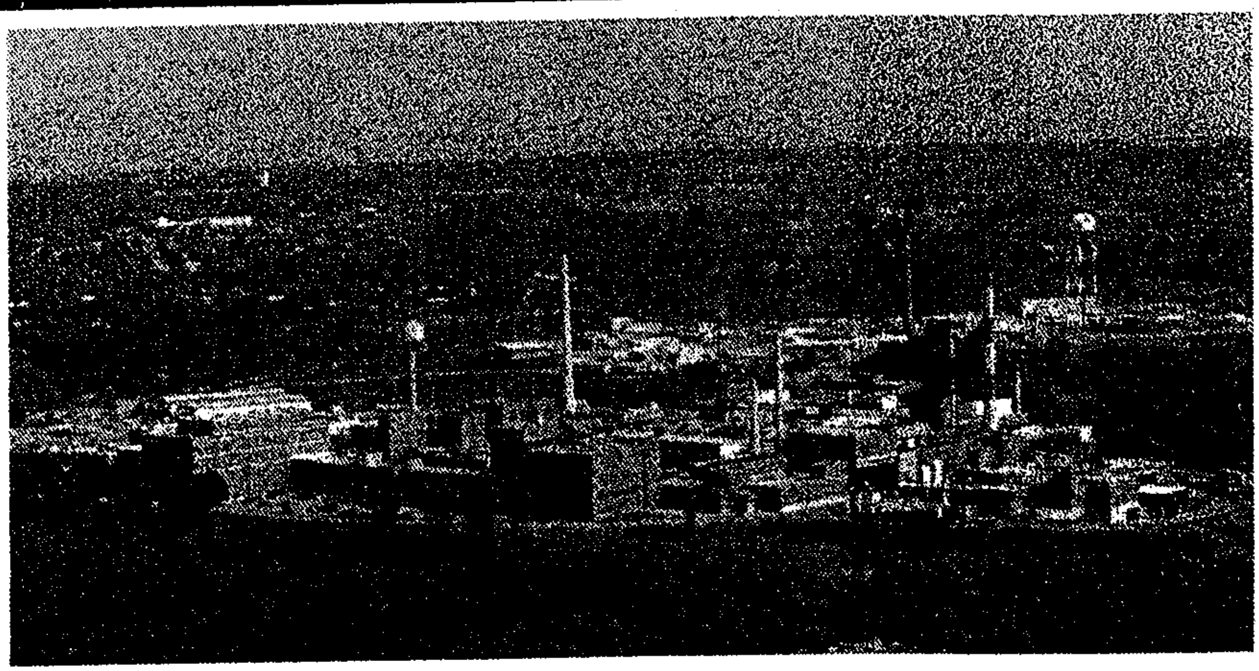
MOUND

Environmental
Restoration
Program

RAM

OhioEPA

MOUND 2000
Residual Risk Evaluation Methodology
MOUND PLANT



Mound 2000 Residual Risk Evaluation Methodology

January 6, 1997
Final
Revision 0

TABLE OF CONTENTS

TABLE OF FIGURES AND TABLES

RESPONSE TO COMMENTS RECEIVED FROM THE PUBLIC

METHODOLOGY (RREM)

The Mound DOE appreciates the input provided by the public stakeholders of the Mound facility. The public stakeholders have significantly contributed to the forward progress that has been made on the entire release-block strategy for establishing the safety of the Mound property prior to its return to public use after remediation and residual risk evaluation.

Responses are in *italic*.

1. Why use the upper threshold limit of the 95% CI (confidence interval) for establishing background levels. The lower bound is appropriate, not the upper bound. You have selected the statistically determined *maximum* value, not the statistically determined *minimum* value for background concentrations. What is the consequence of this decision?

   *The background concentrations used for screening purposes in residual risk assessments were developed and presented in a Mound DOE document entitled, "**Operable Unit 9 Background Soils Investigation Soils Chemistry Report (Technical Memorandum Revision 2)**". As is required, the public had an opportunity to review and comment on this document. All comments and concerns from USEPA and OEPA were addressed in this document. No comments were received from the public.*

   The purpose of a Residual Risk Evaluation is to determine potential risks to construction workers and site employees working within each release block due to residual contamination <u>above background</u> . The 95th% upper tolerance limit (95th UTL) was used to establish whether samples can statistically be determined to be above background. This calculation is used in the Ohio Environmental Protection Agency (OEPA) Division of Energy and Remedial Response "How Clean is Clean" Policy (Final, 1991). Only if values fall above the 95th% UTL can one be statistically sure that contamination exists.

   Additionally, for compounds carried through the full Residual Risk Evaluation, total risks, incremental risks, and background risks are calculated. By lowering the background concentration, more risk would be attributed to Mound activities. While the total risks would not change, the incremental portion of risk attributed to the Mound Plant would be larger. This would force the risk management process to deal with risks that are in part, background risks.

2. Why was 0.1 HI selected to determine if a compound is taken through the risk assessment process? This decision should be tied to the number of contaminants within the block. Again, what is the consequence of this decision, in light of cumulative risks?

   During the course of developing the Residual Risk Evaluation Methodology (RREM), it was determined that use of Guideline Values equal to a Hazard Index of 1 were insufficiently conservative to use as screening criteria for the Residual Risk Evaluation. Therefore to be more conservative, concentrations equal to one tenth of the Guideline

Values were used as screening criteria in order to evaluate the cumulative effect of multiple contaminants that are individually not above the Hazard Index of 1. Tying the decision to the number of contaminants within the release block is not feasible, as the exact number of contaminants contributing to residual risks attributable to Mound activities is not discernible until <u>after</u> the screening process is complete.

3. I believe that using the guidelines values, in its current form is premature. Several concerns were raised in my Wright State Risk Assessment class last year. I will provide a few examples. The Guideline Values need to be calculated using the same methodology that is used to calculate Residual Risks. This is not the case, dermal exposure is an example. All exposure pathways used in the Residual Risk manual need to be identical to the pathways used to calculate the Guideline Values. Also, use of toxicity factors needs to be consistent. The proposed approach for retrieving slope factor, RfD and RfC information is different in the Residual Risk manual compared to the Guideline Value manual. Validation of calculations (QA/QC) is needed on the Guideline Values manual.

*The purpose of the Guideline Values is to serve as one screening tool as part of the Residual Risk Evaluation process. The concept of using Guideline Values as screening tools was developed with substantial input of the Mound DOE stakeholders. Guideline values are only screening criteria for partially determining which compounds to carry through a Residual Risk Evaluation. Guideline values are not cleanup levels at all, but rather concentrations above which a chemical may need to undergo further residual risk evaluation. The "**Risk-Based Guideline Values**" report (available in the Public Reading Room) is considered effectively a finalized report (HAZWRAP, Dec 1995). It is a key part of the Residual Risk Evaluation process. If the Risk-Based Guideline Values report were to be changed continuously, effectively being a moving target, no residual risk evaluations could be completed and no release blocks could be released to the City of Miamisburg.*

We agree that the residual risks need to be evaluated using the same equations as the Guideline Values. Indeed, both residual risks and Guideline Values were calculated using the principles, procedures, equations, and exposure factors set forth in the U.S. Environmental Protection Agency's Risk Assessment Guidance for Superfund (RAGS), Parts A and B. Additional U.S. EPA Guidance for dermal exposures and exposure factors were also used. It is acknowledged that the dermal exposure equations used for groundwater are slightly different between the Guideline Value procedure (old method) and the RREM (new method). At the request of OEPA, DOE is in the process of modifying the Risk-Based Guideline Value Report so the dermal risk in the Risk-Based Guideline Value report is calculated using the same equations presented in the Residual Risk Evaluation Methodology. The numeric results however, do not change significantly as a result of this change.

We disagree that all residual risk exposure pathways must be identical to the pathways used to calculate the Guideline Values. Instead, the Residual Risk Evaluation Methodology directs the consideration of all pathways pertinent to a specific release block, as laid out in the methodology. As an example, these may include surface water for some release blocks and not others. Guideline values are only screening criteria for partially determining which compounds to carry through a Residual Risk Evaluation. Guideline values are applied to all release block residual risk evaluations, while all *pertinent pathways for a specific release block must be considered for onsite construction workers and site employees.*

We agree that the use of toxicity factors for residual risk evaluations needs to be consistent with those used to develop Guideline Values. While the text explaining the determination of toxicity factors is different between the RREM and the Guideline Value report, the approach used is the same. Data retrieved from the Integrated Risk Information System (IRIS) were used first, followed by data from the Health Effects Assessment Tables (HEAST), followed by other information sources (older versions of HEAST, or state or regional guidance).

Validation of calculations (QA/QC) for the Risk-Based Guideline Values report is not an appropriate issue here as this is a discussion on the RREM. However, it should be noted that the draft Risk-Based Guideline Value reports were prepared and completed with substantial review from a number of pertinent stakeholders, including USEPA and OEPA. This would have included substantial checking and rechecking of the Guideline Value approach, equations, parameter values and calculated Guideline Values.

4. The exposure assumptions for the construction worker are not justified. Based on historical experience, what is the average (or upper bound) length of time that construction crews have worked on D&D activities? Need site specific data. Light exercise would increase the daily intake of air above the standard 20 m^3. Also, intake of dust by inhalation is much more substantial than by ingestion. The use of the PEF is incorrect for the construction worker. Please review the derivation of the PEF. This has an important impact on risk assessment calculations because the slope factors for inhalation of important radionuclides is larger than for oral ingestion by up to 100 fold! Thus, the cancer risks would be greatly underestimated for the construction worker.

We agree that intake of dust by inhalation can represent a greater intake than ingestion. We disagree, however, that the exposure assumptions for the construction worker are not justified. D&D activities cannot serve as a site-specific surrogate for construction worker exposures. D&D activities are intentionally conducted in locations of relatively high exposures, as is needed during remediation. However, the D&D workers all are <u>required</u> to wear Personal Protective Equipment (PPE) that eliminates unacceptable exposures to site contaminants.

Experience at the Mound activity has shown that the most significant exposures to dust are to the heavy equipment operators (backhoes, bulldozers, etc.) who are operating their equipment from a drivers seat. This would not be considered light exercise. Therefore, we believe that the standard daily inhalation rate of 20 m^3 of air is appropriate.

The use of the Particulate Emission Factor (PEF) is appropriate for construction workers as a conservative factor defining dust exposures. The PEF is conservatively calculated by considering that there is a large (~22,000 ft^2) completely barren area comprised of an infinite supply of easily suspendable dust particles, and with a wind assumed to be blowing continuously at 10 mph. Thus it is unlikely that risks to construction workers are underestimated, but are rather more likely overestimated.

5. Need to address sediment. For Release Blocks that contain surface water (creek or pond), incidental intake (by ingestion and dermal absorption of chemicals and radionuclides contained in sediment) needs to be included in the risk assessment. Ecological concerns may exist also. One may gain a historical perspective on environmental contamination by sampling sediment.

We agree that sediment needs to be addressed. Sediments and surface waters will be addressed together for release blocks with surface water and sediments. The RREM will be modified to include sediments.

*We agree that ecological health risks need to be addressed at the site. An "**Operable Unit 9, Site-Wide Preliminary Baseline Risk Assessment**" (Draft, Revision 0), containing an Ecological Risk Assessment was initiated, but has not been made public. Overall, ecological risk concerns are addressed on a site-wide basis. DOE proposes to publish the Operable Unit 9, Site-Wide Preliminary Baseline Risk Assessment Report as a technical memorandum for public review.*

6. Page 37, second paragraph. Weighting data based on geographical size seems inappropriate. I do not believe that most samples are collected in an unbiased fashion. The goal is to define areas of contamination, make assumptions about other larger areas of land based on limited data. If the contaminated area is remediated to levels that are similar to the larger land area, then lumping the two may be appropriate.

This comment appears to be largely in concurrence with the RREM as it exists, although the text will be clarified to remove any confusion. We do agree that most samples are not collected in an unbiased fashion. The sampling at many locations was clearly <u>biased</u>, as pointed out by the commenter. To appropriately use biased data, one must use the data within the areas of biased sampling. As these areas generally were seeking to define completely a suspected area of contamination, the samples only are useful for that location, not area-wide. Therefore, as stated in the RREM, the data from such an area defines the contamination from that area, while other sampling from other areas defines those other areas. Weighing of the samples by geographical area is the most appropriate method to define contamination over an entire release block. We agree that after a removal has been performed, it may be appropriate to lump the larger land area with the remediated area for data analysis.

7. The methodology for assessing the impact of soil contamination on groundwater seems undeveloped and not clearly articulated (page 53-54). Include MCL values along with Guideline Values, I bet the MCL values are what you really pay attention to.

We agree that the methodology for assessing soil contamination impacts on groundwater need better articulation. The text will be revised appropriately.

In initial development of the methodology, MCLs were proposed as an initial screening tool. In response to regulatory comment, where it was stated that Mound Plant needed to examine risk regardless of MCLs, it was agreed to evaluate risk for groundwater regardless whether MCLs were met. MCLs will not be added because they are not used anywhere in the Residual Risk Evaluation for any release block. MCLs are regulatory *limits used with drinking water supplies and are inappropriate to use in a Residual Risk Evaluation.*

8. The text contains unsolicited results, obtained from a crystal ball perhaps. For example, on page 52, second paragraph states that "...this analysis will be used for each Release block RRE to demonstrate that cumulative risks from the air pathway are below levels of concern. This type of language in a methods document is unacceptable and brings into question the credentials of the authors involved in the development of this manual.

   The language in the referenced section will be revised to reflect that risks can be above or below levels of concern.

9. Surface water definitely needs to be included in the risk assessment. The language is too wishy washy on surface water. Again, a crystal ball prediction is given about surface water on page 52.

   We agree that surface water needs to be included in a release block residual risk evaluation. As noted in a previous comment, consideration of sediments within those surface waters will be included. The text will be clarified appropriately. It should be noted that only a few release blocks have surface water within their defined borders.

10. Please include specific guidance for oral absorption factors. What is regional and state guidance (page 49)?

    The RREM will be revised to reflect that no pertinent regional or Ohio EPA guidance exists on this subject. Since very few of the required data are available to accomplish the revision of oral toxicity factors for use with dermal equations, the uncertainty analysis section of individual release block-specific Residual Risk Evaluations will be appropriately revised to acknowledge that dermal risks may be underestimated or overestimated for some compounds.

