scoping the stakeholders will determine if the selected alternate and analysis leading to the selected alternative is provided in the CMS/FS or under separate cover. The section provides an analysis that makes comparisons among alternatives. The selected alternative is then future described to show how it satisfies the nine criteria.

GENERIC CMS/FS SCHEDULE

ID	Task Name	Duration
1	Prepare Draft CMS/FS	60d
2	Internal Review Draft CMS/FS	14d
3	Revise Draft CMS/FS	14d
4	Submit Draft CMS/FS for Agency Review	1d
5	Agency Review	30d
6	Recieve Agency Comments	1d
7	Develop Comment Resposes	14d
8	Comment Resolution Meeting	1d
9	CMS/FS Revision Per Comment Resolution Meeting	14d
10	Agency Approval for Release	14d
11	Public Comment Period	30d
12	Incorporate Public Comments	14d
13	Submit Revised CMS/FS	1d
14	CMS/FS Approval	7d
15	Incorporate Final Agency Comments	14d
16	Final Agency Approval	0d



Project: GENERIC CMS/FS SCHED | Task | Progress

Appendix K

MASTER LIST OF POTENTIAL ARARS

RESERVED

Appendix L

SUMMARY OF RISK ASSESSMENT METHODOLOGY FOR RFETS

APPENDIX L

SUMMARY OF RISK ASSESSMENT METHODOLOGY FOR RFETS

1.0 HUMAN HEALTH RISK ASSESSMENT METHODOLOGY

A site-specific HHRAM was developed that differs from standard CERCLA guidance in some respects. The methodology has been documented in the *draft Human Health Risk Assessment Methodology for RFETS* (DOE, 1995b). The risk assessment methodology also includes the conservative screen, developed by the CDPHE and agreed to by the DOE, to ensure that the requirements of the RCRA are met. Several risk assessments for former OUs have been produced using this methodology. In the future, it is likely that it will be used for screening level risk assessment and as the basis for the CRA.

The HHRAM process, including the conservative screen, is shown in Figure N-1. Each step in the HHRAM process is done in consultation with the agencies and documented by a technical memorandum. Step 1 is the evaluation of data to determine if sufficient data of appropriate quality are available to perform a risk assessment or screen. Step 2 is the selection of potential chemicals of concern (PCOCs). Site data for inorganics and radionuclides have been compared to background values, using a battery of statistical test designed by Gilbert (1992), and accepted for use at RFETS by the DOE and the agencies. If the analyte was indicated to be above background by any of the tests it was considered a PCOC. This is a time consuming, costly, and statistically unsound (increased probability of a Type I error) process. For future risk assessments the Gilbert methodology will be treated as a statistical toolbox. The most appropriate test will be selected from the Gilbert toolbox for each analyte (inorganics and radionuclides) that has a maximum concentration greater than the background mean plus two standard deviations (M2SD). The selection of the statistical test will be a balance of the data characteristics (e.g., number of nondetects, distribution of data) of the analyte. A description of the statistical tests and their use is given in Attachment 1. All detected organics are considered to be PCOCs.

The RFCA changed the emphasis for environmental remediation to investigation, evaluation, and remediation of IHSSs and AOCs, instead of an OU-by-OU basis. The PCOC selection process will likely be applied to a particular source or associated sources grouped as an AOC. Fewer samples may be available for statistical analysis due to the change in emphasis to source areas. It will be very important that a sufficient number of samples be available for application of the Gilbert toolbox. After the determination of PCOCs, the conservative screen is applied to the data and the baseline risk assessment may be started.

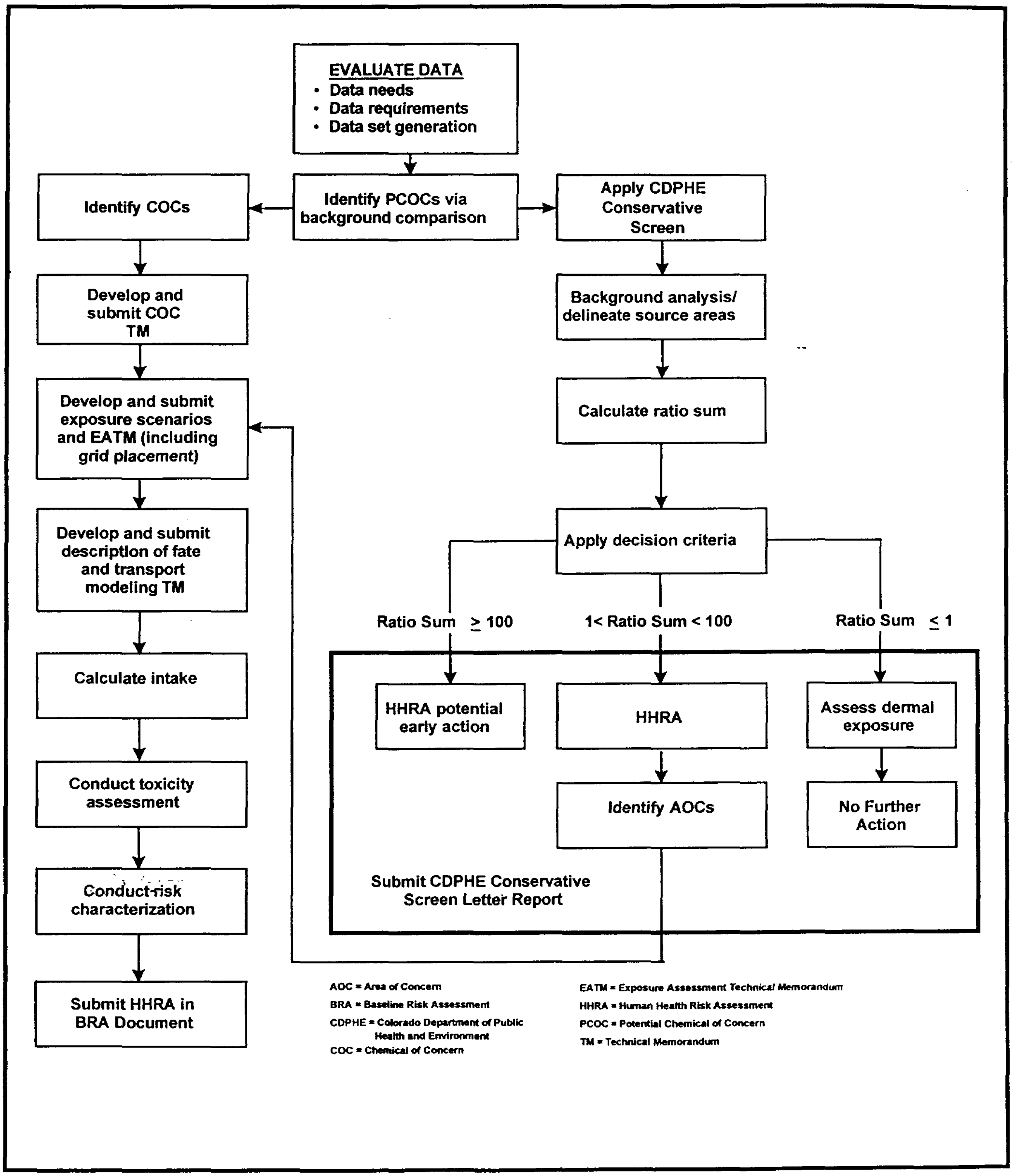


Figure L-1 Human Health Risk Assessment Methodology

1.1 CONSERVATIVE SCREEN

The conservative screen has been accepted for use at the RFETS (DOE, 1994a). The purpose of the conservative screen is to help determine if a particular site is a candidate for no action, accelerated action, or further evaluation through the BRA process. The conservative screen is the basis of the NFA decision criteria presented in Attachment 6 of RFCA. A site that passes the conservative screen is a candidate for NFA status and free release with no land use restrictions.

The screen also provides methodologies for identifying source areas and grouping them into AOCs. The process is shown in Figure N-2. The conservative screen uses the residential PPRGs to calculate the ratios used in the decision criteria (DOE, 1995a). A letter report is submitted to the agencies to document the results.

1.2 CHEMICALS OF CONCERN

The next step in the HHRAM process is the selection of COCs. The selection process, as agreed to by the DOE and the agencies, is shown in Figure N-3.

The COCs have been selected on an OU-wide basis and then applied to each AOC within the OU. Now COC selection will often be done for single sources or sources grouped as an AOC as a result of an action level screen. It is very important that sufficient data be available for this analysis. The COC selection process for the CRA should be based on the present methodology, with COCs selected separately for the two site OUs (Buffer Zone and Industrial Area). The COCs are selected in consultation with the agencies and a TM is submitted to document the results.

1.3 EXPOSURE SCENARIOS AND PARAMETERS

Exposure scenarios and associated exposure factors, developed during negotiations among the DOE, the EPA, and the CDPHE, were transmitted to the agencies in June 1995 (DOE, 1995b). The exposure factors have been used in several BRAs for specific OUs (OUs 2, 3, 4, 5, and 6). The EPA and the CDPHE have accepted all of the exposure factors with the exception of the fraction ingested from contaminated source for the central tendency residential exposure by soil ingestion and the chemical-specific values for the soil ingestion matrix effect (EPA/CDPHE, 1995). Chemical specific soil ingestion matrix values must be submitted to the agencies for approval before being used.

The two exposure scenarios to be used in the CRA to evaluate the on-Site risks and hazards to human health from environmental contamination under the RFCA will be the open-space recreational receptor for the BZ and the office worker for the IA. Off-Site risks and Hazards will be evaluated using the residential scenario. Other scenarios may be evaluated in the CRA if agreed to by the DOE, EPA, and CDPHE.

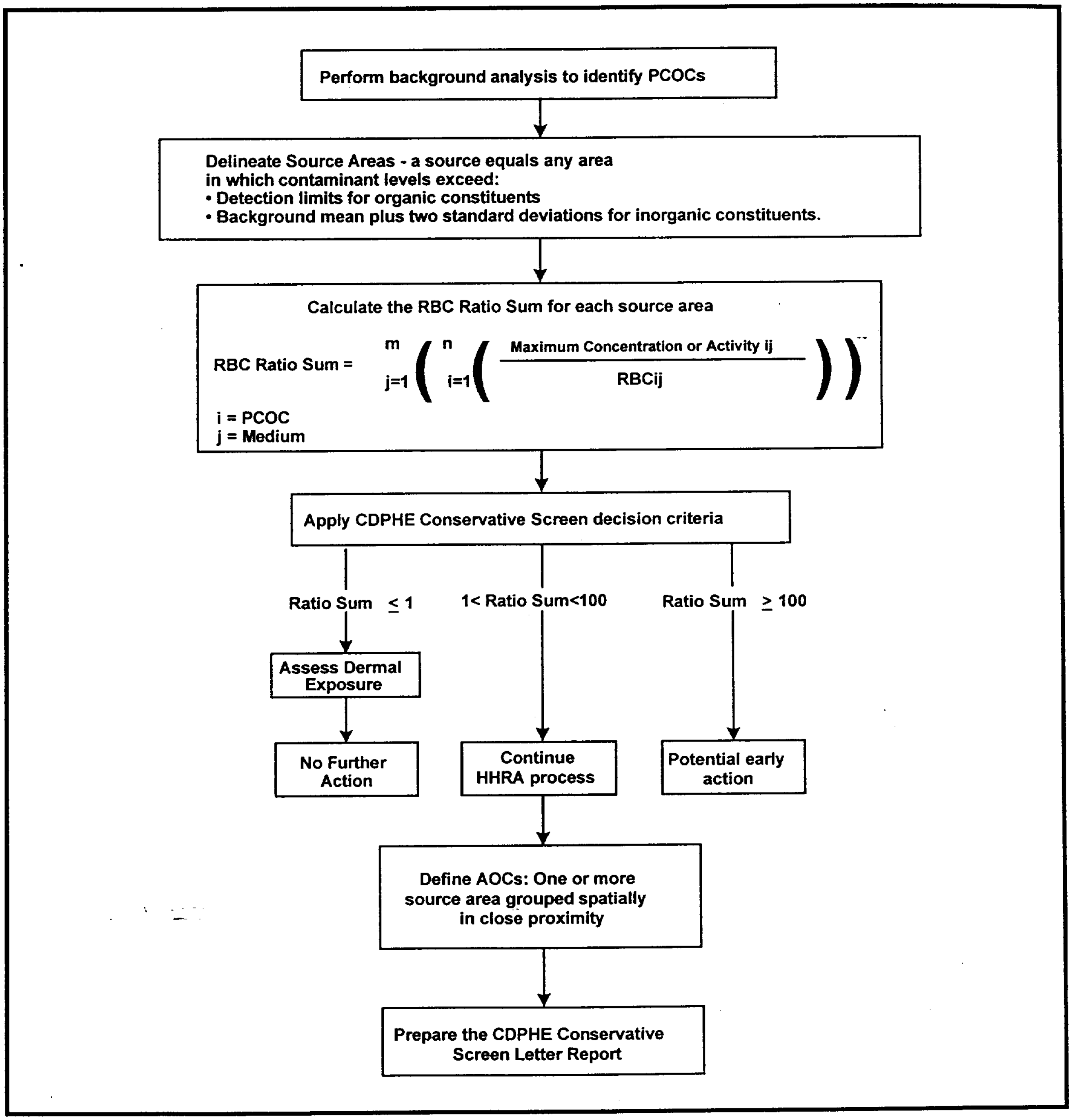


Figure L-2 CDPHE Conservative Screen

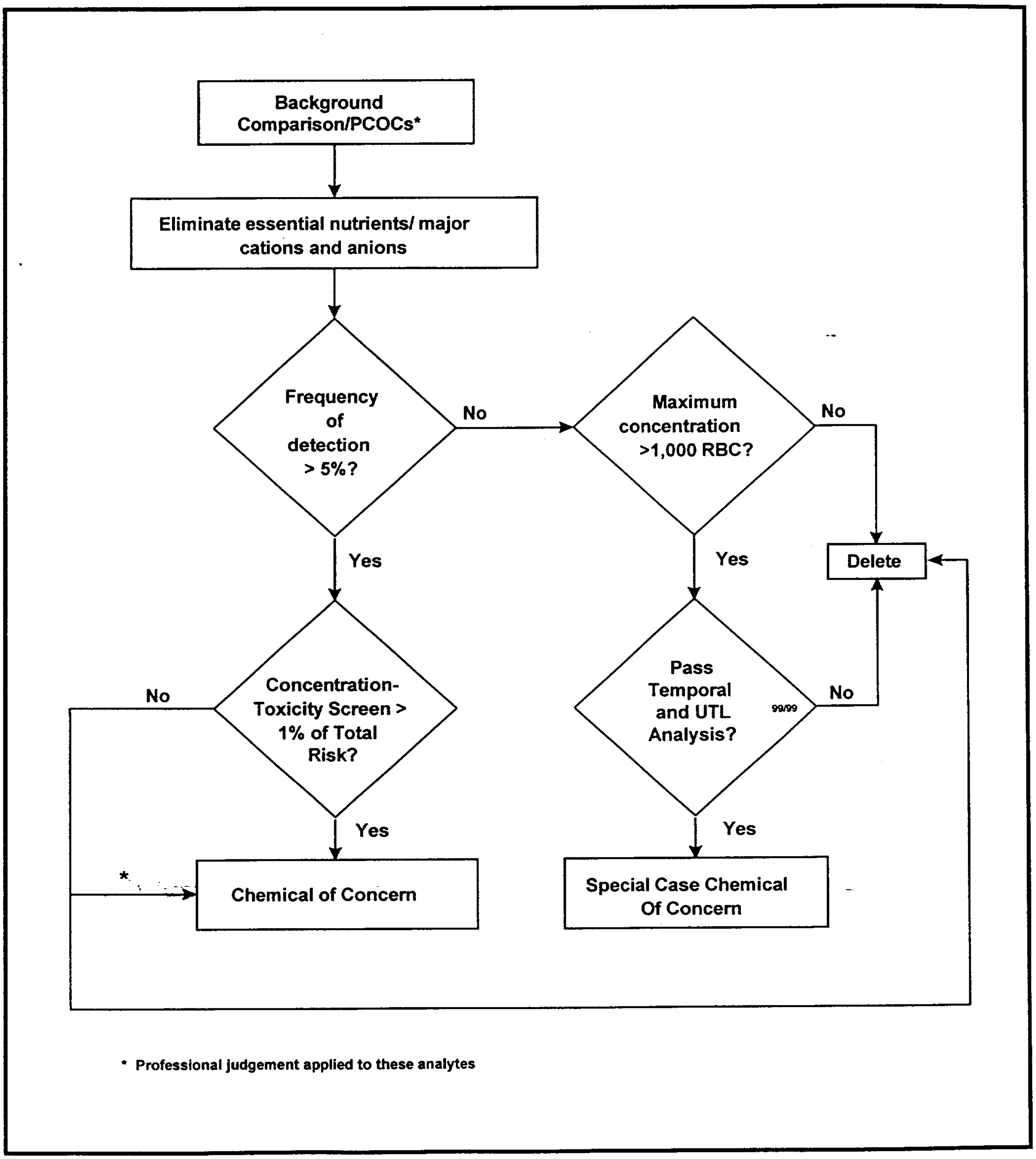


Figure L-3 Chemical of Concern Indentification

1.4 RISK CHARACTERIZATION

Exposure concentrations and risks will be calculated in accordance with EPA guidance (EPA, 1989a) as documented in the HHRAM (DOE, 1995b). Both radiological risk and dose will be estimated. Radiological doses will be calculated using methods and parameters employed for development of the ALF.

1.5 ECOLOGICAL RISK ASSESSMENT

Protection of ecological as well as human receptors is a central goal under CERCLA and the RFCA. The methodology for quantifying possible adverse effects to ecological receptors is similar to that for human receptors. A sitewide ERAM was developed that is consistent with the EPA's eight-step guidance (draft) on conducting ERAs at Superfund sites (EPA, 1994b). This methodology has been used for ecological risk assessments for the Walnut Creek and Woman Creek watersheds at RFETS (DOE,1996c). The screening portion of this site-specific guidance is shown in Figure N-4 as described in the following documents:

- *ERAM Technical Memorandum, Sitewide Conceptual Model* (DOE, 1996a) helps identify environmental stressors and the potentially complete exposure pathways that will become the focus of the ERA.
- *ERAM Technical Memorandum, Ecological Chemicals of Concern Screening Methodology* (DOE, 1996b) describes a tiered screening process for identifying chemicals at potentially ecotoxic concentrations.

The purpose of a screening-level ERA is to detect whether a significant ecological threat exists in a geographic area. After PCOCs have been determined for a geographic area, risks are estimated by comparing maximum analyte concentrations with screening-level ecotoxicity benchmarks, with the subsequent generation of hazard quotient (HQ) values. The HQ is the result of the exposure estimate divided by the benchmark. This step is used to evaluate whether the preliminary screening is adequate to determine the presence of an ecological threat. If none of the PCOCs are present at ecotoxic concentrations, the site is considered to present a negligible or de minimis risk and a more detailed quantitative risk assessment is not warranted (EPA, 1994b). If a given IHSS or source area fails to pass the ERA screen (HQ >1 for any analyte), the data are evaluated in more detail. This includes a much more comprehensive evaluation of exposure pathways and a more accurate method for estimating exposure than a screening-level ERA. The exposure estimation includes methods that account for factors which modify the frequency, duration, and intensity of contact between a receptor and the contaminated media. This evaluation results in a list of chemicals that are subjected to more detailed analysis in the ecological risk characterization.

