Idaho National Engineering and Environmental Laboratory

INEL-95/0190
Revision 0

June 1995

Guidance Manual for Conducting Screening Level Ecological Risk Assessments at the INEL

Principal Investigators:

R. L. VanHorn
N. L. Hampton
R. C. Morris

LOCKHEED MARTIN

DISCLAIMER

ERRATA SHEET

Date:	August 26, 1999
Report Number:	INEL-95/0190 Rev. 0
Report Title:	Guidance Manual for Conducting Screening Level Ecological Risk Assessments at the INEL
Prepared by:	Lockheed Idaho Technologies Company
Date Published:	June 1995
Instructions:	Please note the following corrections to your copy. Word corrections are **bolded.**

GENERAL REVISIONS

This guidance manual represents the first step in the development of methodology for conducting ecological risk assessment at the INEEL. The primary purpose of the guidance was to develop ecologically-based screening levels (EBSLs) for contaminants found at the INEEL. The EBSLs resulting from this guidance document have been incorporated as part of Phase 1 of a four phased approach to INEEL ecological risk assessment (ERA) (see Figure 1, page 6 of this errata sheet). Either stand-alone screening-level ecological risk assessments (SLERAs) or ecological data gap analyses (EDGAs) were conducted as precursors to WAG-level ERAs (Phase 2). The WAG-level ERAs also incorporate the basic methodology presented in this document.

Dr. R. C. Morris is an employee of the Environmental Science and Research Foundation, Inc. Dr. Morris' contributions to this document were completed under DOE Idaho Operations Contract DE-AC07-94ID13268.

Since this report was issued, Lockheed Idaho Technologies Company has been re-structured as **Lockheed Martin Idaho Technologies Company.**

Since this report was published, the Idaho National Engineering Laboratory (INEL) has been re-designated as the **Idaho National Engineering and Environmental Laboratory (INEEL)** - this acronym should be applied throughout the document.

Since this report was published, the Idaho Chemical Processing Plant (ICPP) has been re-designated as the **Idaho Nuclear Technology and Engineering Center (INTEC)** - this acronym should be applied throughout the document.

The methodology presented this guidance manual has been more recently summarized in a series of three articles:

VanHorn, R. L., N. L. Hampton, and R. C. Morris, 1998, "Methodology for conducting screening-level ecological risk assessments for hazardous waste sites. Part I: Overview, *International Journal of Environment and Pollution* 9(1):26-46.

Hampton, N. L., R. C. Morris, and R. L. VanHorn, 1998, "Methodology for conducting screening-level ecological risk assessments for hazardous waste sites. Part II: Grouping ecological components", *International Journal of Environment and Pollution* **9**(1):47-61.

Kester, J. E., R. L. VanHorn, and N. L. Hampton, 1998, "Methodology for conducting screening-level ecological risk assessments for hazardous waste sites. Part III: Exposure and effects assessment", *International Journal of Environment and Pollution* **9**(1):62-89.

SPECIFIC REVISIONS

Page xv, ACRONYMS table

Change acronym FFA/CO to:
"Federal **Facility** Agreement and Consent Order"

Page 1-1, last paragraph, line 2

Omit the word "a":
"...waste area group (WAG) at the INEL."

Page 2-5, Section 2.2.2, line 1

Replace "and" with "an":
".....**an** adverse response."

Table 3-7, pages 3-18-3-19

Status for some species has changed since this report was issued and is updated on a periodic basis. Information included on this table should be verified prior to use and/or citation.

Figure 3-6 page 3-36

Groundwater pathway from leaching and infiltration through subsurface soil should be shown in this model.

Figure 3-8 page 3-78

Groundwater pathway from leaching and infiltration through subsurface soil should be shown in this model.

Table 3-18, Page 3-52, Abbreviations footnote

Parameter values for PP, PV and PS are presented as fractions of diet in Table 3-18, not as percentages.

Page 3-63 , Internal Dose Section

Throughout this section, the word "dose" should be read as "**dose rate**."

Page 3-63, line 11

The phrase "Internal radiation exposure dose estimates..." should read "**Internal radiation dose rate estimates....**"

Page 3-64, line 19

ADE is defined as **Average decay energy**

Page 3-64, Equation 10 – Equation 10 should read as follows:

$$ADE = \sum_{i=1}^{n} Y_i E_i$$

Page 3-64, line 22

Replace the phrase "exposure dosage" with "**internal radiation dose rate.**"

Page 3-65, Table 3-25 caption

Replace the phrase "exposure dose" with "**internal radiation dose rate.**"

Page 3-68, Equation 14

The soil density value of 1.68 g/cm^3 was taken from:
Binda, R. E. 1981. Evaluation of final surface cover proposal for the INEL Subsurface Disposal Area. Internal Technical Report WM-F1-81-007, EG&G Idaho, Inc.

Page 4-2, first citation

Correct journal title is **Environmental Science and Technology**

Page A-6, Table A-1

Second column acronym USC = **U. S. Code**
First column, item 4 (Threatened Fish and Wildlife) – column 2 citation should be **50 CFR Part 227**
Add line to table, **Endangered Fish and Wildlife 50 CFR Part 222**
First column, item 11 (Protection of Bald and Golden Eagles Act) – column 2 citation should be **16 U. S. Code 668**
First column, item 14 - Idaho Fish and Wildlife **(Preservation of Fishery Resources)**
First column, item16 - Wetlands Conservation **Act**

Appendix C – page C-9, last paragraph, line 4

The correct taxonomic spelling for the cottontail is ***Sylvilagus nuttallii***

Appendix C – page C-13, 2nd paragraph, line 1

The correct taxonomic spelling for **Ord's** kangaroo rat is ***Dipodomys ordii***

Appendix C – page C-19, 3rd paragraph, line 1

The correct taxonomic spelling for **Nuttall's** cottontail is ***Sylvilagus nuttallii***

Appendix C – page C-22, last paragraph, line 1

The correct taxonomic spelling for the mallard duck is ***Anas platyrhynchos***

Appendix C – page C-23, 2nd paragraph, line 1

The correct taxonomic spelling for **squirreltail** bottlebrush is ***Sitanion hystrix*** (recently reclassified as ***Elymus elymoides***).

Page C-43, Section C-3.1.2, 3rd paragraph, last two sentences

Replace with "...concentration of Stationary Low-Level Reactor No. 1 (SL-1) soils (700 pCi/g), the most contaminated soil after TRA pond sediments. The maximum concentration of ^{137}Cs in ICPP soils was 18 times maximum background concentration (3.0 pCi/g)."

Page C-51, Section C-3.4, 3rd paragraph, second sentence

Rephrase sentence to "In addition, data may be insufficient to determine...."

Page C-I-12, Section C-I-1.1.3, 3rd paragraph, last sentence

Replace "1.8" with "18":
"……soils was **18** times maximum....."

Page C-I-12, Section C-I-1.1.3

A discussion of ^{238}Pu, which is also present at the site at 16.8 times maximum background, is missing from this section.

Appendix C, Page C-I-35, Table C-1-5

The ^{24}Na level in sage grouse muscle at TRA and ICPP is 3.8 **Ci/g**.

Appendix D, Page D-5, Section D-3., first paragraph, last sentence

Replace the word "annual" with "**species**"

Appendix D, Page D-5, Section D-3, INEL Flora

More current taxonomic nomenclature for several native INEEL grasses and chenopods has been adopted since this manual was issued.

Appendix D, Page D-9, Table D-3

Spelling error in the second sentence of the general comments for Grasslands -*Leymus **cinereus.***

Appendix D, Page D-9, Table D-3

Replace the word "committees" in the general comments for Salt Desert Scrub with "**communities**".

Appendix D, Page D-11, heading Lava, second sentence

The correct taxonomic spelling for fern-bush is *Chamaebatiaria **millefolium.***

Appendix D, Page D-13, 2nd paragraph, fourth sentence

The correct taxonomic spelling for the rough-legged hawk is *Buteo **lagopus*** and for the golden eagle, *Aguila **chrysaetos.***

Appendix D, Page D-13, heading Mammals, fourth sentence

The correct taxonomic spelling for the mountain sheep is ***Orvis** canadensis.*

Appendix D, Page D-13, heading Mammals, eleventh sentence

The current taxonomic name for the least chipmunk is ***Eutamius** minimus.*

Appendix D, Page D-16, Section D-5.

Status for some species has changed since this report was issued and is updated on a periodic basis. Information included in this section should be verified prior to use and/or citation.

Appendix D, Page D-20, Section D-6

Since this manual was issued, INEEL soil mapping has been documented in:
Olson, G. L., D. J. Jeppesen, and R. D. Lee. 1995. "The Status of Soil Mapping for the Idaho National Engineering Laboratory", INEL-95/005, EG&G Idaho, Inc.

Appendix E, Page E-4, Section E-2

Replace bulletized text with the following:

- Potential for contaminant exposure through shared dietary and physical pathways (trophic and habitat parameters)
- Potential for similar biological response to that exposure (taxon).

Appendix E, Table E-4, pages E–8 through E-15

Two avian functional groups have been subdivided to better account for exposures for below ground activity (i.e. burrowing).

Group AV210 (page E-9) contains species up to and including the Common poor-will, remaining species have been reassigned to subgroup AV210A.

Group AV222 (page E-10) contains species up to and including Harris' sparrow, the rock wren and canyon wren have been reassigned to subgroup AV222A and the burrowing owl has been redesignated as group 322A (i.e. changed from an insectivore to a carnivore).

Appendix E, Page E-17, Table E-5, Trophic Category

The correct spelling of the parenthetic contents for the Detritivore code is **saprophagous**.

Appendix E, Page E-18, Table E-6

More current taxonomic nomenclature for several native INEEL grasses and chenopods has been adopted since this manual was issued.

The correct taxonomic spelling for the third species from the bottom of the Dominant Species column is ***Kochia scoparia.***

Appendix E, Page E-26, 2nd paragraph, line 3

Change "to" to "the":

"....SLERAs is **the** identification of....."

INEEL Phase ERA Approach (1995)

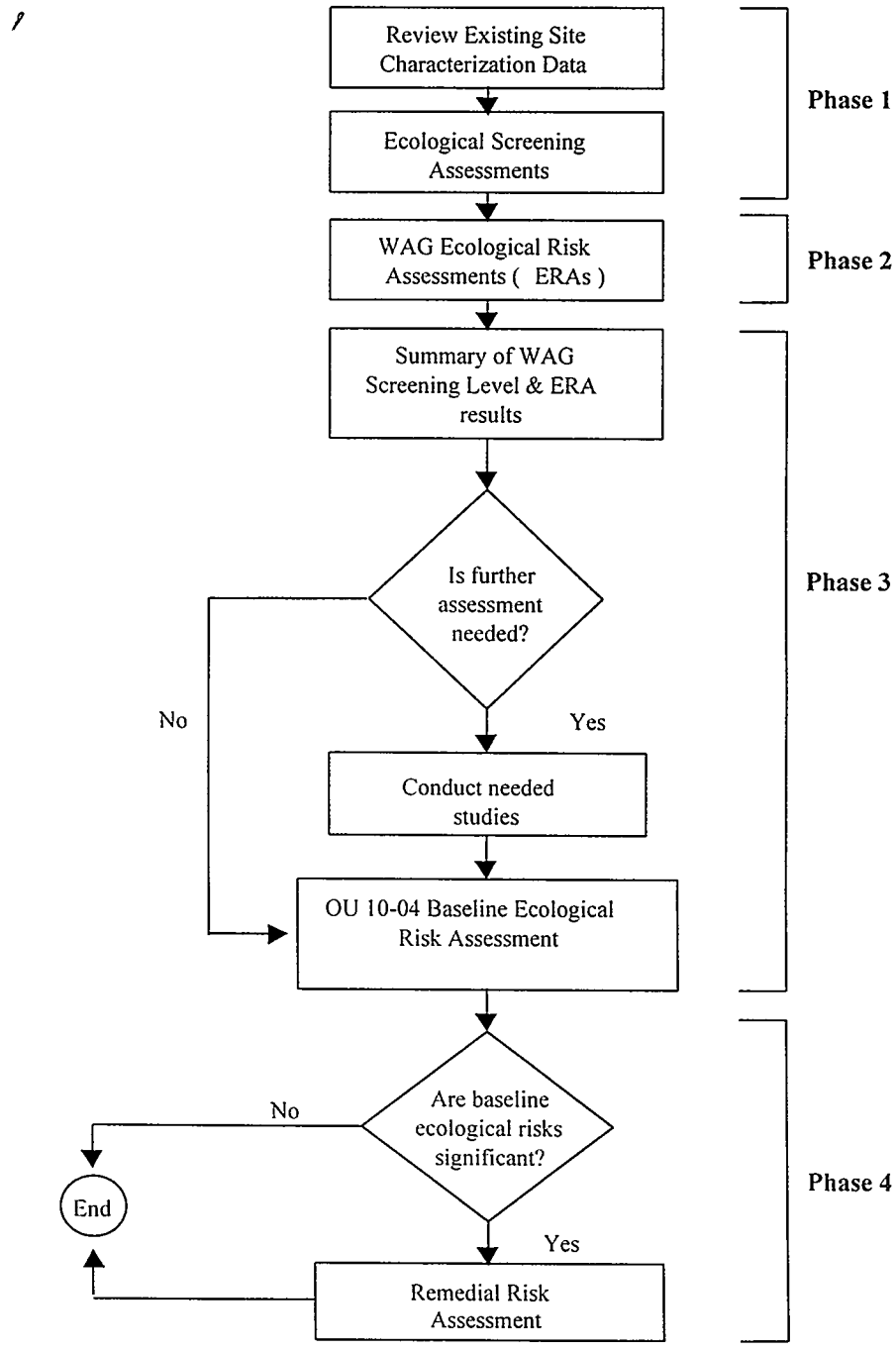


Figure 1 Phased approach to ecological risk assessment at the INEEL.

INEL-95/0190
Revision 0

Guidance Manual for Conducting Screening Level Ecological Risk Assessments at the INEL

Principal Investigators:
R. L. VanHorn
N. L. Hampton
R. C. Morris

Published June 1995

Idaho National Engineering Laboratory
Lockheed Martin Idaho Technologies
Environmental Restoration
Idaho Falls, Idaho 83415

Prepared for the
U.S. Department of Energy
Assistant Secretary for the Office of Environmental Management
Under DOE Idaho Operations Office
Contract DE-AC07-94ID13223

ABSTRACT

This document presents reference material for conducting screening level ecological risk assessments (SLERAs) for the waste area groups (WAGs) at the Idaho National Engineering Laboratory. Included in this document are discussions of the objectives of and processes for conducting SLERAs. The Environmental Protection Agency ecological risk assessment framework is closely followed. Guidance for site characterization, stressor characterization, ecological effects, pathways of contaminant migration, the conceptual site model, assessment endpoints, measurement endpoints, analysis guidance, and risk characterization are included.

ACKNOWLEDGMENTS

This document was prepared in a cooperative effort with assistance from ecologists, radioecologist, risk assessors, and project managers at DOE-ID and Lockheed Idaho. The authors would like to thank, in particular, Tim Green the Lockheed Idaho project manager and Dr. Nathan Siu of the Risk and Reliability Center at the INEL, who provided much risk assessment and uncertainty guidance, as well as a very thorough and thought-provoking review. We also thank other contributors to this document, including Randy Lee, David Combs, Larry Hilton, Michelle Johnson and Marilynne Manguba. The document also benefitted from the contributions of Dr. Steve Peterson and Rone Brewer of E & E who helped to formulate the approach and produced the case study, and Elizabeth Mooney and other Dames & Moore personnel who assisted in the WAG 2 Screening Level Ecological Risk Assessment.

CONTENTS

FIGURES

TABLES

GLOSSARY

Assessment Endpoint: A quantitative or quantifiable expression of the environmental value considered to be at risk in a risk analysis. Examples include a 25% or greater reduction in gamefish biomass or local extinction of an avian species (Suter, 1993).

Baseline ERA: The baseline ERA will use both the information gathered during the screening level ERA and the results of the data collection effort recommended by the screening level ERA to assess the present risks posed by the unremediated site. The baseline ERA will not evaluate accident scenarios that might cause a release to the environment.

Bioaccumulation: The net accumulation of a chemical by an organism as a result of uptake from all routes of exposure (Suter 1993).

Bioconcentration: The net accumulation of a chemical directly from aqueous solution by an aquatic organism (Suter, 1993).

Biomagnification: The tendency of some chemicals to accumulate to higher concentrations at higher levels in the food web through dietary accumulation (Suter, 1993).

Ecological Risk Assessment (ERA): The "process that evaluates the likelihood that undesirable ecological effects may occur or are occurring as a result of exposure to one or more stressors" (EPA, 1992a).

Functional Group: A group of species similar in biological characteristics and potential contamination pathways, and defined by the following shared characteristics: taxon (class), feeding habitat, and loafing habitat.

Indicator: A characteristic of the environment that provides evidence of the occurrence or magnitude of exposure or effects. Formal expressions of the results of measuring an indicator are referred to as measurement endpoints. Abundance, yield, and age/weight ratios are *indicators* of population production. A low cholinesterase level is an *indicator* of exposure to cholinesterase-inhibiting pesticides (Suter, 1993).

Measurement Endpoint: A quantitative summary of the results of a biological monitoring study, a toxicity test, or other activity intended to reveal the effects of a hazard. Examples include catch per unit effort, standing crop, and LC_{50} (Suter, 1993).

Measurement Species: Those species for which measurement endpoint data are obtained.

Operable Unit: A discrete portion of a WAG consisting of one or many release sites considered together for assessment and cleanup activities.

Risk: The probability of adverse consequences. In the case of ecological risk assessment, the concern is with adverse consequences to ecosystems caused by human activities.

Note — Formally, risk is defined as a probability distribution function for consequences. In simple cases, only one consequence measure is of interest (e.g., the steady state concentration of a specified contaminant at a given location). In more general cases, several measures of adverse impact must be treated; risk is then the joint distribution function over all of these measures. Unlike earlier definitions of risk, this definition does not multiply probabilities and consequences to find the mean (average) consequence; such an operation masks differences between high probability/low consequence and low probability/high consequence scenarios (these are often treated quite differently by decision makers).

Site-wide ERA: Site-wide ERA is the result of integrating the risk from each WAG across the INEL.

Stressor: A physical, chemical, or biological entity that can induce an adverse response.

T/E (Species): Threatened/endangered species as defined by the U.S. Fish and Wildlife Service.

WAG-wide ERA: WAG-wide risk is the result of integrating the risk from each operable unit (as defined in the Federal Facility Agreement and Consent Order) within a WAG.

ACRONYMS

AEC	Atomic Energy Commission
ARARs	applicable or relevant and appropriate requirements
BLM	U.S. Bureau of Land Management
BORAX	Boiling Water Reactor Experiment
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
COPC	contaminant of potential concern
DDPs	decision documentation packages
DOE	U.S. Department of Energy
EBR-I	Experimental Breeder Reactor I
EBSL	ecologically-based screening level
ECOLIT	Ecological Literature Database
EPA	U.S. Environmental Protection Agency
ERA	Ecological Risk Assessment
ERIS	Environmental Restoration Information System
FFA/CO	Federal Facilities Agreement and Consent Order
IEDMS	Integrated Environmental Data Management System
INEL	Idaho National Engineering Laboratory
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NPL	National Priorities List
NRDA	natural resource damage assessment
NRTS	National Reactor Test Station
OU	operable unit
RI/FS	remedial investigation/feasibility study

SARA	Superfund Amendments and Reauthorization Act
SLERA	Screening Level Ecological Risk Assessment
SLQ	screening level quotient
TBCs	requirements to be considered
T/E	threatened and endangered
WAG	waste area group

Guidance Manual for Conducting Screening Level Ecological Risk Assessments at the INEL

1. INTRODUCTION

R. L. VanHorn, N. L. Hampton, T. A. Bensen, C. S. Staley

The INEL is a Department of Energy (DOE) facility as defined in Section 101(9) of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), 42 U.S.C. 9601(9). This facility has been devoted to nuclear energy research and related activities since its establishment in 1949. In the process of fulfilling this mission, wastes were generated, including radioactive and hazardous materials. Most materials were effectively treated, stored, or otherwise disposed of; however, some release of contaminants to the environment has occurred (DOE-ID 1994).

The INEL was listed by the U.S. Environmental Protection Agency (EPA) on the National Priorities List (NPL), November 21, 1989. In December 1988, the EPA directed that "thorough and consistent" ecological assessments should be performed at all Superfund sites (EPA 1988). This directive was based on the language in CERCLA mandating remediation of hazardous waste sites to protect human health, as well as the environment. The National Oil and Hazardous Substances Pollution Contingency Plan (NCP), which implements CERCLA, requires that baseline risk assessments characterize the current and potential threats to human health and the environment [40 CFR Part 300.430(d)(4)] and specifies that environmental risk evaluations "assess threats to the environment, especially sensitive habitats and critical habitats of species protected under the Endangered Species Act" [40 CFR Part 300.430(e)(2)(i)(G)].

Ecological risk assessment (ERA) is the evaluation of the likelihood that undesirable ecological effects may occur or are occurring as a result of exposure to one or more stressors (where "stressor" refers to any physical, chemical, or biological entity that can induce an adverse effect) (EPA 1992a). It has been shown that protecting human health does not always result in protecting ecosystem integrity (Hegner 1994). Therefore, it is important that the INEL adequately address the possibility of risk to ecological receptors. The methodology presented in this manual was developed to conduct screening level ecological risk assessment (SLERA) for the INEL. The approach emphasizes limiting the number of contaminants to be addressed in a baseline identifying those sites contributing to ecological risk, and producing comparable results for multiple assessments. It is also important to recognize that this guidance was developed specifically for use at INEL and may not be applicable to other sites.

1.1 Objectives

The overall objective of this manual is to provide site-specific guidance for performing a SLERA for each waste area group (WAG) at the a INEL. The development of a single guidance manual for performing SLERAs at each INEL WAG is logical for several reasons. First, the macro-scale ecological characteristics of the INEL are fairly homogeneous, consisting primarily of sagebrush steppe, so evaluation of each WAG can be similar. Second, the ERA process is

relatively new, and the models, methods, and data used are not yet standardized. This guidance provides a standard approach for the INEL that will eliminate duplication of effort and be cost effective. Finally, the guidance manual will help ensure that the results obtained are comprehensive.

SLERAs at the INEL will use existing information to screen contaminated areas by identifying the sites and contaminants that could *potentially* pose a risk to the ecological components at each WAG. It is stressed that the approach presented in this manual is not intended to directly measure risk; as such, SLERAs are not true risk assessments. Rather, the goal of SLERAs is to answer the question, "Does a given site/contaminant pose a potential risk to ecological receptors, or does the site/contaminant present low likelihood for potential risk?" SLERAs are prerequisites to ERAs, allowing subsequent ERAs to be focused on those important sites and contaminants at each WAG. Furthermore, SLERAs will identify sites and contaminants for which data are lacking or inadequate to perform an ERA.

1.2 Manual Organization

Each segment in this manual is designed to provide support to the SLERA activity in numerous ways. The main body of the document is a source of methodology and provides specific guidance for the performance of SLERAs. The appendices are designed as reference sources providing site-specific information in support of the INEL SLERA process.

Section 1 introduces the manual and provides a brief discussion the justification for development of the methodology. It presents regulatory drivers for performing ERAs, the scientific approach that is the basis of the guidance, and a general description of the INEL. Section 2 provides an overview of the baseline ERA processes and objectives, and relates this to the SLERA processes. It also discusses the limitations and boundary conditions that are assumed in the SLERA methodology.

Section 3 presents the actual methodology and guidance for conducting a WAG SLERA at the INEL. This section provides specific guidance concerning the information that should be contained in each SLERA. Whenever possible and appropriate, INEL-specific examples are presented. Discussions of the strengths and weaknesses of each step of the methodology are also included.

Several detailed appendices are included as references to this document. These include appendices that provide detailed information on the ecosystem at the INEL, the database developed in support of the guidance manual, the ERIS contaminant database, examples of toxicity reference value (TRV) development, and the background correlation study performed for the SLERAs.

Appendix I presents a case study performed to provide lessons learned during the development of the SLERA methodology. Although the study does not specifically follow the finalized approach, inclusion of a case study provided a prototype for the WAG-wide SLERA. The manual development was guided and benefitted by performance of this case study. The study

is intended to be used for reference only, since the finalized screening methodology presented in the main guidance differs significantly.

1.3 Regulatory Framework

Risk management and ecological assessment goals and policies are constructed primarily around federal mandates (including those that regulate hazardous waste cleanup and those that protect natural resources) and are supported by scientific principles. The primary regulatory driver for performing ERA at the INEL is CERCLA as amended by the Superfund Amendments and Reauthorization Act (SARA) of 1986. Additional regulatory drivers are within a set of applicable or relevant and appropriate requirements (ARARs), which entail consideration of numerous federal and state laws and regulations concerning natural resource preservation and protection when evaluating possible response actions.

Section 121(d)(2(A) of CERCLA requires that Superfund remedial actions at hazardous waste sites meet ARARs such as federal and state standards, requirements, criteria, or limitations (EPA 1989b; 1989c). In addition to protecting human health, these ARARs are aimed at protecting ecological resources and public interest in those resources. ARARs to be considered in ERA include, but are not limited to, the Endangered Species Act of 1973 as reauthorized in 1988, the Migratory Bird Treaty Act of 1972, and the Fish and Wildlife Conservation Act of 1980 (EPA 1989b; 1989c). These mandates help to protect resource values that are important to the general public, such as aesthetic (scenery), economic (timber or grazing allotments), or recreational (game species) importance. Efforts such as ERA are expended to fulfill the goals of these regulations.

1.4 Ecological Framework

ERA is a process for identifying ecosystem components at risk, addressing spatial and temporal constraints, assessing stressor effects, and calculating risk. Three ecosystem-level indicators of viability or integrity provide the foundation for assessing stressor effects: (a) diversity (composition), (b) productivity (function), and (c) habitat preservation (structure) (Chapman 1991; Noss 1990). These indicators are the basis for a suite of goals that can be used to evaluate risk to valuable ecological resources at the INEL from chemical and physical stressors, including:

- Protection of threatened and endangered (T/E) individuals and populations
- Protection of critical habitats
- Protection of abundance and diversity of native species
- Protection of primary productivity
- Protection of habitat structure
- Protection of natural succession.

These criteria serve as the foundation for relating assessment endpoints to ecosystem-level effects through the ERA process. ERAs for individual sites will incorporate an approach designed to identify and evaluate threatened ecological components in terms of these criteria.

The EPA Framework (EPA 1992a) states that to be meaningful and effective, ERAs must be scientifically valid as well as relevant to regulatory needs and public concerns. From a scientific viewpoint, the ecological effects and routes of exposure must be examined so that important impacts and transport pathways are not overlooked, and reasonable estimates are made of health and environmental effects.

Examination of effects at all biological/ecological levels must be considered in ERA, since environmental stresses will be expressed in different ways at different levels of organization (Noss 1990). In addition, the "biological significance of an effect is a function of its implications for the next higher level of biological organization" (EPA 1989a). To ensure that potential effects are evaluated for all ecological levels, the ERA process draws from the fundamental concepts of ecological organization (Scheiner et al. 1993):

ECOSYSTEM
|
COMMUNITY
|
GUILD
|
POPULATION
|
INDIVIDUAL

A SLERA is not intended to assess ecosystem integrity. Rather, it is a preliminary assessment, intended to focus ERA on contaminants of potential concern and the ecological components most likely to demonstrate adverse effects as a result of exposure to those contaminants. The methodology presented in this manual emphasizes an approach for evaluating all ecological receptors at the individual level to reduce the possibility that important ecological effects may be overlooked. The results of the SLERA are designed to support assessment of higher level ecological effects in subsequent screening or baseline assessments.

1.5 Existing Guidance for Conducting Ecological Risk Assessments

The development of SLERA guidance for the INEL was based on the EPA's *Framework for Ecological Risk Assessment* (EPA 1992a). This framework was developed in 1992 as a first step in a long-term program for developing guidelines for ecological risk assessment. Supplementary to its framework, EPA has addressed in documents (e.g., EPA 1989b) and bulletins the need for specific guidance for applying ERAs to CERCLA sites. The bulletin series, titled "Environmental Compliance Office (ECO) Update," includes several publications to date (EPA 1991a; 1991b; 1992c; 1992d; 1992e), which provide broad guidance for specific tasks within the ERA process. Additional material pertinent to ERA at sites affected by SARA is presented in EPA (1989a).

National and regional aspects of the *Superfund Human Health Evaluation Manual* (EPA 1989b; 1989c) are also relevant to ERA.

The U.S. Department of Energy (DOE) has recognized the usefulness of ERA in programs at DOE facilities and has published the *Policy Framework and Implementation Plan for using Ecological Risk Assessment at DOE Facilities* (DOE 1993) to incorporate ERA throughout the DOE complex. The DOE Framework states that ecological risk assessment is a promising tool that the DOE can use to meet its legal, institutional, and policy commitments to ecological resources. This framework proposes that DOE adopt the EPA framework as its primary means for providing technical information on past, present, and future risks to ecological resources across the DOE complex. However, the DOE Framework also states:

> "The more detailed EPA methodology will require years to develop, so the current framework does not yet provide guidance on how the risk assessment process should be applied to ecological systems. For example, it does not discuss whether the model should be applied to ecosystems in their entirety, parts of ecosystems (e.g., individual habitats, endangered species), or both. It also does not discuss the measurement endpoints (e.g., changes in numbers of species, changes in abundance, changes in primary productivity, or changes in energy flow) that should be targeted when risk assessments are conducted. Therefore, the EPA process should be considered a generic paradigm for the conduct of ecological risk assessments rather than prescriptive guidance."

Consequently, this screening level manual incorporates information from both the EPA Framework (EPA 1992a) and the DOE Framework (DOE 1993) to develop a site-specific methodology for SLERA at the INEL.

1.6 INEL Description

1.6.1 INEL History

The INEL is a DOE facility that has been devoted to nuclear energy research and related activities since being established in 1949. The INEL was originally designated as the National Reactor Testing Station (NRTS) by the U.S. Atomic Energy Commission (AEC). The NRTS provided an isolated location where nuclear reactors and support facilities could be built and tested. In 1974, the NRTS was redesignated as the INEL to reflect the broad scope of engineering activities taking place. Today, research, training, and production activities related to defense and non-defense programs are conducted at the INEL. Approximately 95% of the INEL has been controlled by DOE (formerly the AEC) for over 40 years. The remaining 5% includes public highways crossing the Site, the Naval Reactors Facility, and the Experimental Breeder Reactor I (EBR-I) historic landmark.

Before the INEL was established, the land was under control of the U.S. Bureau of Land Management (BLM). The land was withdrawn from the public domain through a series of public land orders in 1946, 1949, and 1950. Until then, the area was used primarily as rangeland. From 1,200 to 1,400 km^2 (470 to 550 mi^2) around the perimeter of the INEL are open to grazing

through permits administered through the BLM; however, since 1957, the central portion of the INEL [approximately 1,385 km^2 (535 mi^2)] has been maintained as a grazing exclusion area. Other areas of the Site have been used as bombing and gunnery ranges, and some areas have been cleared for large projects [approximately 700 km^2 (270 mi^2)]. Despite these disturbances, much of the INEL has been excluded from public access and therefore has been left relatively undisturbed.

In 1972, the DOE established the INEL as a National Environmental Research Park. It is the second largest of seven such Parks and is one of two which contain sagebrush steppe ecosystems. The primary purpose of the Research Parks is to provide outdoor laboratories where scientists may study undisturbed ecosystems and the impacts of energy development on them. A secondary purpose of the Research Park network is to provide education about the natural environment and environmental issues.

1.6.2 INEL Location and Description

The INEL occupies 2,300 km^2 (890 mi^2) on the northwestern portion of the eastern Snake River Plain in southeastern Idaho (Figure 1-1). It is nearly 63 km (39 mi) long from north to south and about 58 km (36 mi) wide in its broadest southern portion. Mountain ranges bordering the INEL on the north and west are the Lost River Range, the Lemhi Range, and the Beaverhead Mountains. The INEL is surrounded by agricultural lands, U.S. Forest Service lands, and BLM lands managed as rangeland. Irrigated farmlands exist adjacent to approximately 25% of the INEL boundary. Crops grown on these lands include alfalfa, wheat, and potatoes. These areas also provide food and water resources for some INEL wildlife.

In the western and northern portions of the INEL, intermittently flowing waters from the Big Lost River, the Little Lost River, and Birch Creek flow to the Lost River Sinks in the northwest portion of the INEL. Water evaporates and infiltrates into the Snake River Plain Aquifer at the sinks. Much of the water is diverted for irrigation and power production before reaching the INEL and the waters only flow onto the site when there is sufficient snowpack runoff. Nineteen ninety-three was the first year since 1986 when sufficient runoff existed for the Big Lost River to flow onto the INEL and this occurred for only a few weeks. However, prior to 1986, flows in the section of the Big Lost River on the INEL were a regular, seasonal occurrence (spring). Major surface water drainages do not flow off the INEL.

1.6.3 INEL Waste Area Groups Description

INEL hazardous waste sites have been systematically divided into smaller, more manageable waste areas (i.e., WAGs) through a Federal Facilities Agreement and Consent Order (FFA/CO) between the EPA, State of Idaho, and DOE-ID in December 1991. The FFA/CO divides the INEL into 10 WAGs to facilitate environmental remediation efforts. WAGs 1 through 9 generally correspond to U.S. DOE-INEL operational facilities, while WAG 10 corresponds to overall concerns associated with the Snake River Plain Aquifer and those surface and subsurface areas not included in the bounds of the facility-specific WAGs (EPA 1991c). Within a WAG, the multiple locations, or sites, of contamination (also known as "potential release site") are grouped together by similar contamination problems or boundaries and called operable units (OUs). Sites range in size from large facilities to small rubble piles and also include pits, percolation ponds,

Idaho National Engineering Laboratory

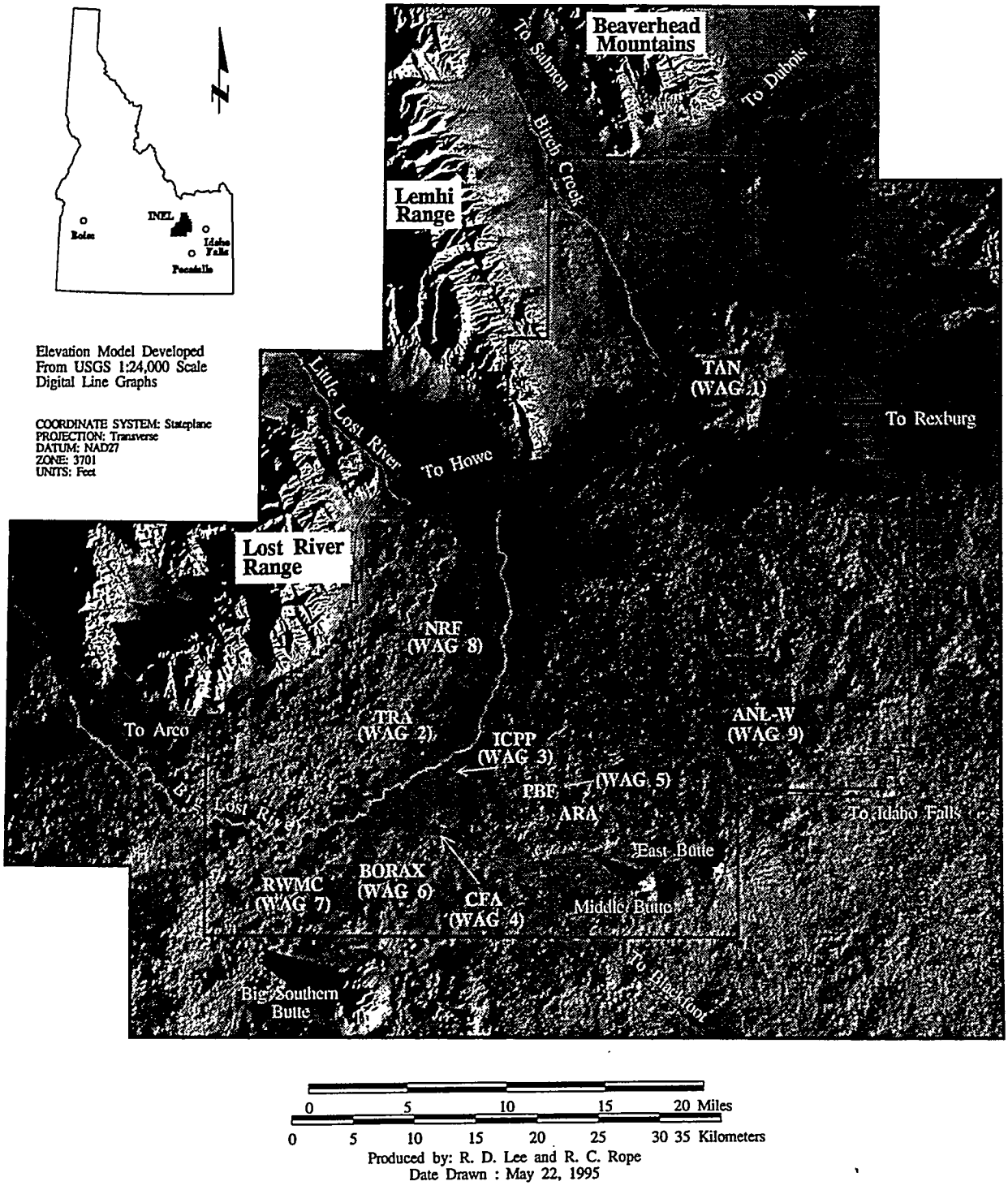


Figure 1-1. Location of major facilities at the Idaho National Engineering Laboratory in southeastern Idaho.

landfills, septic systems, injection wells, trenches, and abandoned tanks. Locations of WAGs 1 through 9 at the INEL are shown on Figure 1-1. SLERAs will be performed for individual WAGs, with each SLERA considering all OUs (hence, all stressors).

1.6.3.1 WAG 1 Description. WAG 1 consists of several subareas at Test Area North (TAN) including the Technical Support Facility (TSF), Water Reactor Research Test Facility (WRRTF), Loss-of-Fluid Test Facility (LOFT), Initial Engine Test Facility (IET) and Specific Manufacturing Capability Facility (SMC).

The TSF consists of facilities for handling, storage, examination, and research and development of spent nuclear fuel. The Process Experimental Pilot Plant (PREPP) is also located at TSF.

The IET was designed as a testing location for the nuclear jet engines developed in the 1950s and early 60s and has been abandoned. It still includes some sites being investigated under the FFA/CO (EPA 1991d).

LOFT and SMC are contiguous facilities west of TSF that consist of structures built for those two operations and old buildings from the Aircraft Nuclear Propulsion program. LOFT is a facility constructed for nuclear reactor tests that has been decommissioned. SMC is an active facility manufacturing components for a U.S. Department of Defense (DOD) non-nuclear weapons system.

WRRTF facility consists of two building that have supported several non-nuclear tests, mainly for simulation and testing water systems used in reactors.

Potential release sites at WAG 1 include underground storage tanks, spills, disposal sites, pits, ponds, waste disposal systems, rubble disposal sites, and injection well(s). Hazardous, radioactive, and mixed waste exist at those sites. WAG 1 is divided into 10 OUS consisting of 71 sites. Possible contaminants include asbestos, petroleum products, acids and bases, and radionuclides.

1.6.3.2 WAG 2 Description. WAG 2 is the Test Reactor Area (TRA). This facility was designed to study the effects of radiation on materials, fuels, and equipment. The Advanced Test Reactor (ATR) is the only large reactor operational within TRA. It is designed to produce a neutron flux that allows simulation of long-duration radiation effects on materials and fuels. It also produces isotopes for use in medicine, research,and industry.

Potential release sites associated with various facilities at TRA include leaching ponds, underground storage tanks, rubble piles, cooling towers, an injection well, french drains, and assorted spills where hazardous and radioactive wastes may exist. WAG 2 is divided into 10 OUs consisting of 51 potential release sites. Possible contaminants include petroleum products, acids, bases, PCBs, radionuclides, and heavy metals.

1.6.3.3 WAG 3 Description. WAG 3 is the Idaho Chemical Processing Plant (ICPP) that houses reprocessing facilities for federal government defense and research spent fuel. Facilities at

ICPP include spent fuel storage and reprocessing areas, a waste solidification area and related waste storage bins, remote analytical laboratories, and a coal-fired steam generating plant.

Potential release sites associated with various facilities at ICPP include sumps, ponds, and injection wells, spills, and tank farm storage of hazardous substances. Potential contaminants include organics, radionuclides, metals, corrosives, petroleum wastes, and mixed wastes. WAG 3 is divided into 14 OUs consisting of 83 potential release sites.

1.6.3.4 WAG 4 Description. WAG 4 is the Central Facilities Area (CFA). Services for all of the INEL are headquartered here, including; environmental laboratories, security, fire protection, medical facilities, communications systems, warehouses, a cafeteria, vehicle and equipment pools, bus system, and laundry.

Potential release sites include spills, underground storage tanks, the INEL landfill, ponds, leach fields, and leach pits. This WAG is divided into 13 OUs with 29 potential release sites. Potential contaminants include solvents, PCBs, asbestos, radionuclides, unexploded ordnance, heavy metals, and construction debris.

1.6.3.5 WAG 5 Description. WAG 5 consists of the Power Burst Facility (PBF) and the Auxiliary Reactor Area (ARA). PBF is located in an area originally constructed for the Special Power Excursion Reactor Tests (SPERT). The four SPERT reactors, built in the late 50s, have been removed and the facilities have undergone partial or complete decontamination and decommissioning (D&D). The PBF reactor is still operational and is currently in standby mode. Four groupings of buildings are designated as the ARA. These facilities supported various activities including the operation of test reactors. All the reactors have been removed and the facility has undergone partial or complete D&D.

Potential release sites include tanks, evaporation ponds, percolation ponds, leach fields, pits, and dry wells. This WAG is divided into 13 OUs with 48 potential release sites. Potential contaminants are petroleum products, hazardous waste, radionuclides, metals, radioactively contaminated soil, rubble, and debris.

1.6.3.6 WAG 6 Description. WAG 6 includes the EBR-I and the Boiling Water Reactor Experiment (BORAX) areas. These areas were both constructed to house test reactors and have since been decommissioned. EBR-I is now a national historic landmark. The BORAX area housed five reactors, but many of the facilities have been dismantled or moved, and no operations (other than monitoring) take place in the area.

Potential release sites include the BORAX-I burial site (grouped under WAG 5), a trash dump, fuel oil tanks, septic tanks and a leach pond. The WAG is divided into five OUs with 21 potential release sites. Potential contaminants from past operations are organic and inorganic chemicals, radionuclides, and metals.

1.6.3.7 WAG 7 Description. WAG 7 is the Radioactive Waste Management Complex (RWMC). The RWMC was established in 1952 as a controlled area for disposal of solid radioactive wastes generated by DOE operations at the INEL and other DOE sites. The primary RWMC site is the Subsurface Disposal Area (SDA), including numerous pits, trenches, and vaults

containing wastes, as well as a large pad where waste was placed above grade and covered. The Transuranic Storage Area (TSA) within the RWMC has been used since the early 1970s for retrievable storage of transuranic waste on earthen-covered pads and in facilities.

The WAG is divided in 14 OUs including the air, groundwater, and surface-water pathways, as well as the vadose zone for both radionuclide/metals and organics.

1.6.3.8 WAG 8 Description. WAG 8 is the Naval Reactors Facility (NRF), operated by Westinghouse Electric Corporation for the DOE Naval Reactors Program. This facility contains prototype Naval reactors used for research and development and for training of Naval personnel. The NRF also contains the Expended Core Facility, which supports research and development efforts on reactor materials by preparation and examination of irradiation test specimens and irradiated Naval reactor fuel.

Potential sites include landfills, old spills, wastewater disposal systems (e.g., ponds, ditches, basins, drains, and drain fields) and storage areas. The WAG is divided into nine OUs with 76 potential release sites.

1.6.3.9 WAG 9 Description. WAG 9 is the Argonne National Laboratory-West (ANL-W) complex. ANL-W operates the Experimental Breeder Reactor II, the first pool-type liquid-metal reactor. The complex also has four other reactors and two fuel examination facilities.

Potential sites include tanks and wastewater handling/disposal systems such as ditches, ponds, pits, and drains. The WAG consists of four OUs with 37 potential release sites.

1.6.3.10 WAG 10 Description. WAG 10 includes areas in and around the INEL that cannot otherwise be addressed on a WAG-specific basis. These include the regional Snake River Plain Aquifer and surface disposal sites and ponds identified at the INEL but which are not included in other WAGs. The boundaries of WAG 10 are INEL boundaries or beyond, as necessary, to encompass real or potential impacts from INEL activities. WAG 10 consists of 12 specifically identified and seven generally identified sites divided into seven OUs. Specific sites at WAG 10 include, among others, the Liquid Corrosive Chemical Disposal Area located between WAGs 6 and 7, the Organic Moderated Reactor Experiment leach pond located between WAGs 4 and 5, former ordnance areas (including the old Naval Ordnance Disposal Area) located at numerous sites on the INEL, and miscellaneous radionuclide-contaminated soil sites.

2. SCREENING LEVEL ECOLOGICAL RISK ASSESSMENT

R. L. VanHorn, N. L. Hampton, T. A. Bensen, C. S. Staley

This SLERA guidance manual was developed based on the approach shown in Figure 2-1. The approach incorporated data evaluation and a case study to assist in the development of the SLERA guidance manual. Therefore, knowledge gained from developing the case study and assimilating the data early in the investigation could be used to refine initial objectives and guide subsequent work on the screening level manual. A SLERA for each WAG at the INEL will be performed based on the methodology developed in this manual. As shown in Figure 2-1, the need for a more detailed ERA is dependent on the results of the SLERA. ERAs, where necessary, will be completed as part of comprehensive remedial investigation/feasibility studies (RI/FS) for selected WAGs.

Input from a Biological Technical Assistance Group (BTAG) is recommended by EPA (1992e) and should be used throughout the ERA process (Figure 2-1). BTAG members should represent a variety of disciplines, including wildlife biology, soil science, wildlife toxicology, ecology, geology, hydrology, risk assessment, and wetland science. In an advisory and review capacity, the BTAG serves several essential functions to ensure adequate consideration of ecological issues at Superfund sites. These functions include initial site review, assistance in work scope development, review of contractor qualifications and performance, review of interim and final products, evaluation of remedial alternatives, and advice on remedial decisions, remedial design, and remedial actions (EPA 1991a).

The EPA Framework (EPA 1992a) stresses the importance of a stepwise approach to ERA at Superfund sites. These steps include the problem formulation, analysis, and risk characterization (Figure 2-2). The EPA Framework (EPA 1992a) very generally discusses each of these steps based on the needs of a baseline ERA. The approach presented for SLERA parallels the three steps of the ERA framework. This section presents a brief discussion on the risk assessment processes as they relate to a baseline ERA and then summarizes the approach as developed for the SLERA. The guidance specific to SLERA for these steps is presented in Section 3.

2.1 Objectives and Directives of an Ecological Risk Assessment

The general goals of a *baseline* ERA are to:

- Contribute information and analysis that will aid in the remedial decision-making process
- Inform risk managers and the public of the magnitude and significance of ecological risks at the site, and
- Enhance the credibility of the entire baseline risk assessment by ensuring that risks to nonhuman receptors are evaluated.

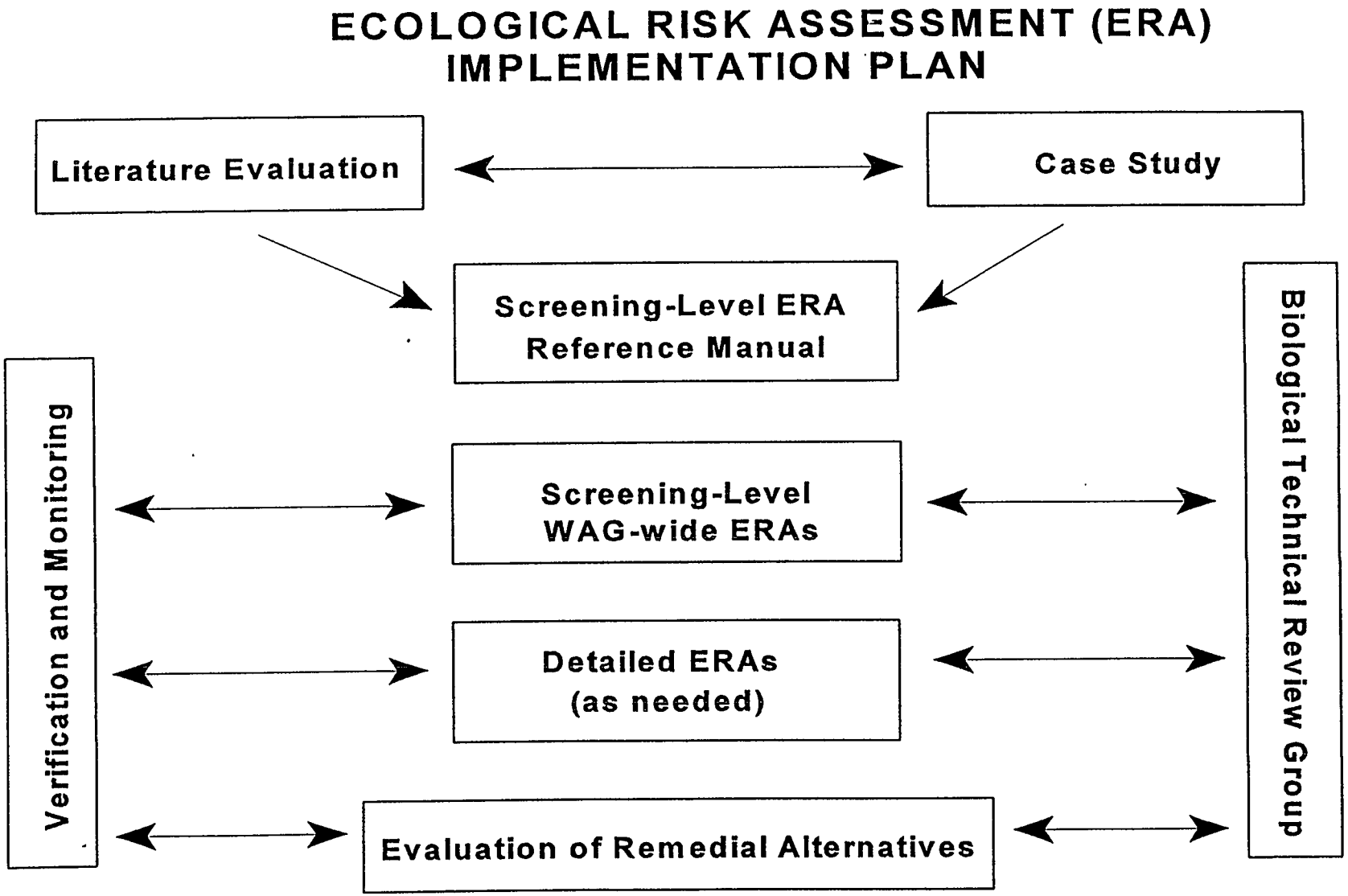


Figure 2-1. Guidance approach to screening level ecological risk assessment.

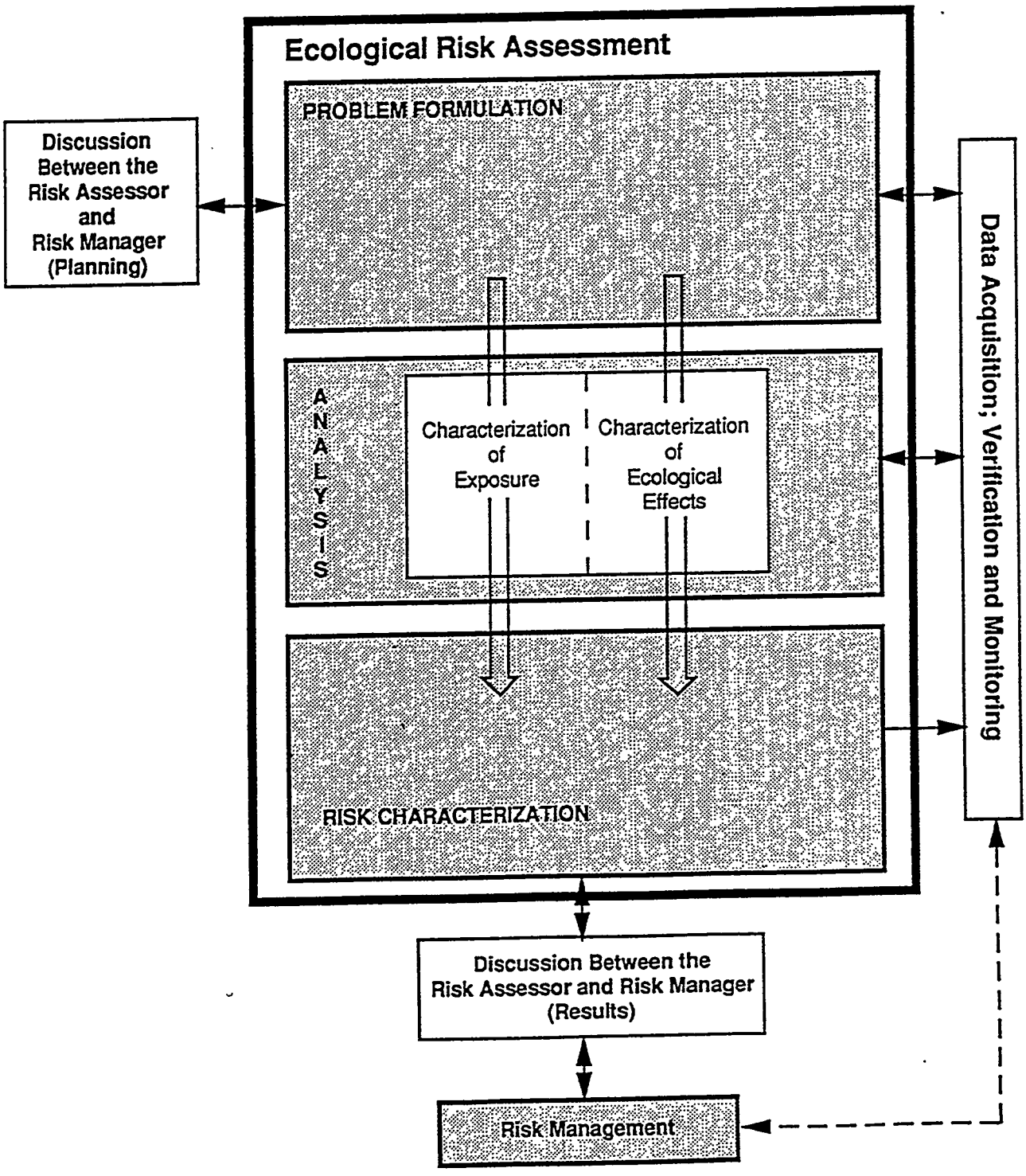


Figure 2-2. A stepwise approach to ERA.

SLERAs are the first step toward attaining these baseline ERA goals. Specifically, SLERAs will identify those sites/OUs at the INEL that could potentially pose a risk to ecological receptors (including sites needing additional data), while eliminating other sites which pose no or low likelihood of risk. SLERA methodology is a semi-quantitative approach and does not actually quantify risk. Those sites identified by SLERAs as posing potential risk will be evaluated in greater detail (i.e., risks will be quantified) in subsequent ERAs. The baseline ERA will be completed during the comprehensive RI/FS for selected sites.

The general SLERA objectives are to:

- Identify contaminants of potential concern (COPCs) (if any) at each WAG that contribute an unacceptable ecological risk and identify sites within the WAG that contribute to this risk. It is possible, using this screening level methodology, that a WAG may be completely eliminated as a contributor to unacceptable ecological risk.

- Identify data and/or monitoring that will be required to perform a baseline ERA if the potential for ecological risk is found through the screening level process.

SLERAs will be conducted at the INEL in accordance with specific federal regulations and other ARARs, as well as in a scientifically valid manner. Consideration of regulatory drivers and adherence to ecological principles ensures that SLERAs will address all important ecological concerns.

2.2 Problem Formulation

"Problem formulation includes a preliminary characterization of exposure and effects, as well as examination of scientific data and data needs, policy and regulatory issues, and site-specific factors to define the feasibility, scope, and objectives for the ecological risk assessment" (EPA 1992a).

The activities performed in the problem formulation are highly interactive and interrelated. The problem formulation directs the level of detail and information that will be needed to complete the assessment and ultimately results in a conceptual site model that describes how a given stressor might affect the ecological components in the environment.

The primary difference between an ERA and a SLERA is the level of detail at which selected components are addressed. In general, SLERA modeling is much more simplistic than that required for a baseline ERA. For example, spatial distribution of contaminants at a WAG may be modeled at high resolution for an ERA, while very little of this type of analysis is appropriate for a SLERA.

2.2.1 Ecosystem Characterization

For SLERA, as in ERA, ecosystem characterization includes defining the assessment area, describing the types and abundance of different flora and fauna species and their trophic relationships, and describing any abiotic factors that may be important to the assessment (e.g.,

climate, topography, soil). The primary difference is the level of detail that is necessary to fulfill the objectives of the risk assessment.

In an ERA, detailed spatial and temporal scale are necessary to define the landscape that the assessment will encompass. As stated in EPA (1992b), spatial scale "delineates the area over which the stress is operative and within which direct ecological effects may occur. Indirect ecological effects may greatly expand the spatial scale required for the assessment." Temporal scale is also defined as "the expected duration for the stress, the time-scale for expression of direct and indirect ecological effects, and the time for the ecosystem to recover once the stress is removed" (EPA 1992b). Spatial scale for SLERA is confined to an area which has been defined using existing contaminant sample data. SLERA addresses only current conditions. As a result, temporal considerations for ecological effects are primarily deferred to the analysis and are incorporated in the calculation of exposure.

Ecosystem characterization, and problem formulation in general, is aided by the large amount of data describing the ecosystem and the stressors at the INEL. DOE-ID supported ecological research has been conducted at the INEL for over 40 years. These studies include investigations of the basic ecology of the species inhabiting INEL, the exposure of these species to contaminants, and the fate and transport of contaminants. Although much of this research has been limited to addressing specific problems unique to the INEL.

A unique aspect of the SLERA process presented in this guidance is the use of "functional grouping" for ecological components. The primary purpose for this approach is to take advantage of existing data from one or more species within the group to address potential effects to the group as a whole. In addition, functional grouping introduces a consistent, systematic approach to defining SLERA assessment and measurement endpoints and a simplifies the process of identifying and screening numerous species. It also provides a repeatable method for focusing the assessment on components at highest potential for exposure to contaminants and allows explicit interpretation of assessment results. The process is applied in all steps of the SLERA. SLERA guidance for applying functional grouping is presented in Section 3.2.3.2.

2.2.2 Stressor characterization

DOE (1993) defines a stressor as "any physical, chemical, or biological entity that can induce and adverse response." Chemical stressors include a variety of organic and inorganic substances. Physical stressors include extremes of natural conditions and habitat alteration or destruction. Biological stressors can include introduced species that compete for resources, or overuse of a habitat by a introduced or native species.

The DOE Framework (DOE 1993) proposes a holistic approach that would execute an "umbrella" ERA for the major combinations of ecological resources and stressors. However, because SLERAs at the INEL are CERCLA-driven, emphasis will be placed on the chemical stressors. While behavioral modifications resulting from both contaminant and physical stressors may affect assumptions regarding receptor exposure, these concepts are outside the scope of SLERA. Physical and biological stressors will not be addressed in the SLERA guidance.

For the SLERA, identification of the COPCs and the development of a concentration for contaminated media will be a major focus. This approach necessitates compiling sample data collected for human health risk assessment and developing a database for use for the SLERA. Large amounts of data are available from sampling at the INEL and will require screening to focus the assessment on those contaminants potentially posing a risk. This is discussed in detailed in Section 3.

2.2.3 Ecological Effects

Ecological effects in the overall context of ecological risk relates to the adverse (toxic) effects possible to the ecosystem due to exposure to a contaminant. There may also be positive, or no effects as a result of exposure, but these are not generally considered in an assessment. According to EPA (1989c), a toxicity assessment includes (a) gathering qualitative and quantitative toxicity information for the substance being evaluated, (b) identifying exposure periods for which toxicity values are necessary, (c) determining toxicity values for noncarcinogenic effects, and (d) determining toxicity value for carcinogenic effects. Relevant sources of ecological effects data are summarized in the problem formulation stage of the ERA process. These sources of information include field observation, field tests, laboratory tests, and chemical structure-activity relationships. Information on ecological effects can help focus the assessment on specific stressors and on ecological components that should be evaluated (EPA 1992a). To support this activity, available ecological literature is reviewed and analyzed for information important to developing the conceptual site model.

2.2.4 Pathway/Exposure Models

An exposure analysis can become extremely complex. This complexity is based on the possibility of qualitatively examining the spatial and temporal relationships in conjunction with quantifying the exposure. In assessing the spatial scale of the interaction between the stressor and potential receptor, the physical extent of the contaminant and the ranging behavior of the potential receptor must be determined. An effect is possible only if the stressor and the potentially affected ecological component overlap in time and space. Assessing the temporal scale of the interaction between stressors and target ecosystem components must take into consideration the time necessary for the contaminant or physical stressor to reach the target component, whether the exposure is acute or chronic and whether the effects occur immediately or are delayed.

The models supporting the SLERA exposure analysis include a food web model, a pathways/exposure model, and a conceptual site model. For the SLERA, major pathways of exposure are identified and evaluated. These pathways generally include surface and subsurface soil, surface water, and sediments. Typically, four direct exposure routes are considered in ecological risk assessments, as they are in human health risk assessments. These routes are (a) ingestion (soil and water), (b) inhalation, (c) dermal contact, and (d) for radionuclides only, external exposure. Indirect exposures resulting from transfer of contaminants from prey to predator are also incorporated in the exposure analysis. For vegetation exposure assessment, analysis of root uptake and leaf absorption is required.

Due to the nature of the contamination at the INEL, it is anticipated that these models will generally account for most of the potential risk to the ecosystem from a WAG. However, consideration of potential effects for other exposure routes may be required depending on the COPC, the functional group at risk, and the site characteristics. Volatile organic compounds present at buried waste sites at the INEL, for example, may require consideration of both dermal contact and inhalation exposure routes. Groundwater pathways have also been eliminated from consideration for several reasons. Primarily, they are considered to have no receptors of concern for which effects can be readily observed or measured. However, groundwater may be evaluated as part of the baseline ERA.

2.2.5 Conceptual Site Model

Simplistically, the conceptual site model combines the ecological and contaminant characteristics of the ecosystem (i.e., the food web and pathways/exposure models) being analyzed to develop exposure scenarios for use in assessing the risk at the site. The EPA Framework (1992a) states that for chemical stressors, the exposure scenario usually involves consideration of the sources, environmental transport, partitioning of the chemical among various environmental media, chemical/biological transformation or speciation processes, and identification of potential routes of exposure (e.g., ingestion).

In the SLERA process, the creation of a conceptual site model involves integrating one or more generic pathways/exposure models and receptors with indirect exposure effects (prey consumption). This step provides an indication of the risk as the situation at the site currently exists.

In ERAs, it is possible for conceptual site modeling to encompass great detail of the interactions of receptors and potential stressors in the environment. Generally, the major focus of the conceptual model is the development of a series of working hypotheses regarding how the stressor might affect ecological components of the natural environment (NRC 1986). Realistically, only those hypotheses that are considered most likely to contribute to risk are selected for further evaluation in the analysis phase. Professional judgment is needed to determine the detail necessary to evaluate the risk and to select the most appropriate risk hypotheses. It is important to document the selection rationale (EPA 1992b).

2.2.6 Assessment and Measurement Endpoints

Assessment endpoints are "formal expressions of the actual environmental values that are to be protected" (Suter 1989). The considerations that must be incorporated to produce appropriate assessment endpoints include (EPA 1992a):

- Policy goals and societal values
- Ecological relevance
- Susceptibility to the stressor
- Accessibility to prediction and measurement.

In an ERA, emphasis is generally placed on assessment endpoints that are defined in terms of societal, as well as biological, relevance. As a consequence, assessment endpoints are often limited to species or other ecosystem components that are highly valued by both the public and decision-makers. However, these highly valued components of the ecosystem do not necessarily have sufficient biological relevance in terms of the risks being assessed (Suter 1993). Establishment of intermediate linkages between the stressor and appropriate endpoints is often complicated, and assessment endpoints are difficult to define. Professional judgement plays an important role in the selection of assessment and measurement endpoints (EPA 1992a).

For SLERA, definition of assessment endpoints is much more simplistic. SLERA endpoints are not intended to reflect ecosystem integrity, nor are they to be used to set remedial clean-up levels. Rather, SLERA endpoints are intended to identify contaminants of concern and the ecological receptors that have the greatest potential for being adversely affected through exposure to those contaminants. Only ecological relevance and regulatory criteria [i.e., consideration of threatened and endangered (T/E) species] are used to define endpoints, and an effects-based approach is applied to interpret assessment results in terms of:

- Potential effects to WAG T/E individuals and populations
- Potential effects to WAG biota (functional groups)
- Potential effects to WAG critical habitats.

ERA endpoint definitions are summarized in the EPA Framework (EPA 1992a) and discussed in detail by Suter (1989; 1992; 1993). These documents emphasize the distinction between assessment and measurement endpoints.

A measurement endpoint is "a quantitative expression of an observed or measured effect of the hazard; it is a measurable environmental characteristic that is related to the valued characteristic chosen as an assessment endpoint" (Suter 1989).

For SLERA, contaminant effects for ecological components are not measured directly. Rather, measurement endpoints are defined as the input values for exposure models used to develop ecologically-based screening levels (EBSLs). EBSLs are then used as benchmark criteria for screening (see Section 3.3.1). Identification of existing data that can be used to model exposures for functional groups or other ecological components is the primary method by which SLERA measurement endpoints values are derived.

2.3 Analysis

The EPA Framework (EPA 1992a) states that the analysis phase of the ERA consists of (a) the exposure assessment (characterization of exposure), and (b) the ecological effects analysis. The exposure assessment involves using the information gathered during the problem formulation phase (i.e., contaminant migration and pathways model and stressor characterization) to identify actual or potential exposure routes to ecological receptors, and evaluate the magnitude of exposure to those receptors. In the exposure assessment, exposure concentrations are estimated for each contaminant, for each exposure pathway, and for each receptor. This exposure

information is then used in conjunction with toxicological information to calculate a dose to the ecosystem (functional group) to determine any ecological effects.

The primary difference between an ERA and a SLERA is the level of conservatism used. Simplified conservative assumptions are made concerning the exposure routes and evaluation of the magnitude of exposure of the receptor to contamination. For example, the conservative assumption that exposure duration (ED) is 1.0 for ecological receptors in the analysis, that are year round residents and 0.5 for ecological receptors that are summer residents is made in the exposure assessment in the SLERA (Section 3.3.1.3). In an ERA, the ED would be more realistically and less conservatively modeled. For SLERA, this section will be referred to as the "screening analysis" rather than "risk analysis" (Section 3.3).

2.3.1 Exposure Assessment

The ERA exposure assessment is used to determine (qualitatively and quantitatively) the magnitude, frequency, duration, and routes of exposure (i.e., the dose to the receptor). The stressor characterization and the ecosystem characterization performed during the analysis phase of the ERA provide the basis for the exposure analysis and profile (EPA 1992a). These processes are generally conducted concurrently.

Using information obtained from the exposure assessment, the exposure profile quantifies the magnitude and spatial and temporal patterns of exposure for the scenarios developed during problem formulation and serves as input to the risk characterization phase. The exposure profile is only effective when its results are compatible with the stressor-response profile. For example, appraisals of potential acute effects of chemical exposure may be averaged over short time periods to account for short-term pulsed stressor events. It is important that characterizations for chronic stressors account for both long-term, low-level exposure and possible shorter term, higher level contact that may elicit similar adverse chronic effects.

2.3.1.1 Stressor Characterization. The contaminant fate and transport through the terrestrial and aquatic environments for the contaminants that have been identified in the problem formulation are discussed here. During the analysis phase, these contaminants are thoroughly discussed to obtain a complete picture of their movement and activity in the environment. This information combined with the ecological effects analysis provides an effective picture of the potential movement of the COPC through the ecosystem and allow for an adequate characterization of the risk. Once the COPCs dominant environmental pathways and fate processes are understood quantitatively, a much clearer picture emerges of the nature of the contamination issue, the behavior of the chemical, and how conditions may be modified to reduce concentration, and hence reduce exposure (Suter 1993).

For the SLERA, a limited fate and transport section will be included. Characterization of the stressor as a value representing the amount of contaminant present in a medium is a major focus of the SLERA. This characterization necessitates compiling sample data that has been collected on the site for human health risk assessment and developing a database for conducting the SLERA. This effort is discussed in detail in Section 3.

2.3.1.2 Ecosystem Characterization. The ecosystem characterization performed as part the problem formulation is the basis for further analysis of the ecosystem characterization conducted for the exposure assessment. In particular, the spatial and temporal distributions of the ecological components are characterized, and the ecosystem attributes that influence the distribution and nature of the stressor are considered (EPA 1992a).

The exposure assessment ideally combines the spatial and temporal distributions of both the ecological components (receptors) and the stressors. The temporal and spatial scales used to evaluate the stressor need to be compatible with the characteristics of the ecological component of interest. A temporal scale may encompass the lifespan of a species, a particular life stage, or a particular cycle (e.g., the long-term succession of a forest community). A spatial scale may encompass a forest, a lake, a watershed, or an entire region. Stressor timing relative to organism life stage and activity patterns can greatly influence the occurrence of adverse effects. Even short-term events may be significant if they coincide with critical life stages. Periods of reproductive activity may be especially important because early life stages often are more sensitive to stressors, and adults also may be more vulnerable at this time.

For SLERA purposes, both the temporal and spatial analyses will be simplified as discussed in Section 3. The receptors are assumed to be exposed to stressors to the maximum extent, perhaps beyond what is actually expected (for example, assuming that a raptor captures 100% of its prey from a contaminated site, and that all the prey are exposed to maximum contaminant concentrations). It is assumed that for all contaminants there are potential pathways to ecological receptors since sites or contaminants with no potential pathway (e.g., diesel fuel in perched water) are eliminated from further analysis. A conservative toxicity reference value (TRV) approach will be used to quantitatively model the exposure. The formula presented in this guidance for use in the SLERA (Section 3.3.2), is appropriate for terrestrial pathways and direct ingestion of abiotic media.

2.3.2 Effects Assessment

The purpose of the effects (or, stressor-response) assessment is to characterize the toxicity of stressors to selected ecological receptors. The relationship between stressors and ecological effects elicited is quantified, in this assessment as cause-and-effect relationships are evaluated, and a stressor-response profile is developed. This stressor-response profile is used as input to risk characterization.

The type of effects data that are evaluated depends largely on the nature of the stressor and the ecological component under evaluation (EPA 1992a). Effects elicited by a stressor may range from mortality and reproductive impairment in individuals and populations to disruptions in community and ecosystem function such as primary productivity.

In a SLERA the effects assessment (i.e., stressor/response relationship is reduced to a threshold concentration or dose below which exposures can be assumed to be safe. Simple extrapolations of critical exposure levels (QCEs) are usually adequate. Site-specific data should be used whenever possible. Whichever source is used to develop QCEs, the primary reference should be obtained when possible to fully review and interpret the data as presented by the authors of the original study.

2.3.3 Stressor-Response Profile

In ERA, the results of the characterization of ecological effects are summarized in a stressor-response profile that describes the stressor-response relationship, any extrapolations and additional analyses conducted, and evidence of causality (e.g., field effects data).