11. Please state how you intend to "lump" cancer risks from chemicals with radionuclides for assessing Release Block cancer risks. I believe that you cannot compare the two or sum the two risks together.

    Prediction of cancer risk from radionuclides and from carcinogenic organic and inorganic chemicals are fundamentally different. Although there is conflicting USEPA guidance on the subject, these risks are often simply added together. While we agree that it may be technically inappropriate to add such risks together, from a risk management standpoint, it is practical to summarize overall risks. The summation of risk does let risk management decisions be made on the cumulative effects that would be lost if the risks were evaluated individually.

12. Off site migration is not adequately addressed. The exposure scenarios are developed to be protective of the site worker, but do not address residential exposure. For completeness, this aspect of the risk assessment is required.

    The purpose of the Residual Risk Evaluation is to assess potential risks associated with any possible contamination remaining within a release block for a future land use. We *chose to use an onsite construction worker and site employee to reflect industrial land use. The decision to use a future industrial land use risk scenario, made with the City of Miamisburg, reflect the anticipated commercial redevelopment of the site.*

The release block specific Residual Risk Evaluations are not intended to address any potential offsite exposures. Any offsite migration issues will be dealt with after all sources have been addressed on site.

EXECUTIVE SUMMARY

As a result of its past weapons program mission, the U.S. Department of Energy's Mound Plant contains over 400 areas where potential releases of hazardous waste may have occurred (these areas are called potential releases sites). To expedite the cleanup of the Mound Plant and transition it for economic redevelopment, the Department of Energy (DOE), the United States Environmental Protection Agency (USEPA), and the Ohio Environmental Protection Agency (OEPA) have designed a decision-making process known formally as the "removal site evaluation process" and informally as the "Mound 2000 process."

As part of the Mound 2000 process, the Mound Plant property has been parceled into 18 tracts of land called "release blocks," each of which is slated for release (from DOE to another party) at a specific time. Before releasing a release block, a "core team" consisting of representatives from DOE, USEPA, and OEPA reviews the potential release sites within the block and, with input from stakeholders, determines the appropriate action, if any, required for each one. If cleanup of a potential release site is recommended, and stakeholders concur, the cleanup is conducted as a removal action performed under the Comprehensive Environmental Response, Liability, and Compensation Act (CERCLA). After all removal actions within a block are completed, it is necessary to evaluate the human health risks associated with any residual contamination that may remain in the block, to ensure that future users of the land will not be exposed to contamination at levels that would pose unacceptable health risks. Hence, a Residual Risk Evaluation (RRE) will be conducted for each release block prior to transfer of the block from DOE to another party. This document provides the methodology for use in conducting the RRE for each release block. In addition, the Residual Risk Evaluation Methodology (RREM) provides a method for evaluating plantwide residual human health risks.

ACRONYMS & NAMES

ARARs	Applicable or Relevant and Appropriate Requirements
AT	Averaging Time
ATSDR	Agency for Toxic Substances and Disease Registry
BRA	Baseline Risk Assessment
BVA	Buried Valley Aquifer
BW	Body Weight
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CF	Conversion Factor
D&D	Decontamination and Decommissioning
DERR	Division of Emergency and Remedial Response
DOE	Department of Energy
ED	Exposure Duration
EF	Exposure Frequency
FIDLER	Field Instrument for the Detection of Low Energy Radiation
GV	Guideline Value
HAZWRAP	Hazardous Waste Remedial Actions Program
HEAST	Health Effects Assessment Summary Tables
HI	Hazard Index
HQ	Hazard Quotient
IR	Ingestion or inhalation rate
IRIS	Integrated Risk Information System
MEIMS	Mound Environmental Information Management System
MCL	Maximum Contaminant Level
NCP	National Contingency Plan
NFA	No Further Assessment
OEPA	Ohio Environmental Protection Agency
ORNL	Oak Ridge National Laboratory
OU	Operable Unit
PEF	Particulate Emission Factor
PETREX	Trade name of a qualitative soil gas sampling technique
PRGs	Preliminary Remediation Goals
PRS	Potential Release Site
RAGS	Risk Assessment Guidance for Superfund
RCRA	Resource Conservation and Recovery Act
RI/FS	Remedial Investigation/Feasibility Study
RfD	Reference Dose
RME	Reasonable Maximum Exposure
RRE	Residual Risk Evaluation
RREM	Residual Risk Evaluation Methodology
SF	Cancer Slope Factor
SMR	Strategic Milestone Review
TCE	Trichloroethene
UCL	Upper Confidence Limit
UTL	Upper Tolerance Limit
USEPA	United States Environmental Protection Agency
VF	Volatilization Factor
VOC	Volatile Organic Compound

1. INTRODUCTION

DOE Plans to release the Mound property for commercial or industrial use.

The U.S. Department of Energy's Mound Plant is located on a 306-acre parcel of land within the city of Miamisburg, Ohio, about 10 miles southwest of Dayton, Ohio. The plant is located approximately 2000 feet east of the Great Miami River and partially overlies the Great Miami Buried Valley Aquifer (BVA). Since 1948, Mound has operated as a research, development, and production facility in support of DOE's weapons and energy programs. Mound's past weapons program mission included process development, production engineering, manufacturing, and surveillance of detonators, explosives, and nuclear components. Mound's current mission is to support DOE's efforts in environmental management and to transition the site, in cooperation with the city of Miamisburg, from a cold-war production facility to a commercial or industrial park.

The Mound 2000 process is expected to save millions of dollars and expedite cleanup.

Because of past operations, over 400 areas exist at the Mound Plant where potential releases of hazardous waste may have occurred. These areas are called potential release sites (PRSs). Due to the contamination at some of these PRSs, the Mound Plant was placed on the CERCLA National Priorities List (NPL) in November, 1989. Pursuant to the NPL designation, a Federal Facilities Agreement (FFA) was signed by DOE and the U.S. Environmental Protection Agency (USEPA) in October, 1990. The Ohio Environmental Protection Agency (OEPA), signed the FFA in July, 1993. DOE, as the lead agency, initiated the clean-up of the Mound Plant under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). After recognizing that the contamination at the Mound Plant occurs at 400 individual release sites rather than in widespread areas, and thus, does not lend itself well to the conventional clean-up strategy based on operable units, DOE, USEPA, and OEPA developed a new decision-making process for the clean-up of

Mound. The new process, which is expected to save millions of dollars and reduce by years the time required for clean-up, is known formally as a "removal site evaluation process" and informally as the "Mound 2000 process" (Nowka 1995). The Mound 2000 process is consistent with the FFA and CERCLA as defined in the National Contingency Plan (NCP).

The overall goal of the Mound 2000 process is to clean-up the Mound property and release it for economic redevelopment. In order to release portions of the land as early as possible, the Mound property has been divided into "release blocks." A release block is a contiguous tract of the Mound property that is designated for release at a specific point in time. At this time, 18 release blocks have been identified (Figure 1). Releasing the property by release block will allow redevelopment of those portions of property released early in the process while DOE proceeds with the clean-up of the remainder of the Mound Plant property. The release of the Mound property will be staggered over time, with certain parts of the Mound property released for redevelopment while others parts are being cleaned-up. Release block A became available for release in 1995. The next release blocks scheduled for release are release blocks B and D, which will be available for economic development in fiscal 1997. All of the release blocks are scheduled to be cleaned-up and released by 2005.

The Mound 2000 process will release 18 separate parcels of land, called "release blocks" to allow industrial re-use to begin early while cleanup of the remaining blocks continues.

By 2005, all release blocks are scheduled to be cleaned up and released for economic re-development.

In the Mound 2000 process, potential contamination at each of over 400 PRSs is summarized in PRS data packages which are reviewed by a "core team" consisting of representatives of DOE, USEPA, and OEPA. The core team determines, with stakeholder input, the appropriate action to take at each PRS by categorizing ("binning") each PRS into one of the following groups: (1) PRSs that require no further assessment (NFA) based on existing information, (2) sites for which clean-up is warranted, based on existing information, and (3) sites for which there is insufficient information available to make a determination and require some additional

PRSs are categorized by the core team to determine which PRSs require further assessment, which ones need removal actions and which ones are considered no further action.

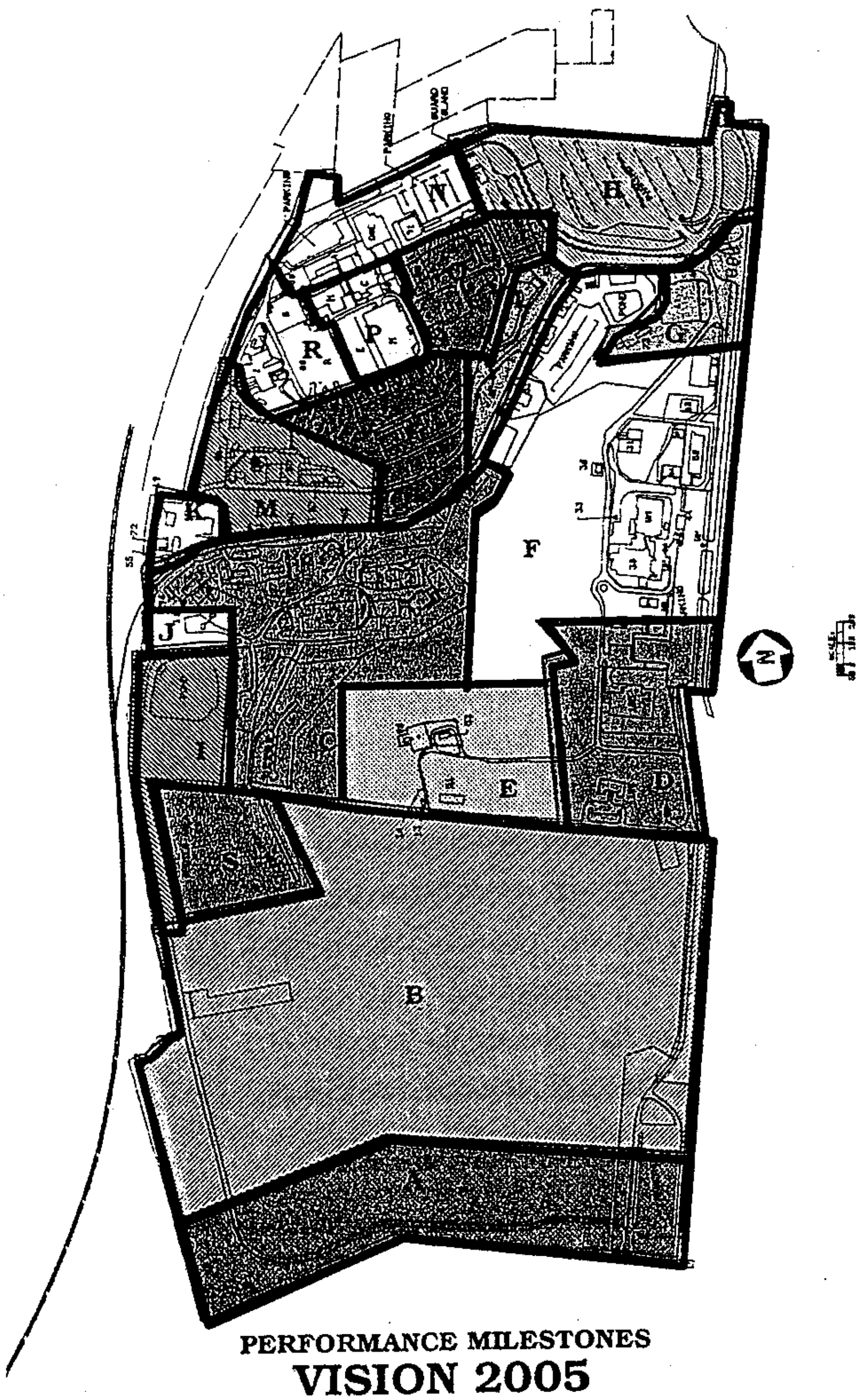
PRSs are summarized in PRS data packages. These data packages summarize all the existing data about a PRS so that the core team can decide on the appropriate course of action.

assessment or information gathering activities. If clean-up of a PRS is recommended and stakeholders concur, the clean-up will be conducted as a CERCLA Removal Action. If there is not enough information available to categorize ("bin") a specific PRS, the core team will recommend that specific additional information about the PRS be collected, or that a removal action be performed, provided that the cost of the removal action is less than the cost of acquiring the additional information. All PRS data packages for PRSs that are binned NFA and for cleanup are available for review in the Public Reading Room. PRSs that need additional information (i.e. sampling) are presented to the public once the additional information is collected and the site is binned NFA or for cleanup.

PRS data packages are available for review in the Public Reading Room.

All PRSs are reviewed by the core team on a release-block by release-block basis. The PRSs are evaluated with the understanding that the Mound Plant site future use will be commercial/industrial, and that the site will not be used for residential purposes. Eventually, all PRSs are categorized as NFA for a commercial/industrial site, either because they required no action initially or because a successful removal action was completed. Once a removal action is complete, however, there may still be residual contamination. It is, therefore, imperative that the risk associated with this residual contamination to future commercial/industrial workers be evaluated to ensure the protection of public health and the environment. The risk associated with residual contamination is calculated assuming the future use of the site is commercial/industrial.

The core team, consisting of DOE, OEPA and USEPA, has agreed that the future use of the site is commercial/industrial, and that the site will not be used for residential purposes. The risks associated with residual contaminants will be evaluated for future commercial/industrial uses.



PERFORMANCE MILESTONES
VISION 2005

Figure 1 Mound Facility location map with release blocks identified.

1.1 Purpose of the Residual Risk Evaluation Methodology

The Residual Risk Evaluation Methodology (RREM) has been developed as a framework for evaluating human health risks associated with residual levels of contamination that remain within a release block after all necessary action is taken and the remaining PRSs are designated as NFA. In the Mound 2000 process, a Residual Risk Evaluation (RRE) will be conducted for each release block prior to transfer of the block from DOE to another party to ensure that future users of the land will not be exposed to contaminant levels that would pose unacceptable risks. The RREM is a tool for conducting the RRE for each release block. In addition, the RREM provides a method for evaluating plantwide residual human health risks.