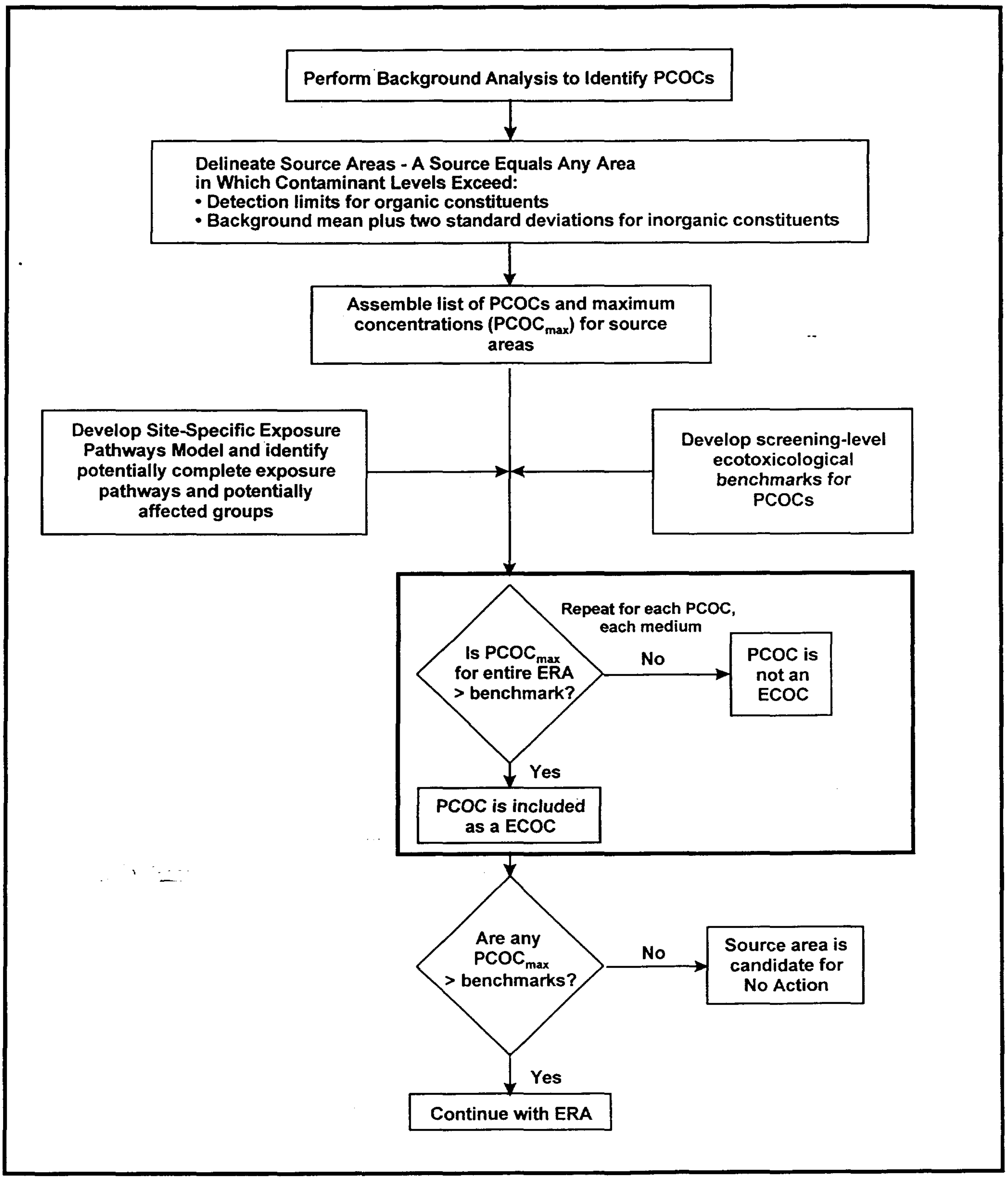


Figure L-4 Screening-Level ERA

The characterization in the ERA integrates the exposure assessment and the effects assessment. It includes a description of risk in terms of the assessment endpoints, a discussion of the ecological significance of the effects, a summary of the overall confidence in the ERA, and a discussion of possible risk management strategies. The ERA performed for the Walnut Creek and Woman Creek watersheds will form the basis for the Ecological component of the CRA (DOE, 1996c).

ATTACHMENT 1

BACKGROUND COMPARISON (Adapted from Chromec et al., 1995)

Analytical results for metals, radionuclides, water-quality parameters, and selected organics, if appropriate, are compared to the chosen background data using one of the following five statistical tests.

Lognormal Upper Tolerance Level (UTL99/99) Each result is compared to the background 99% UTL on the 99th percentile of background. This hot measurement test assures that no hot spots in an area of concern are overlooked. If one or more measurements exceed the UTL99/99 the analyte is considered a PCOC pending application of professional judgment. UTLs cannot be reliably calculated for analytes with a very high rate (>80%) of nondetects.

The Slippage Test This is a rapid screening test. The Slippage test is a nonparametric test and can be used for all data distributions. The test should not be used if the highest value in the data set is a nondetect. If the number of site measurements that exceed the background maximum value are greater than a critical number obtained from the appropriate table, then the analyte may be a PCOC.

The Quantile Test This is also a rapid screening, nonparametric test and can be used with all data distributions. If the number of site results that are among the largest r (number selected from a table of values) measurements exceeds a predetermined number, it may be concluded that the analyte is a PCOC. The test should only be used there are no nondetects among the largest measurements of the combined background and site data sets. A p-value of 0.05 or less is considered to indicate a significant difference from background concentrations.

The Gehan Test (nonparametric ANOVA) The Gehan test is a nonparametric test that can be used when multiple detection levels are present. It is applied without replacing nondetect values. The data are ordered, ranked and scored. A "Z" statistic is calculated and compared to values from a table at a chosen p-value. A p-value of 0.05 or less is considered to indicate a significant difference from background concentrations. Gilbert did not feel that the performance of this test had been sufficiently determined and suggested that it be evaluated at the earliest possible time.

The Student's t Test This is a common parametric test for determining if the means of two populations are different. The t test is the preferred test when the background and site data are normally and independently distributed, with equal variances and no nondetects. The test is applied on populations with at least 20 observations and less than 20% nondetects. A p-value of 0.05 or less indicates a significant difference between means.

Analytes with greater than 80% nondetects cannot be compared using statistical tests and test results for analytes having 50-80% nondetects, should be reviewed with caution.

If the selected statistical test indicates a statistical difference above background levels and it has been applied appropriately, the chemical will be considered a PCOC. Professional judgment will be also be used to retain or eliminate chemicals. Graphics may be used to support such decisions.

Professional Judgment Professional judgment is narrowly defined. It can be used to include a chemical that did not appear to be significantly different from background based on the results of the statistical test, but for which there exists a preponderance of historical data suggesting that the chemical may have been released to the environment in significant quantities. Professional judgment can also be applied to exclude a chemical for which at least one of the statistical tests was significant, but the difference from background can be explained by spatial, temporal, or pattern-recognition concepts.

Professional judgment may also determine that there was an invalid application of the statistical tests; distributional assumptions were violated or nondetect rates were so high that the statistical tests actually compared replacement values; making the test results highly suspect or meaningless. The statistical comparison of data sets where one or both data sets have high nondetect rates or high value nondetects may be an invalid use of the statistical tests (Gilbert and Simpson 1992). For RFETS, various reports (DOE 1993a, 1994, and others) have used 80 percent as the cut-off value for nondetects. However, there is inherent uncertainty in statistical test results that are produced using data sets with greater than 50 percent nondetects.

Other potential pitfalls in the application of statistical tests include violation of distributional assumptions, variance assumptions, data independence assumptions. If such assumptions are violated, the results of such statistical tests are suspect. If the results are accepted as valid, the PCOCs identified continue through the COC selection process.

Appendix M

ACTION LEVELS FOR RADIONUCLIDES IN SOILS

APPENDIX M

Action Levels for Radionuclides in Soils

Appendix L, Action Levels for Radionuclides in Soils, provides the technical basis for the development of the enforceable action levels for radionuclides in soil as defined in Attachment 5 to the Rocky Flats Cleanup Agreement.

ACTION LEVELS FOR RADIONUCLIDES IN SOILS FOR THE ROCKY FLATS CLEANUP AGREEMENT

FINAL

US DEPARTMENT OF ENERGY
US ENVIRONMENTAL PROTECTION AGENCY
COLORADO DEPARTMENT OF PUBLIC HEALTH AND THE ENVIRONMENT

OCTOBER 31, 1996

TABLE OF CONTENTS

ACRONYMS

ALARA	As Low As Reasonably Achievable
ALF	Action Levels and Standards Framework for Surface Water, Ground Water and Soils
ANL	Argonne National Laboratory
CAB	Citizens Advisory Board
CDPHE	Colorado Department of Public Health and the Environment
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CFR	Code of Federal Regulations
DCF	Dose Conversion Factor
DOE	US Department of Energy
EPA	US Environmental Protection Agency
GI	Gastrointestinal
ICRP	International Commission on Radiological Protection
MCL	Maximum Contaminant Level
NESHAPS	National Emission Standards for Hazardous Air Pollutants
NRC	US Nuclear Regulatory Commission
RFCA	Rocky Flats Cleanup Agreement
RFETS	Rocky Flats Environmental Technology Site
RME	Reasonable Maximum Exposure
SCM	Site Conceptual Model

EXECUTIVE SUMMARY

INTRODUCTION

During the Rocky Flats Cleanup Agreement (RFCA) negotiations, the Action Levels and Standards Framework for Surface Water, Ground Water and Soils (ALF) Working Group realized that setting soil action levels and cleanup standards for radionuclides was a complex process and could not be completed before public notice of the draft RFCA. The RFCA Attachment 5 states that "The parties commit to expeditiously convene a working group to determine the derivation and application of the 15 mrem per year level as well as the derivation and potential application of the 75 mrem per year level." This summary explains the consensus recommendation of that Working Group.

The Working Group convened in early March 1996 and was composed of personnel from the Department of Energy (DOE), the Environmental Protection Agency (EPA), the Colorado Department of Public Health and Environment (CDPHE) and Kaiser-Hill, L.L.C. The Working Group agreed that its charter was to develop technically defensible standards which will not exceed the 15/75 mrem per year dose limits in ALF. The Working Group recognized that the 15/75 requirement was based on EPA's draft 40CFR196, Radiation Site Cleanup Regulations, which were intended for the release of government property. Because the RFCA preamble and the Rocky Flats Vision identify future land uses for the RFETS, which exclude release of government property and permit no residential land use, pertinent sections of the draft regulation were used as guidance for the Working Group.

Radiation dose was chosen as the primary criterion for assessing radionuclide action levels. The ALF called for the consideration of both radiation dose assessment and radiation risk assessment by the working group in making its recommendations. The use of radiation dose to develop action levels is consistent with EPA's draft 40CFR196, Nuclear Regulatory Commission decommissioning requirement, DOE Order 5400.5, "Radiation Protection of the Public and the Environment", and DOE's proposed 10CFR834. Since these regulations are all radiation dose based, this is compelling evidence that the radiation protection community is recommending the use of radiation dose to limit environmental levels of radionuclides. In addition, the preamble to draft 40CFR196 compares the risks associated with remediation, transportation and disposal of contaminated soils against the risks of leaving contaminated soils in place at the 15/75 mrem per year dose limit. EPA concluded that the use of a 15/75 mrem dose limit to establish action levels is protective of the public. Furthermore, the dose assessment process incorporates all pertinent facets of EPA's CERCLA risk assessment process. The radionuclide working group agrees with the EPA draft regulation and is recommending the use of a radiation dose basis.

To translate the radiation dose requirements into soil action levels, it is necessary to first model radionuclide transport within the environment to a human receptor and then assess the receptor's radiation dose. The "RESRAD" computer code was chosen to model this complex process. RESRAD was specifically developed to calculate the radiation dose to an individual and also to derive action levels for radionuclides in soil. RESRAD has been verified and validated for use in assessing radioactive material in soils. An asset of the RESRAD code is its capability to assess contaminant transport to a human receptor in air, surface water, ground water and unsaturated zone soils over the 1,000 year modeling period as specified in the draft EPA regulation. This makes it possible to calculate radiation dose and action levels over any applicable exposure routes (e.g., ingestion, inhalation and external irradiation pathways) for a given receptor. RESRAD also has the capability to model multiple exposure scenarios (e.g., residential, open space and office worker) and to assess radioactive daughter products over the 1,000 year modeling period. The radionuclide working group recommends the use of RESRAD in calculating action levels for the RFETS.

SITE CONCEPTUAL MODEL

There are two separate soil types that need to be assessed at the RFETS: surface soils and subsurface soils. Surface soils are defined in the ALF from the surface to a depth of 15 cm. Consistent with the RFCA preamble and the Rocky Flats Vision, ALF specifies that surface soil action levels would be derived using an open space exposure scenario in the buffer zone and an office worker exposure scenario in the industrial area. Subsurface soils are defined in the ALF from a depth of 15 cm to the top of the ground water table. Per the ALF, subsurface soil action levels are protective of surface water standards through ground water transport of contaminants to surface water. Ground water is not considered a potential drinking water source at RFETS as prescribed in the RFCA preamble and the Rocky Flats Vision.

Per the RFCA preamble and the Rocky Flats Vision, institutional controls may be applied at RFETS. Use of institutional controls may be considered under EPA's draft 40CFR196 when releasing a site. EPA's draft regulation states that any radioactive material in surface soils shall not impart an annual radiation dose to the appropriate human receptor (e.g. an open space receptor in the buffer zone or an office worker receptor in the industrial area) in excess of 15 millirem. Since radiation dose is being examined for a 1,000 year time period, the draft EPA regulation conservatively assumes that institutional controls fail in the future and that a hypothetical resident moves onto the site. Due to the long lived nature of radionuclides at Rocky Flats, the working group is recommending the assessment of a hypothetical future resident. This recommendation was a conscious decision by the working group despite the guidance in the vision which provides for no future residential uses. The annual radiation dose received by this hypothetical future resident will not exceed 85 millirem (Note: The annual radiation dose for this hypothetical individual in EPA's draft 40CFR196 recently changed from 75 mrem to 85 mrem).

There are two action levels that need to be calculated for surface soils. Tier I action levels are numeric levels that, when exceeded, trigger an evaluation, remedial action and/or management action, given the presence of institutional controls. Tier II action levels are numeric levels that, when met, do not require remedial action and/or institutional controls. The final action levels were derived by examining both the hypothetical future resident action levels and the action levels based on the most appropriate land use and then choosing the most conservative action level. The radionuclide working group recommends adopting the Tier I and Tier II methodology outlined in the "Action Levels and Standards Framework for Radionuclides in Surface Water, Groundwater and Soils (ALF)." Proposed modifications to ALF and a discussion of put-back levels can be found in the document entitled, "Modifications to the Action Levels and Standards Framework." Table ES-1, "Tier I & II Soil Action Levels," outlines the Tier I and Tier II action levels being recommended by the radionuclide working group. The working group is recommending that the hypothetical future resident exposure scenario at the 85 mrem level be the Tier I action level for surficial soils in the buffer zone. The working group is also recommending that the office worker exposure scenario at the 15 mrem level be the Tier I action level for surficial soils in the industrial area. Further, the working group is recommending that the Tier II action level be the hypothetical future resident exposure scenario at the 15 millirem level.

Per the ALF, subsurface soil action levels must be protective of surface water standards through the transport of contaminants in ground water. The ALF requires that subsurface soil action levels be based on the leaching of contaminants to ground water, such that the ground water levels are protective of surface water standards. This concept was discussed by the radionuclide working group and not recommended for use at RFETS. Since the subsurface soils at RFETS are highly heterogeneous, it is not currently possible to accurately model radionuclide transport in these subsurface soils. Therefore, the radionuclide working group currently recommends a conservative approach by applying the Tier I and Tier II surface soil action levels to the subsurface soils. In addition, subsurface soil leaching of radionuclides to ground water is currently being investigated at the RFETS. If an accurate subsurface soil leaching model can be developed for RFETS in the future, and is agreed upon by the RFCA parties, the current working group recommendations may need to be updated.

RESRAD INPUT PARAMETERS

In the RESRAD computer code, there are approximately seventy different inputs that were discussed and agreed upon by the radionuclide working group for each exposure scenario. Site-specific values were chosen for these inputs whenever possible so that the action levels could be tailored to RFETS. If a site-specific value was not available, the RESRAD default input was used. The RESRAD code was used to evaluate the office worker exposure scenario, the open space exposure scenario and the hypothetical future resident exposure scenario over the 1,000 year modeling period.

RECOMMENDATIONS

The working group recommends that the hypothetical future resident exposure scenario at the 85 mrem level be the Tier I action level for surficial soils in the buffer zone. The working group also recommends that the office worker exposure scenario at the 15 mrem level be the Tier I action level for surficial soils in the industrial area. Further, the working group is recommending that the Tier II action level for the entire site be the hypothetical future resident exposure scenario at the 15 millirem level. Soils with levels of radionuclides at or below the Tier II action level do not require remedial action and/or institutional controls. Although direct exposure to subsurface soils is not anticipated for the hypothetical future resident, open space or office worker exposure scenarios, the radionuclide working group currently recommends conservatively applying the Tier I and Tier II surface soil action levels to the subsurface soils. This subsurface soil recommendation may be updated in the future.

Table ES-1 outlines these Tier I and Tier II action levels.

This working group acknowledges that in the future, new regulations, different guidance, improved calculation methods and models and better input parameters will likely become available. As this new information becomes available it will be considered in accordance with paragraph 5 of RFCA.

APPLICATION

Action levels as calculated above are only applicable when a single radionuclide is found in the environment. This is not the case at RFETS. In the environment at RFETS, the uranium (U) isotopes of U-234, U-235 and U-238 are found together, and the americium (Am) and plutonium (Pu) isotopes of Am-241 and Pu-239/240 are found together. When multiple radionuclides are found in the environment, it must be ensured that the sum of the radiation doses from all radionuclides present does not exceed the action level basis (e.g., a hypothetical future resident assessed at the 15 mrem level).

The action levels for americium and plutonium together can also be calculated since the activity of Am-241 is about 18% of the Pu-239+Pu-240 (Pu-239/240) activity in the environment (Ibrahim, 1996). Given this activity ratio, the action level for Am-241 and Pu-239/240 can be computed so that the sum of their radiation doses equals either 15 or 85 millirem to the appropriate exposure scenario. Table ES-1 includes an example of these adjusted action levels for Am-241 and Pu-239/240 if they are the only radionuclides present in soil. Since the 18% ratio actually varies in the environment, site specific data will be used to make action level comparisons. If uranium is also present in the soil, then the contribution to the radiation dose from the uranium also needs to be assessed so that the Tier I and/or Tier II action level basis is not exceeded.

SECTION 1
INTRODUCTION

During the Rocky Flats Cleanup Agreement (RFCA) negotiations, the Action Levels and Standards Framework for Surface Water, Ground Water and Soils (ALF) Working Group realized that setting soil action levels and cleanup standards for radionuclides was a complex process and could not be completed before public notice of the draft RFCA. Therefore a radionuclide working group was formed to undertake this task. This report discusses the formation of a radionuclide working group, the radionuclide working group's application of the 15/75 mrem methodology as outlined in the draft RFCA and the radionuclide working group's recommendations concerning radionuclide action levels in soils.

Section 2 of this report discusses the formation of the radionuclide working group along with the goals of the working group. The working group members represent the US Department of Energy (DOE), the US Environmental Protection Agency (EPA), the Colorado Department of Public Health and the Environment (CDPHE) and Kaiser-Hill (K-H) , L.L.C.

Section 3 of this report is a regulatory analysis that describes the regulatory basis for deriving radionuclide action levels in soils. Regulations promulgated by the DOE, EPA and Nuclear Regulatory Commission (NRC) are examined.

Section 4 of this report contains the site conceptual model for surface and subsurface soil assessment. The site conceptual model is the basis for the exposure scenarios used to derive action levels for soils.