Ideally, the stressor-response relationship will relate the magnitude, duration, frequency, and timing of exposure in the study setting to the magnitude of effects. For practical reasons, the results of stressor-response curves are often summarized as one reference point, for instance, a 48-hour LC_{50}. Although useful, such values provide no information about the slope or shape of the stressor-response curve. When the entire curve is used, or when points on the curve are identified, the difference in magnitude of effect at different exposure levels can be reflected in risk characterization.

It is important to clearly describe and quantitatively estimate the assumptions and uncertainties involved in the evaluation, when possible. Examples include variability in ecological characteristics and responses and uncertainties in the test system and extrapolations. The description and analysis of uncertainty in characterization of ecological effects are combined with uncertainty analyses for the other ecological risk assessment elements during risk characterization.

However, this type of analysis is beyond the scope of a SLERA since the results are summarized as one reference point as discussed above. The stressor-response profile is not presented.

2.4 Risk Characterization

The final step of ERA, risk characterization, involves the evaluation of the likelihood of adverse effects occurring as a result of exposure to stressors (EPA 1992a). Risk characterization in SLERA includes two major steps: risk estimation and risk description. This section summarizes the uncertainties identified during all phases of the SLERA. Supporting information in the form of a weight-of-evidence discussion is also presented. The results of the SLERA are then discussed with the risk manager.

Differences in risk characterization for ERA and SLERA are substantial. Risk estimation for SLERA incorporates a hazard quotient method to identify those contaminants that potentially could cause an adverse effect to ecological receptors. These contaminants will then be carried into the ERA. The screening-level evaluation includes a qualitative discussion of the uncertainties inherent in the assessment. The evaluation of potential risk is basically a summary of the results of the hazard quotient analysis. It is beyond the scope of the SLERA to include a weight-of-evidence assessment and an interpretation of the ecological significance of the results. Consequently, this section will be referred to as the screening level evaluation rather than "risk characterization."

2.4.1 Risk Estimation

The risk estimation phase of ERA compares the exposure and stressor-response profiles as well as estimates and summarizes the associated uncertainties (EPA 1992a). The results of the

exposure and effects assessments are integrated to obtain an estimate of the level of effects that will result from the exposure. The uncertainty analysis identifies and if possible, quantifies the uncertainty in the assessment (EPA 1992a).

2.4.1.1 Integration of Stressor-Response and Exposure Profiles. There are three general approaches to integrating stressor-response and exposure profiles: (1) comparing single effect and exposure values, (2) comparing distributions of effects and exposure, and (3) conducting simulation modeling. The first approach is used for SLERA. Any of these integrations requires that the dynamics of exposure and effects be expressed in terms of common dimensions (Suter 1993).

Comparing single effect and exposure values. One commonly used method for determining risks is the "quotient method," i.e., ratios of dosage to appropriate effects. These ratios are termed "hazard quotients" (HQs) or screening level quotients (SLQs). The quotient method is an appropriate means of identifying COPCs in a risk assessment. There are analogous uses discussed for human health effects (EPA 1989c). Generally, a quotient less than the risk target, implies low likelihood for adverse effects from that contaminant. Correct usage of the quotient method is highly dependent on professional judgment, particularly in instances when the quotient approaches the risk target.

The quotient approach is useful for a number of reasons. In addition to allowing summation of effects, the approach also enables the determination of relative risk from the suite of contaminants under consideration, and to carry higher risk COPCs through to more detailed risk assessment, while dropping those with low risk. Furthermore, they can be used to prioritize actions (e.g., more sample analyses or site measurements) according to relative risk.

Greater insight into the magnitude of the effects expected at various levels of exposure can be obtained by evaluating the full stressor-response curve instead of a single point and by considering the frequency, timing, and duration of the exposure. This is the next logical step if contaminants with quotients greater than risk target are identified.

Comparing distributions of effects and exposure. This approach examines the overlap in distributions of effects and exposure. Risk is quantified by the degree of overlap between the two distributions. This method requires sufficient data amenable to statistical treatment.

Conducting simulation modeling. Simulation models, which integrate the stressor-response and exposure profiles, can estimate the probability that effects will occur as a result of exposure. This estimation is accomplished by error analysis using Monte Carlo simulation to propagate the uncertainties associated with the model parameters through the model. The product is a probability distribution of outcomes. Most simulation modeling has been directed at population and ecosystem level effects, where test data are scarce.

2.4.1.2 Uncertainty. The ERA uncertainty analysis identifies and, to the extent possible, quantifies the uncertainty in problem formulation, analysis, and risk characterization (EPA 1992a). The uncertainties from each of these phases of the process are carried through as part of the total uncertainty of the risk assessment. The product of the uncertainty analysis is an evaluation of the impact of the uncertainties on the overall assessment and, when feasible, a description of

the ways in which uncertainty could be reduced. For SLERA, assessment uncertainties are qualitively described and addressed. The major sources of uncertainty are discussed in the following paragraphs.

Conceptual Model Formulation. The conceptual model forms the foundation of the analysis phase and development of exposure and stressor-response profiles. If incorrect assumptions are made during conceptual model development about the potential effects of a stressor, the environments impacted, or the species residing within those systems, then the final risk assessment is flawed.

Information and Data. Incomplete data or information can be an important contributor to uncertainty. Life history data or fundamental understanding of some natural processes within an ecosystem may be lacking. Resources (time and/or money) frequently are inadequate to resolve these data gaps. In these cases, professional judgement and judicial use of assumptions are critical for the completion of the assessment.

Natural Variability. Natural variability is a basic characteristic of stressors and ecological components, as well as the factors influencing their distribution (e.g., weather, nutrient availability). Natural variability can be acknowledged and described but not reduced.

Error. Errors can be introduced through experimental design or through procedures used for measurement and sampling. Such errors can be reduced by adhering to protocols for quality assurance and quality control. Uncertainty in the development and use of models can be reduced through sensitivity analyses, "benchmarking," or comparison to similar models, and field validation.

The use of distributors and simulation modeling is beyond the level of a SLERA and is more applicable to an ERA. For SLERAs, the quotient method will be used as an indication of risk. A ratio of EBSLs to the concentration of the contaminant in a media will be determined. This ratio is called the screening level quotient (SLQ) and will be used to characterize the potential risk to the ecosystem at an WAG. The quotient method is an appropriate means of identifying COPCs.

For a SLERA, conservative assumptions are used throughout the risk assessment. For those sites and COPCs not screened out in the SLERA, more in-depth analysis with more realistic assumptions is warranted for subsequent assessments to present a truer picture of ecological risk.

2.4.2 Risk Description

The description of risk has two primary elements:

1. Ecological risk summary, which summarizes the results of the risk estimation and uncertainty analysis and assesses the confidence in the risk estimates through a discussion of the weight-of-evidence; and

2. Interpretation of ecological significance, which describes the magnitude of the identified risks to the assessment endpoint.

The risk summary cannot be reduced to a "yes or no" answer; that is, a contaminated medium is either a potential risk to a given ecological endpoint, or has no or low likelihood of risk. It is important to describe the risk to the risk manager with a weight-of-evidence discussion. The weight-of-evidence discussion provides the risk manager with insight about the confidence of the conclusions of the risk assessment by presenting the positive and negative aspects of the data, including uncertainties identified throughout the process. The following are suggested (EPA 1992) for inclusion in a weight-of-evidence discussion:

- Sufficiency and quality of data—Are data sufficient to support the findings of the assessment? Data validity (e.g., adherence to protocols, having sufficient replications) is an important consideration.

- Corroborative information—Supplementary information relevant to conclusions reached in the assessment.

- Evidence of causality—The degree of correlation between the presence of a stressor and some adverse effect.

The interpretation of ecological significance defines the types and extent of anticipated effects from risk estimates. It is a critical link between the estimation of risks and the communication of assessment results. The interpretation step relies on professional judgment and may emphasize different aspects including the nature and magnitude of the effects, the spatial and temporal patterns of the effects, and the potential for recovery once a stressor is removed.

Nature and Magnitude of the Effects. The relative significance of different effects may require additional interpretation, especially when changes in assessment or measurement endpoints are observed or predicted. For example, if a risk assessment is concerned with the effects of stressors on several ecosystems in an area (such as a sagebrush steppe and wetland), it is important to discuss the types of effects associated with each ecosystem and where the greatest impact is likely to occur.

The extent of an effect will depend on its ecological context. For example, a decline in the reproductive rate may have little effect on a population that reproduces rapidly, but it may significantly reduce the numbers of a population that reproduces slowly. Population-dependent and independent factors in the ecosystem also may influence the expression of the effect.

It is important to consider both the magnitude and the likelihood of the effect occurring. In some cases, the likelihood of exposure to a stressor may be low, but the effect from the exposure would be severe. For example, large pesticide spills may not be common, but if a spill occurs, can cause great harm to ecologically sensitive areas.

Spatial and Temporal Patterns of the Effects. The spatial and temporal distributions of the effect are important considerations in interpreting ecological significance. The size of the area where the stressor is likely to occur is a primary consideration when evaluating the spatial pattern of effects. A stressor distributed over a larger area has a greater potential to affect more organisms than one confined to a small area. However, a stressor that adversely affects small areas can have devastating effects if those areas provide critical resources for certain species. In

addition, adverse effects to a resource that is small in scale (e.g., a sagegrouse lek) may have a small spatial effect but may significantly degrade the resource because of its overall scarcity.

The duration of any effect depends on the persistence of the stressor as well as how often the stressor is likely to occur in the environment. Even short-term effects can be severe if such exposure occurs during critical life stages of organisms.

Recovery Potential. A discussion of the recovery potential may be an important part of risk description. The need for such an evaluation will depend on the objective of the assessment and the assessment endpoints. Evaluation of the recovery potential may require additional analyses, and will depend on the nature, duration, and extent of the stressor.

Depending on the assessment objectives, all of the above elements may be used to place the risks into the broader ecological context. This discussion may consider the consequences of the effects on other ecological components that were not specifically addressed in the assessment. For example, an assessment that focused on the decline of small mammal populations may include a discussion of the broader ecological role of small mammals, such as being a food base for raptors and predatory mammals. In this way, the potential effects on the community that depends on small mammals can be brought out in risk characterization.

2.4.3 Discussion Between the Risk Assessor and Risk Manager

Risk characterization concludes the risk assessment process and provides the basis for discussions between the risk assessor and risk manager, providing input to regulatory decision-making. These discussions should ensure that the results of the risk assessment are clearly and fully presented and provide an opportunity for the risk manager to ask for any necessary clarification. Proper presentation of the risk assessment is essential to reduce the chance of over- or under-interpretation of the results. In order for the risk manager to evaluate the full range of possibilities contained in the risk assessment, it is important that the risk assessor provide the following types of information:

- The goal of the risk assessment
- The connection between the measurement and assessment endpoints;
- The magnitude and extent of the effect, including spatial and temporal considerations and, if possible, recovery potential;
- The assumptions used and the uncertainties encountered during the risk assessment;
- A summary profile of the degrees of risk as well as a weight-of-evidence analysis; and
- The incremental risk from stressors other than those already under consideration (if possible).

The results of the risk assessment feed into the risk management process, where they are used along with other inputs defined in EPA statutes, such as social and economic concerns, to evaluate risk management options.

In addition, based on the discussions between the risk assessor and risk manager, follow-on activities to the risk assessment may be identified, including monitoring studies, to verify the predictions of the risk assessment, or the collection of additional data to reduce the uncertainties in the risk assessment. While a detailed discussion of the risk management process is beyond the scope of this report, consideration of the basic principles of ecological risk assessment described here will contribute to a final product that is both credible and germane to the needs of the risk manager.

For the SLERA, a much more simplified approach to both the risk description and the discussion with the risk managers is appropriate. The risk description and discussion sections will generally be combined and for each WAG, the risk description will be simply a brief discussion of the results of the SLERA and their interpretation. In order for the WAG manager to evaluate the full range of possibilities contained in the SLERA, it is important that this section review the results based on the goals of the assessment.

The process of selecting sites of concern should be briefly summarized. Those sites that do not have accessible data for evaluation for the SLERA will be summarized as shown in Table 6-3. The risk summary will identify where more site information may be obtained if this is known. Some discussion on how additional site information should be used subsequent to this preliminary SLERA should be included. The results of the risk estimation should be discussed in terms of the SLQs. Any uncertainty that may result in either an over or under conservatism in determining the SLQs should be briefly reviewed in this section.

Finally, the risk assessor should communicate the results to the risk manager. The SLERA discussion should include information concerning the adequacy of sampling of the sites of concern and the results of the hazard quotient analysis. If the assessment endpoints were not attained (e.g., all SLQs are not less than the risk target), then the risk assessment will continue into an ERA. The decision points for the risk manager include:

1. The sites at the WAG have been adequately sampled, and based on this sampling, it was determined that there are no risks of adverse effects to receptors. Therefore, there is no need for additional sampling, assessment, or remedial actions.

2. The sampling is not adequate to make a determination, and/or it was determined that potential risks exist. When the sites are inadequately sampled, the risk manager will decide whether to collect additional data and update the SLERA or incorporate the new data in an ERA. If potential risk has been shown and the sampling has been adequate, then the process becomes an ERA.

3. SCREENING LEVEL ECOLOGICAL RISK ASSESSMENT GUIDANCE

**R. L. VanHorn, N. L. Hampton, E. J. Mooney,
H. A. Hattemer-Frey, R. Brewer, S. C. Peterson, T. A. Bensen**

This section provides specific information on the components that should be included as part of each WAG-wide SLERA. Due to the complexity and amount of material in the risk assessment, an executive summary should be included in addition to the information discussed in the following sections.

3.1 Introduction Guidance

Each WAG SLERA will be a stand-alone document. Therefore, it is necessary to provide a general introduction to the process, the objectives, the scope and organization, and the statutory and regulatory basis of the SLERA.

3.1.1 SLERA Objectives

As discussed in Section 2.1, the primary objectives of the SLERA include (a) the identification of those WAG sites and contaminants of potential concern (COPCs) that may contribute to potential ecological risk and (b) identification of data gaps. These should be reiterated in the SLERA to clearly convey the goals of individual WAG SLERAs. The specific SLERA objectives are to:

- Identify those contaminants of potential concern (COPCs) that may contribute to a potential ecological risk
- Identify those sites that contribute to this potential risk
- Indicate those sites requiring additional data and/or monitoring for finalization of the SLERA or performance of the baseline ERA.

3.1.2 Scope and Organization

The scope and organization of the SLERA should be clearly defined. The basis of the SLERA process should be discussed by stressing the importance of the EPA's (1992a) stepwise approach. A brief overview of each of these steps as used in the SLERA process should be included. The identification of data gaps is an important part of the SLERA process. The approach used to identify data gaps should be briefly discussed as necessary. A basic introduction to the strategy for transitioning from SLERA to ERA may also be included. This section should be used to include any specific information regarding scope and organization of the SLERA that may be deemed necessary as part of the SLERA.

3.1.3 Statutory/Regulatory Basis

Each SLERA should include a discussion of the statutory and regulatory basis of ERA. This discussion should include a brief history of the regulatory background such as the history behind the addition of the INEL to the NPL and reference to the FFA/CO agreement. This information is provided in some detail in Sections 1.3 and 1.4 of this document. Some discussion of the statutory basis for SLERAs should also be included such as the federal and state laws and regulations that aid in the current remedial investigation/feasibility study (RI/FS) process as it is proceeding at the INEL. These are termed ARARs or requirements to be considered (TBCs). Appendix A presents requirements that may be applicable for most WAGs, but each WAG-wide SLERA ARAR discussion will be tailored as necessary.

3.2 Problem Formulation Guidance

The problem formulation process begins with a general description of the site and a characterization of the WAG and the ecosystem at risk. Next, the potential stressors to the ecosystem are identified and their ecological effects discussed. The migration pathways of the identified stressors are qualitatively modeled, and the potentially affected components of the ecosystem are identified. The relationship between the stressors, exposure pathways, and ecosystem at risk is then assimilated into the conceptual ecological site model. Assessment and measurement endpoints are then defined and summarized.

3.2.1 Waste Area Group Description

A general WAG overview is required for each SLERA. This description should include the activities occurring at the WAG, including the OUs and the individual sites within an OU. Descriptions should include the facility, its history and location, and facility operations. Potential release sites associated with the facility's operations are discussed, and the OUs at the WAG are listed. The possible contaminants are also broadly identified, e.g., PCBs, radionuclides, and heavy metals. Further discussion of the processes in which waste is generated is also included to provide some insight about the potential release sites. In addition, if deemed necessary, some discussion concerning the regulatory status (e.g., Track 1, Track 2, RI/FS) of each OU should be provided.

OUs and sites can be summarized as shown on Table 3-1. Detailed discussion of sites and OUs can be included in an appendix. A second table summarizing those sites passing the initial screening (sites of concern) should provide additional detail such as the size of individual sites, contaminants present and the affected medium. An example is presented on Table 3-2. This table can be generated from results of the initial site review conducted as part of the SLERA stressor characterization (Section 4.3.1.1). This information is presented in the introductory section of the SLERA to allow readers to quickly determine which WAG sites were included in the SLERA analysis.

Most of the information needed to construct tables for this section is available from the INEL geographic information system (GIS). As an additional aid, a color-coded map of individual WAGs showing both OUs and sites addressed by the SLERA and those that were screened from the analysis can be generated on INEL's GIS. An example map depicting WAG 2 OUs and sites is shown in Figure 3-1.

Table 3-1. Example operable units and site descriptions.

OU	Site code	Site description	Track[a]	IN[b]	Justification for elimination
X-01	XXX-02	Paint Shop Ditch	T1	X	
X-02	XXX-14	Inactive Gasoline Tank	T1		Tank removed. No or minimal soil contamination; contaminated soil removed. No source.
	XXX-17	Inactive Gasoline Tank	T1		Tank removed. No or minimal soil contamination; contaminated soil removed. No source.
	XXX-18	Inactive Gasoline Tank at	T1		Tank removed. No or minimal soil contamination; contaminated soil removed. No source.
	XXX-21	Inactive Tank, North Side of MTR-643	T1		Tank removed. No or minimal soil contamination; contaminated soil removed. No source.
	XXX-22	Inactive Diesel Fuel Tank	T1		Tank removed. No or minimal soil contamination; contaminated soil removed. No source.
X-04	XXX-09	Spills at Loading Dock	T2		Historical spills of small amounts of low hazard oils and volatiles. No were reported. No source.
	XXX-34	North Storage Area	T2	X	
	XXX-619	PCB Spill	T2	X	
	XXX-626	PCB Spill	T2	X	

a. CERCLA process tracks: NA no action; initial investigation determined sites were uncontaminated and no source present; T1 = Track 1; T2 = Track 2, IA = Interim Action; RI = RI/FS

b. Sites marked with "X" were not screened out in SLERA initial site review.

Table 3-2. Example WAG operable units and sites of concern.

OU	Site code	Sites within operable unit	Size (ft^2)	COPCs	Contaminated medium	Comments
X-01	XXX-02	Paint Shop Ditch	1973	Metals, PCBs	Surface, subsurface soil	Concentrations below human risk-based levels but need to be evaluated for ecological risk
X-04	XXX-34	North Storage Area	134,000		Surface, Subsurface soil	This site is being evaluated under OUs 2-13/10-06
	XXX-619	PCB Spill	135	PCBs Aroclor 1260	Surface Soil	Top 2 ft of soil cleaned up to below 25 ppm
	XXX-626	PCB Spill	215	PCBs Aroclor 1260	Surface Soil	PCBs @ 24 ppm 4 ft below ground
	XXX-653	PCB Spill	700	PCBs Aroclor 1260	Surface Soil	Low surface contamination of PCBs
X-05	XXX-15	Hot Waste Tanks #2, #3, #4	961	Metals, organics, radionuclides	Subsurface Soil	Possible contamination @ 4 m below ground
	XXX-16	Inactive Radioactive Contaminated Tank		As, Hg, U-234, U-238	Subsurface Soil	Soil contamination @ ≥1.3 m below ground
	XXX-19	Rad Tanks 1 and 2 Replaced by Tanks 1, 2, 3, & 4	120	Possible radioactive contamination	Subsurface Soil	Possible soil contamination from broken 4 inch drain line @ ≥3 m below ground
X-07	XXX-653	Chromium-Contaminated Soil	700	Cr^{+3}	Surface Soil	Cr contaminated soil
	XXX-36	Cooling Tower Basin	11,380	Cr^{+6}	Surface Soil	Cr contaminated soil
	XXX-38	Cooling Tower	10,290	Cr^{+6}	Surface Soil	Cr contaminated soil
	XXX-39	Cooling Tower	7,904	Cr^{+6}	Surface Soil	Cr contaminated soil
X-09	XXX-08	Cold Waste Disposal Pond	219,656	Barium, gamma rad, possible VOCs	Sediments	Contaminated sediments available to ecological receptors
	XXX-13	Final Sewage Leach Ponds (2)	33,714	alpha, beta, gamma rad; metals, organics	Sediments	Contaminated sediments available to ecological receptors
X-10	XXX-03B	Warm Waste Pond (Sediments)	na	Radioactive contamination beneath 1 ft. clean soil	Subsurface Soil (Sediments)	Site remediated in 1994. Samples taken prior to remediation are included in analysis as soil.
X-13	XXX-06	Comprehensive RI/FS including: Chemical Waste Pond	62,132 4000		Subsurface soil, surface soil, sediments and surface water	These sites will need to be addressed for ecological risk at the time of the Comprehensive RI/FS

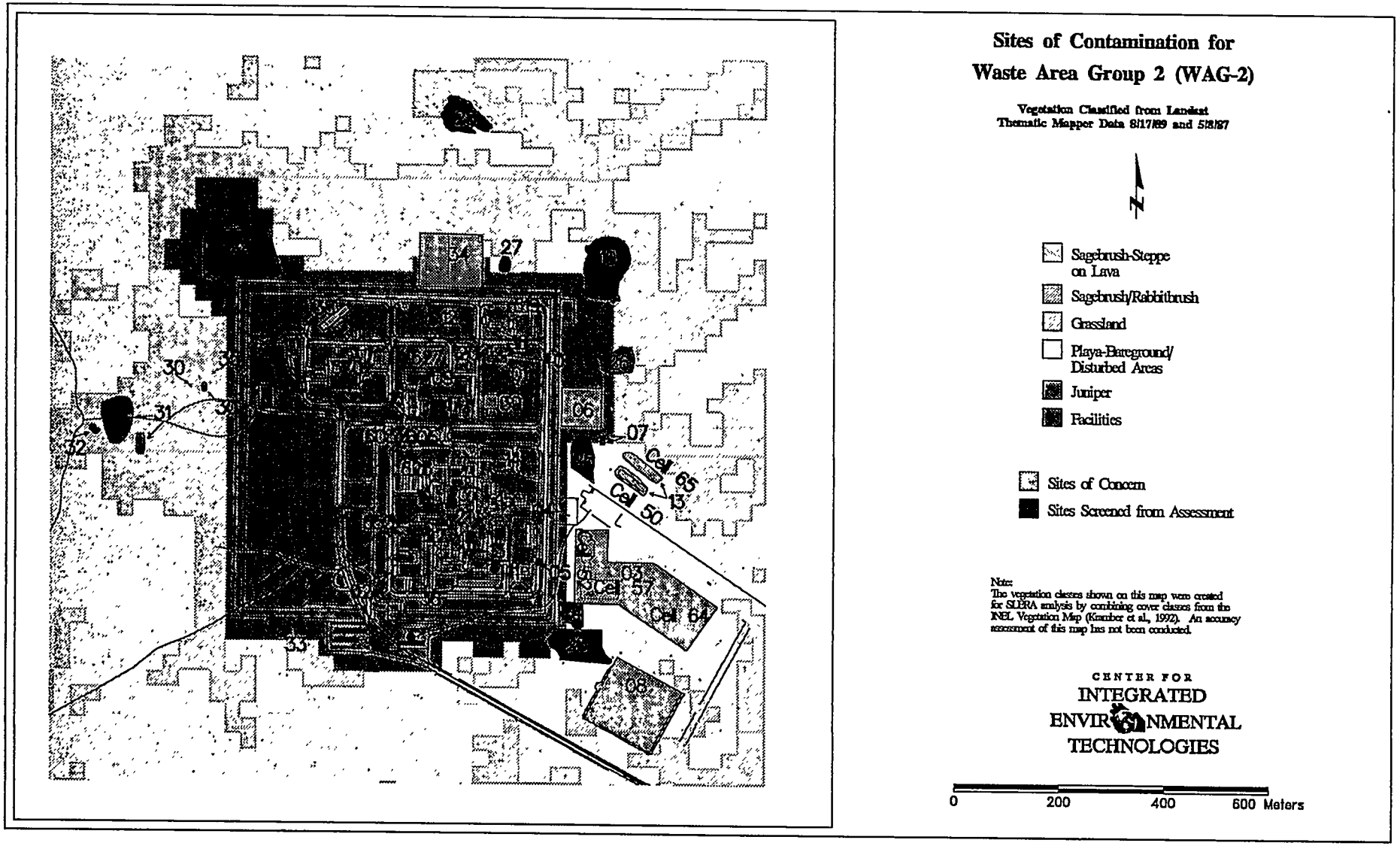


Figure 3-1. Example map depicting waste area group OUs and sites of contamination.

3.2.2 Previous Investigations

The purpose of reviewing previous ecological and contaminant studies is to identify and locate WAG-specific data that may be used to support the SLERA. These data can be used to support both problem formulation, exposure analysis, and interpretation of ecological effects for SLERA risk characterization. In particular, ecological data for individual species are required for SLERA exposure assessment and calculation of EBSLs (Section 3). Data input for the model includes dietary habits and preference, seasonal presence, home range, and body size (weight). Other supportive data includes information addressing species habitat, behavior, distribution, and population status and/or trends. Both ecological and contaminant data can be used to support confirmation of suspected site contaminant effects. Existing sample data (for example, soil surface and subsurface data) can also be used to support the definition of the size and configuration of the assessment area.

Considerable information has resulted from basic research and site characterization studies that is relevant to SLERAs (and ERAs in general) at the INEL. The Radioecology and Ecology Program at the Radiological and Environmental Sciences Laboratory (RESL) [programs recently transferred to the Environmental Science and Research Foundation (the Foundation) in Idaho Falls, ID] performed extensive research in terrestrial ecology and radioecology on the INEL, resulting in over 300 publications (Morris 1994). The Foundation serves as the point of contact between DOE-ID and the U.S. Fish and Wildlife Service for issues regarding Threatened or Endangered Species on the INEL. On behalf of DOE-ID, the Foundation solicits from the U.S. Fish and Wildlife Service every 6 months an updated list of T&E species. The Service consults with the Idaho Department of Fish and Game's Computerized Data Center and subsequently provides a list for the INEL that includes T&E species plus candidate species and others recognized as sensitive by other agencies. Copies of the most recent list are available from the Foundation. The Lockheed Idaho Environmental Assessment Technologies Group has performed some ecological research in support of the GIS. Other sources include the hydrogeologic research performed at the INEL by the U.S. Geological Survey (USGS) and the atmospheric and climatological data collected by the National Oceanic and Atmospheric Administration (NOAA). Previously, this information was not organized in a manner that facilitates the development of ERAs.

As part of the screening level ERA manual, the development of the Ecological Literature Database (ECOLIT) was initiated to improve the accessibility and utility of this information. This database is discussed in detail in Appendix B. From the ECOLIT database, it is possible to compile those previous investigations that relate to the INEL in general as well as those that are WAG-specific. In addition to the ECOLIT database, a literature evaluation of pertinent data sources has been conducted (Appendix D). This review includes a short summary of many INEL references. The WAG-wide SLERAs should use these literature reference sources when characterizing the ecosystem potentially at risk. The sources reviewed in support of the individual SLERAs should be summarized in a separate section of the document. Table 3-3 presents an example summary of a WAG literature review. This is a portion of an existing table that has been completed as part of the SLERA process and can be tailored for other WAGs. Those investigations that are applicable for use in the WAG SLERA are highlighted. The complete table appears in Appendix B. It may be useful to include pertinent summaries obtained from ECOLIT as an appendix to the SLERA.

Table 3-3. Example investigations conducted at the INEL (shaded studies are examples applicable to ICPP).

Reference	Applicability			Study Area	Topic Species	Contaminants Addressed	Data Reported				
	Problem Formulation	Analysis	Risk Characterization				Habitat	Diet	Susceptibility to Contaminant	Biological Response	Tissue Concentration
Anderson, 1991	X	X		ICPP	Vegetation Wildlife Soil						
Arthur, 1982	X	X	X	RWMC/ SDA	Crested wheatgrass Russian thistle	Pu-238 Pu-239,240 Am-241	Terrestrial				X
Arthur, Connelly, Halford, and Reynolds 1984	X			INEL	Vertebrate survey		X				
Arthur, Markham, Groves, Keller, and Halford, 1986	X	X		RWMC/ TSA, SDA	Deer mouse Ord's kangaroo rat		Terrestrial			X	
Arthur, Markham, Groves, and Keller, 1987	X	X		RWMC/ SDA	Deer mouse	Radionuclides					
Arthur and Gates, 1988		X		INEL	Pronghorn antelope Black-tailed jackrabbit	Trace Elements Toxic Elements Rad Elements					
Arthur and Janke, 1986	X	X	X	RWMC/ SDA	Small mammals Avifauna	Radionuclides	Terrestrial				
Arthur and Markham, 1982a	X	X		TRA, RWMC SDA	Coyotes	Radionuclides	Terrestrial				
Arthur and Markham, 1982b	X	X	X	TRA, RWMC/ SDA	Burrowing mammals Coyote Wheatgrass Russian thistle Soil	Radionuclides	Terrestrial				X(?)
Arthur and Markham, 1983	X	X		RWMC/ SDA	Soil	Plutonium	Terrestrial				
Arthur and Markham, 1984	X	X	X	RWMC/ SDA	Soil Crested wheatgrass Deer mouse	Po-210	Terrestrial				X
Blom, Johnson, and Rope, 1991		X		TRA	Harvester ant	Cs-137 Co-60	Soil Mounds/Terrestrial				
Connelly, 1982	X	X	X	INEL	Sage grouse	Radionuclides	Terrestrial/Aquatic	X	X	X	X(?)
Connelly and Markham, 1983	X	X	X	TRA, ICPP, RWMC, CFA	Sage grouse	Radionuclides	Terrestrial/Aquatic			X(?)	X(?)
Craig, Halford, and Markham, 1979	X	X	X	TRA, ICPP	Raptors	Radionuclides	Air/Terrestrial				
Craig, Craig, and Powers, 1985		X		INEL	Long-eared owl		Air	X			
Evenson, 1981		X	X	INEL	Deer mouse	Radionuclides	Terrestrial		X(?)	X	X(?)
Filipovich, 1983	X			ARA	Deer mouse Great Basin pocket mouse Least chipmunk Montane vole Ord's kangaroo rat Western harvest mouse Northern grasshopper mouse Sagebrush vole		Terrestrial	X			
Fraley, Bowman, and Markham 1982	X	X	X	ICPP	Rabbit	I-129/I-127	Terrestrial		X (?)	X	X(?)
Groves and Keller, 1986	X	X		RWMC/ SDA	Small mammals		Crested wheatgrass Russian thistle Sagebrush				

3.2.3 Ecosystem Characterization

A wide range of properties should be considered during the ecosystem characterization portion of problem formulation, including ecosystem structure (i.e., type and abundance of flora and fauna species), trophic-level relationships of flora/fauna species, ecosystem function (i.e., energy source and pathways of utilization, and nutrient processing), as well as abiotic components such as climate, topography, and soil. "Knowledge of the ecosystem potentially at risk can help identify ecological components that may be affected and stressor-ecosystem interactions relevant to developing exposure scenarios. Also, knowledge of the types and patterns of historical disturbances may be helpful in predicting ecological responses to stressors" (EPA 1992a).

General information regarding ecological properties specific to the INEL is provided in this section, while additional information is included in Appendix D, Ecological Components of the INEL. The risk assessor can refer to this appendix and tailor the information to the specific WAG being assessed.

3.2.3.1 Definition of Assessment Area. For SLERA analysis, an area within which ecological components may receive exposure to contaminants, or an assessment area, must be defined. The size of the WAG assessment area is critical input to the exposure model and must be calculated before analysis can be completed. Because the SLERA is primarily a contaminant-driven analysis, existing data for surface and subsurface contamination can be used to define the areal extent of contamination. Scientists at RESL have routinely collected data for sites on and off the INEL to monitor deposition of radionuclides in soil and soil background concentrations. These data have been summarized and reviewed, and isopleths for several radionuclides including Cs-137 and Sr-90 have been developed for most facilities (Jessmore et al. 1994).

These data can be used to determine a source-to-background distance using the WAG center as the generalized source of contamination. The above/below background transition can be defined by the surface soil contamination data (or subsurface contamination, if data are available) and contaminant isopleths. For cases in which isopleth delineation is not supported by adequate sampling, an ecological buffer of one-half the source-to-background distance is added to define the outer extent of the assessment area. This ecological buffer is intended to ensure calculation of maximum exposure for species whose home ranges overlap areas of above and below background contaminant levels. Where a circular configuration is appropriate (i.e., encompasses all OUs and sample locations where above background levels were detected), this dimension may serve as the radius of the assessment area. For elliptical or irregular polygon configurations, additional source-to-background dimensions must be determined. Only sampling points above background levels are used to calculate a contaminant concentration for the assessment area (Section 3.2.4).

Some WAG-specific soil data and aerial gamma survey isopleths can be accessed from the ERIS database. A map delineating the assessment area and a calculation of size can be produced using the INEL GIS.

3.2.3.2 Ecological Organization of Biotic Components. Because all components of an ecosystem cannot be measured, and a single species is unlikely to serve as a surrogate for all other

species, a small number of endpoints must integrate the effects of the stressor being assessed. To accomplish this, the concept of "functional groups" has been incorporated into the SLERA process.

Functional groups, as defined for INEL SLERA, are subjective assemblages of species sharing similar characteristics. Functional grouping can be applied for all biotic ecosystem components, including vegetation, wildlife, insects, and microorganisms. The criteria for grouping individuals for the SLERAs resulted in a structural organization that allows use of surrogate measurements or groups of individual measurements to represent larger components of the ecosystem. Groups of species having similarities that are defined in terms of SLERA goals have been constructed for INEL biota to assess the effects of stressors on INEL ecosystem components.

Species characteristics including dietary preference (trophic level) and breeding and feeding locations were used to construct functional groups for INEL species. The primary division between individual groups was based on taxonomic categories for INEL species including birds, mammals, reptiles, amphibians, fishes, and insects. This separation is required to extrapolate toxicological effects from one species to another within the same functional group. Individual groups were assigned a unique identifier consisting of a one- or two-letter code to indicate taxon (A = amphibians, AV = birds, M = mammals, and R = reptiles, I = insects), and a three-digit number derived from the combination of trophic category and feeding habitat codes (see Appendix E, Section 1.1). For example, AV122 represents the group of seed-eating bird species whose feeding habitat is the terrestrial surface and/or understory. A subset of functional groups developed for an example WAG is shown in Table 3-4. A complete list of INEL functional groups and a detailed discussion of the methods used in developing functional groups for individual WAGs is given in Appendix E.

The primary purpose for functional grouping is to take advantage of existing data from one or more species within the group. It is assumed, based on the knowledge concerning the behavior, habitat, diet, etc., of the species within a group, that these data can be applied to address the potential for risk to the group as a whole. It is unlikely that sufficient ecological and toxicological data will be found for a single species to allow its use as an indicator for a group. It is much more likely that, within a group, consumption rates can be identified for several members, toxicity values for a few members, and concentration values for other members. Species within a functional group, as defined for SLERA, are assumed to have potential for exposure through the same pathways. Therefore, measurement data for several species are combined to address assessment endpoints defined in terms of functional groups.

A second objective of functional grouping is to introduce a consistent, systematic approach to defining SLERA assessment and measurement endpoints. The use of functional grouping simplifies the process of identifying and screening numerous species associated with WAG ecosystems and allows a repeatable method for focusing future assessments on components at highest potential for exposure to contaminants. In addition, the concept can be carried throughout the ERA process, from problem formulation to screening-level evaluation. The process is intended to reduce the subjectivity associated with contaminant specific endpoint selection, and to allow evaluation of all potential receptors by risk assessors.

Table 3-4. Example wildlife functional groups (adapted from Short 1982).

Class	Functional Group Code	Common name	Trophic[a] Category	Feeding[b] Habitat Index	Non-feeding[b] Habitat Index
AMPHIBIA	A232	Great Basin Spadefoot Toad	2	3.2	3.3
AVES	AV122	House Sparrow	1	2.2	2
		Lark Sparrow	1	2.2	2.1
		Rosy Finch	1	2.2	2.1
		Mourning Dove	1	2.2	2.1
		Rufous Hummingbird	1	2.2	2.1
		House Finch	1	2.2	2.1
		Snow Bunting	1	2.2	2.1
MAMMALIA	M122	Mule Deer	1	2.2	2.2
		White-tailed Jackrabbit	1	2.2	2.2
		Western Harvest Mouse	1	2.2	2.2
		Pronghorn	1	2.2	2.2
		Black-tailed Jackrabbit	1	2.2	2.2
REPTILIA	R322	Desert Striped Whipsnake	3	2.2	2.3
		Gopher Snake	3	2.2	2.3
		Western Rattlesnake	3	2.2	2.3
		Western Garter Snake	3	2.2	2.3
		Western Racer	3	2.2	2.3

a. 1 = Herbivore, 2 = Insectivore, 3 = Carnivore, 4 = Omnivore, 5 = Detritivore

b.
- 1.0 AIR
- 2.0 TERRESTRIAL
  - 2.1 Vegetation canopy
  - 2.2 Surface/understory
  - 2.3 Subsurface
  - 2.4 Vertical habitat
- 3.0 TERRESTRIAL/AQUATIC INTERFACE
  - 3.1 Vegetation canopy
  - 3.2 Surface/understory
  - 3.3 Subsurface
  - 3.4 Vertical habitat
- 4.0 AQUATIC
  - 4.1 Surface water
  - 4.1 Water column
  - 4.2 Bottom

WAG functional groups are screened against possible routes of contaminant exposure to focus the SLERA on ecological components that appear in WAG contaminant pathways (see Section 3.2.5). Those groups not appearing in a pathway of contaminant exposure are eliminated from further consideration in the assessment. The groups identified as having potential for exposure are the basis for defining assessment endpoints and are combined with the WAG pathway models to produce the site conceptual model (Section 3.2.6). The process results in a suite of SLERA assessment endpoints that are defined in terms of potential risk to functional groups within those pathways, as well as potential risk to those individual components specified for regulatory compliance (e.g., T/E species). Measurement endpoints are then defined to meet the input requirements for the WAG ecological components that will be modeled in the analysis. Assessment and measurement endpoints are discussed in Sections 3.2.7 and 3.2.8.

A detailed discussion of the development and application of functional grouping for the SLERA process is presented in Appendix E.

3.2.3.3 Biotic Components. Once the assessment area has been defined, identification of the biotic and abiotic components that may be at potential for risk from exposure to WAG contaminants can be characterized. The concept of functional grouping should be incorporated into discussions and descriptions for these components (i.e., flora and fauna) to assist in the analysis stages of the SLERA process.

The INEL is located in a cool desert ecosystem characterized by shrub-steppe vegetative communities. The flora and fauna are typical of the northern Great Basin and Columbia Plateau region (comprehensive species lists are given in Appendix D) [for further information regarding regional ecological components, see West (1983)]. The surface of the INEL is low rolling sagebrush flats with several prominent volcanic buttes and numerous basalt flows that provide important habitat for small and large mammals, reptiles, and some raptors. The shrub-steppe communities are dominated by sagebrush and provide habitat for sagebrush community species, such as sage grouse, pronghorn, and sage sparrows. Rabbitbrush, grasses and forbs, salt desert shrubs, and exotic/weed species comprise other communities. Juniper woodlands occur near the buttes and in the northwest portion of the INEL; these woodlands provide important habitat for raptors and large mammals. Limited riparian communities exist along intermittently flowing waters. See Figure 1-1 in Section 1 for a map depicting specific physical features of the INEL, such as the Big Lost River and nearby mountain ranges and buttes.

Flora of the INEL has been mapped using spectral data and combined into 15 vegetative cover classes (Kramber et al. 1992). The INEL vegetation map, presented in Figure 3-2, shows these cover classes, as well as classes defined for facilities, and shadows. These cover classes have been grouped further into eight classes (functional groups), for use in the INEL SLERAs as described on Table 3-5. Sections of the INEL vegetation map can be produced on a larger scale (e.g., WAG size) using the INEL GIS system. Specific information regarding INEL flora can be found in Appendix D and should be tailored for individual SLERAs based on the unique characteristics at each WAG. The vegetation map can be combined with other GIS data sets to produce more detailed maps depicting soils, topography, etc.

Numerous animal species have been observed on the INEL including two amphibian, six fish, 10 reptile, 184 birds, and 37 mammal species. A comprehensive species list is provided in

INEL Vegetation Map

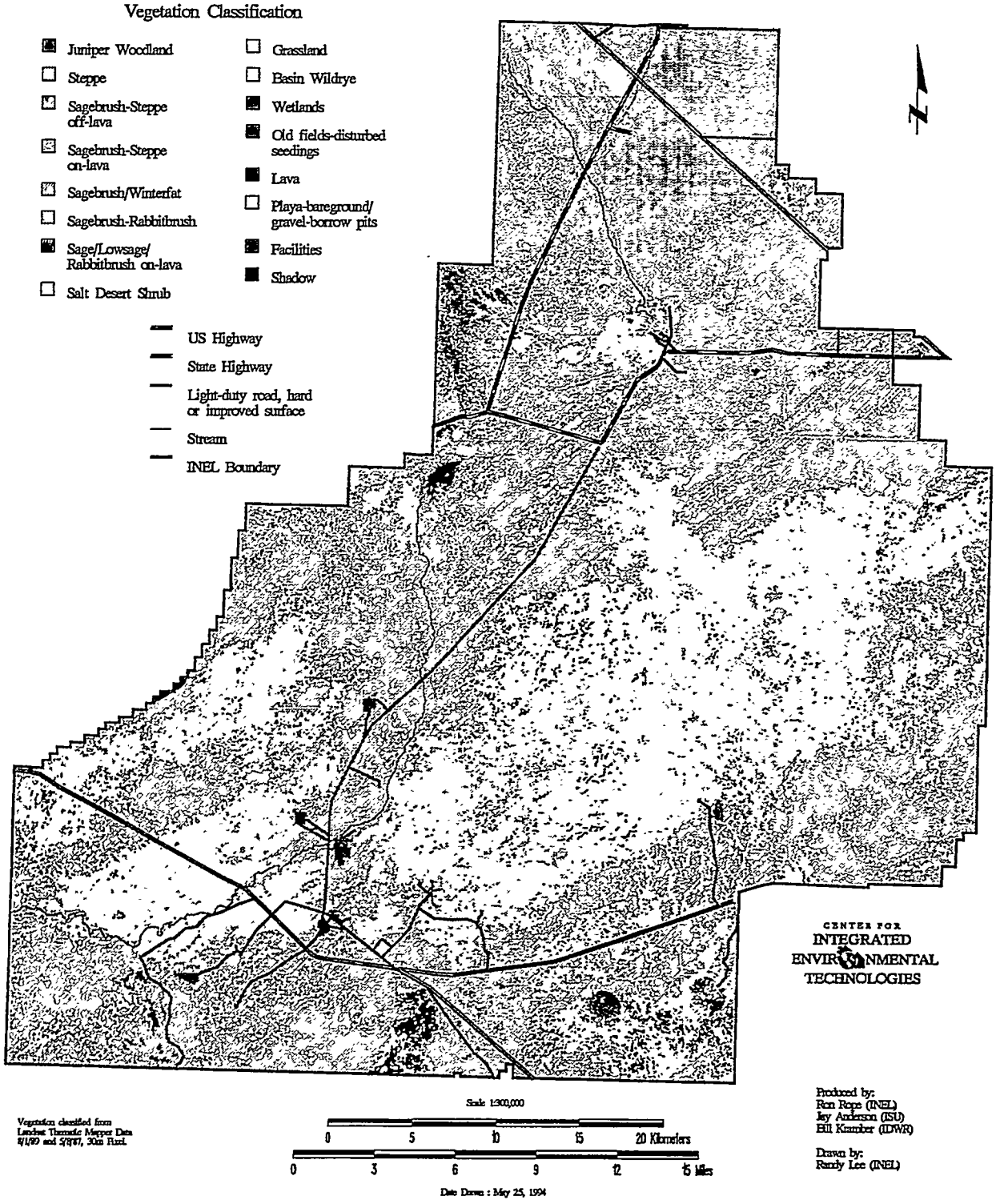


Figure 3-2. Vegetation map of the INEL showing 15 cover classes.

Table 3-5. SLERA vegetation cover classes.

SLERA vegetation cover class	INEL vegetation cover classes	Dominant species
Juniper	Juniper woodlands	*Juniperus osteosperma* *Artemisia tridentata* ssp. *wyomingensis* *Leptodactylon pungens*
Grasslands	Steppe Basin Wildrye Grassland	*Leymus cinereus* *Descurainia sophia* *Sisymbrium altissimum* *Agropyron dasytachyum* *Artemisia tridentata* ssp. *wyomingensis* *Elymus elymoides* *Chrysothamnus viscidiflorus*
Sagebrush/rabbitbrush	Sagebrush-steppe off lava Sagebrush-winterfat Sagebrush-rabbitbrush	*Artemisia tridentata* ssp. *wyomingensis* *Chrysothamnus viscidiflorus* *Bromus tectorum* *Sisymbrium altissimum* *Oryzopsis hymenoides*
Sagebrush-steppe on lava	Sagebrush-steppe on lava	*Artemisia tridentata* ssp. *wyomingensis* *Oryzopsis hymenoides* *Chrysothamnus viscidiflorus*
Playa-bareground/ disturbed areas	Playa-bareground/gravel borrow pits Old fields, disturbed areas, seedings	*Kochia scoparia* *Salsola kali* *Artemisia tridentata* ssp. *wyomingensis* *Chrysothamnus viscidiflorus*
Salt Desert Scrub	Salt Desert Scrub	*Atriplex confertifolia* *Atriplex nutallii* *Atriplex canescens* *Ceratoides lanata*
Lava	Sage, Low sage, rabbitbrush on Lava Lava	*Artemisia tridentata* ssp. *wyomingensis* *Chrysothamnus nauseosus*
Wetland	Wetlands	*Eleocharis palustris* *Typha latifolia* *Agropyron smithii*

Appendix D. Although efforts have been made to make the list as complete as possible, not all species may be may be represented. The size and diversity of INEL habitats is so great that less commonly occurring species may have been overlooked by the surveys supporting Appendix D. A WAG species list incorporating the functional grouping concept and similar in format to Table 3-4 should be included in the WAG ecological characterization. Information to support identification of which species potentially occur at a WAG can be obtained from literature as discussed in Section 3.2.2. In addition, a matrix matching SLERA vegetation classes with associated wildlife functional groups is given on Table 3-6. The matrix can be used in conjunction with the WAG vegetation map to identify functional groups that may be present at the numerous contaminant sites within individual WAGs. This alternative method may be more appropriate for a screening level assessment, since a quick and simple species inventory can be made by identifying the vegetation communities and habitats (terrestrial and aquatic) within the assessment area and including functional groups associated with those habitats in the analysis. Because the SLERA analysis addresses potential effects to functional groups, identification of all individual species (other than T/E and C2) actually present in the assessment area is not critical.

Aquatic and terrestrial invertebrates are important links in dietary exposure for wildlife, and also may function as good indicators for contaminant exposure in soil, aquatic systems and vegetation uptake. Comprehensive species lists, distributions and population data are unavailable for INEL terrestrial and aquatic invertebrates and as a consequence, these organisms cannot be adequately characterized as part of the SLERA problem formulation but should be mentioned since they will be addressed in the analysis. Lack of information for ecological components important to the SLERA (as well as ERA) must be identified as data gaps.

Microflora and microfauna (algae, bacteria, fungi, etc.) form extensive and critical communities in arid ecosystems. Given the magnitude of mass and energy that cycles through the microbial biomass and the importance of their associations with plant species, they are communities that should be addressed in the ERA process. However, the microbiology of shrub-steppe ecosystems is not well understood, and while work has been conducted in other arid ecosystems, detailed sitewide data describing the distribution and activities of microorganisms at the INEL are not available. These organisms also cannot be adequately characterized and represent additional potential SLERA/ERA data gaps.

A comprehensive list of T/E and sensitive plant and animal species that may be found on the INEL is given on Table 3-7. Potential risks to T/E and C2 species must be individually addressed in the SLERA; however, to prevent confusion, it is suggested that Table 3-7 be included in its entirety. Those species pertinent to the individual WAG may be highlighted as shown. Since status for some species may change over time, it will be necessary to update Table 3-7 for SLERAs conducted subsequent to the issuance of this manual.

Habitats critical to T/E species potentially present in the WAG assessment area should be identified and characterized. Critical habitats that may be found on the INEL are listed on Table 3-8.

3.2.3.4 Food Web Model. A food web model for each WAG ecosystem is the culmination of the effort expended to identify the flora and fauna within a WAG assessment area. The purpose of this model is to identify the relationships between the flora and fauna found in the

Table 3-6. Summary of INEL Functional Groups Associated with SLERA Vegetation Types.

	Habitat type[b]								
Functional group[a]	1	2	3	4	5	6	7	8	9
AV232							X		
AV121			X		X				
AV122		X	X	X	X				X
AV132							X		X
AV142							X		X
AV143							X		x
AV210	X	X	X	X	X		X		X
AV221			X	X	X		X		X
AV222	X	X	X	X	X		X		X
AV232			x	x	x		X		x
AV233			x	x	x		X		x
AV241							X		x
AV242							X		x
AV310	X	X	X	X	X	X	X		X
AV322	X	X	X	X	X	X	X		X
AV333							X		x
AV342							X		X
AV422	X	X	X	X	X	X	X		X
AV432		X	X	X	X		X		
AV433		x	x	x	x		X		
AV422							X		x
M121							X		x
M122		X	X	X	X	X			x
M122A		X	X	X	X	X			x
M123			X	X	X				
M132							X		
M210	X								X
A210A			X	X	X	X			X
M222			X	X	X	X			X
M322	X	X	X	X	X	X	X		X
M422	X	X	X	X	X	X	X		x
M422A	X	X	X	X	X	X	X		x
R222	X	X	X	X	X	X	X		x
R322	X	X	X	X	X	X	X		x

a. Individual species for each functional group are listed in Table E-4, Appendix E.

b. 1 = Juniper woodlands, 2 = Grasslands, 3 = Sagebrush/Rabbitbrush, 4 = Salt Desert Shrub, 5 = Sagebrush-Steppe on Lava, 6 = Lava, 7 = Wetlands, 8 = Playa, bareground/disturbed areas (not completed), 9 = Facilities. See Table 3-5 for cover class descriptions. Small (x) = where appropriate habitat exists (e.g., wetland species frequent facility waste ponds).

Table 3-7. Threatened and endangered species, special species of concern and sensitive species that may be found on the INEL.[a] T/E and C2 species to be addressed by WAG SLERAs are in **bold.**

Common names	Scientific name	Regulatory Status				
		Federal status[b]	State status[b]	BLM status[b]	USFS[e] status[b]	INPS status[b]
Plants						
Lemhi milkvetch	*Astragalus aquilonius*	—	—	S	S	S
Painted milkvetch	*Astragalus ceramicus* var. *apus*	3c	—	—	—	M
Plains milkvetch	*Astragalus gilviflorus*	NL	—	S	S	3
Winged-seed evening primrose	*Camissonia pterosperma*	NL	—	S	—	S
Nipple cactus	*Coryphantha missouriensis*	NL	—	—	—	M
Spreading gilia	*Ipomopsis (Gilia) polycladon*	NL	—	S	—	2
King's bladderpod	*Lesquerella kingii* var. *cobrensis*	—	—	—	—	M
Tree-like oxytheca	*Oxytheca dendroidea*	NL	—	S	—	S
Inconspicuous phacelia[c,d]	*Phacelia inconspicua*	C2	SSC	S		S
Puzzling Halimolobos[d]	*Halimolobos perplexa* var. *perplexa*	—	—	—	—	M
Birds						
Peregrine falcon	***Falco peregrinus***	LE	E	—	—	
Merlin	*Falco columbarius*	NL	—	S	—	
Gyrfalcon	*Falco rusticolus*	NL	SSC	S	—	
Bald eagle	***Haliaeetus leucocophalus***	LE	E	—	—	
Ferruginous hawk	***Buteo regalis***	C2	SSC	S	—	
Black Tern	***Chlidonias niger***	C2	—	—	—	
Northern pygmy owl[c]	*Glaucidium gnoma*	—	SSC	—	—	
Burrowing owl	***Athene cunicularia***	C2	—	S	—	
Common loon	*Gavia immer*	—	SSC	—	—	
American white pelican	*Pelicanus erythrorhynchos*	—	SSC	—	—	
Great egret	*Casmerodius albus*	—	SSC	—	—	
White-faced Ibis	***Plegadis chihi***	C2	—	—	—	
Long-billed curlew	*Numenius americanus*	3c	—	S	—	
Loggerhead shrike	***Lanius ludovicianus***	C2	NL	—	—	
Northern goshawk	***Accipiter gentilis***	C2	S	—	S	
Swainson's hawk	*Buteo swainsoni*	—	—	S	—	
Trumpeter Swan	***Cygnus buccinator***	C2	SSC	S	S	
Sharptailed grouse	*Tympanuchus phasianellus*	C2	—	S	S	
Boreal owl	*Aegolius funereus*	—	SSC	S	S	
Flammulated owl	*Otus flammeolus*	—	SSC	—	S	
Mammals						
Pygmy rabbit	***Brachylagus (Sylvilagus) idahoensis***	C2	SSC	—	—	
Townsend's western big-eared bat	***Plecotus townsendii***	C2	SSC	—	S	
Merriam's shrew	*Sorex merriami*	—	S	—	—	
Long-eared myotis	*Myotis evotis*	C2	—	—	—	
Small-footed myotis	***Myotis subulatus***	C2	—	—	—	
Western pipistrelle[c]	*Pipistrellus hesperus*	NL	SSC	—	—	
Fringed myotis[c]	*Myotis thysanodes*	—	SSC	—	—	
California Myotis[c]	*Myotis californicus*	—	SSC	—	—	
Reptiles and Amphibians						
Ringneck snake[c]	*Diadophis punctatus*	NL	SSC	S	—	
Night snake[c]	*Hypsiglena torquata*	—	—	S	—	
Insects						
Idaho pointheaded grasshopper[c]	*Acrolophitus punchellus*	C2	SSC	—	—	

Table 2-7. (continued).

Common names	Scientific name	Regulatory Status: Federal status[b]	State status[b]	BLM status[b]	USFS[e] status[b]	INPS status[b]
Fish						
Shorthead sculpin[c]	*Cottus confusus*	—	SSC	—	—	

a. This list was compiled from the U.S. Fish and Wildlife Service (USFWS) (letter dated January 24, 1995) the Idaho Department of Fish and Game Conservation Data Center threatened, endangered, and sensitive species for the State of Idaho (Moseley and Groves 1992) and RESL documentation for the INEL (Reynolds 1994; Reynolds et al. 1986).
b. Status Codes: S=sensitive; 2=State Priority 2; 3c=no longer considered for listing; M=State monitor species; NL=not listed; 1=State Priority 1; LE=listed endangered; E=endangered; SSC=species of special concern; and C2=Category 2 (defined in Moseley and Groves, 1992). BLM=Bureau of Land Management; INPS=Idaho Native Plant Society.
c. No documented sightings at the INEL, however, the ranges of these species overlap the INEL and are included as possibilities to be considered for field surveys.
d. Recent updates resulting from Idaho State Sensitive Species meeting (BLM, USFWS, INPS, USFS) - (INPS 1995)
e. United States Forest Service (USFS) Region 4

Table 3-8. Sensitive habitats potentially occurring on the INEL (CFR,1982).

Sensitive Habitat[a]
Critical habitat for a Federal designated endangered or threatened species [as defined in 50 CFR 424.02 (CFR, 1982a)].
Habitat known to be used by Federal designated or proposed endangered or threatened species.
National Preserve
Federal land designated for protection of natural ecosystems
Terrestrial areas utilized for breeding by large or dense aggregations of animals
Habitat known to be used by State designated endangered or threatened species.
Habitat known to be used by species under review as to it's Federal endangered or threatened status
State-designated areas, pursuant to Clean Water Act, for protection or maintenance of aquatic life.
State land designated for wildlife or game management
Particular areas, relatively small in size, important to maintenance of unique biotic communities
Wetlands [from table 4-24, 40 CFR Part 300 Appendix A (CFR, 1982)]

a. List compiled from 40 CFR Part 300, Appendix A, Table 4-23.

assessment area. A food web model illustrates the complex system of trophic levels by which matter and energy flow among the biotic components. It is comprised of many food chains that mesh, with links leading from producers through an array of primary and secondary consumers (Smith 1990). Producers support numerous primary consumers (plant consumers) who support many higher consumers (i.e., plant and animal consumers). Through the food web model, the trophic relationships within the ecosystem are identified so that the ecological risk assessor can define potential contamination pathways (see Section 3.2.5 and Calabrese and Baldwin 1993) and estimate the transfer of contaminants through each trophic level in the ecosystem and the change in tissue concentrations of each animal with different source terms via an abiotic medium (e.g., soil, sediment).

The food web models generated to support SLERAs are of particular value in identifying indirect effects of contaminant exposure to species that comprise upper trophic levels, which is important to producing the SLERA pathways/exposure and conceptual site models (Sections 3.2.5 and 3.2.6). Figure 3-3 shows a simplified INEL food web model. This model can be refined for individual WAG use (e.g., omission of aquatic components for sites having no surface water).

3.2.3.5 Abiotic components. Topography, hydrology, geology, soil, and climatic conditions in the WAG assessment area have significant impact on transport, fate, and effects for environmental contaminants. A general characterization of the WAG landscape should be provided as background for interpretation of potential effects identified in the SLERA analysis. Geological and hydrological features of the INEL are summarized in Nace et al. (1972, 1975).

A characterization of soils present in the WAG assessment area should be included as part of this section. A coarse scale soils map can be produced using data currently available on the INEL GIS and overlain on individual WAG vegetation maps as shown in Figure 3-4. Soil physical and chemical properties or detailed soil profile data are not generally available, since in-depth mapping has not been performed in most areas of the INEL.

A brief description of WAG climatic condition including annual precipitation, temperature ranges, and wind patterns should be provided as part of the site characterization write-up.

3.2.4 Chemical Stressor Identification and Characterization

The WAG SLERAs will be chiefly concerned with chemical stressors since, as discussed previously, SLERA at the INEL is CERCLA-driven. This section discusses the methodology that will be used to summarize and classify a list of WAG contaminants that will be screened against toxicology benchmarks. The methodology recommended will utilize the large body of data available from the human health risk assessment activities at the INEL. This data is a result of the sampling performed for sites identified in the FFA/CO since 1991. The screening process will use a stepwise approach as shown in Figure 3-5 that includes five steps:

- Screening for sites of potential concern (Section 3.2.4.1)
- Initial review of contaminant data (Section 3.2.4.2)
- Frequency of detection (Section 3.2.4.3)

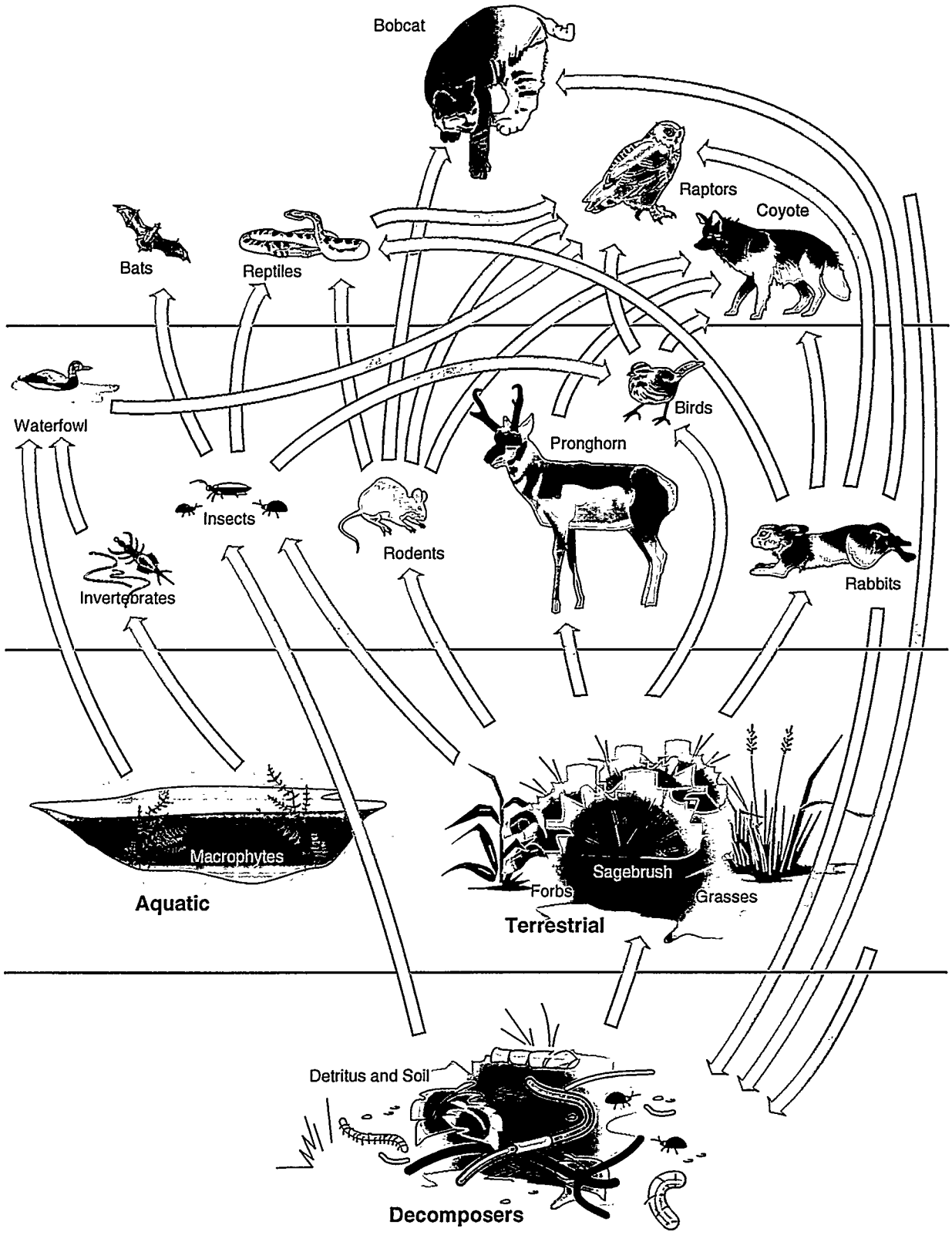


Figure 3-3. Simplified INEL food web.

Y94 0318

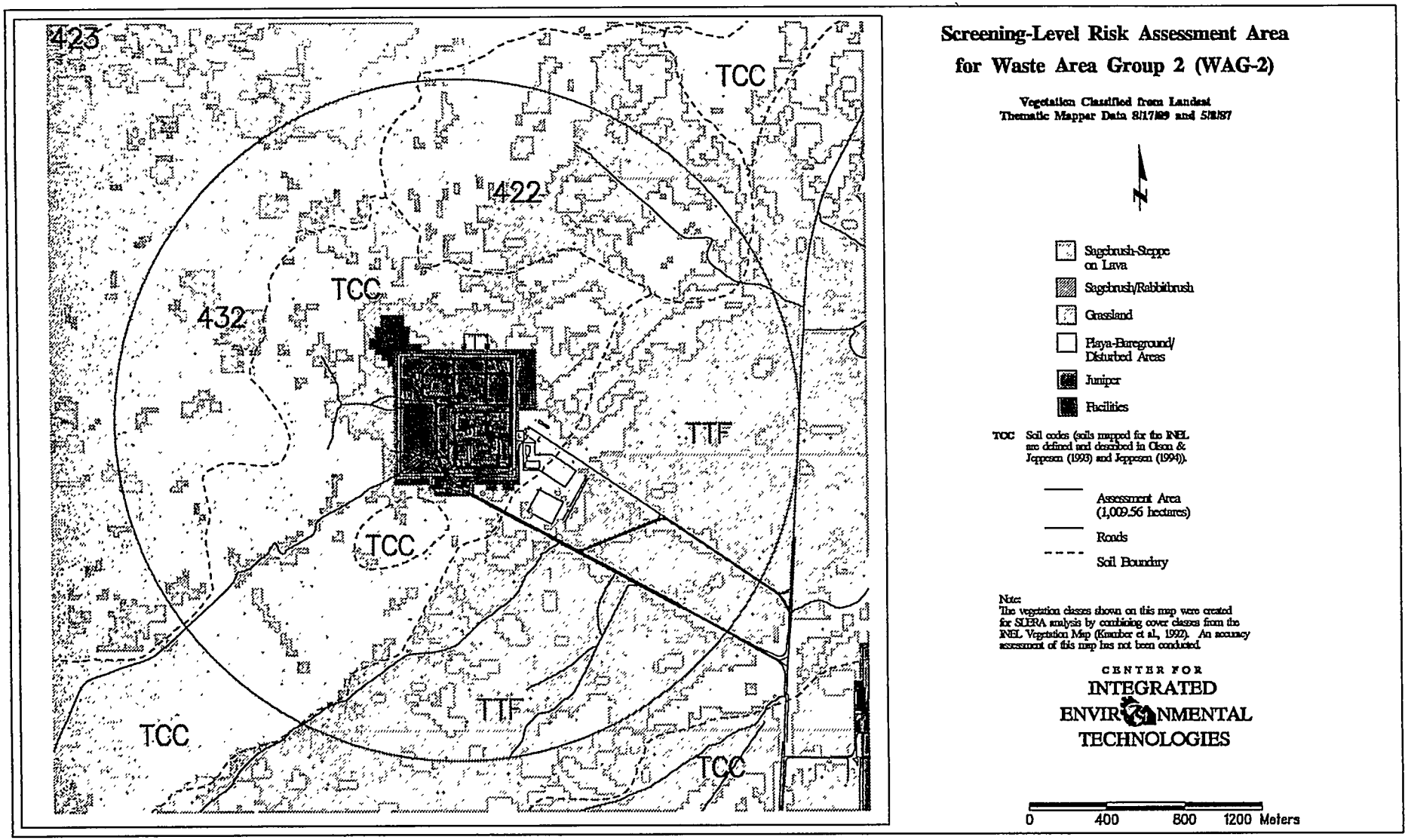


Figure 3-4. Example large scale GIS map showing vegetation, soil types, and assessment area (red circle).

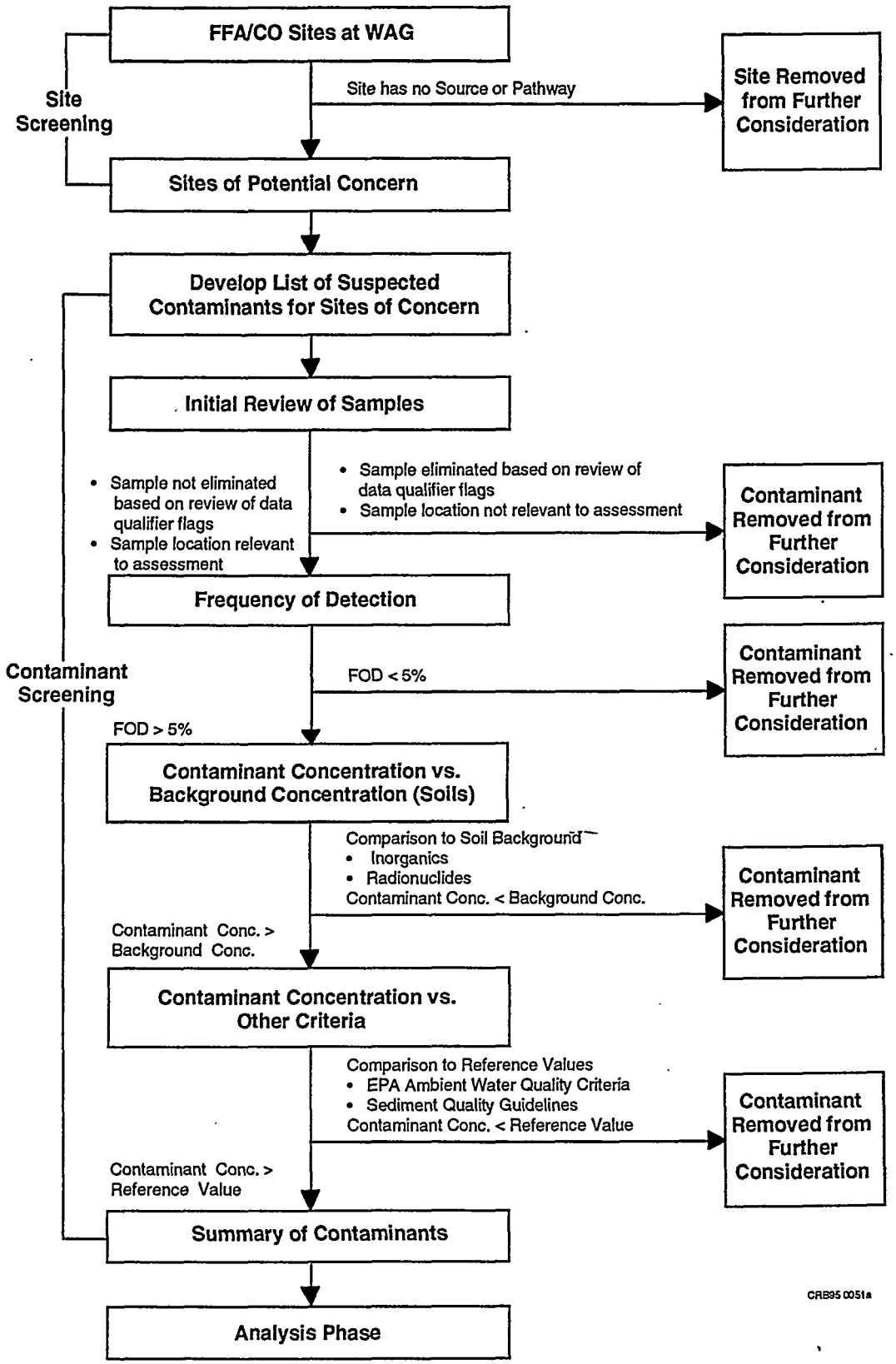


Figure 3-5. Diagram of five steps in the stressor characterization process.

- Background screening (Section 3.2.4.4)
- Other criteria (Section 3.2.4.5).

The initial site review is performed as part of the site characterization. Only the sample data from the sites of concern identified in this process will be included in the analysis.

3.2.4.1 Screening for Sites of Potential Concern. Sites within each WAG have been identified as part of the FFA/CO. Some of these sites can be eliminated based on prior cleanup activities and/or lack of exposure routes to the ecosystem. Only the sample data from the sites of concern identified in this process will be included in the analysis. This screening is usually done as part of the site characterization (Section 3.2.1). Table 3-1 shows an example list of sites that have been identified as present at the WAG by the FFA/CO process. This table has one column that marks whether a site should be included in the assessment, and the next column presents the justification for removing the site. Table 3-2 is an example of the presentation of the WAG operable units and sites of concern that will be assessed.