DOE, in conjunction with its regulatory agencies, has developed an appropriate methodology to determine the health risks caused by residual levels of contamination that remain after all necessary actions within a release block are taken.

Although the RREM is patterned in many respects after the CERCLA baseline risk assessment (BRA) process, it serves a different purpose and, therefore, need not be identical to the CERCLA BRA process. Rather than determining the need for remedial action at a release block, the objective of the RRE is to assess risks associated with residual levels of contamination that remain after all necessary actions within a release block have been taken.

It is important to recognize that the collective knowledge and history of the Mound Plant were considered during the development of the RREM. The RREM is not a "cook-book" approach to quantifying risks; rather, it is a methodology that has been designed specifically for the types of contamination problems that exist at Mound. Although the RREM has been developed specifically for use at Mound, the basic risk evaluation framework can be adapted for use at other sites by modifying the details of the methodology to meet site-specific needs.

1.2 Scope of the Methodology

The RREM is intended to address risks from residual contamination in environmental media. It is not designed to address risks from residual contamination in buildings.

The RREM presented in this report is intended to assess risks associated with residual contamination in soil, surface water, and ground water regulated under CERCLA. The RREM is not intended to assess risks associated with residual contamination in buildings. However, some release blocks may contain buildings that contain residual contamination. For these release blocks, a separate analysis of the health hazards associated with residual building contamination will be performed by the Mound D&D program (as approved by USEPA and OEPA). For this reason, the potential exposures resulting from the future use of a contaminated building (including indoor air exposures) are not included in the RREM. In general the RRE process will wait until all buildings that are scheduled for demolition have been demolished before proceeding. This will allow the inclusion of data from soils and possibly groundwater that may have been previously inaccessible due to the presence of a building. If a building is demolished after the RRE has been performed, data from the newly exposed soils will be evaluated to determine whether the residual risks pose an additional risk. This analysis will be published as an addendum to the original RRE.

1.3 Organization of the Report

This section describes the organization of this report. Chapter 1 provides background information about the Mound Plant and the Mound 2000 process. In addition, the purpose and scope of the RRE are presented in Chapter 1. Chapter 2 provides a detailed description of the methodology for the release block residual risk evaluation. Chapter 3 discusses the methodology for plantwide residual risk evaluation. The Appendix provides approved background contaminant levels for use in determining contaminants to be evaluated in the RRE (discussed in Section 2.1.2).

2. RELEASE BLOCK RESIDUAL RISK EVALUATION METHODOLOGY

The release block RRE consists of five elements. These elements are:

1. identification of contaminants to be evaluated,
2. exposure assessment,
3. toxicity assessment,
4. risk characterization, and
5. evaluation of potential cumulative risks.

The following sections describe these elements in detail. Section 2.1 discusses the identification of contaminants to be evaluated in the RRE, including methods for screening of contaminants. Section 2.2 describes methods to be used for exposure assessment. A discussion of toxicity assessment methods is presented in Section 2.3. Section 2.4 discusses integrating exposure and toxicity information to develop measures of risk characterization. Section 2.5 presents steps for evaluating potential cumulative risks.

2.1 Identifying Contaminants to be Evaluated

This section describes the process for collecting and using data to identify contaminants to be evaluated in the RRE. In a nutshell, this process involves identifying all contaminants detected in the release block and then eliminating contaminants from consideration based upon a set of pre-established criteria (e.g., whether the contaminant concentration in the release block is below background environmental levels). The steps of this process are described in the following sections, and the process is summarized in the flow diagram presented in Figure 2.

Collect all data relevant to residual contamination levels within the release block.

For each release block, the first step in identifying contaminants to be evaluated in the RRE is to gather existing data regarding residual contaminant levels. These data include all sampling data available for each of the PRSs in the release block, including but not limited to, original PRS packages, close-out documentation for PRSs that underwent removal actions (including verification sampling), reports of all sampling that may have been undertaken to categorize (i.e., bin) PRSs, and any calculations made to estimate the potential for leaching of contaminants from the soil to the ground water (i.e., "leaching equation" results). In general, all information that qualitatively and quantitatively describes the residual contamination within the release block will be collected. Historical information describing the past uses of the release block is also required.

All relevant historical data will be used except for FIDLER, PETREX, and soil gas measurements.

An audit of Mound's Soil Screening Facility was performed in the fall of 1995 to evaluate the quality and potential limitations of the historical sampling data currently available at Mound. The purpose of the Soil Screening Facility at Mound is to screen soil samples for radiological contamination. The samples are screened for thorium-232 contamination and plutonium-238 contamination using sodium iodide detectors. The findings of the audit are documented in the "Summary, Audit of Soil Screening Facility and Environmental Radiochemistry Laboratory; U.S. DOE Mound Plant, Miamisburg, Ohio" (Revision 0, December 14, 1995)..

After reviewing the audit findings, the quality of the available data, and the intended uses of the data in the RRE, the core team determined that all

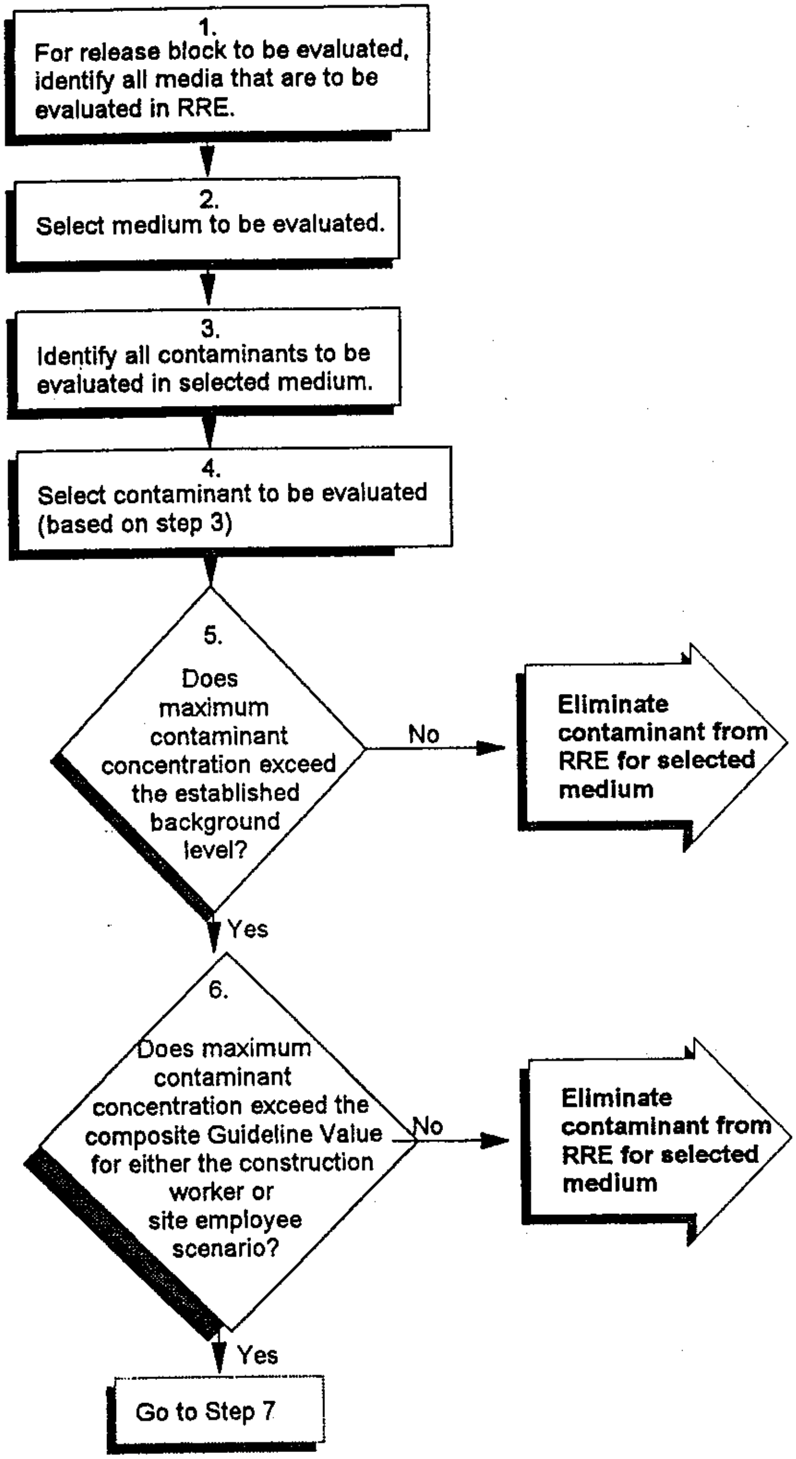


Figure 2 Process for selecting contaminants to be evaluated in the RRE.

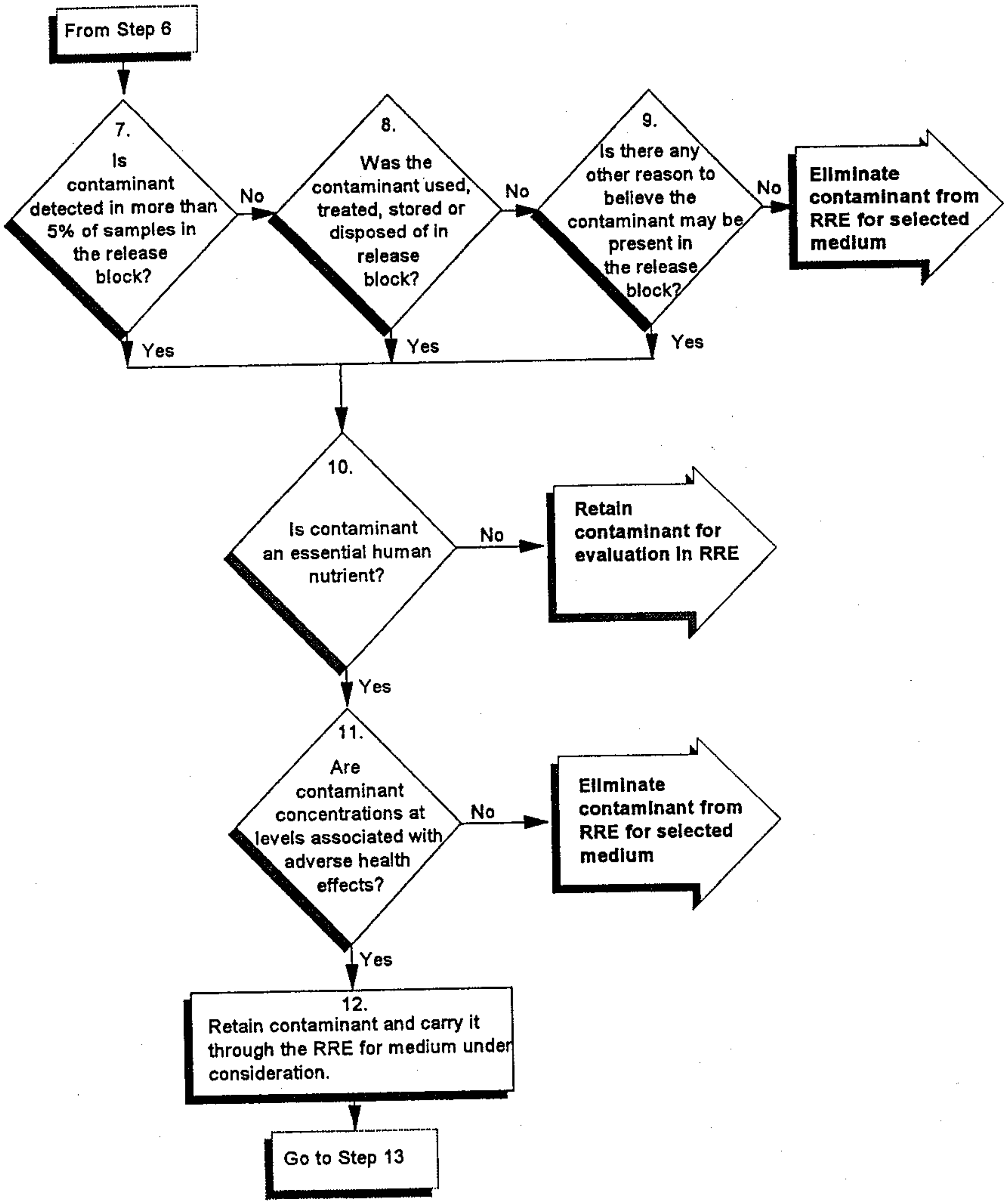


Figure 2 (Continued) Process for selecting contaminants to be evaluated in the RRE

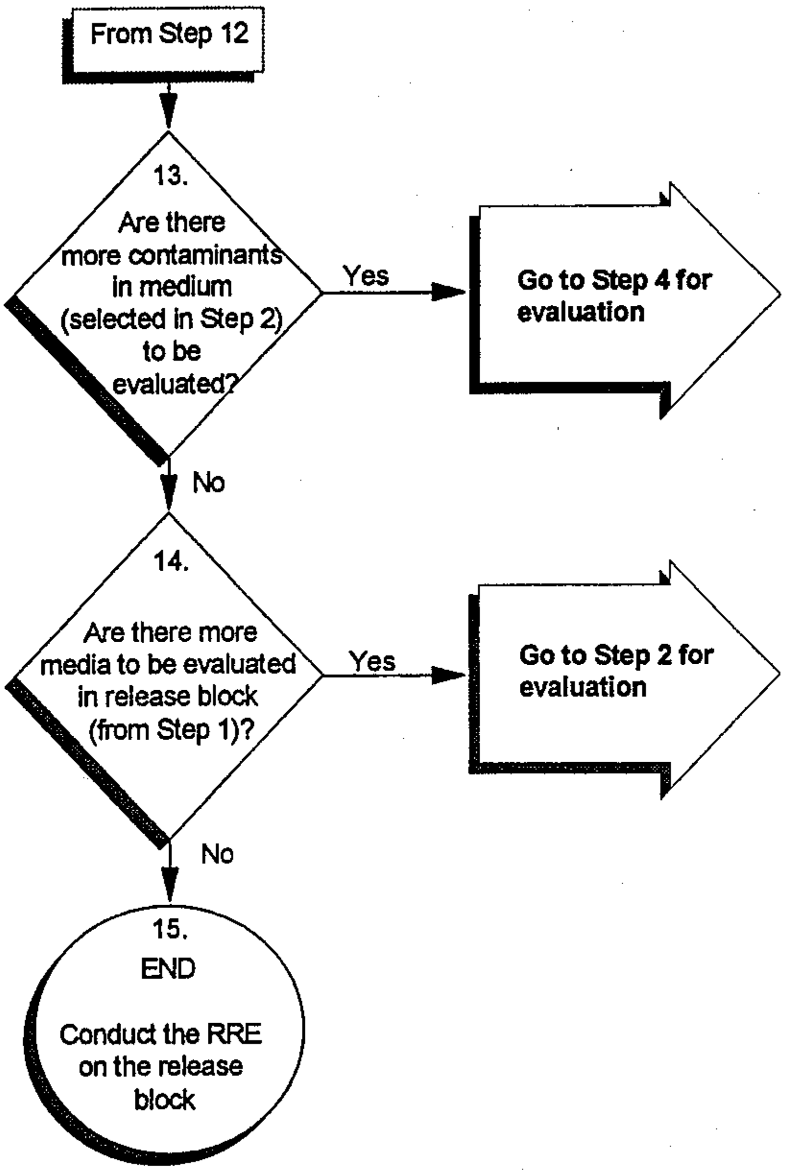


Figure 2 (Continued) Process for selecting contaminants to be evaluated in the RRE

historical soil and ground water sampling data are appropriate for use in the RRE, with the exception of measurements obtained using FIDLER (Field Instrument for the Detection of Low Energy Radiation) and PETREX methods. FIDLER measurements are not useable because FIDLER readings are influenced by many physical factors (such as distance from the soil to the instrument) that render the measurement an approximation too imprecise for use in the RRE. PETREX data are not useable because contamination is measured in relative rather than absolute quantities.