Section 5 of this report discusses how the soil action levels were developed. The use of the RESRAD computer model is discussed and the action levels for all applicable exposure scenarios are given.

Appendix A of this report discusses the development of the parameter inputs to the RESRAD computer code for the hypothetical future resident exposure scenario, the open space exposure scenario and the office worker exposure scenario. RESRAD computer code outputs are also in this appendix.

Appendix B of this report discusses the expected chemical form of plutonium in the environment. The chemical form of radioactive material is significant for assessing radiation dose.

Appendix C of this report is an exposure pathway analysis. The exposure pathways applicable to the hypothetical future resident exposure scenario, the open space exposure scenario and the office worker exposure scenario are discussed and delineated.

Appendix D of this report discusses the relative importance of different isotopes of plutonium with respect to human health. The decay of plutonium, the ingrowth of daughters and plutonium toxicity are examined.

SECTION 2
RADIONUCLIDE WORKING GROUP FORMATION AND GOALS

The radionuclide working group convened in early March 1996 and was composed of personnel from the DOE, the EPA, the CDPHE and the K-H Team. The Working Group agreed that its charter was to determine the derivation and application of the 15 mrem per year level as well as the derivation and potential application of the 75 mrem per year level as outlined in the Rocky Flats Cleanup Agreement. The Working Group recognized that the 15/75 requirement was based on EPA's preliminary proposed 40CFR196, Radiation Site Cleanup Regulations.

The goals of the Working Group were:

- To determine and recommend radionuclide action levels for soil;
- To determine and recommend radionuclide put-back levels for soil; and
- To prepare a draft technical justification document which would explain the Working Group's recommendations.

The Working Group believes its recommendations are based on a sound technical, scientific and regulatory foundation. The Working Group has consulted with the Citizens Advisory Board (CAB), the Cities of Broomfield, Westminster, Northglenn and Thornton, and the Rocky Flats Environmental Technology Site (RFETS) expert panel on radionuclide fate and transport concerning any recommendations. Proposed modifications to ALF and a discussion of put-back levels can be found in the document entitled, "Modifications to the Action Levels and Standards Framework."

SECTION 3
REGULATORY ANALYSIS OF RADIONUCLIDES IN SOILS

3.1 Introduction

In order to calculate action levels for radionuclides, a target radiation dose to an individual must be defined. This target radiation dose could be applicable to a current or future individual. After the target radiation dose is selected, the amount of radioactive material in the environment that corresponds to this target radiation dose can be calculated. This calculated value is the action level.

To select the target radiation dose, applicable regulations need to be reviewed so that regulatory requirements are met. Applicable regulations from the DOE, the EPA and the NRC were reviewed. The following radiation dose standards may apply to the assessment and remediation of radionuclides in the environment at the RFETS. These standards were evaluated so that the requirements of both current and proposed radiation protection standards could be assessed.

* DOE Order 5400.5, "Radiation Protection of the Public and the Environment."

* Proposed Title 10 of the Code of Federal Regulations, Part 834, "Radiation Protection of the Public and the Environment," revised August 25, 1995 (Proposed 10CFR834).

* Draft Title 40 of the Code of Federal Regulations, Part 196, "Radiation Site Cleanup Regulations," dated October 21, 1993 (Draft 40CFR196).

* Proposed Title 10 of the Code of Federal Regulations, Parts 20, 30, 40, 50, 51, 70 & 72, "Radiological Criteria for Decommissioning," dated August 22, 1994 (Proposed

10CFR-NRC).

None of the above regulations is based on assessing and remediating radioactive materials based on risk assessment. EPA is promoting this departure from risk assessment with their draft 40CFR196. Since the DOE, EPA and NRC are promulgating regulations using radiation dose to assess and remediate radioactive material in the environment, risk assessment will not be the basis for calculating action levels.

The requirements of the National Emission Standards for Hazardous Air Pollutants (NESHAPS) are not being considered to develop action levels; however, DOE is obligated to comply with the requirements of NESHAPS as long as RFETS is a DOE site. The DOE currently has a NESHAPS program in place. If monitoring detects a significant increase in emissions of radionuclides to the ambient air that may be due to radionuclides in soils, a source evaluation and mitigating action may be required. The action levels should be consistent with the NESHAPS requirements, since even the worst areas of soil contamination do not currently cause ambient air to exceed the NESHAPS standards.

3.2 DOE Order 5400.5

DOE Order 5400.5 prescribes the use of a 100 millirem annual radiation dose limit as recommended by the International Commission on Radiological Protection (ICRP, 1977). This order includes a recommendation that a 30 mrem radiation dose limit be applied if the actual use of a site is being examined or if the likely future use of a site is being examined. The order states that acceptable levels of radionuclides in soil shall be derived based on an environmental pathway analysis with specific property data where available. The order further states that acceptable residual radionuclide concentrations will be derived using the RESRAD (Argonne, 1993) environmental transport and radiation dose computer code. An

As Low As Reasonably Achievable (ALARA) analysis must be a part of the RESRAD analysis. An ALARA analysis tries to reduce the radiation dose limit taking into account economic, social and technical factors.

The actual use or the likely future use exposure scenario represents the individual that could receive the largest radiation dose. For exposure scenarios considered to be less likely but plausible, the 100 millirem/year limit should not be exceeded. These exposure scenarios could include a resident, an industrial worker and/or a recreational user. Radiation dose is assessed for these exposure scenarios every year in a 1,000 year time period.

3.3 Proposed 10CFR834

The provisions of DOE Order 5400.5 are currently being proposed as 10CFR834. Proposed 10CFR834 reiterates the 100 millirem per year radiation dose standard and also states that the starting point for an ALARA analysis would be 25 to 30 millirem per year. This regulation requires an environmental pathway analysis using approved models such as RESRAD to derive acceptable levels of radionuclides in the soil. With respect to exposure scenarios, 10CFR834 states that the actual and likely use scenarios and the worst plausible use scenario shall be evaluated. The requirement to evaluate the worst plausible use is only a secondary check to ensure that application of the likely use scenario does not overlook an extremely hazardous situation or a very susceptible subgroup. 10CFR834 also recommends that the dose assessment be performed for a 1,000 year time period.

3.4 Draft 40CFR196

Draft 40CFR196 states that a remediation standard of 15 mrem/yr should be used at sites with radioactive material in all environmental media. This radiation dose limit would apply to sites where the future land use is either unrestricted or restricted following remediation activities. If the land use at a site is restricted (e.g., restricting land use to open space use), the 15 mrem/year limit would apply to the restricted land use. If the land use is restricted, draft 40CFR196 also requires the assessment of the unrestricted release exposure scenario (i.e., residential exposure scenario). The radiation dose to be received by an unrestricted release exposure scenario will not exceed 75 mrem/yr (This has recently been updated to 85 mrem/yr.) so that any individual will not receive more than the ICRP recommended dose limit of 100 millirem even if land use restrictions fail in the future. An ALARA analysis is not required.

EPA performed an extensive regulatory review before promulgating draft 40CFR196. The preamble to draft 40CFR196 compares the risks associated with remediation, transportation and disposal of contaminated soils against the risks of leaving contaminated soils in place at the 15/75 mrem per year dose limit. EPA concluded that the use of a 15/75 mrem dose limit is protective of the public. EPA recognized that the dose assessment process incorporates all pertinent facets of a CERCLA risk assessment process.

A 1,000 year time period also needs to be assessed to comply with the requirements in draft 40CFR196. This requirement came from the fact that many sites contain radionuclides with very long half-lives. The use of this assessment period will ensure that the creation of decay products and the long-term integrity of any land use restrictions are adequately considered.

3.5 Proposed 10CFR-NRC

The proposed NRC decommissioning regulations are directly comparable to the EPA's draft 40CFR196 regulations. The NRC uses a 15 mrem/yr radiation dose limit for both unrestricted and restricted land uses at a site just like the EPA draft standard. If a site is implementing land use restrictions, the NRC allows an individual in the future to receive a radiation dose of 100 millirem instead of 85 millirem. The NRC uses a 1,000 year assessment period and requires that an ALARA analysis be performed.

3.6 Rocky Flats Cleanup Agreement Regulatory Basis

The Radionuclide Action Levels Working Group has decided to use the draft 40CFR196, "Radiation Site Cleanup Regulations," regulations to derive action levels at the RFETS. This decision was made by the working group for the following reasons:

* Remediation activities at the RFETS follow EPA and State of Colorado remediation requirements as outlined in the Rocky Flats Cleanup Agreement (RFCA). For radionuclide remediation, EPA's most current regulations need to be addressed.

* Draft 40CFR196 is based on an extensive review of available radiation protection information.

* Draft 40CFR196 is expected to be promulgated in the near future.

* Draft 40CFR196 is not inconsistent with the requirements of DOE Order 5400.5, proposed 10CFR834 and the proposed NRC decommissioning regulations.

* NRC regulations do not apply to DOE facilities.

SECTION 4
SITE CONCEPTUAL MODEL

4.1 Introduction

The Site Conceptual Model (SCM) outlines the land uses that are expected to be present at the RFETS so that action levels can be calculated for these future land uses. The type of land use is very important since the amount of time an individual may contact radioactive material in the environment is directly related to the selected land use. This contact time is then transformed into an amount of radioactive material inhaled or ingested by the individual. Action levels are derived from the radiation dose associated with radioactive material inhaled and ingested, and from external gamma exposure.

4.2 Land Uses at RFETS

Future activities at RFETS include environmental restoration, decontamination and decommissioning, economic development and waste management. The Rocky Flats Local Impact Initiative is currently working with DOE and local development agencies to encourage business development at RFETS. The Rocky Flats Future Site Uses Working Group has also developed recommendations regarding future use of the RFETS property. Residential development at RFETS has not been recommended by this group or by other planning groups. Commercial and industrial uses of developed portions of the site are considered beneficial. Even though commercial development in undeveloped portions of the property has not been ruled out, preservation of this area as open space is consistent with DOE policy, the Rocky Flats Future Site Working Group recommendations and the Jefferson County Planning Department's recommendations. The Jefferson County Board of Commissioners has also adopted a resolution stating its support of maintaining, in perpetuity, the undeveloped buffer zone as open space (DOE, 1995). Open space use assumes no development in these areas.

The land uses for RFETS are prescribed by the Rocky Flats Cleanup Agreement (RFCA) in the preamble to that document (RFCA, 1996). The preamble states that cleanup decisions and activities are to be based on open space use and limited industrial use at RFETS. These land uses are consistent with the direction of local government as outlined above. In the near-term condition, the inner and outer buffer zones will be managed and remediated to accommodate open space uses. At the beginning of the intermediate term condition, open space use in these areas will still be applicable. Industrial uses are applicable in the industrial area of the plant in the near and intermediate term conditions. The RFCA prescribes that specific future land uses and post-cleanup designations will be developed in consultation with local governments.

4.3 Surface Soil Assessment

To be consistent with the RFCA (RFCA, 1996), the basis for radionuclide action levels in surface soils is an open space exposure scenario in the buffer zone and an office worker exposure scenario in the industrial area of the plant. Consistent with 40CFR196, the working group agreed that the hypothetical future residential exposure scenario would also be evaluated. Although conservative, the assessment of a residential exposure scenario is inconsistent with current land use recommendations. Surface soils are defined as the top 15 cm of soil.

The open space exposure scenario assumes that an individual visits the buffer zone a limited portion of the year for recreational activities. This individual could hike on trails or wade in the creeks. This individual is assumed to be exposed to radioactive material in soils by directly ingesting the soils, by inhaling resuspended soils and by external gamma exposure from the soils. Appendix C, "Analysis of Exposure Pathways for use in Deriving Action Levels," contains a detailed discussion on the selection of these three exposure pathways. For an account of the amount of time the open space user spends at RFETS, see Appendix A, "Parameter Justification and RESRAD Output." The action level for the open space exposure scenario is the amount of a specific radioactive material in surface soil that would impart an annual radiation dose of 15 millirem to the open space user during the 1,000 year assessment period.

The office worker exposure scenario assumes that an individual works mainly indoors in a building complex surrounded by extensive paved areas or well maintained landscaping. This individual is assumed to breath outside air and ingest soil from outside the building. This individual is assumed to be exposed to radioactive material in soils by directly ingesting the soils, by inhaling resuspended soils and by external gamma exposure from the soils. Appendix C, "Analysis of Exposure Pathways for use in Deriving Action Levels," contains a detailed discussion on the selection of these three exposure pathways. For an account of the amount of time the office worker spends at RFETS, see Appendix A, "Parameter Justification and RESRAD Output." The action level for the office worker exposure scenario is the amount of a specific radioactive material in surface soil that would impart an annual radiation dose of 15 millirem to the office worker during the 1,000 year assessment period.

The hypothetical future residential exposure scenario assumes that an individual resides at RFETS. This individual lives at RFETS all year and eats homegrown produce. This individual is assumed to breath outside air and ingest soil from outside the residence. This individual is assumed to be exposed to radioactive material in soils by directly ingesting the soils, by inhaling resuspended soils, by external gamma exposure from contaminated soil and by ingesting produce grown in contaminated soil. Appendix C, "Analysis of Exposure Pathways for use in Deriving Action Levels," contains a detailed discussion on the selection of these four exposure pathways. For an account of the amount of time the resident spends at

RFETS, see Appendix A, "Parameter Justification and RESRAD Output." The action level for the residential exposure scenario is the amount of a specific radioactive material in surface soil that would impart an annual radiation dose of 15 millirem or 85 millirem to the hypothetical resident during the 1,000 year assessment period.

In order to carry out the original weapon-building mission, personnel at RFETS handled plutonium (Pu), americium (Am) and uranium (U) in a number of different operations. Rocky Flats plutonium was composed of Pu-238, Pu-239, Pu-240, Pu-241, Pu-242 and Am-241 (DOE, 1980), and the isotopes of uranium handled at RFETS are U-234, U-235 and U-238. Action levels in soils have been derived for Pu-238, Pu-239, Pu-240, Pu-241, Pu-242, Am-241, U-234, U-235 and U-238 in the environment.

To calculate the radiation dose to an individual, appropriate Dose Conversion Factors (DCF) must be chosen. These DCFs convert the radioactive material present in an exposure route to a radiation dose. The three exposure routes are the ingestion, inhalation and external gamma exposure from radioactive material in soil. DCFs are therefore available for the ingestion, inhalation and external exposure routes. The DCF for each exposure route differs with the chemical form of the radionuclide. The chemical form for americium, uranium and all daughter products were conservatively chosen so that the DCF would be maximized for each exposure route. The DCFs for plutonium were chosen based on the oxide form. For a detailed discussion of the chemical form of plutonium in the environment, see Appendix B, "Analysis of the Chemical Form of Plutonium in the Environment."

4.4 Subsurface Soil Assessment

Subsurface soils are defined from 15 cm below the ground surface to the top of the ground water table. There are no exposure pathways present for the open space, office worker or hypothetical resident exposure scenarios to subsurface soils. Therefore, these exposure scenarios are not appropriate for subsurface soils. For this reason, the RFCA (RFCA, 1996) states that action levels derived for subsurface soils will be protective of surface water standards via ground water transport of radionuclides leached from subsurface soils. The surface water standard for radionuclides is the Maximum Contaminant Level (MCL) as defined by the RFCA.

The SCM for subsurface soils is represented by radionuclides first leaching from subsurface soils to ground water. The radionuclides in ground water are then transported to surface water where the radionuclide concentration cannot exceed the MCL. The subsurface soil action level is the smallest amount of a specific radioactive material in subsurface soil that would impart an MCL in surface water over the 1,000 year assessment period.
This subsurface soil SCM was examined closely by the radionuclide working group. The geohydrology of the RFETS was examined along with the subsurface soil transport properties of plutonium, americium, uranium and their daughter products. Also, the relationship between the subsurface soil SCM and the surface soil SCM was examined. The radionuclide working group came to the conclusion that a subsurface soil action level for radionuclides could not be developed at this time with the subsurface soil SCM defined by the RFCA. This conclusion was based on the variable characteristics of the SCM. This variability is attributable to 1) a water infiltration rate into the soil which varies both areally across the site and within the subsurface soils, 2) radionuclide-specific distribution coefficients that vary spatially within the subsurface soil, 3) a variable distance from a source of radioactive material in the subsurface soil to surface water and 4) a variable soil unsaturated/saturated zone thickness across RFETS. For these reasons, the radionuclide working group has decided to conservatively apply surface soil action levels to subsurface soils.

Currently there are efforts proceeding that may reduce the variability in the subsurface soil SCM. In the future, this variability may be reduced sufficiently to allow the application of the prescribed subsurface soil SCM. If this occurs, the current recommendation of the radionuclide working group may be modified.

SECTION 5
ACTION LEVEL DEVELOPMENT

5.1 Introduction

All of the ingredients for developing action levels for radionuclides in surface soils have been delineated in the preceding sections. A radiation dose limit has been established, the applicable exposure scenarios have been defined and the type of soil to be assessed has been defined. All of these facets allow the calculation of a surface soil action level for the open space exposure scenario, the office worker exposure scenario and the hypothetical future residential exposure scenario. Due to the complex nature of action level development, a computer model must be utilized to derive the action levels. The RESRAD computer model was selected for use since it fulfills all modeling requirements. Action levels were developed for the given exposure scenarios in surface soils. These action levels will be used as Tier I and Tier II action levels in the Action Levels and Standards Framework for Surface Water, Groundwater and Soils (RFCA, 1996).

5.2 Computer Code Requirements

There are a number of different processes that need to be assessed to derive action levels. Due to the complexity of each of these processes, it would be beneficial to have a computer code that would assess each of the following processes. For efficiency and compatibility reasons, the ideal computer code would incorporate all of the following processes. It is also important that the computer code(s) be validated and verified.

The first process that has to be modeled is the transport of radioactive material in surface soil to an individual. This transport can include soil transport in air, surface water, ground water and/or unsaturated zone pore water. For assessing surface soil, the most important environmental transport process for deriving action levels is the air transport process. This is important for the inhalation exposure pathway. All other environmental transport processes serve to decrease the amount of radioactive material present in surface soil. This decrease in radioactive material over time increases the action level over time. All environmental transport processes modeled must be able to assess the movement of radioactive material and their daughter products over the 1,000 year assessment period.

The second process that needs to be examined is the exposure of a receptor to the radioactive material in the soil. There are four exposure pathways that need to be assessed by the chosen computer code. These pathways include incidental ingestion of soil, inhalation of resuspended soil, external gamma exposure from radionuclides in the soil and ingestion of homegrown produce.

The next process to be concerned with is radiation dosimetry. Once the radioactive material enters the body, a radiation dose must be calculated so that an action level can be derived. There are three modes through which radioactive material can impart radiation dose to an individual. These are through the ingestion of radioactive material, the inhalation of radioactive material and external gamma exposure from radioactive material in soil. All three of these radiation dose modes need to be assessed for each radionuclide. Since a 1,000 year assessment period is required, the radiation dose from daughter products must also be assessed.

5.3 Computer Code Selection

The RESRAD computer code (Argonne, 1993) was selected for use in deriving surface soil action levels because it meets all modeling requirements. RESRAD was developed at Argonne National Laboratory for the US Department of Energy (DOE) so that radiation dose to an individual as well as action levels could be derived for radioactive material in soils. RESRAD can model all four of the above processes in an integrated manner and can assess daughter products over the 1,000 year modeling period. RESRAD has also been validated and verified (Argonne, 1994).

Surface soils can be physically modeled by the RESRAD code. Soils are broken down into layers within the code, and the top layer, at the ground surface, can be a cover or a contaminated zone. For deriving surface soil action levels, the contaminated zone is considered to be the surface soils with no cover. Underneath the contaminated zone, RESRAD has the capacity to model five separate uncontaminated/unsaturated layers before reaching ground water. This configuration meets the requirements for deriving action levels at the RFETS.