3.2.4.2 Initial Review of Contaminant Data. The primary source of contaminant data available is the Integrated Environmental Data Management System (IEDMS). This database was developed by the INEL to be used in the Environmental Restoration Information System (ERIS). INEL data stored on IEDMS is strictly managed, ensuring that analysis data, methods, and data validation qualifiers for all organic, inorganic, and radiological data are consistent. The data contained in IDEMS is readily accessible and is therefore the primary data source for the SLERA analysis.

The samples included in the IEDMS are not commonly identified by site number. Appendix F discusses the process of relating the sample data entered to the actual site that it represents. Every site at the WAG will not have data stored in the IEDMS. For these sites, values from the maximum concentration data base will be used to provide a limited but validated data set. The maximum database was developed as a task for the site-wide SLERA and the WAG-wide cumulative risk assessments for the comprehensive remedial investigation/feasibility study (RI/FS) risk assessment. This is discussed briefly in Appendix B. For all sites identified in the FFA/CO, the maximum concentration of each contaminant was identified. This database is also on ERIS and is applicable for use for the WAG SLERAs. This maximum value will be used in the assessment when necessary and representing a conservative estimate of the contamination present at that site. The source of data used in the analysis for each site of concern should be identified as shown in Table 3-9.

Laboratory blanks, quality control samples, and other non-applicable samples are included in the IEDMS. The data were screened to eliminate these samples. Appendix G identifies those flags that are present in the IEDMS and indicate those flags that represent a laboratory blank, quality control, or data of questionable quality so that they can be easily eliminated. The quality control data entered in the IEDMS database was used to qualify the field data. The elimination of the quality control data is solely for determining an average concentration. The EPA protocol (1989c) will used as the basis for the eliminating samples.

Table 3-9. Example of a WAG operable units and sites of concern and the sources of contaminant data.

OU	Site code	Sites within operable unit	Track[a]	IEDMS from ERIS	Maximum database	Comments
X-01	XXX-02	XXX Paint Shop Ditch (XXX-606)	T1		X	
X-04	XXX-34	XXX North Storage Area	T2			
	XXX-619	XXX PCB Spill at XXX-619	T2		X	
	XXX-626	XXX PCB Spill at XXX-626	T2		X	
	XXX-653	XXX PCB Spill at XXX-653	T2		X	
X-05	XXX-15	XXX Hot Waste Tanks #2, #3, #4 at XXX-713	T2	X		
	XXX-16	XXX Inactive Rad. Contaminated Tank at XXX-614	T2		X	
	XXX-19	XXX Rad Tanks 1 and 2 at XXX 630, Replaced by Tanks 1, 2, 3, & 4	T2		X	
X-07	XXX-653	XXX-653 Chromium-Contaminated Soil	T2			No data[b]
	XXX-36	XXX ETR Cooling Tower Basin (XXX-751)	T2		X	
	XXX-38	XXX ATR Cooling Tower (XXX-771)	T2			No data[b]
	XXX-39	XXX MTR Cooling Tower N of XXX-607	T2			No data[b]
X-09	XXX-08	XXX Cold Waste Disposal Pond (XXX-702)	T2		X	Soil sample data only; no water data available
	XXX-13	XXX Final Sewage Leach Ponds (2) by XXX-732	T2	X		Soil sample data only; no water data available
X-10	XXX-03B	XXX Warm Waste Pond (Sediments)	IA	X		See note[c]
X-13	XXX-06	WAG 2 Comprehensive RI/FS including: XXX Chemical Waste Pond (XXX-701)	RI	X		

a. State in CERCLA process as follows:

No action. Qualitative risk assessment shows that the maximum-exposed individual is exposed to an acceptably low risk with an acceptable amount of uncertainty.

Table 3-9. (continued).

OU	Site code	Sites within operable unit	Track[a]	IEDMS from ERIS	Maximum database	Comments

T1 = Track 1. Enough data probably exists to justify a decision for the OU. If more than minimal field characterization is required, the Track 1 should be reclassified. Track 1 studies are generally expected to result in a no-further-action determination.

T2 = Track 2. Insufficient data are available to make a decision concerning the level of risk or to select or design a remedy. Field data collection may be necessary to provide eecisionmaking data.

IA = Interim Action. A clear, unacceptable risk is presented by the site. Data are sufficient to perform a qualitative risk assessment, which (a) shows an unacceptable risk and requires an expediated remedial action, (b) is based on identifiable technology, and (c) will not interfere with a final remedial action.

RI = Remedial investigation/feasibility study. Most or all data are available to make a preliminary decision concerning risk and to evaluate alternative remedial actions. A remedial investigation/feasibility study (RI/FS) is selected when the OU poses a possible risk (generally greater than 10^{-6}) and remedial action may be required.

b. These sites cannot be excluded based on present information, but data are not available to perform analyses.

c. The XXX Warm-Waste pond has been remediated. The data sampling performed after the remediation is not available at this time. The sediment data sampled prior to the remediation was included in the analysis as soil.

The data were screened based on ecological considerations. Perched water and soil samples taken at a depth greater than 3 m were eliminated from the analysis since there is no pathway to the terrestrial ecosystem. The use of the 3-m depth is considered conservative based on a comparison of rooting depths of native plant species and burrowing depth of native faunal species that showed the maximum reported depth of penetration was 270 cm for the harvester ant (Loehr et al. 1994). Sagebrush rooting depths have been found to 225 cm (Reynolds and Laundre 1988), and the Townsend's ground squirrel burrowing depths have been found to 200 cm (McKenzie et al. 1982). For this same reason, groundwater well samples were eliminated.

The data in IEDMS represent sampling performed for diverse purposes and, as a result, there is great variation in the depths and medium. The soil data must be grouped into surface and subsurface soil, surface water, and sediment. The soil data must be segregated into surface and subsurface groupings based on the sample depth. Any soil sample taken from between the surface and 0.15 m (0.5 ft) deep is considered a surface soil sample, and any sample from 0.15 m to 3 m (0.5 to 10 ft) deep is considered a subsurface soil sample.

The data from both sources will be combined for each contaminant by medium (i.e., surface and subsurface soil, surface water, and sediment). This combined data base is used for the subsequent screening activity. The combined data base will be presented in an SLERA appendix.

3.2.4.3 Frequency of Detection. The range and frequency of detection (FOD) was calculated for each contaminant within each medium. The FOD was determined as the number of samples in which a contaminant was positively detected (no "U" qualifier) divided by the total

number of samples analyzed for that chemical. If the FOD was less than 5%, it was eliminated from consideration unless there was some indication of a localized area of contamination (hot spot). The Risk Assessment Guidance for Superfund (EPA 1989c) states that hot spots may have a significant impact on direct contact exposures. The sampling plan should consider characterization of hot spots through extensive sampling, field screening, visual observations, or a combination of the above. INEL sites identified by the FFA/CO have been extensively sampled for human health risk assessments. For SLERA, it is assumed that hot spots have been adequately identified and sampled. This may underestimate the potential risk posed by certain contaminants.

If the FOD was greater than 5%, then the contaminant remained in the subsequent screening activity. Non-detect contaminant samples for contaminants that remain as a concern throughout the screening activity will be included in the assessment at one-half the detection level.

3.2.4.4 Background Screening. Background concentrations are consistently a problem for risk assessments. Locating areas that are uncontaminated offsite and are representative of the onsite situation may be problematic. It is also difficult to collect enough representative offsite samples to differentiate from low levels of contamination onsite.

There have been more data collected for characterization of background in soil than any other medium at the INEL. Unfortunately, data have been collected as part of several studies and detection limits and sampling methods are inconsistent. For this guidance, soil background data were examined to determine if a correlation between these studies existed. This effort is presented in detail in Appendix G. The correlation information may be useful in a baseline risk assessment, but is not useful at a screening level. Subsequent efforts at the INEL analyzed the soil background studies available (e.g., Anderson 1992, Martin et al. 1992, and Berry et al. 1994), and developed a background for soils to be used at the INEL (Rood et al. 1995). This study will be used for the SLERAs.

Surface water background data for a few radionuclides can be obtained from a recently published review (Amiro and Zach 1993). Background data for sediments are not typically available for the man-made waste ponds located on the INEL. In this case, soil background concentrations will be used for screening.

Sample concentrations for each contaminant by medium should be obtained and compared to the site background values to obtain a frequency of exceedance (FOE). The contaminants that exceed the INEL site-specific background at a low frequency (less than 5%) or have maximum concentrations less than the 95% upper tolerance limit will be eliminated from consideration.

3.2.4.5 Other Criteria. A number of contaminants may be eliminated from consideration by comparison to risk based criteria, reference values (also called benchmark values), or other criteria. Reference values include ambient water quality criteria, which is the allowable amount of a contaminant in water (generally for human health). The literature should be searched for ambient water quality criteria for the protection of aquatic life that may be available for contaminants at the INEL. These may be regulatory levels or values from research results that have documented biological effects. Depending on the medium and the contaminant, there may

or may not be sources of ecologically-based criteria. An additional screening may be desirable if a common constituent (e.g. a naturally occurring element) of the medium was not eliminated based on the background screening but has a low FOD (i.e., one out of 11 over site-specific background). These can be compared to regional values if available. For example, the USGS (Schacklette and Boerngen 1984) provides concentrations for common soil constituents on a regional and national basis. This second screening can be justified for a common constituent of a medium, based on a small FOD (although still above the criteria), combined with low toxicity and/or identification of the chemical as an essential element. If ecologically-based criteria are not available, it is possible, based on professional judgement, to use human health based criteria (i.e., the ambient water criteria). If human health criteria are used it is necessary to discuss the uncertainty involved, for it is possible to both over or under estimate the potential risk to receptors. Tables 3-10 and 3-11 are examples of screening criteria for surface water and sediments.

It may be possible to eliminate other contaminants based on low toxicity, low concentrations, and/or uncertain soil concentrations. The rationale and summary of this process should be well documented in an appendix.

3.2.4.6 Summary of Contaminants. The final group of samples should be averaged across each medium for each contaminant. Non detects will be included in the average as one-half the detection value. As presented in Table 3-12 the following information should be summarized for the finalized data: the FOD, minimum value, maximum value, average, and FOE for each medium at an WAG. Minimum or maximum values that are within the detection limit of the instrumentation should be identified. Since most of the sampling that has been done for the human health risk assessments has been very biased to contaminated sites, the average across the WAG is assumed to be a conservative estimate. The use of an average concentration for screening is considered a conservative representative of the types of exposure that an ecological receptor would receive at a WAG. As part of the CERCLA process the sites at each WAG identified in the FFA/CO, were sampled (biased) based on the known and/or suspected history of contamination. These areas are a small proportion of the assessment area. For example, at WAG 2 only four out of the 1,009 hectares that comprised the assessment area determined for the SLERA are considered contaminated. Therefore, the use of an average across the assessment area is considered a conservative measure of the concentration of the contaminant. If a potential risk is indicated by this conservative analysis, then weighted averages may be used in the baseline.

Within a WAG, there are attractive habitats for certain native species and some species that would not be natural inhabitants of the area. Those areas that are most attractive to certain species of wildlife include the pond areas and the irrigated lawns surrounding the facilities. Since the irrigated lawn areas are used by the human occupants of the site, these areas are generally not contaminated. Therefore, their attractiveness to certain ecological receptors should not pose additional risk from contaminants. The ponds will be averaged separately (as surface water and sediment). These averages should be representative of the actual potential exposure.

Table 3-10. Sediments contaminant concentrations compared to ecological criteria for a waste pond.[a]

Chemical	WDNR Guidelines[b]	Frequency of Exceedance of WDNR Guidelines	NOAA ER-L Concentrations[c]	Frequency of Exceedance NOAA ER-L Guidelines	USEPA Interim Criteria[d]	Frequency of Exceedance of USEPA Criteria
Radionuclides (pCi/g)						
Americium-241	NA	NA	NA	NA	NA	NA

a. From case study (Appendix I).

b. From: Bennett and Cubbage (1991). Values shown are reference concentrations estimated using the equilibrium partitioning approach by WDNR, normalized for OC.

c. From: Long and Morgan (1990). Values shown are the ER-L, defined as the lower 10 percentile of concentrations observed or predicted to be associated with biological effects. Note that the data used to estimate ER-L are principally from marine and estuarine environments.

d. From: EPA (1991f). Values shown are derived from water criteria using the equilibrium partitioning approach, and normalized for OC.

Key:

EPA	=	U.S. Environmental Protection Agency
ER-L	=	Effects Range Low
IAEA	=	International Atomic Energy Agency
NA	=	Not available
NOAA	=	National Oceanic and Atmospheric Administration
OC	=	Organic carbon
pCi/g	=	PicoCuries per gram
µg/g	=	Micrograms per gram
WDNR	=	Wisconsin Department of Natural Resources

Table 3-11. Surface water contaminant concentration compared to ecological criteria for the waste pond.[a]

Chemical	EPA Ambient Water Quality Chronic Criteria[b]	Frequency of Exceedance of Chronic AWQC	EPA Ambient Water Quality Acute Criteria[b]	Frequency of Exceedance of Acute AWQC
Metals (mg/l)				
Chromium (VI)	11	0/3	16	0/3
Radionuclides (μCi/mL)				
Cesium-137	NA	NA	NA	NA
Others				
Chloride (μg/L)	230,000	15/15	860,000	15/15

a. From case study (Appendix I).

b. From: U.S. Environmental Protection Agency, 1986, Quality Criteria for Water, EPA/440/5-86-001, Office of Water Regulations and Standards, U.S. Government Printing Office, Washington, DC, as updated. Values are the freshwater acute and chronic criteria for the protection of aquatic life unless otherwise noted.

Key:

AWQC	=	Ambient Water Quality Criteria
mg/L	=	Milligrams per liter
NA	=	Not available
μCi/mL	=	MicroCuries per milliliter
μg/L	=	Micrograms per liter

Table 3-12. Example of the summary of data by medium (i.e., soil).

Chemical	FOD	Average	Ranges		Background Concentration	FOE
			Minimum	Maximum		
Metals (μg/g)						
Aluminum	24/24	11,500	2,920	13,400	12,800	1/24
Radionuclide (ρCi/G)						
Americium-241	5/5	2.3	0.072	4	0.005	5/5
Organics (μg/g)						
1,1-Dichoroethene	1/25	0.005	0.005	0.005	na	na

na = not available

Key: pCi/g = Picocuries per gram
μg/g = Micrograms/gram

Berms and other facility structures may or may not be attractive to certain species of small mammals for habitat and/or the plantings of crested wheatgrass may or may not be attractive for feeding. In general, monoculture plantings have smaller populations than the surrounding natural areas. Small mammals studied appear to use both the native (uncontaminated site) and planted sites (possible contaminated) for habitat and feeding, and therefore a good estimate of the potential exposure would be the average between these areas. Species other than small mammals generally have a larger home range and their usage of a small contaminated area would be limited.

Finally, the possibility exists that an individual small mammal will be exposed 100% of the time to the maximum level of contamination. In this situation, this methodology would underestimate the risk to the maximally exposed individual. Although the guidance proposes to use the risk to an individual as a method to screen for risk to the population, the maximum potential risk to an individual is difficult to quantify and is not as important as a reasonably conservative estimate of the exposure to the average individual of the population.

3.2.4.7 Uncertainty Associated with Initial Screening of Contaminants. The uncertainties involved in measuring chemical concentrations in environmental media can be substantial and should be discussed in this section. Sources of uncertainty in environmental sampling and analysis include handling procedures; sampling location, number, and density; selection of contaminants; analyte extraction; sample dilution; analytical detection limits; measurement errors; and handling of non-detects; analyte interference; and instrument limitations. Even with strict quality assurance and control measures, there is no assurance that the environmental samples taken are fully representative of the site. These uncertainties are expected to have a low to moderate potential to over- or under-estimate risk.

3.2.4.8 Potential Problems. Several site-specific problems must be addressed to provide a consistent methodology to be used for each WAG.

First, considerable contaminant data of varying quality is available. Most of these data were collected as part of the CERCLA investigations discussed in the FFA/CO. The FFA/CO process first categorized each site into an OU. These sites were then processed to identify appropriate remedial action decisions for the various OUs at the INEL. There are five levels of activity in which a site can be placed using this process. These activities include, in increasing levels of action: no action sites, Track 1, Track 2, Interim Action, and RI/FS sites. Since 1991, many of the OUs at the INEL have been investigated using this process. Depending on the level of activity assigned to a site, the amount and quality level of data can vary.

Second, after compilation, the data must be analyzed from the ecological risk perspective. This analysis may be more difficult than expected since most of the contaminant data on the INEL have been collected with a bias toward human risk assessment. For example, extensive data exist on groundwater contamination, which is of little consequence to ecological receptors in the absence of humans (pumping). More important, the ERA process may require revisiting sites that have already been resolved previously as having no or a slight potential to adversely affect human health.

Third, a large amount of additional data is available with varying levels of quality and usability. These data have been collected for various reasons, e.g., to meet environmental monitoring requirements to establish pre-operational baselines for facilities, to determine regional background concentrations of contaminants, or to estimate the extent of contamination of the environment caused by the operation of INEL facilities. These data were used to develop the maximum database as discussed in Appendix B. It may be necessary to revisit these data in the baseline ERA.

As discussed in the Bunker Hill ERA (EPA 1991d), two points should be considered before chemicals can be eliminated from the list:

- Standards, criteria, or concentrations derived from toxicity reference values may be smaller than the sample detection limit; thus, the chemical may not be detected in the sample, but may be present at levels considered toxic.

- Detection limits varied among sampling events. Some contaminant concentrations detected in one sampling event may not have been detected in samples from a different sampling event with different detection limits.

It will be assumed that the site sampling was directed at those contaminants identified at the site and therefore the detection limits were adequate. For those contaminants where half the detection limit is greater than the average sample concentration, the use of half the detection limit in the average will be conservative. The analyst will need to be aware that these points may need to be addressed further.

3.2.5 Pathways of Contaminant Migration and Exposure

The contaminant migration and pathways model is a major focus of ERA. It incorporates source and receptor identification, contamination release mechanisms, and contaminant environmental transport. The model takes into account direct exposure to terrestrial species through the identification of exposure pathways, and indirect exposure through ingestion of contaminated prey. Table 3-13 lists typical contaminant sources, media, and release mechanisms.

Characterization of receptors for individual WAGs is a critical part of the problem formulation process. This section of the SLERA focuses the assessment on those functional groups most likely to be at risk to stressor effects. The WAG contaminants of concern and their movement through the media are conceptualized in the pathway model. Exposure routes identified by the model are then used to determine what communities and organisms are at highest potential for direct exposure to those media. The process results in the addition of receptors to the SLERA pathways and exposure models and ultimately, the production of the conceptual site model.

Three generic SLERA pathways/exposure models have been developed to represent the primary INEL contaminant sources, media and exposure scenarios:

- A subsurface storage and disposal site model (subsurface soil)

Table 3-13. Typical release sources, receiving media, and release mechanisms (adapted from EPA, 1989c).

Release Source	Release Mechanism	Receiving Medium
Surface wastes—ponds, pits, spills Contaminated surface water Contaminated surface soil Contaminated wetlands Contaminated subsurface soil	Volatilization	Air
Contaminated surface soil Spills Contaminated groundwater	Surface runoff Episodic overland flow Ground-water seepage	Surface water
Surface or buried wastes Contaminated soil	Leaching	Groundwater
Surface or buried waste Contaminated surface soil Pond overflow Spills, leaking containers Contaminated subsurface soil Waste piles	Leaching Surface runoff Episodic overland flow Fugitive dust generation/deposition Tracking	Surface Soil
Buried waste	Leaching Volatilization	Subsurface Soil
Surface wastes—ponds, pits, spills Contaminated surface soil Contaminated groundwater	Surface runoff Episodic overland flow Groundwater seepage Leaching	Sediment
Contaminated soil, surface water, sediment, groundwater, or air Other biota	Uptake (direct contact, ingestion, inhalation, mechanical displacement	Biota

- A waste treatment pond model (surface water and sediments)
- A contaminated surface site model (surface soil).

These models are presented in Figures 3-6, 3-7, and 3-8. The models incorporate primary release mechanisms for general groups of INEL contaminants (i.e., radionuclides, organics, and metals) including wind suspension, run-off, volatilization, leaching, and infiltration (DOE 1993). Transport pathways include volatilization from soils or water into air, leaching from soils or sediments into surface water or groundwater, translocation or particulate transport via air or water. The SLERAs will most often assess the potential risk from these types of waste sites; however, development of models to address additional sources of contamination may be required.

The WAG sites and contaminants of concern and their associated contaminated media identified in the stressor characterization serve as the basis for determining the appropriate pathways of migration and exposure scenarios (models) to be implemented in the SLERA analysis.

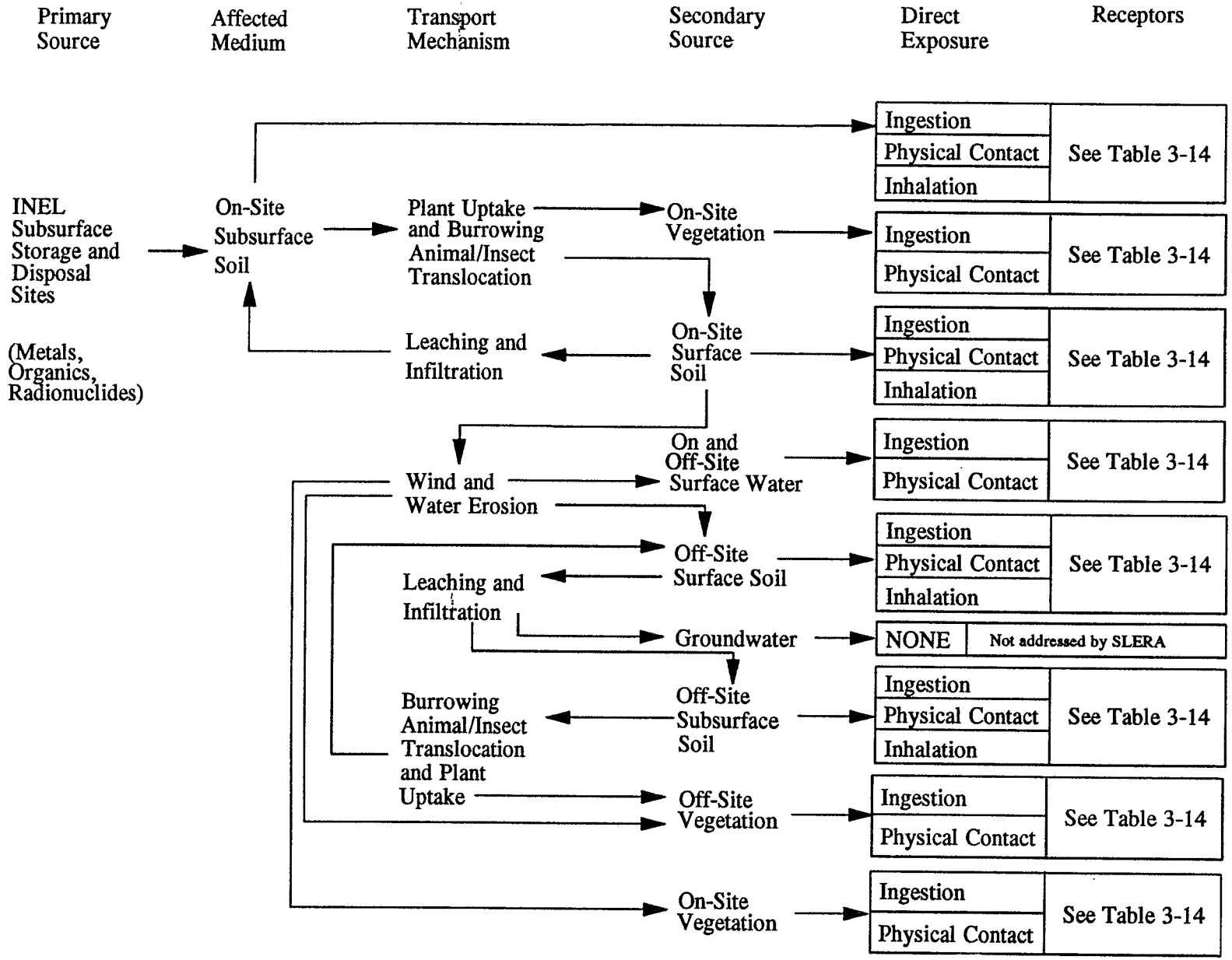


Figure 3-6. SLERA ecological Pathways/Exposure Model for INEL subsurface storage and disposal sites.

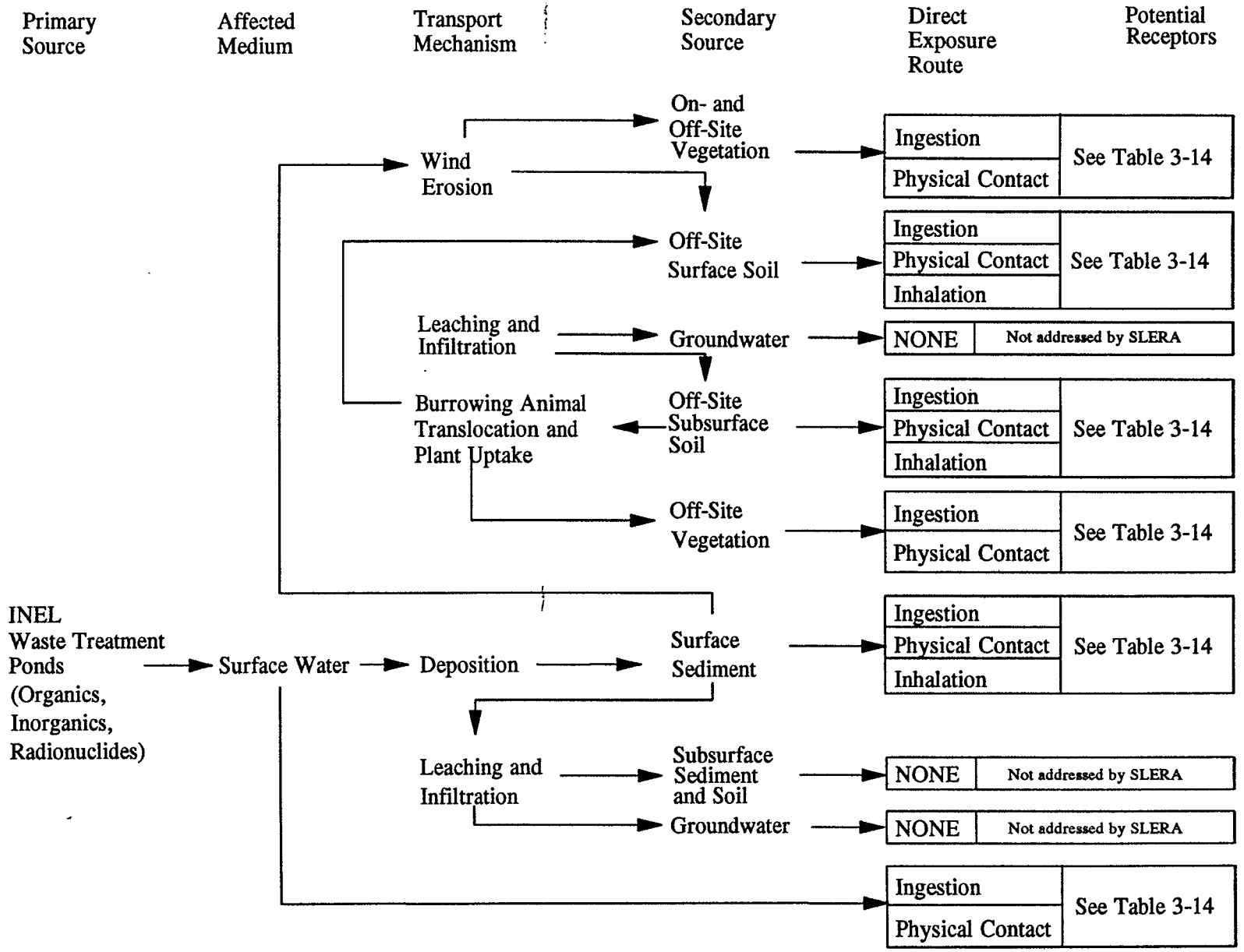


Figure 3-7. SLERA ecological pathways/exposure model for INEL waste treatment ponds.

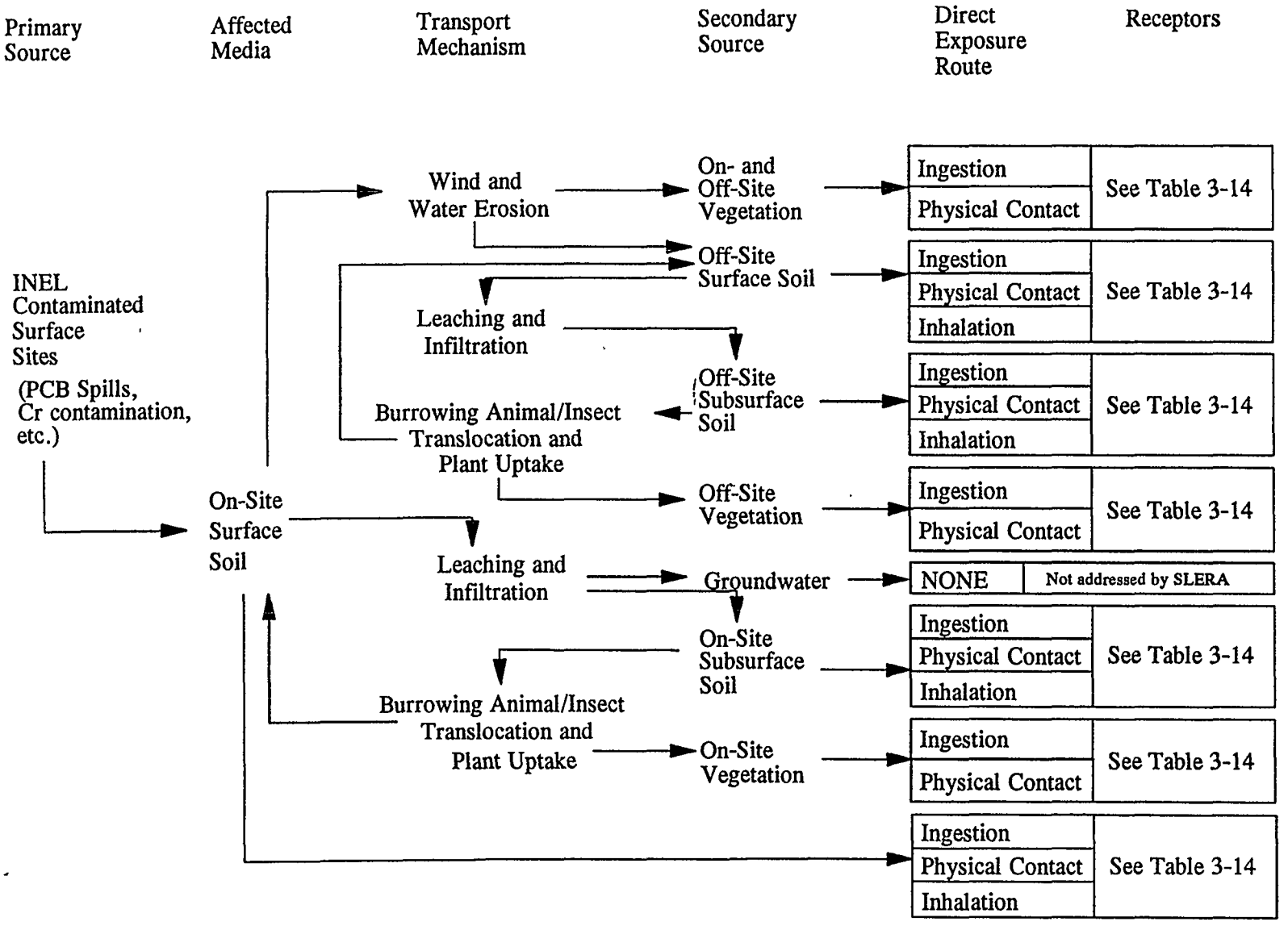


Figure 3-8. SLERA ecological pathways/exposure model for INEL surface contamination.

No formal transport and fate modeling is conducted for SLERA. Instead, behavior of contaminants is qualitatively reviewed in the analysis (Section 3.3). The appropriate pathways for evaluating individual contaminant behavior in the medium of interest are selected and applicable exposure routes identified. This information is then used to identify potential receptors.

One or more of the generic models will be required for the SLERA depending on the characteristics of the WAG sites of concern. Separate subsections should be included for each model addressed in the analysis. Discussions about each model should include the various pathways a contaminant may take and the routes through which biota may be exposed to site contamination. Typically, four exposure routes are considered in ecological risk assessments, as they are in human health risk assessments. These routes are (a) ingestion (soil, water, and biota), (b) inhalation, (c) dermal contact and (d) for radionuclides only, external exposure. However, potential effects for some exposure routes may be minor (dermal contact) compared to others (soil ingestion) for some contaminants. If a route of exposure for which the risk is assumed to be small or nonexistent is eliminated, the decision to eliminate this route should be well documented in the section. For receptors consuming prey species that have been directly exposed, an indirect exposure is assumed.

Once appropriate models are identified, ecological receptors for the associated exposure models must be identified. SLERA receptor characterization incorporates the functional grouping concept discussed in Section 3.2.3.2 (methods in Appendix E) to reduce the requirement for evaluation of potential contaminant exposure for individual species.

The objectives of receptor characterization include:

- Identification of ecological components that will form the framework for defining assessment endpoints and constructing the site conceptual model

- Elimination of ecological components that do not appear in the exposure pathways.

Characterization of contaminant receptors for a WAG begins with the contaminated media and routes of exposure identified using the pathways models discussed above. Functional groups associated with the WAG assessment area (see Section 3.4.3.1) are screened against possible routes of contaminant exposure to focus the SLERA on those groups that appear in WAG contaminant pathways. Functional groups not appearing in a pathway of contaminant exposure are eliminated from further consideration in the assessment. Functional groups identified as having potential for exposure are used as the basis for defining assessment endpoints and are combined with the WAG pathway model to produce the site conceptual model. All INEL functional groups have been evaluated for their potential exposure to contamination through dietary and physical routes for all three generic pathways/exposure models (Figures 3-6, 3-7, and 3-8). Primary exposure pathways for each group have been derived by interpreting the dietary and physical habits for the species associated with that group (see Section 2.1 in Appendix E). Table 3-14 lists the primary media and INEL functional groups (receptors) having potential for exposure through the routes indicated.

Functional groups for WAG biota can be screened for potential exposure to each route identified in a pathway model by consulting Table 3-14. The resulting list of ecological receptors

Table 3-14. Summary of Exposure Pathways and Associated INEL Functional Groups.

Exposure medium	Exposure route	Potential receptors (functional groups)[a]
Subsurface soil (Direct)	Ingestion (dietary)	AV222A, M121, M122A, M123, M222, M322, M422, M422A, R222, R322, A232, terrestrial invertebrates, microorganisms, individual plant species
	Physical contact	AV222A, M121, M122A, M123, M222, M322, M422, M422A, R222, R322, A232
	Inhalation	Not addressed in SLERA
Surface soil (Direct)	Ingestion (dietary)	AV122, AV222, AV222A, AV322, AV422, M121, M122, M122A, M123, M222, M322, M422, M422A, R222, R322, A232, terrestrial invertebrates, microorganisms, individual plant species
	Physical contact	AV122, AV210, AV310, AV322, AV422, M121, M122, M122A, M123, M132, M222, M322, M422, M422A, R222, R322, terrestrial invertebrates, microorganisms, individual plant species
	Inhalation	Not addressed in SLERA
Vegetation (Direct)	Ingestion	AV121, AV122, AV132, AV142, AV143, AV422, AV432, M122, M122A, M123, M132, M422, phytophagous insects
	Physical contact	AV121, AV122, AV132, AV142, AV210, AV222, AV222A, AV233, AV241, AV242, AV310, AV322, AV333, AV342, AV422, AV432, AV433, AV442, M121, M122, M122A, M123, M210, terrestrial invertebrates, individual plant species
Surface water (Direct)	Ingestion (dietary)	AV121, AV122, AV132, AV142, AV143, AV210, AV221, AV222A, AV222, AV232, AV233, AV241, AV242, AV310, AV322, AV333, AV342, AV422, AV432, AV433, AV442, M121, M122, M122A, M210A, M222, M322, M422, M422A, R222, R322, A232, aquatic microfauna
	Physical contact	AV132, AV142, AV143, AV232, AV233, AV241, AV242, AV333, AV432, AV433, AV442, M123, M132, M210, M132, A232, aquatic microflora/fauna
Sediments (Direct)	Ingestion (dietary)	AV132, AV233, AV242, AV333, AV432, AV433, AV442, M132, A232, benthic invertebrates
	Physical contact	AV143, AV232, AV233, AV242, AV333, AV432, AV433, AV442, benthic invertebrates
	Physical contact	AV143, AV232, AV233, AV242, AV333, AV432, AV433, AV442, benthic invertebrates
	Inhalation	Not addressed in SLERA
Prey (Indirect)	Ingestion	A232, AV210, AV221, AV222, AV222A, AV232, AV233, AV241, AV242, AV310, AV322, AV333, AV342, AV422, AV432, AV433, AV442, M210A, M210, M222, M322, M422, M422A, R222, R322, entomophagous, zoophagous, and saprophagous insects

a. Individual species associated with these groups are listed on Table E-4.

should be incorporated with the contaminant and pathways models write-up, including summarized results and tables similar to those presented here. The information contained in this section will serve as an important reference for SLERA endpoint definition and development of the conceptual site. A detailed discussion of the methods and summary documentation is given in Appendix E.

3.2.6 The Conceptual Site Model

Development of the conceptual site model is based on the food web and appropriate pathways/exposure models identified in Section 3.2.5. Simplistically, the conceptual site model combines the ecological and contaminant characteristics of the ecosystem being analyzed to develop exposure scenarios for use in assessing the risk at the site. The model integrates all direct exposure pathway models identified for the WAG with indirect exposure scenarios (i.e., prey consumption).

The basic components of the model are contaminant sources, pathways (including release mechanisms and environmental transport routes), and exposure scenarios (which link the receptors to the source). The conceptual model integrates receptors identified in the receptor characterization process with the pathway model to produce an overall summary of exposure for the ecosystem and serves as input to the analysis phase of the assessment (EPA 1992a).

Conceptual site models can be presented in one of two formats:

- An evaluation model that is a flow chart analysis depicting the movement of contaminants from source to receptor

- An illustrative model that depicts the site, source, affected media, and receptors with arrows indicating contaminant movement through the environment (see Figure 3-9).

An example of a conceptual site model is shown in Figure 3-9. This model incorporates all three major INEL pathway models (surface soil, subsurface soil, and surface water).

3.2.7 Assessment Endpoints

This section provides guidance for use of appropriate assessment endpoints for each WAG SLERA. Assessment endpoints are "formal expressions of the actual environmental values that are to be protected" (Suter 1989). For ERA, assessment endpoints are the focus for risk characterization and link the measurement endpoints to risk management goals (EPA 1992a).

Criteria for ERA assessment endpoints encompass biological relevancy policy goals and societal values, susceptibility to the contaminant, and consideration of measurability and predictability (EPA 1992a; Suter 1993). However, SLERA assessment endpoints are not intended to reflect ecosystem integrity or to be used to set remedial cleanup levels. The primary objective of the SLERA is to identify COPCs and levels of those contaminants that represent potential risk to WAG ecological components, and toxic effects to biota as a result of exposure to a contaminant are of primary concern. The considerations incorporated to produce appropriate SLERA assessment endpoints include (EPA 1992a):

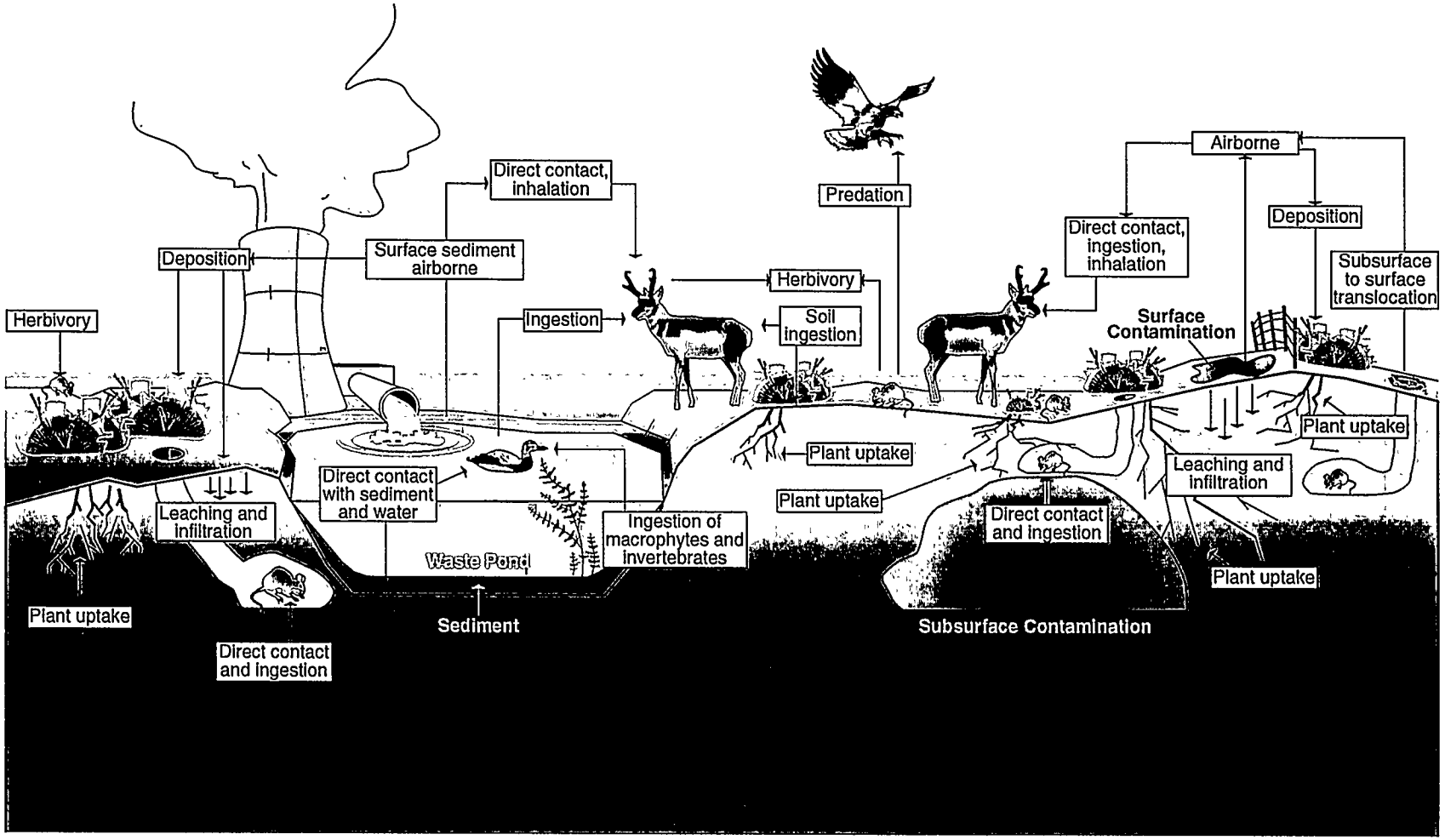


Figure 3-9. Example ecological conceptual site model.

Y95 0189

- Ecological relevance

- Policy goals and regulatory requirements.

Suggested assessment endpoints have been developed for WAG SLERAs and are presented on Table 3-15. These assessment endpoints are focused on the protection of INEL biota represented by functional groups and T/E species identified in the receptor characterization process (Section 3.5.2) as having potential for exposure to contaminants. Additional endpoints may be required to address individual WAG issues (e.g., existence of critical habitat within the assessment area).

It is beyond the scope of SLERA to quantify risk, so an ecologically-based screening level (EBSL) has been applied to establish the potential for WAG contaminants to contribute to ecological risk to ecological components. A screening level quotient (SLQ) is used to indicate whether or not a potential for adverse effects exists. The development and application of SLQs for SLERA analyses are discussed in Section 3.4.

Assessment endpoints for each SLERA should be presented in a format similar to Table 3-15. Documentation for this section requires a brief discussion of how the results of the screening-level evaluation can be related to the assessment endpoints.

3.2.8 Measurement Endpoints

This section of the SLERA is the culmination of the problem formulation phase of the assessment. The purpose of measurement endpoints is to explicitly define the measures that will be used to attain WAG assessment endpoints.

A measurement endpoint is "a quantitative expression of an observed or measured effect of the hazard; it is a measurable environmental characteristic that is related to the valued characteristic chosen as an assessment endpoint" (Suter 1989). For INEL SLERAs, ecological components are not surveyed or measured directly. Rather, these assessments are performed using only existing data. Consequently, measurement endpoints for INEL SLERAs are defined as the model input values required to calculate TRVs, EBSLs, and ultimately an SLQ.

Table 3-16 presents an example summary of SLERA assessment and measurement endpoints. Average contaminant concentration in the media of interest is a pre-defined measurement endpoint since it is required as input for calculating SLQs (Section 3.4). Some measurement endpoints are also pre-defined by the input values required for calculation of EBSLs (see Section 3.3.1.3). These exposure parameters include dietary composition, home range, temporal and spatial habitat use data (site use factors and exposure duration), soil ingestion rate, food digestion rate, and body weights and for plants, uptake factors.

Measurement endpoints supporting the development of TRVs (Section 3.3.1.3) may be defined during the assessment depending on the availability of toxicity effects data. For example, LD50 values may be available for some species (measurement species), where as NOAELs or LOAELs may be available for others.

Table 3-15. Summary of SLERA assessment endpoints (Suter, 1993).

Hazard/policy goal	WAG SLERA endpoint	Indicator of effects[a]
No unacceptable reductions to INEL T/E individuals and populations as a result of exposure to organic, inorganic, and radionuclide contamination	No indication of possible adverse effects to T/E individuals and populations as a result of contaminant exposure: peregrine falcon, bald eagle, northern goshawk, ferruginous hawk, loggerhead shrike, white-faced ibis, black tern, trumpeter swan, pygmy rabbit, and Townsend's big-eared bat individuals and populations (Functional Groups AV310, AV322, AV233, AV210, M122A, and M210A).	SLQ ≥ risk target
No unacceptable reductions to INEL T/E individuals and populations as a result of physical stressors.	Not addressed by SLERA	N/A
No unacceptable reductions to abundance and diversity of INEL native biota as a result of exposure to organic, inorganic, and radionuclide contamination	No indication of possible adverse effects to WAG native vegetation communities as a result of contaminant exposure.	SLQ ≥ risk target
	No indication of possible adverse effects to WAG wildlife populations as a result of contaminant exposure (represented by functional groups identified in the site conceptual model: waterfowl, small mammals, large mammals, song birds, raptors, top predators, invertebrates).	SLQ ≥ risk target
No unacceptable reductions to abundance and diversity of INEL native biota as a result of physical stressors.	Not addressed by SLERA	N/A

a. SLQ - screening level quotient. See Risk Estimation, Section 3.4.1.

Table 3-16. Summary of SLERA assessment and measurement endpoints (Suter 1993).

WAG assessment endpoint	WAG measurement endpoints[a]	Ecological component	Functional group (other groups represented)	Measurement species[b] (TRV/EBSL)	Example INEL group members
No indication of possible effects to T/E individuals and populations as a result of contaminant exposure: peregrine falcon, ferruginous hawk, bald eagle, loggerhead shrike, northern goshawk, pygmy rabbit, and Townsend's big-eared bat (SLQ <risk target)	Average contaminant soil concentrations TRVs: NOAELs LOAELs QECs Adjustment factors EBSLs: Dietary components Home range Site use factors Exposure duration Soil ingestion rate Food digestion rate Body weight	Pygmy rabbit	M122A(M123)	Rat, mouse/meadow vole (M122A), deer mouse	Pygmy rabbit
		Peregrine falcon, northern goshawk	AV310	Chicken, goshawk, American kestrel/red-tailed hawk (AV322)	Peregrine falcon, northern goshawk
		Ferruginous hawk, loggerhead shrike, bald eagle	AV322	Chicken, goshawk, American kestrel/red-tailed hawk (AV322)	Ferruginous hawk, loggerhead shrike, bald eagle
		Townsend's western big-eared bat	M210A (M210)		Townsend's western big-eared bat
No indication of possible effects to WAG native vegetation communities as a result of contaminant exposure (SLQ<risk target)	Average contaminant soil concentrations Plant uptake factors TRVs (equivalent to EBSL)	Vegetation	Sagebrush-steppe on lava Grassland	Bush beans, crop plants	Sagebrush, bunchgrass
No indication of possible effects to WAG wildlife populations as a result of contaminant exposure (represented by functional groups identified in the site conceptual model: waterfowl, small mammals, large mammals, song birds, raptors, top predators, invertebrates) (SLQ<risk target)	Average contaminant soil concentrations TRVs: NOAELs LOAELs Adjustment factors EBSLs Dietary components Home range Site use factors Exposure duration Soil ingestion rate Food digestion rate Body weight	Small mammals	M422, M122A (M222, M123)	Rat, mouse/meadow vole (M122A), deer mouse	Deer mouse, least chipmunk, montane vole, nuttall's cottontail, bushy-tailed woodrat, ord's kangaroo rat
		Mammalian carnivore/ omnivore	M422A, M322	Rat, mouse, dog, cat, mink/fox	Coyote, long-tailed weasel
		Mammalian herbivores	M121 (M122)	Rat, mouse, mule deer/ pronghorn	Pronghorn antelope
		Avian carnivores	AV322	Goshawk, American kestrel/ red-tailed hawk (AV322)	American kestrel, northern harrier
		Avian herbivore	AV122 (AV122)	Chicken, pheasant, quail, passerines/sharp-tailed and ruffed grouse	Sage grouse, rock dove, mourning dove
		Avian insectivore	AV210, AV222 (AV210A, AV221, AV222A)	Chicken, pheasant, quail, passerines/American robin, cliff swallow	Cliff swallow, barn swallow, american robin, brewer's sparrow, western meadowlark
		Avian carnivore/omnivore	AV422	Chicken, pheasant, quail passerines	Black-billed magpie
		Mammalian insectivore	M210A (M210)	None located	Townsend's western big-eared bat
		Reptiles	R222, R322	None located/Western racer	Sagebrush lizard, short-horned lizard, western rattlesnake, gopher snake
		Invertebrates	Unidentified	Unidentified	N/A

a. Measurement endpoints are discussed in Section 3.2.8.
COPC - contaminants of potential concern.
TRV - threshold reference value
NOAEL - no observed adverse-effects-level
LOAEL - lowest-observed-adverse-effects-level
EBSL - health-based screening level

b. Data for measurement species are discussed in detail in Section 3.3.

All species within WAG functional groups identified as receptors for WAG contaminants (Section 3.2.5) qualify as representative species for which existing toxicological or ecological data may serve as input to assessment models. All threatened and/or endangered (T/E) and C2 species potentially present at the WAG assessment area must be individually addressed by the SLERA. This is accomplished by applying an additional factor of conservatism to the exposure/effects calculations for these species (Section 3.3.2.1).

A discussion specifying SLERA measurement endpoints and how they are incorporated in the analysis should be presented in this section. In addition, a table similar to Table 3-16 should be included to summarize SLERA endpoints, ecological components addressed by the analysis (functional groups) and measurement species.

3.3 Screening Analysis Guidance

The SLERA analysis consists of a (1) exposure assessment and (2) ecological effects analysis. In the exposure assessment, exposure concentrations are estimated for each contaminant, for each exposure pathway, and for each receptor. Exposure information is used in conjunction with the ecological effects assessment to evaluate the potential ecological risk to the ecosystem during the risk characterization. The activities necessary to perform the analysis are highly integrated and are generally performed interactively. Therefore, the guidance presented here can be modified to more appropriately fit each individual WAG SLERA.

3.3.1 Exposure Assessment

The SLERA exposure assessment quantitatively determines the magnitude and routes of exposure. The information gathered during the problem formulation directs the analysis phase of the SLERA and provides the basis for calculating an indication of risk. Important issues to present in this section include:

- Stressor characterization
- Ecosystem parameters
- Estimation of exposure for all functional groups and T/E or candidate species.

These issues are presented as subsections within this guidance. Again, it is not necessary to follow the organization presented, but it is more important that each of these issues are discussed within the SLERA.

3.3.1.1 Stressor Characterization. This section involves the summarization of the stressor characterization information compiled during the problem formulation stage [i.e., exposure point concentrations (EPCs)] and a qualitative analysis of the contaminant transport and fate in the environment.

Exposure Point Concentrations

During the stressor characterization performed as part of the problem formulation phase of the SLERA, an average concentration will be calculated for each contaminant in each media. These are the EPCs that will be used during the analysis phase. The EPCs can be summarized initially for all media as shown in Table 3-17 and presented with the calculations (as discussed later).

The use of average concentrations for the SLERA, as discussed in Section 3.2.4, to calculate EPCs is conservative since the sampling at each WAG will be biased towards those areas identified in the FFA/CO as having been contaminated. This approach results in estimated exposure doses that are most likely higher than the actual doses received by ecological receptors at the site. This methodology is especially appropriate for surface and subsurface soil contamination. However, if the variation in any media is large for a particular contaminant, the analyst is cautioned to investigate this in more detail. This finding might necessitate the presentation of a breakdown of averages by sites within the WAG with an analysis of the spatial distribution of the contaminant. Since this type of analysis is generally more appropriate to ERA, the contaminant should be maintained as an COPC and addressed in the subsequent ERA.

This methodology is also appropriate for contaminated water sources but must be used with caution. Water sources may have particular appeal for certain organisms in the INEL ecosystem. The analyst should be aware that in certain circumstances it may be more appropriate to use an upperbound estimate for calculating exposure. In most situations, the average will be appropriate since waste water sites are limited (usually one to a WAG) and generally well sampled. The area of influence is assumed to encompass drinking water use by species over the total assessment area.

Contaminant Transport and Fate

The contaminants previously identified in the stressor characterization effort associated with the problem formulation phase of the SLERA process will be discussed in this section. During the analysis phase, these contaminants are more thoroughly discussed to obtain a complete picture of their movement and activity in the environment using a fate and transport model. Where the contaminant is a radionuclide, information on the half-life and decay mechanism will be included.

In this section, each SLERA will present a literature review and discussion on the transport and fate of each contaminant in the environment. The objective is to gather the available data concerning the contaminant concentrations (or discharge rates where appropriate), with the information on the state of the environment and to look at the rates at which the contaminant is degraded and/or transported from place to place, and how long the contaminant is anticipated to reside in the environment in question. This includes any available information on studies concerning the behavior of a contaminant in the biota (e.g., movement through the foodweb or accumulation in certain tissues). This information combined with the ecological effects assessment will provide an effective picture of the potential movement of this chemical through the ecosystem and allow for an adequate characterization of the risk.

Table 3-17. Example of presentation of exposure point concentrations for all medium.

	Surface water		Sediment		Surface Soil		Subsurface Soil	
Contaminant	Average concentration	N	Average concentration	N	Average concentration	N	Average concentration	N
Chromium	NP	—	NP	—	240.3 μg/g	14	156.8 μg/g	6
Am-241	NP	—	NP	—	21.0 ρCi/g	17	15.0 ρCi/g	14

Key:

N = Number of samples.
NP = Contaminant not present in this medium.

The output from this type of literature review will be a written discussion. These writeups will contain the following information: The contaminant movement and fate through the biota (e.g., in the case of strontium it is closely related to calcium and barium and will follow the calcium route through food chains from environment to organism) and the abiotic ecosystem (e.g., soil) and relate this where possible to the site-specific characteristics at the INEL. The sources of the contaminate on the site should be discussed in this section. This includes documenting other anthropogenic sources for some contaminants (for example, it is informative to discuss the fact that Sr-90 has been released to the atmosphere and dispersed world-wide due to above-ground nuclear detonations).

3.3.1.2 Ecosystem Parameters. The ecosystem characterization that was performed as part of Section 2.1 of the problem formulation will be the basis for the development of the ecosystem parameters performed as part of the analysis. In this section, the functional groups that are potentially at risk are identified. To perform the SLERA, it is necessary to provide input parameters for the exposure assessment and use conservative assumptions whenever necessary. These parameters will directly support the SLERA exposure analysis. The EPA Wildlife Factors Exposure Handbook (EPA 1993) is an excellent source for this type of information.

The ecosystem characterization presented in this section of the analysis phase should include the following subsections:

- Temporal and spatial characteristics
- Ingestion rates
- Body weight and diet
- Food-chain exposure calculations.

Temporal and Spatial Characteristics

The ecological components' temporal characteristics complicates the evaluation of exposure. For example, food preferences, food and water consumption rates, reproductive cycles, seasonal activities, and age of species at exposure can all contribute to the complexity of this issue. Ideally, all these factors would be considered in a detailed risk assessment. For performing screening-level exposure analysis, a simple unitless exposure duration (ED) factor will be calculated.

ED = fraction of the year receptor spent in the assessment area.

An ED value will be developed for functional groups that have been identified in the problem formulation as having potential exposure to contamination. An ED value of 1.0 should be used for any functional group that contains year-round residents of the WAG assessment area, and a conservative value between 0 and 1.0 will be used for those groups containing migratory species based on the fraction of the year spent in the region (generally 0.50). This information will be developed first from any site-specific information available and secondly from available literature. If data are not available for any of the functional group members, a conservative assumption should be used and a value of 1.0 input into the exposure analysis. To ensure conservatism, the highest ED for any member within a functional group is chosen to represent the group as a whole. This information should be presented as shown in Table 3-18.

Once the assessment area has been delineated, the ecological components' spatial characteristics also complicate the evaluation of exposure. Simplistically, this means that a functional group consisting of species with comparatively large home ranges (i.e., pronghorn in mammalian herbivore - M122) compared to the area of contamination will be potentially exposed less than a receptor with a functional group consisting of species with comparatively small home ranges (i.e., pygmy rabbit in mammalian/herbivores - M122A). For performing the exposure analysis for screening, a site use factor (SUF) will be develop for each receptor species.

SUF = assessment area (acres)/area of home range (acres).

SUF values for all applicable functional groups must be developed. An SUF value of 1 should be used for those functional groups containing only species whose home range is 100% within the WAG assessment area. A value from 0 to 1.0 should be developed for those species with a home range larger than the WAG assessment area. The species with the largest SUF is used to represent the functional group. For example, if the assessment area is estimated to be 1,000 ha, and the home range for the mammalian omnivores (M422A) is determined to be 6,400 ha, a SUF of 0.16 results. Incorporation of the SUF adjusts the exposure estimates to account for the estimated time the receptor spends on the site. The less time spent on the site, the lower the exposure.

This information should be developed first from any site-specific information available and secondly from available literature. If data are not available for a particular receptor, a conservative assumption should be used and a value of 1.0 input into the exposure analysis. When using the functional grouping methodology, it will be necessary to use the species within

Table 3-18. Presentation of parameters for analysis.

Functional groups	PP	PV	PS[a]	SUF	ED	IR (kg/day)	W (kg)	Home range (Ha)
Avian herbivores (AV122)	0.00E+00	9.90E-01	1.00E-02	1.00E+00	1.00E+00	1.27E-02	1.94E-01[e]	1.56E+01[e]
Avian insectivores (AV210)	—	—	—	1.00E+00	1.00E+00	6.49E-03	2.67E-02[f]	
Avian insectivores (AV222)	—	—	—	1.00E+00	2.50E-01	1.75E-02	8.60E-02[g]	4.40E-01[g]
Avian carnivores (AV310)	9.80E-01	0.00E+00	2.00E-02	4.54E-01	1.00E+00	5.06E-02	1.36E+00[h]	2.23E+03[k]
Avian carnivores (AV322)	9.80E-01	0.00E+00	2.00E-02	1.00E+00	2.50E-01	9.95E-03	1.38E-01[g]	2.02E+02[g]
Avian omnivores (AV422)	9.90E-01	0.00E+00	1.00E-02	1.00E+00	1.00E+00	3.73E-02	2.09E-01[f]	—
Mammalian herbivores (M122)	0.00E+00	9.46E-01	5.40E-02[b]	9.86E-01	1.00E+00	1.95E+00	5.85E+01[i]	1.02E+03[i]
Small mammals/herbivores (M122A)	0.00E+00	9.76E-01	2.40E-02[c]	1.00E+00	1.00E+00	7.61E-03	8.50E-02[c]	8.00E-02[c]
Mammalian insectivores (M210)	—	—	—	1.00E+00	1.00E+00	1.69E-03	1.10E-02[i]	—
Mammalian carnivores (M322)	9.72E-01	0.00E+00	2.80E-02[d]	1.00E+00	1.00E+00	2.83E-02	3.40E-01[i]	1.42E+01[i]
Small mammals/omnivores (M422)	9.80E-01	0.00E-01	2.00E-02	1.00E+00	1.00E+00	3.88E-03	2.30E-02[g]	1.28E-01[g]
Mammalian omnivores (M422A)	9.72E-01	0.00E+00	2.80E-02[d]	1.56E-01	1.00e+00	8.72E-01	2.20E+01[i]	6.48E+03[i]
Reptiles insectivores (R222)	9.80E-01	0.00E+00	2.00E-02	1.00E+00	1.00E+00	5.00E-03	2.51E-01[j]	3.00E+00[j]
Reptiles carnivores (R322)	9.80E-01	0.00E+00	2.00E-02	1.00E+00	1.00E+00	5.00E-03	2.51E-01[j]	3.00E+00[j]

WAG assessment area = 1000 Ha

Threatened and Endangered Species - values would be the same as those functional group categories listed above with those in parentheses following the name.

Peregrine Falcon (AV310)
Northern Goshawk (AV310)
Bald Eagle (AV322)
Ferruginous Hawk (AV322)
Loggerhead Shrike (AV322)
Pygmy Rabbit (M122A)
Townsend's Big-eared Bat (M210)

Abbreviations

PP = percentage of diet represented by prey ingested (unitless)
PV = percentage of diet represented by vegetation ingested (unitless)
PS = percentage of diet represented by soil ingested (unitless)
SUF = site use factor (total WAG assessment area (ha) divided by home range (ha)) (unitless)
ED = exposure duration (fraction of year spent in the affected area) (unitless)
IR = ingestion rate (derived using allometric equations based on body weight (kg/day)
W = receptor-specific body weight (kg)
– = information not available

Sources

a. Where information did not exist in the literature on soil ingestion rates for terrestrial biota, soil ingestion rates were assumed to be 2% of the food ingestion rate for all burrowing mammals and birds who consume whole terrestrial prey and 1% for all other receptors.
b. Arthur and Gates (1988)
c. EPA (1993) value for meadow vole
d. EPA (1993) value for red fox
e. Hoover and Wills (1987) mean value for sharp-tailed and ruffed grouse
f. Dunning (1993)
g. EPA (1993) actual species value
h. Johnsgard (1990)
i. Burt and Grossenheider (1980)
j. EPA (1993b) value for racer
k. Hoover and Wills (1987)

that group with the smallest home range to ensure conservatism. This information should be presented as shown in Table 3-18.

The SUF is applied simplistically for use in the SLERA. For receptors, such as large herbaceous grazers (e.g., pronghorn), this approach is appropriate and conservative. For receptors that may have specific habitat requirements and are drawn to certain ecotypes, it may not be conservative enough. As discussed in Section 3.2.4.6, the WAGs are generally surrounded by a fairly uniform habitat of sagebrush steppe, although there are attractive habitats (e.g. lawns) for certain native species, and for some species that would not be natural inhabitants of the area. Irrigated lawn areas that would definitely prove attractive to some wildlife, are for human use and are generally not contaminated. Waste ponds are attractive to wildlife but the contaminant concentrations are averaged separately for that pathway, are assumed to be that average throughout the WAG assessment area, and the use of area is assumed to be 100% for year round species and 50% for seasonal. Subsequently, these values should be conservative. The uncertainty in this approach will be discussed in more detail at the end of this section.

Ingestion Rates

The ingestion of contaminants can occur from many of the normal activities of a receptor within a functional group. This includes ingestion of food, water, and soil. The calculation of the amount of food, water, and soil consumed by a receptor and the relationship of this value to the exposure is highly variable. Generally, the ingestion rate for a receptor is not available, and if available, is complicated by the effects of season, availability of forage and water, age, dietary habits, and individual variation as well as many other factors. Therefore, this section of each SLERA should contain a discussion concerning the methods, assumptions, and uncertainties associated with the development of these ingestion rates. In addition, where possible, any relevant literature should be discussed, and any site-specific studies should be included.

Beyer et al. (1994) state that many wildlife species ingest soil while feeding and that knowing ingestion rates may be important for studies of environmental contaminants. There have been many studies performed (Beyer et al. 1994; Fries et al. 1982; Mayland et al. 1975; Russell et al. 1985) and some that are INEL-specific (Arthur and Gates 1988); however, actual ingestion rates are known for only a few species and most soil ingestion estimates are approximate. For each SLERA, site-specific soil ingestion should be used if available.

Suter (1993) provides a fairly detailed discussion on this topic and states that both the conversions between diet and dose and interspecies conversions of food and water consumption require size and consumption-rate data. To the extent possible, these data should come from site-specific studies, but generic literature values are usually used. In the absence of site-specific, species-specific data, allometric regression models can be used as shown in Tables 3-19 and 3-20. There are other methods available and can be used as applicable in the SLERA process. For INEL SLERA, all food items should be considered dry to ensure conservatism.

Body Weight and Diet

It is also necessary to determine an average body weight and the percent of diet that is made up of vegetation, and/or prey items for each functional group. This information is shown in

Table 3-19. Examples of allometric regression models of food and water consumption[a].

Model type	Equation
Dry diet	$F = 0.049\ W^{0.6087}$
	$C = 0.093\ W^{0.7584}$
Wet diet	$F = 0.054\ W^{0.9451}$
	$C = 0.090\ W^{1.2044}$

a. Based on food consumption (F) in kg/day and water consumption (C) in L/day as functions of body weight (W) in kg, derived from data for various mammals, based on direct measurements from captive animals (ECAO, 1987).

Table 3-20. Examples of allometric regression models of feeding rates for wildlife.[a]

Group	Equation
Eutherian mammals	
All eutherians	$F = (0.235\ BW^{0.822})*1E\text{-}3$
Rodents[b]	$F = (0.583\ BW^{0.585})*1E\text{-}3$
Herbivores	$F = (0.577\ BW^{0.727})*1E\text{-}3$
Birds	
All birds	$F = (0.648\ BW^{0.651})*1E\text{-}3$
Passerines	$F = (0.398\ BW^{0.850})*1E\text{-}3$
Desert birds	$F = (1.11\ BW^{0.445})*1E\text{-}3$
Sea birds	$F = (0.495\ BW^{0.704})*1E\text{-}3$
Iguanid lizards	
Herbivores	$F = (0.019\ BW^{0.841})*1E\text{-}3$
Insectivores	$F = (0.013\ BW^{0.773})*1E\text{-}3$

a. From Nagy (1987) based on field metabolic rate. Where body weight (BW) is in grams and feeding rate (F) is in kg/d of dry matter (the 1E-3 is a conversion factor to convert grams to kilograms).

b. A slight modification of this equation was made to correct typographical errors in the original report (personal communication K. Nagy, 1995).

Table 3-18. This necessitates again finding either site-specific or species-specific information in the literature to develop these values for use in the risk assessment. It is necessary to cite any sources used for this information. In the absence of site specific or literature-based data, it is appropriate to use conservative assumptions for the SLERA. When using the functional group methodology, this would include using the smallest body weight of the species represented by the functional group for conservatism. This should be stated in this section, and the decision should be based on the ecological risk assessor's knowledge of a particular functional group and its associated species.

Food-Chain Exposure Calculations

The uptake of contaminants in the terrestrial food chain can be calculated. These contaminant-specific factors are referred to in the literature as uptake factors or plant uptake factors (PUFs) for plants and food-chain transfer coefficients or factors for wildlife. The PUF is the plant tissue concentration of the contaminant divided by the soil or sediment concentration. The food-chain transfer factor is the animal tissue concentration of a contaminant divided by the concentration in its food. These factors will be developed first from site-specific data or from the general literature if possible. Data on chemical concentrations in wild animals, as opposed to domestic or laboratory animals, should be used when available. Hanford has produced the *Ecotoxicity Literature Review of Selected Hanford Site Contaminants* (Driver 1994). This report states that food chain transport information is generally lacking for desert or sagebrush-steppe organisms. In addition, it is shown that these values tend to be highly site-specific, due to the effects that biological and physiochemical factors may have on contaminant bioavailability and toxicity. Table 3-21 presents an example of the development of PUF values for both terrestrial and aquatic plants. To estimate the tissue levels of contaminants in prey items of wildlife, the PUF was multiplied by the transfer factors to derive a "bioaccumulation factor" (BAF), which is the concentration of a contaminant in the tissues of an animal divided by the soil or sediment concentration. The BAF accounts for all ingestion exposure routes. For example, the BAF for an herbivorous small mammal is the PUF times the plant-to-herbivore transfer coefficient. Multiplying the small mammal BAF times the concentration of a contaminant in soil provides an estimate of the tissue levels of the contaminant in small mammals. This tissue level may then be used to estimate exposure for the carnivore/omnivore functional groups that are predators of small mammals. This method for developing BAFs should be used with care and for situations where there are established steady state conditions. Table 3-22 presents an example of the development of food-chain transfer factors for non-radiological contaminants. Table 3-23 presents the development of BAFs for used in the exposure analysis. Site-specific PUFs should be used whenever possible. Element specific PUFs are available from Baes et al. (1984). Baes et al. (1984) give preference to studies that reported the steady-state concentration of metals in plants at edible maturity, various soil properties are not considered, and data for numerous plant species (both animal feeds and those consumed by humans) are combined. Since root uptake is a complex process that depends on various soil properties (e.g., pH, cation exchange capacity, and organic matter content) as well as the element and type of plant involved. The PUF for some organics can be estimated using the geometric mean regression equation developed by Travis and Arms (1988).

Table 3-21. Example table showing plant uptake factors.

Habitat	Contaminant	Uptake factor[a]	Remark	Reference
Terrestrial	Chromium	0.0075	Vegetative parts	Baes et al. 1984
	PCE	1.22	Calculated from log K_{OW}	Travis and Arms 1988
Aquatic	Chromium	0.26	Sediment to macrophyte uptake factor. Calculated by dividing total chromium in macrophytes by total chromium in sediment; value is an average for cattail, bulrush, and pondweed.	Hoffman et al. 1990

a. Dry weight basis; (plant DW concentration)/(soil or sediment DW concentration).

Note: PCE = Tetrachloroethane

Table 3-22. Example food-chain transfer factors for wildlife nonradiological contaminants.

Functional Group	Contaminant	Transfer Factors[a]	Remark	Reference
Mammalian Herbivores (M122)	Chromium	0.008	Determined in feeding studies with cotton rats	Taylor (1980) as cited by Eisler (1986)
	PCE	$1.6E^{-4}$	Calculated from log K_{ow} and an assumed muscle-tissue moisture content of 54%	Travis and Arms (1988); Suter (1993) for tissue moisture

a. Dry weight basis; (tissue DW concentration)/(feed DW concentration).
DW = Dry weight
PCE = Tetrachloroethene

Table 3-23. Example of the development of bioaccumulation factors for nonradiological contaminants.

Contaminant	PUF	Food-Chain Update Factor	BAF[a]
Chromium (total)	0.0075	.008	0.00006
Chromium (VI)	0.0075	.008	0.00006
PCE	1.22	$1.6x10^{-4}$	0.000195

a. Mammal BAF derived by multiplying plant to herbivore transfer factor by plant uptake factor.