Specific data that are appropriate for use in the RRE include, but are not limited to, data from the Operable Unit 9 Site Scoping Report: Volume 3 (DOE, 1992), past and present quantitative soil concentrations from the Mound Soil Screening Facility, and sampling data from the 1996 soil gas confirmation sampling. Soil concentrations that have been "back-calculated" from soil gas measurements should not be used in the RRE.

The core team recognizes that soil samples assayed in the past at the Mound Soil Screening Facility may not have been weighed and dried according to documented procedure. However, the methods that were used to determine the soil concentrations are designed such that any bias in the sample results is a bias toward overestimation of actual soil concentrations when actual soil concentrations are low (i.e., around 55 pCi/g or lower). For these reasons, any historical Soil Screening Facility results considered for use in the RRE will not underestimate sample concentrations and, therefore, are acceptable for use in the RRE.

Where both laboratory data and soil screening data exist for a particular sample, laboratory data will take precedence, and soil screening data will not be used.

In general, all available sampling data (with the exception of FIDLER and PETREX data, as noted above) will be used in the RRE, with no preference given to older versus newer sampling data. That is, newer data should supplement rather than supersede older data, unless a removal action has occurred (in which case, the older data no longer represent site conditions and should not be used). Furthermore, no preference will be given to sampling data obtained from a commercial analytical laboratory versus data obtained from the Mound Soil Screening Facility, except in the case where a sample has been taken from a single location, subsequently "split," and analyzed independently by both a commercial analytical laboratory and the Mound Soil Screening Facility. In such cases, the value obtained from the commercial analytical laboratory will be used in the RRE, and the value from the Mound Soil Screening Facility will not be used in the RRE. The reason for discarding the Soil Screening Facility data when corresponding analytical data is available is that the laboratory analysis is much more sensitive and can achieve greater precision.

2.1.1 Generating a contaminant summary table

Consolidate data by creating a table that includes all relevant contaminant information.

After gathering data regarding residual contaminant levels, the next step is the generation of an initial table that lists, by medium, all contaminants detected in at least one sample taken within the release block. For each contaminant, the table should include the frequency of detection, the maximum detected value, and the range of detection limits. For PRSs that underwent removal actions, the table must distinguish between the samples taken prior to the removal action and those taken after the removal action. Only those samples taken after the removal action will be used in the RRE.

2.1.2 Screening contaminants based on background levels

Eliminate contaminants by screening out those that do not exceed background levels.

After identifying the initial list of contaminants detected in the release block, the next step in identifying contaminants to be evaluated in the

RRE is screening the list of contaminants based on background levels. A contaminant may be eliminated from the RRE if the release block concentration does not exceed the background concentration. Only contaminants with concentrations that exceed background levels will be carried forward in the RRE (assuming that the contaminants are not eliminated from the RRE based on other factors, as described in Sections 2.1.3 and 2.1.4).

Two basic steps are involved in identifying contaminants that exceed background levels: (1) determining background levels and (2) comparing background levels to release block levels to determine whether release block levels exceed background levels. OEPA Division of Emergency and Remedial Response (DERR) "How Clean is Clean Policy" (Final, January 26, 1991) describes in detail the methods required for these two steps. The process to be used for the RRE, which is adapted from the "How Clean is Clean Policy," is described below.

2.1.2.1 Determining background levels[1].

Because background levels for each medium and class of contaminants have already been determined and approved by OEPA and USEPA for use in the Mound 2000 process, the methods for determining background levels will not be discussed further in this methodology (DOE 1994, 1995a, 1995b) The approved background levels to be used in the RRE are presented in the Appendix of this document. Note that these levels

---

[1] **NOTE:** The background levels for the BVA were re-calculated as an error was discovered in the *Operable Unit 9 Hydrogeologic Investigation: Groundwater Sweeps Report.* The corrected data are presented in the Appendix of this report. The corrected *Operable Unit 9 Hydrogeologic Investigation: Groundwater Sweeps Report* is available for public review in the public reading room.

represent the 95th% upper tolerance limit (UTL) of the background sample results for each contaminant.

2.1.2.2 Comparing release block concentrations with background levels.

In general, if a contaminant is detected at the method detection limit or greater in a release block sample and is not detected in background samples, then contamination is assumed to exist and the contaminant will be evaluated in the RRE. The background concentration in this case is assumed to be zero.

If a release block contaminant is detected in background samples, then the contaminant will be retained in the RRE if at least one sample taken from the release block exists at a concentration greater than the background level. The background level is defined as the mean background concentration plus the product of the tolerance factor and the relative standard deviation (of the background concentrations). The tolerance factor is dependent upon the number of background samples available. For each contaminant and medium, regulator-approved background levels are presented in the Appendix of this document.

In practice, this comparison will be performed using the following steps:

(1) Identify the maximum concentration of each contaminant detected in each medium (e.g., soil and ground water).

(2) If the maximum concentration equals or exceeds the background level as given in the Appendix, the contaminant is retained for evaluation in the RRE for that medium. Otherwise, the contaminant is eliminated from the RRE for that medium.

In summary:

- $C_{rb\,\max} > \bar{x} + k\sigma$

where

C_{rbmax} = *is the maximum detected release block concentration*

$\bar{x}$ = *arithmetic average of the data set*

k = *95% upper tolerance factor*

σ = *standard deviation*

then the contaminant concentration is considered statistically greater than background, and the contaminant is evaluated in the RRE;

- if $C_{rb\,\max} < \bar{x} + k\sigma$

then the contaminant concentration is considered statistically less than background, and the contaminant is not evaluated in the RRE;

where C_{rbmax} is the maximum detected release block concentration and the term $\bar{x} + k\sigma$ is the 95th% UTL as provided in the Appendix.

2.1.3 Screening contaminants based on Guideline Values

Further screen out contaminants by eliminating those that are less than the appropriate risk-based guideline value.

After screening contaminants based on a comparison with background levels and eliminating from consideration those contaminants with levels below background levels, the next step is to screen the remaining contaminants based on a comparison with risk-based Guideline Values (GVs). GVs are media-specific concentrations of contaminants that correspond to certain risk levels and exposure scenarios. GVs for the Mound Plant have been developed by the Hazardous Waste Remedial Actions Program (HAZWRAP) and approved by DOE, USEPA, and OEPA. The GVs can be found in HAZWRAP (1995).

A contaminant can be eliminated from the RRE if its concentration in each release block sample is less than the contaminant-specific GV that corresponds to a risk of 1×10^{-6} (if the contaminant is a carcinogen) or one tenth the GV for noncarcinogens.

In practice, the GV screening can be performed using the following steps:

[1] Identify the maximum concentration of each contaminant detected in each medium (e.g., soil and ground water).

[2] (a) If the contaminant is a carcinogen and the maximum concentration exceeds the GV that corresponds to a risk of 1×10^{-6} for that medium for either the construction worker scenario or the site employee scenario, the contaminant is retained for evaluation in the RRE for that medium. Otherwise, the contaminant is eliminated from the RRE for that medium.

(b) If the contaminant is a noncarcinogen and the maximum concentration exceeds the one tenth the GV that corresponds to a hazard quotient of 1 for that medium for either the construction worker scenario or site employee scenario, the contaminant is retained in the RRE for that medium. Otherwise, the contaminant is eliminated from the RRE for that medium. Note that because the GVs given in HAZWRAP 1995 correspond to a hazard quotient of 1.0, the values need to be divided by ten to obtain values corresponding to a hazard quotient of 0.1. It is possible that a contaminant may be eliminated from the RRE for one medium (e.g., ground water) but not from another medium (e.g., soil) based on the GV screening.

2.1.4 Screening contaminants based on frequency of detection and classification as human nutrients

After screening contaminants based on Guideline Values and eliminating those with concentrations below the relevant Guideline Values, the next step is to screen the remaining contaminants based on frequency of detection and classification as human nutrients. At this point, the only contaminants remaining are those that have not been eliminated based on the comparison with background or the comparison with Guideline Values.

Contaminants can be eliminated from further evaluation if they are detected in less than five percent of samples, are not detected at high concentrations and there is no reason to believe that the compound is present based on the history of the release block.

According to Risk Assessment Guidance for Superfund (RAGS) Part A (EPA 1989), compounds that are infrequently detected may be artifacts in the data due to sampling, analytical, or other problems and, therefore, may not be site-related. A compound may be eliminated from the RRE if it is detected infrequently in all media, is not detected at high concentrations in any medium, and there is no reason to believe that the compound may be present (based on the history of the release block). Infrequent detection is defined as a frequency of detection of five percent or less (this is equivalent to one detect in 20 samples). If an insufficient number of samples exists to determine whether the frequency of detection is five percent or less, then the contaminant cannot be eliminated from the RRE based on frequency of detection. As a rule-of-thumb, at least 20 samples of a medium are needed in order to eliminate a contaminant based on frequency of detection of five percent or less. As discussed in RAGS Part A (EPA 1989), the decision to include or exclude an infrequently detected contaminant will be based on relevant factors such as whether the contaminant is expected to be present based on historical data or any other relevant information (such as known degradation products of contaminants known to be present). Although contaminants that are expected to be present should not be eliminated from the RRE on the basis of frequency of detection, it remains the decision of the core team to determine the appropriateness of eliminating any particular contaminant on this basis.

Compounds that are essential human nutrients need not be included in the RRE if they are present at concentrations that are not associated with adverse health effects. Examples of such compounds include iron, magnesium, calcium, potassium, and sodium. Prior to eliminating a contaminant on this basis, the compound must be shown to be present at levels that are not associated with adverse health effects. Methods for demonstrating the lack of adverse health effects are described in Section 5.9.4 of RAGS Part A (EPA 1989).

Compounds that are essential human nutrients and exist at low concentrations can be eliminated from further evaluation.

2.1.5 Summary of contaminants to be evaluated in RRE

The set of contaminants to be evaluated in the RRE should comprise all contaminants from the initial list (Section 2.1.1) that have not been eliminated by this point; that is, the contaminants to be evaluated in the RRE include those that have not been eliminated based on comparison with background levels (Section 2.1.2), comparison with Guideline Values (Section 2.1.3), frequency of detection (Section 2.1.4), or classification as human nutrients (Section 2.1.4). For documentation in the RRE report, a table that summarizes the contaminant screening process will be prepared. This table should include the name and maximum medium-specific concentration of each contaminant from the initial list, whether each contaminant is to be included or excluded from the RRE, and if excluded, the basis upon which the contaminant was eliminated (including the Guideline Value or background value that triggered the contaminant's elimination).

In some cases there may not be an adequate number of samples to represent the release block statistically. In this case the documented historical knowledge is sufficient to qualitatively establish a relative risk.

2.2 Exposure Assessment

Quantify potential human exposures to contaminants that remain after elimination of contaminants during the screening process.

After determining the contaminants to be evaluated in the RRE based on the methods presented in Section 2.1, the next step in the RRE is quantifying potential contaminant exposures. The goal of the exposure assessment is to estimate the type and magnitude of contaminant exposures that may be incurred by an individual located within the release block under consideration. This information is integrated with toxicity information to characterize the potential risks associated with contaminant exposure. This section discusses exposure scenarios, exposure parameters, and equations used to quantify contaminant exposure.

2.2.1 Identifying exposure scenarios

The RRE focuses on those pathways most likely to occur in a commercial or industrial setting.

A conceptual model for human exposures has been prepared as part of this methodology to identify potential human exposure scenarios that will be evaluated in the RRE. The conceptual model, presented in Figure 3, summarizes the pathways that hazardous substances may take to reach potential receptors. Although many pathways are possible, the RRE focuses on those pathways that are likely to occur and likely to contribute significantly to the overall risk. Because DOE and its regulators and stakeholders agree that the future use of the Mound Plant property will be commercial/industrial use, receptor scenarios were selected that represent reasonable exposures in a commercial/industrial setting. Hence, two receptor scenarios have been developed for use in the RRE: the construction worker scenario and the site employee scenario. These scenarios are site-specific adaptations of the standard scenarios presented in the Risk Assessment Guidance for Superfund (RAGS).

RAGS Part A (EPA 1989) recommends the evaluation of exposures based on a reasonable maximum exposure (RME) scenario. The RME is intended to represent a reasonably conservative depiction of potential exposure scenarios, but not the worst case. The construction worker and site employee scenarios presented in this methodology are consistent with the RME concept because (1) the scenarios represent exposures that are reasonably expected to occur at the Mound property and (2) the intake variables used for quantification of potential exposure for these exposure scenarios are conservatively selected such that the exposures represent a reasonable maximum exposure.