RESRAD can model the required environmental transport processes. It contains an air transport algorithm that looks at resuspension of radioactive material in soils and transport to an individual. The assessment of the air transport pathway is essential to calculating surface soil action levels. Unsaturated zone transport and ground water transport processes are also assessed within the RESRAD code. These two algorithms will allow leaching of radioactive material out of the surface soils for the 1,000 year assessment period. These unsaturated zone transport and ground water transport algorithms could be used in the future to model the leaching of contaminants from subsurface soils at the RFETS. With respect to environmental transport requirements, RESRAD meets the requirements for deriving action levels at RFETS.

The RESRAD code can model the four exposure pathways: incidental ingestion of soil, inhalation of resuspended soil, external gamma exposure from radionuclides in the soil and ingestion of homegrown produce. RESRAD can assess nine exposure pathways in total.

These exposure pathways are external gamma exposure, soil inhalation, plant ingestion, meat ingestion, milk ingestion, aquatic food ingestion, drinking water ingestion, soil ingestion and radon exposure. This shows the flexibility of the RESRAD code in assessing many different situations. Exposure pathways can be turned on and off in RESRAD depending on the specific situation. Concerning exposure pathways, this meets the requirements for deriving action levels at the RFETS.

The RESRAD code also has an extensive library of radionuclides in their radiation dosimetry module. This allows the calculation of radiation dose and action levels on the radionuclides of interest and on their daughter products over the 1,000 year modeling period. The radionuclide database includes inhalation, ingestion and external exposure Dose Conversion Factors (DCF). These DCFs are also available within RESRAD for the different chemical forms of radionuclides. Concerning the use of DCFs, this meets the requirements for deriving action levels at the RFETS.

5.4 RESRAD Parameter Input Development

There were four separate RESRAD computer runs that needed to be performed to obtain all required action levels. These included the following:

* An Open Space Exposure Scenario Assessed at the 15 Millirem Level
* An Office Worker Exposure Scenario Assessed at the 15 Millirem Level
* A Hypothetical Future Resident Assessed at the 15 Millirem Level
* A Hypothetical Future Resident Assessed at the 85 Millirem Level

There were 53 separate input parameters to the RESRAD code for the open space and office worker exposure scenarios. The hypothetical future resident had 83 separate input parameters. The parameters for all of these exposure scenarios were chosen to be as site specific as possible to satisfy the requirements of the site conceptual model. When a site specific parameter was not available, the RESRAD default parameter was used. For a discussion of all parameter inputs with their selected values, see Appendix A, "Parameter Justification and RESRAD Output."

5.5 RESRAD Modeling Results

Table 5-1, "Single Radionuclide Soil Action Levels," outlines the Tier I and Tier II action levels developed using RESRAD. The action levels in this table represent the radionuclide-specific activity in the soil that would impart a maximum radiation dose of either 15 millirem or 85 millirem to the given exposure scenario over the 1,000 year modeling period.

5.6 Use of RESRAD Modeling Results

The action levels outlined above need to be applied in the field. To do this, a number of simplifying assumptions can be made while still assuring the protectiveness of the action levels. This simplification allows implementation of these action levels in an efficient manner.

The first simplification is that the number of radionuclides needing assessment at RFETS can be reduced. All uranium (U) radionuclides present at RFETS (e.g., U-234, U-235 and U-238) in the environment will be assessed with respect to their action levels. Appendix D, "Analysis of Assessment Needs for Rocky Flats Plutonium," outlines the reasons why the only constituents from Rocky Flats plutonium that need to be assessed in the environment are Pu-239, Pu-240 and Am-241. All isotopes of Rocky Flats plutonium were initially assessed for completeness since plutonium in the nuclear fabrication process was composed of Pu-238, Pu-239, Pu-240, Pu-241 and Pu-242 (DOE, 1980). Am-241 is also contained in this mix of plutonium due to its ingrowth from Pu-241 (DOE, 1980). The plutonium found in the environment though will have different activities of plutonium and americium than what is found in the fabrication process because of radionuclide decay and ingrowth over time. In examining this decay and ingrowth with regard to radionuclide toxicity, it is shown in Appendix D that it is necessary to only assess Pu-239, Pu-240 and Am-241 in the environment.

The number of exposure scenarios that need to be examined can also be reduced. The more conservative of the Tier I action level for the open space exposure scenario and the Tier I action level for the hypothetical future resident will be applied in the buffer zone at RFETS. Also, the more conservative of the Tier I action level for the office worker exposure scenario and the Tier I action level for the hypothetical future resident will be applied in the industrial area at RFETS. These comparisons were made and the result is that the Tier I action level in the buffer zone will be based on the hypothetical future resident exposure scenario and that the Tier I action level in the industrial area will be based on the office worker exposure scenario. Table 5-2, "Tier I & II Soil Action Levels," outlines the soil action levels after the above simplifications are made.

To assure that the soil action levels will be protective of human health when multiple radionuclides are present, the sum of the radiation doses from all radionuclides in soil must not exceed the Tier I or Tier II dose limit of 15 millirem or 85 millirem. A "Sum of Ratios" method will be used when more than one radionuclide is present in soils. Table 5-3, "Sum of Ratios Example," outlines this method. First, a ratio is formed for each radionuclide by dividing the activity of the radionuclide found in soils by the appropriate soil action level. This ratio actually represents the fraction of the radiation dose from the action level. In Table 5-3, the action level chosen for comparison is the Tier II action level for RFETS which is the hypothetical future resident assessed at the 15 millirem level. In this example, the radiation dose from U-235 is 1% of 15 millirem or 0.15 millirem at a soil activity of 0.3 pCi/gram. Therefore, when the ratio from each radionuclide is summed, this ratio sum is the fraction of the radiation dose limit for the action level. In Table 5-3, the sum of the ratios is 0.22 or 22% of 15 millirem. In this example, the Tier II action level is not exceeded since the sum of ratios is less than or equal to 1.0. If the sum of ratios exceeded 1.0, the action level would be exceeded.

The action levels for americium and plutonium together can also be calculated since the activity of Am-241 is about 18% of the Pu-239+Pu-240 (Pu-239/240) activity in the environment (Ibrahim, 1996). Given this activity ratio, the action level for Am-241 and Pu-239/240 can be computed so that the sum of their radiation doses equals either 15 or 85 millirem to the appropriate exposure scenario. Table 5-2 includes an example of these adjusted action levels for Am-241 and Pu-239/240 if they are the only radionuclides present in soil. Since the 18% ratio actually varies in the environment, site specific data will be used to make action level comparisons. If uranium is also present in the soil, then the contribution to the radiation dose from the uranium also needs to be assessed so that the Tier I and/or Tier II action level basis is not exceeded.

Chemical action levels are risk-based, and chemical risk is considered additive when multiple chemicals are present. Radionuclide action levels are dose-based, and radiation dose is considered additive when multiple radionuclides are present. Chemicals and radionuclides will be assessed independently on a project-specific basis using methodology that is protective of human health and the environment. The cumulative effects of chemicals and radionuclides will be assessed on a project- specific basis if the chemical risk and the radionuclide dose are near their respective Tier I action levels.

5.7 Action Level Uncertainties

The calculated values recommended as action levels are based on several assumptions which have associated limitations. These include:

1. The regulatory basis for developing these action levels is EPA's draft rule, 40CFR196, which is not yet final and may be changed before it is promulgated.

2. Any environmental computer model, including the RESRAD model, has inherent limitations with regard to precise simulation of the actual environment. Some of these limitations involve which input parameters are chosen to represent the complex natural setting which may vary across a large site. Environmental transfer factors and dose conversion factors used in the model may not always reflect site-specific conditions.

3. There are inherent uncertainties in estimating either dose or risk from ionizing radiation.

4. Institutional controls will eliminate the ground water ingestion pathway by establishing specific land uses and controls on ground water use. A basic assumption of RFCA is that ground water from contaminated areas of the site is captured, controlled and measured within the surface water system before leaving the site. An additional assumption is that the small amount of shallow ground water is not a sustainable, viable source of residential drinking water.

5. Attachment 5 of RFCA requires subsurface soil action levels to be protective of surface water standards via ground water, and surface soil action levels to be

protective of surface water standards via runoff. Existing data supports the proposition that radionuclides in soil are stable and relatively immobile. This is the basis for determining not to include these transport pathways in the modeling done to develop the proposed action levels. It is also assumed that actions required by the proposed action levels for radionuclides in soil (removals and/or stabilization) will provide sufficient protection for surface water. Those actions will control the worst areas of radiological contamination in soils, and so far, even these areas have not impacted surface water above the 0.15 pCi/L level at the point of compliance.

6. The proposal to set subsurface soil action levels equal to surface soil action levels assumes there will be no uncontrolled human exposure to subsurface soils and presumes that surface soil action levels will be protective of surface water via ground water. It is also assumed that the proposed surface soil action levels are lower than values that any subsurface soil modeling would produce.

This working group acknowledges that in the future, new regulations, different guidance, improved calculation methods and models and better input parameters will likely become available. As this new information becomes available it will be considered in accordance with paragraph 5 of RFCA.

TABLE 5-1
SINGLE RADIONUCLIDE SOIL ACTION LEVELS

Radionuclide	**TIER I ACTION LEVEL** **Open Space Exposure Scenario, Surficial Soils Exposure, 15 Millirem Dose Limit (pCi/gram)**	**TIER I ACTION LEVEL** **Office Worker Exposure Scenario, Surficial Soils Exposure, 15 Millirem Dose Limit (pCi/gram)**	**TIER I ACTION LEVEL** **Hypothetical Residential Exposure Scenario, Surficial Soils Exposure, 85 Millirem Dose Limit (pCi/gram)**	**TIER II ACTION LEVEL** **Hypothetical Residential Exposure Scenario, Surficial Soils Exposure, 15 Millirem Dose Limit (pCi/gram)**
Americium-241	1283	209	215	38
Plutonium-238	10580	1164	1529	270
Plutonium-239	9906	1088	1429	252
Plutonium-240	9919	1089	1432	253
Plutonium-241	48020	7801	19830	3499
Plutonium-242	10430	1145	1506	266
Uranium-234	11500	1627	1738	307
Uranium-235	1314	113	135	24
Uranium-238	5079	506	586	103

* The action levels in this table apply to single radionuclides only which does not exist at RFETS. See text for application of these action levels.

SECTION 6
REFERENCES

References

Argonne, 1993 - Manual for Implementing Residual Radioactive Material Guidelines Using RESRAD, Version 5.0, Environmental Assessment and Information Sciences Division, Argonne National Laboratory, ANL/EAD/LD-2, September 1993

DOE, 1980 - Final Environmental Impact Statement, Rocky Flats Plant Site, Golden, CO, US Department of Energy, DOE/EIS-0064, April 1980

DOE, 1995 - Phase II RFI/RI Report, 903 Pad, Mound and East Trenches Area, Operable Unit Number 2, Draft Final, US Department of Energy, May 1995

Ibrahim, 1996 - Comparative Distribution of Am-241 and Pu-239/240 in Soils Around the Rocky Flats Environmental Technology Site, Health Physics, Vol. 70, No. 4, April 1996

ICRP, 1977 - International Commission on Radiological Protection (ICRP), Recommendations of the ICRP, ICRP Publication 26, 1977

RFCA, 1996 - Rocky Flats Cleanup Agreement, Joint Agreement between the US Department of Energy, the US Environmental Protection Agency, the Colorado Department of Public Health and Environment and the State of Colorado, dated July 19, 1996

Appendix N

PROGRAMMATIC PRELIMINARY REMEDIATION GOALS TABLES

1.0 INTRODUCTION

DOE developed risk-based PPRGs in 1995 to establish initial site-wide cleanup targets for contaminants for each environmental medium. The PPRGs are currently used in RFCA Attachment 5, as action levels for the following mediums:

- Groundwater Action Levels: PPRGs based on residential groundwater ingestion scenario are used where no Maximum Contaminant Level (MCL) is available from EPA;

- Surface Soil Action Levels: For non-radionuclides, PPRGs are used as action levels for the appropriate land use, e.g., industrial used or open space use; and

- Subsurface Soil Action Levels: For non-radionuclide inorganics, PPRGs are used as action levels for the appropriate land use, e.g., industrial use or open space use.

PPRGs are reviewed and updated, as necessary, on an annual basis.

2.0 EXPOSURE PATHWAYS

In order to standardize the risk-based PPRGs across RFETS, programmatic exposure pathways and receptors were established. The following tables identify the receptors and exposure pathways selected for each environmental medium:

Table 1: Residential Groundwater Exposure Scenario
Table 2: Office Worker Soil Exposure Scenario
Table 3: Open Space Surface Water Exposure Scenario
Table 4: Open Space Surface Soil Exposure Scenario

Standard assumptions given in Risk Assessment Guidance for Superfund (RAGS), Part B (USEPA, 1991) were used in developing risk-based PPRG pathways where available. For situations not addressed by RAGS, Part B, standard assumptions given in RAGS, Part A (USEPA, 1989) were used. In addition, site-specific information was used where appropriate to supplement assumptions given in EPA guidance. Best professional judgement was applied when default values differed from site-specific information.

In addition to EPA and site-specific information, CDPHE guidance (*Interim Final Policy and Guidance on Risk Assessments for Corrective Action at RCRA Facilities)* was consulted for exposure pathways and parameters. While this guidance has not been finalized, it was reviewed and CDPHE was consulted on its use during development of the risk-based PPRG pathways.

3.0 METHODOLOGY, EQUATIONS, AND ASSUMPTIONS

Risk-based PPRGs were developed for all Target Analyte List metals, Target Compound List organics and 13 radionuclides for the residential groundwater exposure scenario; the office worker surface soil exposure scenario; the open space surface water exposure scenario; and the open space surface soil exposure scenario. Separate risk-based equations were developed to account for the carcinogenic, noncarcinogenic, and/or radiological effects of the contaminant. Risk-based PPRGs for carcinogens (including radionuclides) were calculated by setting the carcinogenic target risk level at 10-6. A target risk level of 10-6 means that an individual has a one-in-one million probability of developing cancer over a lifetime as a result of exposure to a specific contaminant. This risk is in addition to the probability of an individual developing cancer from some other factors such as those associated with heredity or lifestyle. Similarly, risk-based PPRGs for toxicants (noncarcinogens) were calculated by setting the hazard quotient equal to 1 for each contaminant. A hazard quotient is the ratio of a single substance exposure level of a chemical contaminant over a specified period to the reference dose for the chemical. The reference dose represents an estimate of an exposure level for the human population, including sensitive subpopulations that is likely to be without appreciable deleterious effects during a lifetime. For some of the contaminants, both a carcinogenic and noncarcinogenic toxicity information was available. For these contaminants, both a carcinogenic and noncarcinogenic risk-based concentration was calculated and the more restrictive value was selected as the risk-based PPRG. The risk-based equations for radiological effects were used to calculate the risk-based PPRGs for the 13 radionuclides.

The risk-based PPRG exposure scenarios and equations provided in Table 1 through 4 include all of the exposure pathways (e.g., direct ingestion of soils) identified for the exposure scenario; separate risk-based PPRGs were not calculated for each exposure pathway.

4.0 CHEMICAL TOXICITY INFORMATION

The chemical –specific toxicity values used for the calculation of the risk-based PPRGs are presented in Table 5. The toxicity information used to calculate the risk-based PPRGs included in the slope factor and unit risk for evaluating carcinogenic effects; the reference dose (RfD); and the reference concentration (RfC) for evaluating noncarcinogenic effects. Toxicity values were obtained from the latest information in EPA's Integrated Risk Information System (IRIS) files and the 1997 EPA Health Effects Assessment Summary Tables. Values for polycyclic aromatic hydrocarbons were calculated using EPA's Provisional Guidance for Quantitative Risk Assessment of Polycyclic Aromatic Hydrocarbons.

5.0 RFETS PPRGs

Table 6 is a summary of the PPRGs for each exposure scenario.

Table 1: Residential Exposure Scenario RFETS PPRGs

The **Residential Groundwater Exposure Scenario** consists of the following pathway: ingestion of groundwater (which includes radiation exposure while ingesting groundwater) for an adult resident living at the site for 30 years. This scenario includes only pathways that were evaluated in the Rocky Flats Cleanup Agreement (RFCA) to derive action levels.

Exposure Parameter	Variable	Unit	Value	Source
General Assumptions				
Target hazard index	THI	--	1	EPA, 1991a
Target excess lifetime cancer risk	TR	--	1E-06	EPA, 1991a
Adult body weight	BW	kg	70	EPA, 1991b
Residential Exposure Scenario Assumptions				
Averaging time - noncarcinogenic	AT_NC	yr	30	EPA, 1991b
Averaging time - carcinogenic	AT_C	yr	70	EPA, 1991b
Exposure frequency	EF	day/yr	350	EPA, 1991b
Exposure duration	ED	yr	30	EPA, 1991b
Daily water ingestion rate	IRw	L/day	2	EPA, 1991b
Toxicity Values				
Oral reference dose	RfDo	mg/kg-day	chemical-specific	--
Oral slope factor	SFo	$(mg/kg\text{-}day)^{-1}$	chemical-specific	--
Ingestion slope factor - radiological effects	SFo_{RAD}	risk/pCi	chemical-specific	--

Risk-Based PPRG

Residential Groundwater Exposure Scenario-Noncarcinogenic Effects
PPRG (mg/L) = (THI x BW x AT_NC x 365d/yr)/(EF x ED x IRw x 1/RfDo)

Residential Groundwater Exposure Scenario-Carcinogenic Effects
PPRG (mg/L) = (TR x BW x AT_C x 365d/yr)/(EF x ED x IRw x SFo)

Residential Groundwater Exposure Scenario-Radiological Effects
PPRG (pCi/L) = TR/(EF x ED x IRw x SFo_{RAD})

Notes:
-- Not applicable

Sources:

EPA, 1991a = U.S. Environmental Protection Agency. 1991. Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual, Part B, Development of Risk-Based Preliminary Remediation Goals. Interim. Office of Emergency and Remedial Response, Washington, D.C. Publication 9285.7-01B. December.

EPA, 1991b = U.S. Environmental Protection Agency. 1991. Human Health Evaluation Manual, Supplemental Guidance: Standard Default Exposure Factors. Office of Solid Waste and Emergency Response, Washington, D.C. OSWER Directive 9285.6-03. March 25.

Table 2: Office Worker Exposure Scenario RFETS PPRGs

The **Office Worker Surface Soil Exposure Scenario** consists of the following pathways: incidental ingestion of surface soil and indoor inhalation of surface soil particulates for an adult office worker at the site for 25 years. This scenario includes only pathways that were evaluated in the Rocky Flats Cleanup Agreement (RFCA) to derive action levels.