PUF = Plant uptake factor
BAF = Bioaccumulation factor
PCE = Tetrachloroethene

In the exposure analysis, the following equation will yield the concentration of contaminant in the prey item.

$$CP = CS \times BAF \quad (1)$$

where

CP = Concentration in prey item ingested (mg/kg)

CS = Concentration of contaminant in soil (mg/kg)

BAF = Contaminant-specific bioaccumulation factor (unitless).

The concentration of contaminant in vegetation (CV) can be estimated using the equation:

$$CV = CS \times PUF \quad (2)$$

where

CV = Concentration in vegetation (mg/kg)

CS = Concentration of contaminant in soil (mg/kg)

PUF = Contaminant-specific plant uptake factor (unitless).

For discussion of food-chain transfer factors for radionuclides, it is more appropriate to refer to a concentration factor (CF). An example of the presentation of CFs is shown in Table 3-24. Note that to develop site-specific CFs as shown in Table 3-24, it was necessary to use studies that were developed for different purposes. This greatly extends the actual use of the studies cited, and the values should be used with extreme caution.

Uncertainty in the Selection of Ecosystem Parameters

The selection of most sensitive receptor parameters from each functional group used in the risk assessment is designed to ensure that each functional group identified as potentially at risk in the problem formulation is conservatively evaluated. The functional grouping approach assumes that members of a group will be similarly exposed to site-related contaminants. The use of selected species parameters, within the functional group, for input parameters is expected to provide sufficient data to assess the general condition of the ecosystem and to be adequately protective of the majority of species within the group. In addition, T/E species are included on the list of receptors for which parameters are developed.

For functional groups with small mammals (M122, M122A and M422) having relatively small home ranges, SUF is set to 1. This implies that, given the small home range of the receptor relative to the assessment area, it is likely that the receptor would spend 100% of its life onsite. Uncertainty associated with using the entire assessment area exists, since this assumption implies that the entire site is contaminated at levels equal to the mean concentrations found in the soil

Table 3-24. Example of the concentration factors (CFs) for Sr-90.

Functional group	Concentration factor[a]	Remark	Reference
Vegetation	1.11	Calculated by dividing the Sr-90 concentration in crested wheatgrass by the Sr-90 concentration in soil. Plant and soil data from INEL site.	Arthur (1982)
Mammalian/ omnivores/(M122A)	1.07	Mouse carcass/soil CF. Calculated by dividing the Sr-90 concentration in deer mouse carcass from a background site by the Sr-90 levels in background soils surrounding the INEL site.	Arthur et. al., (1987) for mouse tissue data; Arthur and Markham (1983) for soil data.
Mammalian herbivores (M122)	1.54	Antelope carcass/soil CF. Calculated by dividing the Sr-90 activity in pronghorn bone ash from a background site by the Sr-90 activity in soil from the site. The resulting CF was adjusted to a whole carcass CF by multiplying by 0.08. The animals body composition was assumed to be 8% skeleton and 92% soft tissues.	Markham and Halford (1980) for Sr-90 data).
Avian Carnivores (AV310)	1.0	Bird carcass/soil CF. Conservative assumption	None. No Sr-90 tissue data are available for raptors on or near the INEL site.

a. Dry weight basis (tissue DW concentration)/(soil DW concentration)

BAF	=	Bioaccumulation factor
DW	=	Dry weight
INEL	=	Idaho National Engineering Laboratory
Sr-90	=	Strontium-90

Taken from the case study (Appendix I).

samples. Since it is likely that the entire assessment area is not equally contaminated, this assumption could substantially affect the exposure estimates. While use of a smaller area would decrease the exposure time, a larger assessment area is recommended to ensure conservatism.

Use of PUFs to estimate plant concentrations is easy to use and requires minimum data inputs (i.e., the measured or estimated concentration of metal in soil and a PUF taken from the literature). Although preference should be given to studies that reported the steady-state concentration of metals in plants at edible maturity, various soil properties are not considered, and data for numerous plant species (both animal feeds and those consumed by humans) are combined. Since root uptake of metals is a complex process that depends on various soil properties (e.g., pH, cation exchange capacity, and organic matter content) as well as the metal and type of plant involved, the use of generic or crop-specific PUFs taken from the literature or developed from allometric equations may not accurately estimate the concentration of metals in plants for all environmental conditions and species that may occur on the assessment area.

There is a great deal of uncertainty associated with the BAFs and CFs. Very few of the food-chain transfer factors necessary to develop these values are available in the scientific literature, since they must be both contaminant- and receptor-specific. In the absence of site-specific information for the calculation of BAFs and CFs, a value of 1.0 can be assumed for all contaminants and functional groups if data are not available. This assumption could result in an over- or under-estimation of the exposure to the contaminant, and the magnitude of error cannot be quantified. Travis and Arms (1988) report BAFs for contaminants to beef and milk, many of these are less than 1 for the contaminants at the INEL. If the terrestrial receptors of concern accumulate other contaminants in a similar way and to a comparable degree as beef and dairy cattle, the use of a BAF (or CF) of 1 for all contaminants and receptors would overestimate the exposure. This is unlikely since there is some indication of BAFs greater than one for contaminants known to be present at the INEL. For example, there is evidence of a high bioconcentration in some plant and animal species. An example is the Chernobyl fallout in Sweden, where some contaminants reached sixfold higher concentrations in certain animals (IAEA 1992). For these contaminants, a CF value of 1.0 would greatly underestimate the exposure.

The exposure assessment also incorporates the percentage of soil ingested by each representative of the functional groups. Although food ingestion rates have the greatest effect on intake estimates, soil ingestion rates could also influence intake rates. Where information does not exist in the literature on soil ingestion rates for terrestrial biota, soil ingestion rates can be assumed to be 2% of the food ingestion rate for all burrowing mammals and birds who consume whole terrestrial prey and 1% for all other species. Estimating the percent soil ingested may over- or under-estimate the exposure.

Each SLERA should include a discussion of the uncertainty that may be present in the ecological parameters developed for use in the analysis. This should be brief but include some indication of whether the assumptions made will over- or under-estimate the parameter and how this could potentially affect the exposure assessment.

3.3.1.3 Exposure Analysis. This section will summarize the information compiled during the problem formulation as part of the exposure pathways and conceptual modeling. The

characterization of the environmental media and contaminants is performed as part of the problem formulation phase of the ERA. For SLERA, it is assumed that for all contaminants, there are potential pathways to ecological receptors. This is because those sites or contaminants with no potential pathway (e.g., diesel fuel in perched water) are eliminated from further analysis early in the SLERA process. This information can be presented as a review with a brief discussion. This review should include a discussion of the pathways identified, the functional groups potentially exposed, and review the assumptions that will be made concerning the endpoint species.

For screening purposes, receptors are assumed to be exposed to stressors to the maximum extent, perhaps beyond what is actually expected (for example, assuming that a raptor captures 100% of its prey from a contaminated site, and that all the prey are exposed to maximum contaminant concentrations). This is similar to the human risk assessment concept of the "maximally exposed individual," a hypothetical individual who is assumed to live and grow his own food at a location of maximum exposure to a stressor. This conservative approach helps assure that a potentially important contaminant will not be eliminated from future evaluations.

The analyses for exposure to nonradiological and radiological contaminants are presented in the next sections. Radionuclides, due to the potential external dose, must be analyzed in a different manner from the nonradionuclides.

Exposure Formulas for Nonradiological Contaminants

The total exposure of each of the wildlife receptors to nonradiological contaminant was calculated as the sum of the dietary, soil (or sediment), and drinking water exposure estimates:

$$EE_{total} = EE_{soil/food} + EE_{water} \quad (3)$$

where

EE_{total} = Estimated exposure from ingestion of food, soil, and water (mg/kg body weight-day)

$EE_{soil/food}$ = Estimated exposure from ingestion of food and soil (mg/kg body weight-day)

EE_{water} = Estimated exposure from ingestion of water (mg/kg body weight-day).

The equation for estimated exposure from soil and food ingestion is

$$EE_{soil/food} = \frac{[(PP \times CP) + (PV \times CV) + (PS \times CS)] \times IR \times ED \times SUF}{BW} \quad (4)$$

where

$EE_{soil/food}$	=	Estimated exposure from all ingestion of food and soil (mg/kg body weight-day)
PP	=	Percentage of diet represented by prey ingested (unitless)
CP	=	Concentration of contaminant in prey item ingested (mg/kg)
PV	=	Percentage of diet represented by vegetation ingested (unitless)
CV	=	Concentration of contaminant in vegetation ingested (mg/kg)
PS	=	Percentage of diet represented by soil/sediment ingested (unitless)
CS	=	Concentration of contaminant in soil/sediment ingested (mg/kg)
IR	=	Ingestion rate (kg/day)
ED	=	Exposure duration (fraction of year spent in the assessment area) (unitless)
BW	=	Receptor-specific body weight (kg)
SUF	=	Site use factor (unitless).

Using Equations 1 and 2, Equation 5 can be rewritten as

$$EE_{soil/food} = \frac{[(PP \times CS \times BAF) + (PV \times CS \times PUF) + (PS \times CS)] \times IR \times ED \times SUF}{BW} \quad (5)$$

where

PP	=	Percentage of diet represented by prey ingested (unitless)
CS	=	Concentration of contaminant in soil (mg/kg)
BAF	=	Contaminant-specific bioaccumulation factor (unitless)
PV	=	Percentage of diet represented by vegetation ingested (unitless)
PUF	=	Contaminant-specific plant uptake factor (unitless)
PS	=	Percentage of diet represented by soil/sediment ingested (unitless)
IR	=	Ingestion rate (kg/day)
ED	=	Exposure duration (fraction of year spent in the assessment area) (unitless)

BW = Receptor-specific body weight (kg)

SUF = Site use factor (unitless).

When a surface water exposure pathway exists, exposure estimates due to ingestion of surface water for each receptor must be included in the exposure assessment. The equation for estimating exposure for drinking water is

$$EE_{water} = C \times EPC \quad (6)$$

where

EE_{water} = Estimated exposure from drinking water ingestion (mg/day)

C = Water consumption (liters/day) as function of body weight in kilograms (see Table 3-18)

EPC = Exposure point concentration of surface water (mg/liter).

Exposure Formulas for Radioactive Contaminants

The IAEA report (IAEA 1992) states that there is little doubt that radionuclides in the environment can produce doses to certain organisms similar to or even substantially higher than doses to people living in and deriving sustenance from the same environment. Therefore, the risk of effects for natural biota (discounting variations in radiosensitivity, life span, etc.) would appear to be as high, or higher than that for humans. However, there is a basic difference in the manner that risk assessment for humans is performed. For humans, the risk assessment is directed at the individual, while other species are viewed and valued more as populations than as individuals.

The assumption will be made that radionuclides emitting alpha and beta particles will not present a external dose risk since the basic rule of thumb (Sclein 1992) is that it requires an alpha particle of at least 7.5 MeV or a beta particle of at least 70 keV to penetrate a protective layer of skin (0.07 mm thick). Therefore, only the internal dose for these emitters will be assessed. Gamma emitters can produce a dose rate to tissues from both external and internal exposure and will be included in both assessments. Radionuclides can potentially cause both internal and external exposure since they emit particles with different energies and characteristics.

External Dose

The rule of thumb calculation for external dose (Shleien 1992) is recommended for SLERA to calculate the external dose to tissue. The following equation is used to calculate the dose rate to tissue in an infinite medium uniformly contaminated by a gamma emitter:

$$DR_{external} = \frac{2.12EC}{\rho} \quad (7)$$

where

$DR_{external}$ = External radiation dose estimate (rad/hour)

E = Average decay energy (MeV)

C = The concentration of the radionuclide ($\mu Ci/cm^3$)

ρ = The density of the medium (g/cm^3).

The average energy per disintegration is assumed to be 100% of the gamma emitters. This is assumed to be a conservative estimate of the dose to burrowing functional groups. Exposure to nonburrowing functional groups is assumed to be 50% (a hemisphere).

Internal Dose

Internal radiation exposure dose estimates should be calculated using the approach presented by IAEA (1992). The technical report (IAEA 1992) provides valuable information on the estimated doses to both plants and animals under current radiation protection standards. The dose estimates in this technical report (IAEA 1992) have been calculated for three different scenarios: (1) controlled releases of radionuclides to the atmosphere, (2) controlled releases of radionuclides to a freshwater aquatic system, and (3) uncontrolled releases of radionuclides from a shallow land nuclear waste repository. The last scenario is considered applicable for use with contaminated media at the INEL and it is recommended the SLERA analysis use the equations presented in this paper to calculate radiation dose estimates. It is also important to review the information found in the technical report (IAEA 1992) during the SLERA analysis phase, since some simplifying (and conservative) assumptions concerning decay energy and absorption are presented.

For terrestrial receptors (either plant or animal), the dose from radionuclide contaminants is estimated by assuming the internal radiation dose estimate (calculated from the steady-state whole body concentration) is equivalent to the steady-state concentration of radionuclides in reproductive organs. The equation of interest is

$$DR_{internal} = \frac{TC \times E \times FA \times 3200\ dis/day\text{-}pCi}{6.24x10^9\ MeV/g\text{-}Gy} \quad (8)$$

where

$DR_{internal}$ = Internal radiation dose estimate (Gy/day)

TC = Tissue radionuclides concentration (pCi/g)

E = Average decay energy (MeV/dis)

FA = Fraction of decay energy absorbed (unitless).

Since tissue levels (TCs) for radionuclides are derived by multiplying the concentration of radionuclide in soil by a radionuclide-specific concentration factor (CF) for all terrestrial animals or terrestrial plants, Equation (12) can be rewritten as

$$DR_{internal} = \frac{CS \times CF \times ADE \times FA \times 3200\ dis/day\text{-}pCi}{6.24x10^{9}\ MeV/g\text{-}Gy} \quad (9)$$

where

$DR_{internal}$ = Internal radiation dose estimate (Gy/day)

CS = Concentration of contaminant in soil ingested (pCi/g)

CF = Concentration factor (unitless)

ADE = Average decay energy (MeV/dis)

FA = Fraction of decay energy absorbed (unitless).

Assumptions used in the calculation of the ADE values were (a) for ß or α radiations from a radionuclide the FA was set equal to 1 (100%) and (b) for γ the FA was set equal to 0.3 (30%). Only emissions with an intensity of 1% or greater were considered, and Auger and conversion electrons were not considered. The ADE values were calculated using the following equation (Kocher 1981):

$$ADE = \sum_{i}^{1} Y_i E_i \quad (10)$$

where

ADE = Average disintegration energy (MeV/dis)

Y_i = Yield or intensity

E_i = Energy of radiation, for ß = average energy.

Table 3-25 presents an example of the calculation of exposure dosage to selected functional groups.

3.3.1.4 Development of Ecologically-Based Screening Levels. Development of ecologically-based screening levels (EBSLs) for contaminated media at each WAG allows a rational, consistent approach for (1) screening of sites that may require further investigation or remedial action, and (2) prioritization of sites based on comparison of concentrations of contaminants with EBSLs. It also allows inclusion of additional data as sites are subsequently

Table 3-25. Example table showing the estimated exposure dose to functional groups for radionuclide (Sr-90).

Functional group	Level in food or soil[a] (pCi/kg)	CF[b]	SUF[c]	ED[c]	TC[d] (pCi/kg)	Internal dose rate[e] (Gy/day)
Vegetation	534,000	1.11	1	1	592,740	5.94E-05
Mammalian/omnivores (M122A)	592,740	0.006	1	1	3,556	3.57E-07
Avian carnivores (AV310)	3,556	0.003	1	1	10.7	1.07E-09
Mammalian herbivores (M122)	592,740	0.006	0.5	1	1,778	1.78E-07

a. For those functional groups representing vegetation the value is the level in soil; for the functional groups representing herbivores and omnivores the value is the level in plants; for functional groups representing predators the value is the level in small mammals.

b. CF = concentration factor. For functional groups representing vegetation the value is the plant uptake factor; for the other functional groups the value is the food chain transfer factor.

c. SUF = site use factor, ED = exposure duration. See Table 3-19.

d. Tissue concentration = TC. The concentration in soil or food times the concentration factor times the site use factor times the exposure duration.

e. See text for explanation of calculation of internal dose rate from prey concentration.

sampled. It is a basic modification of the equations previously presented and is the recommended method for those WAGs that have not yet sampled all the sites identified in the FFA/CO.

The approach includes the following elements: compilation of ecological-based toxicity criteria to generate appropriate toxicity reference values (TRVs); rearrangement of exposure equations to calculate EBSLs in media from target intakes and default exposure assumptions; development of general (site-wide) EBSLs for each functional group by contaminant using best available estimates for species-specific exposure parameters and TRVs these general EBSLs are modified for application at a WAG by dividing by the SUF); calculation of screening level quotients (SLQs; the ratio of [contaminant] to EBSL) for each contaminant; and evaluation of risks from multiple contaminants. Since conservative assumptions are inherent in the process of EBSL development, if no exceedance occurs and the existence of multiple contaminants does not appear to be a contributor to potential risk, then the contaminant can be eliminated from further consideration as potential sources of risk to the receptors. Exceedance of the EBSLs indicate that further investigation of potential risks to ecological receptors is warranted, depending on the magnitude of the exceedance, the uncertainty involved in TRV and EBSL development, and other considerations. If EBSLs are used in the SLERA for a WAG, the results of this effort need to be presented as shown in Table 3-26. Summarization of the EBSL provides a useful tool that can be incorporated into further SLERA work as applicable.

be presented as shown in Table 3-26. Summarization of the EBSL provides a useful tool that can be incorporated into further SLERA work as applicable.

EBSL Formulas for Nonradiological Contaminants

The following example is presented to show the development of EBSLs for screening against nonradiological soil contamination concentrations. The toxicity quotient (TQ), which represents a quantitative method for evaluating potential adverse impacts to exposed populations, is defined as

$$TQ = \frac{EE}{TRV} \tag{11}$$

where

TQ = Toxicity quotient (unitless)

EE = Estimated exposure (mg/kg body weight-day)

TRV = Contaminant-specific toxicity reference value (mg/kg-day).

Thus, solving for the concentration of the nonradionuclide contaminant in the soil (CS) and assuming that when TQ equals 1 that EE_{soil} = TRV, the equation becomes

$$EBSL_{soil} = \frac{TRV \times BW}{[(PP \times BAF) + (PV \times PUF) + PS] \times IR \times ED} \tag{12}$$

where

$EBSL_{soil}$ = INEL-specific ecologically-based screening level for non-radiological contaminants in soil (mg/kg)

TRV = Toxicity reference value (mg/kg-day)

PP = Percentage of diet represented by prey ingested (unitless)

PV = Percentage of diet represented by vegetation ingested (unitless)

PS = Percentage of diet represented by soil ingested (unitless)

IR = Ingestion rate (kg/day)

ED = Exposure duration (fraction of year spent in the assessment area) (unitless)

BW = Receptor-specific body weight (kg).

Table 3-26. Example table showing the calculated EBSLs for nonradionuclides (mg/kg) for a WAG with assessment area of 1000 ha.

Functional groups	Antimony	Chromium VI	Chromium III	Mercury
Avian herbivores (AV122)	—	2.37E+03	—	1.87E-01
Avian insectivores (AV210)	—	4.45E+03	—	2.01E-01
Avian insectivores (AV222)	—	2.30E+02	—	1.60E-01
Avian carnivores (AV310)	—	5.41E+01	—	1.07E+00
Avian carnivores (AV322)	—	5.05E+01	—	9.98E-01
Avian omnivores (AV422)	—	5.10E+00	—	2.13E-02
Mammalian herbivores (M122)	2.50E+01	2.44E+03	1.79E+05	7.40E+00
Mammalian/herbivores (M122A)	2.04E+01	3.50E+03	2.60E+05	3.84E-01
Mammalian insectivores (M210)	2.14E+01	3.45E+03	6.05E+03	4.00E-01
Mammalian carnivores (M322)	1.20E+00	6.05E+03	6.85E+04	4.80E+01
Mammalian/omnivores (M422)	2.37E+00	2.90E+03	2.16E+05	1.84E-01
Mammalian omnivores (M422A)	1.62E+01	5.77E+02	9.23E+05	6.47E+02
Reptiles/insectivores (R222)	—	—	—	—
Reptiles/carnivores (R322)	—	—	—	—
Peregrine Falcon and Northern Goshawk (AV312)[a]	—	2.71E+01	—	5.35E-01
Bald Eagle, Ferruginous Hawk, and Loggerhead Shrike (AV322)[a]	—	2.53E+01	—	1.99E-01
Pygmy Rabbit (M122A)[a]	1.02E+01	1.75E+03	1.30E+05	1.92E-01
Townsend's big-eared bat (M210)[a]	1.07E +01	1.72E+03	3.03E+03	2.00E-01

a. A factor of 2 was included in the calculation of the WAG-specific EBSL for these T/E species.

Note: A dash (—) indicates that the ecosystem parameters were not available to calculate the EBSL for this functional group/contaminant combination.

EBSL Formulas for Radiological Contaminants

The same concept used to develop the EBSLs formulas for nonradionclides can be used for radionuclides. In this case, TQs are defined as:

$$TQ = \frac{DR}{TRV} \qquad (13)$$

where

TQ = Toxicity quotient (unitless)

DR = Estimated dose rate (rad/hour)

TRV = Toxicity reference value (rad/hour).

External EBSL

First solving for radionuclide concentration (C) and assuming that when TQ equals 1, then DR = TRV, Equation (7) becomes

$$(C \times 10^6 \rho Ci/\mu Ci) \div (1.68\ g/cm^3) = \frac{(TRV \times \rho \times 10^6 \rho Ci/\mu Ci)}{(2.12 \times E \times 1.68\ g/cm^3)} \quad (14)$$

where

C = The concentration of the radionuclide ($\mu Ci/cm^3$)

TRV = Toxicity reference value (rad/hour)

ρ = The density of the medium (1.68 g/cm^3)

E = Average decay energy (MeV).

The density of the medium is eliminated, on the right side of the equation and the concentration of the radionuclide is converted from uCi to pCi by multiplying by a factor of 10^6. Next, the equation is simplified, and the left side of the equation becomes the EBSL. In other words the concentration of radionuclide in the soil that results when the TQ = 1. The EBSL equation for external dose becomes

$$EBSL_{external} = (TRV_{external} \times 10^6 pCi/uCi) \div 2.12 \times E \quad (15)$$

where

$EBSL_{external}$ = Ecologically-based screening level value for external dose (pCi/g)

TRV = Toxicity reference value (rad/hour)

E = The average gamma energy per disintegration (MeV).

Internal EBSL

Solving for the concentration of radionuclide in soil (C) and setting DR = TRV in Equation (9), the concentration for radiological contaminants in soil is redefined as an EBSL for internal dose

$$EBSL_{internal} = \frac{TRV \times 6.24x10^{9}\ MeV/g\text{-}Gy}{CF \times ED \times ADE \times FA \times 3200\ dis/day\text{-}pCi} \quad (16)$$

where

$EBSL_{internal}$	=	Ecological based screening level for radionuclides in soil (pCi/g)
TRV	=	Toxicity reference value (Gy/day)
CF	=	Concentration factor (unitless)
ED	=	Exposure duration (unitless)
ADE	=	Average decay energy (MeV/dis)
FA	=	Fraction of decay energy absorbed (unitless).

3.3.2 Effects Assessment

The purpose of the effects (or, stressor-response) assessment is to characterize the toxicity of stressors to selected measurement endpoints. In this section effects of the contaminants on those functional groups identified as potential receptors will be quantified as TRVs. This process relies on professional judgment, especially when few data are available or when choices among several sources of data are required. If available data are inadequate, this will be identified as a data gap and will be addressed in the screening evaluation.

There are numerous sources of these data, including:

- Primary literature sources (veterinary science literature, journal articles, and scientific publications)
- Registry of Toxic Effects of Chemical Substances
- Hazardous Substances Database
- Integrated Risk Information System
- Agency for Toxic Substances and Disease Registry
- Phytotox Database
- Aquatic Information Retrieval
- Chemical Evaluation Search and Retrieval System

- Fish and Wildlife Service Contaminant Hazard Reviews
- Fish and Wildlife Service Contaminant Data Source.

Whichever source is used, the primary reference should be obtained to fully review and interpret the data as presented by the authors of the original study. This information should be documented for the SLERA.

The effects of chronic irradiation were discussed in the IAEA report (IAEA 1992). In this report, it was concluded that irradiation at chronic dose rates of 1 and 10 mGy/d or less does not appear likely to cause observable changes in terrestrial animal and plant populations, respectively. These values can therefore be conservatively used as the TRV values for animals and plants at the INEL.

For other nonradiological contaminants, the derivation of TRVs from quantified critical exposures (QCEs) will often involve various extrapolations. Extrapolations commonly used include those between species, between responses from laboratory to field, and from field to field (Table 3-27). Differences in responses among taxa depend on many factors, including physiology, metabolism, resource utilization, and life history strategy. The relationship between responses also depends on many factors, including the mechanism of action and internal distribution of the stressor within the organism. When extrapolating between different laboratory and field settings, important considerations include differences in the physical environment and organism behavior that will alter exposure, interactions with other stressors, and interactions with other ecological components.

Depending on available data and endpoints, various factors are used to derive TRVs from QCEs in order to adjust quotients to account for uncertainty and extrapolation. This allows for a certain conservatism to be included in the assessment. There are various methods that are applicable to this task. This guidance presents one method that is applicable for use in an SLERA.

The method for performing exposure assessment for non radionuclides consists of three elements:

- Selecting quantified critical exposure (QCE) levels
- Developing adjustment factors (AFs)
- Developing TRVs.

A TRV is defined as a dose for a receptor taxon (including sensitive subgroups such as taxa under regulatory protection) that is likely to be without appreciable risk of deleterious effects from chronic exposure. Application of toxicity data derived from surrogate species introduces uncertainty into the risk assessment. The magnitude of this uncertainty depends largely upon (1) the degree of taxonomic difference between the key and test species, (2) the conditions under which the toxicity data are obtained, and (3) the endpoint of interest [e.g., chronic lowest-observed-adverse-effect-level (LOAEL) or no-observed-adverse-effect-level (NOAEL)] and the

Table 3-27. Extrapolations and other analyses relating measurement and assessment endpoints.[a]

Extrapolation	Example
Between taxa	From bluegill sunfish mortality to rainbow trout mortality
Between responses	From bobwhite quail LC_{50} to bobwhite quail NOEL
From laboratory to field	From mouse mortality under laboratory conditions to mouse mortality in the field
From field to field	From reduced invertebrate community diversity in one stream to another stream
Analysis	**Example**
Indirect effects	Relating removal of long-leaf pine to reduced populations of red-cockaded woodpecker
Higher organization levels	Relating reduced individual fecundity to reduced population size
Spatial and Temporal Scales	Evaluation of the loss of a specific wetland used by migratory birds in relation to the larger scale habitat requirements of the species
Recovery	Relating short-term mortality to long-term depauperation

a. Source: EPA, 1992b.

endpoint measured (e.g., death). Uncertainties associated with extrapolation of toxicity information from literature to site conditions can therefore be offset by applying AFs to the endpoint values identified in the literature.

Information in the literature on the toxicity of contaminants to native INEL plants is limited. TRVs can be taken directly from Suter et al. (1993a), and no AF values need to be assigned. The values presented in that paper are toxicological benchmarks for screening potential contaminants of concern for effects on terrestrial plants in soil. These values are for those contaminants potentially associated with U.S. Department of Energy (DOE) sites and were, therefore, appropriately used in the calculations for the INEL.

The approach for TRV derivation for nonradionuclides for faunal functional groups, and recommended for use for SLERA, was developed by Ludwig et al. (1994) for use at the Rocky Mountain Arsenal Superfund site in Commerce City, CO, and is generally based on the EPA reference dose approach as modified by Lewis et al. (1990). It is predicated on the development and application of AFs, which are intended to explicitly account for variations and uncertainties in

the data and necessary extrapolations from it. The types of variation and extrapolation uncertainties explicitly quantified are:

- Variation in sensitivity among the members of a receptor population
- Uncertainty in extrapolating data from one taxon to another
- Uncertainty in using various effect levels to estimate no-effect levels in receptors
- The inability of any single study to adequately address all possible adverse outcomes in a wild receptor population.

The approach of Ludwig et al. (1994) offers several distinct advantages. By carefully identifying the specific types of adjustments needed in the extrapolation, this method permits maximum resolution of what each adjustment is intended to achieve. It emphasizes consensual, data-quality-based development of values for specific AFs rather than defaulting to arbitrary factors. It clearly discriminates between "best estimates" of the values of individual factors and adjustment for overall uncertainty, including the uncertainty associated with the AFs themselves.

3.3.2.1 Selecting QCEs. TRV development is initiated by reviewing the available toxicological literature and relevant data bases for each contaminant and receptor to identify QCEs from the best available study. Studies considering nonlethal endpoints and reporting NOAELs are selected, if available; those reflecting reproductive competence are most preferred as such endpoints are considered to best reflect the population-level impacts of greatest concern in ERA. The following criteria are used to select QCEs:

- Experimental taxa should be as similar as possible to receptors at INEL site(s), both physiologically and ecologically. With respect to body size, feeding and behavioral habits, anatomy, and physiology, the surrogate species should be matched as closely as possible to the receptors. When available, toxicity information on sheep, pigs, and cows should be selected.
- Test exposure route and medium should be similar to that expected for receptors in the field. For most of the receptors at INEL, exposure media are limited to soil and dietary items (both animal and vegetable). Liquid intake is largely in the form of metabolic water. Dietary laboratory studies are therefore the most appropriate models for extrapolation. Gavage and drinking water studies will be considered if necessary, but reduce confidence in the applicability of the study.
- Long-term (preferably lifetime) exposures should be used, as they are closest to exposure patterns occurring in the field. It should be noted that although chronic exposure studies over longer periods of time are generally the most ecologically representative, some discretion should be used in selecting lifetime studies. The life expectancy of a laboratory mouse probably far exceeds that of its relative in the field. Therefore, effects that occur after a year of exposure to that species (for example, liver necrosis) may not be as ecologically significant as shorter term effects on reproduction.

- Experimental endpoints should represent ecologically significant effects at the population level. In general, loss of a few individuals of a species is unlikely to significantly diminish the viability of the population or disrupt the community or ecosystem of which it is a part. As a result, the fundamental unit for ecological risk assessment is generally the population rather than the individual, with the exception of threatened and endangered species (EPA 1992a). In general, the most appropriate endpoints for ecological risk assessment are reproduction, neurological function, and growth and development. For species under regulatory protection, TRVs are based on the most sensitive nonlethal endpoints referring specifically to individuals.

- Doses within the NOAEL-LOAEL bracket should be identified. If these data are not available, the following dose levels (in decreasing order of preference) may be used: chronic-nonlethal-adverse-effect-level > no-effect-level > frank-effect-level (including lethality). The definition of adversity requires considered analysis of the potential ecological significance of the effects reported. For example, elevated liver weight or enzyme induction could represent an adaptive response rather than toxic injury.

- Studies should be of high quality, defined as complete in design, with adequate numbers of subjects and dose levels, lifetime duration, explicit analysis of experimental uncertainty, clear results, and well-justified conclusions.

If a single study cannot be selected (e.g., where only acute exposure, lethal endpoint studies are available), then an average of several studies of similar quality using the same or closely similar species may be used. In averaging, extreme outliers (defined as greater than two standard deviations away from the mean) are excluded. Where similar endpoints are observed in more than one study of similar quality, the lowest QCE should be used.

3.3.2.2 Developing AFs. Six AFs for extrapolation from experimental studies to field exposures at INEL are defined for:

I = Intrataxon variability

R = Intertaxon variability

Q_1 = Risk assessor's certainty that the contaminant actually causes the critical effect in the receptor, and that it is an ecologically significant effect

Q_2 = Extrapolation from short- to long-term exposure durations

Q_3 = Extrapolation across endpoint types to estimate a NOAEL

U = Any residual uncertainty in the data evaluation process and estimation of other AFs based on data quality, study design, and known but otherwise unaccounted for extrapolation issues

M = Correction of differences in metal bioavailability between QCE studies where soluble salts are administered via drinking water and INEL exposure conditions (i.e., metal species are encountered in soil and dietary items).

Values for these AFs are set based on the quality of the selected study in particular, and of the data base in general. Other potentially influential factors include the ecological circumstances of the receptor, regulatory criteria and standards, background contaminant levels, and protection status. To prevent needless overestimation of risk, the maximal AF product (all AFs multiplied together) is scaled to the overall extrapolation error observed in experimental studies designed specifically to determine the uncertainty in such extrapolations. Barnthouse et al. (1990) quantified the range of maximal uncertainty necessary to permit extrapolation of various kinds of toxicity data for various taxa of finfish at the population level. The types of toxicity data used included studies involving particular species of interest and other species, for acute, partial life-cycle, and full life-cycle exposures. The range of maximal uncertainty varied with the type of data used, and ranged from approximately 200 to 400 (Barnthouse et al. 1990). It is assumed that the degree of variability observed among fish taxa is similar to that occurring among other vertebrate taxa.

Based on a systematic review of all available information (Ludwig et al. 1994), a simple, relative scale is developed consisting of "low," "medium," and "high" rankings for each AF, with adjustments made of the basis of specific inherent uncertainty or variability in the particular extrapolations. The quantitative valuation of this scale is designed to be constrained by an upper bound in the range of 200 to 400, and use the most plausible values for each AF.

Values for these AFs and a brief description of criteria for their use are presented in Table A-1. Values for all AFs except Q_1 and M are set at 1 ("low"), 2 ("medium"), and 3 ("high"), with lower values generally representing greater confidence that the QCEs correspond well with "safe" doses for receptors. The factor Q_1, which expresses the degree of certainty that the experimental effect will not occur in the field or is not of ecological significance, runs on a positive scale equivalent where 0.1 represents high certainty that the effect either does not occur in the receptor or is ecologically irrelevant, 0.5 represents moderate certainty that the effect does not occur or is irrelevant, and 1 represents reasonable certainty that the effect will occur in the receptor species and is ecologically significant. The medium of exposure factor M is set at 1 if the medium of exposure in the QCE study is similar to field exposure media at this site (i.e., primarily food and soil ingestion). However, because a number of toxicological studies for metals used soluble salts in drinking water as a means of exposure, and both the contaminant species and exposure matrix tend to maximize metal absorption (e.g., Steele et al. 1990; Griffin and Turck 1991; Witmer et al. 1991), M is set at 0.5 to conservatively represent the significantly lower bioavailability of the metal species associated with soils and dietary items in the natural environment. Thus, the maximum product of the seven AFs is 243. This AF maximum represents the extent to which valid extrapolation of the data can be applied across experimental protocols or among taxa. More detailed information on the definition and valuation of these factors is available in Ludwig et al. (1994).

3.3.2.3. Developing TRVs. The third element in ecological effects assessment is the derivation of TRVs. TRVs will be derived for each functional group by selecting the experimental study with the most appropriate QCE for that chemical and assigning numeric values

for all AFs to account for uncertainties associated with extrapolation across species and exposure conditions.

It is possible that several studies are available for a contaminant. These may be of equal quality but for different test organisms. When this occurs, it will be necessary to choose from several TRVs for each functional group. The following criteria should be used for SLERA, when a test organism and functional group members are in the same taxonomic order and trophic category (R=1), the corresponding TRV will be chosen for that functional group. Otherwise, the minimum TRV for each contaminant will be chosen from those developed. An example of this process is shown in Appendix H.

The algorithm used for deriving a TRV is:

$$TRV = \frac{QCE}{AF} (17)$$

where

QCE = quantified critical endpoint

AF = $[I] \times [R] \times [Q_1] \times [Q_2] \times [Q_3] \times [U] \times [M]$.

The TRVs that are developed during the analysis are used to develop the EBSLs as discussed previously. The TRVs can be presented for each functional group and contaminant as shown in Table 3-28. Appendix H will present this process of TRV development through the development of screening level quotients (SLQs).

3.4 Screening Evaluation Guidance

The final phase of risk assessment, risk characterization, involves the evaluation of the likelihood of adverse effects occurring as a result of exposure to stressors. Risk characterization includes two major steps: risk estimation and risk description. In the risk estimation, the SLERA for each WAG will summarize the COPCs that had an indication of potential risk based on a screening level quotient (SLQ). In the risk description, this potential risk will be discussed and any FFA/CO sites that could not be adequately characterized will be presented.

3.4.1 Risk Estimation

A screening level quotient (SLQ) will be used to indicate risk to the ecosystem. SLQs are derived for all contaminants and functional groups/T/E species identified in as present at an WAG. If data are not available to derive TRVs or EBSL input data (body weights, home ranges, percent intake of vegetable, prey, or soil) can not be located, no EBSL can be derived for that contaminant and/or functional group/T/E species. Thus, no SLQ can be estimated. These data gaps are indicated as blanks on the associated summary tables. Pathways not considered in the exposure assessment should also be indicated. SLQs are calculated using the following equation:

Table 3-32. Toxicity reference values (TRVs) for functional group.

Functional groups	Antimony	Chromium VI	Chromium III	Mercury
Avian herbivores (AV122)	—	2.70E+00	—	1.10E-02
Avian insectivores (AV210)	—	9.10E-01	—	3.80E-03
Avian insectivores (AV222)	—	9.10E-01	—	3.80E-03
Avian carnivores (AV310)	—	9.10E-01	—	1.80E-02
Avian carnivores (AV322)	—	9.10E-01	—	1.80E-02
Avian omnivores (AV422)	—	9.10E-01	—	3.80E-03
Mammalian herbivores (M122)	2.00E-01	4.90E+00	3.60E+02	2.20E-01
Mammalian herbivores (M122A)	4.00E-01	9.80E+00	7.30E+02	3.10E-02
Mammalian insectivores (M210)				
Mammalian carnivores (M322)	1.00E-01	1.00E-01	1.60E+02	4.00E+00
Mammalian/omnivores (M422)	4.00E-01	9.80E+00	7.30E+02	3.10E-02
Mammalian omnivores (M422A)	1.00E-01	1.00E-01	1.60E+02	4.00E+00
Reptiles/insectivores (R222)	—	—	—	—
Reptiles/carnivores (R322)	—	—	—	—
Plants	5.00E+00	1.20E+01	2.50E+01	3.00E-01

Note: __ means ecosystem parameters not available.

$$SLQ = \frac{CS}{EBSL} \tag{18}$$

where

SLQ = Screening level quotient

CS = Average concentration of contaminant in soil (mg/kg or pci/g)

EBSL = Minimum ecological-based screening level (mg/kg or pci/g).

A SLQ less than the risk factor (usually 1 for nonradionuclides and 0.1 for radionuclides) implies no effect from that contaminant. Tables 3-29 and 3-30 present examples of presentation of the SLQs for several media for both a selection of functional groups and T/E species.

The SLQs could be summed across the pathways by functional group and/or T/E species. It is important to consider additive effects for all pathways and COPCs, so it is useful to sum SLQs across pathways and contaminants; the total of SLQs could be termed the total SLQ (TSLQ). A

Table 3-29. Example of screening level quotients for WAG functional groups.

Contaminant	Media	Functional group									
		AV122	AV210	AV222	AV310	AV422	M122	M210	M322	M422	R222
Nonradionuclides											
Chromium VI	Surface soil	1.27E-04	na	na	5.55E-03	5.88E-02	1.23E-04	na	na	1.03E-04	na
	Subsurface soil	5.06E-05	na	na	2.22E-03	2.35E-02	4.92E-05	na	na	4.14E-05	na
	Surface water										
	Sediment										
Chromium III (total)	Surface soil	na	na	na	na	na	4.08E-04	na	1.07E-03	3.38E-04	na
	Subsurface soil	na	na	na	na	na	3.18E-04	na	8.32E-04	2.64E-04	na
	Surface water										
	Sediment										
Mercury	Surface soil	1.39E+02	na	na	2.43E+01	1.22E+03	3.51E+00	na	5.42E-01	1.41E+02	na
	Subsurface soil	8.56E+00	na	na	1.50E+00	7.51E+01	2.16E-01	na	3.33E-02	8.70E+00	na
	Surface water										
	Sediment										
Radionuclides											
Am-241	Surface soil	5.87E-02	5.87E-02	1.47E-02	2.66E-02	5.87E-02	5.79E-02	5.87E-02	5.87E-02	5.87E-02	5.87E-02
	Subsurface soil	3.07E-03	3.07E-03	7.69E-04	1.39E-03	3.07E-03	3.03E-03	3.07E-03	3.07E-03	3.07E-03	3.07E-03
	Surface water										
	Sediment										

Note: na = data not available; blanks indicate exposure pathway not at this WAG.

Table 3-30. Example of screening level quotients for a WAG T/E species.

Contaminant	Media	Peregrine falcon and northern goshawk	Bald eagle, ferruginous hawk, and loggerhead shrike	Pygmy rabbit
Nonradionuclides				
Chromium	Surface soil	1.11E-02	1.19E-02	1.71E-04
	Subsurface soil	4.44E-03	4.76E-03	6.36E-05
	Surface water			
	Sediment			
Chromium III (total)	Surface soil	na	na	5.62E-04
	Subsurface soil	na	na	4.38E-04
	Surface water			
	Sediment			
Mercury	Surface soil	4.86E+01	5.22E+01	1.35E+02
	Subsurface soil	3.00E+00	3.20E+00	8.34E+00
	Surface water			
	Sediment			
Radionuclides				
Am-241	Surface soil	5.32E-02	2.94E-02	1.17E-01
	Subsurface soil	2.78E-03	1.54E-04	6.14E-03
	Surface water			
	Sediment			

Note: na = not available; blanks indicate exposure pathway not at this WAG

TSLQ greater than some risk factor (again traditionally one) would imply a possible effect from all contaminants and all pathways combined.

The advantages of using a TSLQ approach is that it allows the summation of effects, the determination of relative risk from a suite of contaminants under consideration, and the propagation of higher risk contaminants through to more detailed risk assessment, while dropping those with low risk. Furthermore, one can prioritize actions (e.g., more sample analyses or site measurements) according to relative risk.

The disadvantages of a TSLQ approach is that it assumes that effects from contaminants are additive. It is more likely that some effects will be additive and still other effects may be synergistic (either positively or negatively). Little is known about synergism of contaminant effects. Strictly speaking, summing contaminant effects may only be appropriate when the contaminants affect the same target organ. Additionally at the INEL, there are two classes of contaminants, non-radiological or radiological contaminants that can cause different effects in exposed populations. Effects from the non-radioactive metals and organics are expected to cause systemic toxicity (although some are also carcinogens), while the effect associated with exposure to ionizing radiation is typically cancer. This may also be true of other classes of contaminants. The effects of the uncertainty inherent in the summation of SLQs should be discussed.

For multiple contaminants, especially radionuclides, it is recommended to set the target SLQ to 1/n, where n is the number of contaminants of concern. This approach would be more conservative than strictly adding the SLQs but it still does not address the possible synergistic behavior of a group of contaminants in a given receptor.

It is important to discuss the TSLQs in the WAG SLERA results if it is applicable, but it will be difficult to actually determine their meaning. The correct usage of any quotient method is highly dependent on professional judgment, particularly in instances when the quotient approaches the risk target.

3.4.2 Risk Description and Summary

For each WAG, the risk description will be simply a brief discussion of the results of the SLERA and their interpretation. In order for the WAG manager to evaluate the full range of possibilities contained in the SLERA, it is important that this section review the results based on the goals of the assessment. The goals of the SLERA are to identify any FFA/CO sites that are not adequately characterized, to identify the COPCs that are contributing to potential risk, and to identify data gaps.

The process of selecting sites of concern should be briefly summarized. Those sites that do not have accessible data for evaluation for the SLERA will be summarized as shown in Table 3-31. The risk summary will identify where more site information may be obtained if this is known. Some discussion on how additional site information should be used subsequent to this preliminary SLERA should be included.

The results of the risk estimation should be discussed in terms of the SLQs. This would include a brief overview of the functional groups and T/E species at potential risk and should be

Table 3-31. WAG sites needing further evaluation.

OU	Site code	Sites within operable unit	Track[a]	IEDMS from ERIS	Maximum database	Further evaluation is necessary
X-07	XXX-653	Chromium-Contaminated Soil	T2			No data[b]
	XXX-38	Cooling Tower	T2			No data[b]
	XXX-39	Cooling Tower	T2			No data[b]
X-09	XXX-08	Cold Waste Disposal Pond	T2		X	Soil sample data only; no water data available
	XXX-13	Final Sewage Leach Ponds (2) by	T2	X		Soil sample data only; no water data available
X-10	XXX-03B	Warm Waste Pond (Sediments)	IA	X		
X-13	XXX-06	Comprehensive RI/FS including: Chemical Waste Pond	RI	X		

a. State in CERCLA process as follows: T1 = Track 1; T2 = Track 2; IA = Interim Action; RI = Remedial Investigation/Feasibility Study.

b. These sites cannot be excluded based on present information and data are not available in either IEDMS or the Maximum database to perform screening.

directly related to the contaminants that are indicated as potential concern. This should be presented as shown in Table 3-32. This table is a subset of Table 3-31 and 3-32 which includes only those COPCs indicating potential risk (i.e., SLQ > risk target value). Any uncertainty that may result in either an over- or under-conservatism in determining the SLQs should be briefly reviewed in this section.

The SLERA is a conservative screening level approach to provide a preliminarily assessment of the potential risk to ecological receptors from contaminant sources at a WAG. To compensate for potential uncertainties, the SLERA approach was developed to err on the side of conservatism rather than result in a conclusion of nonrisk when a risk may exist. Subsequently, uncertainties exist that could effect the estimation of true risk.

The principal sources of uncertainty lie within the development of an exposure assessment. Uncertainties inherent in the exposure assessment are associated with estimation of receptor ingestion rates, selection of acceptable screening level quotients, estimation of site usage by receptors of concern, and estimation of plant uptake factors and bioaccumulation factors. Additional uncertainties are associated with the description of site characteristics, the determination of the nature and extent of contamination, and the derivation of toxicity reference values. These factors will all influence the estimation of risk. When a potential risk is indicated, a discussion should be included that will direct the WAG manager to the necessary steps to eliminate some of the built-in over-conservatism and to reduce the uncertainty in the SLERA.

Table 3-32. Example of the summary of screening level quotients.

	Mercury			
	Surface soil	Subsurface soil	Surface water	Sediment
Avian herbivores (AV122)	1.39E+02	8.56E+00		
Avian insectivores (AV210)	—	—		
Avian insectivores (AV222)	—	—		
Avian carnivores (AV310)	2.43E+01	1.50E+00		
Avian omnivores (AV422)	1.22E+03	7.52E+01		
Mammalian herbivores (M122)	3.51E+00	2.16E-01		
Mammalian insectivores (M210)	—	—		
Mammalian carnivores (M322)	5.41E-01	3.33E-02		
Mammalian/omnivores (M422)	1.41E+02	8.70E+00		
Reptiles/insectivores (R222)	—	—		
Peregrine Falcon & Northern Goshawk	4.86E+01	3.00E+00		
Bald Eagle, Ferruginous Hawk, & Loggerhead Shrike	5.20E+01	3.20E+00		
Pygmy Rabbit	1.35E+02	8.34E3+00		

Note: — indicates ecological parameter data are not available. A blank indicates an exposure pathway is not analyzed for this contaminant.

If all the WAG sites have not been adequately evaluated or if the assessment endpoints were not attained (e.g., all SLQs are not less than the risk target value), then it is important to state that no final management decision can be made using the SLERA at its present stage. A discussion that presents the next steps in the SLERA/ERA process and/or direction for finalization of the SLERA process should be included.

3.4.3 Transition from SLERA to ERA

The primary purpose of the SLERA is to identify potential data gaps that could, if identified, be addressed in the individual WAG Comprehensive RI/FS Work Plans. It is anticipated that the SLERA will be submitted as an appendix in the Work Plan. Only existing data are used in SLERA exposure/effects calculations. Additional data collected since the performance of the SLERA or identified by the SLERA would be incorporated/collected in order

to complete the risk assessment. These data could be either from additional site characterization or a more extensive review of existing data. Additionally, assumptions made in the SLERA would be evaluated as part of transition to the ERA.

Inherently conservative values were used in the SLERA in an effort to identify and eliminate those sites that are accessible to ecological receptors and those contaminants that pose little or no likelihood for risk to ecological receptors. This allows the ERA to focus on the site and contaminants that have potential to adversely effect the environment. Once contaminants of concern are identified, more realistic values for contaminant concentrations and exposure can be developed. The SLERA used the potential risk to the individual to develop EBSLs for screening purposes. For ERA (vs. human health risk assessment), risk to populations is of greater interest and ecologically more important than that for individuals. This places a different emphasis on the risk assessment and will be used in the ERA to provide a more ecologically based assessment.

The concern for cumulative risk should be considered in ERA process. Certain receptors (e.g., pronghorn) have home ranges that include other INEL WAGs. It will be necessary to have an INEL approach to cumulative ecological risk assessment at the WAG 10 level. This effort should parallel the cumulative risk assessment effort being developed for human health.

4. REFERENCES

Amiro, B.D. and R. Zach, 1993, "A method to assess environmental acceptability of releases of radionuclides from nuclear facilities," Environmental International, 19:341-358.

Anderson, I. A., 1992, *Summary Report: Preliminary Assessment of Surface Soils at the Proposed New Production Reactor Site at the Idaho National Engineering Laboratory,* NPRD-92-024, EG&G Idaho, Inc., Idaho Falls.

Arthur, W. J., 1982, "Radionuclide concentrations in vegetation at a solid radioactive waste disposal area in southeastern Idaho," *Journal of Environmental Quality,* 11:394-399.

Arthur, W. J. and R. J. Gates, 1988, "Trace element intake via soil ingestion in pronghorns and in black-tailed jackrabbits," *Journal of Range Management,* 41:162-166.

Arthur, W. J. and O. D. Markham, 1983, "Small mammal soil burrowing as a radionuclide transport vector at a radioactive waste disposal area in southeastern Idaho," *Journal of Environmental Quality,* 12:117-122.

Arthur, W. J., O. D. Markham, C. R. Groves, and B. L. Keller, 1987, "Radionuclide export by deer mice at a solid radioactive waste disposal area in southeastern Idaho," *Health Physics,* 52:45-53.

Baes, C. F., III, R. D. Sharp, A. Sjoreen, and R. Shor, 1984, *A Review and Analysis of Parameters for Assessing Transport of Environmentally Released Radionuclides Through Agriculture,* ORNL-5786, U.S. Department of Energy, Oak Ridge National Laboratory, Oak Ridge, TN.

Barnthouse, L. W., G. W. I. Suter, and A. E. Rosen, 1990, "Risk of toxic contaminants to exploited fish populations: Influence of life history, data uncertainty and exploitation intensity," *Environ Toxicol Chem,* 9:297-311.

Bennett, S., and J. Cubbage, 1991, "Summary of Criteria and Guidelines for Contaminated Freshwater Sediments," Washington State Department of Ecology.

Berry, G. A., S. N. Stanisich, and M. J. Spry, 1994, *Interim Final Sampling and Analysis Plan/Quality Assurance Plan for the Naval Ordnance Disposal Area,* EGG-ESQ-107-33, MSE, Idaho Falls, Idaho.

Beyer, W. N., E. E. Connor, and D. Gerould, 1994, "Estimates of Soil Ingestion by Wildlife," *Journal of Wildlife Management,* 58 2, pp. 375-382.

Burt, W. H. and R. P. Grossenheider, 1980, A Field Guide to the Mammals, Houghton Mifflin Co., New York, NY.

Calabrese, E. J. and L. A. Baldwin, 1993, *Performing Ecological Risk Assessments,* Lewis Publishers, Chelsea, MI.

Chapman, P.M., 1991, "Environmental Quality Criteria," *Environmental Scientific Technology, 25, 8,* pp. 1353–7.

Code of Federal Regulations, 40 CFR 300, "Protection of the environment", Office of the Federal Register.

Code of Federal Regulations, 50 CFR 424, "Wildlife and Fisheries," Office of the Federal Register.

DOE (U.S. Department of Energy), 1993, Policy Framework and Implementation Plan for Using Ecological Risk Assessment at DOE Facilities, Office of Environmental Guidance, Washington, DC, June.

DOE-ID, 1993a, Track 2 Sites: Guidance for Assessing Low Probability Hazard Sites at the INEL, Draft, DOE/ID-10389, Revision 5, August.

DOE-ID, 1994, *1994 INEL Site-Specific Plan,* DOE/ID-10253, (FY 94), U.S. Department of Energy, Idaho Operations Office, Idaho Falls, ID.

Driver, C. J. 1994, *Ecotoxicity Literature Review of Selected Hanford Site Contaminants,* PNL-9394, UC-600, Pacific Northwest Laboratory, Richland, WA.

Dunning, J.P., 1993, CRC Handbook of Avian Body Masses, CRC Press, Boca Raton, FL.

ECAO (Environmental Cirteria and Assessment Office), 1987, Recommendations for and Documentation of Biological Values for Use in Risk Assessment, EPA/600/6-87-008, U.S. Environmental Protection Agency, Cincinnati, OH.

Eisler, R., 1986, Chromium Hazards to Fish, Wildlife, and Invertebrates: A Synoptic Review, U.S. Fish and Wildlife Service Biological Report, 85(1.6).

EPA, 1986, "Quality Criteria for Water," EPA/440/5-86-001, Office of Water Regulations and Standards, U.S. Government Printing.

EPA, 1988, Joint Memorandum of the Office of Emergency and Remedial Response and the Office of Waste Programs Enforcement, (cited in EPA, 1991b)

EPA, 1989a, Ecological Assessment of Hazardous Waste Sites: A Field and Laboratory Reference Document, W. Warren-Hicks, B. R. Parkhurst, and S. S. Baker (eds.), EPA/600/3-89/013, U.S. Environmental Protection Agency, March.

EPA, 1989b, Risk Assessment Guidance for Superfund: Volume II, Human Health Evaluation Manual, Part A, Interim Final, EPA/540/1-89/001, Office of Emergency and Remedial Response, Washington, DC, December.

EPA, 1989c, Risk Assessment Guidance for Superfund: Volume I, Human Health Evaluation Manual, Part A, Interim Final, EPA/540/1-89/002, OSWER Directive No. 9285. 7-01A, Office of Emergency and Remedial Response, Washington, DC, December.

EPA, 1991a, The Role of BTAGs in Ecological Risk Assessment, Publication 9345, 005I (ECO Update), Office of Solid Waste and Emergency Response, Washington, DC, September.

EPA, 1991b, Ecological Assessment of Superfund Sites: An Overview, Publication 9345. 005I (ECO Update), Office of Solid Waste and Emergency Response, Washington, DC, September.

EPA, 1991c, Federal Facility Agreement and Consent Order for the Idaho National Engineering Laboratory, 1088-06-29-120, U.S. Environmental Protection Agency, Region 10, Idaho Department of Health and Welfare and U.S. Department of Energy, December 4, 1991.

EPA, 1991d, Ecological Risk Assessment for the Bunker Hill Superfund Site, DCN:TZ4-C10010-RA-09040, U.S. Environmental Protection Agency, Region 10, Seattle, WA, November.

EPA, 1991e, US EPA Water Quality Criteria Summary, Map, Office of Science and Technology, Health and Ecological Criteria Division, Washington, DC.

EPA, 1992a, Framework for Ecological Risk Assessment, EPA/630/R-92/001, PB93-102192, U.S. Environmental Protection Agency, ORD/Risk Assessment Forum, February, 55 pp.

EPA, 1992b, Report on the Ecological Risk Assessment Guidelines Strategic Planning Workshop, EPA/630/R-92/002, U.S. Environmental Protection Agency, Risk Assessment Forum, February.

EPA, 1992c, The Role of Natural Resource Trustees in the Superfund Process, Publication 9345. 0-05I (ECO Update), Office of Solid Waste and Emergency Response, Washington, DC, March.

EPA, 1992d, Developing a Work Scope for Ecological Assessments, Publication 9345. 0-05I (ECO Update), Office of Solid Waste and Emergency Response, Washington, DC, May.

EPA, 1992e, Briefing the BTAG: Initial Description of Setting, History, and Ecology of a Site, Publication 9345. 0-05I (ECO Update), Office of Solid Waste and Emergency Response, Washington, DC, August.

EPA, 1993, Wildlife Exposure Factors Handbook, Volumes I and II, EPA/600/R-93/187a and EPA/600/R-93/187b, Office of Research and Development, Washington, D.C.

Fries, G. F., G. S. Marrow, and P. A. Snow, 1982, "Soil Ingestion by Swine as Dairy Cattle," Environmental Chemistry, 1, pp. 201-204.

Griffin, S., and P. Turck, 1991, "Bioavailability in Rabbits of Sodium Arsenite Absorbed to Soils," *The Toxicologist,* 11:718.

Hampton, N. L., R. C. Rope, J. M. Glennon, and K. S. Moor, 1995, A Preliminary Survey of the National Wetlands Inventory as mapped for the Idaho National Engineering Laboratory, INEL-95/0101, February.

Hegner, R. E., 1994, "Does Protection for Human Health Protect Ecological Health?", Risk Anlaysis, 14, 1, pp. 3-4.

Hoffman, R. J., et al., 1990, "Reconnaissance Investigation of Water Quality, Bottom Sediment, and Biota Associated with Irrigation Drainage In and near Stillwater Wildlife Management Area, Churchill County, Nevada, 1986–1987," *U.S. Geological Survey Water Resources Investigation Report,* 89-4105, U.S. Geological Survey, Carson City, NV.

Hoover, R.L. and D.L. Wills, eds., 1987, Managing Forested Lands for Wildlife, Developed in cooperation with the U.S. Department of Agriculture, Forest Service, Rocky Mountain Region, Colorado Division of Wildlife.

IAEA (International Atomic Energy Agency), 1992, "Effects of Ionizing Radiation on Plants and Animals at Levels Implied by Current Radiation Standards," *Technical Reports Series* No. 332, Vienna, Austria.

INPS (Idaho Native Plant Society), 1995, Results of the Eleventh Annual Idaho Rare Plant Conference, February 7-8, 1995, Boise, ID.

Jessmore, P. J., L. A. Lopez, and T. J. Haney, 1994, Compilation of Evaluation of INEL Radiological and Environmental Sciences Laboratory Surface Soil Sample Data for Use in Operable Unit 10-06 Baseline Risk Assessment, EGG-ER-11227, September.

Johnsgard, P.A., 1990, Hawks, Eagles, and Falcons of North America, Smithsonium Institute Press, Washington, DC, 403 pp.

Khera, KS. and S.A. Tabacova, 1973, "Effects of methylmercuric chloride on the progeny of mice and rats treated before or during gestation." Food and Cosmetic Toxicology, ll:245-254.

Kocher, 1981, Radioactive Decay Data Tables, NTIS DOE-TIC-11026.

Kramber, W.J., R.C. Rope, J.E. Anderson, J.M. Glennon, and A. Morse, 1992, "Producing a Vegetation Map of the Idaho National Engineering Laboratory Using LANDSAT Thematic Mapper Data," In: *Proceedings of ASPRS 1992 Annual Meeting,* Albuquerque, NM, March.

Lewis, S. C., J. R. Lynch, and A. I. Nikiforov, 1990, "A new approach to deriving community exposure guidelines from No- Observed-Adverse-Effect-Levels," Regul Toxicol Pharmacol, 11:314-330.

Loehr, C. A., B. H. Becker, S. M. Rood, and A. J. Sondrup, 1994, Risk Assessment of Remedial Ofjectives for Nontransuranic Waste in Pit 9, EGG-ER-11093, January, 1994.

Long, E. R., and L. G. Morgan, 1990, "The Potential for Biological Effects of Sediment-Sorbed Contaminants Tested in the National Status and Trends Program," National Oceanic and Atmospheric Administration Technical Memorandum, NOS OMA 52.

Ludwig, D. F. et al., 1994, "Toxicity reference values for ecological risk assessment," submitted for publication.

Martin, K. L., et. al. 1992, *Preliminary Assessment of Surface Soils at Active EG&G Idaho Facilities Data Document,* EGG-ESQ-9225, EG&G Idaho, Idaho Falls, Idaho.

Markham, O. D., D. K. Halford, and R. E. Autenrieth, 1980, "Strontium-90 concentrations in pronghorn antelope bones near a nuclear fuel reprocessing plant," Health Physics, 38:811- 816.

Mayland, H. F., A. R. Florence, R. G. Rosenau, V. A. Lazar, and J. A. Turner, 1975, "Soil Ingestion by Cattle on Semiarid Range as Reflected by Titanium Analysis of Feces," Journal of Range Management, 28, pp. 448-452.

Maughan, J. T., 1993, *Ecological Assessment of Hazardous Waste Sites,* Van Nostrand Reinhold, New York, NY, 352 pp.

McKenzie, D. H., L. L. Cadwell, L. E. Eberhardt, W. E. Kennedy, R. A. Peloquin, and M. A. Simmons, 1982, *Relevance of Biotic Pathways to the Long-Term Regulation of Nuclear Waste Disposal,* NUREG/CR-2675.

Morris, R. C., 1994, "Radioecology and Ecology Publications of the Idaho National Engineering Laboratory," Environmental Science and Research Foundation, ESRF-003.

Moseley, R. K., and C. Groves, 1992, "Rare, Threatened and Endangered Plants and Animals of Idaho," Conservation Data Center, Idaho Department of Fish and Game, Boise.

Nace, R. L., Deutsch, M., and P. T. Voegeli, 1972, *Physical Environment of the National Reactor Testing Station, Idaho—A Summary,* Geology, Hydrology, and Waste Management at the National Reactor Testing Station, Idaho.

Nace, R. L., Voegeli, P. T., Jones, J. R., and M. Deutsch, 1975, Generalized Geologic Framwork of the National Reactor Testing Station, Idaho, Geology, Hydrology, and Waste Management at the National Reactor Testing Station, Idaho.

Nagy, K. A., 1987, "Field Metabolic Rate and Food Requirement Scaling in Mammals and Birds," *Ecological Mono.* 57:111–128.

National Research Council, 1986, Ecological Knowledge and Environmental Problem-solving: Concepts and Case Studies. National Research Council, National Academy Press, Washington, D.C.

Noss, R. F., 1983, "A Regional Landscape Approach to Maintain Diversity," Bioscience, 33, 11, pp. 700-706.

Noss, R. F., 1990, "Indicators for Monitoring Biodiversity: A Hierarchical Approach," Conservation Biology, 4, 4, pp. 355-364.

Peterle, T. J., 1991, *Wildlife Toxicology,* Van Nostrand Reinhold, New York, NY.

Reynolds, T. D., et al. 1986, "Vertebrate Fauna of the Idaho National Engineering Laboratory," *Great Basin Naturalist, 46,* pp. 513–527.

Reynolds, T., and J. Laundre, 1988, "Vertical Distribution of Soil Removed by Four Species of Burrowing Rodents in Disturbed and Undisturbed Soils," *Health Physics, 54,* 4.

Reynolds, T. D., and L. Fraley, Jr., 1989, "Root Profiles of Some Native and Exotic Plant Species in Southeastern Idaho, *Environ. & Expt.* Bot. 29:241–248.

Reynolds, T. D., 1994, Environmental Science and Research Foundation, Idaho Falls, ID, personal communication with Randy Morris, Environmental Science and Research Foundation, Idaho Falls, Idaho.

Rood, S. M., G. A. Harris, and G. J. White, 1995, *Background Dose Equivalent Rates and Surficial Soil Metal and Radionuclide Concentrations for the Idaho National Engineering Laboratory,* INEL-94/0250, February, 1995.

Russell, K., J. Brebner, I. Thornton, and N. F. Suttle, 1985, "The Influence of Soil Ingestion on the Intake of Potentially Toxic Metals and Absorption of Essential Trace Elements by Grazing Livestock," pp. 847-849 in C. F. Mills, I. Aden, and J. K. Chesters, eds. Proc. fifth international symposium on trace elements in man and animals. Grampian, Aberdeen, U.K.

Scheiner, S. M., A. S. Hudson, and M. A. Vanderheusen, 1993, "An Epistemology for Ecology," Bulletin of the Ecological Society of America, 74, 1, March, pp. 17-21.

Shacklette, H. T. and J. G. Boerngen, 1984, Element Concentrations in Soils and Other Surficial Material of the Conterminous United States, U.S. Geological Survey, Professional Paper 1270, Washington, D.C.

Shleien, B., 1992, The Health Physics and Radiological Health Handbook, Scinta Publishers, Silver Springs, MD.

Short, H. L., 1982, "Development and Use of a Habitat Gradient Model to Evaluate Wildlife Habitat," *Proceedings of the North American Wildlands Natural Resources Conference No. 47,* pp. 57–72.

Steele, M. J., B. D. Beck, B. L. Murphy, and H. S. Strauss, 1990, "Assessing the Contribution from Lead in Mining Wastes to Blood Lead," *Regulatory Toxicology and Pharmacology,* 11:158–190.

Sigal, L. L. and G. W. Suter II, 1989, "Potential Effects of Chemical Agents on Terrestrial Resources," Environ. Profess., 11, pp. 376-384.

Smith, R. L., 1990, Ecology and Field Biology, Fourth Edition, Harper & Row, New York, NY.

Suter, G.W., II, 1989, Chapter 2, "Ecological Endpoints," Ecological assessments of Hazardous Waste Sites: A Field and Laboratory Reference Document, W. Warren-Hicks, B.R. Parkhurst, and S.S. Baker (eds.), U.S. Environmental Protection Agency, March, EPA 1600/3-89/013

Suter, G. W. II, 1992, "Endpoints for Regional Ecological Risk Assessments," Environmental Management, 14, 1, pp. 9-23.

Suter, G. W. II, 1993, Ecological Risk Assessment, Lewis Publishers, Ann Arbor, MI, 538 pp.

Suter, G.W., II, M.E. Will, and C. Evans, 1993a, Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Terrestrial Plants, Environmental Restoration Division, ORNL Environmental Restoration Program, Oak Ridge National Laboratory, September, ES/ER/TM-85.

Travis, C. C. and A. D. Arms, 1988, "Bioconcentration of organics in beef, milk, and vegetation," Environmental Science and Technology, 22:271-274.

U.S. Environmental Protection Agency, 1986a, *Quality Criteria for Water,* EPA/440/5-86-001, Office of Water Regulations and Standards, Washington, DC.

West, N. E., 1983, "Western Intermountain Sagebrush Steppe," pp. 351–374, in Temperate Deserts and Semi-Deserts, N. E. West (ed.), Elsevier Scientific Publishing Co., New York, NY.

Witmer, C. M., R. Harris, and S. I. Shupack, 1991, "Oral bioavailability of chromium from a specific site," Environmental Health Perspective, 92:105-110.

Appendix A

Identification of Applicable or Relevant and Appropriate Requirements for Ecological Risk Assessment

Appendix A

Identification of Applicable or Relevant and Appropriate Requirements for Ecological Risk Assessment

M. L. Paarmann

The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), [as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA) and other statutes], requires the Environmental Protection Agency (EPA) to ensure the protection of the environment in the selection of remedial alternatives, and assessment of the degree of cleanup necessary. Section 121(d)(A) of CERCLA incorporates into law the CERCLA Compliance Policy, which specifies that Superfund remedial action meet any federal and state standards, requirements, criteria, or limitations that determined to be legally applicable or relevant and appropriate requirements (ARARs) (EPA, 1989a). Compliance with ARARS is a threshold requirement that a remedial/restoration activity must meet in order to be eligible for selection as a remedy.

The interim final CERCLA *Compliance with Other Laws Manual* (EPA 1989b), or ARARs guidance, was developed to assist in the selection of onsite remedial actions that meet the ARARs of the Resource Conservation and Recovery Act, Clean Water Act, Safe Drinking Water Act, Clean Air Act, and other federal and state environmental laws, as required by CERCLA section 121 (EPA, 1989a). Although there is no available guidance for determining ARARs specifically for ecological risk assessment (ERA) a list of potential federal and state ARARs are provided in the *Table of Potential and State ARARs for the INEL* (DOE-ID 1993). Other documents of interest include the *Federal Environmental Standards of Potential Importance to Operations and Activities at U.S. Department of Energy Sites* (PNL 1993).

The determination that a requirement is relevant and appropriate is a two-step process: 1) determination if a requirements is relevant and 2) determination if a requirement is appropriate. In general, this involves a comparison of a number of site-specific factors, including the characteristics of the remedial action, the hazardous substances present at the site, or the physical circumstances of the site, with those addressed in the statutory or regulatory requirements. In some cases, a requirement may be relevant, but not appropriate, given site-specific circumstances. The requirements may be either applicable or relevant and appropriate, not both.

Applicable requirements are those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting laws that specifically address a hazardous substance, pollutant, contaminant, remedial action, location or other circumstance found at a CERCLA site. Only those state standards that are identified by a state in a timely manner and that are more stringent than federal requirements may be applicable. Applicable requirements are those that would have to be complied with under the law regardless of CERCLA enforcement.

Relevant and appropriate requirements are those substantive environmental protection requirements promulgated under federal or state laws that, while not legally applicable to the circumstances at the site or facility, address situations sufficiently similar so that their use is well suited to the particular site. The determination of relevant and appropriate is not a legal procedure as for applicable requirements, but relies upon professional judgement with regard to the site-specific conditions and hazards.

ARARs are either chemical-, action-, or location-specific depending upon whether the requirement is triggered by the presence or emission of a chemical, by a vulnerable or protected location, or by a particular action:

- Chemical-specific: Risk-based numerical values or methodologies that establish an acceptable amount of concentration of a contaminant in the ambient environment

- Action-specific: Technology or activity-based requirements for remedial/restoration actions

- Location-specific: Restrictions place upon the concentration of hazardous substances or the conduct of activity.

In certain circumstances, it may be desirable to list other state and local regulations, advisories, or requirements that may not classify as ARARs, but may be pertinent to the ecological assessment of the INEL. These items may become the "To Be Considered" requirements (TBCs). TBCs are non-promulgated advisories or guidance issued by the federal or state government that are not legally binding and do not have the status of potential ARARs. However, in many circumstances, TBCs are considered along with ARARs as part of the site risk assessment and may be used to determine the necessary level of cleanup for protection of health or the environment.

Table A-1 provides a listing of all ARARs that generally apply to ecological risk assessment. These were developed as a subset of those ARARs discussed in the Table of Potential Federal and State ARARs for the INEL (DOE-ID, 1993) and are very general in nature. It must be stressed, as is stated in this document, that this table is only a tool to be used as a starting point for ARARs identification. Since identification of ARARs must be done on a site-specific basis, Table A-1 must be modified as necessary for each individual WAG screening level risk assessment.

Table A-1. Applicable or relevant and appropriate requirements (ARARs).

Resource Conservation and Recovery Act (Groundwater Protection Standards (federal and state-equivalent	42 USCA 7401-7642; CFR 260-280	Chemical specific Action specific Location specific
Federal Water Pollution Control Act/ Clean Water Act	33 USCA 1251-1376 Chemical specific 40 CFR 100-149	Action specific
Idaho Water Quality Standards and Wastewater Treatment Requirements	Title 1, Chapter 2	Chemical specific Action specific
Safe Drinking Water Act and Regulations (Federal and/or State)		Chemical specific
Nuclear Regulatory Standards for Protection Against Radiation		Chemical specific
State radiation protection standards		Chemical specific
State radiation emission standards		Chemical specific
Clean Water Act (federal)		Chemical specific
Toxic Substances Control Act		Chemical specific
National Emission Standards for Radionuclide Emissions from DOE Facilities		Chemical specific
EPA Radiation Protection Standards for managing and disposing of spent nuclear fuel, high-level, and transuranic radioactive wastes		Chemical specific
Clean Air Act		Chemical specific
National Primary and Secondary Ambient Air Quality Standards		Chemical specific

Table A-1. (continued).