The RRE is consistent with EPA's Risk Assessment Guidance for Superfund in that it evaluates exposures based on a reasonable maximum exposure.

In general, the RRE will be limited to the evaluation of risks associated with only the construction worker and site employee scenarios. However, it is recognized that certain release blocks may have unique characteristics that would allow other types of exposures to be feasible (e.g., potential exposures at the seeps located outside the Mound property line). Additional exposure scenarios may be developed for these release blocks on a case-by-case basis. In cases where additional exposure scenarios are used, risks must be calculated and presented for both the additional scenarios and the construction and site employee scenarios.

In general, only the construction worker and the site employee scenario are evaluated. Other exposure scenarios may be evaluated on a case-by-case basis.

An individual located within a specific release block (i.e., either the construction worker receptor or site employee receptor) may potentially be exposed to contaminants originating from several locations, including:

- contaminants located within the boundaries of the release block under consideration. Risks from these exposures are addressed in Sections 2.1 through 2.4 of this document.

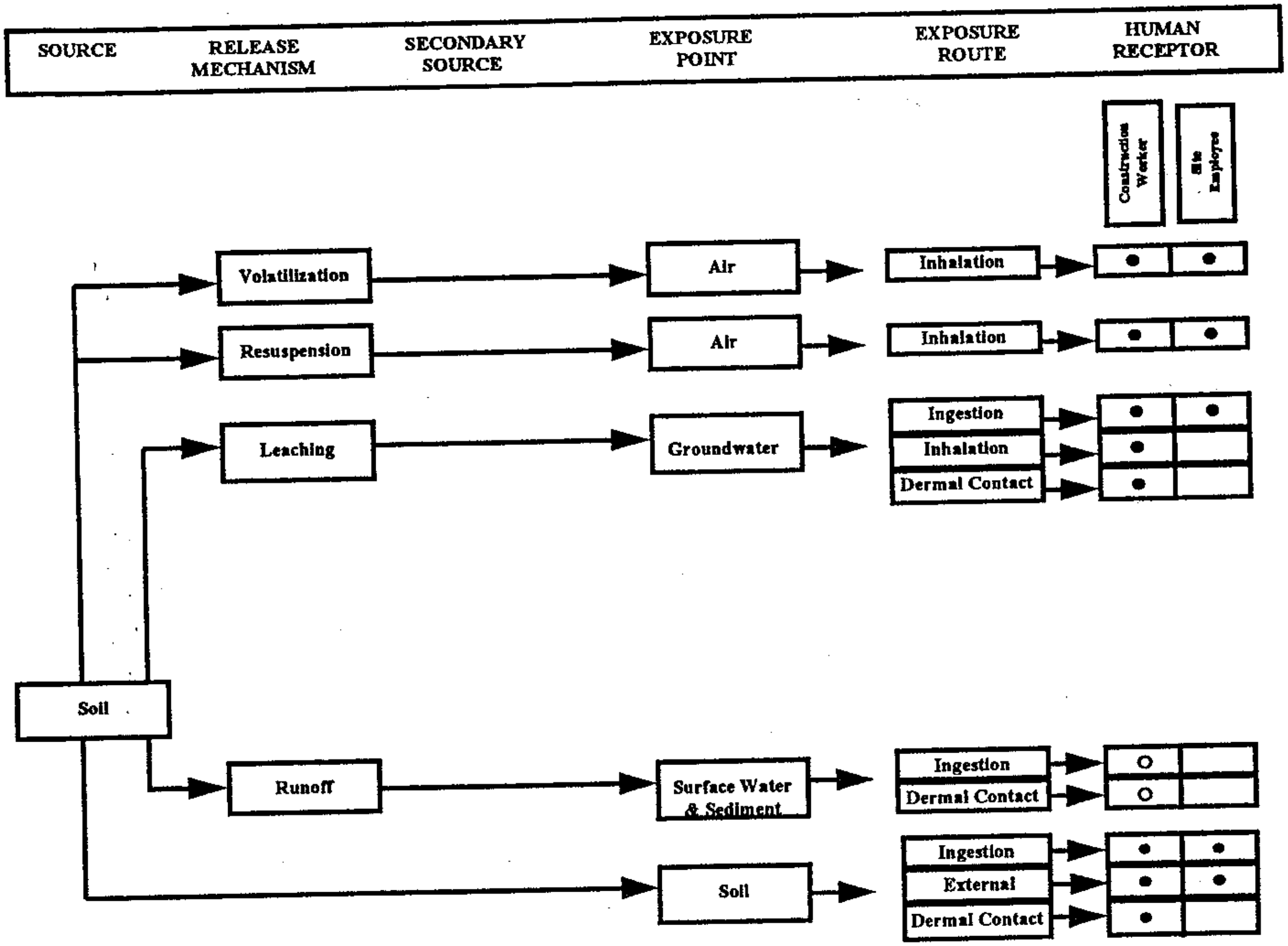
- contaminants from other release blocks that may migrate or be transported to the release block under consideration.

Examples of these exposures include exposures to airborne contaminants migrating from nearby release blocks and exposures to contaminants from other release blocks that have migrated to the BVA, which is the assumed drinking water source for the release block under consideration. Risks from these exposures, called "cumulative risks," are addressed in Section 2.5 of this document.

2.2.1.1 Construction Worker Scenario

It is reasonable to assume that construction activities will occur in the future on the Mound property as new commercial or industrial activities commence once the land has been released. These construction activities could result in worker exposures to residual surface soil, subsurface soil, ground water contamination, and in some release blocks which contain creeks or ponds, sediment and surface water. This scenario characterizes the potential exposure of a construction worker assumed to work on the property eight hours per day for 250 days per year over a five year period. Since construction workers are assumed to be adults, a body weight of 70 kg is used to evaluate both carcinogenic and noncarcinogenic contaminants

Both a current and future exposure scenario will be evaluated for the construction worker scenario. The current and future scenarios include the evaluation of the same exposure pathways with the exception of the ground water exposure pathways. In the current scenario, risk from ground water exposure is estimated using measurements of current ground water contaminant concentrations (in the BVA). In the future scenario,



- • Probable Pathway
- o Potential Pathway

Figure 3 Residual Risk Evaluation exposure scenarios the risk from ground water exposure is calculated using estimates of future ground water contaminant concentrations.

The exposure pathways to be evaluated for the construction worker, for both current and future scenarios, include:

Direct soil exposure pathways

Exposure pathways that will be evaluated include:

- inadvertent ingestion of small amounts of contaminated soil,
- external exposure to ionizing radiation from radionuclides in soil, and
- dermal contact to contaminants in soil.

The parameters used to evaluate soil exposure pathways and their references are provided in Table 1.

Direct sediment exposure pathways

Exposure pathways that will be evaluated include:

- inadvertent ingestion of small amounts of contaminated sediment,
- external exposure to ionizing radiation from radionuclides in sediment, and
- dermal contact to contaminants in sediment.

Guidance from RAGS suggests the use of sediment monitoring data to estimate exposure concentrations rather than surface water concentrations because sediment monitoring data "can be expected to provide better temporal representativeness than surface water". Since models for soil erosion releases are equally applicable for estimating exposure concentrations for sediment, the values for soil provided in Table 1 will be used.

Air exposure pathways

The potential air exposure pathways include:

- inhalation of airborne contaminated soil particulates, and
- inhalation of volatile emissions from soil.

Airborne contaminants may originate from the release block under consideration or from other nearby release blocks. The evaluation of risks from airborne contaminants from release blocks other than the release block under consideration is addressed in Section 2.5.1. The parameters used to evaluate air exposure pathways and their references are provided in Table 1.

Surface water exposure pathways

Due to the ephemeral nature of potential surface water exposures, USEPA has concluded in RAGS that "In general, use sediment monitoring data to estimate exposure concentrations. Sediment monitoring data can be expected to provide better temporal representativeness than surface water concentrations". Therefore exposure to surface water will be approximated by the Direct Sediment Exposure Pathway.

Ground water exposure pathways

The potential ground water exposure pathways that should be evaluated include:

- ingestion of contaminated ground water as drinking water,
- inhalation of volatile contaminants from showering in contaminated ground water while at work, and
- dermal contact with contaminated ground water during showering.

Table 1 Exposure parameters for quantifying contaminant

Variable	Definition	Value Used	Source
IR	Daily water ingestion rate	1.0 L/d (both scenarios)	EPA 1991a
K	Volatilization factor	0.0005×1000 L/m^3 (construction worker only)	EPA 1991b
IR_{air}	Daily inhalation rate	20 m^3/d (both scenarios)	EPA 1991a
IR_{soil}	Daily soil ingestion rate	480 mg/d (construction worker) 50 mg/d (site employee)	EPA 1991a
SA	Skin surface area available for contact	19,400 cm^2 during showering (construction worker only)	Whole body, EPA/600/8-89/043
		5000 cm^2 during incidental contact (construction worker only)	EPA Dermal Risk Assessment Supplemental Guidance, Aug. 1992
K_p	Permeability coefficient	chemical-specific (cm/hr) (construction worker only)	Literature
ET	Exposure time for shower	0.167 hr/d (construction worker only)	EPA Dermal Risk Assessment Supplemental Guidance, Aug. 1992
EF	Exposure frequency	250 d/yr. (both scenarios)	EPA 1991a

Variable	Definition	Value Used	Source
ED	Exposure duration for all pathways except external exposure	5 yr. (construction worker) 25 yr. (site employee)	Core Team; EPA 1991a
ED_{ex}	Exposure duration for external exposure pathway only	5 yr. × 0.685 (construction worker) 25 yr. × 0.685 (site employee)	Core Team; EPA 1991a $0.685 = \frac{250\ d/yr}{365\ d/yr}$
BW	Body weight	70 kg (both scenarios)	EPA 1991a
AT	Averaging time	70 yr. (carcinogens, both scenarios) exposure duration (noncarcinogens, both scenarios)	EPA 1991a
VF	Soil-to-air volatilization factor	chemical-specific (m^3/kg) (both scenarios)	EPA 1991b, EPA 1992d
PEF	Particulate emission factor	$4.28 \times 10^9\ m^3/kg$ (both scenarios)	EPA 1991b
S_e	Gamma shielding factor	0.1 (unitless) (construction worker) 0.2 (unitless) (site employee)	EPA 1991b, EPA 1992d
T_e	Gamma exposure time factor	1/3 (unitless) (construction worker) 1/12 (unitless) (site employee)	EPA 1991b, EPA 1992d

Assessing the risks associated with exposure to contaminated ground water requires estimating both the risk from current ground water contamination and the risk from potential future ground water contamination. As stated above, the need to evaluate both current and future ground water risks is the basis for including both a current and future construction worker scenario in the RRE. Currently, all ground water used at Mound is drawn from the production wells located in the southwestern portion of the property. Hence, the risk posed by current ground water contamination (i.e., the ground water risk associated with the current construction worker scenario) is the risk resulting from exposure to contaminants found in the production wells. This risk is identical for all release blocks and represents a cumulative risk from contamination that migrates to the BVA from multiple release blocks. Because this risk is not due to contamination located within the release block itself, it is considered a cumulative risk and is addressed in Section 2.5.3. Similarly, because future ground water risk (i.e., ground water risk associated with the future construction worker scenario) will be caused by exposure to contaminants that have migrated to the BVA from multiple release blocks, the future ground water risk is considered a cumulative risk and is addressed in Section 2.5.3. Specific exposure parameters that will be used to evaluate the ground water exposure pathway and their references are provided in Table 1.

Surface water exposure pathways

Ingestion of surface water as drinking water is not considered a probable pathway because (1) all current onsite drinking water is ground water drawn from the BVA and (2) any probable future drinking water source will be the BVA and not surface water. However, incidental ingestion of surface water and dermal contact with surface water are possible. The need to evaluate incidental ingestion of and dermal exposure to surface water will be determined on a case-by-case basis. It is expected that these surface water exposures will be a potential concern only for those release blocks with current surface water bodies, including release blocks C, F, J, I, and blocks containing seeps. The potential for cumulative risks from surface water is considered negligible, as discussed in Section 2.5.2.

2.2.1.2 Site Employee Scenario

Although exposures will vary depending on the type of work performed, it is reasonable to assume that future employees at the Mound property will be exposed to residual contamination left on the property. The exposure routes evaluated for the site employee scenario are similar to the those for the construction worker, but the site employee is assumed to ingest smaller amounts of soil. In addition, it is assumed that the site employee does not shower in water from a well on the property and works for eight hours per day for 250 days per year over a 25-year period. As with the construction worker scenario, the site employee scenario will be evaluated for both a current and future scenario, with the only difference being the use of current versus predicted future ground water concentrations in the ground water exposure pathways. The exposure pathways evaluated for the site employee for both current and future scenarios include:

Direct soil exposure pathways

The potential direct soil exposure pathways that should be evaluated include:

- inadvertent ingestion of small amounts of contaminated soil, and
- external exposure to ionizing radiation from radionuclides in soil.

The site employee scenario assumes that a worker will be employed in an office or commercial setting, with the majority of working hours spent indoors. Such occupations are not expected to involve direct work with surrounding soils, as would be expected with the construction worker scenario. As a result, potential dermal exposure to soils would be minimal or non-existent. Hence, it can reasonably be assumed that dermal contact is not a viable pathway for the site employee scenario. The parameters used to evaluate soil exposure pathways and their references are provided in Table 1.

Air exposure pathways

The potential air exposure pathways include:

- inhalation of airborne contaminated soil particulates, and
- inhalation of volatile emissions from soil.

As with the construction worker scenario, potential cumulative risks from airborne contaminants originating from release blocks other than the release block under consideration are addressed in Section 2.5.1. The parameters used to evaluate air exposure pathways and their references are provided in Table 1.

Ground water exposure pathways

The potential ground water exposure pathways that should be evaluated include:

- ingestion of contaminated ground water as drinking water.

It is assumed that the site employee drinks one liter of water per day from a ground water well on the property but does not shower while at work. As described above under the construction worker scenario, assessing risks associated with exposure to contaminated ground water requires estimating risks from current ground water contamination and potential future ground water contamination. These ground water risks are considered cumulative risks and are addressed in Section 2.5.3. The specific exposure parameters that will be used to evaluate ground water exposure pathways and their references are provided in Table 1.