Exposure Parameter	Variable	Unit	Value	Source
General Assumptions				
Target hazard index	THI	--	1	EPA, 1991a
Target excess lifetime cancer risk	TR	--	1E-06	EPA, 1991a
Adult body weight	BW	kg	70	EPA, 1991b
Office Worker Exposure Scenario Assumptions				
Averaging time - noncarcinogenic	AT_NC	yr	25	EPA, 1991b
Averaging time - carcinogenic	AT_C	yr	70	EPA, 1991b
Exposure frequency	EF	day/yr	250	EPA, 1991b
Exposure duration	ED	yr	25	EPA, 1991b
Daily indoor inhalation rate	IRa	m^3/day	8.8	ICRP 66, 1993
Particulate Emission Factor	PEF	m^3/kg	1.32E+09	EPA, 1996
Soil ingestion rate	IRs	mg/day	50	EPA, 1991b
Gamma shielding factor	Se	--	0.2	EPA, 1991a
Gamma exposure factor (annual) = (EF / 365 day/yr) [a]	Te_A	--	6.85E-01	EPA, 1991a
Gamma exposure factor (daily) = (8 hr/day / 24 hr/day)	Te_D	--	3.33E-01	EPA, 1991a
Toxicity Values				
Oral reference dose	RfDo	mg/kg-day	chemical-specific	--
Oral slope factor	SFo	$(mg/kg\text{-}day)^{-1}$	chemical-specific	--
Ingestion slope factor - radiological effects	SFo_{RAD}	risk/pCi	chemical-specific	--
Inhalation reference dose	RfDi	mg/kg-day	chemical-specific	--
Inhalation slope factor	SFi	$(mg/kg\text{-}day)^{-1}$	chemical-specific	--
Inhalation slope factor - radiological effects	SFi_{RAD}	risk/pCi	chemical-specific	--
External exposure slope factor	SFe	(risk/yr per pCi/g)	chemical-specific	--

Risk-Based PPRG

Office Worker Surface Soil Exposure Scenario-Noncarcinogenic Effects

PPRG (mg/kg) = (THI x BW x AT_NC x 365d/yr)/(EF x ED x ((1/PEF x IRa x 1/RfDi)
+ (1E-06 kg/mg x IRs x 1/RfDo)))

Office Worker Surface Soil Exposure Scenario-Carcinogenic Effects

PPRG (mg/kg) = (TR x BW x AT_C x 365d/yr)/(EF x ED x ((1/PEF x IRa x SFi) + (1E-06 kg/mg x IRs x SFo)))

Office Worker Surface Soil Exposure Scenario-Radiological Effects

PPRG (pCi/g) = TR / [ED x ((EF x 1/PEF x 10^3 g/kg x IRa x SFi_{RAD}) + (EF x 1E-03 g/mg x IRs x SFo_{RAD}) + (SFe x (1-Se) x (Te_A x Te_D)))]

Notes:

-- Not applicable

[a] Extrapolated to calculate annual exposure.

Sources:

EPA, 1991a = U.S. Environmental Protection Agency. 1991. Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual, Part B, Development of Risk-Based Preliminary Remediation Goals. Interim. Office of Emergency and Remedial Response, Washington, D.C. Publication 9285.7-01B. December.

EPA, 1991b = U.S. Environmental Protection Agency. 1991. Human Health Evaluation Manual, Supplemental Guidance: Standard Default Exposure Factors. Office of Solid Waste and Emergency Response, Washington, D.C. OSWER Directive 9285.6-03. March 25.

EPA, 1996 = U.S. Environmental Protection Agency. 1996. Soil Screening Guidance: Technical Background Document. Office of Emergency and Remedial Response, Washington, D.C. EPA/540/R-95/128. May.

ICRP 66, 1993 = International Commission on Radiological Protection (ICRP). 1993. Human Respiratory Tract Model for Radiological Protection. ICRP Publication 66. September.

Table 3: Open Space Surface Water Exposure Scenario RFETS PPRGs

The **Open Space Surface Water Exposure Scenario** consists of the following pathway: incidental ingestion of surface water for an open space visitor who recreates at the site for 30 years. The open space receptor visits the site 100 times per year. This scenario includes only pathways that were evaluated in the Rocky Flats Cleanup Agreement (RFCA) to derive action levels.

Exposure Parameter	Variable	Unit	Value	Source
General Assumptions				
Target hazard index	THI	--	1	EPA, 1991a
Target excess lifetime cancer risk	TR	--	1E-06	EPA, 1991a
Adult body weight	BW	kg	70	EPA, 1991b
Open Space Exposure Scenario Assumptions				
Averaging time - noncarcinogenic	AT_NC	yr	30	EPA, 1991b
Averaging time - carcinogenic	AT_C	yr	70	EPA, 1991b
Contact rate	CR	L/hr	0.05	(1)
Exposure time	ET	hr/day	1	(2)
Exposure frequency	EF	day/yr	100	JeffCo, 1996
Exposure duration	ED	yr	30	EPA, 1991b
Toxicity Values				
Oral reference dose	RfDo	mg/kg-day	chemical-specific	--
Oral slope factor	SFo	$(mg/kg\text{-}day)^{-1}$	chemical-specific	--
Ingestion slope factor - radiological effects	SFo_{RAD}	risk/pCi	chemical-specific	--

Risk-Based PPRG

Open Space Surface Water Exposure Scenario-Noncarcinogenic

PPRG(mg/L) = {THI x BW x AT_NC x 365 d/yr} / {CR x ET x EF x ED x 1/RfDo}

Open Space Surface Water Exposure Scenario-Carcinogenic

PPRG(mg/L) = {TR x BW x AT_C x 365 d/yr} / {CR x ET x EF x ED x SFo}

Open Space Surface Water Exposure Scenario-Radiological Effects

PPRG(pCi/L) = {TR} / {CR x ET x EF x ED x SFo_{RAD}}

Sources:

(1) Ingestion Rate based upon open-space recreational user wading at Denver's Lowry Landfill Superfund Site (50 mL/day, RME; 25 mL/day, CT). For comparison, a single value of 35 mL/day is specified for DOE's Fernald Site (wading in shallow Paddy's Run).

(2) Exposure Time based upon DOE's Fernald Site recreational use (0.5 hr/day, CT) and on the Clear Creek/Central City Superfund Site recreational user (1.0 hr/day, RME, assuming that wading time would be the same as swimming time).

EPA, 1991a = U.S. Environmental Protection Agency. 1991. Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual, Part B, Development of Risk-Based Preliminary Remediation Goals. Interim. Office of Emergency and Remedial Response, Washington, D.C. Publication 9285.7-01B. December.
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Jeffco, 1996 = Jefferson County Parks and Open Space Study, Jefferson County, CO. 1996.

Table 4: Open Space Surface Soil Exposure Scenario RFETS PPRGs

The **Open Space Surface Soil Exposure Scenario** consists of the following pathways: inhalation of surface soil particulates and incidental ingestion of surface soil for an open space visitor who recreates at the site for 30 years including six years as a child. The open space receptor visits the site 100 times per year. This scenario includes only pathways that were evaluated in the Rocky Flats Cleanup Agreement (RFCA) to derive action levels.

Exposure Parameter	Variable	Unit	Value	Source
General Assumptions				
Target hazard index	THI	--	1	EPA, 1991a
Target excess lifetime cancer risk	TR	--	1E-06	EPA, 1991a
Adult body weight	BW	kg	70	EPA, 1991b
Child body weight	BWc	kg	15	EPA, 1991b
Open Space Exposure Scenario Assumptions				
Averaging time - noncarcinogenic	AT_NC	yr	30	EPA, 1991b
Averaging time - carcinogenic	AT_C	yr	70	EPA, 1991b
Exposure time	ET	hr/day	2.5	JeffCo, 1996
Exposure frequency	EF	day/yr	100	JeffCo, 1996
Exposure duration (adult and child, combined)	ED	yr	30	EPA, 1991b
Exposure duration (adult)	EDa	yr	24	EPA, 1991b
Exposure duration (child)	EDc	yr	6	EPA, 1991b
Inhalation rate	IRa_h	m^3/hr	1.7	EPA, 1997; JeffCo, 1996
Inhalation rate = [IRa_h x ET]	IRa	m^3/day	4.25	Calculated
Particulate Emission Factor	PEF	m^3/kg	1.32E+09	EPA, 1996
Soil ingestion rate (adult)	IRs_a	mg/day	50	EPA, 1995
Soil ingestion rate (child)	IRs_c	mg/day	100	(1)
Age-adjusted soil ingestion factor = [(IRs_a x EDa) / BW] + [(IRs_c x EDc) / BWc]	IFs	mg-yr/kg-day	57	EPA, 1991a
Age-adjusted soil ingestion factor - radiation = (IRs_a x EDa) + (IRs_c x EDc)	IFs_RAD	mg-yr/day	1,800	EPA, 1991a
Gamma shielding factor	Se	--	0	EPA, 1991a
Gamma exposure factor (annual) = (EF / 365 day/yr) [a]	Te_A	--	2.74E-01	EPA, 1991a; JeffCo, 1996
Gamma exposure factor (daily) = (ET / 24 hr/day)	Te_D	--	1.04E-01	EPA, 1991a; JeffCo, 1996
Toxicity Values				
Oral reference dose	RfDo	mg/kg-day	chemical-specific	--
Oral slope factor	SFo	$(mg/kg\text{-}day)^{-1}$	chemical-specific	--
Ingestion slope factor - radiological effects	SFo_{RAD}	risk/pCi	chemical-specific	--
Inhalation reference dose	RfDi	mg/kg-day	chemical-specific	--
Inhalation slope factor	SFi	$(mg/kg\text{-}day)^{-1}$	chemical-specific	--

Table 4: Open Space Surface Soil Exposure Scenario RFETS PPRGs

Inhalation slope factor - radiological effects	SFi_{RAD}	risk/pCi	chemical-specific	--
External exposure slope factor	SFe	(risk/yr per pCi/g)	chemical-specific	--

Risk-Based PPRG

Open Space Surface Soil Exposure Scenario-Noncarcinogenic Effects

PPRG (mg/kg) = {THI x AT_NC x 365 d/yr} / {EF x {(IRa x ED x 1/RfDi x 1/BW x 1/PEF) + (1/RfDo x 1E-06 kg/mg x IFs)]}

Open Space Surface Soil Exposure Scenario-Carcinogenic Effects

PPRG (mg/kg) = {(TR x AT_C x 365d/yr)} / EF x {(SFi x IRa x ED x 1/BW x 1/PEF) + (1E-06 kg/mg x IFs x SFo)}

Open Space Surface Soil Exposure Scenario-Radiological Effects

PPRG (pCi/g) = TR / [(ED x EF x IRa x SFi_{RAD} x 10^3 g/kg x 1/PEF) + (EF x SFo_{RAD} x 1E-03 g/mg x IFs_{RAD}) + (ED x SFe x (1-Se) x (Te_A x Te_D))]

Notes:
[a] Extrapolated to calculate annual exposure.
Sources:
(1) Based on the assumption that outdoor ingestion of soil accounts for one-half the daily residential intake (200 mg/day for children, as cited in EPA (1991b)).

EPA, 1991a = U.S. Environmental Protection Agency. 1991. Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual, Part B, Development of Risk-Based Preliminary Remediation Goals. Interim. Office of Emergency and Remedial Response, Washington, D.C. Publication 9285.7-01B. December.
EPA, 1991b = U.S. Environmental Protection Agency. 1991. Human Health Evaluation Manual, Supplemental Guidance: Standard Default Exposure Factors. Office of Solid Waste and Emergency Response, Washington, D.C. OSWER Directive 9285.6-03. March 25.
EPA, 1995 = U.S. Environmental Protection Agency. Baseline Human Health Risk Assessment for the California Gulch Superfund Site. Part C. Screening-level Soil Concentrations for Workers and Recreational Site Visitors Exposed to Lead and Arsenic. February. Prepared for EPA Region VIII, Denver, CO. by Roy F. Weston, Inc.
EPA, 1996 = U.S. Environmental Protection. 1996. Soil Screening Guidance: Technical Background Document. Office of Emergency and Remedial Response, Washington, D.C. EPA/540/R-95/128. May.
EPA, 1997 = U.S. Environmental Protection Agency. 1997. Exposure Factors Handbook. Office of Research and Development, Washington, D.C. EPA/600/P-95/002Fa. August.
JeffCo, 1996 = Jefferson County Parks and Open Space Study. Jefferson County, CO. 1996.

Table 5: Toxicity Values Used for the RFETS PPRGs

Target Analyte List Chemical		CAS Number	Oral RfD (mg/kg-day)	Oral/Ingestion Slope Factor (mg/kg-day)-1	Inhal RfC (mg/m3)	Inhalation Unit Risk (m3/µg)	Inhalation RfD (mg/kg-day)	Inhalation Slope Factor (mg/kg-day)-1	External Slope Factor (risk/yr pCi/g)
Acenaphthene	(V)	83-32-9	6.00E-02						
Acenaphthylene	(V)	208-96-8							
Acetone	(V)	67-64-1	1.00E-01						
Aldrin		309-00-2	3.00E-05	1.70E+01		4.90E-03		1.70E+01 b	
Aluminum		7429-90-5	1.00E+00 y		5.00E-03 y		1.00E-03 y		
Anthracene	(V)	120-12-7	3.00E-01						
Antimony		7440-36-0	4.00E-04						
Aroclor 1016		12674-11-2	7.00E-05	2.00E+00 c,q		5.70E-04 c,q		2.00E+00 c,q	
Aroclor 1221		11104-28-2		2.00E+00 c,q		5.70E-04 c,q		2.00E+00 c,q	
Aroclor 1232		11141-16-5		2.00E+00 c,q		5.70E-04 c,q		2.00E+00 c,q	
Aroclor 1242		53469-21-9		2.00E+00 c,q		5.70E-04 c,q		2.00E+00 c,q	
Aroclor 1248		12672-29-6		2.00E+00 c,q		5.70E-04 c,q		2.00E+00 c,q	
Aroclor 1254		11097-69-1	2.00E-05	2.00E+00 c,q		5.70E-04 c,q		2.00E+00 c,q	
Aroclor 1260		11096-82-5		2.00E+00 c,q		5.70E-04 c,q		2.00E+00 c,q	
Arsenic		7440-38-2	3.00E-04	1.50E+00 i		4.30E-03		1.51E+01	
Barium		7440-39-3	7.00E-02		5.00E-04 b		1.43E-04 b		
Benzene	(V)	71-43-2	3.00E-03 y	2.90E-02	6.00E-03 y	7.80E-06 dd		2.73-02	
alpha-BHC		319-84-6		6.30E+00		1.80E-03		6.30E+00 b	
beta-BHC		319-85-7		1.80E+00		5.30E-04		1.80E+00 b	
delta-BHC		319-86-8							
gamma-BHC (Lindane)		58-89-9	3.00E-04	1.30E+00 b					
Benzo(a)anthracene		56-55-3		7.30E-01 k		8.80E-02 y		3.10E-01 y	
Benzo(a)pyrene		50-32-8		7.30E+00		8.80E-01 y		3.10E+00 y	
Benzo(b)fluoranthene		205-99-2		7.30E-01 k		8.80E-02 y		3.10E-00 y	
Benzo(g,h,i)perylene		191-24-2							
Benzo(k)fluoranthene		207-08-9		7.30E-02 k		8.80E-03 y		3.10E-02 y	
Benzoic Acid		65-85-0	4.00E+00						
Benzyl Alcohol		100-51-6	3.00E-01 b						
Beryllium		7440-41-7	2.00E-03	4.30E+00 w	2.00E-05	2.40E-03	5.71E-06	8.40E+00 b	
bis(2-chloroethoxy)methane	(V)	111-91-1							
bis(2-chloroethyl)ether	(V)	111-44-4		1.10E+00		3.30E-04		1.10E+00 b	
bis(2-chloroisopropyl)ether	(V)	39638-32-9	4.00E-02	7.00E-02 b,u		1.00E-05 b,u		3.50E-02 b,u	
bis(2-ethylhexyl)phthalate		117-81-7	2.00E-02	1.40E-02				1.40E-02 y	
Bromodichloromethane	(V)	75-27-4	2.00E-02	6.20E-02					
Bromoform	(V)	75-25-2	2.00E-02	7.9E-03		1.10E-06		3.90E-03	
Bromomethane	(V)	74-83-9	1.40E-03		5.00E-03		1.43E-03		
4-Bromophenyl phenyl ether		101-55-3							
2-Butanone	(V)	78-93-3	6.00E-01		1.00E+00		2.86E-01		
Butylbenzylphthalate		85-68-7	2.00E-01						
Cadmium (water)		7440-43-9	5.00E-04 r			1.80E-03		6.30E+00	
Cadmium (food)		7440-43-9	1.00E-03 r		3.00E-04 ee	1.80E-03	8.60E-05 ee	6.30E+00	
Calcium		7440-70-2							

Table 5: Toxicity Values Used for the RFETS PPRGs

Target Analyte List Chemical		CAS Number	Oral RfD (mg/kg-day)	Oral/Ingestion Slope Factor (mg/kg-day)-1	Inhal RfC (mg/m3)	Inhalation Unit Risk (m3/µg)	Inhalation RfD (mg/kg-day)	Inhalation Slope Factor (mg/kg-day)-1	External Slope Factor (risk/yr per pCi/g)
Carbon disulfide	(V)	75-15-0	1.00E-01		7.00E-01		2.00E-01		
Carbon tetrachloride	(V)	56-23-5	7.00E-04	1.30E-01	2.00E-03 y	1.05E-05	5.71E-04 y	5.30E-02 b	
Cesium		7440-46-2							
alpha-Chlordane		5103-71-9	5.00E-04 d	3.50E-01 d	7.00E-04 d	1.00E-04 d	2.00E-04 d	3.50E-01 d	
beta-Chlordane		5103-74-2	5.00E-04 d	3.50E-01 d	7.00E-04 d	1.00E-04 d	2.00E-04 d	3.50E-01 d	
gamma-Chlordane		12789-03-6	5.00E-04	3.50E-01	7.00E-04	1.00E-04	2.00E-04	3.50E-01	
4-Chloroaniline		106-47-8	4.00E-03						
Chlorobenzene	(V)	108-90-7	2.00E-02		2.00E-02 b		5.71E-03 b		
Chloroethane	(V)	75-00-3	4.00E-01 y	2.90E-03 y	1.00E+01		2.86E+00		
Chloroform	(V)	67-66-3	1.00E-02	6.10E-03	3.00E-04 y	2.30E-05		8.05E-02	
Chloromethane	(V)	74-87-3		1.30E-02 b		1.80E-06 b		6.30E-03 b	
4-Chloro-3-methylphenol		59-50-7							
2-Chloronaphthalene	(V)	91-58-7	8.00E-02						
2-Chlorophenol	(V)	95-57-8	5.00E-03						
4-Chlorophenyl phenyl ether		7005-72-3							
Chromium III		16065-83-1	1.50E+00				5.71E-07 w,y		
Chromium VI		18540-29-9	3.00E-03		1.00E-04 ff	1.20E-02		4.20E+01	
Chrysene		218-01-9		7.30E-03 k		8.80E-04 y		3.10E-03 y	
Cobalt		7440-48-4	6.00E-02 y,bb						
Copper		7440-50-8	3.70E-02 w,o						
Cyanide		57-12-5	2.00E-02						
4,4-DDD		72-54-8		2.40E-01					
4,4-DDE		72-55-9		3.40E-01					
4,4-DDT		50-29-3	5.00E-04	3.40E-01		9.70E-05		3.40E-01	
Dibenz(a,h)anthracene		53-70-3		7.30E+00 k		8.80E-01 y		3.10E+00 y	
Dibenzofuran		132-64-9	4.00E-03 y						
Dibromochloromethane		124-48-1	2.00E-02	8.40E-02					
Di-n-butylphthalate		84-74-2	1.00E-01						
1,2-Dichlorobenzene	(V)	95-50-1	9.00E-02		2.00E-01 b		5.70E-02		
1,3-Dichlorobenzene	(V)	541-73-1	9.00E-04 y						
1,4-Dichlorobenzene	(V)	106-46-7	3.00E-02 y,cc	2.40E-02 b	8.00E-01		2.30E-01		
3,3-Dichlorobenzidine		91-94-1		4.50E-01					
1,1-Dichloroethane	(V)	75-34-3	1.00E-01 b		5.00E-01 b		1.43E-01		
1,2-Dichloroethane	(V)	107-06-2	3.00E-02 y	9.10E-02	5.00E-03 y	2.60E-05	1.40E-03 y	9.10E-02	
1,1-Dichloroethene	(V)	75-35-4	9.00E-03	6.00E-01		5.00E-05		1.75E-01	
1,2-Dichloroethene (total)	(V)	540-59-0	9.00E-03 b						
2,4-Dichlorophenol		120-83-2	3.00E-03						
1,2-Dichloropropane	(V)	78-87-5		6.80E-02 b	4.00E-03		1.14E-03		
cis-1,3-Dichloropropene	(V)	10061-01-5	3.00E-04 e	1.80E-01 b,e	2.00E-02 e	3.70E-05 b,e	5.71E-03 e	1.30E-01 b,e	
trans-1,3-Dichloropropene	(V)	10061-02-6	3.00E-04 e	1.80E-01 b,e	2.00E-02 e	3.70E-05 b,e	5.71E-03 e	1.30E-01 b,e	
Dieldrin		60-57-1	5.00E-05	1.60E+01		4.60E-03		1.60E+01	
Diethylphthalate		84-66-2	8.00E-01						