Guidance Document for the Cleanup of Radiologically Contaminated Sites	EPA/540/2-88/002	Action specific
Concentration Limits for Radioactive Materials in Wastes and Air	10 CFR 10,20,40,60 61,72,960	Action specific
Endangered Species Act	16 USC 1531-1543	Location specific
Threatened Fish and Wildlife	50 CFR 227.4	Location specific
Migratory Bird Conservation Act	16 USC 715	Location specific
Migratory Bird Treaty Act	16 USC 703	Location specific
Fish and Wildlife Coordination Act	16 USC 661 et seq.	Location specific
Biological Assessment	50 CFR 402.12	Location specific
Designated Critical Habitats	50 CFR 226	Location specific
List of Endangered and Threatened Wildlife	50 CFR 17.11,12	Location specific
Protection of Bald and Golden Eagles Act	16 USC 1531	Location specific
Eagles: General Restrictions	50 CFR 22.12	Location specific
Cave Resources Protection Act		Location specific
Idaho Fish and Wildlife	16 USC 756,757	Location specific
Wetlands Regulations	33 USC 1344	Location specific
Wetlands Conservation Protection of Wetlands Protection of Floodplain	16 USC 4404; 40 CFR 6 Executive order 11990; Executive order 11988	Location specific

Table A-1. (continued).

RCRA treatment, storage, and disposal (TSD) siting requirements	Location specific
Clean Water Act, Section 404, Wetlands protection	Location specific
Protection of areas that are part of the National Wildlife Refuge System	Location specific
Wild and Scenic Rivers Act	Location specific
National Historic Preservation Act	Location specific
National Pollutant Discharge Elimination System	Location specific
Clean Air Act: National Emissions Standards for Hazardous Air Pollutants	Location specific

REFERENCES

DOE-ID, 1993, *Table of Potential Federal and State ARARs for the INEL,* Revision 0, Department of Energy, Idaho Field office, QG1010.

EPA, 1989a, *CERCLA Compliance With Other Laws Manual, Part I. Office of Emergency and Remedial Response,* EPA/540/G-89/006.

EPA, 1989b, *CERCLA Compliance With Other Laws Manual, Part II. Office of Emergency and Remedial Response,* EPA/540/G-89/009.

Pacific Northwest Laboratories (PNL), 1993, *Federal Environmental Standards of Potential Importance to Operations and Activities at U.S. Department of Energy Sites,* Office of Environmental Guidance, Water and Radiation Division, DOE/RL/01830-H15.

Appendix B

Ecological Literature Database (ECOLIT)

Appendix B

Ecological Literature Database (ECOLIT)

B-1. INTRODUCTION

P. D. Ritter, T. A. Bensen, S. M. Rood

There is considerable information available that may be applicable to ecological risk assessment (ERA) efforts at the Idaho National Engineering Laboratory (INEL). These data are not always easily accessible and have not been organized in a manner that facilitates their use in the performance of ERAs. To improve accessibility and utility of this information, the ERA Library database system, ECOLIT, was developed to provide a common database in which to compile this information. In general, the types of data required for ERAs are: (1) the concentrations and physical/chemical distributions of contaminants in the environment, (2) site-specific ecological data, particularly as needed to define the physical/temporal distribution of plants and animals in the environment, and (3) the response of ecosystems or their parts to exposure to contaminants. ECOLIT serves as an index of this information in the form of a bibliographic database, and also provides access to any associated quantitative data sets and geographic information system (GIS) data. The connection of bibliographic data, quantitative data, and GIS data are particularly useful in ERA development.

B-1.1 Data Sources

The concentrations of radioactive materials in the environment on and around the INEL have been measured in response to long-standing requirements for environmental surveillance around nuclear facilities. Both the Department of Energy (DOE) and DOE contractor organizations have responsibilities for conducting environmental measurements. Results of these studies typically have been reported in DOE reports or DOE contractor reports. The availability of these reports and associated supporting information varies considerably—in some cases, the results of relevant research are only available as raw data with minimal documentation and distribution. In addition to the required environmental surveillance programs, the INEL has been part of the federal research and development system since 1949, and has been designated a National Environmental Research Park (NERP). As a result, a large body of ecological data has been developed for the INEL providing a well-developed basis for evaluating ecological risks.

The Radioecology and Ecology Program at the DOE's Radiological and Environmental Sciences Laboratory (RESL), recently reorganized as the Environmental Science and Research Foundation (ESRF), has performed extensive research in terrestrial ecology and radioecology on the INEL. The research has resulted in over 300 publications including species lists, vegetation maps, and results of research into the basic ecology and radioecology of the INEL. The Lockheed Idaho Center for Integrated Environmental Technologies (CIET) has also conducted ecological research that is applicable to INEL ERAs, and has provided substantial technical support for development of ecological databases that are compatible with the INEL's GIS. Other sources of potentially useful information include reports of hydrogeologic research performed at

the INEL by the U.S. Geological Survey (USGS), and atmospheric and climatological data collected by the National Oceanic and Atmospheric Administration (NOAA). University researchers and other basic research organizations are also potential sources for data.

B-2. SPECIFICATIONS FOR THE ECOLIT

RESL and CIET personnel were queried regarding the general functional requirements for the ECOLIT. It was determined that the database should:

- Provide access control for data sets that are placed into the database
- Provide the best possible accessibility to the database for on- and off-site users
- Serve as a reliable archive for reference material
- Have fields for quality assurance information including references to quality control sample data, as appropriate
- Provide extended fields for comments by the author/researcher concerning the applicability and limitations of the study and data
- Have download capability to personal computer software for further processing of the information.

Both the RESL and the CIET have made efforts to develop databases for ecological data. These were examined to determine if the ECOLIT could be derived from an existing database. After discussions with several database developers/users, the INEL Ecological Data Management System (IEDMS) was selected as the best starting point for developing the bibliographic part of the ECOLIT because:

- The IEDMS was derived from the Research Parks System - Research Information Relational Database Management System (RDBMS). The RDBMS was developed by the RESL and the CIET, and meets the requirements of these two organizations with regards to the types of data fields.
- The IEDMS implemented with Oracle software, which allows a great deal of flexibility in controlling read/write access to data -- an advantage considering the potentially wide variety of sources, QA levels, etc. that must be accommodated by the system,
- The IEDMS is compatible with the Environmental Restoration Information System (ERIS), and acts as a bibliographic "front-end" for the datasets stored in ERIS. This also provides access to the ERIS source lineage report tables, so that source lineage data for GIS datasets can be included in a bibliographic data record or search.
- The IEDMS was developed for machines operating with UNIX, so users can access the database through the INTERNET.

The final structure of the bibliographic part of ECOLIT is summarized in the data entry forms that are used to prepare information on reports or studies for input to the database. Figure B-1 is the data entry form (hardcopy) used for the dBase V version of ECOLIT. The most significant modifications to the IEDMS database are incorporation of (1) unlimited text fields for author and reviewer comments concerning the report, (2) quality assurance/quality control data fields for each record, (3) incorporation of fields for input and recovery of source lineage report information.

The field data portion of ECOLIT is designed to accommodate large data sets, e.g., population distribution data or contaminant distribution data. Each data set will contain an identifier to associate it with a particular entry (or entries) in the bibliographic database. Each data record can include location information (if available), and an estimate of the accuracy of the location information. As appropriate, quality assurance data will be associated with the field data for each study.

B-3. ORGANIZATION OF ECOLIT

ECOLIT is a bibliographic database that also provides access to quantitative datasets describing, for example, contaminant concentrations or population census data, and that may include spatial coordinate data for GIS applications. ECOLIT can provide separation of the bibliographic and quantitative sections. This is advantageous because:

- The ERA bibliographic database will serve as a reference source for researchers or risk analysts performing literature searches, so its structure and contents should be compatible with commonly available PC-DOS based bibliographic software

- Segregation of bibliographic and quantitative databases will ensure that adequate access control can be maintained for researchers who agree to provide conditional access to their field data.

Figure B-2 shows samples of the bibliographic data input screen for the ECOLIT database, and Figure B-1 shows a listing of the bibliographic information fields that are defined for ECOLIT. The input screens open into larger windows for extended text fields, and help menus are available for each field. There are several fields devoted to prompting the user for GIS information and access to the ERIS source lineage report system through the ECOLIT input screen.

Queries to ECOLIT are made using SQL*Plus commands (SQL stands for "Structured Query Language"). Users may browse through the database and search for key words or character strings in each field. Keyword searches are directly accessible through the ECOLIT menu. More complex queries can be developed if required.

Table B-1 is a sample of a summary of information on previous investigations conducted at the INEL compiled from ECOLIT. This table is useful for identifying studies that are applicable to individual SLERAs.

INEL Environmental Studies Documentation Sheet

(Screening Form)

Reviewer(s): _____ Date Reviewed: _____

Title: _____

_____

Author(s)/Affiliation: _____

_____

Subject: (purpose/objective of study) _____

_____

_____

_____

_____

Annotation: _____

_____

_____

_____

_____

_____

Key Words: _____

Spatial Scale of Data Collection: _____

Temporal Scale of Data Collection: _____

Duration of Data Collection: _____ to _____

Data Were Collected:

Year: _____ Months: 1___2___3___4___5___6___7___8___9___10___11___12___

Year: _____ Months: 1___2___3___4___5___6___7___8___9___10___11___12___

Year: _____ Months: 1___2___3___4___5___6___7___8___9___10___11___12___

Year: _____ Months: 1___2___3___4___5___6___7___8___9___10___11___12___

Year: _____ Months: 1___2___3___4___5___6___7___8___9___10___11___12___

Year: _____ Months: 1___2___3___4___5___6___7___8___9___10___11___12___

Year: _____ Months: 1___2___3___4___5___6___7___8___9___10___11___12___

Location of Study: (general geographic area or exact location if known)

_____

_____

Was Study Published?: Yes _____ No _____

If yes, cite references: _____

_____

_____

Figure B-1. Data entry form used for the dBase V version of ECOLIT.

Data Information:

1. Data Collected:

Data Type	Primary Data	Secondary Data	Qualitative	Quantitative
Aquatic	_____	_____	_____	_____
Archeological	_____	_____	_____	_____
Fauna	_____	_____	_____	_____
Flora	_____	_____	_____	_____
Geological	_____	_____	_____	_____
Human	_____	_____	_____	_____
Hydrologic	_____	_____	_____	_____
Meteorological	_____	_____	_____	_____
Microbial	_____	_____	_____	_____
Seismic	_____	_____	_____	_____
Soils	_____	_____	_____	_____
Chemical Analysis	_____	_____		
Radiological Analysis	_____	_____		
Other				
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____

List fauna species/species groups:_____

_____

List primary flora species/communities:_____

_____

2. Availability of source data:

   a. Who owns the data and location?: _____

   _____

   _____

   b. Are raw data from study available?:

   Yes ____ No ____ Unknown ____

   If yes, from where: _____

   _____

   c. Are there any restrictions for its use?: _____

   _____

   d. Format of data: (digital/paper) _____

   _____

Quality Assurance/Quality Control:

1. Was QA/QC part of sampling design?: Yes ____ No ____
2. If Yes what level of QA/QC: A ____ B ____ C ____ Unknown ____

   Comments: _____

   _____

   _____

Figure B-1. (continued).

Any additional comments regarding other information on the study: _____

_____

_____

_____

GIS Compatibility of Data:

1. Are maps, location data, or coordinates associated with this study?:
   Maps: Yes ___ No ___ Unknown ___
   Data: Yes ___ No ___ Unknown ___
2. What method was used to determine locations?: (survey, GPS, map)
   _____
3. What is the accuracy of the location data?: _____
   _____
4. In what form are the location data (map, text, digital)?: _____
   _____
5. Have location data been entered into a GIS?: Yes ____ No ____
   If yes:
   Describe: _____
   _____
   What is the availability?: _____
   _____
   What software was used to process the data? _____
   _____
   What format is data in? _____
   What is the storage media? _____
6. Are there aerial photographs or satellite images associated with study?: Yes ____ No ____
   If yes:
   Describe: _____
   _____
   _____
   What is the availability?: _____
   _____
   For digital image data:
   What software was used to process the data? _____
   _____
   What format is data in? _____
   What is the storage media? _____

Figure B-1. (continued).

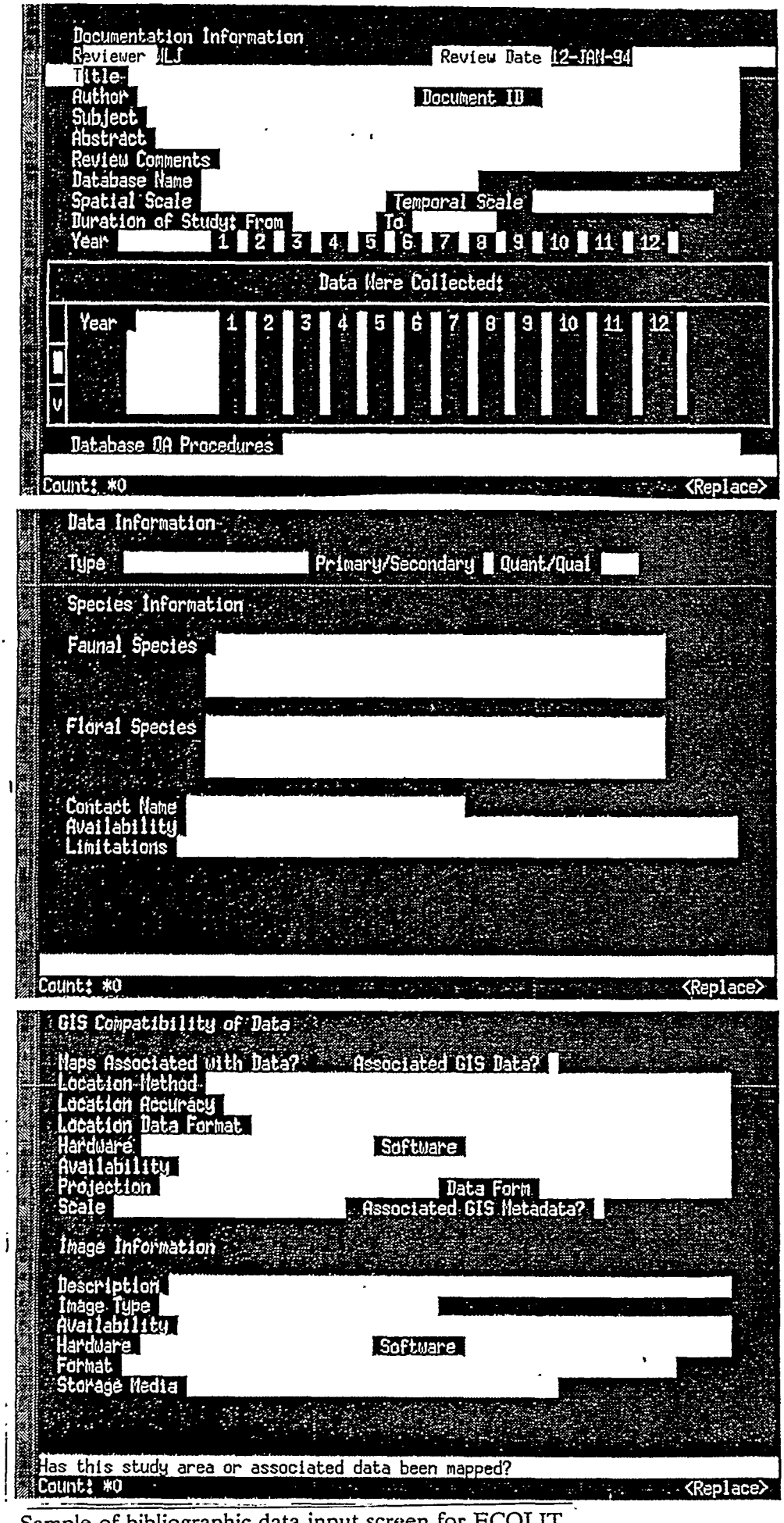


Figure B-2. Sample of bibliographic data input screen for ECOLIT.

Table B-1. Previous investigations conducted at the INEL.

Reference	Applicability			Study Area	Topic Species	Contaminants Addressed	Data Reported				
	Problem Formulation	Analysis	Risk Characterization				Habitat	Diet	Susceptibility to Contaminant	Biological Response	Tissue Concentration
Anderson, 1991	X	X		ICPP	Vegetation Wildlife Soil						
Arthur, 1982	X	X	X	RWMC/ SDA	Crested wheatgrass Russian thistle	Pu-238 Pu-239,240 Am-241	Terrestrial				X
Arthur, Connelly, Halford, and Reynolds 1984	X			INEL	Vertebrate survey		X				
Arthur, Markham, Groves, Keller, and Halford, 1986	X	X		RWMC/ TSA, SDA	Deer mouse Ord's kangaroo rat		Terrestrial			X	
Arthur, Markham, Groves, and Keller, 1987	X	X		RWMC/ SDA	Deer mouse	Radionuclides					
Arthur and Gates, 1988		X		INEL	Pronghorn antelope Black-tailed jackrabbit	Trace Elements Toxic Elements Rad Elements					
Arthur and Janke, 1986	X	X	X	RWMC/ SDA	Small mammals Avifauna	Radionuclides	Terrestrial				
Arthur and Markham, 1982a	X	X		TRA, RWMC SDA	Coyotes	Radionuclides	Terrestrial				
Arthur and Markham, 1982b	X	X	X	TRA, RWMC/ SDA	Burrowing mammals Coyote Wheatgrass Russian thistle Soil	Radionuclides	Terrestrial				X(?)
Arthur and Markham, 1983	X	X		RWMC/ SDA	Soil	Plutonium	Terrestrial				
Arthur and Markham, 1984	X	X	X	RWMC/ SDA	Soil Crested wheatgrass Deer mouse	Po-210	Terrestrial				X
Blom, Johnson, and Rope, 1991		X		TRA	Harvester ant	Cs-137 Co-60	Soil Mounds/Terrestrial				
Connelly, 1982	X	X	X	INEL	Sage grouse	Radionuclides	Terrestrial/Aquatic	X	X	X	X(?)
Connelly and Markham, 1983	X	X	X	TRA, ICPP, RWMC, CFA	Sage grouse	Radionuclides	Terrestrial/Aquatic			X(?)	X(?)
Craig, Halford, and Markham, 1979	X	X	X	TRA, ICPP	Raptors	Radionuclides	Air/Terrestrial				
Craig, Craig, and Powers, 1985		X		INEL	Long-eared owl		Air	X			
Evenson, 1981		X	X	INEL	Deer mouse	Radionuclides	Terrestrial		X(?)	X	X(?)
Filipovich, 1983	X			ARA	Deer mouse Great Basin pocket mouse Least chipmunk Montane vole Ord's kangaroo rat Western harvest mouse Northern grasshopper mouse Sagebrush vole		Terrestrial	X			
Fraley, Bowman, and Markham 1982	X	X	X	ICPP	Rabbit	I-129/I-127	Terrestrial		X (?)	X	X(?)
Groves and Keller, 1986	X	X		RWMC/ SDA	Small mammals		Crested wheatgrass Russian thistle Sagebrush				

Table B-1. (continued).

Reference	Applicability: Problem Formulation	Applicability: Analysis	Applicability: Risk Characterization	Study Area	Topic Species	Contaminants Addressed	Data Reported: Habitat	Data Reported: Diet	Data Reported: Susceptibility to Contaminant	Data Reported: Biological Response	Data Reported: Tissue Concentration
Halford, 1987		X		TRA	Small mammals	Transuranic Rad	Terrestrial				X
Halford, Millard, and Markham, 1981	X	X		TRA	Duck Geese Swan American coot	Radionuclides	Aquatic				X
Halford, Markham, and Dickson, 1982	X	X		TRA	Green-winged teal Mallard Northern pintail Lesser scaup Common goldeneye Bufflehead American coot		Aquatic/Air	X		Dose	
Halford, Markham, and White, 1983a	X	X		TRA	Mallard	Radioisotopes	Aquatic/Air		X	X	X(?)
Halford, Markham, and White 1983b	X	X		TRA	Wing-clipped mallards	Cs-134 I-131 Cs-137 Ba-140 Se-75 Co-58 Zn-66 Co-67 Cr-51	Liquid radioactive waste pond			X	X
Halford and Markham, 1978	X	X		TRA	White-footed deer mouse Least chipmunk Ord's kangaroo rat		Terrestrial		X		
Halford and Markham, 1984		X		TRA	Mallard	I-129/I-127	Aquatic/Air			X(?)	X(?)
Halford and Millard, 1978	X			TRA	Vertebrate fauna		Leaching pond (Aquatic)				
Howe and Flake, 1989	X	X		INEL	Mourning dove		Aquatic/Air				
Ibrahim and Culp, 1989	X	X		TRA	Net plankton Suspended particulates Sediment	Pu-239 Pu-240 Pu-238	Aquatic				
Janke and Arthur, 1985	X	X		RWMC/ SDA, TSA	Cottontail rabbit	Radionuclides	Terrestrial				
Johnson, 1979	X			INEL	Rabbits Black-tailed jackrabbit Pronghorn antelope Sheep Cattle		Terrestrial	X			
Johnson and Hansen, 1979a	X			INEL	Coyote		Terrestrial	X			
Johnson and Hansen, 1979b	X			INEL	Coyote		Terrestrial	X			
Koehler and Anderson, 1991	X			RWMC/ SDA	Deer mouse Montane vole Ord's kangaroo rat Townsend's ground squirrel		Terrestrial				
Kuzo, Fraley, Whicker, and Markham, 1987	X	X		TRA	Sediment Seston Periphyton	Pu-238 Pu-239,240 Am-241 Cm-242 Cm-244	Aquatic				

Table B-1. (continued).

Reference	Applicability			Study Area	Topic Species	Contaminants Addressed	Data Reported				
	Problem Formulation	Analysis	Risk Characterization				Habitat	Diet	Susceptibility to Contaminant	Biological Response	Tissue Concentration
Markham, 1974	X	X		INEL		Radionuclides Environmental	Terrestrial				
Markham, 1978	X	X		RWMC/ SDA	Small mammals Soil	Radionuclides Cs-137 Co-60 Sr-90	Terrestrial				X
Markham, Autenrieth, and Hoskinson, 1976	X	X		INEL	Pronghorn antelope	Radionuclides	Terrestrial				X
Markham, Puphal, and Filer, 1978	X	X		RWMC/ SDA	Soil Deer mouse	Pu-238 Pu-239 Am-241	Terrestrial				X(?)
Markham, Autenrieth, and Dickson, 1979		X		ICPP	Pronghorn	Pu-238 Pu-239,240	Terrestrial Atmospheric				X
Markham, Halford, and Autenrieth, 1980	X	X		INEL	Pronghorn antelope	Sr-90	Terrestrial			X	
Markham, Halford, Bihl, and Autenrieth, 1980	X	X		INEL	Pronghorn antelope	I-131	Terrestrial			X	X
Markham, Halford, Autenrieth, and Dickson, 1982		X		ICPP	Pronghorn antelope	Radionuclides	Terrestrial				X
Markham, Hakonson, Whicker, and Morton, 1983	X			ICPP	Mule deer	I-129	Terrestrial		X (?)	X(?)	X
Markham, Halford, Rope, and Kuzo, 1988		X		TRA	Mallard	Plutonium Americium Cm Strontium	Aquatic/Air				
Markham and Halford, 1982	X	X	X	TRA, ARA, EBR-II, ICPP, LOFT, NRF, RWMC	Mourning dove	Radionuclides	Terrestrial/Aquatic		X	X	X
Markham and Halford, 1985	X	X		ICPP	Pronghorn	Cs-137	Terrestrial Atmospheric				X
Markham and Trost, 1986	X	X		INEL	Mourning dove		Terrestrial/Air	X			
McBride, French, Dahl, and Detmer, 1978	X	X		INEL	Vegetation						
McGiff, 1985	X	X		INEL	Vegetation Pronghorn meat	I-129 I-127	Terrestrial			X	
Millard, 1986	X			—	Big sagebrush Wildrye (E. elimoides)	Ce-141 Cs-134	Terrestrial				
Millard, Fraley, and Markham, 1983	X	X		INEL	Big sagebrush Bottlebrush grass	Ce-141 Cs-134	Terrestrial				
Millard, Whicker, and Markham, 1990	X	X	X	TRA	Barn swallow	Radionuclides	Elevated nesting (?)			Growth rate	
Olson and Jeppesen, 1993	X	X		INEL	Soils						
Parmenter, 1985	X	X		—	Coyotes	H-3 Water Na-22	Terrestrial	X		X	
Petersen and Best 1986	X			INEL	Sage sparrow Brewer's sparrow		Terrestrial/Air	X			
Reynolds, 1991	X			—	Harvester ant	—	Soil Mounds/Terrestrial				
Reynolds, Connelly, Halford, and Arthur, 1986	X			INEL	Vertebrate survey	None	Terrestrial Aquatic				
Rope, Anderson, and Kramber, in press	X	X		INEL	Vegetation						
Rope, Arthur, Craig, and Craig, 1988	X			INEL, ICPP	Big sagebrush Bluegrass/Muttongrass Bottlebrush grass Soil	Nutrients Trace Elements	Terrestrial				X

The quantitative dataset portion of ECOLIT contains datasets (typically numerical) for ecological studies, environmental measurement programs, etc. The types of information contained in records in the quantitative information databases varies depending on whether contaminant data or biotic data sets are considered. Because of the importance of defining the spatial relationships between contaminants and receptors, a long-term objective of the ECOLIT is to organize the data so that these spatial relationships can be revealed and investigated as easily as possible, preferably by use of a GIS. This type of database is well-suited for supporting the ERA process, and would also provide a powerful tool for future management of the site. Furthermore, the GIS can be a valuable tool for presenting information to the public in an accessible and understandable format.

B-4. DATA COLLECTION AND INPUT TO THE ECOLIT

Environmental contaminant concentration data have been gathered for various reasons, e.g. to meet environmental monitoring requirements (currently, per DOE Order 5400.1 and DOE/EH-0173T) to determine regional background concentrations of contaminants (currently, per DOE/EH-0173T and DOE Order 5400.1), or to estimate the extent of contamination of the environment caused by the operation of INEL facilities (currently, per DOE Order 5400.1, and the Comprehensive Environmental Response, Compensation and Liability Act [CERCLA]).

In addition to its basic research-oriented Radioecology and Ecology program, the RESL has had the responsibility for site-wide and off-site routine environmental radiological surveillance. The results of this surveillance program have been presented in annual reports (available in hardcopy only) and are an important source of information concerning the concentration of radioactive materials in environmental media. INEL contractors also have conducted routine radiological environmental surveillance, but the contractor's routine programs are generally restricted to coverage of areas within facility boundaries. INEL contractors have performed soil sampling outside of facility fences at DOE-ID's request. These programs included measurement of radioactive materials and metals in soils.

In contrast to the availability of information concerning radioactive contaminants, there is relatively little information concerning hazardous material contamination prior to DOE's response to CERCLA in the late 1980s. Since then, there has been a substantial effort to develop comparable and consistently well-documented data sets for areas contaminated with hazardous materials. Most of these data are produced through INEL contractor studies (rather than DOE/RESL, the USGS, or other federal agency/agency contractors), and essentially all of the data generated for CERCLA response is tracked using two database software systems, the Environmental Restoration Information System (ERIS) and the INEL Environmental Data Management System (IEDMS). These two databases capture the sampling and analysis information required for developing sampling and analysis reports that are admissible as legal evidence. These data are readily accessible for use in the performance of an ERA.

The primary limitation in the data gathered for CERCLA response is that information is only available for the areas at or near potentially contaminated locations. There is a considerable amount of data for locations on the INEL site that are unaffected by facility operations; however, these data may not be usable for baseline comparison. There are relatively few data for

concentrations of hazardous materials (particularly metals) in soils at locations off the INEL site. All data must be reviewed to determine the quality level and applicability for use in an ERA.

B-4.1 Development of the Maximum Database

For screening purposes in the site-wide ecological risk assessment and the waste area group (WAG)-wide cumulative risk assessments, as part of their comprehensive remedial investigation/ feasibility study risk assessment, concentrations of contaminants at sites identified in the Federal Facility Agreement and Consent Order were collected. Two databases were generated in this process. Of the two, the Maximum database is applicable for use in the SLERA.

Data collected were operable unit, site code, site dimensions, sampling date, date of disposal, matrix sample with maximum detected concentration was collected from, contaminant, maximum concentration and units, identification of any tentatively identified compounds, data flags, depth sample with maximum concentration was detected, source(s) of information, and comments. Sources for contaminant data for each site were sought according to a hierarchy as shown in Table B-2. The Track 1 and Track 2 remediation decisions were reached using conservative ("qualitative") risk assessments. The decision documentation packages (DDPs) for each operable unit list the maximum contaminant concentrations for that unit. For Track 1 sites, most DDPs are complete, and it was usually not necessary to look further for contaminant data. Because of the availability of Track 1 DDPs, they were the preferred source of information for initial data gathering efforts. Track 2 sites may or may not have had scoping summary reports available or finalized.

B-4.2 Chemical/Radiological Inventory Data for Facilities

The Chemical Inventory Tracking System (CITS) is used to track the location and inventory of chemicals at all Lockheed Idaho-operated facilities. Robert Fox is the database manager. The CITS operates using ORACLE software. Ron Likovitch and Chris Kent operate a similar database. As of May 1994, there is no information concerning a comparable tracking program for ANL-W.

Lockheed Idaho industrial hygiene operations organizations maintain Hazardous Agent Inventory databases for each facility area. This database does not contain quantities, but does specify a broader range of hazardous materials than are on the SARA reportable list. The industrial hygiene cognizant professional who is responsible for the database is Cheryl Floreen. This database may not be of much use for the ERA, except to screen for the presence of hazardous materials.

B-4.3 Sources of Toxicological Data

The selection of critical exposure levels begins with evaluation of effects data that are relevant to the stressor. The numerous sources of these data and a brief description of their contents is listed in Table B-3.

Table B-2. Hierarchy of sources of contaminant data collected for the cumulative risk assessment.

Type of site	Primary source	Secondary source	Other sources
Track 1	Decision Documentation Packages (DDPs)[a]	Environmental Restoration project files	D&D files on confirmation sampling
Track 2	Scoping Track 2 Summary Reports	ERIS Database[b]	Environmental Restoration project files; D&D files on confirmation sampling
Interim Action	Proposed plans	ERIS Database[b]	Environmental Restoration project files; D&D files on confirmation sampling
RIFS	RIFS report	ERIS Database[b]	Environmental Restoration project files; D&D files on confirmation sampling; Proposed Plans

a. Peak contaminant concentration values only.

b. ERIS contains full data sets, with position information (position information are not yet available for all ERIS data, but will be backfit to the data).

Table B-2. Sources of toxicological information.

Primary literature sources (journal articles and scientific publications)

Registry of Toxic Effects of Chemical Substances (RTECS). This database includes data from both animal studies and human exposures addressing chemical toxicity and biomedical effects (i.e., mutagenicity, carcinogenicity, skin and eye irritation, reproductive studies, and general toxicity studies) for both acute and chronic exposures. It was developed and is updated quarterly by the National Institute for Occupational Safety and Health. A drawback of this database is that data on exposure duration, dose administered, or circumstances that resulted in exposure, are not included; therefore, source data (i.e., from the literature) should be reviewed directly to ensure results are applicable to a particular ERA scenario. More than 118,700 chemicals.

Hazardous Substances Database (HSDB). This database is organized by chemical record, with nearly 4200 chemical substance records contained in the file. The file is being built, maintained, reviewed, and updated on the National Library of Medicine's Toxicology Data Network (TOXNET), and co-supported by the Agency for Toxic Substances and Disease Registry.

Integrated Risk Information System (IRIS). This database was developed by EPA to assist with quantifying health effects in humans (though a majority of the data are obtained from animal studies). NOAELs, LOAELs, NOELs, and LOELs are presented, along with a brief discussion of the studies (e.g., dose, exposure route, duration, frequency). IRIS is updated monthly. More than 400 compounds.

Agency for Toxic Substances and Disease Registry (ATSDR) Toxicological Profile Series. These profiles were developed for hazardous substances (some 200, so far) found at EPA Superfund sites. Profiles include general toxicity information and levels of exposure associated with lethality, cancer, genotoxicity, neurotoxicity, development and reproductive toxicity, immunotoxicity, and systemic toxicity (i.e., liver, kidney, respiratory, cardiovascular, gastrointestinal, hematological, musculoskeletal, and dermal/ocular effects). Health effects are presented for both acute and chronic exposure durations for all exposure routes.

Phytotox Database (PHYTOTOX). Data in PHYTOTOX were obtained from the open literature and compiled by the Department of Microbiology at the University of Oklahoma under sponsorship of EPA. The database includes effects of both natural and synthetic compounds administered to native, crop, and weed plant species. Data included are plant species, chemical, dosage, application methods, effects noted, and bibliographic references.

Aquatic Information Retrieval (AQUIRE). This database, developed by EPA, contains information from worldwide literature (1970 - present) on toxicity of chemicals to both freshwater and marine aquatic organisms, excluding mammals, birds, and bacteria. Data on over 4,000 chemicals include both bioconcentration factors and toxicities, study protocols, experimental details, results, and bibliographic references.

Chemical Evaluation Search and Retrieval System (CESARS). Oil and Hazardous Materials/Technical Assistance Database (OHM/TAD) Primary literature sources (journal articles and scientific publications).

Fish and Wildlife Service Contaminant Hazard Reviews (R. Eisler, ed.). These are a series of reports reviewing and summarizing the literature on specific compounds to invertebrates and wildlife. Chemicals reviewed to date (5/94) are: arsenic, atrazine, cadmium, carbofuran, chlorpyrofos, chromium, diazinon, dioxins, lead, mercury, mirex, pentachlorophenol, PCBs, PAHs, selenium, tin, and toxaphene.

Appendix C

Ecological Literature and Data Evaluation

Appendix C

Ecological Literature and Data Evaluation

C-1. INTRODUCTION

S. C. Peterson, R. Brewer, R. C. Morris

This report summarizes published and unpublished ecological research that is pertinent to scoping and conducting ecological risk assessments (ERAs) for Waste Area Groups (WAGs) at the Idaho National Engineering Laboratory (INEL). Numerous radioecological and descriptive ecological studies have been conducted at the INEL since its establishment as the National Reactor Testing Station in 1948 (Markham 1973; Reynolds and Markham 1987; Markham and Reynolds 1991). Many of these studies were conducted for the INEL Radioecology and Ecology Program, established in 1974, and represent the efforts of numerous scientists from academic institutions, government agencies, and private-sector firms. The designation of the INEL as a National Environmental Research Park (NERP) in 1975 provided a further impetus for investigations. More than 300 research papers, dissertations and theses, technical reports, and popular articles have been published on a broad array of ecological subjects. In addition, radioecological monitoring studies have been conducted by the Radiological and Environmental Sciences Laboratory (RESL). Many of the RESL data are unpublished or are available only in annual summary reports.

The results of published and unpublished radioecological and ecological research conducted previously at the INEL are an important resource for personnel conducting ERAs for the WAGs. However, the previous investigations were primarily done to address specific research questions and may have limited relevance to an ERA, or their relevance may not be immediately obvious to risk assessors. Therefore, this literature evaluation was conducted to assemble, organize, and summarize the available reports in a format useful for risk assessment of site-related contamination. The literature and data evaluation is designed to be a companion document to the *Screening Level Ecological Risk Assessment Guidance Manual* and Case Study. The literature and data evaluation is integral to the development of the manual [Ecology and Environment, Inc., 1993], and is consistent with the current federal ecological risk assessment framework [U.S. Environmental Protection Agency (EPA) 1992, 1993].

C-1.1 Objectives

The main objectives of the ecological literature and data evaluation are to:

- Compile the existing information, and review and organize it in a manner useful to risk assessors.
- Identify and evaluate potential stressors, pathways, and effects known to occur at the site, and assess the contribution of existing ecological information to the weight-of-evidence concerning potential ecological risks at the INEL.

Because ERA relies upon a weight-of-evidence approach and ecological research has taken place at the INEL for many years, this review of the available data is essential for realistic planning and interpretation of risk assessments conducted for remedial investigations at the INEL.

C-1.2 Scope

The scope of the literature evaluation includes to published and unpublished results of ecological research conducted at the INEL and covers a broad range of publications and data. The ecological literature and data considered to be the most critical to ERA at the INEL are emphasized. Because the preponderance of investigations at the site has focused on radionuclides, the literature and data evaluation are likewise focused on this class of potential stressors.

C-1.3 Technical Approach

The literature evaluation was accomplished in the following steps:

1. Published and unpublished reports of ecological research at the INEL were identified and hard copies were obtained. The publication lists of Markham (1973), Reynolds and Markham (1987), and Markham and Reynolds (1991) served as the basis for identification of potentially relevant information. Hard copies of most of these publications were obtained from the Radioecology and Ecology Group of RESL.

2. These publications were entered into a computerized bibliographic database. The software selected for this was the PAPYRUS bibliographic software, Version 7.0.9 (Software Design 1993).

3. Publications were subjected to an initial review to prioritize them with regard to their usefulness to the ERA process. Publications were classified as most useful, potentially useful, or least useful, based on information contained in the title, abstract, key words, or summary. Publications were considered most useful if they contained information regarding potential stressors, pathways, or effects. In addition, emphasis was placed on articles published in peer-reviewed journals, because this information is likely to be of higher quality and credibility and, therefore, more usable for risk assessment. Potentially useful publications contained information on site ecosystems that could support characterization of the exposure setting or other supporting ecological information. Many of these potentially useful publications are descriptive in nature. Some are only indirectly related to assessing risks at the site, or their usefulness may depend on site-specific considerations. The least useful publications had no obvious relevance to the ERA process at the site or were judged to have critical deficiencies and were not reviewed. This category also includes some of the more dated or obscure reports and popular articles.

4. The most useful and potentially useful publications were subjected to a detailed review, and pertinent information was summarized (Section C-2). In addition, the relevance of each publication to each of the phases of ecological risk assessment is identified. The

phases used here are outlined in EPA's ecological risk assessment framework (EPA 1992) and include Problem Formulation, Analysis, and Risk Characterization.

5. Published and unpublished radioecological data were assembled and a preliminary risk evaluation was conducted (Section C-3). The most useful publications identified in Section C-2 provided the basis for this evaluation. The preliminary evaluation is qualitative in nature and is based on an assessment of the extent of contamination and published dose estimates for ecological receptors at the site. Major data gaps are also identified.

C-2. PUBLICATION SUMMARIES

The following brief reviews summarize the pertinent information from published ecological studies at the INEL. The publications classified as most useful for ERA are presented alphabetically in Section C-2.1. Publications considered potentially useful are presented alphabetically in Section C-2.2. Each document is listed by the author(s) and date. This method allows easy cross-referencing with Tables C-1 and C-2 and with the electronic bibliographic database.

Each of the publication summaries in Sections C-2.1 and C-2.2 consists of an abstract of the publication. These abstracts were based to the extent possible on the author's abstract or summary, but information most relevant to ERA was also included or emphasized. In addition, the usefulness of each publication to ERA is briefly described. Table C-1 provides a summary of the applicability of INEL publications to various phases of the ERA process. The facilities and waste management areas represented by each publication were also identified and are summarized in Table C-2.

C-2.1 Publications Most Useful for Ecological Risk Assessment

Arthur (1982). The concentrations of ^{238}Pu, $^{239,240}Pu$, and ^{241}Am in crested wheatgrass (*Agropyron cristatum* [L.] Gaertn) and Russian thistle (*Salsola kali* L.) growing on or near the subsurface disposal area (SDA) were significantly greater than those in control vegetation. However, the total inventory of radionuclides in site vegetation was not significantly greater than in the control area. This lack of a significant difference between the site and the control area was a result of the fact that 90% or more of the radioactivity in vegetation was attributed to ^{90}Sr and ^{137}Cs, and concentrations of these radionuclides were not significantly elevated in vegetation at the site. Russian thistle concentrated more radionuclides than crested wheatgrass, presumably as a result of its deeper rooting and spreading growth characteristics. Radionuclide transport through vegetation was also investigated and was not considered to be a major transport pathway at the site.

The data in this paper could be used by ecological risk assessors to calculate site-specific soil-to-plant uptake factors for ^{238}Pu, $^{239,240}Pu$, ^{241}Am, ^{90}Sr, and ^{137}Cs for the INEL site. Uptake factors would be calculated by dividing the average plant concentration of a nuclide (picoCuries per gram [pCi/g] dry weight [DW]) by the nuclide's average soil concentration (pCi/g DW). Indeed, the data from this publication were used by E & E to calculate a site-specific plant uptake factor for ^{90}Sr for crested wheatgrass (see Appendix A, Case Study).

Arthur and Gates (1988). Soil ingestion rates were estimated for the pronghorn (*Antilocapra americana*) and black-tailed jackrabbit (*Lepus californicus*). The mean soil intake rates for pronghorn and jackrabbit were 48.7 and 9.7 grams per day (g/d), respectively. Soil comprised 5.4% and 6.3%, respectively, of the pronghorn and jackrabbit total dry matter intake. For both species, the estimated percentage of elemental intake attributable to soil was 75% for Na, Fe, V, and F and 10 to 50% for Mn, Cr, Mg, Ni, K, and Zn. Vegetation consumption resulted in greater than 90% of the daily intake of Ca, Cu, and P.

Table C-1. INEL publications and their applicability to ecological risk assessment.

Publication	Problem Formulation	Analysis	Risk Characterization
Abbott et al. (1991)	X	X	
Anderson (1986)	X		X
Anderson and Holte (1981)	X		X
Anderson and Marlette (1986)	X		X
Arthur (1982)	X	X	X
Arthur and Gates (1988)		X	
Arthur and Janke (1986)	X	X	X
Arthur and Markham (1982)	X	X	X
Arthur and Markham (1983)	X	X	
Arthur and Markham (1984)	X	X	
Arthur et al. (1984)	X		
Arthur et al. (1986)	X	X	
Arthur et al. (1987)	X	X	
Blom et al. (1991a)	X	X	
Blom et al. (1991b)	X	X	
Cholewa and Henderson (1984)	X		
Clark and Blom (1992)		X	
Connelly and Markham (1983)	X	X	X
Connelly et al. (1981)	X		X
Connelly et al. (1988)	X	X	
Corn (1993)	X		
Craig (1978)	X		
Craig (1979)	X		
Craig and Craig (1984)	X		
Craig and Renn (1977)	X	X	
Craig and Trost (1979)	X	X	X
Craig et al. (1979)	X	X	X
Craig et al. (1984)	X		X
Craig et al. (1985)		X	
Craig et al. (1986)	X		
Fraley et al. (1982)	X	X	X
French and Mitchell (1983)	X		X
Gates et al. (1985)			X
Genter (1986)	X		
Gleason and Johnson (1985)	X	X	
Groves and Keller (1983)	X		X
Groves and Keller (1986)	X	X	
Guyer and Linder (1985a)	X		
Guyer and Linder (1985b)	X	X	

Table C-1. (continued).

Publication	Problem Formulation	Analysis	Risk Characterization
Halford (1983)	X	X	
Halford (1987)	X		
Halford and Markham (1978)	X	X	
Halford and Markham (1984)		X	
Halford and Millard (1978)	X		
Halford et al. (1981)	X	X	
Halford et al. (1982a)	X	X	
Halford et al. (1982b)	X	X	
Hironaka et al. (1983)	X		
Howe and Flake (1988)	X	X	
Howe and Flake (1989a)	X	X	
Howe and Flake (1989b)	X	X	X
Ibrahim and Culp (1989)	X	X	
Janke and Arthur (1985)	X	X	
Johnson and Anderson (1984)	X	X	
Knick (1990)	X	X	X
Koehler and Anderson (1991)	X	X	
Kuzo et al. (1984)	X	X	
Laundre (1989a)	X	X	
Laundre (1989b)	X	X	
Linder and Sehman (1977)	X		
MacCracken and Hansen (1982a)	X		
MacCracken and Hansen (1982b)	X		
MacCracken and Hansen (1984)	X		
Markham (1974)	X	X	
Markham (1978)	X	X	
Markham and Halford (1982)	X	X	X
Markham and Halford (1985)	X	X	
Markham and Trost (1986)	X	X	
Markham et al. (1978)	X	X	
Markham et al. (1979)		X	
Markham et al. (1980a)		X	
Markham et al. (1980b)		X	
Markham et al. (1982)		X	
Markham et al. (1983)	X		
Markham et al. (1988)		X	
Millard et al. (1983)	X	X	
Millard et al. (1990)	X	X	X

Table C-1. (continued).

Publication	Problem Formulation	Analysis	Risk Characterization
Mullican (1986)	X		
Mullican and Keller (1986)	X	X	
Mullican and Keller (1987)	X		
Reynolds (1979)	X		
Reynolds (1980)	X		
Reynolds (1981)	X	X	X
Reynolds (1990)	X		
Reynolds and Fraley (1989)	X		
Reynolds and Laundre (1988)	X		
Reynolds and Rich (1978)	X	X	X
Reynolds and Trost (1979)	X		X
Reynolds and Trost (1981)	X		X
Reynolds and Wakkinen (1987)	X		
Reynolds et al. (1986)	X		
Stafford et al. (1986)	X		
Stauber et al. (1980)			X
Watson (1984)	X	X	
Watson (1986)	X	X	
Woodruff and Keller (1982)		X	
Youtie et al. (1987)	X		

This article is significant because ingestion of soil is an important exposure pathway for some species of wildlife. The site-specific estimates of soil ingestion could be used as input parameters for exposure assessment. The paper also provides referenced estimates of average daily food ingestion rates for jackrabbits and pronghorn, which could be used for estimating exposure through the food chain for these animals. Data provided for element concentrations in plants (sagebrush and grass) and soil could be used to derive site-specific plant uptake factors for certain elements.

Arthur and Janke (1986). Eighteen wildlife species were sampled for radionuclides from solid waste storage and disposal areas at the Radioactive Waste Management Complex (RWMC) over a 24-month period. Deer mice (*Peromyscus maniculatus*) carcasses and hides had the highest concentrations of radionuclides (^{90}Sr, ^{137}Cs, ^{238}Pu, $^{239,240}Pu$, and ^{241}Am). These concentrations were significantly higher than control values. Cottontail (*Sylvalagus nuttallii*) carcasses also had ^{241}Am levels above background. Horned lark (*Eremophila alpestris*), sage grouse (*Centrocercus urophasianus*), and mourning dove (*Zenaida macroura*) tissue samples did not have radionuclide concentrations above control levels, and all radionuclides except ^{241}Am were below control levels in coyote feces.

Table C-2. Facilities and waste management areas represented by INEL publications.

Publication	Facility or Waste Management Area
Abbott et al. (1991)	INEL
Anderson (1986)	INEL
Anderson and Holte (1981)	INEL
Anderson and Marlette (1986)	INEL, PBF
Arthur (1982)	RWMC/SDA
Arthur and Gates (1988)	INEL
Arthur and Janke (1986)	RWMC/TSA, RWMC/SDA
Arthur and Markham (1982)	RWMC/SDA, TRA
Arthur and Markham (1983)	RWMC/SDA
Arthur and Markham (1984)	RWMC/SDA
Arthur et al. (1984)	INEL
Arthur et al. (1986)	RWMC/TSA, RWMC/SDA
Arthur et al. (1987)	RWMC/SDA
Blom et al. (1991a)	INEL
Blom et al. (1991b)	TRA
Cholewa and Henderson (1984)	INEL
Clark and Blom (1992)	INEL
Connelly and Markham (1983)	CFA, TRA, ICPP, RWMC
Connelly et al. (1981)	INEL
Connelly et al. (1988)	INEL
Corn (1993)	INEL
Craig (1978)	INEL
Craig (1979)	INEL
Craig and Craig (1984)	INEL
Craig and Renn (1977)	INEL
Craig and Trost (1979)	INEL
Craig et al. (1979)	ICPP, TRA
Craig et al. (1984)	INEL
Craig et al. (1985)	INEL
Craig et al. (1986)	INEL
Fraley et al. (1982)	ICPP
French and Mitchell (1983)	INEL
Gates et al. (1985)	INEL
Genter (1986)	INEL
Gleason and Johnson (1985)	INEL
Groves and Keller (1983)	RWMC/SDA
Groves and Keller (1986)	RWMC/SDA
Guyer and Linder (1985a)	INEL
Guyer and Linder (1985b)	INEL
Halford (1983)	TRA

Table C-2. (continued).

Publication	Facility or Waste Management Area
Halford (1987)	TRA
Halford and Markham (1978)	TRA
Halford and Markham (1984)	TRA
Halford and Millard (1978)	TRA
Halford et al. (1981)	TRA
Halford et al. (1982a)	TRA
Halford et al. (1982b)	TRA
Hironaka et al. (1983)	INEL
Howe and Flake (1988)	INEL
Howe and Flake (1989a)	INEL
Howe and Flake (1989b)	INEL
Ibrahim and Culp (1989)	TRA
Janke and Arthur (1985)	RWMC/TSA, RWMC/SDA
Johnson and Anderson (1984)	INEL
Knick (1990)	INEL
Koehler and Anderson (1991)	RWMC/SDA
Kuzo et al. (1984)	TRA
Laundre (1989a)	INEL
Laundre (1989b)	INEL
Linder and Sehman (1977)	INEL
MacCracken and Hansen (1982a)	INEL
MacCracken and Hansen (1982b)	INEL
MacCracken and Hansen (1984)	INEL
Markham (1974)	INEL
Markham (1978)	RWMC/SDA
Markham and Halford (1982)	TRA, RWMC, ARA, TAN, LOFT, NRF, ICPP, EBR-II
Markham and Halford (1985)	ICPP
Markham and Trost (1986)	INEL
Markham et al. (1978)	RWMC/SDA
Markham et al. (1979)	ICPP, INEL
Markham et al. (1980a)	ICPP, INEL
Markham et al. (1980b)	INEL
Markham et al. (1982)	ICPP
Markham et al. (1983)	ICPP
Markham et al. (1988)	TRA
Millard et al. (1983)	INEL
Millard et al. (1990)	TRA
Mullican (1986)	INEL

Table C-2. (continued).

Publication	Facility or Waste Management Area
Mullican and Keller (1986)	RWMC
Mullican and Keller (1987)	INEL
Reynolds (1979)	INEL
Reynolds (1980)	INEL
Reynolds (1981)	INEL
Reynolds (1990)	RWMC/SDA
Reynolds and Fraley (1989)	RWMC/SDA
Reynolds and Laundre (1988)	INEL
Reynolds and Rich (1978)	INEL
Reynolds and Trost (1979)	INEL
Reynolds and Trost (1981)	INEL
Reynolds and Wakkinen (1987)	INEL
Reynolds et al. (1986)	INEL
Shumar et al. (1982)	
Stafford et al. (1986)	INEL
Stauber et al. (1980)	INEL
Watson (1984)	INEL
Watson (1986)	INEL
Woodruff and Keller (1982)	INEL
Youtie et al. (1987)	INEL

—

Key:

ANL = Argonne National Laboratory.
ARA = Auxiliary Reactor Area.
CFA = Central Facilities Area.
EBR-II = Experimental Breeder Reactor-II.
INEL = The publication was not WAG-specific but was conducted within the INEL boundaries.
ICPP = Idaho Chemical Processing Plant.
LOFT = Loss-of-Fluids Test Facility.
NRF = Naval Reactors Facility.
PBF = Power Burst Facility.
RWMC = Radioactive Waste Management Complex.
SDA = Subsurface Disposal Area at the RWMC.
TAN = Test Area North.
TRA = Test Reactor Area.
TSA = Transuranic Storage Area at the RWMC.

This paper is a useful summary of the wildlife radionuclide research conducted at the SDA. The data indicate the importance of small mammals as vectors for radionuclide uptake and transport. On the other hand, the birds studied at the SDA do not appear to be receiving significant radionuclide doses, although birds preying on small mammals were not investigated. The information presented in this paper is particularly pertinent to identification of receptors and pathways during Problem Formulation for sites containing buried nuclear waste. In addition, the levels of radionuclide contamination reported for various wildlife species could be useful during Analysis and Risk Characterization.

Arthur and Markham (1982). Coyote fecal samples were collected at two sites on the INEL and at an offsite control area. One site was a liquid radioactive waste pond located at Test Reactor Area (TRA) and the other was a solid radioactive waste pit located at the RWMC/SDA. The fecal samples of coyotes at TRA had elevated concentrations of ^{137}Cs, ^{90}Sr, and ^{238}Pu versus controls. The increased radionuclide content of the fecal matter was attributed to the coyotes' drinking water from the waste pond and/or consuming small mammals. Elevated ^{241}Am concentrations in coyote fecal samples collected at the RWMC/SDA were attributed to ingestion of small mammals. Export inventory calculations indicated that ^{90}Sr and ^{137}Cs accounted for 86%, 99%, and 99% of the radionuclide inventory estimates within a 6.3-km radius of each of the SDA, TRA, and control areas, respectively. The results indicate that coyotes can be a transport vector for radionuclides from contaminated sites, but they account for similar or lesser quantities of radionuclide export than other transport sources such as waterfowl and vegetative uptake.

This paper provides important information on transfer of radionuclides through the food chain at the INEL. The data could be used to develop food chain transfer coefficients or estimates of contaminant transport by animal vectors at contaminated sites. The levels of contamination in ecosystem components at TRA and RWMC have likely changed since this research was conducted, however, as a result of remedial activities and other physical changes at these sites.

Arthur and Markham (1983). Over a 2-year period, small mammals excavated 12,450 kilograms (kg) of soil to the 36-hectare (ha) surface of the SDA at the INEL. Elevated levels of ^{238}Pu, $^{239,240}Pu$, and ^{241}Am were detected in the excavated soils. A total calculated inventory of 66 microCuries (μCi) (^{90}Sr, ^{137}Cs, ^{238}Pu, $^{239,240}Pu$, and ^{241}Am), which was significantly greater than the 20 μCi estimated to occur in excavated soils at a control area, was transported to the surface by the excavations. The deer mouse (*Peromyscus maniculatus*), Ord's kangaroo rat (*Dipodomys ordii*), montane vole (*Microtus montanus*), Great Basin pocket mouse (*Perognathus parvus*), and Townsend's ground squirrel (*Spermophilus townsendii*) were the most frequently occurring species. Northern pocket gophers (*Thomomys talpoides*) were less than 1% of the species composition at the site but may have contributed significantly to the radionuclide transport to the surface soils due to their large excavations.

This article demonstrates the importance of burrowing small mammals as vectors of radionuclide transport at the SDA. The cap has been thickened in recent years, however, and the extent of transport at the site has likely been decreased as a consequence. Even at the time this study was conducted, it was concluded that small mammal excavations had not deposited appreciable quantities of ^{137}Cs and ^{90}Sr on the SDA soil surface. Transport of the transuranics ^{238}Pu, $^{239.240}Pu$, and ^{241}Am was more significant but was considered by the

authors to be a relatively minor source compared to previous releases to surface soils from flooding and subsequent wind transport at the site. The potential for burrowing small mammals to transport contaminants from the subsurface at specific WAGs should be carefully evaluated by risk assessors.

Arthur et al. (1984). This report presents a comprehensive list of the vertebrates occurring on the INEL. Abundance, habitat use, and seasonal occurrence are described for each species. According to the article, five fish, one amphibian, nine reptile, 159 bird, and 37 mammal species have been recorded at the INEL. Some discussion of species of concern at the state and federal level is also provided. In conjunction with Reynolds et al. (1986), this report is useful for identifying endpoint species and for setting exposure parameters for wildlife.

Arthur et al. (1986). Deer mice and kangaroo rats [*Diposomus ordii* (Woodhouse)] were live-trapped intermittently for 14 months after the cap was placed on the waste burial pit. Deer mice were the most numerous. Thermoluminescent dosimeters (TLDs) were implanted in a representative sample of the trapped small mammals, and 53% of the TLDs were recovered. An estimated 49% of the deer mice and 20% of the kangaroo rats were exposed to areas of buried waste and/or contaminated soil. Dose rates to small mammals on or near the waste burial pit were significantly higher than those in a control area. Also, during the winter, dose rates were higher and a higher percentage of the small mammals at the burial pit received doses greater than control mammals. This was felt to be due to more time spent in the subsurface soils during the colder months.

One objective of an ERA for a site contaminated with radionuclides is to calculate the radiation dose rate to animals at the site. Because this publication presents measured radiation dose rates to small mammals, it can be used as a "reality check" by risk assessors attempting to model radiation exposure to small mammals at the INEL site. It is important to note that the radiation dose rates reported in this paper are combined dose rates for all nuclides to which the receptors were exposed and are for the whole body, not for specific tissues or organs. Risk assessors interested in the exposure of specific tissues to radionuclides in small mammals should see Arthur et al. (1987).

Arthur et al. (1987). Concentrations of ^{90}Sr (1.2 to 3,600 pCi/g), ^{137}Cs (0.32 to 437 pCi/g), ^{238}Pu (0.0006 to 0.12 pCi/g), $^{239,240}Pu$ (0.0006 to 0.12 pCi/g), and ^{241}Am (below detection limit to 0.07 pCi/g) were determined in the carcasses (whole body gamma count) of deer mice collected at the solid radioactive waste burial pit on the INEL. The concentrations were also determined for lungs, gastrointestinal tracts, and hides of deer mice. Significantly higher concentrations of radionuclides were found in the gastrointestinal tracts (^{137}Cs, ^{238}Pu, $^{239,240}Pu$, and ^{241}Am), hides (^{238}Pu, and $^{239,240}Pu$), carcasses (^{137}Cs, and ^{90}Sr), and lungs (^{238}Pu) of the deer mice from the burial pit versus controls. Both surface and subsurface soils appeared to be responsible for the contamination of the mice. A total minimum inventory of 22.8 μCi of radioactivity was estimated to be contained in deer mice tissues over the entire area of the burial pit, and 22.7 μCi of this was due to ^{90}Sr and ^{137}Cs. An estimated 28.8 μCi was deposited on the burial pit surface due to deer mice feces and 8.4 μCi was estimated to be transported from the pit to the surrounding environs.

This paper will appeal to risk assessors interested in the exposure of small mammals to radionuclides at the INEL site. . The data on radionuclide activities in various tissues of deer mice clearly show that radionuclides are not distributed uniformly in small mammals. For example, ^{90}Sr activity in a deer mouse carcass was 10 to 100 times greater than in the lungs or gastrointestinal tract, most likely as a result of the association of ^{90}Sr with bone in the carcass. This paper does not present radiation dose rates to deer mice, but the data on radionuclide levels in tissues and carcass could be used to calculate the internal radiation dose rate from radionuclides in the body. Risk assessors interested in the radiation dose rates received by small mammals at the INEL site should see Arthur et al. (1986) and Halford and Markham (1978).

Connelly and Markham (1983). Movements and radionuclide concentrations in the muscle and gastrointestinal tract of sage grouse (*Centrocercus urophasianus*) summering near nuclear facilities of the INEL were studied from 1977 to 1980. The majority of grouse were located within 2 kilometers (km) of feeding areas on lawns surrounding the facilities during the summer months but were not near the facilities after September or mid-November. The grouse remained near the facilities for a mean number of 95 days/year (d/y). Mean radionuclide concentrations in muscle (0.29 pCi/g; $\underline{n} = 29$) and gastrointestinal tract (0.80 pCi/g; $\underline{n} = 29$) of sage grouse were higher at the TRA and Idaho Chemical Processing Plant (ICPP) than at offsite control areas. ^{51}Cr had the highest average concentration in the gastrointestinal tract and ^{137}Cs had the highest average concentration in muscle tissue. Levels of radionuclides in birds at the RWMC were not significantly higher than levels in control birds.

This paper is important for risk assessors because sage grouse are identified as commonly using facility lawns for feeding and loafing and are, therefore, potentially exposed to site contaminants. However, the concentrations of radionuclides in sage grouse were generally lower than those reported for waterfowl and mourning doves in the same areas. This was likely a result of the greater use of TRA ponds by these other birds and the comparatively greater summer home range of sage grouse. Potential exposure of sage grouse and other birds should be evaluated on a site-specific basis during Problem Formulation.

Craig et al. (1979). Concentrations of gamma-emitting radionuclides were determined in young from 17 nests of three species of raptor: American kestrel, long-eared owl, and marsh hawk. The nests were located near ICPP or TRA. Food habits were determined by examination of castings and prey remains found at the nests. Rodents captured near the TRA waste ponds were also analyzed for gamma radiation. ^{137}Cs had the highest concentration of any radionuclide. Northern harriers measured at 11 and 21 days of age had the most radionuclides detected (9) at the highest levels (up to 87 pCi/g). The American kestrel also had several radionuclides detected (8) with activity levels (up to 44 pCi/g) below those found in harriers. Long-eared owls monitored at 15 days of age had very few radionuclides detected (0 to 1) and had very low levels of activity (up to 0.4 pCi/g). Levels of radionuclides in the raptors' prey were approximately 4 to 290 times greater than the levels in the raptors at TRA. Doses to raptors from internal gamma radiation were estimated to range from 0 to 0.1 millirems per day (mrem/d). Based on these results, the authors suggest that raptors were exposed to radionuclides through their prey. Concentrations in raptors were diluted relative to their prey, most likely as a result of consumption of uncontaminated prey.

This article is significant for risk assessors in that it provides data on radionuclide exposure for raptors at the INEL and transfer through the terrestrial food chain.

Fraley et al. (1982). Thyroids were collected from four species of rabbits on and near the INEL and analyzed for ^{129}I and ^{127}I. Fifty-nine of 63 rabbits collected from the INEL had detectable concentrations of ^{129}I; and the $^{129}I/^{127}I$ ratios for rabbits on the INEL, especially the ICPP, were higher than those from control areas off the INEL. The highest ^{129}I concentration was 25 pCi/g and the highest $^{129}I/^{127}I$ ratio was 9.1×10^{-4}. Only one control rabbit had detectable ^{129}I concentrations (13 pCi/g) and a ratio of 3.9×10^{-7}. The highest concentrations of iodine were in areas downwind from the ICPP.

Dose rates from the ^{129}I in rabbit thyroids were calculated and ranged from 0.1 to 260 microGrays per year (μGy/y) for all rabbits with detectable concentrations of ^{129}I on the INEL. For rabbits collected within 10 km of the ICPP, the average dose rate was estimated to be 24 μGy/y. These dose equivalent rates were considered negligible when compared to the average background dose from terrestrial and cosmic radiation on the INEL or when compared to human health standards.

This article contains useful information on exposure to ^{129}I for herbivorous wildlife across the INEL. Rabbits have a relatively small home range; therefore, the levels of ^{129}I reported in rabbit thyroids are good indicators of the spatial extent of contamination. This paper establishes the ICPP as a source of radioactive iodine to the INEL terrestrial ecosystem. The information in this paper could be useful at any stage of an ERA (e.g., identifying stressors and endpoints, evaluating exposure, characterizing risks).

Groves and Keller (1983). Species composition, diversity, biomass, and densities of small mammal populations were examined over a 15-month period in crested wheatgrass (*Agropyron cristatum*) and Russian thistle (*Salsola kali*) on the SDA and on a sagebrush (*Artemisia tridentata*) control area. The deer mouse (*Peromyscus maniculatus*) was the most numerous species in all habitats. Species diversity was highest in the control sagebrush habitat, but overall densities did not vary significantly between the three vegetation types or between the waste burial pit area and control area.

Groves and Keller (1986). The range of movements of small mammals on a radioactive waste disposal area was measured. The maximum distance traveled by small mammals was approximately 50 meters (m). This suggests significant contamination from the site is not transported far from the site.

Halford (1983). Deer mice, Ord's kangaroo rats, western harvest mice (*Reithrodontomys megalotis*), and Great Basin pocket mice were the most common small mammals at a liquid radioactive waste disposal area on the INEL. The number of small mammals was estimated to be 31/ha and the average distance between consecutive captures for all species combined was 41 m and ranged from 7 to 201 m. Approximately 30% of the animals trapped within the boundaries of the area were also captured outside of the boundaries. The total population inventory of ^{238}Pu, $^{239,240}Pu$, ^{241}Am, ^{242}Cm, and ^{244}Cm was 44, 30, 19, 21, and <1 pCi, respectively. It appeared that about one-third (35 pCi) of transuranics could be translocated from the waste area by small mammals.

The information in this paper on the activities of ^{238}Pu, $^{239,240}Pu$, ^{241}Am, ^{242}Cm, and ^{244}Cm in the carcass and tissues of small mammals has three potential uses for ecological risk assessors: (a) to calculate site-specific bioaccumulation factors (BAFs) for rodents at the INEL site (assuming soil activities of these nuclides have been measured); (b) as a "reality check" by risk assessors modeling transfer of these nuclides in terrestrial food chains (i.e., small mammals consume plant materials from the site and in turn are consumed by raptors and coyotes); and (c) to calculate internal radiation dose rate. Other papers presenting information on radionuclide levels in small mammals from the INEL Site include Arthur et al. (1987), Arthur and Markham (1983), Halford and Markham (1978), and Markham et al. (1978).

Halford and Markham (1978). Small mammals were live trapped in a dry liquid radioactive waste pond at the TRA and had TLDs implanted. Upon recapture, the TLDs were removed and dose rates were determined. Deer mice (*Peromyscus maniculatus*) were the most numerous species trapped. All species captured on the site received significantly greater doses than controls. The mean deer mouse dose equivalent rate was 160 mrem/day (range 7 to 982 mrem/day), which was 356 times the dose rate received by control deer mice. These dose rates would result in a 1-year lifetime average exposure of 58 rem with a maximum exposure of 358 rem. Deer mice also had the highest radionuclide concentrations in whole body tissues. The contribution of internal radionuclides to the measured dose was stated as negligible; however, as whole body radionuclide counts increased, so did internal dose rates. This indicates that the internal dose rate may become significant for the more highly exposed individuals (>100 pCi/g whole-body inventory).

Because this paper presents measured radiation dose rates to small mammals at the INEL, it can be used as a "reality check" by risk assessors attempting to estimate small mammal exposure to radionuclides. The paper presents the total whole-body radiation dose (as measured by surgically implanted dosimeters) and the internal, whole-body radiation dose (calculated from measured radionuclide activities in the body). The total whole-body dose was considerably greater than the internal whole-body dose and, thus, suggests that deer mice, kangaroo rats, and chipmunks at INEL receive a greater radiation dose from the surrounding environment than from consumption of contaminated food. This observation should be considered by risk assessors when estimating radiation doses to small mammals at the INEL. A similar study on radiation dose rates received by small mammals at the INEL is described by Arthur et al. (1986).

Halford and Markham (1984). Wild free-ranging waterfowl were collected from the liquid radioactive waste pond at the TRA and on control areas to determine the $^{129}I/^{127}I$ ratios in muscle tissue. Wing-clipped mallards were also released on test and control areas for from 2 to 156 days before collection and testing. The mean iodine ratios for wild waterfowl were not significantly different between test and control areas. However, the wing-clipped waterfowl iodine ratios from the waste pond were significantly higher than all the other tested birds. Although there was no significant correlation between time spent on the waste pond and iodine ratios, the authors felt it was the most likely reason for the higher iodine ratios in wing-clipped mallards. The total whole-body dose from ^{129}I ranged from 1.0×10^{-5} mrad for control waterfowl to 3.0×10^{-5} mrad for waste pond waterfowl.

Halford et al. (1981). Wild waterfowl were collected from a liquid radioactive waste pond at the INEL and analyzed for radionuclide content. Up to 29 radionuclides were found in body tissues of the waterfowl. Eighty percent of the total radioactivity in the collected waterfowl tissues was from radionuclides with half-lives less than 1 year. Those radionuclides with half-lives of less than 15 hours were not detected due to their radioactive decay before analysis. The highest sum of all radionuclide concentrations occurred in the gastrointestinal tract, followed by feathers, liver, muscle, and skin. Certain radionuclides concentrated to a greater extent in some of the tissues versus others and the total average radionuclide concentration in wild waterfowl was 27,798 pCi/g fresh weight. ^{60}Co and ^{137}Cs were the only two radionuclides detected in control waterfowl tissues at levels below 1 pCi/g.

The data in this paper on the activities of 29 gamma-emitting radionuclides in waterfowl have three potential uses for ecological risk assessors: (a) to calculate site-specific BAFs for waterfowl at the INEL site (assuming sediment and water activities of the nuclides have been measured); (b) as a "reality check" by risk assessors modeling transfer of radionuclides to waterfowl at the site; and (c) to calculate internal radiation dose rates. In addition, the paper may be of use to human-health risk assessors because it estimates the radiation dose to a human from consumption of contaminated waterfowl.

Halford et al. (1982a). ^{137}Cs and ^{134}Cs were the two radionuclides most responsible for internal and external doses to wild, free-ranging waterfowl from a liquid radioactive waste pond at the INEL. Other contributors included ^{51}Cr, ^{58}Co, ^{60}Co, ^{66}Zn, ^{75}Se, and ^{131}I. The lowest and highest average internal doses for individual species were 330 mrad (range 1 to 1,300 mrad, $\underline{n}$ = 6) for the lesser scaup (*Aythya affinis*) and 2,000 mrad (range 40 to 4,000, $\underline{n}$ = 2) for the American coot (*Fulica americana*), respectively. An average internal dose for all wild waterfowl (700 mrad) was added to the ventral and dorsal external dose to get the average total dose rate (1,900 mrad) for a wild waterfowl residing at the ponds for 6 days. Due to modeling factors and other assumptions, these estimates likely overestimate the actual exposure, possibly by a factor of five or more. Wing-clipped mallards held on the ponds for 43 to 145 days also had the internal, external, and total doses calculated. Waterfowl residing on the ponds for 145 days were exposed to an average total dose of 32,145 mrad.

Because this publication presents measured radiation dose rates to waterfowl and radionuclide activity in waterfowl muscle, it can be used as a "reality check" for risk assessors attempting to model waterfowl exposure to radionuclides at the INEL site. It is interesting to note that waterfowl contained higher radionuclide concentrations and received higher doses from internal radionuclides than other birds and small mammals studied near the liquid radioactive waste disposal area (cf. Halford and Markham 1978).

Halford et al. (1982b). The biological elimination of nine gamma-emitting radioisotopes was studied in wing-clipped mallards held on a liquid radioactive waste pond at the INEL. Whole-body and feces-urine radioactivity counts were made for 51 days after the ducks were removed from the pond, then they were dissected and tissue analyzed. Body burdens of nine radionuclides were at an average of 90% of equilibrium with the radioactive waste pond water after 68 days on the pond. The biological half-lives in the mallards were 10 days (^{134}Cs), 10 days (^{131}I), 11 days (^{137}Cs), 22 days (^{140}Ba), 26 days (^{75}Se), 32 days (^{58}Co), 67 days (^{66}Zn), 67 days (^{67}Co), and 86 days (^{51}Cr). The gastrointestinal tract had the highest concentrations

of radionuclides immediately after removal from the ponds, followed by the feathers, liver, and muscle. After 51 days, the feathers had the highest concentrations followed by the liver, muscle, and gut.

Ibrahim and Culp (1989). Concentrations of ^{239}Pu, ^{240}Pu, and ^{238}Pu were determined in water, net plankton, suspended particulates, and sediment at the TRA waste ponds. The oxidation states of plutonium were also measured and found to be mostly Pu^{+3} and Pu^{+4}, unlike larger natural water bodies, which usually support plutonium in the +5 and +6 oxidation states. The highest plutonium concentrations were found in net plankton, but sediments were found to be the main reservoir for plutonium in the pond. The lowest plutonium concentrations were in filtered water. This indicates that the plutonium is taken up by or bound to the plankton in the water column before eventually settling to the bottom sediments where it remains.