Surface water exposure pathways

Ingestion of surface water as drinking water is not considered a potential pathway because (1) all current onsite drinking water is ground water drawn from the BVA and (2) any probable future drinking water source will be the BVA and not surface water. Furthermore, site employees are not expected to have dermal contact with or incidental ingestion of surface water.

2.2.2 Estimating release block exposure concentrations

Before exposure can be quantified, exposure concentrations must be calculated for each contaminant.

The exposure concentration represents the concentration of a contaminant across the release block and is used to quantify the intake of contaminant by each receptor. Exposure concentrations are derived from data collected during sampling of the release block. The following paragraphs describe the procedure for calculating the exposure concentration. For all release block exposures (i.e., those exposures resulting from contaminants located within the release block under consideration), the contaminant-specific exposure concentration is the representative soil concentration of the contaminant across the release block. This exposure concentration is used to estimate contaminant intake for all release block exposures using the equations presented in Section 2.2.3. The exposure concentrations used to calculate cumulative risks are discussed in Sections 2.5.1 through 2.5.3. Because there are minor differences in calculating the exposure concentration between the two receptor scenarios, the method for each receptor scenario is presented separately.

2.2.2.1 Exposure concentration for the construction worker scenario

For each contaminant that has been identified for inclusion in the RRE, all available soil sampling data will be used to calculate the exposure point concentration, with the exception of (1) FIDLER results, (2) PETREX results, and (3) analytical results from samples collected at locations that have been subsequently removed as a result of a PRS-specific removal action. Both subsurface and surface soil samples will be used to estimate the exposure concentration. Soil concentrations that have been "back-calculated" from soil gas measurements are not considered quantitative sampling data and should not be used to calculate exposure concentrations. All available soil samples will be used to calculate the exposure concentration even if the soil samples are located in close proximity to or under a building.

Once all relevant sampling data have been collected, the next step is to quantify the exposure concentration for each contaminant in accordance with USEPA's "Supplemental Guidance to RAGS: Calculating the Concentration Term" (EPA 1992c). In general, sampling data from Superfund sites have shown that data sets with fewer than 10 samples per exposure area provide poor estimates of the mean concentration, while data sets with 10 to 20 samples per exposure area provide somewhat better estimates of the mean, and data sets with 20 to 30 samples provide fairly consistent estimates of the mean (i.e., the 95 percent UCL is close to the sample mean).

Because environmental data at the site may have been collected as stratified samples from several different sampling events that tried to either refine a potential contaminant location or to verify a clean up, it may be important to group data into *non-overlapping* geographic sampling groups if the data permits (Gilbert, 1987 Chapter 5

In general, most large environmental contaminant data sets from soil sampling are lognormally distributed rather than normally distributed (EPA 1992c). In most cases, it is reasonable to assume the soil sampling data are lognormally distributed. However, in cases where there is a question about the distribution of the data set, a statistical test should be used to identify whether the data set is normally or lognormally distributed. Plotting data on probability plots to determine normality (Isaaks *et al*, 1989) or using the W-test (Gilbert, 1987) are two such tests. The equations for calculating the UCL of the arithmetic mean for a lognormal distribution are presented in Gilbert, 1987 and EPA, 1992c.

In general the exposure concentration for the contaminant is the 95th% upper confidence limit (UCL) of the arithmetic mean of all available samples within a data set. If the 95th% UCL of the arithmetic mean exceeds the maximum detected concentration, the 95th% UCL is generally not considered a satisfactory indicator of the mean concentration. This situation may occur when few samples are available or when the samples are highly variable. For cases in which the 95th% UCL of the arithmetic mean exceeds the maximum detected concentration, the spatial and temporal distribution of the contaminants will be carefully evaluated to determine the most appropriate concentration to use as the exposure concentration. For these cases, the maximum detected concentration will be used as the exposure concentration unless there is consensus among DOE, USEPA, and OEPA that a different value is more appropriate.

In calculating the 95th% UCL of the arithmetic mean, values listed as nondetects will be quantified as one-half the detection limit unless the contaminant was not detected at all within the release block (in which case the contaminant should have already been eliminated from the RRE).

In cases where the 95% UCL of the arithmetic mean falls below the maximum detected value, the 95% UCL is compared to background to determine whether the 95% UCL is below background. If the 95% UCL is below the background value for a contaminant, the contaminant is not carried forward through the rest of the RRE process because the incremental risk would actually be a "negative" risk.

An alternate geostatistical approach, called kriging, may be utilized where appropriate and with the consensus among DOE, USEPA, and OEPA to obtain the appropriate geostatistical averages that can be utilized in the Risk Evaluation Process. This approach examines the spatial distribution of sample results and weights the results to achieve a site average that best reflects the physical distribution of the data. Unlike classical statistics, spatially biased data sets may be used without adversely affecting the statistical results (Isaaks *et al*, 1989).

2.2.2.2 Exposure concentration for the site employee scenario

Exposure concentrations for the site employee scenario will be calculated in the same manner as those calculated for the construction worker scenario except that only surface samples (above 24" in depth) will be used to calculate the exposure concentration for the following pathways:

- soil ingestion
- inhalation of resuspended particulates, and
- external exposure to ionizing radiation.

Exposure concentrations for inhalation of volatile contaminants from soil will be based on both surface and subsurface soil samples.

2.2.3 Exposure equations and parameters

Exposures are quantified by estimating the intake of each contaminant for each receptor. The equations for calculating contaminant intake differ depending on the exposure route. The equations needed for the exposure routes considered in the RRE are presented in this section. The exposure parameters to be used in conjunction with the exposure equations are provided after the equations in Table 1.

Once contaminant exposure concentrations have been calculated, the intake of each contaminant by each receptor must be estimated.

2.2.3.1 Nonradioactive contaminants

Standard EPA equations for exposure and risk assessment, as presented in RAGS Part A (EPA 1989), are the basis for all calculations of intake, with appropriate conversion factors where necessary. The basic equation for calculating intakes from ingestion (of soil or water) or inhalation is:

$$\text{Intake} = \frac{C \times IR \times EF \times ED \times CF}{BW \times AT}$$

where:

C	=	concentration of chemical in the medium
IR	=	ingestion or inhalation rate
EF	=	exposure frequency (d/yr.)
ED	=	exposure duration (yr.)
CF	=	conversion factor (as appropriate)
BW	=	body weight (kg)
AT	=	averaging time (yr. × 365 d/yr.)

Concentration units for chemicals in soil, water, and air are typically mg/kg, mg/L, and mg/m^3, respectively. Ingestion rates are typically expressed in units of mg/d for soil ingestion and L/d for water ingestion. Inhalation rates are expressed in units of m^3/d. This basic equation will be used in the RRE to calculate intakes from soil ingestion and ground water ingestion.

The following equation will be used in the RRE to calculate contaminant intake from inhalation of contaminants that have volatilized from the soil:

$$\text{Intake (mg / kg - d)} = \frac{C_{air} \times IR_{air} \times EF \times ED}{BW \times AT}$$

where:

$$C_{air} = C_{soil} \times \frac{1}{VF}$$

C_{air}	=	contaminant concentration in air (mg/m^3)
C_{soil}	=	contaminant concentration in soil (mg/kg)
IR_{air}	=	inhalation rate (m^3/d)
EF	=	exposure frequency (d/yr.)
ED	=	exposure duration (yr.)
VF	=	soil-to-air volatilization factor (m^3/kg)
BW	=	body weight (kg)
AT	=	averaging time (yr. × 365 d/yr.)

The following equation will be used in the RRE to calculate contaminant intake from inhalation of contaminants bound to airborne soil particles:

$$\text{Intake (mg / kg - d)} = \frac{C_{air} \times IR_{air} \times EF \times ED}{BW \times AT}$$

where:
$$C_{air} = C_{soil} \times \frac{1}{PEF}$$

C_{air}	=	contaminant concentration in air (mg/m^3)
C_{soil}	=	contaminant concentration in soil (mg/kg)
IR_{air}	=	inhalation rate (m^3/d)
EF	=	exposure frequency (d/yr.)
ED	=	exposure duration (yr.)
PEF	=	particulate emission factor (m^3/kg)
BW	=	body weight (kg)
AT	=	averaging time (yr. × 365 d/yr.)

The following equation will be used in the RRE to calculate absorbed doses from dermal exposures to water:

$$\text{Dermally absorbed dose (mg / kg - d)} = \frac{DA_{event} \times EV \times EF \times SA \times ED}{BW \times AT}$$

where:

$$\text{(for organics) } DA_{event} = 2 \times K_p \times C_w \times 10^{-3}\frac{L}{cm^3} \times \sqrt{\frac{6 \times T x \times t_{event}}{\pi}}$$

$$\text{(for inorganics) } DA_{event} = K_p \times C_w \times t_{event} \times 10^{-3}\frac{L}{cm^3}$$

C_w	=	contaminant concentration in water (mg/L)
K_p	=	chemical-specific permeability coefficient (cm/hr)
SA	=	skin surface area available for contact (cm^2)
T	=	chemical-specific lag time (hr)
t_{event}	=	duration of exposure event (hr)
EV	=	events per day (d^{-1})
EF	=	exposure frequency (d/yr.)
ED	=	exposure duration (yr.)

BW = body weight (kg)

AT = averaging time (yr. × 365 d/yr.)

The following equation will be used in the RRE to calculate absorbed doses from dermal exposures to soil:

$$\text{Dermally absorbed dose (mg / kg - d)} = \frac{DA_{event} \times EF \times SA \times ED}{BW \times AT}$$

$$DA_{event} = C_{soil} \times AF \times ABS \times CF$$

where:

C_{soil} = contaminant concentration in soil (mg/kg)

AF = adherence factor of soil to skin (mg/cm^2-event)

SA = skin surface area available for contact (cm^2)

ABS = chemical-specific absorption factor (dimensionless)

EF = exposure frequency (events/yr.)

ED = exposure duration (yr.)

BW = body weight (kg)

AT = averaging time (yr. × 365 d/yr.)

CF = conversion factor (10^{-6} kg/mg)

The following equation will be used in the RRE to calculate contaminant intake from inhalation during showering:

$$\text{Intake (m / kg - d)} = \frac{C_w \times K \times IR_{air} \times EF \times ED \times ET \times CF}{BW \times AT}$$

where:

C_w = chemical concentration in water (mg/L)

K = volatilization factor (L/m^3)

IR_{air}	=	inhalation rate (m^3/d)
EF	=	exposure frequency (d/yr.)
ED	=	exposure duration (yr.)
ET	=	exposure time (hr/d)
CF	=	conversion factor (1 d/24 hr)
BW	=	body weight (kg)
AT	=	averaging time (yr. × 365 d/yr.)

2.2.3.2 Radioactive contaminants

Calculating exposures from radioactive contaminants requires the use of a different set of equations. Unlike estimates of intake for nonradioactive contaminants, the intake estimates for radionuclides represent a total intake over a lifetime and, thus, are not divided by body weight and averaging time. The basic equation for calculating intakes from ingestion (of soil or water) is:

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

where:

C	=	radionuclide concentration in water or soil (pCi/L or pCi/g)
IR	=	ingestion rate (mg/d or L/d)
ED	=	exposure duration (yr.)
EF	=	exposure frequency (d/yr.)
CF	=	conversion factor (as appropriate)

This basic equation for radionuclide intake will be used in the RRE to calculate radionuclide intakes from soil ingestion and ground water ingestion.

The following equation will be used in the RRE to calculate intake from inhalation of radionuclides that volatilize from soil:

$$\text{Intake (pCi)} = C_{air} \times ED \times EF \times IR_{air}$$

$$C_{air} = C_{soil} \times \frac{1000g}{kg} \times \frac{1}{VF}$$

where: C_{air} = concentration of contaminant in air (pCi/m^3)

C_{soil} = concentration of contaminant in soil (pCi/g)

ED = exposure duration (yr.)

EF = exposure frequency (d/yr.)

IR_{air} = inhalation rate (m^3/d)

VF = chemical-specific volatilization factor (m^3/kg)

The following equation will be used in the RRE to calculate the intake from inhalation of radionuclides bound to airborne soil particles:

$$\text{Intake (pCi)} = C_{air} \times ED \times EF \times IR_{air}$$

$$C_{air} = C_{soil} \times \frac{1000g}{kg} \times \frac{1}{PEF}$$

where: C_{air} = concentration of contaminant in air (pCi/m^3)

C_{soil} = concentration of contaminant in soil (pCi/g)

ED = exposure duration (yr.)

EF = exposure frequency (d/yr.)

IR_{air} = inhalation rate (m^3/d)

PEF = particulate emission factor (m^3/kg)

The following equation will be used in the RRE for calculating external exposure to gamma radiation:

$$IR_{ext} = CS \times T_e \times (1 - S_e) \times ED$$

where:

IR_{ext}	=	external exposure contact rate (pCi-yr./g)
CS	=	radionuclide concentration in soil (pCi/g)
T_e	=	gamma exposure time factor (unitless)
S_e	=	gamma shielding factor (unitless)
ED	=	exposure duration (yr.)

The following equation will be used in the RRE to calculate intake for tritium from inhalation during showering:

$$\text{Intake (pCi)} = C_w \times IR_{air} \times EF \times ED \times M_{total} \times \frac{L}{1000g}$$

where

C_w	=	tritium concentration in water (pCi/L)
IR_{air}	=	inhalation rate (m^3/d)
EF	=	exposure frequency (d/yr.)
ED	=	exposure duration (yr.)
M_{total}	=	airborne mass concentration of water in shower (66.96 g/m^3) (HAZWRAP, 1995)
ET_s	=	shower duration (hr/d)

Tritium is the only radionuclide present at the Mound Plant that is volatile enough that its vapor needs to be considered for inhalation. The following equation will be used in the RRE to calculate intake of radionuclides from dermal contact with water:

$$\text{Intake (pCi)} = C_w \times SA \times K_p \times EF \times 1000 \times \frac{L}{m^3} \times ED \times ET$$

where

C_w	=	concentration of contaminant in water (pCi/L)

SA	=	surface area of body available for contact (m^2)
K_p	=	chemical-specific permeability constant (m/hr)
EF	=	exposure frequency (d/yr.)
ED	=	exposure duration (yr.)
ET	=	duration of event (hr/d)

2.2.3.3 Exposure parameters

The exposure equations used in the RRE require multiple exposure parameters. The exposure parameters that will be used in the RRE are provided in Table 1.