Table 5: Toxicity Values Used for the RFETS PPRGs

Target Analyte List Chemical		CAS Number	Oral RfD (mg/kg-day)	Oral/Ingestion Slope Factor (mg/kg-day)-1	Inhal RfC (mg/m3)	Inhalation Unit Risk (m3/µg)	Inhalation RfD (mg/kg-day)	Inhalation Slope Factor (mg/kg-day)-1	External Slope Factor (risk/yr per pCi/g)
2,4-Dimethylphenol	(v)	105-67-9	2.00E-02						
Dimethylphthalate		131-11-3	1.00E+01 w,y						
4,6-Dinitro-2-methylphenol	(V)	534-52-1	1.00E-04 y						
2,4-Dinitrophenol		51-28-5	2.00E-03						
2,4-Dinitrotoluene		121-14-2	2.00E-03	6.80E-01					
2,6-Dinitrotoluene		606-20-2	1.00E-03 b	6.80E-01					
Di-n-octylphthalate		117-84-0	2.00E-02 b	1.40E-02		4.00E-06 y			
Endosulfan I		959-98-8	6.00E-03 z						
Endosulfan II		33213-65-9	6.00E-03 z						
Endosulfan sulfate		1031-07-8	6.00E-03 z						
Endosulfan (technical)		115-29-7	6.00E-03						
Endrin ketone		53494-70-5							
Endrin (technical)		72-20-8	3.00E-04						
Ethylbenzene	(V)	100-41-4	1.00E-01		1.00E+00		2.86E-01		
Fluoranthene		206-44-0	4.00E-02						
Fluorene	(V)	86-73-7	4.00E-02						
Heptachlor		76-44-8	5.00E-04	4.50E+00		1.30E-03		4.50E+00	
Heptachlor epoxide		1024-57-3	1.30E-05	9.10E+00		2.60E-03		9.10E+00	
Hexachlorobenzene		118-74-1	8.00E-04	1.60E+00		4.60E-04		1.60E+00	
Hexachlorobutadiene		87-68-3	2.00E-04 b	7.80E-02		2.20E-05		7.70E-02	
Hexachlorocyclopentadiene		77-47-4	7.00E-03		7.00E-05 b		2.00E-05 b		
Hexachloroethane		67-72-1	1.00E-03	1.40E-02		4.00E-06		1.40E-02	
2-Hexanone	(V)	591-78-6							
Indeno(1,2,3-cd)pyrene		193-39-5		7.30E-01 k		8.80E-02 y		3.10E-01 y	
Iron		7439-89-6	3.00E-01 y						
Isophorone		78-59-1	2.00E-01	9.50E-04					
Lead		7439-92-1							
Lithium		7439-93-2	2.00E-02 w,y						
Magnesium		7439-95-4							
Manganese		7439-96-5	4.70E-02 s		5.00E-05		1.43E-05		
Mercury (elemental)		7439-97-6	gg		3.00E-04 b		8.60E-05 j		
Mercuric chloride			3.00E-04 gg						
Methoxychlor		72-43-5	5.00E-03						
Methylene chloride	(V)	75-09-2	6.00E-02	7.50E-03	3.00E+00 b	4.70E-07	8.57E-01	1.65E-03	
2-Methylnaphthalene	(V)	91-57-6	2.00E-02 y,aa						
4-Methyl-2-pentanone	(V)	108-10-1	8.00E-02 b		8.00E-02 b		2.29E-02		
2-Methylphenol		95-48-7	5.00E-02						
4-Methylphenol		106-44-5	5.00E-03 b						
Molybdenum		7439-98-7	5.00E-03						
Naphthalene	(V)	91-20-3	2.00E-02		3.00E-03				
Nickel (soluble)		7440-02-0	2.00E-02						
2-Nitroaniline		88-74-4	6.00E-05 w,y		2.00E-04		5.71E-05		

Table 5: Toxicity Values Used for the RFETS PPRGs

Target Analyte List Chemical		CAS Number	Oral RfD (mg/kg-day)	Oral/Ingestion Slope Factor (mg/kg-day)-1	Inhal RfC (mg/m3)	Inhalation Unit Risk (m3/µg)	Inhalation RfD (mg/kg-day)	Inhalation Slope Factor (mg/kg-day)-1	External Slope Factor (risk/yr per pCi/g)
3-Nitroaniline		99-09-2							
4-Nitroaniline		100-01-6							
Nitrobenzene	(V)	98-95-3	5.00E-04		2.00E-03 b		5.70E-04 j		
2-Nitrophenol		88-75-5							
4-Nitrophenol	(V)	100-02-7	8.00E-03 y						
n-Nitrosodiphenylamine	(V)	86-30-6		4.90E-03					
n-Nitrosodipropylamine		621-64-7		7.00E+00					
Pentachlorophenol		87-86-5	3.00E-02	1.20E-01					
Phenanthrene	(V)	85-01-8							
Phenol		108-95-2	6.00E-01						
Potassium		7440-09-7							
Pyrene		129-00-0	3.00E-02						
Selenium		7782-49-2	5.00E-03						
Silver		7440-22-4	5.00E-03						
Sodium		7440-23-5							
Strontium		7440-24-6	6.00E-01						
Stryene	(V)	100-42-5	2.00E-01		1.00E+00		2.86E-01		
1,1,2,2-Tetrachloroethane	(V)	79-34-5	6.00E-02 y	2.00E-01		5.80E-05		2.00E-01 b	
Tetrachloroethene	(V)	127-18-4	1.00E-02	5.20E-02 y	6.00E-01 y	5.80E-07 y		2.03E-03 l	
Thallium		7440-28-0							
Tin		7440-31-5	6.00E-01 b						
Toluene	(V)	108-88-3	2.00E-01		4.00E-01		1.14E-01		
Toxaphene		8001-35-2		1.10E+00		3.20E-04		1.10E+00	
1,2,4-Trichlorobenzene	(V)	120-82-1	1.00E-02		2.00E-01 b		5.71E-02 j		
1,1,1-Trichloroethane	(V)	71-55-6	2.80E-01 y		2.20E+00 y		2.86E-01 w,y		
1,1,2-Trichloroethane	(V)	79-00-5	4.00E-03	5.70E-02		1.60E-05		5.60E-02	
Trichloroethene	(V)	79-01-6	6.00E-03 y	1.10E-02 w		1.70E-06 l		6.00E-03 l	
2,4,5-Trichlorophenol		95-95-4	1.00E-01						
2,4,6-Trichlorophenol		88-06-2		1.10E-02		3.10E-06		1.00E-02	
Vanadium		7440-62-2	7.00E-03 b						
Vinyl acetate		108-05-4	1.00E+00 b		2.00E-01		5.71E-02		
Vinyl chloride	(V)	75-01-4		1.90E+00 b		8.40E-05 b		3.00E-01	
Xylene (total)	(V)	1330-20-7	2.00E+00						
Zinc		7440-66-6	3.00E-01						
Nitrate		14797-55-8	1.60E+00						
Nitrite		14797-65-0	1.00E-01						
Sulfide		18496-25-8							
Ammonium (as Ammonia)		7664-41-7	9.70E-01 x		1.00E-01		2.86E-02		
Bicarbonate		71-52-3							
Bromide		24959-67-9							

Table 5: Toxicity Values Used for the RFETS PPRGs

Target Analyte List Chemical	CAS Number	Oral RfD (mg/kg-day)	Oral/Ingestion Slope Factor (mg/kg-day)-1	Inhal RfC (mg/m3)	Inhalation Unit Risk (m3/μg)	Inhalation RFD (mg/kg-day)	Inhalation Slope Factor (mg/kg-day)-1	External Slope Factor (risk/yr per pCi/g)
Carbonate	3812-32-6							
Chloride	16887-00-6							
Fluoride (as fluorine)	7782-41-4	6.00E-02						
Orthophosphate	14265-44-2							
Silica (as Si and SiO_2)	7631-86-9							
Sulfate	14808-79-8							
[illegible]	[illegible]		(Risk/pCi)				(Risk/pCi)	(Risk/pCi)
Am-241	14596-10-2		3.28E-10 b				3.85E-08 b	4.59E-09 b
Cs-137+D	10045-97-3(+D)		3.16E-11 b				1.91E-11 b	2.09E-06 b
Pu-239	15117-48-3		3.16E-10 b				2.78E-08 b	1.26E-11 b
Pu-240	14119-33-6		3.15E-10 b				2.78E-08 b	1.87E-11 b
Ra-226+D	13982-63-3(+D)		2.96E-10 b				2.75E-09 b	6.74E-06 b
Ra-228+D	15262-20-1(+D)		2.48E-10 b				9.94E-10 b	3.28E-06 b
Sr-89	14158-27-1		1.03E-11 b				3.68E-12 b	5.38E-10 b
Sr-90+D	10098-97-2(+D)		5.59E-11 b				6.93E-11 b	0.00E+00 b
Tritium	10028-17-8		7.15E-14 b				9.59E-14 b	0.00E+00 b
U-233	13968-55-3		4.48E-11 b				1.41E-08 b	3.52E-11 b
U-234	13966-29-5		4.44E-11 b				1.40E-08 b	2.14E-11 b
U-235+D	15117-96-1(+D)		4.70E-11 b				1.30E-08 b	2.65E-07 b
U-238+D	7440-61-1(+D)		6.20E-11 b				1.24E-08 b	6.57E-08 b

Notes:
(V) = *Chemicals listed are volatile.*
a = All toxicity values and notes are from IRIS, 1999 unless otherwise noted. Several inhalation slope factors have been derived by multiplying the inhalation unit risk from IRIS by a conversion factor of 3500: [SFi = (Inh Unit Risk x 70kg x 1,000 ug/mg) / 20 m^3/d].

Several inhalation reference doses have been derived by multiplying the inhalation reference concentration by a conversion factor of 0.2857: [RfDi = (RfCi x 20 m^3/d) / 70 kg].

Several oral slope factors have been derived by multiplying the drinking water unit risk by a conversion factor of 35,000: [SFo = (DW Unit Risk x 70 kg x 1,000 ug/mg) / 2 L/day].

b = Value from HEAST, 1997.

c = Values given are for PCBs.

d = Values given are for chlordane (CAS no. 12789-03-6).

e = Values given are for 1,3-dichloropropene.

i = Value given for arsenic is calculated from an oral unit risk of 5E-05 (L/μg).

j = Values given for chemicals were calculated from HEAST, 1997.

k = Values given for PAHs were found in EPA, 1993.

l = Value given is from an EPA memo from the Office of Research and Development, National Center for Environmental Assessment (NCEA).

o = *Value based on the copper drinking water standard of 1.3 mg/L.*

q = The upper-bound slope factor for high risk and persistence is recommended by EPA for the oral slope factor of PCB environmental mixtures.

r = Dual oral RfDs available for cadmium. 5E-04 is representative of pathways involving water and 1E-03 is representative of pathways involving food (soil).

s = According to IRIS, 1998, the oral RfD of 0.14 represents total oral intake of manganese. It is recommended that a modifying factor of three be applied (resulting oral RfD = 0.047) if oral RfD is used for assessments involving nondietary exposures (ingesting soil or drinking water).

u = Values given for 70 percent bis(2-chloro-1-methyl ethyl) ether and 30 percent bis(2-chloroisopropyl) ether.

w = Value given has been withdrawn by EPA; greater uncertainty is associated with this toxicity value than values listed in IRIS and HEAST.

x = Ammonia oral RfD specifically related to organoleptic threshold.

y = NCEA (as referenced in EPA, 1997).

z = Values given for Endosulfan (technical).

aa = Value is for naphthalene. NCEA, 1999 recommends using the RfD for naphthalene as a surrogate for its methylated derivative, 2-methylnaphthalene until additional studies are available.

bb = Value is upper range of average intake for children, recommended by NCEA, 1999 in lieu of an oral RfD, given the relatively well characterized intake of cobalt in food.

cc = Value given is the higher of two possible provisional RfDs provided by NCEA. Higher value was chosen for more conservatism.

dd = Value given is the high end of the range provided of acceptable URFs. This value was chosen for more conservatism.

ee = Value given is Region VIII EPA RfC for cadmium.

ff = Value given is IRIS RfC for chromium VI in particulates, the likely form in RFETS soils.

gg = Elemental mercury and ionic mercury have been separated to reflect reporting in IRIS.

References:

EPA, 1993 = U.S. Environmental Protection Agency. 1993. Research and Development-Provisional Guidance for Quantitative Risk Assessment of Polycyclic Aromatic Hydrocarbons. Prepared for the Office of Health and Environmental Assessment by the Environmental Criteria and Assessment Office, Office of Health and Environmental Assessment, Cincinnati, OH. Final Draft. ECAO-CIN-842. March.

EPA, 1997 = U.S. Environmental Protection Agency. 1997. Region III Risk-Based Concentration Table. Philadelphia, PA. October 22.

HEAST, 1997 = U.S. Environmental Protection Agency. 1997. Health Effects Assessment Summary Tables, FY-1997 Annual. Office of Solid Waste and Emergency Response, Washington, D.C. EPA/540/R-97/036. July.

IRIS, 1998 = U.S. Environmental Protection Agency. 1998. Integrated Risk Information System. On-line database. Office of Research and Development, Cincinnati, OH. April.

Target Analyte List Chemical		CAS Number	Residential Groundwater (mg/L or pCi/L)	Office Worker Soil (mg/kg or pCi/g)	Open Space Surface Water (mg/L or pCi/L)	Open Space Soil (mg/kg or pCi/g)
Acenaphthene	(V)	83-32-9	2.19E+00	1.23E+05	3.07E+02	1.15E+05
Acenaphthylene	(V)	208-96-8	-	-	-	-
Acetone	(V)	67-64-1	3.65E+00	2.04E+05	5.11E+02	1.92E+05
Aldrin		309-00-2	5.01E-06	3.37E-01	7.01E-04	2.64E-01
Aluminum		7429-90-5	3.65E+01	>1E+06	5.11E+03	>1E+06
Anthracene	(V)	120-12-7	1.10E+01	6.13E+05	1.53E+03	5.76E+05
Antimony		7440-36-0	1.46E-02	8.18E+02	2.04E+00	7.68E+02
Aroclor 1016		12674-11-2	4.26E-05	2.86E+00	5.96E-03	2.24E+00
Aroclor 1221		11104-28-2	4.26E-05	2.86E+00	5.96E-03	2.24E+00
Aroclor 1232		11141-16-5	4.26E-05	2.86E+00	5.96E-03	2.24E+00
Aroclor 1242		53469-21-9	4.26E-05	2.86E+00	5.96E-03	2.24E+00
Aroclor 1248		12672-29-6	4.26E-05	2.86E+00	5.96E-03	2.24E+00
Aroclor 1254		11097-69-1	4.26E-05	2.86E+00	5.96E-03	2.24E+00
Aroclor 1260		11096-82-5	4.26E-05	2.86E+00	5.96E-03	2.24E+00
Arsenic		7440-38-2	5.68E-05	3.81E+00	7.95E-03	2.99E+00
Barium		7440-39-3	2.56E+00	1.34E+05	3.58E+02	1.33E+05
Benzene	(V)	71-43-2	2.94E-03	1.97E+02	4.11E-01	1.55E+02
alpha-BHC		319-84-6	1.35E-05	9.08E-01	1.89E-03	7.11E-01
beta-BHC		319-85-7	4.73E-05	3.18E+00	6.62E-03	2.49E+00
delta-BHC		319-86-8	-	-	-	-
gamma-BHC (Lindane)		58-89-9	6.55E-05	4.40E+00	9.17E-03	3.45E+00
Benzo(a)anthracene		56-55-3	1.17E-04	7.84E+00	1.63E-02	6.14E+00
Benzo(a)pyrene		50-32-8	1.17E-05	7.84E-01	1.63E-03	6.14E-01
Benzo(b)fluoranthene		205-99-2	1.17E-04	7.84E+00	1.63E-02	6.14E+00
Benzo(g,h,i)perylene		191-24-2	-	-	-	-
Benzo(k)fluoranthene		207-08-9	1.17E-03	7.84E+01	1.63E-01	6.14E+01
Benzoic Acid		65-85-0	1.46E+02	>1E+06	2.04E+04	>1E+06
Benzyl Alcohol		100-51-6	1.10E+01	6.13E+05	1.53E+03	5.76E+05
Beryllium		7440-41-7	1.98E-05	1.33E+00	2.77E-03	1.04E+00
bis(2-chloroethoxy)methane	(V)	111-91-1	-	-	-	-

Table 6: Preliminary Risk-Based Remediation Goals for RFETS

Target Analyte List Chemical		CAS Number	Residential Groundwater (mg/L or pCi/L)	Office Worker Soil (mg/kg or pCi/g)	Open Space Surface Water (mg/L or pCi/L)	Open Space Soil (mg/kg or pCi/g)
bis(2-chloroethyl)ether	(V)	111-44-4	7.74E-05	5.20E+00	1.08E-02	4.07E+00
bis(2-chloroisopropyl)ether	(V)	39638-32-9	1.22E-03	8.18E+01	1.70E-01	6.40E+01
bis(2-ethylhexyl)phthalate		117-81-7	6.08E-03	4.09E+02	8.52E-01	3.20E+02
Bromodichloromethane	(V)	75-27-4	1.37E-03	9.23E+01	1.92E-01	7.23E+01
Bromoform	(V)	75-25-2	1.08E-02	7.24E+02	1.51E+00	5.67E+02
Bromomethane	(V)	74-83-9	5.11E-02	2.86E+03	7.15E+00	2.69E+03
4-Bromophenyl phenyl ether		101-55-3	-	-	-	-
2-Butanone	(V)	78-93-3	2.19E+01	>1E+06	3.07E+03	>1E+06
Butylbenzylphthalate		85-68-7	7.30E+00	4.09E+05	1.02E+03	3.84E+05
Cadmium (water)		7440-43-9	1.83E-02	NA	2.56E+00	NA
Cadmium (food)		7440-43-9	NA	2.04E+03	5.11E+00	1.92E+03
Calcium		7440-70-2	-	-	-	-
Carbon disulfide	(V)	75-15-0	3.65E+00	2.04E+05	5.11E+02	1.92E+05
Carbon tetrachloride	(V)	56-23-5	6.55E-04	4.40E+01	9.17E-02	3.45E+01
Cesium		7440-46-2	-	-	-	-
alpha-Chlordane		5103-71-9	2.43E-04	1.63E+01	3.41E-02	1.28E+01
beta-Chlordane		5103-74-2	2.43E-04	1.63E+01	3.41E-02	1.28E+01
gamma-Chlordane		12789-03-6	2.43E-04	1.63E+01	3.41E-02	1.28E+01
4-Chloroaniline		106-47-8	1.46E-01	8.18E+03	2.04E+01	7.68E+03
Chlorobenzene	(V)	108-90-7	7.30E-01	4.09E+04	1.02E+02	3.84E+04
Chloroethane	(V)	75-00-3	2.94E-02	1.97E+03	4.11E+00	1.55E+03
Chloroform	(V)	67-66-3	1.40E-02	9.38E+02	1.95E+00	7.35E+02
Chloromethane	(V)	74-87-3	6.55E-03	4.40E+02	9.17E-01	3.45E+02
4-Chloro-3-methylphenol		59-50-7	-	-	-	-
2-Chloronaphthalene	(V)	91-58-7	2.92E+00	1.64E+05	4.09E+02	1.54E+05
2-Chlorophenol	(V)	95-57-8	1.83E-01	1.02E+04	2.56E+01	9.61E+03
4-Chlorophenyl phenyl ether		7005-72-3	-	-	-	-
Chromium III		16065-83-1	5.48E+01	8.73E+03	7.67E+03	4.46E+04
Chromium VI		18540-29-9	1.10E-01	1.02E+03	1.53E+01	4.41E+03
Chrysene		218-01-9	1.17E-02	7.84E+02	1.63E+00	6.14E+02
Cobalt		7440-48-4	2.19E+00	1.23E+05	3.07E+02	1.15E+05
Copper		7440-50-8	1.35E+00	7.56E+04	1.89E+02	7.11E+04