Janke and Arthur (1985). The authors studied the transport of radionuclides by cottontail rabbits (*Sylvilagus nuttalli*) from a solid radioactive waste disposal site at the INEL. The mean movement distance for the rabbits was 90 m and the maximum distance by any one rabbit was 839 m. ^{90}Sr and ^{137}Cs were the most frequently detected radionuclides of eight detected compounds (^{51}Cr, ^{54}Mn, ^{57}Co, ^{60}Co, ^{90}Sr, ^{134}Cs, ^{137}Cs, and ^{140}Ba). Six other gamma-emitting radionuclides (^{7}Be, ^{40}K, ^{208}Tl, ^{212}Pb, ^{214}Pb, and ^{214}Bi) were not considered or measured in this investigation because they were considered to occur naturally in the environment. Ninety-six percent of the disposal area rabbit radionuclide body burden was due to ^{90}Sr and ^{137}Cs. A total of 11.2 nCi occurred in the rabbits from the disposal area and 13.2 nCi would have occurred in a similar number of control rabbits. Given this low amount of radioactivity, it was concluded that very little transport of radioactivity would be facilitated by the rabbits.

Koehler and Anderson (1991). Habitat use and food selection data were collected for deer mice, montane voles, Ord's kangaroo rats, and Townsend's ground squirrels at the INEL. Significantly more captures occurred in the native sagebrush habitat than in areas planted in crested wheatgrass or in disturbed sites, but over 30% of the captures were in the wheatgrass. Voles and ground squirrels used the crested wheatgrass throughout the summer, while deer mice and kangaroo rats used the grass heavily only after seed set.

The small mammal ecology studied during this paper is most useful for determining ecological endpoints for an area based upon the type of dominant vegetation present. This is an important part of the problem formulation. A useful discussion of habitat use patterns could help define the exposure models during the analysis phase of ERA.

Kuzo et al. (1984). The distribution and kinetics of ^{238}Pu, $^{239,240}Pu$, ^{241}Am, ^{242}Cm, and ^{244}Cm were studied in abiotic and biotic components of test reactor leaching ponds located on the INEL from June to July 1979. Highest transuranium concentrations were recorded for seston and periphyton with lowest concentrations for filtered water. Concentration ratios for each nuclide differed among components with highest values recorded for seston and periphyton matrices (10^4 to 10^5) and lowest values for sediments (10^2 to 10^3). Concentration ratios were similar for all plankton types (10^4). For each component, plutonium isotope concentration ratios were consistently higher than values for americium and curium nuclides. Intra-element differences were observed for concentration ratios between the isotopes of plutonium

($^{239,240}Pu > {}^{238}Pu$) and also the isotopes of curium ($^{244}Cm > {}^{242}Cm$). An in situ experiment monitoring sorption of the five transuranium isotopes by soil resulted in continued nuclide accumulation throughout a 15-day experiment with the overall soil nuclide concentrations positively correlated with nuclide concentrations in filtered water and/or seston. Model parameter estimates describing the fractional rates of increase were similar among ^{238}Pu, ^{241}Am, ^{242}Cm, and ^{244}Cm ranging from 4.4 to 0.59×10^{-3}/h to 6.0×10^{-3}/h. In contrast, this value for $^{239,240}Cs$, 1.3×10^{-3} was lower than for the other nuclides. Possible explanations for the observed similarities and differences in the distribution and kinetics of the five transuranium nuclides are discussed.

Markham (1974). Routine environmental monitoring results are presented for the air, soil, surface water, and groundwater of the INEL in 1973. The data from onsite and nearby community sampling locations were compared to background concentrations and the applicable standards established by the U.S. Atomic Energy Agency. Some concentrations of radionuclides in air, soil, and surface water were above background concentrations but are infrequent and generally near known source areas for radionuclides.

Markham (1978). Small mammals and soil samples were collected in 1972 and 1973 near the solid radioactive waste disposal area at the INEL and tested for activation and fission radionuclides. Levels of radioactivity in pooled deer mice tissues from the eastern perimeter of the area had the highest radioisotope concentrations in hides (2,026 pCi/g), gastrointestinal tracts (415 pCi/g), lungs (86 pCi/g), and carcasses (145 pCi/g). Only 10 of approximately 95 mammals were responsible for these high levels. ^{137}Cs, ^{60}Co, and ^{90}Sr were the most frequently detected radionuclides in soils, but seven other radionuclides were also detected. The average ^{137}Cs concentration of 4.2 pCi/g (maximum 16.1 pCi/g) was nearly three times the background concentration. Average ^{60}Co concentration (2.3 pCi/g; maximum 11.3 pCi/g) was 300 times the background, and average ^{90}Sr (6.8 pCi/g; maximum 26 pCi/g) was 15 times background. These increased levels of radionuclides rapidly decreased to near background concentrations at 350 m from the site.

Markham and Halford (1982). ^{137}Cs occurred frequently in mourning dove (*Zenaida macroura*) tissues from several areas on the INEL. The highest average concentrations in dove muscle tissue were found at the TRA and ICPP at 15.85 pCi/g (1976) and at 3.24 pCi/g (1974), respectively. Average radionuclide concentrations in the gastrointestinal tract of the doves were found to be highest (41.1 pCi/g) at the TRA. Twenty other radionuclides were detected in dove tissues and, of these, ^{134}Cs, ^{131}I, ^{60}Co, and ^{51}Cr were the most significant contributors to the total radiation dose for the dove.

This paper is of interest to risk assessors in that it documents mourning dove exposure to radionuclides at seven INEL facilities [TRA, ICPP, RWMC, Test Area North (TAN), Experimental Breeder Reactor-II (EBR-II), Auxiliary Reactor Area (ARA), and Naval Reactors Facility (NRF)] as well as several other locations. According to the authors, the radiation dose rates received by doves are similar to or less than the doses received by raptors, deer mice, or barn swallows studied at the TRA and ICPP. The exposure routes for doves at various sites are discussed, including drinking and feeding. The levels of radionuclides reported for doves could be used to estimate the potential exposure to dove predators such as raptors.

Markham and Halford (1985). During 1975, additional prefilters and high-efficiency particulate air (HEPA) filters were added to the existing air filtering system for atmospheric effluents from the ICPP at the INEL. Prior to filter installation, the pronghorn muscle and liver samples collected near the ICPP averaged 13 (0.57 pCi/g) and 18 (1.04 pCi/g) times, respectively, of the ^{137}Cs concentrations found in the same tissues of control animals (0.04 and 0.06 pCi/g for muscle and liver, respectively). Muscle and liver samples collected after filter installation (0.05 and 0.07 pCi/g for muscle and liver, respectively) had only 2.5 times the ^{137}Cs concentrations found in control samples (0.02 and 0.03 pCi/g in muscle and liver, respectively).

Markham et al. (1978). From 1954 to 1970, transuranic waste from the Rocky Flats facility near Golden, Colorado, was shipped to the INEL and buried in the SDA at the RWMC. Soil samples collected near the SDA indicate that this storage has resulted in transuranic contamination outside the SDA perimeter. Maximum concentrations in surface soils (0 to 4 cm) occurred in the drainage depression near the perimeter of the SDA and were 2,048 nCi $^{241}Am/m^2$, 1,377 nCi $^{239}Pu/m^2$, and 32 nCi $^{238}Pu/m^2$. Contamination outside this drainage channel was lower and has primarily spread in the northeast-southwest directions. The maximum distance from the SDA perimeter at which above background concentrations of ^{241}Am, ^{239}Pu, and ^{238}Pu could be detected was approximately 2,500, 2,400 and 1,000 m, respectively. Surface water runoff in 1962 and 1969 and wind transport appear to be the primary mechanisms that transported these nuclides out of the SDA. The vertical soil migration of ^{238}Pu from 0 to 4 cm to the 4 to 8 cm depth was significantly greater than that for ^{239}Pu ($P = 0.001$). Hides and gastrointestinal tracts for deer mice (*Peromyscus manicu-latus*) from two of the four study areas had higher concentrations of transuranics than lungs or carcass. Ingestion appeared to be a more important mechanism than inhalation in the intake of transuranics into the deer mice. The $^{241}Am/^{239}Pu$ ratio in the carcass was significantly ($P = 0.02$) higher than the ratio in soil indicating a greater uptake of ^{241}Am in deer mice. The data indicated that ^{238}Pu, ^{239}Pu, and ^{241}Am may behave differently in the terrestrial environment.

Markham et al. (1979). Ratios of ^{238}Pu to $^{239,240}Pu$ in the lungs of pronghorn from the INEL near the ICPP ranged from 0.7 to >3.5. These ratios were compared to those expected in soils of natural fallout areas (0.13) and from one pronghorn collected from an offsite area (0.15). The ratios from near the ICPP to up to 35 km away from the site (in predominant wind direction) are higher than the expected values. The ^{238}Pu concentrations in the lungs were calculated to correspond to an average annual dose of 0.1 mrad for lungs.

Markham et al. (1980a). Metacarpal bones were collected from pronghorn antelope (*Antilocapra americana*) near a nuclear fuel reprocessing plant and adjacent areas in the INEL in southeastern Idaho. Control bones were collected from offsite animals at high elevations. Average concentrations in metacarpals were 9.6 pCi/g (ash) within 10 km of the ICPP, 4.0 pCi/g for animals on the remainder of the INEL, and 5.5 pCi/g for control animals. The ICPP atmospheric releases of ^{90}Sr appeared to have caused a significant ($P < 0.05$) increase in ^{90}Sr concentrations in pronghorn bones with 10 km of the ICPP as compared to bones of other INEL pronghorn. However, the ICPP pronghorn bone ^{90}Sr concentrations were not statistically different from that occurring in bones of the control animals from higher elevations. Antelope near the ICPP received approximately double the radiation doses to bone compared to dose received by other ICPP sources which resulted in an estimated average radiation dose of 40 mrad/yr to endosteal cells and 20 mrad/yr to active bone marrow.

Markham et al. (1980b). ^{131}I concentrations were determined in air, milk, and pronghorn (*Antilocapra american*) thyroids from southeastern Idaho during each year from 1972 to 1977. Samples were collected in the vicinity of the INEL, which has 17 operating nuclear reactors, a fuel reprocessing plant, and a nuclear waste management facility. Samples were also collected from control areas. During the study, fallout occurred from five Peoples Republic of China above-ground nuclear weapon detonations. All ^{131}I detected in air and milk samples was attributed to fallout from the Chinese nuclear tests. ^{131}I occurred in antelope thyroids during the five fallout periods and following at least one atmospheric release from facilities at the INEL. Thyroids were the most sensitive indicators of ^{131}I in the environment followed by milk and then air. Maximum concentrations in thyroids, milk, and air were 400, 20, and 4 times higher, respectively, than their respective detection limits.

Markham et al. (1982). From 1972 to 1976, rumen, lung, muscle, and liver tissues from pronghorn (*Antilocapra americana*) collected near the ICPP on the INEL, on adjacent INEL areas, and on offsite control areas were analyzed for gamma-emitting radionuclides. Although up to 14 radionuclides appeared in pronghorn rumen contents, only ^{137}Cs was consistently detected in muscle and liver samples. ^{137}Cs concentrations in pronghorn muscle from near (within 10 km) the ICPP averaged 384 pCi/kg and were higher than concentrations in other onsite pronghorn (53 pCi/kg) and offsite controls (38 pCi/kg). Concentrations of ^{137}Cs in the liver were slightly higher, and lung concentrations were much lower than muscle concentrations. Radiation doses to pronghorn from radionuclides reported in this and other studies were discussed in relation to the three study areas and are compared to doses pronghorn received from naturally occurring radionuclides. Pronghorn appear to be useful bioindicators of radionuclides in the environment.

Markham et al. (1983). Thyroids from mule deer (*Odocoileus hemionus*) were collected in New Mexico, Colorado, Wyoming, and Idaho; and $^{129}I/^{127}I$ atom ratios were determined. $^{129/127}I$ atom ratios were significantly ($P < 0.005$) different among states. Ratios in Wyoming and Idaho control thyroids were significantly larger than ratios in New Mexico and Colorado. Fallout from past atmospheric nuclear tests at the Nevada Test Site is suggested as a possible explanation for the differences in ratios. Average $^{129}I/^{127}I$ ratios in thyroids of other larger mammals collected 54 km west and 116 km northeast of the INEL in southeastern Idaho were up to 15 times greater than those found in control thyroid samples from Idaho. Atmospheric effluents from the ICPP located on the INEL were likely responsible for the increased ratios in animals collected in the INEL vicinity. ^{129}I in deer thyroids may be a sensitive indicator of contaminants from nuclear fuel processing plants and atmospheric nuclear tests or accidents.

Markham et al. (1988). Concentrations of ^{90}Sr, ^{238}Pu, $^{239,240}Pu$, ^{241}Am, ^{242}Cm, and ^{244}Cm were determined in tissues of mallard ducks (*Anas platyrhynochos*) maintained for 43 to 145 days on radioactive leaching ponds at the TRA. Highest concentrations of transuranics occurred in the gastrointestinal tract, followed closely by feathers. Approximately 75%, 18%, 6%, and 1% of the total transuranic activity in tissues analyzed were associated with the bone, feathers, gastrointestinal tract, and liver, respectively. Concentrations in gastrointestinal tracts were similar to concentrations in vegetation and insects in the littoral area of the ponds. The calculated total dose rate to the ducks from both ^{90}Sr and the transuranic nuclides was 0.69 mGy/d, of which 99% was to the bone. Based upon average concentrations in experimental ducks and on surveys of wild waterfowl using this area, a conservative estimate

of transuranic activity exported by wild ducks using the ponds during one year was 305 nCi. Similarly, the total amount of ^{90}Sr exported in muscle, bone, and lung of wild ducks in one year was 68.70 μCi.

Millard et al. (1983). Deposition velocities and retention times were obtained for submicron aerosols of ^{141}Ce and ^{134}Cs deposited in two cool desert plant species, big sagebrush (*Artemisia tridentata*) and bottlebrush grass (*Sitanion hystix*). Mean deposition velocities for sagebrush were 0.18 cm/s (^{141}Ce) and 0.13 cm/s (^{134}Cs). Species differences were significant; however, nuclide differences were not significant. The loss of activity on the vegetation consisted of two components. A rapid initial loss was found with effective half-times of approximately 1 day (1 to 8 days for ^{141}Ce and 0.6 day for ^{134}Cs) on sagebrush and approximately 2 days (2.8 days for ^{141}Ce and 2.3 days for ^{134}Cs) on grass. This was followed by a slower, long-term loss with effective half-times ranging from 11 days for ^{141}Ce and 15 days for ^{134}Cs on sagebrush to 9 days for ^{141}Ce and 11 days for ^{134}Cs on grass.

Millard et al. (1990). Concentrations of radionuclides and potential effects on barn swallows were examined at the TRA waste ponds. The swallows were found to feed on pond arthropods and use contaminated mud for nest building. More than 20 radionuclides were detected in immature and adult birds. ^{51}Cr was found in the highest concentrations and 72% of the total dose resulted from ^{24}Na. Total mortality rate of the swallows was not found to be different from control populations, but the first clutch of young swallows was found to have lower growth rates and lower body weights than controls. These depressed growth factors were not found to be below the normal range of values, however, and could not be attributed to exposure to radioactivity.

Reynolds et al. (1986). The relative abundance, habitat use, and seasonal occurrence are reported for the 6 fish, 1 amphibian, 9 reptile, 164 bird, and 39 mammal species recorded on the National Environmental Research Park in southeastern Idaho.

C-2.2 Publications Potentially Useful for Ecological Risk Assessment

Abbott et al. (1991). The root depths and lateral spread of two shrubs and four perennial grasses were investigated in disturbed and undisturbed soil. The two shrubs were big sagebrush (*Artemisia tridentata* ssp. *wyomingensis*) and green rabbitbrush (*Chrysothamnus viscidiflorus*) and the four grasses were crested wheatgrass (*Agropyron cristatum* L.), streambank wheatgrass (*Elymus lanceolatus*), basin wildrye (*Leymus cinereus*), and bottlebrush squirreltail (*Elymus elymoides*). Big sagebrush roots extended the most in disturbed soil, down to maximum of 1.25 m below the ground surface and had a maximum lateral reach of 0.6 m. Green rabbitbrush and basin wildrye roots extended the most in undisturbed soils down to 1.0 m. Basin wildrye had the maximum lateral reach of 0.9 m in both soil types.

This article could be of interest in determining from which soil depth contaminant data should be selected for use in the risk assessments, selecting the most appropriate measurements species, and for assessing potential uptake of contaminants from subsurface soils by various

plants. These procedures are important in both the problem formulation and analysis phases of ecological risk assessment.

Anderson (1986). Previously grazed sagebrush steppe plant communities of the INEL were monitored from 1950 to 1983 with regard to the succession of plant species. Although standard successional thought suggests a deterministic directional process from one species to another until the climax community composition is reached, this research does not support such a process. The total percent cover of shrubs and grasses varied over time but there was no sequential replacement of one species by another, and no consistent directional change in total cover or in the amount of cover provided by either shrubs or grasses. The results suggest a variety of relatively stable communities each made up of similar species but in different cover amounts. The continued dominance of the majority of plots by big sagebrush (*Artemisia tridentata*) and other stable characteristics of individual stands was attributed to "inertia" imparted by longevity of individuals and/or colonization of openings by propagules.

This publication will be helpful in discussions of the ecology of the INEL during problem formulations and may provide for a comparison to site-specific vegetation conditions during the discussion of potential risks in the risk characterization phase of the assessment. Within the risk characterization, this publication may help support the weight-of-evidence approach frequently used for ERA.

Anderson and Holte (1981). Data from previously grazed permanent vegetation transects, established at the INEL in 1950, indicate the total cover of shrubs and perennial grasses had nearly doubled by 1975. This occurred after all grazing was halted within the transects in 1950. The percent cover of grasses increased exponentially over the 25-year study period, but not at the expense of the shrub overstory. The population of big sagebrush was relatively stable.

This paper provides potentially useful information on plant community composition of relatively undisturbed areas of the INEL and long-term trends in vegetation change. This information may be most useful in the problem formulation phase during the ecosystem components and measurement species sections and in the risk characterization phase for discussion and presentation of risks to vegetation at an area versus what vegetation is present in undisturbed areas.

Anderson and Marlette (1986). The stability of crested wheatgrass stands at the INEL was investigated. Wheatgrass can invade and displace native species from an area. Once crested wheatgrass is established, especially as a monoculture, it becomes very difficult for native species to reestablish themselves in the wheatgrass area. Given its competitive advantages and higher reproductive rate, crested wheatgrass can displace many native species, especially in disturbed areas.

This article may be of interest to risk assessors for disturbed sites dominated by crested wheatgrass. It might be useful in the problem formulation phase or risk characterization phase of an ERA.

Arthur and Markham (1984). Polonium-210 concentrations were determined for soil (0.58 to 2.27 pCi/g), vegetation (0.06 to 4.90 pCi/g), deer mice carcasses (0.04 to 0.16 pCi/g), and deer mice hides (0.01 to 0.31 pCi/g) at a solid radioactive waste disposal area on the INEL. These values were compared to those from near a phosphate ore processing plant and from two rural areas in southeastern Idaho. The ^{210}Po concentrations at the waste disposal area were similar to those found at the two rural areas but the concentrations in soils, hide, and carcasses from near the phosphate ore processing plant were statistically significantly greater than all the other sampling locations. No differences were found between any of the ^{210}Po concentrations in vegetation among any of the locations. Vegetation (bunchgrasses)/soil, deer mouse carcass/soil, and deer mouse hide/soil concentration ratios were also calculated for each of the sites. For the waste disposal area these values ranged from 0.39 to 0.43, 0.05 to 0.08, and 0.01 to 0.14, respectively, for the vegetation, carcass, and hide.

This publication provides area specific and control (background) soil concentrations of ^{210}Po, which may be used for Contaminants of Potential Concern (COPC) identification in the problem formulation. The area specific soil, vegetation, and carcass ^{210}Po concentrations could also be used to calculate exposure point concentrations in the "Exposure" section of the analysis phase.

Blom et al. (1991a). Nest densities of harvester ants (*Pogonomyrmex salinus* Olsen) varied from 0 to 164/ha for different vegetation communities on the INEL. The highest mean nest density was found on plots within juniper communities, but the greatest density for a single area was found in sagebrush (*Artemisia tridentata wyomingensis*) communities. The authors hypothesize that soil characteristics may play a more important role than vegetation type in the determination of nest densities. This document cites other investigations that indicate that harvester ants may burrow to depths of 2.7 m below the ground surface.

Harvester ants may be important components of the ecosystem at some INEL hazardous waste sites (see also Blom et al. 1991b) and may need to be considered as a contaminant transport mechanism or measurement species in the problem formulation phase. The information in this paper may also help in the calculations of exposure during the analysis phase.

Blom et al. (1991b). Geometric mean concentrations of ^{137}Cs (10 Bq/g) and ^{60}Co (1.8 Bq/g) in harvester ant mounds near (0 to 6 m) the TRA liquid radioactive waste pond were higher than in soils surrounding the mounds or in offsite mounds. Mounds are created from vertical exhumation of soils by the ants as they build nests in the subsurface soil. The subsurface soil became contaminated with radionuclides due to movement of radioactive wastes from the ponds through adjacent soils. Erosion of contaminants from the mound to surrounding areas was not apparent. However, the authors suggest that radionuclide transport from the mounds cannot be ruled out, since colonies can persist up to 50 years and may undergo erosion by wind and rain during this period. Redistribution of radionuclides could also occur as a result of vertebrates digging in the mounds or due to harvester ant colony relocation.

These processes may be considered by risk assessors during problem formulation at those INEL hazardous waste sites where ant density is high. The concentrations of radionuclides

detected during this investigation may also be useful in the exposure assessment of the analysis phase of an ERA.

Cholewa and Henderson (1984). A 2-year study was conducted at the INEL regarding the abundance, distribution, and habitat features of eight rare plant taxa. *Astrogalus ceramicus* Sheld var. *apus* Barneby was found to be common on the INEL and adjacent areas and was recommended to be removed from further consideration at the federal level and placed on Idaho's Federal Watch List. *Coryphanta missouriensis* (Sweet) Britt. & Rose was also common but was recommended for retainment on Idaho's State Watch List. *Gymnosteris nudicaulis* (H. & A.) Greene and *Oxytheca dendroidea* Nutt. were also recommended for retention on the State Watch List. The remaining four taxa *Astragalus gilviflorus* Sheld., *Astragalus kentrophyta* Gray var. *jessiae* (Peck) Barneby, *Gilia polycladon* Torr., and *Lesquerella kingii* S. Wats. var. *cobrensis* Roll. & Shaw were unexpectedly encountered and recommended for the State Watch List.

Although this article is of potential use to risk assessors in characterizing the abundance and distribution of rare plants on the INEL, the occurrence of rare plants at specific WAGs is not discussed. It would appear, however, that based on the results of this investigation, no rare plants occur at the INEL with potential for listing by the federal government. This information should be considered during the problem formulation phase.

Clark and Blom (1992). A sage thrasher (*Oreoscoptes montanus*) was observed feeding on a mating swarm of harvester ants. The importance of the harvester ants and other insects of the INEL as dietary items in passerine diets is discussed and several references are provided.

The main use of this publication for risk assessment could be to help characterize diet and food habits of birds during analysis.

Connelly et al. (1981). Fifty-one sage grouse breeding display areas (leks) had been located on the INEL by 1981. Three of these leks were located on anthropogenically created clearings and this may indicate the potential for proactive sage grouse management in areas where leks are destroyed by anthropogenic or natural disturbances or where natural clearings are not available.

This article confirms the presence of sage grouse leks on the INEL. This solidifies the potential use of sage grouse as measurement species for ERA and presents information important in problem formulation. The article may also support risk characterization in that it provides some sage grouse management applications.

Connelly et al. (1988). Sage grouse seasonal movements were monitored on and adjacent to the INEL from the summer of 1977 to the fall of 1983. The grouse moved as far as 82 km from winter and breeding grounds to their summer range. Juveniles moved a mean distance of 14.9 km and adults moved a mean distance of 11.3 km. The seasonal movements did not appear to be dictated by vegetation and may be along traditional routes.

The sage grouse movement patterns presented in this publication suggest the grouse may be present only in a particular area for short periods. This may be helpful to know during problem formulation and for calculation of exposure during the analyses phase.

Craig (1978). Raptors of the INEL were surveyed along vehicle routes during the nonbreeding seasons from November 1974 to May 1976. The rough-legged hawk, American kestrel (*Falco sparverius*), and golden eagle were the most abundant species, respectively. Northern harriers (*Circus cyaneus*) and prairie falcons (*Falco mexicanus*) were also locally abundant in agricultural lands and river valleys, respectively.

The listings of abundance of the raptors will help in describing the ecosystem components and choosing measurement species during the problem formulation phase.

Craig (1979). During the non-breeding season the most numerous raptors found on the INEL were the rough-legged hawk, American kestrel, golden eagle, and prairie falcon. Northern harrier, ferruginous hawk (*Buteo regalis*), red-tailed hawk (*Buteo jamaicensis*), Swainson's hawk (*Buteo swainsoni*), great horned owl (*Bubo virbinianus*), short-eared owl (*Asio flammeus*), merlin (*Falco columbaris*), Cooper's hawk (*Accipiter cooperii*), bald eagle (*Haliaeetus leucocephalus*), and peregrine falcon (*Falco peregrinus*) were also observed on the INEL. Nesting raptor species included American kestrel, long-eared owl (*Asio otus*), ferruginous hawk, merlin, prairie falcon, red-tailed hawk, Swainson's hawk, golden eagle, great horned owl, and burrowing owl; but a decline occurred in the number of nesting ferruginous hawks, golden eagles, and red-tailed hawks. The author provides brief ecological summaries for each of the above species and discusses the apparent declines of some species.

The listings of abundance of the raptors will help in describing the ecosystem components and choosing measurement species during the problem formulation phase.

Craig and Craig (1984). Large concentrations of golden eagles were located throughout the INEL, and some of these birds roosted communally on power line structures. This paper may be useful in describing the ecosystem components in the problem formulation phase.

Craig and Renn (1977). Two merlin nests were located in different areas of southeastern Idaho near the INEL. Both pairs of merlins were utilizing old magpie nest structures. One of the nests was revisited several times and prey remains near the nest included 18 mourning doves (*Zenaida macroura*), three horned larks (*Eremophila alpestris*), and two western meadowlarks (*Sturnella neglecta*).

This investigation presents data pertinent to the problem formulation and analysis phases of ERA. The presence of merlins on the INEL may be important in the ecosystem components and measurement species sections. The characterization of prey items may also help calculate exposure of the merlins and percent of diet made up by different prey species.

Craig and Trost (1979). Some nesting parameters were studied for populations of American kestrel and long-eared owl, which inhabit the INEL. Kestrels arrived at the INEL in late March or early April and began incubating in early to mid-May. The eggs hatched in early June and the young fledged in early July. Mean clutch size was 4.5 to 4.7 eggs, mean hatching

rate was 3.7 to 4.0 eggs, and mean fledgling was 3.7 to 4.0 young. The majority of the diet for the hatchlings was passerine prey. Long-eared owls are year around residents of the INEL; however, migrants also appear during the nesting season. Egg laying may begin from late April to late May and hatching dates were widely variable but the mean date was May 25 in 1976. The mean fledgling date was July 14 with most of the young staying in the nest for 21 days. The owls laid a mean of 3 and 5.3 eggs in 1975 and 1976, respectively, and of these an average 2.3 and 4.2 young hatched. In 1976, 41% of the nests produced 4 to 5 fledglings. Small mammals, especially pocket gophers and kangaroo rats, were the major food source.

The explanations of the ecology of kestrels and long-eared owls are helpful in understanding the ecosystem components of the INEL during problem formulation. The dietary information may allow construction of appropriate exposure models for the analysis phase, and the nesting data may be used in the risk characterization for comparisons to off-INEL or area specific data to determine if nesting parameters are normal.

Craig et al. (1984). The numbers of rough-legged hawks, ferruginous hawks, golden eagles, and bald eagles increased over the period from 1974 to 1982 at the INEL. This increase was felt to be related to the increase in the numbers of black-tailed jackrabbits over the same period.

This investigation helps to link the raptor populations to prey populations. It provides information helpful in understanding the ecology of the INEL for description in the problem formulation. It may also be useful during risk characterization for explaining uncertainties (i.e., high numbers versus low numbers of raptors) associated with potential risks at the INEL.

Craig et al. (1985). Mammals made up 93.5% of the diet of long-eared owls at the INEL. The authors identify the mammalian species and calculate the percent biomass each species contributed toward the owls' diet.

The percent biomass contributed to the owls' diet by each species provides documented evidence for the development of an exposure model for the owl. This would be most helpful in the analysis phase of the risk assessment.

Craig et al. (1986). The authors investigated the wintering habitats of golden eagles (*Aquila chrysaetos*) and rough-legged hawks (*Buteo lagopus*) on and around the INEL. During the winter of 1981 and 1982, 283 golden eagle locations and 626 rough-legged hawk locations were plotted on vegetation maps of the INEL. The golden eagles preferred areas of native vegetation where perches (power poles, trees, rock outcroppings) were present. Rough-legged hawks were located in both native and agricultural areas but had a much higher preference for agricultural areas. The habitat preferences of both species was felt to be directly related to the presence of preferred prey species.

The description in this article of preferred area use by raptors would aid in the appropriate selection of measurement species. This would be most helpful in the problem formulation phase of the ERA.

French and Mitchell (1983). The trends of long-term vegetation changes were studied at the INEL. Sixteen permanent vegetation plots were established between 1957 and 1959 and the

plant cover of each was documented. The vegetation dynamics of the INEL was concluded to be controlled by many aspects including long-term succession especially following grazing, fire, and insect infestations, and short-term fluctuations due primarily to changing seasonal weather patterns. The variations over a 25-year period were sufficient to mask obvious signs of secondary succession. The shrub populations found at the INEL are relatively stable regardless of the perturbations caused by climate or grazing. The herbaceous species respond most to such disturbances and they were found to be most susceptible when subjected to deteriorating environmental conditions and other anthropogenic factors such as grazing. Finally, the contamination due to radionuclides did not appear to have any long-term effects on vegetation.

The vegetation changes discussed in this publication provide insight into the ecology of the INEL and would be most helpful in preparing the problem formulation. The information presented may also be useful in understanding the risks presented by area contaminants and might be discussed in the risk characterization phase.

Gates et al. (1985). A controlled burn area on the INEL apparently caused a change in the use of breeding display arenas by sage grouse. Two known areas on or near the burn were abandoned over a 2- to 3-year period after the burn, and a new third display area was established. This new area was established by younger birds. It appears the established display areas are dominated by a few males, and younger males may not be allowed to display. This suggests a lack of new areas where the young males can emigrate to establish themselves. When the fire cleared new areas suitable for displaying, they were utilized and appeared to become the central displaying areas over a several year period. These findings have management implications in that the creation of suitable new displaying areas may enhance the breeding of younger birds and, therefore, the grouse populations.

This paper presents a description of the behavior of sage grouse under relatively natural conditions. The management implications of the paper may be used in the risk characterization phase to describe risk management strategies.

Genter (1986). The distribution and habitat selection of hibernating bats were investigated on and near the INEL. Two species (*Myotis leibii* and *Plecotus townsendii*) were located hibernating in lava tube caves. Other bats known to inhabit the INEL during the summer were not found during searches of the lava tubes during the winter.

The bats inhabiting the INEL throughout the year may have a higher potential for exposure than those present only in the summer. This must be considered during the problem formulation phase of the ERA.

Gleason and Johnson (1985). The burrowing owls nesting on the INEL utilize holes dug by badgers. The badgers create the burrows as they pursue small mammal prey. Since many adequate burrows were not used by the owls and populations were not expanding, it was assumed that the availability of nesting burrows was not a population limiting factor. The burrowing owls fed mainly on the common small mammals found at the INEL but insects and arachnids made up approximately 25% of the biomass of their diet.

This publication presents two areas of useful information. The nesting habits of the burrowing owls may be most useful in determinations of ecological endpoints within the problem formulation phase. The diet composition information could help define the exposure models for the owl during the analysis phase of the ERA.

Guyer and Linder (1985a). Short-horned lizards (*Phrynosoma douglassi*) and sagebrush lizards (*Sceloporus graciosus*) were studied in 1976 and 1977 with a mark-recapture study at the INEL. The three age classes in each of the two species were young of the year, juvenile, and adult. Approximately 14 individuals of each species were found per hectare. The survival of the juveniles (0.80) and the adults (0.64) was high for the sagebrush lizard while only the adult survivorship was high for the short-horned lizards (0.67). Female lizards of both species were markedly larger than the males.

The known presence of these lizards is helpful for descriptions of the ecology of the INEL and for selection of measurement species. Both of these aspects are important in the problem formulation phase. The survivorship data may be helpful for risk characterization if detailed ERA are necessary for an area.

Guyer and Linder (1985b). Short-horned lizards and the sagebrush lizards were active from mid-April through late August at the INEL. Juvenile (approximately 1 year old) and young of the year lizards of both species were more active in August after the seasonal peak activity periods for the adults had passed. Peak daytime activity period for the lizards occurred between 1200 and 1500 MST and the primary prey species of the lizards was ants.

The ecological information provided in this paper is useful for problem formulation. The diet composition data for the lizards may also be useful for developing exposure models during the analysis phase of the ERA.

Halford (1987). Twenty-four (8 adult and 16 juvenile) pen-reared mallards (*Anas platyrhyncos*) were wing-clipped and released onto a liquid radioactive waste pond at the INEL for 56 to 188 days. Nine radionuclides were detected consistently in the mallard's tissues after residing on the ponds. These were ^{60}Co, ^{61}Cr, ^{65}Zn, ^{75}Se, ^{110}Ag, ^{131}I, ^{134}Cs, ^{137}Cs, and ^{203}Hg. No adult/juvenile or time-related factors are provided nor are any concentrations given in the publication.

The identification of nine radionuclides in the tissues of the mallards may help select the most appropriate contaminants of potential concern (COPCs). The COPCs selection occurs in the problem formulation phase of ERA.

Halford and Millard (1978). An inventory of the terrestrial vertebrate fauna and the seasonal occurrence of each species was determined for the radioactive waste pond at the TRA. The pond was found to be a food, water, and habitat source for many species. Three reptile, 11 mammal, and 94 bird species were identified over a 4-year period. The bull snake was the only common reptile seen at the pond. The most abundant small mammal was the deer mouse. Mule deer were observed drinking from the pond on several occasions. Four raptor species were seen at the pond. Northern harriers nested near the site each year of the study and were common. Kestrels were the only other common raptor seen at the pond. Game

birds frequenting the ponds included mourning doves, sage grouse, and waterfowl. Other birds commonly using the pond area were killdeer, spotted sandpipers, and barn swallows.

The identification of species inhabiting the TRA waste ponds will be very useful in determining the ecosystems components and the ecological endpoints during the problem formulation. The presence of these species at the TRA waste ponds also provides insight into the species likely to be found at other WAGs with ponds.

Hironaka et al. (1983). Quantitative techniques were used to define the sagebrush-grass habitat types found in southern Idaho. Thirty-eight habitat types are described.

The definition of habitat types found in southeastern Idaho will help in preparing the "Ecosystem Components" section. This section is part of the problem formulation phase of ERA.

Howe and Flake (1988). Mourning doves at the INEL traveled up to 12.3 km from feeding and loafing sites to watering and nest sites. However, the average maximum distances for up to 40 doves was 3.1 and 3.7 km to watering and nest sites, respectively. These relatively short distances suggest mourning dove populations would be enhanced by the placement of permanent watering areas at distances of approximately 6 km apart.

The presence of doves and their use of the INEL habitats will help define ecosystem components and ecological endpoints in the problem formulation. The definition of distances traveled by the doves will also provide important information for developing a dove exposure model in the analysis phase of the ERA.

Howe and Flake (1989a). Mourning doves from the INEL use the man-made ponds for watering, feeding, gritting, loafing, and courting. The use of the ponds by the doves peaked in the morning (0800 until 1300 hrs) and evening within 30 minutes before and after sunset. Monthly pond use did not vary greatly during the summer months and the average number of mourning doves arriving daily at a pond varied from 0 to 80 birds and from 0.5 to 32.3 birds when averaged over individual months.

This definition of use of man-made sands by doves at the INEL will be helpful while writing the problem formulation phase for areas with ponds. Exposure models for the dove may also be refined using these data. This data use supports the analysis phase.

Howe and Flake (1989b). Ground nesting mourning doves were studied on the INEL from 1983 to 1985. Nests located on the ground were difficult to locate; density on the INEL was 0.02 nests/ha. Of a total of 24 active nests, young doves fledged from 75% of the active nests, and 63% of the total number of nests found, over the 3-year study. Survival of the doves from beginning of incubation to fledgling was 0.50. Peak hatching occurred the fourth week of June, the third week of July, and the first two weeks of August. It appears the doves prefer to nest on the ground under big sagebrush with a good deal of grass cover nearby, surrounding the nest.

Similar to the other Howe and Hake (1988, 1989a) investigations, this article supports the problem formulation and analysis phases of ERA. This article also presents nesting success data that may be useful in risk characterization.

Johnson and Anderson (1984). Diets of black-tailed jackrabbits and composition of plant communities were compared among habitats that supported different densities of the rabbits. The jackrabbits did not consume plants in proportion with the plants' abundance within the rabbits' home range. The rabbits selectively fed on winterfat (*Ceratoides lanata*) and perennial grasses, which comprised 80% of the diets of the rabbits in all areas combined. Forbs were also important at selected sites and made up a maximum of 23% of the rabbits' diets at a given site. Distribution of rabbits in the summer of 1980 appeared related to the relative cover of grasses at a given site. The type of grass did not seem to contribute to the rabbits' selection of habitats and it appears the rabbits may not nest in the grasslands as young of the year were rarely seen during this investigation.

The rabbit distribution information presented will help in the appropriate selection of ecological endpoints in the problem formulation. The diet composition data would be most helpful in the development of exposure models in the analysis phase of an ERA.

Knick (1990). Bobcat (*Felis rufus*) population responses to exploitation and a decline in prey populations were studied in southeastern Idaho from January 1982 to December 1985. None of the studied bobcats produced young in either the hunted or the nonhunted populations during the study but the hunted population had more yearlings. Annual survival rates were also lower for the hunted population (0.49 versus 0.67). Black-tailed jackrabbits and cottontails were the preferred prey of the bobcats; however, as the numbers of the rabbits declined naturally during the course of the study, the bobcats began eating more small mammals such as mice and voles. They also made more extra-territorial hunting forays. The author suggests an area of 3 to 5 bobcat territories be used as a minimum refuge size to adequately protect a viable population within the area.

This publication presents data that may be useful in the problem formulation, analysis, and risk characterization phases of an ERA. Much of the data, however, would be most appropriate for use in a detailed ERA.

Laundre (1989a). The burrows of least chipmunks (*Tamias minimus*) were studied at the INEL. The investigated burrows were of similar depth (mean = 21.4 cm, range 17 to 31 cm) and diameter (mean = 7.5 cm, range 6.5 to 8.7 cm), and had an average of 2.6 openings (range 2 to 4). The lengths of the burrows varied a great deal and some were a group of convoluted tunnels, whereas others were nearly linear with little branching.

The depth of the burrows may be an important factor in the use of data. Soil contaminant data taken from depths below the maximum burrow depths may not need to be considered for the risk assessment. This is an important factor of the problem formulation and analysis phases if the ground squirrel is chosen as a measurement species.

Laundre (1989b). Horizontal and vertical burrow diameters of Townsend's ground squirrels, Wyoming ground squirrels (*Spermophilus elegans*), Ord's kangaroo rats, montane voles, and

deer mice were determined at the INEL. The burrows of all the small mammals were 1.2 to 1.6 times wider than they were tall. Montane vole and deer mouse burrows were the smallest with average horizontal diameters of 4.3 cm (range 1.1 to 7.3) and 6.1 cm (range 1.9 to 10.5), respectively, and average vertical diameters of 3.4 cm (range 0.5 to 6.7) and 3.8 cm (range 1.5 to 5.2). The Townsend's and Wyoming ground squirrels had the largest burrows with average horizontal diameters of 8.0 cm (range 1.1 to 7.3) and 7.8 cm (range 2.4 to 12.3), respectively, and average vertical diameters of 5.2 cm (range 4.3 to 6.4) and 5.6 cm (range 1.4 to 7.3). The kangaroo rat burrows were of intermediate diameter with average horizontal diameter of 7.6 cm (range 5.7 to 13.2) and an average vertical diameter of 4.7 cm (range 3.7 to 7.3). Burrow size corresponded directly with body size and the kangaroo rats and ground squirrels were the strongest diggers that would not be influenced by soil properties as much as the other species.

Similar to Laundre (1989a), the burrowing data for several species of small mammals may determine the data to be used to develop exposure models. This information is useful in problem formulation and analysis phases of ERA.

Linder and Sehman (1977). The only amphibian species found at the INEL was the Great Basin spadefoot toad (*Scaphiopus intermontanus*), which inhabits areas where standing water is found for a considerable length of time. The sagebrush lizard (*Sceloporus graciosus*) and short horned lizard (*Phrynosoma douglassi*) are common over the entire INEL during the summer. The western skink (*Eumeces skiltonianus*) and leopard lizard (*Crotaphytus wislizeni*) are less common and have restricted distribution. Four species of snake occur on the INEL. The Great Basin gopher snake (*Pituophis melanoleucus*) and the western rattlesnake (*Crotalus viridis*) are widespread and abundant, while the western garter snake (*Thamnophis elegans*) and desert striped whipsnake (*Masticophis taeniatus*) both have limited distributions.

The presence of amphibians and reptiles at the INEL is an important consideration for the "Ecosystems Components" and "Ecological Endpoints" sections. Both of these sections are found in the problem formulation phase.

MacCracken and Hansen (1982a). The abundance of black-tailed jackrabbits and nuttall cottontails was positively related to the biomass of herbaceous vegetation on the INEL. Abundance of the jackrabbits was highest in areas with greater grass biomass, while cottontails preferred a greater forb biomass and numerous rock outcrops. Grazing by livestock decreased the abundance of rabbits in the area grazed.

This investigation may be useful in determining appropriate measurement species in the problem formulation phase of an ERA. The dominant types of vegetation at an area may determine which species is selected.

MacCracken and Hansen (1982b). The food preferences of coyotes were significantly different between seasons at the INEL. Nuttall cottontails, montane voles, and northern pocket gophers made up the bulk of coyote foods. Other food items of significance included Townsend ground squirrels, pygmy rabbits (*Brachylagus idahoensis*), plants, pronghorn (*Antilocapra americana*), pocket mice, bushy-tailed woodrats (*Neotoma cinereus*), reptiles, whitetail jackrabbits (*Lepus townsendi*), Cricetid mice, birds, and least chipmunks. Birds,

Townsend ground squirrels, plant fragments, and bushy-tailed woodrats were eaten by coyotes in all seasons. Reptiles were indicative of summer diets, pronghorn of fall diets, grasses of winter diets, and whitetail jackrabbits of spring diets.

The food preferences of coyotes may be important in the problem formulation phase for selecting measurement species from several trophic levels. To build a conceptual ecological exposure model for the risk assessment, it is important to tie each of the trophic levels together and this article allows this. It also provides for selecting important exposure pathways.

MacCracken and Hansen (1984). The diets of black-tailed jackrabbits and nuttall cottontails were estimated by examination of fecal pellet botanical composition. Two distinct feeding periods were observed: spring-summer and fall-winter. Grasses (*Agropyron* spp.) and forbs (mainly *Eurotia lanata*) were most abundant in the pellets during the spring-summer period, and shrubs were most abundant during the fall-winter period. The diversity of forage was greatest during the spring-summer period. The use of different habitats by the two species reduces competition between them and livestock grazing appeared to limit the population densities of the rabbits.

This publication will help in the selection of measurement species and exposure pathways. These two selections are part of the problem formulation phase.

Markham and Trost (1986). Mourning doves of the INEL commonly ate only 11 species of plants. Of these Halogeton (*Halogeton glomeratus*) and Indian ricegrass (*Oryzopsis hymenoides*) made up 48% of the doves' diet. The remaining plant species included wheat (*Triticum aestivum*), barley (*Hordium vulgare*), oats (*Avena sativa*), pigweed (*Amaranthus glomeratus*), common vetch (*Vicia* spp.), collomia (*collomia* spp.), barnyard grass (*Echinochloa crusgalli*), Gromwell (*Lithospermum rudrale*), and cottonwood (*Populus* spp.). The presence of cereal grains indicated the doves were leaving the INEL for some of their food requirements. Grit was present in 63% of the crops and provided an average of 14% of the mass of the contents.

The study of doves will aid in the selection of measurement endpoints and exposure pathways within the problem formulation. The specific data regarding percentage of diet made up by different vegetation and grit will be useful in the exposure assessment during the analysis phase.

Mullican (1986). This publication documents the finding of Merriam's shrew (*Sorex merriami*) on the INEL. Four specimens were collected from 1983 to 1984 in longworth live traps.

This information will add to the "Ecosystem Components" section within the problem formulation phase of ERA. The rarity of Merriam's shrew at the INEL may also need to be considered in the measurement species selection.

Mullican and Keller (1986). Populations of the sagebrush vole (*Lemmiscus curtatus*) were monitored on three study plots in sagebrush steppe of southeastern Idaho over a 13-month period. Average densities of the voles ranged from 4 to 16/ha. Sagebrush voles bred during

winter after a period of population decline and prior to a population increase. Summer median weights at sexual maturity were 14.6 g for males, 16.4 g for females, and did not differ significantly. Evidence showed that sagebrush voles tagged with ^{182}Ta occurred singly or in pairs during the summer rather than in colonies as suggested by previous investigators. Food habit analysis revealed that the most common food items in June and August were *Castilleja* sp. and *Lupinus* sp., respectively.

This paper presents information pertinent to the "Ecosystem's Components" and "Exposure Pathways" sections and may be helpful for the selection of measurement species. Each of these sections is important in problem formulation. Vole weight data, which is useful for creating exposure models in the analysis phase, are also provided.

Mullican and Keller (1987). Burrows of the sagebrush vole were analyzed by injecting them with expanding polyurethane foam. Average mean depth for four burrows was 12.5 cm. Tunnels were wider than high and flat on the bottom. Three or four burrows were nearly linear, with an average of five entrances. Burrows usually contained one nest made of sagebrush bark. No middens or communal nests were found. The burrow structure in sagebrush habitat suggests that sagebrush voles occur singly or in pairs rather than in colonies.

The burrow depths provided will aid in the selection of appropriate data. Soil contaminant data below the maximum burrow depth would be unnecessary for calculations of exposure for the vole if it were chosen as a measurement species. This information is most useful for the problem formulation phase.

Reynolds (1979). Populations of reptiles were examined in grazed and ungrazed habitats dominated by sagebrush or by crested wheatgrass on the INEL in southeastern Idaho. The sagebrush lizard and the short-horned lizard were the only species or reptiles encountered in sufficient numbers to permit statistical analysis. Both of these species preferred sagebrush habitats to areas dominated by crested wheatgrass. The sagebrush lizard was most abundant in the native, ungrazed sagebrush habitat, and the short-horned lizard was most plentiful in the sheep-grazed area dominated by big sagebrush.

The information provided in this investigation may be helpful in the "Ecosystem Components" and "Ecological Endpoints" sections. Both of these sections are part of problem formulation.

Reynolds (1980). The deer mouse was the most commonly trapped small mammal in four study areas dispersed across the INEL. They comprised 61 to 82% of the catch in each area. No correlation was found between grazing intensities and densities of the deer mice, but the lowest densities of deer mice were found at grazed sites. The highest densities were found in sagebrush dominated areas. Western harvest mice were also found in the lowest densities at grazed areas but preferred ungrazed grassland over sagebrush areas. Both least chipmunks and northern grasshopper mice (*Eutamias minimus*) were found at similar densities in the grazed and ungrazed grasslands; however, the chipmunks were restricted mainly to areas of sagebrush. The grasshopper mice did not seem to prefer any one habitat and were the fourth most abundant species trapped.

The information provided in this article may be helpful in the "Ecosystem Components" and "Ecological Endpoints" sections. Both of these sections are found in the problem formulation phase of ERA.

Reynolds (1981). The author examined the territory size, mating success, nest placement, nest development, and nesting success of the three passerine species restricted to the sagebrush habitat in southeastern Idaho. Territories defended by male sage thrashers (*Oreoscoptes montanus*) were larger than those defended by either sage sparrows (*Amphispiza belli*) or Brewer's sparrows (*Spizella breweri*). All but one of the territorial sage thrashers (n = 19) were successful in securing mates and nesting. Fifty-three percent of the territorial sage sparrows (n = 30) and 23% of the displaying Brewer's sparrows (n = 30) secured mates and nested. Thrashers nested either on the ground below sagebrush or in the branches of sagebrush plants. Brewer's and sage sparrows nested only in the shrub canopy of sagebrush. Average incubation and nesting periods (rounded to the nearest whole day) for the sage thrasher, sage sparrow, and Brewer's sparrow were 15 and 12 days, 14 and 10 days, and 11 and 9 days, respectively. Sage thrashers and sage sparrows had similar probability of nesting success (0.45 and 0.40, respectively), while the Mayfield success rate for Brewer's sparrows was only 0.09. Male sage sparrows that attracted mates had established larger territories than those that failed to mate. Brewer's sparrows nested about 10 days later than the other species, which may have resulted in their lower nesting success, since nest site requirements of all species were similar.

The documented presence of these passerine species at the INEL will help to define the ecosystem's components and possibly the measurement species for the ERA. The territory size may be useful for determining exposure models for the analysis phase, and the mating and nesting success data may be useful for comparisons to other populations in the risk characterization.

Reynolds (1990). The root masses of big sagebrush, Great Basin wild rye, Russian thistle, streambank wheatgrass, and crested wheatgrass were determined at 20-cm depth increments from plants grown in high clay content soils in cylindrical containers. All species had roots in the deepest (100 to 120 cm) depth increment. Crested wheatgrass had the greatest average total root mass (775 g). Results provided data for some scenarios for fate and effect models for shallow-land burial of low-level radioactive waste in semi-arid environments.

If root mass can be correlated to contaminant translocation rate, this article may be useful in selecting the appropriate vegetation measurement species and determining exposure pathways. Each of these aspects is important in problem formulation.

Reynolds and Fraley (1989). Root depth and lateral spread were determined for five plant species using radiotracers techniques. Depth data only were collected from two additional species. Big sagebrush, the deepest rooted species examined, had roots extending to a depth of 225 cm. Roots of Great Basin wildrye (*Leymus cinereus*), the deepest rooted grass, were detected to 200 cm. The maximum lateral spread of both of these species was 100 cm and occurred at a depth of 40 cm.

The root depth data are most helpful in the problem formulation phase in decisions of data use (i.e., what depth of soil samples to use), selection of exposure pathways, and determination of ecological endpoints.

Reynolds and Laundre (1988). Burrow volumes were determined in disturbed and undisturbed soils for four species of rodents in southeastern Idaho. Comparisons were made between soil types for the average volume and the proportion of the total volume of soil excavated from 10-cm increments for each species, and the relative number of burrows and proportion of total soil removed from beneath the minimum thickness of soil covers over buried low-level radioactive wastes. Burrows of montane voles (*Microtus montanus*) and deer mice (*Peromyscus maniculatus*) rarely extended below 50 cm and neither volumes nor depths were influenced by soil disturbance. Townsend's ground squirrels (*Spermophilus townsendii*) had the deepest (up to 140 cm) and most voluminous burrows that, along with Ord's kangaroo rat (*Dipodomys ordii*) burrows (up to 90 cm), were more prevalent beneath 50 cm in disturbed soil.

The burrow depth and volume data are important in several aspects of the problem formulation phase of ERA. The depths determine from which soil horizons the contaminant data are gathered. The burrow volumes help determine the transport pathways. The burrow depth and volumes information may also help in the selection of measurement species.

Reynolds and Rich (1978). The reproductive ecology of the sage thrasher (*Oreoscoptes montanus*) was studied at the INEL. All nests were either in or under sagebrush and 21 of 34 nests were on the ground. Sagebrush plants with nests in them were significantly taller than the sagebrush plants with nests under them, but the average distance from the top of the sagebrush plant to either a ground or nonground nest was the same (66 cm). The thrashers had an average territory size of 0.96 ha (range 0.64 to 1.64). The probability that an egg will produce a fledgling was 0.46 over all the study areas. Average clutch size was 3.5, and average number of young fledged was 2.6. First clutches were significantly larger (3.8 eggs) than the second clutches (3.2 eggs).

The availability of reproductive data for the thrasher may aid in selection of measurement species during the problem formulation. The home range data are useful for calculating exposure models in the analysis phase and the survival and reproductive data may be helpful in comparisons to other populations in the risk characterization phase.

Reynolds and Trost (1979). The species diversity and relative density of native vertebrates from habitats dominated by sagebrush or crested wheatgrass were determined and compared. The species diversity of nesting birds and large mammals and the relative density of nesting birds, nonnesting birds, reptiles, and both larger and small mammals were significantly lower in the crested wheatgrass plantings than in sagebrush habitats.

The diversity and density of vertebrates should be considered in the selection of ecological endpoints during problem formulation. The data may also provide for comparisons to data from other areas during the risk characterization phase.

Reynolds and Trost (1981). Populations of nesting and nonnesting birds were examined and compared in grazed and ungrazed habitats dominated by sagebrush and crested wheatgrass. Sheep grazing in a sagebrush community did not alter the density or the diversity of nesting bird populations. Planting a former sagebrush range with crested wheatgrass, with or without grazing pressures, reduced the diversity and abundance of nesting species. More species and individuals of migrant and nonnesting birds used the sagebrush habitats than the crested wheatgrass plantings. Habitat selection by birds appears to be related to the vegetational physiognomy rather than the floral composition of the habitat.

Similar to Reynolds and Trost (1979), this publication may be useful in problem formulation and risk characterization.

Reynolds and Wakkinen (1987). Dimensions of the burrow systems for four small mammals common to southeastern Idaho (Townsend's ground squirrels, Ord's kangaroo rats, montane voles, and deer mice) were determined in undisturbed soils. The ground squirrels constructed two distinct burrow systems: more than 120 cm deep and less than 60 cm deep. The deeper systems were significantly longer and had larger volume than the shallower burrows and the systems constructed by the other species. Burrow parameters for the kangaroo rats were bimodal, suggesting deep and shallow burrows, but this was not demonstrated statistically. All parameters for the rat burrows were similar to shallow ground squirrel burrows. Volumes of both were significantly greater than volumes for deer mice and voles. A significant portion of the variability of all parameters for voles and shallow ground squirrel burrows was explained by the distribution of soil particle sizes, but equations based on these were only of limited value in predicting burrow parameters.

Burrow dimensions are useful in determining the appropriate soil contaminant concentration data to use during problem formulation. Volume calculations can also be used for contaminant transport analysis.

Stafford et al. (1986). An insect survey was conducted on the INEL during the summers of 1981 to 1983. This publication presented an annotated checklist of the Coleptera collected. Successful collecting methods, dates of adult occurrence, and relative abundance are given for each species. Relevant biological information is also presented for some species.

Invertebrates are often difficult to include during ERA. This paper presents a listing of some of the insect species found and may be used to consider important invertebrates in the assessment during problem formulation.

Stauber et al. (1980). Sera from 104 adult and 42 fawn pronghorn antelope from southeastern Idaho were tested against selected livestock pathogens. The numbers positive/numbers tested (% positive) were as follows: bovine virus diarrhea—adults 2/102 (2), fawns 0/41 (0); infectious bovine rhinotrachetis—adults 27/101 (27), fawns 9/42 (22); parainfluenza 3—adults 79/104 (76), fawns 22/42 (52); bovine adenovirus 7—adults 42/103 (41), fawns 20/48 (48); bovine adenovirus 3—adults 11/32 (34), fawns 4/14 (23); *Anaplasma marginale*—adults 1/104 (1), fawns 1/42 (2). There are no reactors to brucellosis, bluetongue, or epizootic hemorrhagic disease. The prevalence of reactors varied considerably for different locations and for different years.

An increase in pathogen types and occurrences can indicate a stressed population. In this regard, the data from the INEL could be compared to other areas in the risk characterization phase.

Watson (1984). Rough-legged hawks were found to switch from their preferred microtine prey to road-kill or other carrion during the winter months when microtine rodents are less accessible due to snow cover. This ability to switch prey likely keeps many of the rough-legged hawks on the INEL during the winter, instead of migrating to other locations of more abundant or easily captured prey.

The information contained in this paper should be considered in the problem formulation during selection of small mammals and other measurement species. The changing diet may also need to be accounted for in the exposure models in the analysis phase of ERA.

Watson (1986). The patterns of range use and range fidelity of rough-legged hawks were monitored during 1982 and 1983 at the INEL. The hawks exhibited two major patterns of range use. The first was represented by approximately 15% of the monitored population and was characterized by extra-range movements among nonoverlapping ranges. Ranges of these individuals were separated by 33 to 70 km. The second pattern was characterized by well defined but variably sized home ranges. These ranges were influenced by the presence of power poles, which were used as perches. Overlapping ranges were common and there appeared to be little territoriality. Range fidelity was tested by marking birds and sighting them in subsequent years. Six of eleven marked birds were seen on the INEL up to three years after marking, indicating some extent of fidelity of the birds for the INEL.

This information provides insight into hawk behavior and provides a better understanding of the hawks' ecology for consideration in the problem formulation. The data on annual return of the hawks to the INEL may be important in calculations of exposure during the analysis phase.

Woodruff and Keller (1982). Data on dispersal, home range, and daily activity patterns were collected during 11 months for 15 coyotes (*Canis latrans*) radio-collared on the INEL. Dispersal distance ranged from 0 to 57 km for 10 juveniles. Mean home range with standard error for four adult females was 45.9 $\pm$ 1.7 km^2 by the ellipse method and 29.3 $\pm$ 2.4 km^2 by the modified minimum area method. Home range of one adult male was 133.0 km^2 and 80.6 km^2 by the two methods, respectively. When more than 100 relocations were available, the modified minimum area method appeared to estimate home range size more accurately. During the summer, coyotes were most active near dawn and dusk. A period of general lack of activity was noted from 1100 to 1500 MST. Analysis of 15-min interval fixes obtained over a 24-hr period suggested that some areas within the home range received more intensive use than others, particularly areas around resting points.

This investigation provides important data for calculating exposure of coyotes to area-specific contaminants. These data should be considered for the analysis phase if coyotes are chosen as a measurement species.

Youtie et al. (1987). Insects inhabiting Great Basin wildrye (*Elymus cinereus* Scribn. & Merr.) were surveyed at two sites on the Snake River Plain in southern Idaho during 1982 and 1983. Forty-six species of phytophagous insects were observed. In addition, eight parasitoid species were reared from insect hosts in the plant culms and identified. Life stage, abundance, plant part used, and study site were recorded for each insect species collected. Insect guilds at the two sites were compared based on species presence determined by Sorensen's similarity index. Overall, 26 insect species were common to both sites, yielding a moderate similarity index of 0.62. The majority of the species that constitute the wildrye herbivore guilds were oligophagous (restricted to grasses). Many of these insects feed on grain crops as well as other native and introduced grasses. The relatively high diversity of phytophages on wildrye may be due to its tall bunchgrass growth form, abundance within its habitat, broad geographic range, and the large number of related species of grasses in the region.

Similar to Stafford et al. (1986), this article presents invertebrate information useful for better understanding of the INEL ecology. This information may aid risk assessors during problem formulation.

C-3. QUALITATIVE RISK EVALUATION OF PREVIOUS INVESTIGATIONS OF ANTHROPOGENIC RADIONUCLIDES AT THE INEL

The purpose of this section is to describe the extent of contamination of natural systems on the INEL by human-made or human-enhanced radionuclides. These include fission products, neutron activation products, and transuranic radionuclides, all of which were created or artificially enhanced in quantity by human activities. Natural radionuclides, in their natural concentrations, are not considered.

To the extent possible, contamination trends are described and the potential consequences of contamination for ecosystems are discussed. Where data are not available or too limited to adequately discuss these concepts, the data gaps are identified and an assessment of their significance is offered.

The primary sources of the data used in this section are the over 300 publications of the Radioecology and Ecology Group of RESL (Markham 1973; Markham and Reynolds 1991) and the Environmental Science and Research Foundation (Morris 1994). In addition, the INEL Site Environmental Reports (e.g., Hoff et al. 1992), published annually by until 1992 by RESL and susequently by the Environmental Science and Research Foundation the periodic reports from the Radioactive Waste Management Information System (e.g., Litteer et al. 1991) contain useful data. Miscellaneous technical publications from the U.S. Geological Survey, the National Oceanic and Atmospheric Administration, the U.S. Department of Energy, and a former INEL contractor were also consulted. While the data presented here are primarily from published sources, nonpublished data were used when available. For example, most of the soil data in this section are unpublished data from RESL's soil monitoring program.

C-3.1 Summary of Available Concentration Data

The data reviewed in this section were collected for a variety of purposes, usually related to a specific research interest at a specific site facility. Except for the soil data from RESL, they do not represent the results of a comprehensive survey of radioactive contamination in the environment of the INEL. Where data are not reported for a given radionuclide concentration in a given medium at a particular location, it does not necessarily mean that such contamination was not present but only that it was not of interest to the investigators. Thus, while a great deal of information is available, there may be significant data gaps. These gaps will be discussed as they appear. The potential data gaps are only tentatively identified at this time for purposes of scoping the WAG-wide ERAs. It is recommended that screening-level ERAs be conducted for each WAG to accomplish a more comprehensive identification and evaluation of data gaps.

For comparison among the data sets, the maximum reported ^{137}Cs and $^{239,240}Pu$ concentrations in soils will be used (the α spectra of ^{239}Pu and ^{240}Pu cannot be distinguished and these two radionuclides are treated as one). These radionuclides in soils were emphasized because soil data exist for every facility from RESL's soil monitoring program and because ^{137}Cs and $^{239,240}Pu$ represent the gamma-emitters and transuranics, respectively. Data for the other radionuclides are

provided in the tables; however, the approach taken for ^{137}Cs and $^{239,240}Pu$ could be adopted for other site contaminants.

The highest concentrations of both ^{137}Cs and $^{239,240}Pu$ exist in sediments from the TRA radioactive waste pond. Comparisons of the soils data with these sediment data would be misleading because of the different characteristics between pond sediments and surface soil such as total organic carbon and grain size, and because the pond sediments are not exposed and therefore are not subject to the aerobic conditions of surface soils. Each of these factors may change the contaminant concentrations, and transport and fate between sediments and soils. Therefore, comparisons of soils and sediments data are avoided.

The only data set with sufficient time duration to determine temporal and spatial trends at the INEL is the RESL soil data. The samples from which these data were derived have been collected as part of a routine surveillance program since about 1970. Permanent sampling grids were established by RESL around nine facilities, and each grid is resampled approximately every seven years on a rotating basis. Thus, all facilities have been sampled at least twice. Soil samples are collected from two depths, 0 to 5 cm and 5 to 10 cm. The maximum distance from the facility to which the 0 to 5-cm soil samples contain concentrations of ^{137}Cs or $^{239,240}Pu$ significantly (t-test; $\alpha = 0.05$) greater than 1 geometric standard deviation (GSD) above the median offsite concentrations can be used to show the extent of contamination around each facility and whether the contaminated area is changing over time. Changes in the contaminant concentrations of either soil layer between the initial sampling and the most recent sampling at a given facility can be assessed using a Kruskal-Wallis One-way Analysis of Variance test ($\alpha = 0.05$). These tests help determine the degree to which contaminant concentrations are changing over time.

If a facility has contaminated the surrounding environment, that contamination is not expected to be evenly distributed around the facility. In general, because of the prevailing wind directions on the INEL, contamination is expected to be found at highest levels and farthest distances in the northeast and southwest directions from the facilities.

C-3.1.1 Background Concentrations

Small concentrations of human-made or -enhanced radionuclides are found in environmental media that have not been directly influenced by INEL operations or any other nuclear facility. These background concentrations are due, in some cases, to natural generative processes (e.g., the formation of ^{129}I in the upper atmosphere). The most common source for this contamination, however, is world-wide fallout from nuclear weapons testing.

In general, background concentrations have been determined from samples taken from outside the INEL boundaries. In certain cases, the investigators determined that onsite background samples were available for their studies.

Background concentrations of fission products, neutron activation products, and transuranics have been detected in soil, surface water, vegetation, small mammals, game mammals, coyote feces, upland game birds, waterfowl, other birds, terrestrial invertebrates, and rainbow trout.

The maximum background soil concentration of ^{137}Cs detected by RESL was 3.0 pCi g^{-1}. The maximum background concentration of $^{239,240}Pu$ in soils was 0.089 pCi g^{-1}. Background soil concentrations of ^{137}Cs and $^{239,240}Pu$ were log-normally distributed with geometric means (GM) of 0.81 and 0.018 pCi g^{-1}, and GSD of 2.0 and 2.2, respectively.

C-3.1.1.1 Spatial and Temporal Trends. Between 1970 and 1990, radioactive decay should have resulted in a 37% decrease in surface soil concentrations of ^{137}Cs. Such a decrease was not observed in the soil data, possibly due to continuing inputs from foreign atmospheric weapons tests and the Chernobyl accident. Because of its long half-life, no decrease was expected or observed for $^{239,240}Pu$.

No spatial trends were apparent in the offsite soil concentration data.

C-3.1.1.2 Potential Data Gaps. No background data are available for radionuclide concentrations in raptors, reptiles, or bats. These data could be necessary to determine the significance of contamination that may be found in these organisms onsite. Some species of raptors and bats at the INEL are classified by the federal government as Threatened and Endangered (T&E) or C2 (considered for proposal as threatened or endangered) species (Moseley and Groves 1992).

The background data cited by Hoff et al. (1992) for ^{137}Cs concentration in game mammals is six times that found in onsite animals. This finding implies a deficiency in the background data because it is expected that the background concentrations should be less than or equal to onsite concentrations. These data require further evaluation or additional investigation of radionuclides in offsite mammals.

C-3.1.2 Idaho Chemical Processing Plant

The environment surrounding the ICPP has been contaminated with a variety of fission products and transuranics. Studies of radioactive contamination from ICPP have been conducted in soil, vegetation, rabbits, pronghorn, mourning doves, sage grouse, waterfowl, and fish from the Big Lost River near ICPP.

In at least one case (Connelly and Markham 1983), samples of sage grouse were collected from the ICPP/TRA area, and no attempt was made to discriminate between the two facilities. Although not generally made explicit, this confounding of data from the two areas may be common for animal studies with some mobile species (e.g., birds or large mammals).

The maximum ^{137}Cs concentration in soil near ICPP was reported as 54 pCi g^{-1}. This is approximately 7% of the ^{137}Cs concentration of Stationary Low-Level Reactor No. 1 (SL-1) soils, the most contaminated soil after TRA pond sediments. The maximum concentration of ^{137}Cs in ICPP soils was 1.8 times maximum background concentrations.

The maximum soil concentration of $^{239,240}Pu$ in soil near ICPP was 0.073 pCi g^{-1}, which is approximately 0.1% of that found in SDA surface soils (the highest concentration reported other than TRA pond sediments) and 82% of the maximum background.

The nuclide ^{129}I has been of particular interest at ICPP because it is a result of the fuel dissolution process and is transported relatively long distances from the plant by atmospheric processes. Studies of vegetation (McGiff 1985) and rabbit thyroids (Fraley et al. 1982) have identified ^{129}I contamination in these media greater than background out to 30 km from the ICPP. ^{129}I has been detected above background concentrations in pronghorn tissues site-wide (Markham 1974) and as far offsite as Craters of the Moon National Monument and Monida Pass (Markham et al. 1983).

C-3.1.2.1 Spatial and Temporal Trends. ^{137}Cs is found in above background concentrations out to a distance of greater than 2 km from the stack at ICPP. Background concentrations were observed beyond about 10 km. No data are available for the intermediate distances so the extent of the plume cannot be precisely determined. No evidence exists for a change in the extent of the soil contamination plume but concentrations in the 0- to 5-cm depth decreased significantly between 1973 and 1979. During the same period, concentrations in the 5- to 10-cm depth have increased, arguing for downward migration of soil contamination. Site-wide concentrations of ^{137}Cs in the lower soil depth are about 18% of those in the surface soils.

With the exception of one sample, $^{239,240}Pu$ is found in background concentrations at all distances from the stack at ICPP. A single above background concentration was observed at 1.7 km from the stack in 1989, the last sampling from the ICPP grid. All other samples, including those from greater distances, were at background concentrations. This single concentration is insufficient evidence to argue for an increase in plume size; however, ICPP will be sampled again in 1996. Concentrations of $^{239,240}Pu$ remained constant in both soil depths between 1982 and 1989, indicating little vertical migration of plutonium. Site-wide concentrations of $^{239,240}Pu$ in the lower soil depth are negligible compared to those in the surface soils.

Because ^{129}I is produced in the calcining process, it is reasonable to expect ^{129}I concentrations in the environment to increase in magnitude and extent when the calcining process is in operation. However, because of the long half-life of ^{129}I (1.6×10^7 y) and the strong affinity of some chemical forms of iodine for organic fractions of the soil, it may not be reasonable to expect decreases in magnitude or extent of contamination when calcining stops. Studies are currently under way to determine whether these arguments are valid. Similar arguments may apply for some transuranic elements.

C-3.1.2.2 Potential Data Gaps. Potentially significant data gaps exist in the ICPP data. Limited vegetation and small mammal data are available, particularly for the transuranics and gamma-emitting radionuclides. These data are important because these two groups serve as the base of the herbivore and carnivore food chains and because small mammals include one of INEL's C2 species (the pygmy rabbit). Raptors, other birds, and bats, all of which include C2 species, are not represented in the ICPP data. On the other hand, the data for game species that are important for human food chain exposure are well represented. Soil samples were not collected between about 2 to 10 km from the stack and these samples may be necessary to determine the extent of the contaminant plume at ICPP.

C-3.1.3 Subsurface Disposal Area

Transuranics, ^{90}Sr, and gamma-emitters have been detected in a variety of environmental media at the SDA. Transuranics have been of particular interest because the SDA has been used as a transuranic storage area.

Media that have been thoroughly investigated include soils, vegetation, small mammals, and coyotes. In addition, a limited amount of work has been carried out on mourning doves, horned larks, rattlesnakes, and terrestrial invertebrates. Contrary to the practice at most other facilities, a significant amount of environmental research has been conducted by RESL within the boundaries of the SDA and these data are reported here.

The maximum soil concentration of ^{137}Cs was reported as 16 pCi g^{-1} and was found at the perimeter of the SDA (Markham 1978). This concentration is approximately 2% of the maximum concentration reported for SL-1 soils but six times maximum background concentrations.

The maximum soil concentration of $^{239,240}Pu$ at the SDA, found within the facility fence, was reported to be 54 pCi g^{-1} (Arthur and Markham 1983). This concentration was the highest reported soil concentration among the studies reviewed here and was 600 times the maximum background concentration.

C-3.1.3.1 Spatial and Temporal Trends. The data for soils, vegetation, and, to a lesser extent, small mammals at the SDA are quite comprehensive with respect to spatial extent and radionuclide coverage. The transuranic elements ^{238}Pu, $^{239,240}Pu$, and ^{241}Am have been detected at above background concentrations in soils on the SDA and out to 1.0, 2.4, and 2.5 km, respectively, from the SDA perimeter (Markham et al. 1978). In small mammals, above background concentrations were detected out to about 350 m from the SDA fence. Highest concentrations for soil and small mammals were found at the perimeter drainage area of the SDA; concentrations decreased with distance from the fence. Transport to the perimeter was attributed to localized flooding, and transport beyond that point resulted from windblown materials. Similar conclusions have been drawn for gamma-emitters in soils and small mammals (Markham 1978).