2.3 Toxicity Assessment

After estimating contaminant intake, a toxicity assessment should be performed for use in risk characterization.

The purpose of the toxicity assessment is (1) to identify potential adverse effects associated with exposure to release block-related substances and (2) to estimate, using numerical toxicity values, the likelihood that these adverse effects may occur. In practice, the toxicity assessment involves identifying the appropriate numerical toxicity values for use in estimating health risks. Toxicity values used in the RRE include slope factors (for carcinogenic contaminants) and reference doses (for noncarcinogenic contaminants). The Integrated Risk Information System (IRIS), the EPA's on-line database, is the preferred source for these numerical toxicity values. If IRIS does not provide a toxicity value for a specific contaminant, the value will be obtained from the latest EPA Health Effects Assessment Summary Table (HEAST). In general, if a contaminant toxicity value has recently been withdrawn from IRIS and HEAST (e.g., TCE), the last available toxicity value will be used in order to maintain consistency with earlier assessments until a new value becomes available. If no toxicity values exist in IRIS or HEAST for a particular contaminant, the contaminant will be evaluated qualitatively rather than quantitatively in the RRE. In the case that a contaminant is widespread at relatively high concentrations and there are no toxicity values in IRIS or HEAST, the National Center for Environmental Assessment in Cincinnati, Ohio may be contacted to assist in developing the necessary toxicity values.

A brief toxicity profile for each contaminant evaluated in the RRE will be included in the toxicity assessment chapter of the RRE report for each release block. The toxicity profile should summarize the mechanism of toxic action (including target organs), present the carcinogenic weight-of-evidence for the contaminant, and provide references for more detailed toxicological information.

2.4 Risk Characterization

Information from the exposure assessment (i.e., estimated contaminant intakes) combined with information from the toxicity assessment (i.e., slope factors or reference doses) is used to characterize human health risks. Health risks are characterized differently for carcinogenic and noncarcinogenic contaminants, and the methods for each are presented in the following sections.

Contaminant intakes from the exposure assessment and toxicity values from the toxicity assessment are combined for use in estimating human health risks.

2.4.1 Quantification of carcinogenic risk

For carcinogens, the risk is expressed as the likelihood of an individual developing cancer as a result of exposure to a carcinogen (i.e., incremental lifetime cancer risk). For each carcinogenic contaminant, a toxicity value known as the slope factor is used to estimate the cancer risk based on the calculated intake of the contaminant. The slope factor is obtained during the toxicity assessment from the dose-response curve for each contaminant (a dose-response curve is a graph that shows the relationship between the dose of a contaminant received and the adverse health effects observed).

A slope factor is used to convert the intake into the incremental lifetime cancer risk using the following equation:

$$Risk = \frac{1}{Intake\ (mg / kg - d) \times Slope\ Factor \times (mg / kg - d)}$$

This equation is valid at low risk levels (i.e., below approximately 0.01, or 1 in 100) and should be appropriate for all residual contamination situations evaluated at Mound. Because the slope factor for chemical carcinogens is based on the 95th% UCL of the slope of the dose-response curve, it is likely that the actual risk is lower than the estimated risk. Cancer risk estimates should be expressed with one significant figure. Cancer risks are assumed to be additive, and risks from different pathways and chemicals can be summed.

Slope factors are not specifically derived for the dermal exposure pathway. However, in most cases, the dermal exposure pathway can be evaluated using slope factors derived for the oral ingestion pathway (EPA, 1989). Most slope factors are expressed in terms of the amount of substance administered per unit time and unit body weight. However, exposure estimates calculated with this methodology for dermal exposure are expressed as *absorbed* rather than administered dose. Adjustments are required to ensure that both the exposure estimate and the toxicity value are expressed as absorbed doses or as administered doses. To obtain a dermal slope factor for a given substance, it is necessary to adjust the oral ingestion slope factor by the gastrointestinal (GI) absorption efficiency for that substance. For carcinogens, the slope factor is adjusted as follows (EPA 1989):

$$absorbed\ dose\ SF\ (mg\ /\ kg\text{ - }d)^{-1} = \frac{oral\ ingestion\ SF\ (mg\ /\ kg - d)^{-1}}{GI\ absorbtion\ efficiency}$$

GI absorption factors are based on data in the scientific literature. Regional and state guidance should be consulted to obtain the GI absorption factors recommended for use at the Mound Plant. Thus, the absorbed dose SF should be multiplied by the estimate of exposure (measured as dermal absorbed dose as described in section 2.2.3) to estimate risk. If the oral SF is already expressed as an absorbed dose, it is not necessary to adjust the SF.

As recommended by USEPA in RAGS Part A (EPA 1989), the RRE should report the incremental risk, total risk, and risk from background for each carcinogenic contaminant evaluated in the RRE. The incremental risk is the risk posed by site-related contamination above and beyond the risk posed by background environmental levels. Background risk is the risk resulting from sources other than the site-related residual contamination (i.e., other sources present in the environment). The total risk is the sum of background and incremental risk. Incremental risk will be reported in the main body of the RRE report. Estimates of background and total risk will be presented in an appendix to the RRE report. Providing background and total risk allows the comparison of the relative contributions of site-related and background risks to total risk.

2.4.2 Quantifying noncarcinogenic hazard

Potential human health hazards from exposure to noncarcinogenic contaminants are evaluated by comparing the estimated intake for each noncarcinogenic contaminant to a reference dose (RfD) for that contaminant to generate a ratio called the hazard quotient (HQ). A reference dose is an estimate of the individual daily exposure level that is likely to be without harmful effects. Thus, the hazard quotient is calculated using the following equation:

$$\text{Hazard Quotient} = \frac{\text{Intake (mg / kg - d)}}{\text{Reference Dose (mg / kg - d)}}$$

A hazard quotient that exceeds unity (1.0) indicates that effects may occur but is not an indication of the severity of the effects. Chemical-specific hazard quotients may be summed to yield the hazard index (HI). If the hazard index exceeds unity (1.0), an evaluation of the specific contaminants will be conducted to ensure that only contaminants with similar systemic effects are summed. For each noncarcinogenic contaminant, the RRE should report the site-related hazard quotient (i.e., the incremental hazard quotient) in the main body of the report and the hazard quotient attributable to background levels (i.e., the background hazard quotient) and the total hazard quotient in an appendix to the report.

Reference doses are not specifically derived for the dermal exposure pathway. However, in most cases, the dermal exposure pathway can be evaluated using reference doses derived for the oral ingestion pathway (EPA 1989). Adjustments are required to ensure that both the exposure estimate and the toxicity values are expressed as absorbed doses or as administered doses. Because exposure estimates calculated with this methodology for the dermal pathway are expressed as absorbed doses, it is necessary to adjust the reference dose to reflect absorbed dose. Hence, to obtain a dermal reference dose for a given substance, it is necessary to adjust the oral ingestion reference dose by the gastrointestinal (GI) absorption efficiency for that substance. For noncarcinogens, the reference dose is adjusted as follows (EPA 1989):

$$\begin{aligned}&\textit{absorbed dose RfD}(mg/kg-d) = \\ &\textit{oral ingestion RfD}(mg/kg-d) \times \textit{GI absorption eficiency}\end{aligned}$$

GI absorption factors are based on scarce data in the scientific literature. There is no regional or state guidance available to obtain the GI absorption factors recommended for use at the Mound Plant. Therefore the absorbed dose RfD is often conservatively stated as being the same as the oral ingestion RfD. This assumes that dermal absorption is as efficient GI absorption. The absorbed dose RfD should be used with the estimate of exposure (as measured as the dermally absorbed dose described in section 2.2.3) to derive the hazard quotient.

2.5 Evaluating Potential Cumulative Risks

In some cases, contaminants from release blocks other than the release block currently being evaluated may migrate or be transported to the release block under evaluation. For the purposes of this methodology, risks resulting from contaminants that originate outside the release block under consideration are called cumulative risks and risks from contaminants located within a release block are called release block risks. The risks from exposures to contaminants originating outside the release block can be added to the risks from exposures to contaminants within the release block to provide a measure of overall risk. Examples of cumulative risks include risks resulting from exposures to airborne contaminants migrating from nearby release blocks and risks resulting from exposures to contaminants from other release blocks that have migrated to the BVA, which is the presumed drinking water source for the release block under evaluation. In general, cumulative risks are possible via air, surface water, and ground water. Specific cumulative risks for

In some cases, contaminants from release blocks other than the one being evaluated may be transported into the release block under evaluation. The risks resulting from these exposures are called "cumulative risks".

Mound are discussed below. The following sections describe the methods by which the cumulative risks are to be evaluated in the RRE.

2.5.1 Evaluating cumulative risks from the air pathway

Cumulative risks from the air pathway are not expected to exist at levels of concern. To confirm this expectation, the risks associated with the maximum annual air concentrations of plutonium and tritium will be calculated using data provided in the 1994 Mound annual environmental report (EG&G, 1994) and the methods presented in Sections 2.2 through 2.4 of this methodology. The highest annual average air concentration detected in any of the 14 onsite air monitors in 1994 will be the exposure concentration used to quantify these risks.

Risks based on 1994 air monitoring data are likely to be overestimates of actual risk because the maximum 1994 air concentrations included both routine emissions and higher-than-average releases from D&D activities, which will not occur after the conclusion remediation activities at Mound. This makes the calculated risk more conservative than the actual expected condition. The calculation of the cumulative risks from the air pathway will be performed once; this analysis will be used for each release block RRE to demonstrate that cumulative risks from the air pathway are above or below levels of concern. The analysis will be included as an appendix for each release block RRE.

2.5.2 Evaluating cumulative risks from the surface water pathway

Cumulative risks from the surface water pathway are not expected to be at levels of concern due to the small number of surface water bodies at the

Mound property and the fact that surface water exposures would typically be limited only to dermal exposures and incidental ingestion, which generate risks that are orders of magnitude lower than risks from other pathways. Due to the ephemeral nature of potential surface water exposures, USEPA has concluded in RAGS that "In general, use sediment monitoring data to estimate exposure concentrations. Sediment monitoring data can be expected to provide better temporal representativeness than surface water concentrations". Since RAGS suggests that risk from surface water can be approximated by the risk from sediment, which is treated the same as soil, cumulative risks form multiple release blocks is not necessary for the RRE.

2.5.3 Evaluating cumulative risks from the ground water pathway

Assessing the risk associated with exposure to contaminated ground water requires estimating both the risk from current ground water contamination and the risk from potential future ground water contamination. The following paragraphs discuss the methods used to quantify current and future ground water risks.

<u>2.4.3.1 Current risk from ground water</u>

Current risk from ground water exposure is based on concentrations of contaminants measured in the Mound Plant production wells.

Currently, all ground water used at Mound is drawn from the production wells located in the southwestern portion of the property. Hence, the risk posed by current ground water contamination is the risk resulting from exposure to contaminants found in the production wells. This risk is identical for all release blocks at any point in time and represents the cumulative risk from contamination that migrates to the production wells from multiple release blocks. For each release block RRE, the current ground water risk is quantified using the methods presented in Sections 2.2 through 2.4, using the 95th% UCL of the mean of the contaminant concentrations in the current production wells as the exposure concentrations.

As per current USEPA guidance only the contaminant levels from the unfiltered ground water samples, also known as "total concentrations", will be used in determining the current ground water risks and hazards. The current risk from ground water produced from the Mound Plant Production wells will be calculated from all of the available historical ground water data at the time the RRE is performed. The production well data to be used in this calculation are from the production wells which are identified as wells 0076 and 0271. The ground water data resides in the Mound Plant Mound Environmental Information Management System (MEIMS) Database.

2.4.3.2 Future risk from ground water.

Future risk from ground water exposure is based on predicted future concentrations of contaminants in the Mound Plant production wells.

Future risk from ground water exposure may occur due to exposure to contaminants that have migrated to the BVA from multiple release blocks. This future risk from ground water exposure is quantified using the methods presented in Sections 2.2 through 2.4, using estimates of the future contaminant concentration in the Mound Plant Production wells as the exposure concentrations. These methods overestimate the concentrations that would occur within the BVA because dilution within the BVA is not calculated. This conservative approach is used to account for the uncertainties in ground water flow and modeling.

The current Fate and Transport model that is being used for Release Block evaluation is a very conservative model that does not allow for adsorption to soil particles or dilution within the BVA. This model divides the Mound Plant into approximately 100 meter wide zones called flow tubes. The highest chemical concentration found in the groundwater (from monitoring wells) in any flow tube is assumed to represent the chemical concentration that enters the BVA at some future time. Dilution, adsorption, mixing, and attenuation are all ignored. The most conservative assumption of this model is that the contaminated groundwater form the bedrock enters the Mound Plant Production wells without any dilution from the surrounding BVA. Any existing contamination in the BVA is simply added to contamination contributed by the bedrock to arrive at a total possible future concentration.

Future concentrations of contaminants in the Mound Plant production wells can be calculated by estimating the amount of contaminant that will enter the Buried Valley Aquifer in the future.

Due to the highly conservative and simplistic nature of the existing Fate and Transport model, future models that better represent the actual processes that affect contaminant migration may be used for future Risk Evaluations (such as MT3D for 3-dimensional modeling, or TRANS1D for one dimensional modeling).

2.6 Documenting the Release Block Residual Risk Report

DOE is responsible for conducting and documenting the release block RRE. DOE will submit the RRE for each release block to OEPA and USEPA for a 30-day review. Additionally, after the 30-day regulatory review, there will be a 30-day public review period prior to the report becoming final.

There will be a 30-day regulatory review period and a 30-day public review period of the RRE for each release block.

3. PLANTWIDE RESIDUAL RISK EVALUATION METHODOLOGY

Plantwide risk can be estimated just like the risks from each release block.