Table 6: Preliminary Risk-Based Remediation Goals for RFETS

Target Analyte List Chemical		CAS Number	Residential Groundwater (mg/L or pCi/L)	Office Worker Soil (mg/kg or pCi/g)	Open Space Surface Water (mg/L or pCi/L)	Open Space Soil (mg/kg or pCi/g)
Cyanide		57-12-5	7.30E-01	4.09E+04	1.02E+02	3.84E+04
4,4-DDD		72-54-8	3.55E-04	2.38E+01	4.97E-02	1.87E+01
4,4-DDE		72-55-9	2.50E-04	1.68E+01	3.51E-02	1.32E+01
4,4-DDT		50-29-3	2.50E-04	1.68E+01	3.51E-02	1.32E+01
Dibenz(a,h)anthracene		53-70-3	1.17E-05	7.84E-01	1.63E-03	6.14E-01
Dibenzofuran		132-64-9	1.46E-01	8.18E+03	2.04E+01	7.68E+03
Dibromochloromethane		124-48-1	1.01E-03	6.81E+01	1.42E-01	5.34E+01
Di-n-butylphthalate		84-74-2	3.65E+00	2.04E+05	5.11E+02	1.92E+05
1,2-Dichlorobenzene	(V)	95-50-1	3.29E+00	1.84E+05	4.60E+02	1.73E+05
1,3-Dichlorobenzene	(V)	541-73-1	3.29E-02	1.84E+03	4.60E+00	1.73E+03
1,4-Dichlorobenzene	(V)	106-46-7	3.55E-03	2.38E+02	4.97E-01	1.87E+02
3,3-Dichlorobenzidine		91-94-1	1.89E-04	1.27E+01	2.65E-02	9.96E+00
1,1-Dichloroethane	(V)	75-34-3	3.65E+00	2.04E+05	5.11E+02	1.92E+05
1,2-Dichloroethane	(V)	107-06-2	9.36E-04	6.29E+01	1.31E-01	4.93E+01
1,1-Dichloroethene	(V)	75-35-4	1.42E-04	9.54E+00	1.99E-02	7.47E+00
1,2-Dichloroethene (total)	(V)	540-59-0	3.29E-01	1.84E+04	4.60E+01	1.73E+04
2,4-Dichlorophenol	(V)	120-83-2	1.10E-01	6.13E+03	1.53E+01	5.76E+03
1,2-Dichloropropane	(V)	78-87-5	1.25E-03	8.42E+01	1.75E-01	6.59E+01
cis-1,3-Dichloropropene	(V)	10061-01-5	4.73E-04	3.18E+01	6.62E-02	2.49E+01
trans-1,3-Dichloropropene	(V)	10061-02-6	4.73E-04	3.18E+01	6.62E-02	2.49E+01
Dieldrin		60-57-1	5.32E-06	3.58E-01	7.45E-04	2.80E-01
Diethylphthalate		84-66-2	2.92E+01	>1E+06	4.09E+03	>1E+06
2,4-Dimethylphenol	(V)	105-67-9	7.30E-01	4.09E+04	1.02E+02	3.84E+04
Dimethylphthalate		131-11-3	3.65E+02	>1E+06	5.11E+04	>1E+06
4,6-Dinitro-2-methylphenol	(V)	534-52-1	3.65E-03	2.04E+02	5.11E-01	1.92E+02
2,4-Dinitrophenol	(V)	51-28-5	7.30E-02	4.09E+03	1.02E+01	3.84E+03
2,4-Dinitrotoluene		121-14-2	1.25E-04	8.42E+00	1.75E-02	6.59E+00
2,6-Dinitrotoluene		606-20-2	1.25E-04	8.42E+00	1.75E-02	6.59E+00
Di-n-octylphthalate		117-84-0	6.08E-03	4.09E+02	8.52E-01	3.20E+02
Endosulfan I		959-98-8	2.19E-01	1.23E+04	3.07E+01	1.15E+04
Endosulfan II		33213-65-9	2.19E-01	1.23E+04	3.07E+01	1.15E+04
Endosulfan sulfate		1031-07-8	2.19E-01	1.23E+04	3.07E+01	1.15E+04

Table 6: Preliminary Risk-Based Remediation Goals for RFETS

Target Analyte List Chemical		CAS Number	Residential Groundwater (mg/L or pCi/L)	Office Worker Soil (mg/kg or pCi/g)	Open Space Surface Water (mg/L or pCi/L)	Open Space Soil (mg/kg or pCi/g)
Endosulfan (technical)		115-29-7	2.19E-01	1.23E+04	3.07E+01	1.15E+04
Endrin ketone		53494-70-5	-	-	-	-
Endrin (technical)		72-20-8	1.10E-02	6.13E+02	1.53E+00	5.76E+02
Ethylbenzene	(V)	100-41-4	3.65E+00	2.04E+05	5.11E+02	1.92E+05
Fluoranthene		206-44-0	1.46E+00	8.18E+04	2.04E+02	7.68E+04
Fluorene	(V)	86-73-7	1.46E+00	8.18E+04	2.04E+02	7.68E+04
Heptachlor		76-44-8	1.89E-05	1.27E+00	2.65E-03	9.96E-01
Heptachlor epoxide		1024-57-3	9.36E-06	6.29E-01	1.31E-03	4.93E-01
Hexachlorobenzene		118-74-1	5.32E-05	3.58E+00	7.45E-03	2.80E+00
Hexachlorobutadiene		87-68-3	1.09E-03	7.34E+01	1.53E-01	5.75E+01
Hexachlorocyclopentadiene		77-47-4	2.56E-01	1.37E+04	3.58E+01	1.33E+04
Hexachloroethane		67-72-1	6.08E-03	4.09E+02	8.52E-01	3.20E+02
2-Hexanone	(V)	591-78-6	-	-	-	-
Indeno(1,2,3-cd)pyrene		193-39-5	1.17E-04	7.84E+00	1.63E-02	6.14E+00
Iron		7439-89-6	1.10E+01	6.13E+05	1.53E+03	5.76E+05
Isophorone		78-59-1	8.96E-02	6.02E+03	1.26E+01	4.72E+03
Lead		7439-92-1	-	1.00E+03 [a]	-	-
Lithium		7439-93-2	7.30E-01	4.09E+04	1.02E+02	3.84E+04
Magnesium		7439-95-4	-	-	-	-
Manganese		7439-96-5	1.72E+00	6.68E+04	2.40E+02	8.36E+04
Mercury (elemental)		7439-97-6	-	>1E+06	-	>1E+06
Mercuric chloride	[b]		1.10E-02	6.13E+02	1.53E+00	5.76E+02
Methoxychlor		72-43-5	1.83E-01	1.02E+04	2.56E+01	9.61E+03
Methylene chloride	(V)	75-09-2	1.14E-02	7.63E+02	1.59E+00	5.98E+02
2-Methylnaphthalene	(V)	91-57-6	7.30E-01	4.09E+04	1.02E+02	3.84E+04
4-Methyl-2-pentanone	(V)	108-10-1	2.92E+00	1.64E+05	4.09E+02	1.54E+05
2-Methylphenol		95-48-7	1.83E+00	1.02E+05	2.56E+02	9.61E+04
4-Methylphenol		106-44-5	1.83E-01	1.02E+04	2.56E+01	9.61E+03
Molybdenum		7439-98-7	1.83E-01	1.02E+04	2.56E+01	9.61E+03
Naphthalene	(V)	91-20-3	7.30E-01	4.09E+04	1.02E+02	3.84E+04
Nickel (soluble)		7440-02-0	7.30E-01	4.09E+04	1.02E+02	3.84E+04
2-Nitroaniline		88-74-4	2.19E-03	1.23E+02	3.07E-01	1.15E+02

Table 6: Preliminary Risk-Based Remediation Goals for RFETS

Target Analyte List Chemical		CAS Number	Residential Groundwater (mg/L or pCi/L)	Office Worker Soil (mg/kg or pCi/g)	Open Space Surface Water (mg/L or pCi/L)	Open Space Soil (mg/kg or pCi/g)
3-Nitroaniline		99-09-2	-	-	-	-
4-Nitroaniline		100-01-6	-	-	-	-
Nitrobenzene	(V)	98-95-3	1.83E-02	1.02E+03	2.56E+00	9.61E+02
2-Nitrophenol		88-75-5	-	-	-	-
4-Nitrophenol	(V)	100-02-7	2.92E-01	1.64E+04	4.09E+01	1.54E+04
n-Nitrosodiphenylamine	(V)	86-30-6	1.74E-02	1.17E+03	2.43E+00	9.15E+02
n-Nitrosodipropylamine	(V)	621-64-7	1.22E-05	8.18E-01	1.70E-03	6.40E-01
Pentachlorophenol		87-86-5	7.10E-04	4.77E+01	9.94E-02	3.74E+01
Phenanthrene	(V)	85-01-8	-	-	-	-
Phenol		108-95-2	2.19E+01	>1E+06	3.07E+03	>1E+06
Potassium		7440-09-7	-	-	-	-
Pyrene		129-00-0	1.10E+00	6.13E+04	1.53E+02	5.76E+04
Selenium		7782-49-2	1.83E-01	1.02E+04	2.56E+01	9.61E+03
Silver		7440-22-4	1.83E-01	1.02E+04	2.56E+01	9.61E+03
Sodium		7440-23-5	-	-	-	-
Strontium		7440-24-6	2.19E+01	>1E+06	3.07E+03	>1E+06
Stryene	(V)	100-42-5	7.30E+00	4.09E+05	1.02E+03	3.84E+05
1,1,2,2-Tetrachloroethane	(V)	79-34-5	4.26E-04	2.86E+01	5.96E-02	2.24E+01
Tetrachloroethene	(V)	127-18-4	1.64E-03	1.10E+02	2.29E-01	8.62E+01
Thallium		7440-28-0	-	-	-	-
Tin		7440-31-5	2.19E+01	>1E+06	3.07E+03	>1E+06
Toluene	(V)	108-88-3	7.30E+00	4.09E+05	1.02E+03	3.84E+05
Toxaphene		8001-35-2	7.74E-05	5.20E+00	1.08E-02	4.07E+00
1,2,4-Trichlorobenzene	(V)	120-82-1	3.65E-01	2.04E+04	5.11E+01	1.92E+04
1,1,1-Trichloroethane	(V)	71-55-6	1.02E+01	5.72E+05	1.43E+03	5.38E+05
1,1,2-Trichloroethane	(V)	79-00-5	1.49E-03	1.00E+02	2.09E-01	7.86E+01
Trichloroethene	(V)	79-01-6	7.74E-03	5.20E+02	1.08E+00	4.07E+02
2,4,5-Trichlorophenol		95-95-4	3.65E+00	2.04E+05	5.11E+02	1.92E+05
2,4,6-Trichlorophenol		88-06-2	7.74E-03	5.20E+02	1.08E+00	4.07E+02
Vanadium		7440-62-2	2.56E-01	1.43E+04	3.58E+01	1.34E+04
Vinyl acetate		108-05-4	3.65E+01	>1E+06	5.11E+03	>1E+06
Vinyl chloride	(V)	75-01-4	4.48E-05	3.01E+00	6.28E-03	2.36E+00

Table 6: Preliminary Risk-Based Remediation Goals for RFETS

Target Analyte List Chemical		CAS Number	Residential Groundwater (mg/L or pCi/L)	Office Worker Soil (mg/kg or pCi/g)	Open Space Surface Water (mg/L or pCi/L)	Open Space Soil (mg/kg or pCi/g)
Xylene (total)	(V)	1330-20-7	7.30E+01	>1E+06	1.02E+04	>1E+06
Zinc		7440-66-6	1.10E+01	6.13E+05	1.53E+03	5.76E+05
Nitrate		14797-55-8	5.84E+01	>1E+06	8.18E+03	>1E+06
Nitrite		14797-65-0	3.65E+00	2.04E+05	5.11E+02	1.92E+05
Sulfide		18496-25-8	-	-	-	-
Ammonium (as Ammonia)		7664-41-7	3.54E+01	>1E+06	4.96E+03	>1E+06
Bicarbonate		71-52-3	-	-	-	-
Bromide		24959-67-9	-	-	-	-
Carbonate		3812-32-6	-	-	-	-
Chloride		16887-00-6	-	-	-	-
Fluoride (as fluorine)		7782-41-4	2.19E+00	1.23E+05	3.07E+02	1.15E+05
Orthophosphate		14265-44-2	-	-	-	-
Silica (as Si and SiO2)		7631-86-9	-	-	-	-
Sulfate		14808-79-8	-	-	-	-
Am-241		14596-10-2	1.45E-01	8.00E+00	2.03E+01	1.58E+01
Cs-137+D		10045-97-3(+D)	1.51E+00	1.05E-01	2.11E+02	5.57E-01
Pu-239		15117-48-3	1.51E-01	1.00E+01	2.11E+01	1.75E+01
Pu-240		14119-33-6	1.51E-01	1.00E+01	2.12E+01	1.75E+01
Ra-226+D		13982-63-3(+D)	1.61E-01	3.24E-02	2.25E+01	1.72E-01
Ra-228+D		15262-20-1(+D)	1.92E-01	6.64E-02	2.69E+01	3.51E-01
Sr-89		14158-27-1	4.62E+00	1.76E+02	6.47E+02	4.32E+02
Sr-90+D		10098-97-2(+D)	8.52E-01	5.72E+01	1.19E+02	9.94E+01
Tritium		10028-17-8	6.66E+02	4.47E+04	9.32E+04	7.77E+04
U-233		13968-55-3	1.06E+00	6.78E+01	1.49E+02	1.22E+02
U-234		13966-29-5	1.07E+00	6.87E+01	1.50E+02	1.23E+02
U-235+D		15117-96-1(+D)	1.01E+00	8.16E-01	1.42E+02	4.25E+00
U-238+D		7440-61-1(+D)	7.68E-01	3.13E+00	1.08E+02	1.48E+01

Notes:

(V) = Chemicals listed are volatile.

\- = No toxicity value available.

NA = PPRG value is not applicable for this exposure scenario. Dual oral RfDs available for cadmium. The first value (5E-04) is representative of pathways involving water and the second value (1E-03) is representative of pathways involving food (soil).

[a] U.S. Environmental Protection Agency (EPA). 1994. Revised Interim Soil Lead Guidance for CERCLA Sites and RCRA Corrective Action Facilities. Office of Solid Waste and Emergency Response, Washington, D.C. Directive 9355.4-12.

[b] The value for residential groundwater ingestion is based on the oral RfD for mercuric chloride since an oral toxicity factor is lacking for elemental mercury.

Appendix O

PROCESS DESCRIPTION FOR EVALUATING GROUNDWATER IMPACTS TO SURFACE WATER AND ECOLOGICAL RESOURCES

APPENDIX O

Process Description for Evaluating Groundwater Impacts to Surface Water and Ecological Resources

1.0 INTRODUCTION

The purpose of this appendix is to provide a "process description" to integrate the goals and objectives of groundwater monitoring, hydrogeologic characterization, and remedial actions at RFETS. The intent of this process description is not to prescribe specific analyses that must be performed, but to present a general approach that defines how groundwater contamination at RFETS will be assessed and addressed. By developing an integrated process, it is expected that the basis for decisions regarding the need for remediation and the evaluation of remediation performance will be consistent and will effectively protect surface water and ecological resources. A description of the groundwater plume management and remediation strategy is provided in the IMP Background Document. This appendix encompasses the content of the strategy in the IMP.

In essence, the groundwater contamination assessment and remediation evaluation process consists of the following phases:

- Initial determination of actual or potential groundwater contamination
- Development of a conceptual model based on adequate characterization of the source, nature, and extent of groundwater contamination
- Evaluation of whether contaminated groundwater has or will adversely impact surface water and ecological resources
- Evaluation of alternatives for mitigating groundwater contamination which impacts surface water or ecological resources, and the selection of an appropriate remedial action
- Verification of the appropriateness or effectiveness of the selected remedial action

In the following sections, each of these phases is discussed in more detail.

1.1 INITIAL DETERMINATION OF GROUNDWATER CONTAMINATION

This phase is intended to determine whether there is a potential contamination problem. During this phase, no attempt will be made to determine the cause of contamination or how the groundwater contamination is distributed. The evaluation of the presence of groundwater contamination, and if the contamination could impact surface water, is the first threshold when determining if further action is required.

Previous groundwater monitoring programs such as the OU RI/RFI and site-wide characterization activities have made an initial determination of the areas where groundwater is contaminated. The IMP provides for continued monitoring to assess changes in these areas of groundwater contamination and to identify new problem areas.

1.2 CHARACTERIZATION OF THE GROUNDWATER CONTAMINATION AREA (PLUME EVALUATION)

The primary purpose for characterizing and evaluating the nature and extent of groundwater contamination is to obtain sufficient data to support the development of a conceptual model of the problem area and to support the analyses necessary to evaluate the impact to surface water or ecological resources. Characterization may include, but is not limited to:

- Defining the extent of groundwater contamination
- Identifying potential source areas and contaminants of concern
- Defining plume extent through determining the linear and areal extents of the pathway through subsurface correlation of standard thickness and permeable lithologies
- Recharge and discharge through quantification of water balance, velocity, gradient, and direction of groundwater flow
- Concentration loadings and mass flux of contaminants to surface water
- Effects due to seasonal variations, natural attenuation of contaminants, or changes in discharge due to construction/removal of containment structures, treatment systems or removal of sources

Decisions with respect to plume evaluations will be made with consultation from the groundwater workgroup during various stages of the process. Results of the characterizations will be used to update the ER ranking process under RFCA to ensure that the available budget will be allocated to areas with the highest potential for contamination.

1.2.1 Evaluation of Existing Data

Once the available data have been compiled they can be used to develop a conceptual model of the groundwater contamination area. As the conceptual model is being formulated, ongoing evaluations will be performed to determine whether the data set is of sufficient quantity and quality to support the conceptual model. Some of the questions that should be answered include:

- Are the types of data adequate for the conceptual model (e.g., hydraulic conductivity, stratigraphic, and geologic, piezometric, water quality analyses for the contaminants of concern)
- Is the quantity of data sufficient (e.g., spatial or temporal coverage)
- Is the quality of the data set sufficient to address the program objectives (e.g., use of accepted analytical methods, meeting QA/QC objectives)

If a consideration of these questions shows that the available data are inadequate, then additional data should be collected to fill the data gaps.

1.2.2 Collection of Additional Data

Prior to collecting any additional data, the DQOs should be defined to provide a clear purpose for collecting the additional characterization data. For example, an objective might be to better delineate groundwater flow direction, or to determine concentration trends within specific wells. Once the DQOs have been defined, then the appropriate sampling program may be developed and implemented. At this stage, the new data are incorporated and the conceptual model refined. The data questions outlined above should be addressed to determine whether the conceptual model is valid.