The 1978 RESL soil sampling data show concentrations above background of ^{137}Cs out to about 42 m from the SDA fence. In 1985, no soil samples outside the SDA fence had concentrations above background of ^{137}Cs. This finding implies a possible decrease in contamination levels from the SDA and might be attributed to the addition of extra soil layers on portions of the SDA since 1978 (Arthur et al. 1986) as well as decay of the ^{137}Cs transported off the SDA by flood waters in the 1960s. Although the increase in ^{137}Cs contamination of the 5- to 10-cm soil layer is not statistically significant, downward migration of ^{137}Cs may also have contributed to the decrease in surface soil contamination.

Concentrations above background of $^{239,240}Pu$ were found to a distance of 94 m from the SDA fence in 1978 and 43 m from the fence in 1985. Combined with the Markham et al. (1978) data, which were based on samples collected in 1973, the soil contaminant plume appears to have decreased in extent over a 12-year period. This apparent decrease cannot be attributed to decay because of the long half-life of the nuclides involved. There is some indication that the downward

migration of $^{239,240}Pu$ may be responsible for this decrease because concentrations in the 5- to 10-cm layer were higher in 1985 than in 1978, but too few data exist to make firm conclusions.

C-3.1.3.2 Potential Data Gaps. No data are available for radioactive contamination of game mammals, raptors, or bats near the SDA. All of these could be relatively important data gaps; game mammals are important for assessing human food chain transport and raptors and bats for assessing potential doses to T&E or C2 species. Data are limited for birds in general and this gap limits the ability to determine potential doses to loggerhead shrikes, a C2 species. Further transuranic analyses of soil samples from the 5 to 10-cm soil layer would help to determine whether downward migration of transuranics is responsible for the apparent decrease in the extent of the transuranic contamination plume.

C-3.1.4 Stationary Low-Level Reactor No. 1 Area

All the available data for environmental contamination at the SL-1 facility (except the RESL soil data) are from two studies (Arthur et al. 1983; Markham and Halford 1982). Gamma-emitters were investigated in soils, small mammals, coyote feces, mourning doves, and terrestrial invertebrates. In addition, transuranics were measured in soils by RESL.

^{137}Cs was the most common radionuclide detected with a maximum detected concentration of 700 pCi g^{-1} in soils (Arthur et al. 1983). This concentration is the largest for soil reported in the studies reviewed here (other than TRA pond sediments, which are 4 times greater) and is 240 times the maximum background soil concentration.

The maximum soil concentration of $^{239,240}Pu$ at SL-1 was 0.046 pCi g^{-1}. This concentration is about 0.09% of the maximum contamination at the SDA and about half the maximum background.

C-3.1.4.1 Spatial and Temporal Trends. The RESL soil data from the Auxiliary Reactor Area (ARA)/SL-1 area were sampled from a radial grid centered on ARA-II. SL-1 is located about 600 m from ARA-II in a downwind direction and a small peak is observable in these data at this location. Thus, while SL-1 contributes to the RESL data for this area, the focus of the data is ARA.

In 1977, surface soils at ARA were contaminated with ^{137}Cs at above background concentrations out to 1.5 km from the center, the farthest distance at which samples were taken. In 1985, the extent of the contamination was 1.0 km, also the farthest distance at which samples were taken. These data indicate that the true extent of the plume is unknown.

Above background concentrations of $^{239,240}Pu$ were detected in 1977 at 0.1 km from ARA-II. This location was not sampled in 1985 so no elevated concentrations were detected that year. No expansion of the $^{239,240}Pu$ concentration plume is evident.

C-3.1.4.2 Potential Data Gaps. No data exist for the SL-1 waste disposal area for vegetation, game mammals, raptors, bats, or reptiles; and limited data are available for other media. Although these data gaps might be important, the relatively small area and lack of continued operations at SL-1 make them less likely to be significant. On the other hand, the high

soil concentration of ^{137}Cs may indicate that further work should be done to determine the potential for spread of this contamination. The extent of the contaminant plume should be defined by sampling soils at greater distances from ARA-II than have been previously sampled.

C-3.1.5 Test Reactor Area

The contamination of environmental media near TRA has been intensively studied. Gamma-emitting and transuranic radionuclides have been detected in soils; sediment, vegetation, and water from the radioactive waste percolation pond; small mammals; coyote feces; raptors; upland game birds; waterfowl; and barn swallows. Almost all studies at the TRA have been focused on the currently inactive radioactive waste percolation ponds.

The sediments of the radioactive waste percolation ponds at TRA are the most contaminated soils in the studies reported here. The mean concentration of ^{137}Cs in barn swallow nests made with TRA pond sediments was 2500 pCi g^{-1}. The mean concentration of $^{239,240}Pu$ in TRA pond sediments was 43 pCi g^{-1}. However, as noted above, comparison of these values with values for terrestrial soils has a high degree of uncertainty. The maximum soil ^{137}Cs and $^{239,240}Pu$ concentrations found in the RESL surveys of the area surrounding the TRA were 220 and 0.065 pCi g^{-1}, respectively. For ^{137}Cs, this value is 32% of the maximum soil concentration found at SL-1 and 75 times background. For $^{239,240}Pu$, this represents 0.1% of the maximum at the SDA and 73% of background.

C-3.1.5.1 Spatial and Temporal Trends. ^{137}Cs was found in elevated concentrations in surface soils out to 750, 280, and 600 m in 1976, 1983, and 1990, respectively. Thus, there is no evidence for a regular pattern of expansion or contraction of the plume size during the 14 years it was studied. A statistically significant increase in average ^{137}Cs concentration occurred within the 5- to 10-cm soil layer between 1976 and 1983, indicating that downward migration was occurring.

The surface soil concentration of $^{239,240}Pu$ was determined in only one year (1976) and is, therefore, insufficient to determine temporal trends. Above background concentrations were found out to 28 m from the fence.

Few TRA data sets allow estimation of spatial trends in media other than soil. Craig et al. (1979) found decreasing concentrations of radioactivity in raptors with distance from the TRA, probably due to decreasing contamination of the prey. The authors estimated that the maximum distance at which radionuclides from the TRA/ICPP complex could be detected in nestling raptors was 3.5 km.

C-3.1.5.2 Potential Data Gaps. The data set from the TRA is the most complete set in this review with respect to the variety of environmental media sampled. In spite of the large amount of data a potentially significant data gap exists. No data are available in these studies for contamination of terrestrial vegetation near TRA. Thus, no data are available at this site for the base of the terrestrial food chain.

The radioactive waste percolation pond has been the focus of most of the studies at TRA because it has probably been the most significant source of contamination. However, remediation

activities are currently underway for the pond, which is being replaced with a lined evaporation pond. Thus, the data currently available may not be applicable to future operations at TRA.

Studies of the waterfowl using the new pond will begin as soon as it is completed. Studies of the terrestrial environment surrounding the pond will be necessary to determine the potential impact of the new pond on radioactive contamination of the environment.

C-3.1.6 Miscellaneous Locations

Limited amounts of data are available for other on- and offsite locations that have been influenced by INEL operations. These locations include Argonne National Laboratory–West (ANL-W), the Boiling Water Reactor Experiment/Experimental Breeder Reactor (BORAX/EBR-I) area, the Central Facilities Area (CFA), the NRF, the area surrounding the Waste Reduction Operations Complex (WROC) [formerly Waste Experimental Reduction Facility (WERF)], TAN, and various other locations on- and offsite.

Radionuclides detected at these locations include ^{129}I, ^{90}Sr, gamma-emitters, and transuranics. The media include soils from the RESL surveys, game mammals, upland game birds, and waterfowl.

The maximum detected soil concentration of ^{137}Cs was 120 pCi g^{-1} found in soils from the area surrounding the NRF. This concentration is 17% of the maximum concentration at SL-1 and 40 times background concentrations. The maximum detected soil concentration of $^{239,240}Pu$ was 0.041 pCi g^{-1}, from a survey of soils near all facilities. This value is 0.08% of the maximum concentration at the SDA and 45% of maximum background. The maximum soil concentrations of ^{137}Cs and $^{239,240}Pu$ detected in a survey conducted near all facilities onsite were 24 and 0.076 pCi g^{-1}, respectively (Markham 1974).

C-3.1.6.1 Spatial and Temporal Trends. Soils surrounding ANL-W and Power Burst Facility (PBF)/Special Power Excursion Reactor Test (SPERT)/WROC (formerly WERF) do not contain concentrations of ^{137}Cs or $^{239,240}Pu$ at above background levels.

At the NRF, ^{137}Cs was found in above background concentrations out to 14 and 9 m in 1980 and 1988, respectively. The small difference between the concentrations at these locations and the small distances involved do not provide sufficient evidence for a change in the size of the contaminant plume. There was no analysis for $^{239,240}Pu$ in any year at NRF.

Soils surrounding facilities at TAN have not contained above background concentrations of $^{239,240}Pu$ in any measurement year since the first RESL measurements in 1976. In 1976, ^{137}Cs was not detected in above background levels either. However, in that year, samples were taken only from around the Loss-of-Fluid Test (LOFT) Facility. In 1981 and 1989, sampling was expanded to the areas surrounding the Initial Engineering Test Facility (IET), the Water Reactor Research Test Facility (WRRTF), and the Technical Services Facility (TSF), all at TAN. This additional sampling has found above background concentrations of ^{137}Cs to a distance of 24 m from the fence surrounding the TSF. Apparently no change in the extent of the plume occurred between 1981 and 1988.

In most cases, spatial or temporal trends cannot be determined for environmental media other than soils.

C-3.1.6.2 Potential Data Gaps. Substantial data gaps appear to exist for the facilities grouped together under this heading. The only cases where data are sufficient to determine current contamination are soils, gamma-emitters in waterfowl, and ^{137}Cs in mourning doves. Surveys of the environment surrounding these facilities would allow determination of the potential for harmful contaminant levels surrounding these facilities.

C-3.2 Summary of Extent of Contamination

C-3.2.1 Spatial Extent of Contamination

The farthest distance from any facility to which ^{137}Cs or $^{239,240}Pu$ contamination was found at above background levels in soils was greater than 2 km but less than 10 km. This situation was found at ICPP. Using the most recent values for the maximum extent of the plumes around the nine facilities examined in this report, and assuming that each plume is an ellipse with the short axis half the length of the long axis, the total contaminated area onsite is approximately 160 km^2. This area is approximately 7% of the total area of the INEL.

Evidence exists that contamination from INEL facilities, particularly ICPP, extends much farther. As indicated in Section C-3.1.2, ^{129}I has been detected in vegetation and mammal thyroids at great distances from the ICPP including areas well offsite. The source of this contamination and the mechanism of transport have not been conclusively demonstrated, but it is presumed to be wind-borne contamination from ICPP (Markham 1974; Fraley et al. 1982; Markham et al. 1983; McGiff 1985).

C-3.2.2 Potential for Contaminant Migration

No evidence exists for increases in the horizontal extent of contaminant plumes from any facility on the INEL. There is evidence, however, for very slow downward migration of ^{137}Cs, probably due to transport by water. This process is undoubtedly slow because of the tendency of ^{137}Cs to bind strongly to soils (Whicker and Schultz 1982), and the concentration is expected to decrease rapidly and in a nonlinear manner with depth. The concentration of ^{137}Cs in the 5 to 10-cm soil layer is approximately 18% of that in the 0 to 5-cm soil layer.

Although the evidence is slight, radioactivity may potentially be transported away from contaminated areas by animals. Morris et al. (in preparation) reported a potential for 18,036 waterfowl y^{-1} using INEL ponds to transport 162 $\mu Ci\ y^{-1}$ (12 $pCi\ g^{-1}\ y^{-1}$) of gamma-emitting radioactivity offsite. Seventy-seven percent of that activity was ^{137}Cs. Waterfowl transport is likely to be the most important single source of offsite transport of radioactivity from the INEL by biota (Hoff et al. 1991). However, this small amount of radioactivity, added to the soil when a waterfowl dies and decays offsite, is not likely to add significantly to the background soil

concentration of ^{137}Cs (Hoff et al. 1991). Thus, biotic transport of radioactivity offsite is not likely a concern at the INEL.

C-3.3 Preliminary Qualitative Ecological Risk Evaluation

When discussing the potential for risks to ecological receptors, it is important to distinguish between harm to individuals and harm to populations. In most cases, biologists are primarily concerned about harm to populations. For most populations, large numbers of individuals can suffer morbidity or mortality without affecting the viability of the population of which they are members. However, in the case of T&E species, where the viability of the population is already in question, harm to individuals becomes an important issue.

Because of the limited data available, it is difficult to determine the potential for harm to individuals of INEL's T&E and C2 species from radioactive contaminants in the INEL environment. For some of the T&E or C2 species on the INEL, data about distribution and home range size are insufficient to determine whether the species are potentially exposed to high levels of contamination. Projects are under way to provide such information for ferruginous hawks and Townsend's big-eared bats. Some limited distribution data are available for bald eagles and loggerhead shrikes from winter eagle counts and breeding bird surveys, respectively; but these data are not comprehensive. One study has been published on the ecology of pygmy rabbits on the site (Wilde 1978), but the distribution data in the study are very limited and dated.

In addition, data about contamination of the prey base (for the carnivores) or the individuals themselves are limited or nonexistent. Good (albeit dated) data are available for contamination of small mammals from the SDA, SL-1, and the TRA radioactive waste percolation pond. However, no data are available for small mammal contamination from other areas. No data are available for contamination of the prey base of loggerhead shrikes and very limited data are available for contamination of the prey base of Townsend's big-eared bats.

On the basis of these limited data, one must conclude that all of INEL's T&E or C2 species are potentially exposed to above background levels of radioactive contamination. It is unlikely but possible because of potential bioconcentration that bald eagles and ferruginous hawks consume harmful concentrations of radioactive contaminants in their prey. No conclusions of this nature are possible for loggerhead shrikes, Townsend's big-eared bats, or pygmy rabbits.

Doses received by individual organisms provide a basis for determining the potential for harm to populations. A number of authors have calculated or estimated doses to ecological receptors from internal and external contamination received at the INEL (Craig et al. 1979; Fraley et al. 1982; Halford et al. 1982; Markham and Halford 1982; Markham et al. 1982; Halford and Markham 1984; Halford 1987; Halford 1987b; Markham et al. 1988; Morris 1993; Morris et al. in preparation).

Halford and Markham (1978) found that some maximally exposed small mammals inhabiting the TRA radioactive waste pond basin received doses that had been found to reduce life expectancy in earlier studies (French et al. 1969). Arthur et al. (1986) found similar results for small mammals at the SDA. In neither of these studies were the doses sufficient to cause observable population effects.

Millard et al. (1990) observed a statistically significant difference in growth rate between barn swallow nestlings exposed to contaminated sediments from the TRA radioactive waste percolation pond and control birds. However, the difference could not be definitely attributed to their exposure.

Evenson (1981) found statistically significant differences in several physiological parameters between deer mice inhabiting the TRA radioactive waste percolation pond basin, the SDA, and control areas. The conclusion was that levels of radiation exposure were too low to cause somatic changes in the mice.

The above four were the only studies to report potential individual effects on organisms receiving radiation dose from INEL activities. In no case were the observed effects expressed as somatic changes in the organisms.

Some of the radiation dose estimates derived from field investigations at the INEL are provided in Table C-3. To evaluate the potential for impacts to populations of these receptors (or others at the site that may be similarly exposed), dose rate estimates were compared to radiological effects thresholds established by the IAEA (1992). These criteria vary among taxonomic groups but, in general, 1 mGy/d is considered by the IAEA (1992) to be the lowest chronic dose rate that could adversely affect animal or plant populations. This dose rate has been marginally exceeded in a few cases at the INEL (e.g., deer mice at SDA and TRA, mallards and barn swallows at TRA), but in most cases the dose rate estimates are less than 1 mGy/d. As a result of interim remedial activities at the SDA and TRA sites, it is likely that exposure of wildlife to radionuclides has decreased subsequent to the studies reviewed in Table C-3. Therefore, for species that have been investigated at the INEL, the available data indicate radiation dose rates to individual organisms are likely to be too low to cause population level effects. Based on the concentrations of radionuclides observed in media throughout the site, this is likely the case for most populations of wildlife. Comprehensive screening-level ecological risk assessments, such as the example provided in the Case Study, are required to evaluate this hypothesis.

C-3.4 Conclusions

The data examined in this report indicate that little potential exists for harm to populations of plants and wildlife from radioactive contamination of the environment on the INEL. However, past levels of contamination have existed in some areas that could have been sufficient to cause physiological changes and reduced life expectancy in individuals of some species. Whether harmful exposure is occurring now is the subject of current and planned investigations and risk assessments.

Little evidence is available that contamination from the INEL is spreading beyond currently contaminated areas. Further information needs to be collected relative to ^{129}I concentrations in various media both on- and offsite to determine the source and means of transport of this radionuclide.

In some areas and for some media, insufficient data may be available to adequately determine environmental levels of contamination. In addition, insufficient data may be available to determine the potential for harmful levels of contamination in some of INEL's T&E or C2

species. This lack of data could make conclusions about the potential for harm to these species difficult. Therefore, it is recommended that planning for verification and monitoring activities should be initiated to address the potential data gaps identified in this report.

Table C-3. Radiation dose rate estimates from INEL field studies.

Receptor	Radiation Dose Rates (Gy/day)	Exposure Duration	Location	Methods	Reference
Mallard (*Anas platyrhynchos*)	Internal 1.87×10^{-4} Gy/day Average external 1.12×19^{-4} Gy/day Total 1.31×10^{-3} Gy/day	75 days	TRA radioactive leaching ponds	Birds were wing clipped and released on the TRA radioactive leaching ponds. Whole-body internal dose was calculated from measured tissue concentrations. External dose was measured by implanted dosimeters.	Halford et al. (1982)
Mallard (*Anas platyrhynchos*)	Internal 5.86×10^{-4} Gy/day Average external 8.15×10^{-4} Gy/day Total 1.40×10^{-3} Gy/day	145 days	TRA radioactive leaching ponds	Birds were wing clipped and released on the TRA radioactive leaching ponds. Whole-body internal dose was calculated from measured tissue concentrations. External dose was measured by implanted dosimeters.	Halford et al. (1982)
Deer mouse (*Peromyscus maniculatus*)	$3.64 \times 10^{-3} \pm 2.66 \times 10^{-2}$ (SD)	Annual average exposure	SDA	Whole-body dose to mice was measured with surgically implanted dosimeter packets.	Arthur et al. (1986)
Ord's kangaroo rat (*Dipodomys ordii*)	$9.90 \times 10^{-5} \pm 6.72 \times 10^{-4}$ (SD)	Annual average exposure	SDA	Whole-body dose to rats was measured with surgically implanted dosimeter packets.	Arthur et al. (1986)
Deer mouse (*Peromyscus maniculatus*)	9.10×10^{-4} to 2.79×10^{-3}	21 to 57 days	TRA radioactive leaching ponds	Whole-body dose was measured with surgically implanted dosimeter packets.	Halford and Markham (1978)
Ord's kangaroo rat (*Dipodomys ordii*)	3.0×10^{-5} to 7.0×10^{-5}	29 to 54 days	TRA radioactive leaching ponds	Whole-body dose was measured with surgically implanted dosimeter packets.	Halford and Markham (1978)
Least chipmunk (*Eutamias minimus*)	6.0×10^{-5} to 7.0×10^{-5}	20 to 31 days	TRA radioactive leaching ponds	Whole-body dose was measured with surgically implanted dosimeter packets.	Halford and Markham (1978)
Pronghorn (*Antilocapra americana*)	8.2×10^{-9} to 5.5×10^{-8}	NA	INEL	Whole-body dose rate from ^{137}Cs in muscle for animals collected on the INEL site.	Markham et al. (1982)
	4.1×10^{-7} to 1.1×10^{-6}	NA	INEL	Average dose to bone-endosteal cells from ^{90}Sr in bone for animals collected on the INEL site.	Markham et al. (1982)
	1.9×10^{-7} to 5.5×10^{-7}	NA	INEL	Average dose to active bone marrow from ^{90}Sr in bone for animals collected on the INEL site.	Markham et al. (1982)
	2.7×10^{-9}	NA	INEL	Average dose to lung tissue from plutonium nuclides in the lungs for animals collected on the INEL site.	Markham et al. (1982)

Table C-3. (continued).

Receptor	Radiation Dose Rates (Gy/day)	Exposure Duration	Location	Methods	Reference
	9.3×10^{-7} to 9.9×10^{-7}	NA	INEL	Average dose to the thyroid from ^{131}I in the thyroid for animals collected on the INEL site.	Markham et al. (1982)
	1.6×10^{-7} to 8.2×10^{-7}	NA	INEL	Average dose to the thyroid from ^{129}I in the thyroid for animals collected on the INEL site.	Markham et al. (1982)
	1.1×10^{-7} to 5.5×10^{-7}	NA	INEL	Average dose to the rumen from nuclides in the rumen for animals collected on the INEL site.	Markham et al. (1982)
	4.1×10^{-7}	NA	INEL	Average whole-body dose from naturally occurring ^{40}K in muscle tissue for animals on the INEL site.	Markham et al. (1982)
Barn swallow (*Hirundo rusfica*)	2.19×10^{-4}	Breeding season	TRA radioactive leaching ponds	Internal whole-body dose calculated from measured radionuclide activities in bird tissues.	Millard et al. (1990)
	4.30×10^{-3}	Breeding season	TRA radioactive leaching ponds	Dose to the thyroid from ^{131}I in the thyroid.	Millard et al. (1990)
	8.40×10^{-4}	Pre-hatch	TRA radioactive leaching ponds	External dose to whole eggs measured by dosimeters in the nest.	Millard et al. (1990)
	2.2×10^{-3}	Pre-hatch	Near the TRA radioactive leaching ponds	External whole-body dose to nestlings measured by dosimeters in the nest.	Millard et al. (1990)
	1.1×10^{-6}	1974 to 1977	TRA	Internal dose to mourning doves from ^{137}Cs in muscle.	Markham and Halford (1982)
	4.0×10^{-7}	1974 to 1976	ICPP	Internal dose to mourning doves from ^{137}Cs in muscle.	Markham and Halford (1982)
	1.0×10^{-7}	1974 to 1975	RWMC	Internal dose to mourning doves from ^{137}Cs in muscle.	Markham and Halford (1982)

a. Dose rates reported in other units were converted to Gy/day for comparability.

b. SD = Standard deviation.

C-4. BIBLIOGRAPHY

Arthur, W. J., III, 1982, "Radionuclide Concentrations in Vegetation at a Solid Radioactive Waste-Disposal Area in Southeastern Idaho," *Journal of Environmental Quality, 11,* pp. 394–399.

Arthur, W. J., J. C. Grant, and O. D. Markham, 1984, "Importance of Biota in Radionuclide Transport at the SL-1 Radioactive Waste Disposal Area," *Idaho National Engineering Laboratory Radioecology and Ecology Programs 1983 Progress Report,* DOE/ID-12098, U.S. Department of Energy, Idaho Operations Office, Idaho Falls.

Arthur, W. J., and D. H. Janke, 1986, "Radionuclide Concentrations in Wildlife Occurring at a Solid Radioactive Waste Disposal Area," *Northwest Science, 60,* pp. 154–159.

Arthur, W. J., III, and O. D. Markham, 1982, "Radionuclide Export and Elimination by Coyotes at Two Radioactive Waste Disposal Areas in Southeastern Idaho," *Health Physics, 43,* pp. 493–500.

Arthur, W. J., III, and O. D. Markham, 1983, "Small Mammal Soil Burrowing as a Radionuclide Transport Vector at a Radioactive Waste Disposal Area in Southeastern Idaho," *Journal of Environmental Quality, 12,* pp. 117–122.

Arthur, W. J., et al., 1986, "Radiation Dose to Small Mammals Inhabiting a Solid Radioactive Waste Disposal Area," *Journal of Applied Ecology, 23,* pp. 13–26.

Arthur, W. J., et al., 1987, "Radionuclide Export by Deer Mice at a Solid Radioactive Waste Disposal in Southeastern Idaho," *Health Physics, 52,* pp. 45–53.

Blom, P. E., J. B. Johnson, and S. K. Rope, 1991, "Concentrations of ^{137}Cs and ^{60}Co in Nests of the Harvester Ant, *Pogonomyrmex salinus*, and Associated Soils Near Nuclear Reactor Waste Water Disposal Ponds," *American Midlands Naturalist, 126,* pp. 140–151.

Craig, T. H., D. K. Halford, and O. D. Markham, 1979, "Radionuclide Concentrations in Nestling Raptors Near Nuclear Facilities," *Wilson Bulletin, 91,* pp. 72–77.

Connelly, J. W., and O. D. Markham, 1983, "Movements and Radionuclide Concentrations of Sage Grouse in Southeastern Idaho," *Journal of Wildlife Management, 47,* pp. 169–177.

Evenson, L. M., 1981, "Systemic Effects of Radiation Exposure on Rodents Inhabiting Liquid and Solid Radioactive Waste Disposal Areas," Thesis, Colorado State University, Fort Collins.

Fraley, L., Jr.. and G. C. Bowman, 1982, "Iodine-129 in Rabbit Thyroids Near a Nuclear Fuel Reprocessing Plant in Idaho," *Health Physics, 43*, pp. 251–258.

French, N. R., B. G. Maza, and H. W. Kaaz, 1969, *Mortality Rates in Irradiated Rodent Populations, Symposium on Radioecology*, Report 670503, D. J. Nelson and F. C. Evans (eds.), U.S. Atomic Energy Commission, Washington, DC, pp. 46–52.

Halford, D. K., 1987, "Density, Movement, and Transuranic Tissue Inventory of Small Mammals at a Liquid Radioactive Waste Disposal Area," *Proceedings of the Symposium on Environmental Research on Actinide Elements,* CONF-86008713, pp. 147–156.

Halford, D. K., 1987, "Effect of Cooking on Radionuclide Concentrations in Waterfowl Tissues," *Journal of Environmental Radioactivity, 5,* pp. 229–233.

Halford, D. K., and O. D. Markham, 1978, "Radiation Dosimetry of Small Mammals Inhabiting a Liquid Radioactive Waste Disposal Area," *Ecology, 59,* pp. 1047–1054.

Halford, D. K., and O. D. Markham, 1984, "Iodine-129 in Waterfowl Muscle from a Radioactive Leaching Pond Complex in Southeastern Idaho," *Health Physics, 46,* pp. 1259–1263.

Halford, D. K., O. D. Markham, and R. L. Dickson, 1982, "Radiation Doses to Waterfowl Using a Liquid Radioactive Waste Disposal Area," *Journal of Wildlife Management, 46,* pp. 905–914.

Halford, D. K., J. B. Millard, and O. D. Markham, 1981, "Radionuclide Concentrations in Waterfowl Using a Liquid Radioactive Waste Disposal Area and the Potential Radiation Dose to Man," *Health Physics, 40,* pp. 173–181.

Halford, D. K, O. D. Markham, and G. C. White, 1982b, "Biological Elimination Rates of Radioisotopes by Mallards Contaminated at a Liquid Radioactive Waste Disposal Area," *Health Physics, 45,* pp. 745–756.

Hoff, D. L., et al., 1991, *The Idaho National Engineering Laboratory Site Environmental Report for Calendar Year 1990,* DOE/ID-12082(90), U.S. Department of Energy, Idaho Operations Office, Idaho Falls.

Hoff, D. L., et al., 1992, *The Idaho National Engineering Laboratory Site Environmental Report for Calendar Year 1991,* DOE/ID-12082(91), U.S. Department of Energy, Idaho Operations Office, Idaho Falls.

Ibrahim, S., and T. Culp, 1989, "Plutonium Distribution and Oxidation States in a Reactor Leaching Ponds System," *Health Physics, 57,* pp. 607–614.

Janke, D. H., and W. J. Arthur, 1985, "Radionuclide Transport by Cottontail Rabbits at a Radioactive Waste Disposal Area," *Northwest Science, 59,* pp. 221–229.

Kuzo, G. B., et al., 1987, "Comparative Behavior and Distribution of Transuranium Nuclides in Selected Components of Test Reactor Leaching Ponds," *Proceedings of the Symposium on Environmental Research on Actinide Elements,* CONF-86008713, pp. 319–340.

Litteer, D. L., C. N. Peterson, and A. M. Sims, 1991, *Radioactive Waste Management Information for 1990 and Record-To-Date,* DOE/ID-10054(90), U.S. Department of Energy, Idaho Operations Office, Idaho Falls.

Markham, O. D., 1973, *National Reactor Testing Station Environmentally Related Publications,* IDO-12078, U.S. Atomic Energy Commission, Idaho Operations Office, Idaho Falls.

Markham, O. D., 1974, "Environmental and Radiological Monitoring at the National Reactor Testing Station During FY-1973 (July 1972–June 1973)," *Radiological Data Report, 15,* pp. 227–246.

Markham, O. D., 1976, "Radioactivity in Tumbling Weeds at the Radioactive Management Waste Complex on the INEL Site," *1975 Progress Report: Idaho National Engineering Laboratory Site Radioecology-Ecology Programs*, IDO-12080, O. D. Markham (ed.), Energy Research and Development Administration, Idaho Falls, p. 49.

Markham, O. D., 1978, *Activation and Fission Products in the Environment Near the Idaho National Engineering Laboratory Radioactive Waste Management Complex*, IDO-12085, U.S. Department of Energy, Idaho Operations Office, Idaho Falls.

Markham, O. D., R. Autenrieth, and R. Hoskinson, 1976, "Concentrations of Radionuclides in Tissues of Antelope On and Near the INEL Site," *Proceedings of the 7th Biennial Pronghorn Antelope Workshop*, R. Autenrieth (ed.), Idaho Department of Fish and Game, Boise, pp. 63–65.

Markham, O. D., R. L. Dickson, and R. E. Autenrieth, 1979, "Plutonium in the Lungs of Pronghorn Antelope Near a Nuclear Fuel Reprocessing Plant," *Health Physics, 37,* pp. 398–400.

Markham, O. D., et al., 1983, "Iodine-129 in Mule Deer Thyroids in the Rocky Mountain West," *Health Physics, 45,* pp. 31–37.

Markham, O. D., and D. K. Halford, 1982, "Radionuclides in Mourning Doves Near a Nuclear Facility Complex in Southeastern Idaho," *Wilson Bulletin, 94,* pp. 185–197.

Markham, O. D., et al., 1982, "Radionuclides in Pronghorn Resulting from Nuclear Fuel Reprocessing and Worldwide Fallout," *Journal of Wildlife Management, 46,* pp. 30–42.

Markham, O. D., et al., 1988, "Plutonium, Americium, Cesium, and Strontium in Ducks Maintained on Radioactive Leaching Ponds in Southeastern Idaho," *Health Physics, 55,* pp. 517–524.

Markham, O. D., K. W. Puphal, and T. D. Filer, 1978, "Plutonium and Americium Contamination Near a Transuranic Storage Area in Southeastern Idaho," *Journal of Environmental Quality, 7,* pp. 422–428.

Markham, O. D., and T. D. Reynolds, 1991, *Publications of the Idaho National Engineering Laboratory Radioecology and Ecology Program: 1974–1991*, DOE/ID-12125, U.S. Department of Energy, Idaho Operations Office, Idaho Falls.

McGiff, T. J., 1985, "Determination of ^{129}I and ^{127}I in Vegetation at the Idaho National Engineering Laboratory," Ph.D. dissertation, Colorado State University, Fort Collins.

Millard, J. B., F. W. Whicker, and O. D. Markham, 1990, "Radionuclide Uptake and Growth of Barn Swallows Nesting by Radioactive Leaching Ponds," *Health Physics, 58,* pp. 429–439.

Morris, R. C., 1993, "The Implications of Lined Radioactive Waste Ponds for Waterfowl Contamination," *Environmental Health Physics: Proceedings of the Twenty-Sixth Midyear Topical Meeting of the Health Physics Society,* R. L. Kathren, D. H. Denham, and K. Salmon (eds.), Columbia Chapter, Health Physics Society, Richland, WA, pp. 147–155.

Morris, R. C., S. K. Rope, and O. D. Markham, in preparation, "Transport of Radionuclides by Waterfowl Using Wastewater Ponds at the Idaho National Engineering Laboratory," *Health Physics.*

Moseley, R., and C. Groves, 1992, "Rare, Threatened, and Endangered Plants and Animals of Idaho," Conservation Data Center, Idaho Department of Fish and Game, Boise.

Overton, C. K., and D. W. Johnson, 1976, "Ecological Study of the Big Lost River with Emphasis on Environmental Impact," *1975 Progress Report: Idaho National Engineering Laboratory Site Radioecology-Ecology Programs,* IDO-12080. O. D. Markham (ed.), U.S. Energy Research and Development Administration, Idaho Falls, pp. 166–180.

Reynolds, T. D., et al., 1986, "Vertebrate Fauna of the Idaho National Engineering Laboratory," *Great River Basin Naturalist, 46,* pp. 513–527.

DOE, 1990, "Radiation Protection of the Public and the Environment," Order 5400.5, U.S. Department of Energy, Washington, DC.

Whicker, F. W., and V. Schultz, 1982, *Radioecology: Nuclear Energy and the Environment*, CRC Press, Inc., Boca Raton, FL.

Wilde, D. B., 1978, "A Population Analysis of the Pygmy Rabbit (*Sylvilagus Idahoensis*) on the INEL Site," Ph.D. dissertation, Idaho State University, Pocatello.

Attachment I

Radionuclide Contaminant Data for the INEL

Attachment I

Radionuclide Contaminant Data for the INEL

R. C. Morris

C-I.1. INTRODUCTION

The purpose of this attachment is to describe the extent of contamination of natural systems on the INEL by human-made or human-enhanced radionuclides. These include fission products, neutron activation products, and transuranic radionuclides, all of which were created or artificially enhanced in quantity by human activities. Natural radionuclides, in their natural concentrations, are not considered.

To the extent possible, contamination trends will be described and the potential consequences of contamination for human and nonhuman portions of the ecosystem will be discussed. Where data are not available or are too limited to adequately discuss these concepts, the data gaps will be described and an assessment of their significance will be offered.

The primary sources of the data used in this section are the more than 300 publications of the Radioecology and Ecology Group of RESL (Markham 1973; Markham and Reynolds 1991). In addition, the INEL Site Environmental Reports (e.g., Hoff et al. 1992), published annually by RESL, and the periodic reports from the Radioactive Waste Management Information System (e.g., Litteer et al. 1991) contain useful data. Miscellaneous technical publications from the U.S. Geological Survey (USGS); the National Oceanic and Atmospheric Administration; DOE; and a former INEL contractor were also consulted. While the data presented here are primarily from published sources, nonpublished data were used when available. For example, most of the soil data in this attachment are unpublished data from RESL's soil monitoring program.

C-I-1.1 Summary of Available Information

The current information about offsite concentrations of human-made or -enhanced radionuclides and onsite data for human-made or -enhanced radionuclide contamination in environmental media are summarized. These data are discussed on a facility-by-facility basis, reflecting the way the data were collected. With the exception of the SDA, all media were sampled outside facility fences.

The data in these tables were collected for a variety of purposes, usually related to a specific research interest at a specific site facility. Except for the soil data from RESL, they do not represent the results of a comprehensive survey of radioactive contamination in the environment of the INEL. Where data are not reported for a given radionuclide concentration in a given medium at a particular location, it does not necessarily mean that such contamination was not present, but only that it was not of interest to the investigators. Thus, while a great deal of information is available, significant data gaps exist. These gaps will be discussed as they appear.

For comparison between the data sets, the maximum reported ^{137}Cs and $^{239,240}Pu$ concentrations in soils will be used. (The α spectra of ^{239}Pu and ^{240}Pu cannot be distinguished and these two radionuclides are treated as one.) Soil data exist for every facility because of RESL's soil monitoring program and these two radionuclides represent the gamma-emitters and transuranics, respectively.

The highest concentrations of both ^{137}Cs and $^{239/240}Pu$ exist in sediments from the TRA radioactive waste pond. However, comparisons with these sediments would be misleading because of the different characteristics between pond sediments and surface soil and because the pond sediments will not be exposed. Further, the pond in question has been drained and the sediments have been buried. Therefore, comparisons with these sediments are avoided.

The only data set with sufficient time duration to determine temporal and spatial trends is the RESL soil data. The samples from which these data were derived have been collected as part of a routine surveillance program since about 1970. Permanent sampling grids were established around nine facilities and each grid is resampled approximately every seven years on a rotating basis. Thus, all facilities have been sampled at least twice. Soil samples are collected from two depths: 0 to 5 cm and 5 to 10 cm. The maximum distance to which the 0 to 5-cm soil samples contain concentrations of ^{137}Cs or $^{239/240}Pu$ were approximately log-normally distributed with significantly (t-test; $\alpha=0.05$) greater than 1 GSD above the median offsite concentrations is used to show how far contamination has spread from each facility and whether the contaminated area is changing in extent over time. Changes in the contaminant concentrations of either soil layer between the initial sampling and the most recent sampling at a given facility were assessed using a Kruskal-Wallis One-Way Analysis of Variance test ($\alpha=0.05$). These tests help determine the degree to which contaminant concentrations are changing over time.

If a facility has contaminated the surrounding environment, that contamination is not expected to be evenly distributed around the facility. In general, because of the prevailing wind directions on the INEL, contamination will be found at highest levels and farthest distances northeast and southwest of the facilities.

C-I-1.1.2 Background (Table C-I.1)

Small concentrations of human-made or -enhanced radionuclides are found in environmental media that have not been directly influenced by INEL operations or any other nuclear facility. These background concentrations are due, in some cases, to natural generative processes (e.g., the formation of ^{129}I in the upper atmosphere). The most common source for this contamination, however, is worldwide fallout from nuclear weapons testing.

In general, background concentrations have been determined from samples taken from outside the INEL boundaries. In certain cases, the investigators determined that onsite background samples were available for their studies and these data are included in this report.

Background concentrations of fission products, neutron activation products, and transuranics have been detected in soil, surface water, vegetation, small mammals, game mammals, coyote feces, upland game birds, waterfowl, other birds, terrestrial invertebrates, and rainbow trout.

Table C-I.1. Background concentrations of radionuclides in various environmental media on or near the INEL but distant from facilities. Data are ranges unless otherwise noted.

Medium or Location	Nuclides	Levels ($pCi\ g^{-1}$)	References
		Soil	
Surface or excavated by small mammals	^{90}Sr	ND[a] - 1.3	Arthur (1982)
	^{95}Nb	ND - 0.20	Arthur and Markham (1983)
	^{137}Cs	0.30 - 2.6	
	^{144}Ce	0.89[b]	Arthur et al. (1983)
	^{238}Pu	ND - 0.0089	Markham (1974)
	^{239}Pu[c]	ND - 0.089	Markham (1978)
	^{241}Am	ND - 0.017	
	Other γ[d]	ND	
Offsite	^{90}Sr	0.22 - 0.41[e]	Hoff et al. (1991)
	^{137}Cs	0.54 - 1.0[e]	
	^{238}Pu	0.00030 - 0.0011[e]	
	^{239}Pu[c]	0.017 - 0.035[e]	
	^{241}Am	0.0030 - 0.0081[e]	
Offsite, <10-cm depth	^{7}Be	ND - 1.2	Unpublished data from RESL, 1971 to 1990
	^{90}Sr	ND - 8.9	
	^{95}Nb	ND - 0.10	
	^{95}Zr	ND - 0.20	
	^{106}Ru	ND - 0.20	
	^{125}Sb	ND - 0.23	
	^{134}Cs	ND - 0.71	
	^{137}Cs	0.070 - 3.0	
	^{144}Ce	ND - 0.89	
	^{238}Pu	ND - 0.022	
	^{239}Pu[c]	ND - 0.089	
	^{241}Am	ND - 0.027	
	Other γ[d]	ND	
Offsite ant mounds	^{60}Co	ND	Blom et al. (1991)
	^{137}Cs	0.027 - 1.2[f]	
		Water	
Big Lost River near MacKay	^{3}H	ND	Unpublished data from USGS
	^{137}Cs	ND	
	Gross α	ND	
	Gross β	ND	
	Other γ[d]	ND	
Birch Creek near Blue Dome	^{3}H	ND	Unpublished data from USGS

Table C-I.1. (continued).

Medium or Location	Nuclides	Levels ($pCi\ g^{-1}$)	References
Little Lost River near Howe	^{3}H	ND	Unpublished data from USGS
Mud Lake	^{3}H	ND	Unpublished data from USGS
Snake River	^{3}H	ND	Markham (1974)
	Gross α	ND	
	Gross β	ND	
		Vegetation	
Crested wheatgrass	^{90}Sr	0.15 - 0.41	Arthur (1982)
	^{137}Cs	ND - 0.38	
	^{238}Pu	ND - 0.00051	
	^{239}Pu[c]	0.0010 - 0.0020	
	^{241}Am	ND - 0.0010	
Pronghorn rumen contents	^{54}Mn	ND - 0.070	Markham et al. (1982)
	^{95}Nb	ND - 11	
	^{95}Zr	ND - 8.4	
	^{103}Ru	ND - 0.27	
	^{106}Ru	ND - 1.5	
	^{125}Sb	ND - 0.27	
	^{137}Cs	ND - 1.5	
	^{140}La	ND - 0.32	
	^{141}Ce	ND - 1.0	
	^{144}Ce	ND - 6.8	
	Other γ[d]	ND	
Russian thistle	^{60}Co	1.0 - 1.5	Arthur (1982)
	^{90}Sr	0.15 - 1.1	Markham (1976)
	^{137}Cs	ND - 0.59	
	^{238}Pu	0.0010 - 0.0.0020	
	^{239}Pu[c]	0.00049 - 0.0016	
	^{241}Am	ND - 0.00070	
Sagebrush and grasses	^{129}I[g]	ND - 2.1×10^{-6}	McGiff (1985)
		Small Mammals	
Cottontail	^{90}Sr	0.30 - 0.65	Janke and Arthur (1985)
	^{137}Cs	ND - 0.38	
	^{238}Pu	ND - 0.0081	
	^{239}Pu[c]	0.00081 - 0.0030	
	^{241}Am	ND - 0.0030	

Table C-I.1. (continued).

Medium or Location	Nuclides	Levels ($pCi\ g^{-1}$)	References
Deer mice	^{90}Sr	ND - 6.2	Arthur et al. (1983)
	^{137}Cs	ND - 15	Arthur et al. (1987)
	^{238}Pu	0.00020 - 0.041	
	^{239}Pu[c]	0.0020 - 0.92	
	^{241}Am	ND - 0.70	
	Other γ[d]	ND	
Pocket mice	^{137}Cs	0.30 - 25	Arthur et al. (1983)
Rabbit thyroids	^{129}I[g]	ND - 3.9×10^{-7}	Fraley et al. (1982)
		Game Mammals	
Pronghorn muscle and liver	^{54}Mn	ND - 0.010	Markham (1974)
	^{60}Co	ND - 0.059	Markham et al. (1976)
	^{103}Ru	ND - 0.038	Markham et al. (1982)
	^{129}I[g,h]	$9.6\times10^{-9} \pm 8.0\times10^{-8}$	Hoff et al. (1992)
	^{137}Cs	ND - 0.15	
	Other γ[d]	ND	
Pronghorn bone ash	^{90}Sr	5.4 ± 1.4[h]	Markham et al. (1976)
Pronghorn bone ash	^{90}Sr	1.9 - 19	Markham and Halford (1980)
	^{238}Pu	ND	Markham et al. (1979)
Pronghorn thyroids	^{129}I[g]	1.5×10^{-8} - 7.1×10^{-7}	Markham et al. (1983)
		Predatory Mammals	
Coyote feces	^{60}Co	ND - 0.20	Arthur and Markham (1982)
	^{90}Sr	0.70 - 1.2	
	^{106}Ru	9.5[g]	Arthur et al. (1983)
	^{137}Cs	ND - 1.8	
	^{238}Pu	ND - 0.0089	
	^{239}Pu[c]	ND - 0.010	
	^{241}Am	ND - 0.0049	
	^{242}Cm	ND - 0.0070	
	^{244}Cm	ND - 0.0059	
	Other γ[d]	ND	
		Upland Game Birds	
Mourning doves	^{51}Cr	ND - 11	Markham and Halford (1982)
	^{137}Cs	ND - 7.0	
	Other γ[d]	ND	

Table C-I.1. (continued).

Medium or Location	Nuclides	Levels ($pCi\ g^{-1}$)	References
Sage grouse GI	^{95}Nb	ND - 0.70	Connelly and Markham (1983)
	^{95}Zr	ND - 0.70	
	^{103}Ru	ND - 0.59	
	^{137}Cs	ND - 0.20	
	^{141}Ce	ND - 0.81	
	^{144}Ce	ND - 1.5	
	Other γ[d]	ND	
Sage grouse muscle	^{103}Ru	ND - 0.30	Connelly and Markham (1983)
	^{106}Ru	ND - 1.5	
	^{137}Cs	ND - 0.41	
	Other γ[d]	ND	
		Waterfowl	
Mallard bone	^{90}Sr	0.19 - 89	Markham et al. (1988)
	^{238}Pu	0.0073 - 0.026	
	^{239}Pu[c]	0.0097 - 0.032	
	^{241}Am	ND - 0.011	
	^{242}Cm	ND	
	^{244}Cm	0.0086 - 0.016	
Mallard soft tissues	^{90}Sr	0.022 - 0.18	Markham et al. (1988)
	$^{238,239}Pu$[c]	ND	
	^{241}Am	ND	
	$^{242,244}Cm$	ND	
Waterfowl	^{137}Cs	<1.0[i]	Halford et al. (1981)
	^{60}Co	<1.0[i]	
	Other γ[d]	ND	
Waterfowl (whole body)	All γ[d]	ND	Morris et al. (in preparation)
Waterfowl muscle	^{129}I[g]	4.6×10^{-7} - 3.1×10^{-6}	Halford and Markham (1984)
		Other Birds	
Horned Lark	^{137}Cs	0.21 ± 2.5[h]	Arthur and Janke (1986)
Immature barn swallows	^{137}Cs	0.54[b]	Millard et al. (1990)

Table C-I.1. (continued).

Medium or Location	Nuclides	Levels ($pCi\ g^{-1}$)	References
		Terrestrial Invertebrates	
Composite	^{90}Sr	0.70[j]	Arthur and Janke (1986)
	^{137}Cs	1.5 - 12	Arthur et al. (1983)
	$^{238,239}Pu$[c]	ND[j]	
	^{241}Am	ND[j]	
	Other γ[d]	ND	
		Fish	
Rainbow trout in Big Lost River above Arco	^{137}Cs	ND	Overton and Johnson (1976)

a. Not detected. Detection limits varied between studies.

b. Maximum.

c. Assumed to include both ^{239}Pu and ^{240}Pu.

d. Samples were analyzed by gamma scan.

e. 95% confidence interval on the geometric mean.

f. Range of geometric means.

g. Atoms ^{129}I (atoms $^{127}I)^{-1}$.

h. Mean ± 1 standard deviation.

i. Mean only. No error reported.

j. Only one sample measured.

The maximum background soil concentration of ^{137}Cs detected by RESL was 3.0 $pCi\ g^{-1}$. The maximum background concentration of $^{239,240}Pu$ in soils was 0.089 $pCi\ g^{-1}$. Background soil concentrations of ^{137}Cs and $^{239/240}Pu$ were log-normally distributed with GM of 0.81 and 0.018 $pCi\ g^{-1}$, and GSD of 2.0 and 2.2, respectively.

C-I-1.1.2.1 Trends. Between 1970 and 1990, radioactive decay should have resulted in a 37% decrease in surface soil concentrations of ^{137}Cs. Such a decrease was not observed in the soil data (Figure C-I.1), possibly due to continuing inputs from foreign atmospheric weapons tests and the Chernobyl accident. Because of its long half-life, no decrease was expected or observed for $^{239,240}Pu$ (Figure C-I.2).

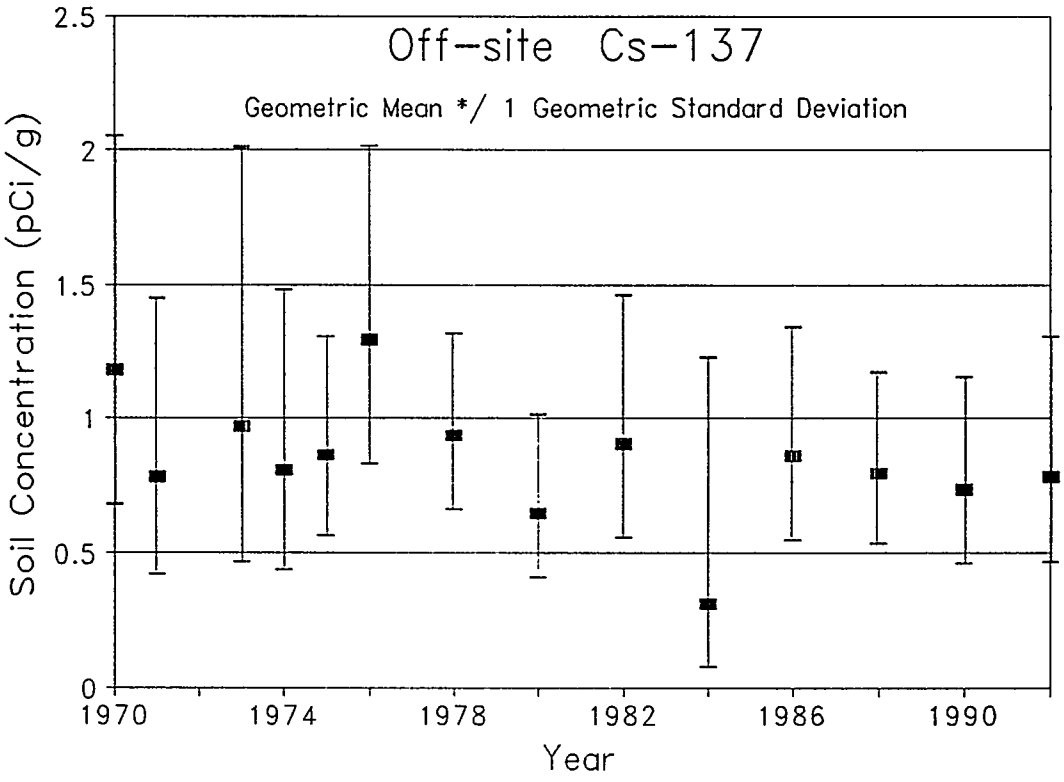


Figure C-I.1. Geometric mean concentrations of 137 Cs in surface soils (0 to 5-cm depth) from areas that are unlikely to have been contaminated by INEL operations.

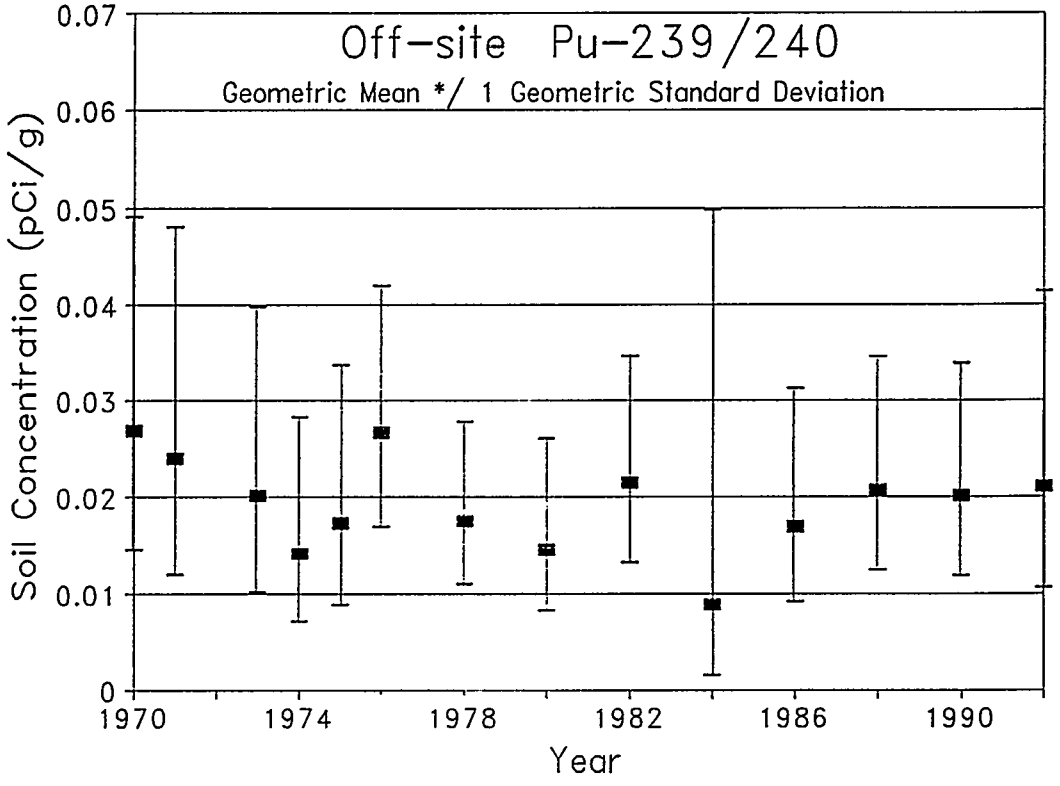


Figure C-I.2. Geometric mean concentrations of $^{239/240}Pu$ in surface soils (0 to 5-cm depth) from areas that are unlikely to have been contaminated by INEL operations.

No spatial trends were apparent in the offsite soil concentration data.

C-I-1.1.2.2 Data Gaps. No background data are available for radionuclide concentrations in raptors, reptiles, or bats. These data are necessary to determine the significance of contamination that may be found in these organisms onsite. Some species of raptors and bats are Threatened and Endangered (T&E) or C2 (being considered for proposal as threatened or endangered; Moseley and Groves 1992) species.

The background data cited by Hoff et al. (1992) for ^{137}Cs concentration in game mammals is six times that found in onsite animals. This implies a deficiency in the background data because it is expected that the background concentrations should be less than or equal to onsite concentrations. These data should be updated.

C-I-1.1.3 Idaho Chemical Processing Plant (Table C-I.2)

The environment surrounding the ICPP has been contaminated with a variety of fission products and transuranics. Studies of radioactive contamination from ICPP have been conducted in soil, vegetation, rabbits, pronghorn, mourning doves, sage grouse, waterfowl, and fish from the Big Lost River near ICPP.

In at least one case, the sage grouse study (Connelly and Markham 1983), samples were collected from the ICPP/TRA area and no attempt was made to discriminate between the two facilities. Although not generally made explicit, this confounding of data from the two areas may be common for animal studies with some mobile species (e.g., birds or large mammals).

The maximum ^{137}Cs concentration in soil near ICPP was reported as 54 pCi g^{-1}. This is approximately 7% of the ^{137}Cs concentration of SL-1 soils, the most contaminated soil after TRA pond sediments. The maximum concentration of ^{137}Cs in ICPP soils was 1.8 times maximum background concentrations (Table C-I.1).

The maximum soil concentration of $^{239,240}Pu$ in soil near ICPP was 0.073 pCi g^{-1}, which is approximately 0.1% of that found in SDA surface soils (the highest concentration reported other than TRA pond sediments) and 82% of the maximum background (Table C-I.1).

The nuclide ^{129}I has been of particular interest at ICPP because it is a result of the fuel dissolution process and is transported relatively long distances from the plant by atmospheric processes. Studies of vegetation (McGiff 1985) and rabbit thyroids (Fraley and Bowman 1982) have identified ^{129}I contamination in these media greater than background out to 30 km from the ICPP. Iodine-129 has been detected above background concentrations in pronghorn tissues site-wide (Markham 1974) and as far offsite as Craters of the Moon National Monument and Monida Pass (Markham et al. 1983).

Table C-I.2. Radioactive contamination of various environmental media near the ICPP at the INEL. Data are ranges unless otherwise noted.

Medium	Nuclides	Levels ($pCi\ g^{-1}$)	References
		Soil	
Area surrounding ICPP, <10-cm depth	^{7}Be	ND[a] - 0.81	Unpublished data from RESL, 1971 to 1989
	^{54}Mn	ND - 0.25	
	^{60}Co	ND - 5.7	
	^{90}Sr	ND - 27	
	^{95}Nb	ND - 0.20	
	^{95}Zr	ND - 0.20	
	^{106}Ru	ND - 0.57	
	^{125}Sb	ND - 0.81	
	^{134}Cs	ND - 0.59	
	^{137}Cs	ND - 54	
	^{144}Ce	ND - 0.89	
	^{238}Pu	ND - 0.37	
	^{239}Pu[b]	ND - 0.073	
	^{241}Am	ND - 0.035	
	Other γ[c]	ND	
		Vegetation	
Sagebrush and grasses <31 km from ICPP	^{129}I[d]	1.8×10^{-5} - 1.4×10^{-3}	McGiff (1985)
Pronghorn rumen contents ≤10 km from ICPP	^{60}Co	ND - 0.43	Markham et al. (1982)
	^{95}Zr	ND - 1.0	
	^{95}Nb	ND - 1.8	
	^{106}Ru	ND - 54	
	^{125}Sb	ND - 4.1	
	^{134}Cs	ND - 1.1	
	^{137}Cs	ND - 24	
	^{140}Ba	ND - 0.18	
	^{140}La	ND - 0.18	
	^{141}Ce	ND - 0.97	
	^{144}Ce	ND - 2.2	
	^{154}Eu	ND - 0.43	
	Other γ[c]	ND	
		Small Mammals	
Rabbit thyroids <30 km from ICPP	^{129}I[d]	ND - 9.1×10^{-4}	Fraley et al. (1982)
		Game Mammals	
Pronghorn lungs <10 km from ICPP	^{238}Pu	0.00062[e]	Markham et al. (1976)
	^{239}Pu[b]	0.00060[e]	Markham et al. (1979)

Table C-I.2. (continued).

Medium	Nuclides	Levels ($pCi\ g^{-1}$)	References
Pronghorn muscle and liver ≤10 km from ICPP	^{60}Co	ND - 0.10	Markham et al. (1976)
	^{65}Zn	ND - 0.035	Markham et al. (1982)
	^{134}Cs	ND - 0.15	
	^{137}Cs	ND - 2.6	
	^{238}Pu	ND - 2.0	
	Other γ[c]	ND	
Pronghorn bone ash ≤10 km from ICPP	^{90}Sr	1.4 - 46	Markham et al. (1976)
	^{238}Pu	ND - 0.017	Markham et al. (1979)
Upland Game Birds			
Mourning dove GI	^{51}Cr	ND - 27	Markham and Halford (1982)
	^{60}Co	ND - 1.2	
	^{95}Nb	ND - 0.59	
	^{106}Ru	ND - 54	
	^{125}Sb	ND - 4.9	
	^{131}I	ND - 15	
	^{134}Cs	ND - 9.5	
	^{137}Cs	ND - 140	
	Other γ[c]	ND	
Mourning dove muscle	^{51}Cr	ND - 0.49	Markham and Halford (1982)
	^{60}Co	ND - 8.4	
	^{134}Cs	ND - 0.70	
	^{137}Cs	ND - 12	
	Other γ[c]	ND	
Sage grouse GI at TRA and ICPP	^{51}Cr	ND - 540	Connelly and Markham (1983)
	^{54}Mn	ND - 0.70	
	^{58}Co	ND - 0.10	
	^{60}Co	ND - 25	
	^{65}Zn	ND - 13	
	^{75}Se	ND - 4.6	
	^{95}Nb	ND - 1.8	
	^{95}Zr	ND - 1.1	
	^{103}Ru	ND - 0.89	
	^{134}Cs	ND - 27	
	^{137}Cs	ND - 110	
	^{140}La	ND - 0.59	
	^{141}Ce	ND - 2.2	
	^{144}Ce	ND - 7.0	
	^{203}Hg	ND - 0.59	
	Other γ[c]	ND	

Table C-I.2. (continued).

Medium	Nuclides	Levels (pCi g^{-1})	References
		Upland Game Birds	
Sage grouse muscle at TRA and ICPP	^{24}Na	ND - 3.8	Connelly and Markham (1983)
	^{54}Mn	ND - 0.30	
	^{60}Co	ND - 1.9	
	^{65}Zn	ND - 1.5	
	^{75}Se	ND - 1.4	
	^{95}Nb	ND - 0.20	
	^{103}Ru	ND - 0.41	
	^{134}Cs	ND - 5.7	
	^{137}Cs	ND - 30	
	^{140}Ba	ND - 2.7	
	^{203}Hg	ND - 0.49	
	Other γ[c]	ND	
		Waterfowl	
ICPP waste ponds	^{60}Co	0.57 - 18	Morris et al. (in preparation)
	^{95}Nb	0.84 - 2.6	
	^{95}Zr	0.70 - 0.81	
	^{106}Ru	3.8 - 4.3	
	^{134}Cs	0.51 - 2.6	
	^{137}Cs	0.32 - 38	
	^{144}Ce	ND - 3.0[f]	
	Other γ[c]	ND	
		Fish	
Rainbow trout in Big Lost River near ICPP	^{137}Cs	ND - 2.4	Overton and Johnson (1976)

a. Not detected. Detection limits varied between studies.

b. Assumed to include both ^{239}Pu and ^{240}Pu.

c. Samples were analyzed by gamma scan.

d. Atoms ^{129}I (atoms $^{127}I)^{-1}$.

e. Maximum.

f. Detected in a single sample.

C-I-1.1.3.1 Trends.. Cesium-137 is found in above background concentrations out to a distance of greater than 2 km from the stack at ICPP (Figure C-I.3). Background concentrations were observed beyond about 10 km. No data are available for the intermediate distances so the extent of the plume cannot be precisely determined. There is no evidence for a change in the extent of the soil contamination plume but concentrations in the 0 to 5-cm depth decreased significantly between 1973 and 1979. During the same period, concentrations in the 5 to 10-cm depth have increased, arguing for downward migration of soil contamination. Sitewide, concentrations of ^{137}Cs in the lower soil depth are about 18% of those in the surface soils.

With the exception of one data point, $^{239/240}Pu$ is found in background concentrations at all distances from the stack at ICPP (Figure C-I.4). A single, above background concentration was observed at 1.7 km from the stack in 1989, the last sampling from the ICPP grid. All other samples, including those from greater distances, were at background concentrations. This single point is insufficient evidence to argue for an increase in plume size; ICPP will be sampled again in 1996. Concentrations of $^{239/240}Pu$ remained constant in both soil depths between 1982 and 1989, indicating little vertical migration of plutonium. Sitewide, concentrations of $^{239/240}Pu$ in the lower soil depth are negligible compared to those in the surface soils.

Because ^{129}I is produced in the calcining process, it is reasonable to expect ^{129}I concentrations in the environment to increase in magnitude and extent when the calcining process is in operation. However, because of the long half-life of ^{129}I (1.6×10^7 y) and the strong affinity for some chemical forms of iodine for organic fractions of the soil, it may not be reasonable to expect decreases in contamination magnitude or extent when calcining stops. Studies are currently under way to determine whether these arguments are valid. Similar arguments may hold true for some transuranic elements.

C-I-1.1.3.2 Data Gaps. Significant data gaps exist in the ICPP related data. Limited vegetation and small mammal data are available, particularly for the transuranics and gamma-emitting radionuclides. These data are important because these two groups serve as the base of the herbivore and carnivore food chains and because small mammals include one of INEL's C2 species (the pygmy rabbit). Raptors, other birds, and bats, all of which include C2 species, are not represented in the ICPP data. On the other hand, the data that are important for human food chain exposure, the game species, are well represented. Soil samples were not collected between about 2 to 10 km from the stack and these samples are necessary to determine the extent of the contamination plume at ICPP.

C-I-1.1.4 Subsurface Disposal Area (Table C-I.3)

Transuranics, ^{90}Sr, and gamma-emitters have been detected in a variety of environmental media at SDA. Transuranics have been of particular interest because SDA has been used as a transuranic storage area.

Media that have been thoroughly investigated include soils, vegetation, small mammals, and coyotes. In addition, a limited amount of work has been carried out on mourning doves, horned larks, rattlesnakes, and terrestrial invertebrates. Contrary to the practice at other facilities, a significant amount of environmental research has been conducted by RESL within the boundaries of the SDA and these data are reported here.

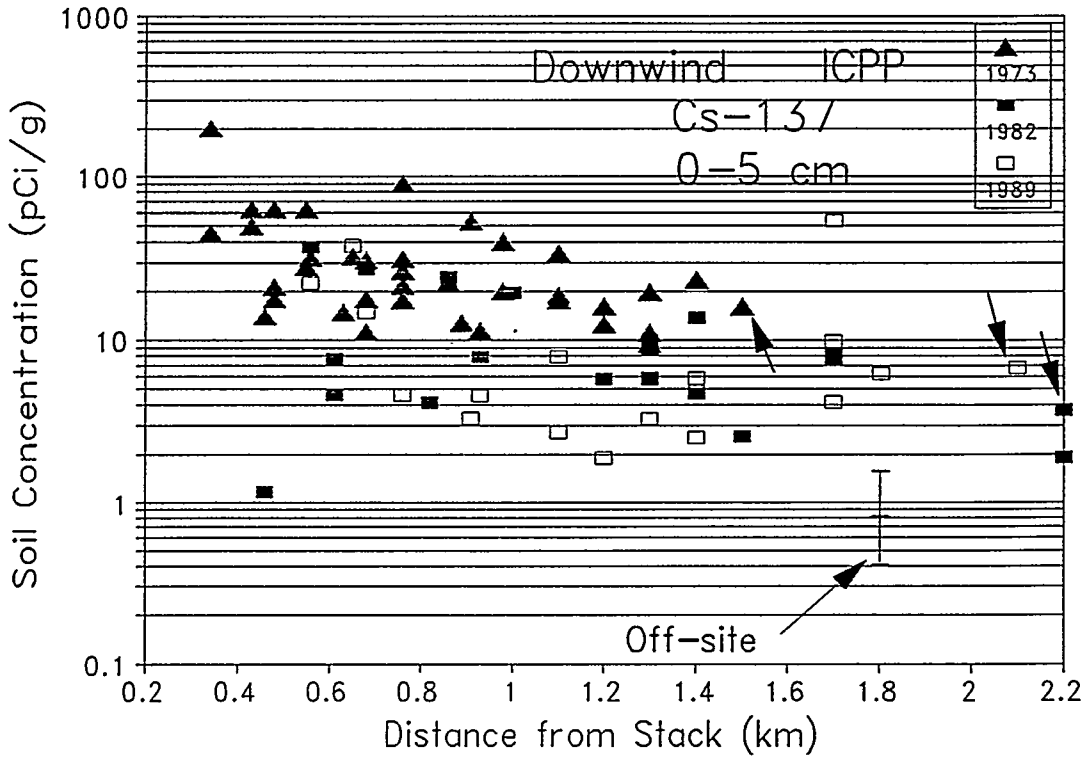


Figure C-I.3. Concentrations of ^{137}Cs in the soil downwind from ICPP. Samples were taken at the soil surface down to 5 cm. The offsite error bar indicates the median background concentration ±1 GSD. The above-background concentration found at the farthest distance from the stack in each year is indicated by an arrow.

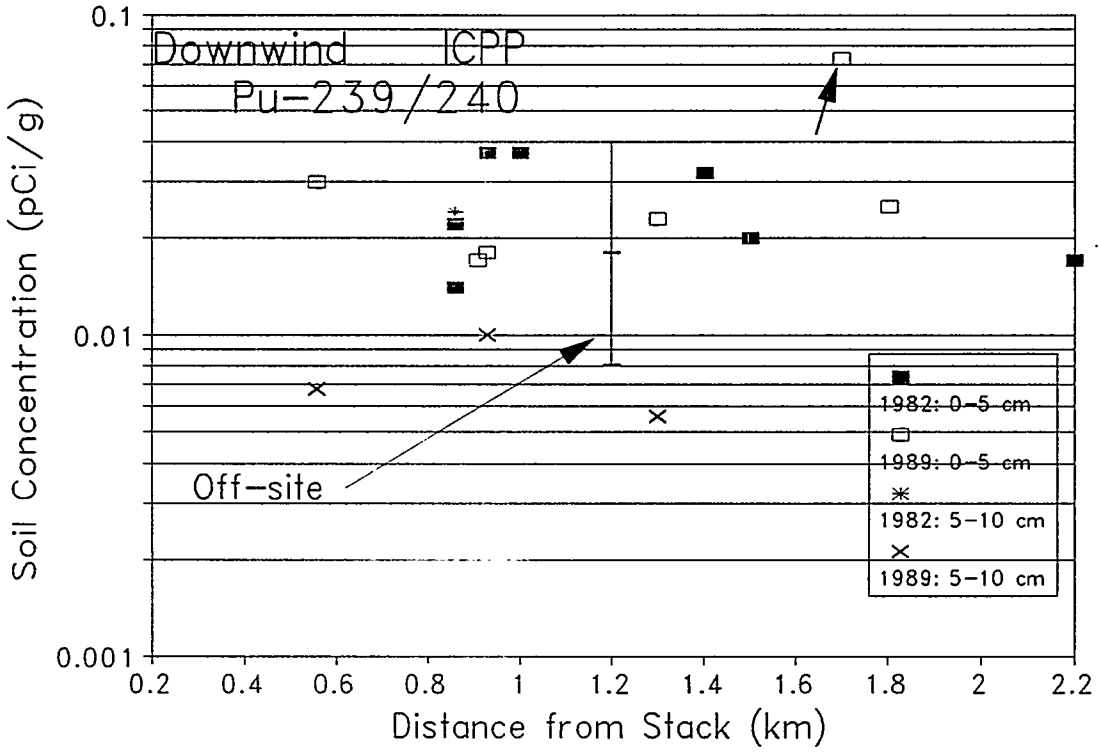


Figure C-I.4. Concentrations of $^{239,240}Pu$ in the soil downwind from ICPP. Samples were taken at the soil surface down to 5 cm or from 5 to 10 cm. The offsite error bar indicates the median background concentration ±1 GSD. The above-background concentration in the surface soil layer found at the farthest distance from the stack in each year is indicated by an arrow.

Table C-I.3. Radioactive contamination of various environmental media at and near the SDA. Data are ranges unless otherwise noted.

Medium or Location	Nuclides	Levels ($pCi\ g^{-1}$)	References
		Soil	
On SDA, 10-cm depth	^{7}Be	ND[a] - 2.1	Arthur (1982)
	^{54}Mn	ND - 0.41	Arthur and Markham (1983)
	^{60}Co	0.11 - 62	Unpublished data from
	^{90}Sr	ND - 4.6	RESL, 1972 to 1973
	^{95}Nb	ND - 41	
	^{95}Zr	ND - 20	
	^{106}Ru	ND - 12	
	^{124}Sb	ND - 2.1	
	^{125}Sb	ND - 5.4	
	^{134}Cs	ND - 6.2	
	^{137}Cs	ND - 2.0	
	^{144}Ce	ND - 140	
	^{238}Pu	ND - 1.4	
	^{239}Pu[b]	ND - 54	
	^{241}Am	ND - 300	
SDA perimeter drainage, <10-cm depth	^{60}Co	ND - 11	Markham (1978)
	^{90}Sr	0.17 - 26	Markham et al. (1978)
	^{106}Ru	ND - 1.4	Unpublished data from
	^{125}Sb	ND - 0.30	RESL, 1978
	^{134}Cs	ND - 0.068	
	^{137}Cs	0.081 - 16	
	^{144}Ce	ND - 1.9	
	^{152}Eu	ND - 0.21	
	^{154}Eu	ND - 0.27	
	^{238}Pu	ND - 0.81	
	^{239}Pu[b]	0.010 - 38	
	^{241}Am	0.022 - 51	
	^{244}Cm	ND - 0.086	
	Other γ[c]	ND	
≤350 m from SDA fence, <10-cm depth	^{60}Co	ND - 2.1	Markham (1978)
	^{90}Sr	0.30 - 26	
	^{106}Ru	ND - 5.1	
	^{125}Sb	ND - 0.20	
	^{137}Cs	1.2 - 3.8	
	^{144}Ce	ND - 0.81	
	Other γ[c]	ND	

Table C-I.3. (continued).