Just as risks can be calculated from the residual concentrations of contaminants across a release block to judge whether the conditions at the release block are protective of human health, so can risks be calculated from the residual concentrations of contaminants across the entire Mound property to judge whether the plantwide conditions are protective. Theoretically, an individual could potentially wander across the entire plant, spending a certain percentage of time in each release block. The worst case scenario would be the scenario in which this individual spends 100% of his time in the release block with the greatest residual contamination levels. Hence, a conservative upper bound estimate of the plantwide residual risk is the risk posed by the individual release block with the greatest residual risk.

Plantwide risk is no greater than the greatest residual risk form any individual release block.

Documenting the plantwide risk should consist of compiling summaries of the release block Residual Risk Evaluations and demonstrating, using the above logic, that the plantwide residual risk level is no greater than, and most likely much lower than, the risk level of the release block with the greatest residual risk. Note that the RRE for the release block with the greatest residual risk will incorporate risk from release block exposures and cumulative risks.

REFERENCES

DOE 1992. *Operable Unit 9 Site Scoping Report, Volume 3, Radiological Site Survey*. December.

DOE 1994. *Operable Unit 9 Background Soils Investigation Soil Chemistry Report.* September.

DOE 1995a. *Operable Unit 9 Regional Soil Investigation Report, Volume 1-Text, Revision 0. February.*

DOE 1995b. *Operable Unit 9 Hydrogeologic Investigation: Groundwater Sweeps Report (April 1995) Re-calculated Background Groundwater Criteria. June 1996.*

EG&G 1995. *Mound Site Environmental Report for Calendar Year 1994. MLM-3814.*

EPA 1989. *Risk Assessment Guidance for Superfund (Vol. 1) Human Health Risk Evaluation Manual (Part A), Interim Final.* EPA/540/1-89/002. Office of Emergency and Remedial Response. Washington, DC.

EPA 1990. *Exposure Factors Handbook.* Office of Health and Environmental Assessment. EPA/600/8-89/043. Washington, DC.

EPA 1991a. *Risk Assessment Guidance for Superfund (Vol. 1) Human Health Evaluation Manual, "Standard Default Exposure Factors," Interim Final.* OSWER Directive 9285.6-03. Office of Emergency and Remedial Response. Washington, DC.

EPA 1991b. *Risk Assessment Guidance for Superfund (Vol. I) Human Health Evaluation Manual (Part B), Development of Risk-based Preliminary Remediation Goals*. Office of Emergency and Remedial Response. OSWER Directive 9285.7-01B. Washington, DC. December.

EPA. 1992a. *Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual, Supplemental Guidance, Dermal Risk Assessment, Interim Guidance*. Office of Emergency and Remedial Response. Washington, DC. August.

EPA 1992b. *Dermal Exposure Assessment: Principles and Applications, Interim Report*. EPA/600/8-91/011B. Office of Research and Development. Washington, DC January.

EPA 1992c. *Supplemental guidance to RAGS: Calculating the Concentration Term*, Office of Solid Waste and Emergency Response, Intermittent Bulletin Volume 1 Number 1, Publication 9285.7-081, Washington, DC. May.

EPA 1992d. Memorandum from Janine Diane to Regional Toxic Integration coordinators, Office of Solid Waste and Emergency Response, Washington, DC. November 9.

Gilbert R. O. 1987. Statistical Methods for Environmental Pollution Monitoring.

HAZWRAP 1995. *Risk-based Guideline Values, Mound Plant, Miamisburg, Ohio.* Submitted to Office of Southwestern Area Programs, Environmental Restoration, U.S. Department of Energy and the U.S. Department of Energy, Dayton Area Office. December.

Isaaks E. O., Srivastava R. H. 1989. *An Introduction to Applied Geostatistics.* Oxford University Press. New York, NY.

Nowka S. 1995. "Mound 2000 Cleans-up Decision Making." *Superfund Update*. Published by the Mound Environmental Restoration Program. Miamisburg, Ohio.

OEPA 1991. *"How Clean is Clean Policy."* Division of Emergency and Remedial Response. Columbus, OH. July.

APPENDIX: BACKGROUND LEVELS

Table A-1: Radionuclide Background Values for Comparison to Mound Plant Soils
Operable Unit 9 Background Soils Investigation Soil Chemistry Report. September 1994.

	Maximum Value (pCi/g)	**Background Value (pCi/g)**[1]
Americium-241	Not detected in any sample	Not detected in any sample
Bismuth-207	Not detected in any sample	Not detected in any sample
Bismuth-210	Not detected in any sample	Not detected in any sample
Cesium-137	0.73	0.42
Cobalt	1.01	[2]
Plutonium-238	0.25	0.13
Plutonium-239/240	0.32	0.18
Potassium-40	37.9	37.0
Radium-226	2.95	2.0
Strontium-90	21.9	0.72
Thorium-228	2.13	1.5
Thorium-230[3]	2.44	1.9
Thorium-232	1.69	1.4
Tritium	8.28	1.6
Uranium-234	1.16	1.1
Uranium-235/236	0.12	0.11
Uranium-238	1.29	1.2

[1] Upper 95th% Tolerance Limit
[2] The background value could not be computed due to the large number of non-detects in the sample set.
[3] From Regional Soils Investigation (DOE, 1995a)

Table A-2: Anion Background Values for Comparison to Mound Plant Soils
Operable Unit 9 Background Soils Investigation Soil Chemistry Report. September 1994.

	Maximum Value (mg/kg)	**Background Value (mg/kg)**[1]
Chloride	116	107
Fluoride	18.3	6.7
Nitrate/Nitrite	30.9	26
Sulfate	196	150
TOC	40,300	28,000

[1] Upper 95th% Tolerance Limit

Table A-3: Inorganic Background Values for Comparison to Mound Plant Soils
Operable Unit 9 Background Soils Investigation Soil Chemistry Report. September 1994.

	Maximum Value (mg/kg)	Background Value (mg/kg)[1]
Aluminum	71,000	19,000
Antimony	Data Rejected	Data Rejected
Arsenic	11	8.6
Barium	250	180
Beryllium	2.4	1.3
Bismuth	38	[2]
Cadmium	3.2	2.1
Calcium	260,000	310,000
Chromium	32	20
Cobalt	29	19
Copper	43	26
Cyanide	Not detected in any sample	Not detected in any sample
Iron	53,000	35,000
Lead	85	48
Lithium	28	26
Magnesium	56,000	40,000
Manganese	1,700	1,400
Mercury	0.15	[3]
Molybdenum	31	27
Nickel	50	32
Potassium	2,400	1,900
Selenium	0.59	[4]
Silver	5.1	1.7
Sodium	400	240
Thallium	0.47	0.46
Tin	23	20
Vanadium	31	25
Zinc	740	140

[1]Upper 95th% Tolerance Limit
[2]The background value could not be computed due to the large number of non-detects in the sample set.
[3]The background value could not be computed due to the large number of non-detects in the sample set.
[4]The background value could not be computed due to the large number of non-detects in the sample set.

Table A-4: Pesticides/PCB Background Values for Comparison to Mound Plant Soils
Operable Unit 9 Background Soils Investigation Soil Chemistry Report. September 1994.

	Maximum Value (mg/kg)	Background Value (mg/kg)[1]
4,4-DDD	21	4.2
4,4-DDE	39	4.3
4,4-DDT	65	13
Aldrin	Not detected in any sample	Not detected in any sample
Alpha chlordane	Not detected in any sample	Not detected in any sample
Alpha-BHC	Not detected in any sample	Not detected in any sample
Arochlor-1016	Not detected in any sample	Not detected in any sample
Arochlor-1221	Not detected in any sample	Not detected in any sample
Arochlor-1232	Not detected in any sample	Not detected in any sample
Arochlor-1242	Not detected in any sample	Not detected in any sample
Arochlor-1248	Not detected in any sample	Not detected in any sample
Arochlor-1254	65	58
Arochlor-1260	Not detected in any sample	Not detected in any sample
Beta-BHC	Not detected in any sample	Not detected in any sample
Delta-BHC	Not detected in any sample	Not detected in any sample
Dieldrin	Not detected in any sample	Not detected in any sample
Endosulfan I (alpha)	Not detected in any sample	Not detected in any sample
Endosulfan II (beta)	1.9	[2]
Endosulfan Sulfate	Not detected in any sample	Not detected in any sample
Endrin	Not detected in any sample	Not detected in any sample
Endrin Aldehyde	Not detected in any sample	Not detected in any sample
Endrin Ketone	Not detected in any sample	Not detected in any sample
Gamma Chlordane	Not detected in any sample	Not detected in any sample
Gamma-BHC (Lindane)	Not detected in any sample	Not detected in any sample
Heptachlor	Not detected in any sample	Not detected in any sample
Heptachlor Epoxide	Not detected in any sample	Not detected in any sample
Methoxychlor	50	30
Toxaphene	Not detected in any sample	Not detected in any sample

[1] Upper 95th% Tolerance Limit
[2] The background value could not be computed due to the large number of non-detects in the sample set.

Table A-5: Operable Unit 9 Hydrogeologic Investigation: Ground water Sweeps Report (April 1995) Re-calculated Background Ground water Criteria June 1996.

PARAMETER NAME	METALS SOLUBILITY	UNITS	MEAN	STANDARD DEVIATION	95% UTL	DETECTIONS	SAMPLES ANALYZED
INORGANIC COMPOUNDS							
Aluminum	Total	UG/L	10.400	13.561	37.523	1	8
Antimony	Total	UG/L	0.327	0.125	0.578	1	8
Antimony	Soluble	UG/L	1.344	1.636	4.615	3	8
Arsenic	Total	UG/L	8.631	12.183	32.997	5	8
Arsenic	Soluble	UG/L	9.400	13.947	37.295	5	8
Barium	Total	UG/L	193.313	58.448	310.209	8	8
Barium	Soluble	UG/L	184.875	51.424	287.723	8	8
Calcium	Total	UG/L	96231.250	7439.707	111110.664	8	8
Calcium	Soluble	UG/L	92912.500	10552.378	114017.256	8	8
Chloride		MG/L	48.631	28.595	105.821	8	8
Chromium	Total	UG/L	1.968	2.054	6.076	3	8
Chromium	Soluble	UG/L	0.918	0.751	2.419	3	8
Cobalt	Soluble	UG/L	0.645	0.194	1.032	1	8
Copper	Total	UG/L	0.651	0.258	1.167	3	8
Copper	Soluble	UG/L	0.610	0.316	1.242	2	8
Dissolved Solids		MG/L	513.125	45.041	603.207	8	8
Fluoride		MG/L	0.284	0.068	0.419	8	8
Iron	Total	UG/L	1723.313	1170.788	4064.888	8	8
Iron	Soluble	UG/L	1467.638	1086.938	3641.514	8	8
Lead	Soluble	UG/L	2.113	3.969	10.050	1	8
Lithium	Total	UG/L	19.579	18.064	55.707	2	7
Lithium	Soluble	UG/L	19.579	18.064	55.707	3	7
Magnesium	Total	UG/L	36206.250	2110.930	40428.111	8	8
Magnesium	Soluble	UG/L	35518.750	2464.018	40446.786	8	8
Manganese	Total	UG/L	101.538	64.015	229.568	8	8
Manganese	Soluble	UG/L	96.675	59.669	216.013	8	8
Molybdenum	Total	UG/L	3.534	1.031	5.597	4	8
Molybdenum	Soluble	UG/L	3.434	1.179	5.793	4	8
Nickel	Total	UG/L	7.731	13.613	34.957	3	8
Nickel	Soluble	UG/L	7.906	15.795	39.496	2	8
Nitrate/Nitrite		MG/L	1.145	2.102	5.349	2	8
Nitrogen		MG/L	0.126	0.099	0.324	4	8
Phosphate		MG/L	0.071	0.080	0.231	4	8
Potassium	Total	UG/L	2758.125	851.469	4461.063	8	8
Potassium	Soluble	UG/L	2658.750	908.302	4475.354	8	8
Sodium		UG/L	26562.500	17931.531	62425.563	8	8
Sodium		UG/L	26062.500	17791.727	61645.953	8	8
Sulfate		MG/L	62.919	39.868	142.655	7	8
Suspended Solids		MG/L	8.625	8.907	26.440	5	8
Tin	Total	UG/L	12.188	11.097	34.382	3	8
Tin	Soluble	UG/L	11.188	9.776	30.740	3	8
Vanadium	Total	UG/L	8.616	4.230	17.076	3	8
Vanadium	Soluble	UG/L	8.363	4.222	16.807	3	8
Zinc	Total	UG/L	20.428	49.594	119.617	2	8
Zinc	Soluble	UG/L	20.238	45.220	110.678	2	8

Table A-5: Operable Unit 9 Hydrogeologic Investigation: Ground water Sweeps Report (April 1995) Re-calculated Background Ground water Criteria June 1996.

PARAMETER NAME	METALS SOLUBILITY	UNITS	MEAN	STANDARD DEVIATION	95% UTL	DETECTIONS	SAMPLES ANALYZED
ORGANIC CHEMCALS							
1,1,1-Trichloroethane		UG/L	0.256	0.206	0.668	2	8
1,2-cis-Dichloroethene		UG/L	0.575	0.212	0.999	1	8
Ammonia		MG/L	0.074	0.044	0.162	2	8
Bis(2-ethylhexyl)phthalate		UG/L	5.688	1.361	8.410	1	8
Chloroform		UG/L	0.290	0.113	0.516	1	8
Organic Carbon		MG/L	0.921	0.533	1.987	7	8
Phenol		UG/L	4.625	1.685	7.995	1	8
RADIONUCLIDES							
Americium-241		PCI/L	0.043	0.048	0.139	2	8
Plutonium-238		PCI/L	0.030	0.029	0.087	1	8
Plutonium-239/240		PCI/L	0.036	0.044	0.125	2	8
Radium-226		PCI/L	0.470	0.263	0.996	4	8
Strontium-90		PCI/L	0.640	0.168	0.975	3	8
Thorium-228		PCI/L	0.294	0.242	0.779	5	8
Thorium-232		PCI/L	0.103	0.106	0.314	1	2
Tritium		PCI/L	827.188	329.143	1485.473	8	8
Uranium-234		PCI/L	0.453	0.169	0.792	8	8
Uranium-235		PCI/L	0.253	0.280	0.814	1	4
Uranium-238		PCI/L	0.322	0.183	0.688	7	8