1.2.3 Establishing Baseline Conditions

The baseline assessment may have either of two purposes. The first purpose is to establish the current level of impacts to surface water or ecological resources. The second purpose may be to establish hydrogeologic conditions at specified locations prior to, during, or immediately after remediation.

In the first instance, the baseline case is used to determine whether changes in upgradient conditions will have an adverse or beneficial impact on downgradient surface water or ecological resources. In addition, the first type of baseline case can factor into the decision whether remediation or continued monitoring is the appropriate course of action to protect surface water or ecological resources. In the second instance, the baseline assessment will be the basis for evaluating how downgradient conditions change in response to upgradient remedial actions.

1.3 EVALUATION OF IMPACTS TO SURFACE WATER OR ECOLOGICAL RESOURCES

Pursuant to the RFCA, "[p]rotection of all surface water uses with respect to fulfillment of the Intermediate and Long-Term Site Conditions will be the basis for making soil and ground water remediation and management decisions." Therefore, it is necessary to evaluate the current and future impacts of groundwater on surface water or ecological resources to ensure that these resources are protected.

The evaluation of impacts to surface water will focus on three areas: the direct discharge of groundwater or seeps to surface water; the impact of groundwater to a specified reach of the stream (surface water and alluvium) downgradient from the point of discharge; and the concentration of contaminants at downstream surface water monitoring locations.

Ecological impact assessments will be based on site-specific conditions. The impact evaluations may either be supported directly by the data, by the use of analytical methods, or, if necessary, through the application of numerical models. The determination of which method of analysis to use will be based on the issues that are to be addressed, the limitations inherent in the data, the accuracy of the desired results, or available resources.

1.4 EVALUATION OF ALTERNATIVE REMEDIAL ACTIONS

Upon determination that contaminated groundwater has or may potentially impact surface water or ecological resources, alternative remediation scenarios should be evaluated. Alternative remedial actions include, but are not limited to:

- No action
- Source removal
- Source containment
- Plume containment
- Plume interception

Alternatives will be developed and considered on a site-by-site basis. The evaluation of alternatives will generally consist of the following steps:

- Definition of remediation objectives
- Determination of whether the data and conceptual model will support the analyses necessary to evaluate the different alternatives
- Completion of an alternatives assessment including the evaluation of surface-water or ecological impacts during remedy implementation, and in the future, considering the compatibility with other RFETS closure activities
- Selection of an alternative that is protective of surface water and ecological resources

The results of the alternatives analysis will be presented in a RFCA decision document. In essence, the documentation should summarize:

- The conceptual model describing hydrogeologic conditions
- The analytical tools used to evaluate the data
- The basis for selecting the parameters used for assessing system performance
- The type of impact, if any, to surface water or ecological resources
- How impacts have changed and may change with time
- The assessment of alternatives if remedial action is necessary
- Outline of remedial design/construction and/or monitoring actions as necessary

Development and consideration of alternatives will involve consultation with the groundwater working group during key phases of the process. Within this context, the parties should reach a consensus regarding specific contaminant source areas, groundwater plumes, and the appropriate response. Once an alternative has been selected, a remediation/management project will be developed with its own scope, schedule, and budget.

1.5 REMEDIAL DESIGN/CONSTRUCTION

If a remedial action decision has been reached, additional information may be needed to aid the design and construction of the remedial system. A DQO process, as defined in the IMP, will be employed to establish the decision, and data needs to aid in the construction of the remedial system. The remedial system may consist of a groundwater containment or treatment system, or a source removal action. Components of this step may include:

- Preparation and presentation of design documents and construction workplans
- Preparation and presentation of additional sampling and analysis plans
- Determination of performance monitoring requirements

Development and consideration of alternatives will involve consultation with the groundwater workgroup during key phases of the project.

1.6 VERIFICATION OF THE SELECTED REMEDIAL ACTION

Once a selected remedial action has been implemented, it may be necessary to demonstrate that the action meets the prescribed remediation goals. To verify the adequacy of a remedial action, the performance criteria must be clearly defined. For example, the performance criteria for a source removal remedy would be quite different than the performance criteria for a plume intercept remedy. The effectiveness of the former could be easily demonstrated by a trend showing a reduction with time of contaminant concentrations in and immediately downgradient of the remediated area; whereas the effectiveness of a plume intercept system might be evaluated relative to water quality criteria at a point of compliance. The performance criteria will need to be defined on a case-by-case basis, accounting for the site- and contaminant-specific characteristics of different plumes. Decisions will require consultation of the groundwater working group during key phases of the evaluation, and performance monitoring will be implemented through the IMP process.

Appendix P

METHODOLOGY FOR UPDATED ENVIRONMENTAL RESTORATION RANKING

APPENDIX P

METHODOLOGY FOR UPDATED ENVIRONMENTAL RESTORATION RANKING

1.0 FISCAL YEAR 1996 - UPDATE ENVIRONMENTAL RESTORATION RANKING

This document presents the fiscal year 1996 (FY96) update to the methodology presented in the RFCA Attachment 4, which contains the 1995 prioritized list of ER sites developed to select the top priority sites for remediation (DOE, 1995a). The ER ranking was developed to be used as an aid in planning and prioritizing remedial actions at RFETS. The sequence of remediation activities at RFETS has generally followed the prioritization. Other factors that also influence the remediation sequence are funding, project cost, resource availability, data sufficiency, and integration with other remedial and Site activities. Prioritization accelerates the cleanup process of the worst sites first, and more quickly reduces risks to human health and the environment. The prioritization of cleanup targets also results in cost reductions by allowing better planning, and more efficient utilization of resources.

The 1995 prioritization methodology was developed by a working group of the EPA, CDPHE, DOE, Kaiser-Hill, and RMRS staff and was implemented by RMRS. The result was a prioritized list of ER sites, including a list of ranked sites that require more information (DOE, 1995a). In accordance with RFCA Attachment 4, the ranking has been updated during FY96. The evaluation process is essentially the same as was used in the September 1995 ranking, with the following exceptions:

- ALF for Surface Water, Groundwater, and Soils (RFCA Attachment 5) values were used
- The scoring scale was adjusted to reflect the greater range in ALF ratios
- Impact to surface water was evaluated instead of mobility
- A professional judgment factor was added to account for process knowledge
- Groundwater plumes were evaluated and ranked separately from the contaminant source
- The secondary evaluation, which included project cost and schedule estimates, has been omitted due to other planning activities ongoing at the RFETS

1.1 METHODOLOGY

The ranking process detailed in RFCA Attachment 4 was slightly modified in 1996 to incorporate the ALF and process knowledge. This ranking was generated by using concentrations of contaminants present at different sites, action levels for the appropriate media and location, and factors for impact to surface water, potential for further release, and professional judgment to develop a score for each site. The scores were then ranked to determine which sites have the highest priority. This methodology is conservative and is used only to generate a list to prioritize remedial actions, and pre-remediation investigations. It is not meant to replace a formal risk assessment.

Ecological risk was also considered during the ranking. The recently completed ecological risk assessment was considered during evaluation of the Buffer Zone. There is no unacceptable ecological risk from Buffer Zone IHSSs under present conditions and exposure pathways. An ecological risk assessment has not been completed for the Industrial Area. Ecological factors were not considered when ranking IHSSs in this area.

The following steps were used in the 1996 ranking process:

- The existing analytical data were compared to background data
- Data exceeding background were compared to the ALF values
- Ratios of Tier II ALF values to contaminant concentrations/activities were used for the ranking, unless Tier II values were not available
- A column was added to the ranking sheet to note Tier I exceedances
- The resulting ratios were converted to a score of 1 to 10
- The impact to surface water was evaluated, and assigned a factor of 1 to 3
- The potential for further release was evaluated, and a factor of 1 to 3 applied
- Process knowledge of the site was evaluated, and a professional judgment factor of 0.5 to 2 applied
- The results of the previous steps were multiplied to generate a score per site; this score was used to rank the ER sites

Analytical data in the SWD from 1990 to the present were evaluated for three media; surface soils, subsurface soils, and groundwater. The analytical data were extracted from the SWD and compiled into data sets by media and analytical suite. The media-specific analytical data were compared to the media- and chemical-specific background mean plus two standard deviations (M2SD). All data above the background M2SD were then compared to the appropriate ALF values in RFCA. The draft radiological ALF values for surface soils (See Appendix L) were applied to both surface and subsurface soils. The ALF values for metals in subsurface soils were not agreed upon in time to be included in the 1996 ranking and metals data from subsurface soils were not used in the ranking. A review of the data suggests that this will not effect the ranking significantly.

All exceedances of the values were tabulated for groundwater, subsurface soils, and surface soils at each sample location. The locations were plotted on maps using available survey information. Where no survey data is available, approximate locations were derived from work plan maps. The sample locations were assigned to areas-of-concern, IHSSs, and groundwater plumes based on the media, location of the exceedance, and the analyte.

Media Specific Evaluations

Groundwater - Sitewide groundwater data were compared to background M2SD values presented in the 1993 *Background Geochemical Characterization Report* (DOE, 1993a). Groundwater data were then compared to the ALF values. All well locations where a chemical concentration exceeds a ALF value were plotted. The locations were then associated with the most probable source area and known groundwater plumes. Ratios of analyte concentrations to the Tier II ALF values were used in the scoring.

Subsurface Soil - All available subsurface soil data collected since 1990 were compared to subsurface soil background M2SD values (DOE, 1993a). The data for volatile organic compounds were compared to the ALF values the radiological activities were compared to the surface soil ALF values. The ALF values for metals in subsurface soils are in ALF. The locations of all borings where a chemical concentration exceeded an ALF value were plotted and associated with the most likely source area.

Surface Soil - All available surface soil data for metals and radiologicals were compared to M2SD background values computed from data presented in the *Geochemical Characterization of Background Surfacial Soils, Background Soils Characterization Program, May 1995* (DOE, 1995c). The inorganic and radiological results above background and all data for organic compounds were compared to the ALF values for surface soil. Within the boundaries of the Industrial Area OU, the surface soil data were compared to office worker ALF values. In the Buffer Zone OU, the surface soil data were compared to open space ALF values. The ALF exceedances were plotted to determine the most likely source area, IHSS or group of IHSSs, using the most common wind patterns. Ratios of analyte concentrations to the Tier II ALF values were used in the scoring.

Chemical Score Tabulation

All ALF exceedances were tabulated by IHSS, group of IHSSs, or source area. The chemical score was calculated for each media, within each site, by adding the maximum ratio for each analyte per media. The groundwater, subsurface soil, and surface soil scores were then summed to generate a total score per site. This is a conservative approach that allows the sites to be judged on a uniform basis.

A separate score was derived for each groundwater plume by evaluating only the groundwater exceedances. A risk score was calculated for each plume, as above, by adding the maximum ALF ratios for groundwater contaminants associated with all sites within the estimated plume area. This method results in groundwater being used twice; once in the scoring of sources, and again for the scoring of groundwater plumes. The total chemical scores were graded according to the following table so that the risk component of the ranking system would be weighted similarly to the other components. This table has been adjusted from the 1995 methodology due to the increase in the range of the scores.

Total Chemical Score	ALF Score
>20001	10
10001-20000	9
5001-10000	8
1001-5000	7
501-1000	6
251-500	5
126-250	4
75-125	3
26-75	2
1-25	1

Surface Water Impacts

The impact of contamination at a site on surface water quality was evaluated and each site was assigned a factor of 1 to 3 to indicate the impact on surface water from each site. The impact to surface water factors were assigned on a scale of 1 to 3 as follows:

1. Contaminants that are immobile in the environment or for which there is no pathway to surface water. Radionuclides and metals were given a score of one unless adjacent to surface water, or on a steep slope bordering surface water. This rating was used where engineered structures are in place that prevent the spread of contaminants.

2. This rating was applied where contaminants have or are expected to have an impact on surface water at the Tier II ALF level (MCL).

3. This rating will apply where there is a documented or probable impact to surface water above the Tier I ALF value (100 x MCL).

Potential for Further Release

This factor takes into account the potential for additional release of contaminants into the environment and includes cross-media movement of contaminants within the environment. Sites were assigned a value of 1 to 3 based on the following criteria:

1. Assigned to a location when contamination were not present as free product, very high concentrations, and/or show no cross contamination of environmental media.

2. Any location where free product may be present in the ground and/or where there is a potential for cross contamination.

3. Locations where there is indication or certainty that free product exists in the ground, were significant levels of contamination exist, and/or where cross contamination of environmental media is present.

Professional Judgment
A professional judgment factor was added to the FY97's ranking based on process knowledge not represented by the other factors. The reasons for assigning the professional judgment factor are given in the comment column of the ranking. The values for this factor are:

0.5 The ranking overestimates the priority of a site. This was used if a risk assessment or conservative screen has been completed indicating an acceptable risk, but the site ranks high on the priority listing.

1 The ranking reflects process knowledge of a site.

2 The ranking underestimates the priority of a site. This may be due to a lack of data, coupled with process knowledge of significant releases.

Total Score and Ranking
The total score was calculated by multiplying the ALF score times the impact to surface water, potential for further release, and professional judgment factors. A formal risk assessment is a more precise evaluation of the same data, and, where risk assessment data exist, they were used to refine the ranking of the sites through the use of the professional judgment factor.

Where insufficient data currently exist to rank sites, these sites were assigned to the category of needs further investigation (INV) and ranked using the professional judgment factor. This placed them on the ranking above known low-risk sites. As data become available, the ranking for these sites will be updated.

The Solar Ponds groundwater score was calculated without using data from an upgradient well which shows the effects of an upgradient plume. Instead, this well was used in the calculations for the groundwater score for IHSS 118.1 and the carbon tetrachloride spill plume.

Where analytical data and process knowledge indicate that there are localized areas of contamination, the associated data were eliminated from site evaluation, and assigned to a hot spot list. These sites will be evaluated to verify that these are hot spots. Most of the localized extent sites are PCB sites, including a PCB site in IHSS 150.6 and those surrounding Bowman's Pond. The Old Landfill has analytical data indicating the presence of small radiological anomalies at the surface. Best management practices will be used on these hot spots as part of the final remedy for the Original Landfill.

Radium 226 and 228 data were not evaluated for the following reasons:

- Radium 226 and 228 are not listed as having been used at RFETS in either the *Historical Release Report* (DOE, 1992a) or the *Project Task 3/4 Report: Reconstruction of Historical Rocky Flats Operations and Identification of Release Points* (ChemRisk, 1992)
- The decay chains and half-lives of decay products make it highly unlikely that significant amounts of radium 226 or 228 would have accumulated by radioactive decay of radionuclides known to have been used at RFETS
- The soils and groundwater in the foothills to the west of RFETS are known to have high levels of both uranium (total) and radium 226
- The background amount for radium 226 in surface soil has a PPRG ratio of 48. Therefore, any surface soil analytical result above background would skew the prioritization score to a higher result. This is not justified given the information on usage and natural occurrence

Appendix Q

EXAMPLE OF HISTORICAL RELEASE REPORT UPDATE

APPENDIX Q

1.0 EXAMPLE OF HISTORICAL RELEASE REPORT UPDATE

PAC REFERENCE NUMBER: NW–195

IHSS Reference Number:	195, Operable Unit 16
Unit Name:	Nickel Carbonyl Disposal
Approximate Location:	N754,500; E2,083,000

Date(s) of Operation or Occurrence

March through August 1972

Description of Operation or Occurrence

From March through August 1972, cylinders of nickel carbonyl were disposed in a dry well located in the buffer zone. The cylinders were opened inside the well and vented with small arms fire to allow decomposition in air (DOE 1994b).

Physical/Chemical Description of Constituents Released

Nickel carbonyl vapors are denser than air. Consequently, the vapors collected and decomposed in the bottom of the well. Because these vapors ignite spontaneously, ignition occurred either immediately after release into the well or sometime after collection at the bottom of the well (DOE 1992a, 1992b).

Response to Operation or Occurrence

After 24 hours of placement in the well, the cylinders were removed from the hole, vented by small arms fire, and buried in the Present Landfill. Two cylinders became stuck in the hole and were buried in place. A minimal amount of nickel carbonyl was probably released to the atmosphere during disposal. Samples (presumably of air) from the lip of the well taken after the initial disposal indicated nickel carbonyl concentrations of approximately 10 parts per million being released during disposal (DOE 1992a, 1992b). This IHSS was then studied in accordance with the IAG as part of OU 16 (DOE 1992b).

Fate of Constituents Released to the Environment

Nickel carbonyl is highly volatile and readily decomposes in the presence of oxygen, forming nickel oxide. Nickel oxide is highly insoluble in groundwater. For every gram (0.002 pound) of nickel oxide in contact with typical groundwater, approximately 10–26 microgram of nickel per liter is transferred to solution. Wind dispersion subsequently disseminated the nickel oxide particles, which therefore would not be detected at concentrations exceeding background. IHSS 195 does not pose a risk to human health and the environment because there are no viable transport pathways.

Action/No Action Recommendation

Based on information presented in the *Final No Further Action Justification Document for Operable Unit 16, Low–Priority Sites* (DOE 1992b), a CAD/ROD recommending no action under CERCLA for IHSS 195 was prepared, and received final approval on October 28, 1994 (see attached declaration).

Comments

None.

Appendix R

ADMINISTRATIVE RECORD

APPENDIX R

1.0 ADMINISTRATIVE RECORD DOCUMENT IDENTIFICATION

In assessing the relevance of a document to the AR, there are two basic questions: 1) could the document be used or relied upon in deciding how to clean up an IHSS, and 2) will the document be used to inform or involve the public in the clean up of IHSSs at Rocky Flats? A document does not need to be specific to an IHSS to be considered for its remediation. An example would be a document outlining procedures for protecting endangered species at Rocky Flats. While this does not address itself to any particular IHSS, all proposals for remediation would have to take the endangered species procedure into consideration.

Below are some specific documents types that would be included in the AR. Documents generally excluded from the AR are listed in the Level 1 procedure, 1-F78-ER-ARP.001, CERCLA *Administrative Record Program* (RMRS, 1994b).

In accordance with 40 CFR § 300.810, the AR for the selection of a response action may contain the following types of documents.

1. Documents containing factual information and data, and analysis of the factual information and data that form a basis for the selection of a response action, such as the following:

    - CEARP reports
    - RI/FS Work Plan
    - Amendments to the Final Work Plan
    - SAP (consisting of a QAPjP and a FSP)
    - Validated and verified sampling and analysis data
    - Chain of Custody forms
    - Site inspection and evaluation reports
    - Data summary sheets
    - Technical and engineering evaluation performed for the site
    - IHSS-specific HSPs
    - Documents supporting the LRA's determination of imminent and substantial endangerment assessment
    - Documentation of applicable of relevant and appropriate requirements
    - RI/FS Report

- RFI/RIs
- RFI/RI TMs
- Data submitted by the public (including potentially responsible parties)

2. Documents received, published, or made available to the public for remedial actions or removal plans, such as:

- RFSIPIP
- PP
- Public notices of AR availability and public comment periods
- Documentation of public hearings
- Public comments
- Transcripts of public meetings
- Response to significant comments
- Responses to comments from state or federal agencies

3. Other information, such as:

- AR File Index
- Documentation of State involvement
- Health assessments
- Natural Resource Trustee notices and responses, findings of fact, final reports and natural resource damage assessments
- Decision documents rising from dispute resolutions

4. Decision Documents, such as:

- IM/IRA
- RODs (including responsiveness summary)
- Explanations of significant differences
- Amended RODs and underlying information

5. For CERCLA sites with a history of RCRA activity, any relevant RCRA information that may be considered or relied on in selecting the CERCLA response action.