Medium or Location	Nuclides	Levels (pCi g^{-1})	References
		Soil	
<1.6 km from SDA fence, <10-cm depth	^{60}Co	ND - 0.18	Unpublished data from RESL, 1971 to 1985
	^{90}Sr	ND - 2.5	
	^{95}Nb	ND - 0.20	
	^{95}Zr	ND - 0.10	
	^{106}Ru	ND - 0.30	
	^{125}Sb	ND - 0.18	
	^{137}Cs	ND - 3.5	
	^{144}Ce	ND - 0.89	
	^{238}Pu	ND - 0.0089	
	^{239}Pu[b]	ND - 0.35	
	^{241}Am	ND - 0.62	
	Other γ[c]	ND	
<2.5 km from SDA fence, <10-cm depth	^{241}Am	8.4[d]	Markham et al. (1978)
	^{238}Pu	0.059[d]	
	^{239}Pu[b]	2.6[d]	
		Vegetation	
Crested wheatgrass on SDA	^{90}Sr	ND - 2.7	Arthur (1982)
	^{137}Cs	ND - 3.0	
	^{238}Pu	ND - 0.043	
	^{239}Pu[b]	0.0020 - 1.9	
	^{241}Am	0.0030 - 5.1	
	Other γ[c]	ND	
Russian thistle on SDA	^{60}Co	0.41 - 4.6	Arthur (1982)
	^{90}Sr	ND - 160	Markham (1976)
	^{137}Cs	ND - 57	
	^{238}Pu	ND - 0.057	
	^{239}Pu[b]	0.010 - 0.070	
	^{241}Am	0.010 - 0.19	
	Other γ[c]	ND	
Vegetation on SDA	^{144}Ce	ND - 230	Arthur (1982)
	Other γ[c]	ND	

Table C-I.3. (continued).

Medium or Location	Nuclides	Levels ($pCi\ g^{-1}$)	References
		Small Mammals	
Cottontail on SDA	^{90}Sr	ND - 0.76	Janke and Arthur (1985)
	^{137}Cs	ND - 1.1	
	^{238}Pu	ND - 0.0070	
	^{239}Pu[b]	0.00049 - 0.035	
	^{241}Am	0.00070 - 0.16	
Deer mice on SDA	^{90}Sr	ND - 3500	Arthur et al. (1987)
	^{137}Cs	0.30 - 6200	
	^{238}Pu	0.00060 - 8.9	
	^{239}Pu[b]	0.00060 - 3.0	
	^{241}Am	ND - 3.8	
Deer mice on SDA perimeter drainage	^{57}Co	ND - 5.7	Markham (1978) Markham et al. (1978)
	^{60}Co	ND - 700	
	^{95}Nb	ND - 150	
	^{95}Zr	ND - 62	
	$^{103,106}Ru$	ND - 270	
	^{125}Sb	ND - 57	
	^{134}Cs	ND - 130	
	^{137}Cs	ND - 620	
	^{238}Pu	ND - 41	
	^{239}Pu[b]	ND - 2100	
	^{241}Am	ND - 270	
	Other γ[c]	ND	
Deer mice ≤350 m outside SDA fence	^{60}Co	ND - 23	Markham (1978) Markham et al. (1978)
	^{95}Nb	ND - 54	
	^{95}Zr	ND - 24	
	^{137}Cs	ND - 16	
	^{238}Pu	ND - 0.089	
	^{239}Pu[b]	ND - 5.7	
	^{241}Am	ND - 0.59	
	Other γ[c]	ND	

Table C-I.3. (continued).

Medium or Location	Nuclides	Levels (pCi g^{-1})	References
		Predatory Mammals	
Coyote feces on SDA	^{60}Co	ND - 1.7	Arthur and Markham (1982)
	^{90}Sr	ND - 5.0	
	^{134}Cs	ND - 1.7	
	^{137}Cs	ND - 30	
	^{238}Pu	ND - 0.073	
	^{239}Pu[b]	ND - 3.0	
	^{241}Am	0.0049 - 2.3	
	Other γ[c]	ND	
		Upland Game Birds	
Mourning dove GI on SDA	^{137}Cs	ND - 4.0	Markham and Halford (1982)
Mourning dove muscle on SDA	^{137}Cs	ND - 0.89	Markham and Halford (1982)
		Other Birds	
Horned lark on SDA	^{137}Cs	1.1 ± 2.5[e]	Arthur and Janke (1986)
	Other γ[c]	ND	
		Reptiles	
Rattlesnake on SDA	^{137}Cs	0.32 ± 0.21[e]	Arthur and Janke (1986)
	Other γ[c]	ND	
		Terrestrial Invertebrates	
SDA composite	^{90}Sr	2.4 ± 3.2[e]	Arthur and Janke (1986)
	^{137}Cs	0.46 ± 0.54[e]	
	^{238}Pu	0.0081 ± 0.011[e]	
	^{239}Pu[b]	0.078 ± 0.11[e]	
	^{241}Am	0.022 ± 0.020[e]	
	Other γ[c]	ND	

a. Not detected. Detection limits varied between studies.
b. Assumed to include both ^{239}Pu and ^{240}Pu.
c. Samples were analyzed by gamma scan.
d. Maximum.
e. Mean ±1 standard deviation.

The maximum soil concentration of ^{137}Cs was reported as 16 pCi g^{-1} and was found at the SDA perimeter (Markham 1978). This concentration is approximately 2% of the maximum reported for SL-1 soils but six times maximum background concentrations (Table C-I.1).

The maximum soil concentration of $^{239,240}Pu$ at the SDA, found within the facility fence, was reported to be 54 pCi g^{-1} (Arthur and Markham 1983). This value was the largest reported soil concentration among the studies reviewed here and was 600 times the maximum background concentration (Table C-I.1).

C-I-1.1.4.1 Trends. The data for SDA soils, vegetation, and, to a lesser extent, small mammals are quite comprehensive with respect to spatial extent and radionuclide coverage. The transuranic elements ^{238}Pu, $^{239,240}Pu$, and ^{241}Am have been detected at above background concentrations in soils on the SDA and out to 1.0, 2.4, and 2.5 km, respectively, from the SDA perimeter (Markham et al. 1978). In small mammals, above-background concentrations were detected out to about 350 m from the SDA fence. Highest concentrations, for soil and small mammals, were found at the SDA perimeter drainage area, and concentrations decreased with distance from the fence. Transport to that point was attributed to localized flooding and transport beyond that point to windblown materials. Similar conclusions have been drawn for gamma-emitters in soils and small mammals (Markham 1978).

The RESL soil sampling data show above-background concentrations of ^{137}Cs out to 42 m from the SDA fence in 1978 (Figure C-I.5). In 1985, no soil samples outside the SDA fence had above-background concentrations of ^{137}Cs. This finding implies a possible decrease in contamination levels from the SDA and might be attributed to the addition of extra soil layers on portions of the SDA since 1978 (Arthur et al. 1986) as well as decay of the ^{137}Cs transported off the SDA by flood waters in the 1960s. Although the increase in ^{137}Cs contamination of the 5 to 10-cm soil layer (Figure C-I.5) is not statistically significant, downward migration of ^{137}Cs may also have. contributed to the decrease in surface soil contamination.

Above-background concentrations of $^{239,240}Pu$ were found out to 94 m from the SDA fence in 1978 and 43 m from the fence in 1985 (Figure C-I.6). Combined with the Markham et al. (1978) data, which were based on samples collected in 1973, the soil contamination plume appears to have decreased in extent over a 12-year period. This apparent decrease cannot be attributed to decay because of the long half-life of the nuclides involved. There is some indication that the downward migration of $^{239,240}Pu$ may be responsible for this decrease because concentrations in the 5 to 10-cm layer were higher in 1985 than in 1978 (Figure C-I.6) but too few data exist to make firm conclusions.

C-I-1.1.4.2 Data Gaps. No data are available for radioactive contamination of game mammals, raptors, or bats near SDA. All of these are relatively important gaps: game mammals for assessing human food chain transport and raptors and bats for assessing potential doses to T&E or C2 species. Data are limited for birds in general and this gap limits our ability to determine potential doses to Loggerhead shrikes, a C2 species. Further transuranic analyses of soil samples from the 5 to 10-cm soil layer would help to determine whether downward migration of transuranics is responsible for the apparent decrease in the extent of the transuranic contamination plume.

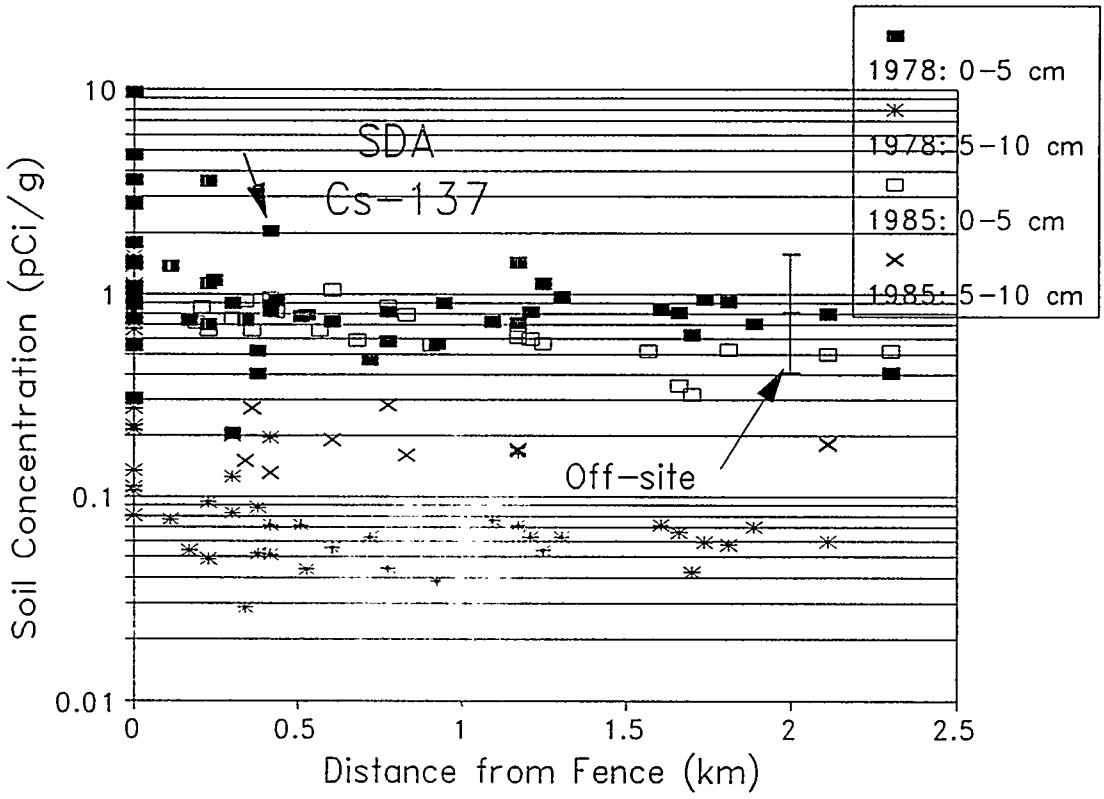


Figure C-I.5. Concentrations of ^{137}Cs in the soil downwind from the SDA. Samples were taken at the soil surface down to 5 cm or from 5 to 10 cm. The offsite error bar indicates the median background concentration ±1 GSD. The above background concentration in the surface soil layer found at the farthest distance from the stack in each year is indicated by an arrow.

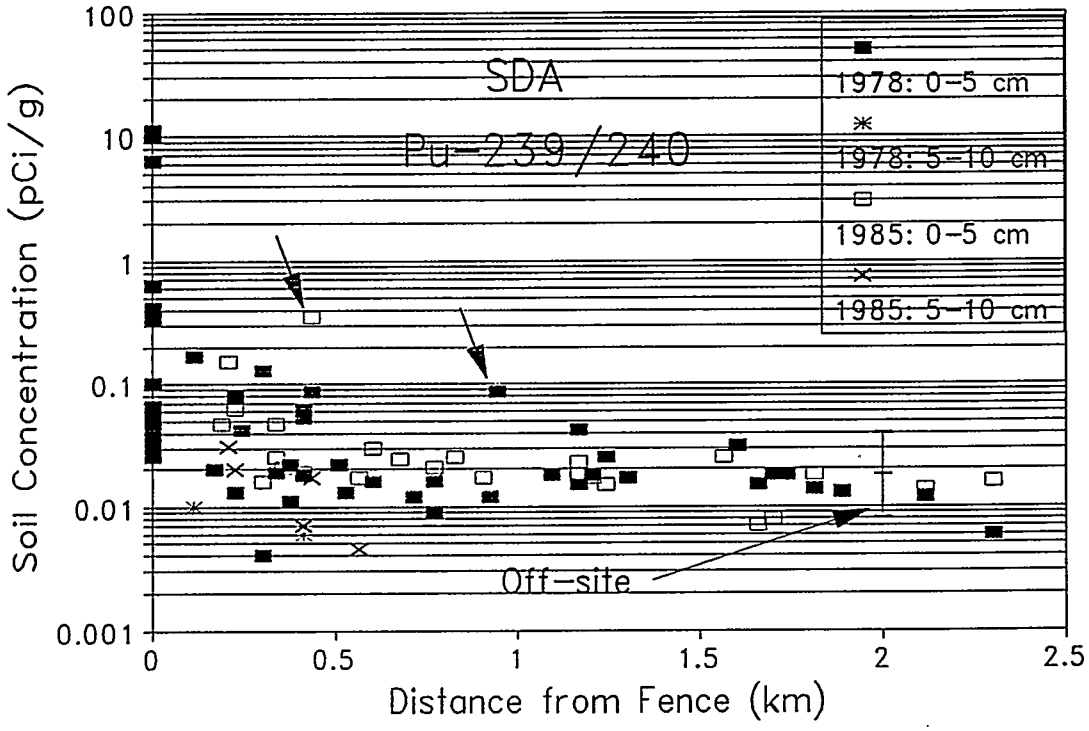


Figure C-I.6. Concentrations of $^{239,240}Pu$ in the soil downwind from the SDA. Samples were taken at the soil surface down to 5 cm or from 5 to 10 cm. The offsite error bar indicates the median background concentration ±1 GSD. The above background concentration in the surface soil layer found at the farthest distance from the stack in each year is indicated by an arrow.

C-I-1.1.5 SL-1 Area (Table C-I.4)

All the available data for environmental contamination at the SL-1 facility (except the RESL soil data) are from two studies (Arthur et al. 1983; Markham and Halford 1982). Gamma-emitters were investigated in soils, small mammals, coyote feces, mourning doves, and terrestrial invertebrates. In addition, transuranics were measured in soils by RESL.

Cesium-137 was the most common radionuclide detected with a maximum detected concentration of 700 pCi g^{-1} in soils (Arthur et al. 1983). This concentration is the largest for soil reported in the studies reviewed here (other than TRA pond sediments which are four times greater; Table C-I.5) and is 240 times the maximum background soil concentration (Table C-I.1).

The maximum soil concentration of $^{239,240}Pu$ at SL-1 was 0.046 pCi g^{-1}. This concentration is about 0.09% of the maximum contamination at the SDA and about half the maximum background.

C-I-1.1.5.1 Trends. The RESL soil data from the ARA/SL-1 area were sampled from a radial grid centered on ARA-II. SL-1 is located about 600 m from ARA-II in a downwind direction, and a small peak is observable in these data at this location (Figure C-I.7). Thus, while SL-1 contributes to the RESL data for this area, the focus of the data is ARA.

In 1977, surface soils at ARA were contaminated with ^{137}Cs at above-background concentrations out to 1.5 km from the center, the farthest distance to which samples were taken. In 1985, the extent of the contamination was 1.0 km, also the farthest distance at which samples were taken (Figure C-I.7). The only conclusion possible from these data is that the true extent of the plume is unknown. From the observed concentrations, however, it is unlikely that the above-background plume extends much beyond 2 km.

Above-background concentrations of $^{239,240}Pu$ were detected in 1977 at 0.1 km from ARA-II (Figure C-I.8). This location was not sampled in 1985 so no above background concentrations were detected that year. There is no evidence for expansion of the $^{239,240}Pu$ concentration plume.

C-I-1.1.5.2 Data Gaps. No data exist for the SL-1 waste disposal area relative to vegetation, game mammals, raptors, bats, or reptiles; and limited data are available for other media. Although these data gaps might be important, the relatively small area and lack of continued operations at SL-1 make them less likely to be significant. On the other hand, the large soil concentration of ^{137}Cs may indicate that further work should be done to determine the potential for spread of this contamination. The extent of the contamination plume should be defined by sampling soils at greater distances from ARA-II than have been previously sampled.

C-I-1.1.6 Test Reactor Area (Table C-I.5)

The contamination of environmental media near TRA has been intensively studied. Gamma-emitting and transuranic radionuclides have been detected in soils; sediment, vegetation, and water from the radioactive waste percolation pond; small mammals; coyote feces; raptors; upland game birds; waterfowl; and barn swallows. Almost all studies at the TRA have been focused on the currently inactive, radioactive waste percolation ponds.

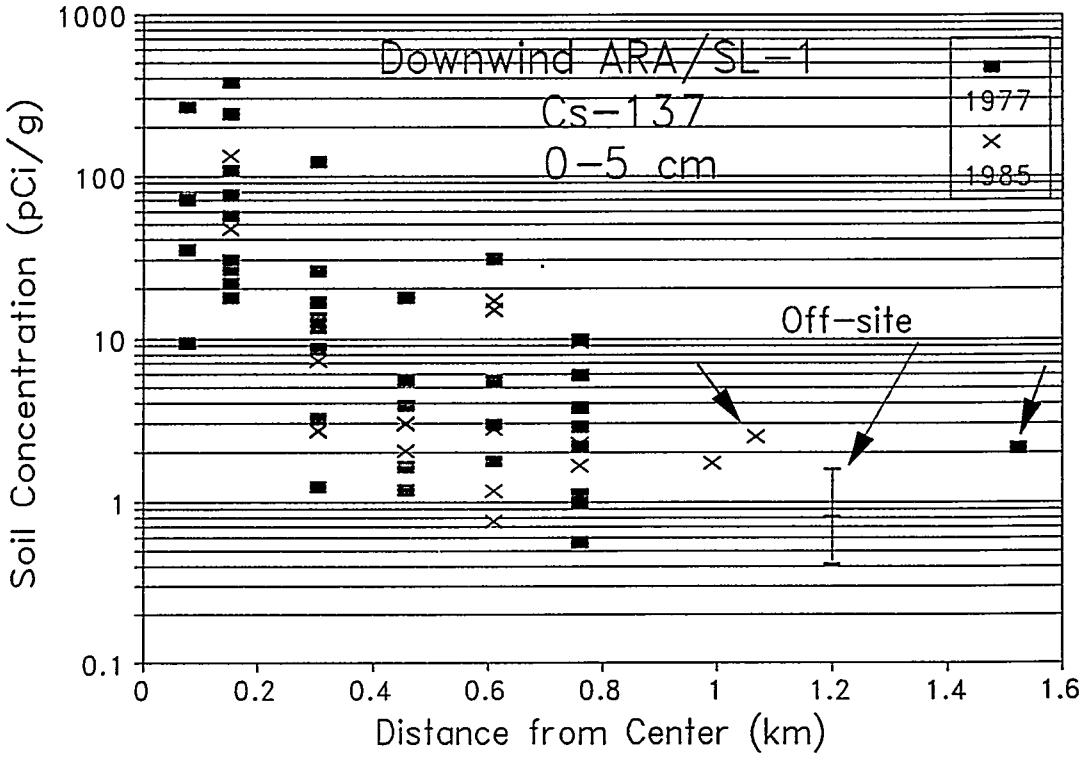


Figure C-I.7. Concentrations of ^{137}Cs in the soil downwind from ARA/SL-1. Samples were taken at the soil surface down to 5 cm. The offsite error bar indicates the median background concentration ±1 GSD. The above-background concentration in the surface soil layer found at the farthest distance from the stack in each year is indicated by an arrow.

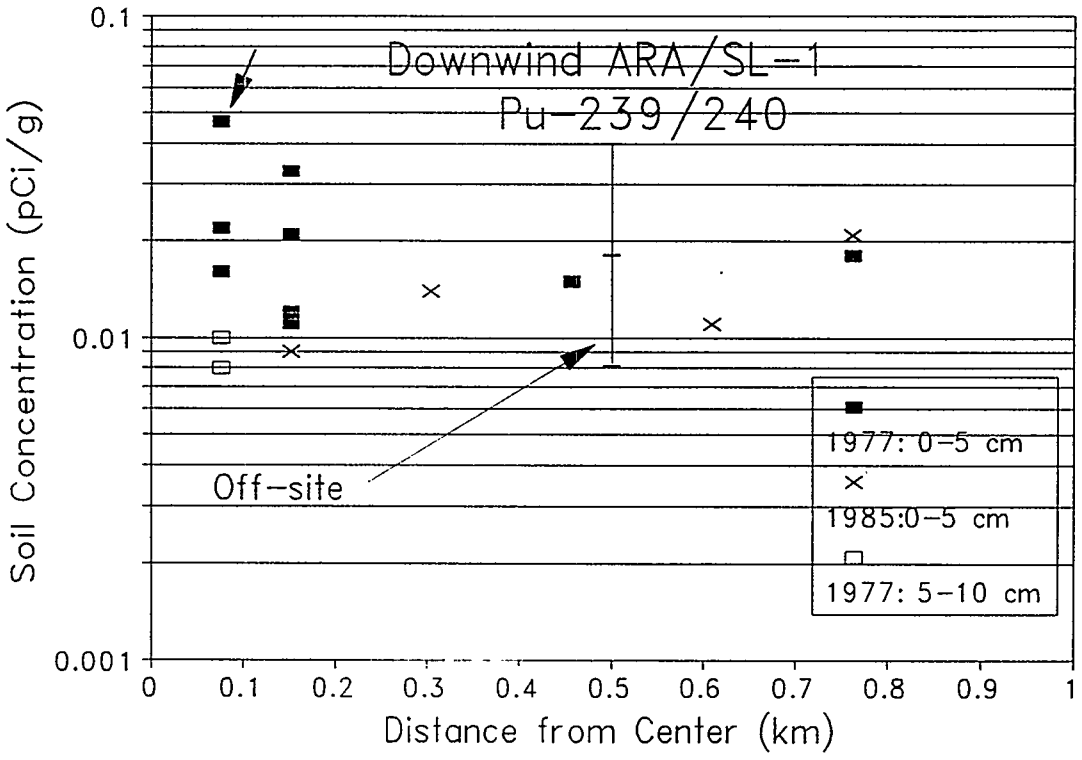


Figure C-I.8. Concentrations of $^{239,240}Pu$ in the soil downwind from ARA/SL-1. Samples were taken at the soil surface down to 5 cm or from 5 to 10 cm. The offsite error bar indicates the median background concentration ±1 GSD. The above background concentration in the surface soil layer found at the farthest distance from the stack in each year is indicated by an arrow.

Table C-I.4. Radioactive contamination of various environmental media at the SL-1 area of INEL. Data are ranges unless otherwise noted.

Medium or Location	Nuclides	Levels (pCi g^{-1})	References
		Soil	
ARA/SL-1	^{52}Mn	ND[a] - 8600	Arthur et al. (1983)
	^{54}Mn	ND - 0.10	
	^{60}Co	ND - 11	Unpublished data from
	^{90}Sr	ND - 57	RESL, 1971 to 1985
	^{95}Nb	ND - 0.20	
	^{95}Zr	ND - 0.30	
	^{106}Ru	ND - 0.20	
	^{125}Sb	ND - 0.24	
	^{134}Cs	ND - 0.46	
	^{137}Cs	ND - 700	
	^{140}Ba	ND - 4.1	
	^{144}Ce	ND - 0.70	
	^{152}Eu	ND - 0.59	
	^{155}Eu	ND - 0.41	
	^{238}Pu	ND - 0.025	
	^{239}Pu[b]	0.0081 - 0.046	
	^{241}Am	ND - 0.020	
	Other γ[c]	ND	
		Small Mammals	
Deer mice at SL-1	^{54}Mn	ND - 2.7[d]	Arthur et al. (1983)
	^{95}Nb	ND - 70[d]	
	^{137}Cs	4.1 - 1300	
	^{141}Ce	ND - 14[d]	
	^{144}Ce	ND - 2.7[d]	
	Other γ[c]	ND	
Pocket mice at SL-1	^{137}Cs	0.041 - 25	Arthur et al. (1983)
		Predatory Mammals	
Coyote feces at SL-1	^{95}Zr	ND - 6.8[d]	Arthur et al. (1983)
	^{106}Ru	ND - 18[d]	
	^{137}Cs	0.41 - 11	
	Other γ[c]	ND	
		Upland Game Birds	
Mourning dove GI	^{137}Cs	ND	Markham and Halford (1982)
Mourning dove muscle	^{137}Cs	ND	Markham and Halford (1982)

Table C-I.4. (continued).

Medium or Location	Nuclides	Levels ($pCi\ g^{-1}$)	References
		Terrestrial Invertebrates	
SL-1 composite	^{137}Cs	0.30 - 86	Arthur et al. (1983)
	Other γ[c]	ND	

a. Not detected. Detection limits varied between studies.

b. Assumed to contain both ^{239}Pu and ^{240}Pu.

c. Samples were analyzed by gamma scan.

d. Detected in a single sample.

Table C-I.5. Radioactive contamination of various environmental media from TRA at INEL. Data are ranges unless otherwise noted.

Medium or Location	Nuclides	Levels ($pCi\ g^{-1}$)	References
		Soil	
Radioactive waste pond sediments	^{238}Pu	13 ± 5.4[a]	Kuzo et al. (1987)
	^{239}Pu[b]	3.2 ± 2.2[a]	Markham et al. (1988)
	^{241}Am	2.4 ± 1.1[a]	
	^{242}Cm	0.54 ± 0.27[a]	
	^{244}Cm	4.1 ± 1.1[a]	
Radioactive waste pond sediments	^{238}Pu	41 ± 4.3[a]	Ibrahim and Culp (1989)
	^{239}Pu[b]	43 ± 4.9[a]	
Barn swallow nests made with radioactive waste pond sediment	^{46}Sc	1.4 ± 0.95[a]	Millard et al. (1990)
	^{51}Cr	6200 ± 12000[a]	
	^{54}Mn	10 ± 10[a]	
	^{57}Co	3.5 ± 3.8[a]	
	^{58}Co	9.2 ± 8.4[a]	
	^{59}Fe	2.4 ± 4.6[a]	
	^{60}Co	840 ± 950[a]	
	^{65}Zn	49 ± 51[a]	
	^{95}Zr	6.5 ± 9.5[a]	
	^{103}Ru	1.4 ± 0.95[a]	
	^{106}Ru	10 ± 27[a]	
	^{131}I	23 ± 35[a]	
	^{134}Cs	370 ± 350[a]	
	^{137}Cs	2500 ± 2500[a]	
	^{140}Ba	32 ± 54[a]	
	^{141}Ce	32 ± 38[a]	
	^{144}Ce	110 ± 140[a]	
	^{181}Hf	10 ± 14[a]	
	Other γ[c]	ND[d]	
Ant mounds at the radioactive waste pond	^{60}Co	3.2 - 49[e]	Blom et al. (1991)
	^{137}Cs	12 - 270[e]	
Area surrounding TRA, <10-cm depth	^{7}Be	ND - 0.76	Unpublished data from RESL, 1971 to 1990
	^{54}Mn	ND - 0.059	
	^{60}Co	ND - 68	
	^{90}Sr	ND - 5.7	
	^{95}Nb	ND - 0.089	
	^{95}Zr	ND - 0.081	
	^{125}Sb	ND - 0.22	
	^{134}Cs	ND - 2.7	
	^{137}Cs	ND - 220	
	^{141}Ce	ND - 0.041	

Table C-I.5. (continued).

Medium or Location	Nuclides	Levels ($pCi\ g^{-1}$)	References
Area surrounding TRA, <10-cm depth	^{144}Ce	ND - 1.0	
	^{152}Eu	ND - 0.70	
	^{155}Eu	ND - 0.11	
	^{238}Pu	ND - 0.016	
	^{239}Pu[b]	ND - 0.065	
	^{241}Am	ND - 0.016	
	Other γ[c]	ND	
		Water	
Radioactive waste pond filtered water	^{238}Pu	0.0018 ± 0.00022[a]	Kuzo et al. (1987)
	^{239}Pu[b]	0.00035 ± 0.00049[a]	Markham et al. (1988)
	^{241}Am	0.0012 ± 0.00035[a]	
	^{242}Cm	0.0013 ± 0.00049[a]	
	^{244}Cm	0.0020 ± 0.00060[a]	
Radioactive waste pond	^{238}Pu	0.00081[f]	Ibrahim and Culp (1989)
	^{239}Pu[b]	0.00070[f]	
		Vegetation	
Radioactive waste pond periphyton	^{238}Pu	410 ± 84[a]	Kuzo et al. (1987)
	^{239}Pu[b]	140 ± 43[a]	Markham et al. (1988)
	^{241}Am	110 ± 24[a]	
	^{242}Cm	30 ± 8.1[a]	
	^{244}Cm	180 ± 54[a]	
Radioactive waste pond plankton	^{238}Pu	14 ± 12[a]	Kuzo et al. (1987)
	^{239}Pu[b]	9.5 ± 20[a]	Markham et al. (1988)
	^{241}Am	8.1 ± 7.8[a]	
	^{242}Cm	3.2 ± 0.81[a]	
	^{244}Cm	11 ± 6.5[a]	
Radioactive waste pond plankton	^{238}Pu	130 ± 46[a]	Ibrahim and Culp (1989)
	^{239}Pu[b]	150 ± 49[a]	
		Small Mammals	
Internal contamination from radioactive waste pond basin	^{238}Pu	ND - 0.14	Halford (1987)
	^{239}Pu[b]	ND - 0.10	
	^{241}Am	ND - 0.043	
	^{242}Cm	ND - 0.059	
	^{244}Cm	ND - 0.062	

Table C-I.5. (continued).

Medium or Location	Nuclides	Levels ($pCi\ g^{-1}$)	References
External contamination from radioactive waste pond basin (gut and hide)	^{238}Pu	ND - 5.9	Halford (1987)
	^{239}Pu[b]	ND - 2.3	
	^{241}Am	ND - 1.6	
	^{242}Cm	ND - 0.030	
	^{244}Cm	ND - 1.8	
Radioactive waste pond basin	^{51}Cr	700[g]	Halford and Markham (1978)
	^{60}Co	320[g]	
	^{65}Zn	73[g]	
	^{75}Se	25[g]	
	^{95}Nb	ND - 15	
	^{131}I	73[g]	
	^{134}Cs	30[g]	
	^{137}Cs	270[g]	
	^{140}La	17[g]	
	^{141}Ce	ND - 38	
	^{144}Ce	ND - 26	
	Other γ[c]	ND	
	Predatory Mammals		
Coyote feces from radioactive waste pond perimeter	^{54}Mn	ND - 120	Arthur and Markham (1982)
	^{57}Co	ND - 0.51	
	^{60}Co	0.59 - 150	
	^{65}Zn	ND - 3.8	
	^{90}Sr	2.7 - 22	
	^{95}Nb	ND - 11	
	^{95}Zr	ND - 9.5	
	^{103}Ru	ND - 1.1	
	^{134}Cs	0.59 - 17	
	^{137}Cs	ND - 270	
	^{144}Ce	ND - 35	
	^{238}Pu	ND - 0.073	
	^{239}Pu[b]	ND - 3.0	
	^{241}Am	0.0041 - 2.3	
	^{242}Cm	ND - 0.030	
	^{244}Cm	ND - 0.026	
	Other γ[c]	ND	
	Raptors		
Kestrel	Many γ[h]	0.30 - 43	Craig et al. (1979)
Long-eared owl	^{137}Cs	ND - 0.41	Craig et al. (1979)
	Other γ[c]	ND	

Table C-I.5. (continued).

Medium or Location	Nuclides	Levels ($pCi\ g^{-1}$)	References
Marsh Hawk	Many γ[h]	35 - 86	Craig et al. (1979)
	Upland Game Birds		
Mourning dove GI	^{51}Cr	ND - 2600	Markham and Halford (1982)
	^{60}Co	ND - 230	
	^{54}Mn	ND - 8.6	
	^{57}Co	ND - 0.30	
	^{58}Co	ND - 0.49	
	^{65}Zn	ND - 22	
	^{75}Se	ND - 11	
	^{95}Nb	ND - 46	
	^{95}Zr	ND - 38	
	^{103}Ru	ND - 0.89	
	^{125}Sb	ND - 4.9	
	^{131}I	ND - 86	
	^{134}Cs	ND - 41	
	^{137}Cs	ND - 430	
	^{140}Ba	ND - 4.9	
	^{140}La	ND - 3.0	
	^{141}Ce	ND - 38	
	^{144}Ce	ND - 68	
	^{181}Hf	ND - 17	
	Other γ[c]	ND	
Mourning dove muscle	^{51}Cr	ND - 140	Markham and Halford (1982)
	^{60}Co	ND - 2.2	
	^{75}Se	ND - 6.5	
	^{95}Nb	ND - 0.20	
	^{131}I	ND - 1.8	
	^{132}Cs	ND - 89	
	^{134}Cs	ND - 19	
	^{137}Cs	ND - 7.0	
	Other γ[c]	ND	

Table C-I.5. (continued).

Medium or Location	Nuclides	Levels ($pCi\ g^{-1}$)	References
		Upland Game Birds (Continued)	
Sage grouse GI at TRA and ICPP	^{51}Cr	ND - 540	Connelly and Markham (1983)
	^{54}Mn	ND - 0.70	
	^{58}Co	ND - 0.10	
	^{60}Co	ND - 25	
	^{65}Zn	ND - 13	
	^{75}Se	ND - 4.6	
	^{95}Nb	ND - 1.8	
	^{95}Zr	ND - 1.1	
	^{103}Ru	ND - 0.89	
	^{134}Cs	ND - 27	
	^{137}Cs	ND - 110	
	^{140}La	ND - 0.59	
	^{141}Ce	ND - 2.2	
	^{144}Ce	ND - 7.0	
	^{203}Hg	ND - 0.59	
	Other γ[c]	ND	
Sage grouse muscle at TRA and ICPP	^{24}Na	ND - 3.8	Connelly and Markham (1983)
	^{54}Mn	ND - 0.30	
	^{60}Co	ND - 1.9	
	^{65}Zn	ND - 1.5	
	^{75}Se	ND - 1.4	
	^{95}Nb	ND - 0.20	
	^{103}Ru	ND - 0.41	
	^{134}Cs	ND - 5.7	
	^{137}Cs	ND - 30	
	^{140}Ba	ND - 2.7	
	^{203}Hg	ND - 0.49	
	Other γ[c]	ND	
		Waterfowl	
TRA chemical waste ponds (whole body)	^{137}Cs	0.19 - 0.62	Morris et al. (in preparation)
	^{198}Au	3.0[i]	
	Other γ[c]	ND	

Table C-I.5. (continued).

Medium or Location	Nuclides	Levels (pCi g^{-1})	References
TRA radioactive waste ponds (muscle, skin, liver, gut feathers)	^{24}Na	ND - 73	Halford et al. (1981)
	^{46}Sc	ND - 380	
	^{51}Cr	130000[g]	
	^{54}Mn	ND - 350	
	^{57}Co	ND - 120	
	^{58}Co	1700[g]	
	^{59}Fe	ND - 270	
	^{60}Co	7000[g]	
	^{65}Zn	1500[g]	
	^{75}Se	590[g]	
	^{95}Nb	ND - 6500	
	^{95}Zr	ND - 6800	
	^{103}Ru	ND - 3800	
	^{106}Ru	ND - 59	
	^{110m}Ag	ND - 89	
	^{124}Sb	ND - 3.0	
	^{131}I	2100[g]	
	^{132}Te	81[g]	
	^{134}Cs	1200[g]	
	^{136}Cs	ND - 17	
	^{137}Cs	5400[g]	
	^{140}Ba	ND - 12000	
	^{140}La	5900[g]	
	^{141}Ce	8100[g]	
	^{144}Ce	6800[g]	
	^{147}Nd	ND - 3000	
	^{154}Eu	ND - 12	
	^{175}Hf	ND - 7.0	
	^{181}Hf	ND - 4900	
	Other γ[c]	ND	
TRA radioactive waste ponds (muscle)	^{51}Cr	ND - 210	Halford et al. (1982)
	^{58}Co	ND - 65	
	^{60}Co	ND - 140	
	^{65}Zn	ND - 240	
	^{75}Se	ND - 320	
	^{131}I	ND - 300	
	^{134}Cs	ND - 920	
	^{137}Cs	ND - 4100	
	Other γ[c]	ND	
TRA radioactive waste ponds (muscle)	^{129}I[j]	1.5×10^{-7} - 3.8×10^{-6}	Halford and Markham (1984)

Table C-I.5. (continued).

Medium or Location	Nuclides	Levels (pCi g^{-1})	References
TRA radioactive waste ponds (whole body)	^{51}Cr	8.6 - 260	Morris (1993) Morris et al. (in preparation)
	^{54}Mn	2.1 - 3.5	
	^{60}Co	1.4 - 180	
	^{65}Zn	1.6 - 35	
	^{75}Se	3.0 - 18	
	^{95}Nb	ND - 2.5[i]	
	^{110m}Ag	ND - 2.7[i]	
	^{124}Sb	ND - 590[i]	
	^{134}Cs	0.81 - 20	
	^{137}Cs	5.4 - 460	
	^{141}Ce	ND - 10[i]	
	^{181}Hf	ND - 3.2[i]	
	^{203}Hg	4.3 - 8.1	
	Other γ[c]	ND	
TRA sewage disposal pond (muscle)	^{129}I[j]	2.8×10^{-7} - 4.6×10^{-6}	Halford and Markham (1984)
		Other Birds	
Immature barn swallows near TRA	^{24}Na	32 ± 35[a]	Millard et al. (1990)
	^{51}Cr	57 ± 57[a]	
	^{60}Co	2.4 ± 1.3[a]	
	^{65}Zn	22 ± 4.6[a]	
	^{75}Se	5.9 ± 2.6[a]	
	^{131}I	8.1 ± 13[a]	
	^{134}Cs	3.2 ± 2.0[a]	
	^{137}Cs	7.0 ± 4.6[a]	
	^{140}Ba	5.9 ± 4.6[a]	
	Other γ[c]	ND	
Immature barn swallows at TRA	^{24}Na	150 ± 150[a]	Millard et al. (1990)
	^{51}Cr	300 ± 350[a]	
	^{60}Co	21 ± 18[a]	
	^{65}Zn	240 ± 140[a]	
	^{75}Se	62 ± 38[a]	
	^{131}I	65 ± 41[a]	
	^{134}Cs	15 ± 10[a]	
	^{137}Cs	54 ± 41[a]	
	^{140}Ba	46 ± 35[a]	
	Other γ[c]	ND	

Table C-I.5. (continued).

Medium or Location	Nuclides	Levels (pCi g^{-1})	References
Mature barn swallows at TRA	^{24}Na	230 ± 190[a]	Millard et al. (1990)
	^{51}Cr	430 ± 260[a]	
	^{60}Co	41 ± 21[a]	
	^{65}Zn	160 ± 110[a]	
	^{75}Se	140 ± 100[a]	
	^{131}I	150 ± 130[a]	
	^{134}Cs	35 ± 27[a]	
	^{137}Cs	170 ± 160[a]	
	^{140}Ba	22 ± 21[a]	
	Other γ[c]	ND	

a. Mean ±1 standard deviation.

b. Assumed to include both ^{239}Pu and ^{240}Pu.

c. Samples were analyzed by gamma scan.

d. Not detected. Detection limits varied between studies.

e. Range of geometric means.

f. Mean only. No error reported.

g. Maximum.

h. Combined results from many gamma-emitting radionuclides.

i. Detected in a single sample.

j. Atoms ^{129}I (atoms $^{127}I)^{-1}$.

The sediments of the radioactive waste percolation ponds at TRA are the most contaminated soils in the studies reported here. The mean concentration of ^{137}Cs in barn swallow nests made with TRA pond sediments was 2,500 pCi g^{-1}. The mean concentration of $^{239,240}Pu$ in TRA pond sediments was 43 pCi g^{-1}. However, as noted above, comparison of these values with values for terrestrial soils may be invalid. The maximum ^{137}Cs and $^{239,240}Pu$ concentrations found in the RESL surveys of the area surrounding the TRA were 220 and 0.065 pCi g^{-1}, respectively. For ^{137}Cs, this value is 32% of the maximum soil concentration found at SL-1 (Table C-I.4) and 75 times background (Table C-I.1). For $^{239,240}Pu$, this represents 0.1% of the maximum at the SDA (Table C-I.3) and 73% of background (Table C-I.1).

C-I-1.1.6.1 Trends. Cesium-137 was found in above background concentrations in surface soils out to 750, 280, and 600 m in 1976, 1983, and 1990, respectively (Figure C-I.9). Thus, there

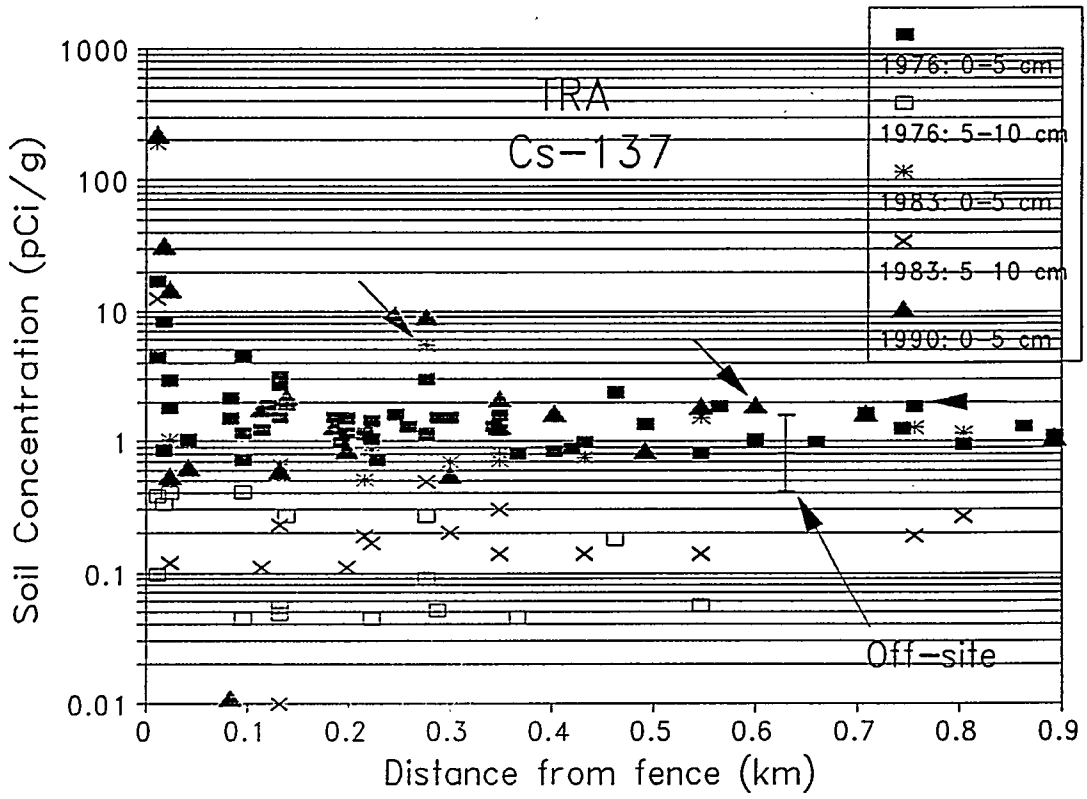


Figure C-I.9. Concentrations of ^{137}Cs in the soil downwind from the TRA. Samples were taken at the soil surface down to 5 cm or from 5 to 10 cm. The offsite error bar indicates the median background concentration ±1 GSD. The above background concentration in the surface soil layer found at the farthest distance from the stack in each year is indicated by an arrow.

is no evidence for a regular pattern of expansion or contraction of the plume size over the 14 years studied. There was a statistically significant increase in average ^{137}Cs concentration within the 5 to 10-cm soil layer between 1976 and 1983, indicating that downward migration was occurring.

The surface soil concentration of $^{239,240}Pu$ was determined in only one year (1976) and is therefore insufficient to determine temporal trends. Above background concentrations were found out to 28 m from the fence (Figure C-I.10).

Few data sets allow estimation of spatial trends in media other than soil. Craig et al. (1979) found decreasing concentrations of radioactivity in raptors with distance from the TRA, probablydue to decreasing contamination of the prey. They estimated that the maximum distance at which radionuclides from the TRA/ICPP complex could be detected in nestling raptors was 3.5 km.

C-I-1.1.6.2 Data Gaps. The data set from the TRA is the most complete set in this review with respect to the environmental media covered. In spite of this, a significant data gap exists. No data are available in these studies for contamination of terrestrial vegetation near TRA. Thus, no data are available for the base of the terrestrial food chain.

The radioactive waste percolation pond has been the focus of most of the studies at TRA because it has probably been the most significant source of contamination. However, remediation activities have been completed for the pond, which has been replaced with a lined evaporation pond. Thus, the data currently available may not be applicable to future operations at TRA.

Studies of the waterfowl using the new pond have been initiated. Studies of the terrestrial environment surrounding the pond will also be necessary to determine the potential impact of the new pond on radioactive contamination of the environment.

C-I-1.1.7 Miscellaneous Locations (Table C-I.6)

Limited amounts of data are available for other locations on- and offsite which have been influenced by INEL operations. These locations include ANL-W; the BORAX/EBR-I area; CFA; NRF; the area surrounding PBF, SPERT, and WROC; TAN; and various other locations on- and offsite.

Radionuclides detected at these locations include ^{129}I, ^{90}Sr, gamma-emitters, and transuranics. The media include soils from the RESL surveys, game mammals, upland game birds and waterfowl.

The maximum detected soil concentration of ^{137}Cs was 120 pCi g^{-1} found in soils from the area surrounding the NRF. This maximum is 17% of the maximum concentration at SL-1 and 40 times background concentrations. The maximum detected soil concentration of $^{239,240}Pu$ was 0.041 pCi g^{-1}, from a survey of soils near all facilities. This value is 0.08% of the maximum concentration at the SDA and 45% of maximum background. The maximum soil concentrations of ^{137}Cs and $^{239,240}Pu$ detected in a survey conducted near all facilities onsite (Markham 1974) were 24 and 0.076 pCi g^{-1}, respectively.

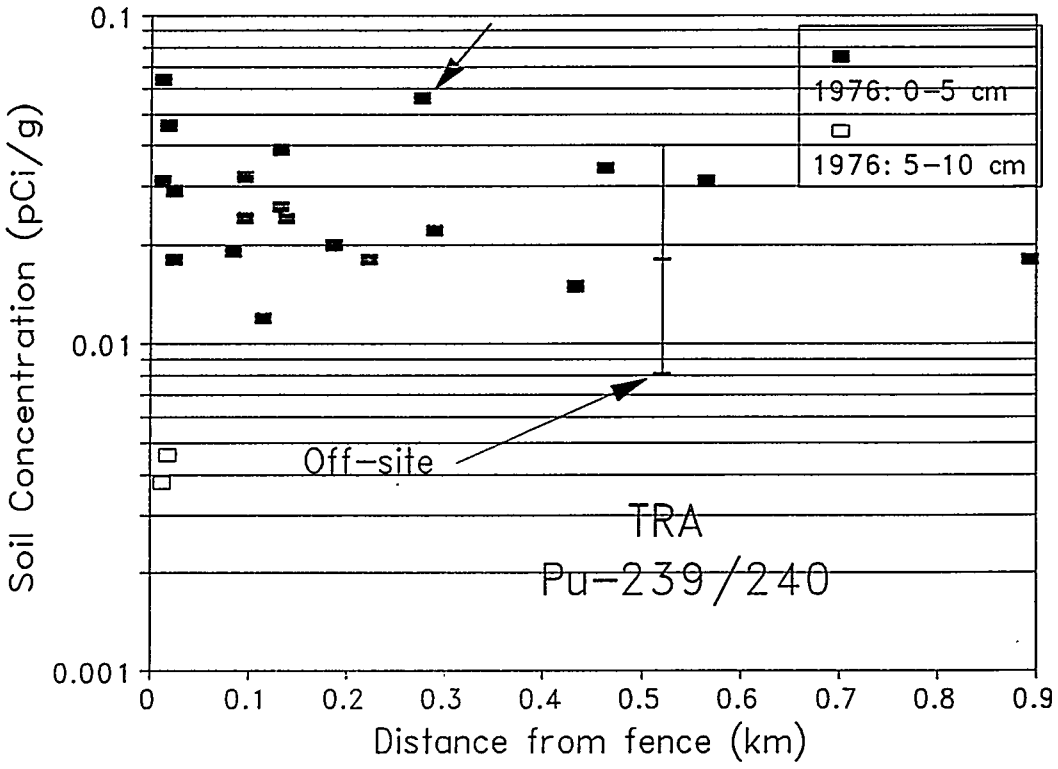


Figure C-I.10. Concentrations of $^{239,240}Pu$ in the soil downwind from TRA. Samples were taken at the soil surface down to 5 cm or from 5 to 10 cm. The offsite error bar indicates the median background concentration ±1 GSD. The above background concentration in the surface soil layer found at the farthest distance from the stack in each year is indicated by an arrow.

Table C-I.6. Radioactive contamination of various environmental media at miscellaneous locations on or influenced by INEL. Data are ranges unless otherwise noted.

Location and Medium	Nuclides	Levels ($pCi\ g^{-1}$)	References
		Soil	
Near all facilities	^{90}Sr	27[a]	Markham (1974)
	^{137}Cs	24[a]	
	^{144}Ce	0.89[a]	
	^{238}Pu	0.057[a]	
	^{239}Pu[b]	0.076[a]	
Area surrounding ANL-W, <10-cm depth	^{90}Sr	ND[c] - 0.81	Unpublished data from RESL, 1971 to 1986
	^{95}Zr	ND - 0.20	
	^{106}Ru	ND - 0.20	
	^{137}Cs	ND - 2.0	
	^{144}Ce	ND - 0.51	
	^{238}Pu	ND - 0.010	
	^{239}Pu[b]	ND - 0.032	
	^{241}Am	ND - 0.0081	
	Other γ[d]	ND	
Area surrounding BORAX/EBR-I, <10-cm depth	^{7}Be	ND - 1.2	Unpublished data from RESL, 1971 to 1987
	^{90}Sr	ND - 0.86	
	^{137}Cs	ND - 2.0	
	^{144}Ce	ND - 0.70	
	^{238}Pu	ND - 0.0041	
	^{239}Pu[b]	ND - 0.041	
	^{241}Am	ND - 0.015	
	Other γ[d]	ND	
Area surrounding CFA, <10-cm depth	^{7}Be	ND - 0.70	Unpublished data from RESL, 1976 and 1987
	^{90}Sr	ND - 0.78	
	^{137}Cs	0.041 - 2.6	
	^{238}Pu	ND - 0.0041	
	^{239}Pu[b]	ND - 0.018	
	^{241}Am	ND	
	Other γ[d]	ND	

Table C-I.6. (continued).

Location and Medium	Nuclides	Levels (pCi g^{-1})	References
Area surrounding NRF, <10-cm depth	^{60}Co	ND - 15	Unpublished data from RESL, 1971 to 1987
	^{90}Sr	ND - 3.5	
	^{125}Sb	ND - 0.57	
	^{134}Cs	ND - 0.46	
	^{137}Cs	ND - 120	
	^{144}Ce	ND - 0.51	
	^{238}Pu	ND - 0.086	
	^{239}Pu[b]	ND - 0.025	
	^{241}Am	ND - 0.014	
	Other γ[d]	ND	
		Soil	
Area surrounding PBF/SPERT/WROC, <10-cm depth	^{7}Be	ND - 4.6	Unpublished data from RESL, 1971 to 1989
	^{60}Co	ND - 0.41	
	^{90}Sr	ND - 0.49	
	^{137}Cs	ND - 1.4	
	^{144}Ce	ND - 0.51	
	^{238}Pu	ND - 0.0051	
	^{239}Pu[b]	ND - 0.026	
	^{241}Am	ND	
	Other γ[d]	ND	
Area surrounding TAN, <10-cm depth	^{60}Co	ND - 0.38	Unpublished data from RESL, 1971 to 1988
	^{90}Sr	ND - 1.2	
	^{137}Cs	ND - 24	
	^{144}Ce	ND - 0.30	
	^{238}Pu	ND - 0.0041	
	^{239}Pu[b]	ND - 0.035	
	^{241}Am	ND - 0.086	
	Other γ[d]	ND	
		Game Mammals	
Sitewide mule deer muscle and liver	^{137}Cs	ND - 0.025	Hoff et al. (1992)
	Other γ[d]	ND	
Sitewide pronghorn muscle and liver	^{54}Mn	ND - 0.010	Markham (1974) Hoff et al. (1992)
	^{60}Co	ND - 0.0016	
	^{129}I[e]	1.6×10^{-6} - 3.9×10^{-4}	
	^{134}Cs	ND - 0.0041	
	^{137}Cs	ND - 0.049	
	Other γ[d]	ND	

Table C-I.6. (continued).

Location and Medium	Nuclides	Levels (pCi g^{-1})	References
Mule deer thyroids from Monida Pass	$^{129}I^{e}$	6.5×10^{-7} - 7.9×10^{-6}	Markham et al. (1983)
Pronghorn thyroids from near Craters of the Moon National Monument	$^{129}I^{e}$	7.5×10^{-7} - 3.0×10^{-6}	Markham et al. (1983)
Pronghorn thyroids from the Medicine Lodge area	$^{129}I^{e,f}$	3.9×10^{-6}	Markham et al. (1983)
		Upland Game Birds	
Mourning dove GI at TAN	^{137}Cs	ND - 1.6	Markham and Halford (1982)
Mourning dove GI at ANL-W	^{137}Cs	ND - 3.3	Markham and Halford (1982)
Mourning dove GI at NRF	^{137}Cs	ND	Markham and Halford (1982)
Mourning dove muscle at TAN	^{137}Cs	ND - 1.1	Markham and Halford (1982)
Mourning dove muscle at ANL-W	^{137}Cs	ND - 0.59	Markham and Halford (1982)
Mourning dove muscle at NRF	^{137}Cs	ND	Markham and Halford (1982)
		Waterfowl	
ANL-W	All γ^{d}	ND	Morris et al. (in preparation)
NRF	All γ^{d}	ND	Morris et al. (in preparation)
TAN	^{60}Co ^{137}Cs Other γ^{d}	0.20 - 0.35 0.25 - 0.62 ND	Morris et al. (in preparation)

Table C-I.6. (continued).

Location and Medium	Nuclides	Levels ($pCi\ g^{-1}$)	References

a. Maximum.

b. Assumed to include both ^{239}Pu and ^{240}Pu.

c. Not detected. Detection limits varied between studies.

d. Samples were analyzed by gamma scan.

e. Bq $^{129}I\ g^{-1}$ iodine.

f. Mean only. No error reported.

C-I-1.1.7.1 Trends. Soils surrounding ANL and PBF/SPERT/WROC do not contain concentrations of ^{137}Cs or $^{239,240}Pu$ at above-background levels (Figures C-I.11 through C-1.14).

At the NRF, ^{137}Cs was found in above-background concentrations out to 14 and 9 m in 1980 and 1988, respectively (Figure C-I.15). The small difference between the concentrations at these locations and the small distances involved do not provide sufficient evidence for a change in the size of the contamination plume. There was no analysis for $^{239,240}Pu$ in any year at NRF.

Soils surrounding facilities at TAN have not contained above-background concentrations of $^{239,240}Pu$ in any measurement year since the first RESL measurements in 1976 (Figure C-I.16). In 1976, ^{137}Cs was not detected in above background levels, either. However, in that year, samples were only taken from around the LOFT facility. In 1981 and 1989, sampling was expanded to the areas surrounding IET, WRRTF, and TSF, all at TAN. This additional sampling has found above-background concentrations of ^{137}Cs out to 24 m from the fence surrounding TSF (Figure C-I.17). There appears to be no change in the extent of the plume between 1981 and 1988.

In most cases, spatial or temporal trends cannot be determined for environmental media other than soils. However, the contamination of game mammal thyroids with ^{129}I provides evidence that contamination from the ICPP has spread several miles from the INEL boundary. Contaminated thyroids have been found from as far away as Craters of the Moon National Monument and Monida Pass (Markham et al. 1983). In contrast, the concentration of gamma-emitters in game mammal tissues on site are equivalent to background concentrations (Hoff et al. 1992; Table C-I.1). This issue needs further exploration.

C-I-1.1.7.2 Data Gaps. Substantial data gaps exist for the facilities grouped together under this heading. The only cases where data are sufficient to determine current contamination

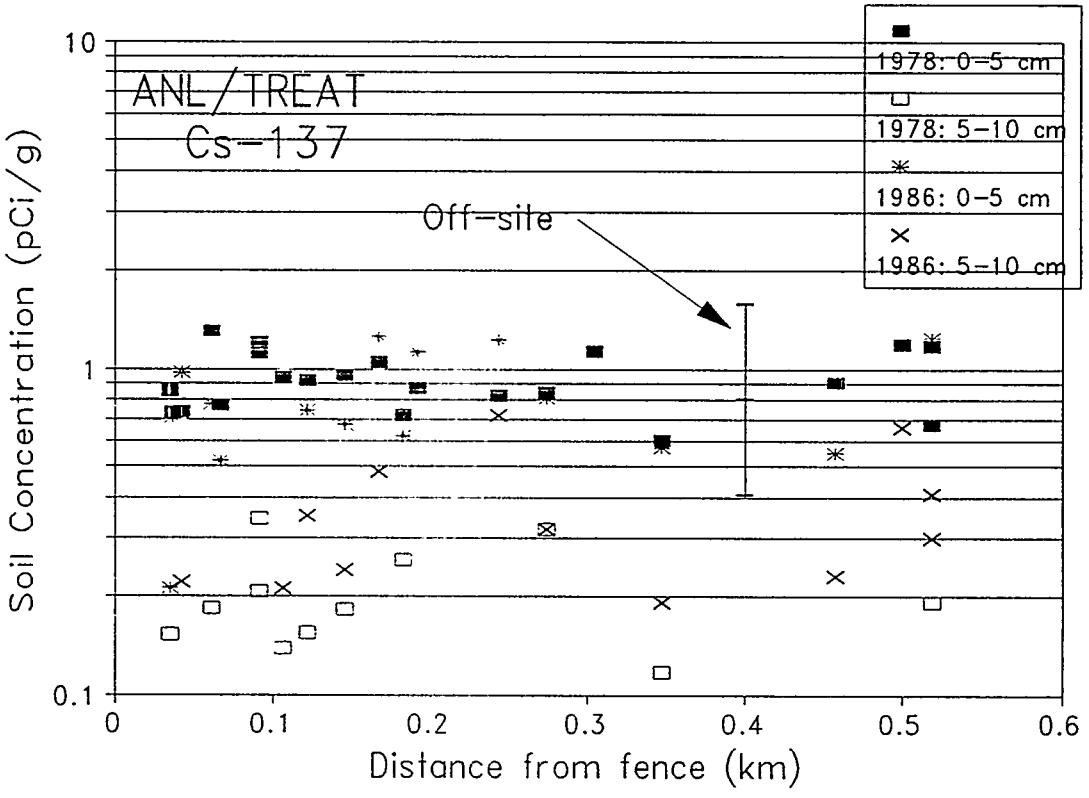


Figure C-I.11. Concentrations of ^{137}Cs in the soil downwind from ANL-W. Samples were taken at the soil surface down to 5 cm or from 5 to 10 cm. The offsite error bar indicates the median background concentration ±1 GSD.

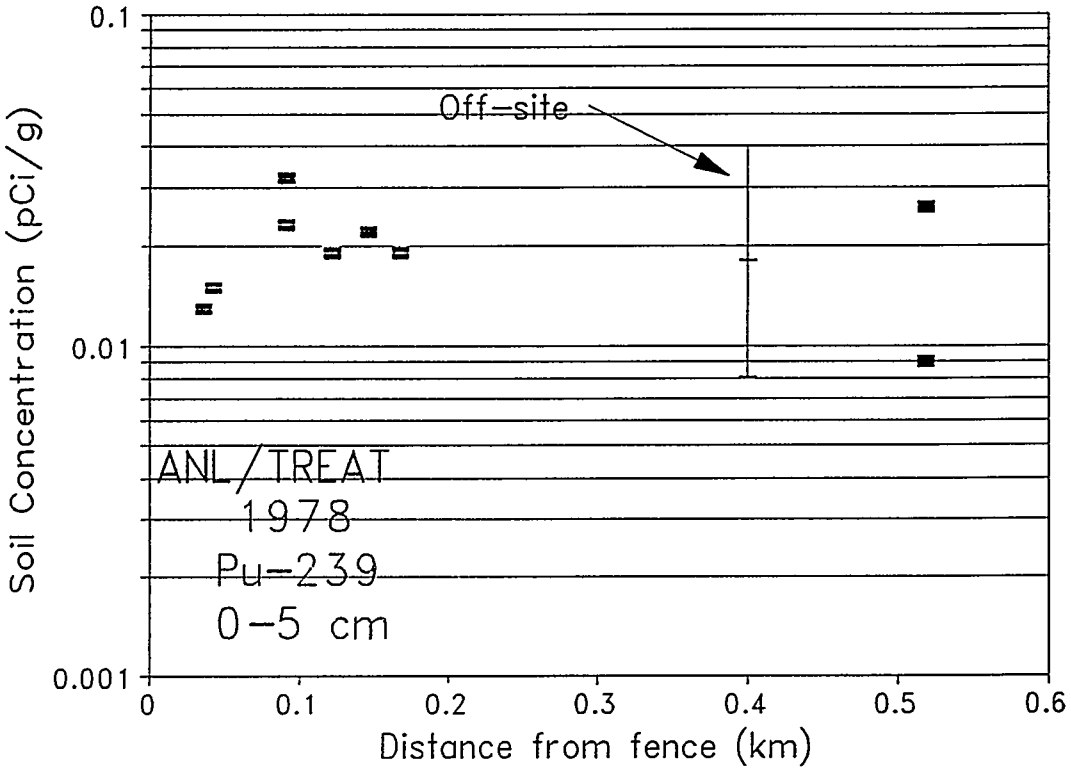


Figure C-I.12. Concentrations of $^{239,240}Pu$ in the soil downwind from ANL-W. Samples were taken at the soil surface down to 5 cm. The offsite error bar indicates the median background concentration ±1 GSD.

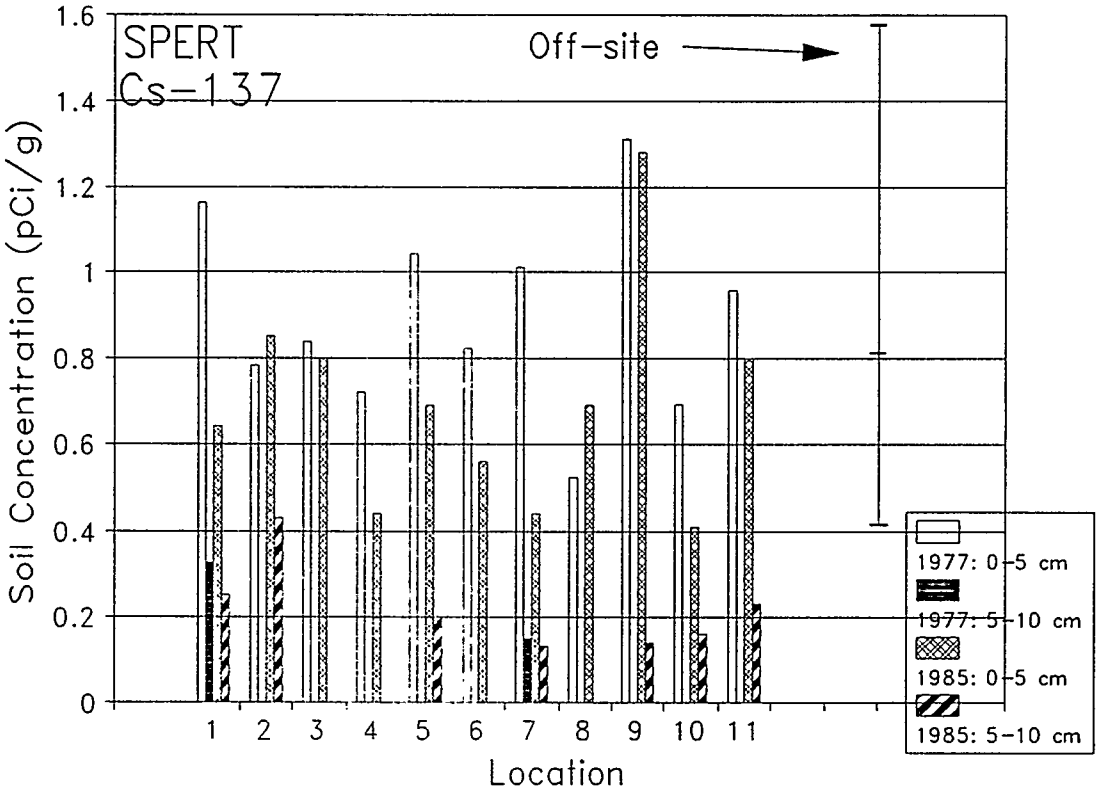


Figure C-I.13. Concentrations of ^{137}Cs in the soil surrounding SPERT. Samples were taken at the soil surface down to 5 cm or from 5 to 10 cm. The offsite error bar indicates the median background concentration ±1 GSD.

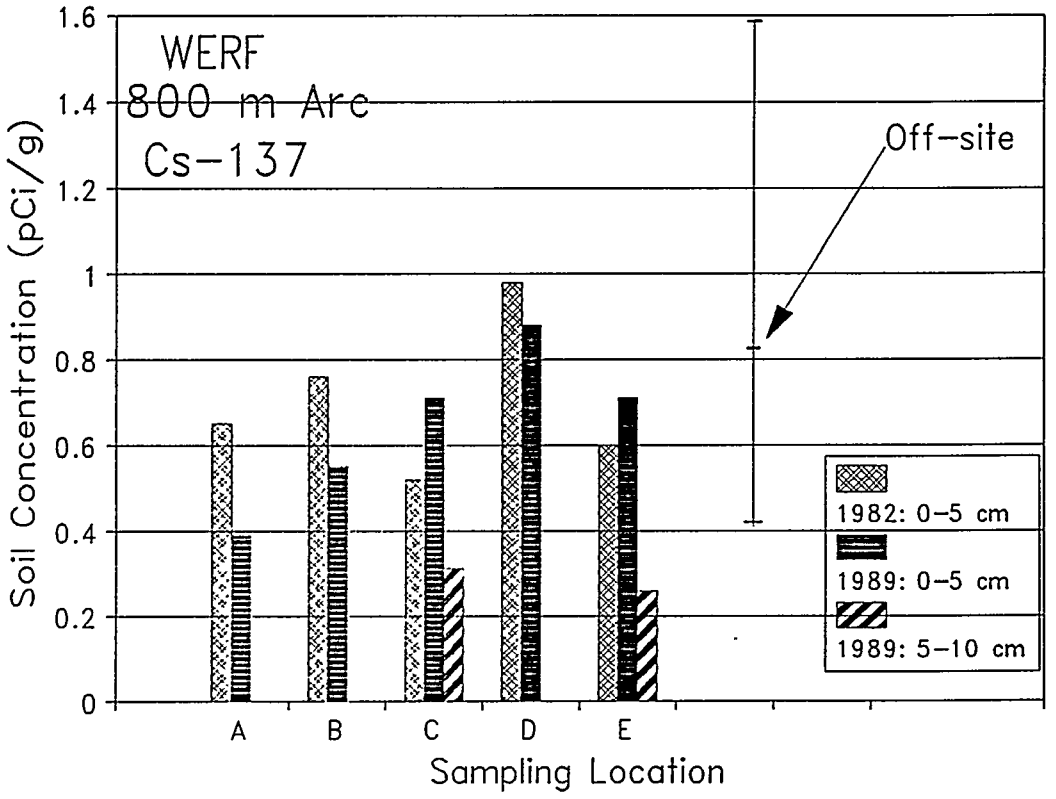


Figure C-I.14. Concentrations of ^{137}Cs in the soil on an arc 800 m downwind from WROC. Samples were taken at the soil surface down to 5 cm or from 5 to 10 cm. The offsite error bar indicates the median background concentration ±1 GSD.

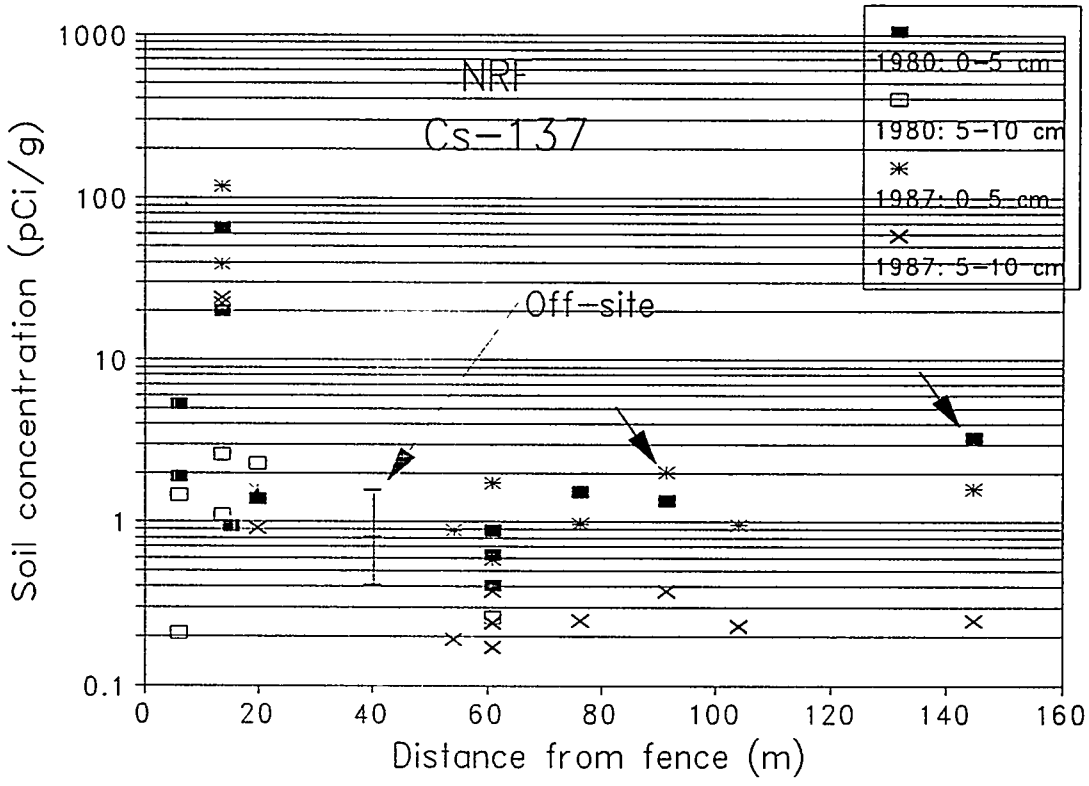


Figure C-I.15. Concentrations of ^{137}Cs in the soil surrounding NRF. Samples were taken at the soil surface down to 5 cm or from 5 to 10 cm. The offsite error bar indicates the median background concentration ±1 GSD. The above background concentration in the surface soil layer found at the farthest distance from the stack in each year is indicated by an arrow.

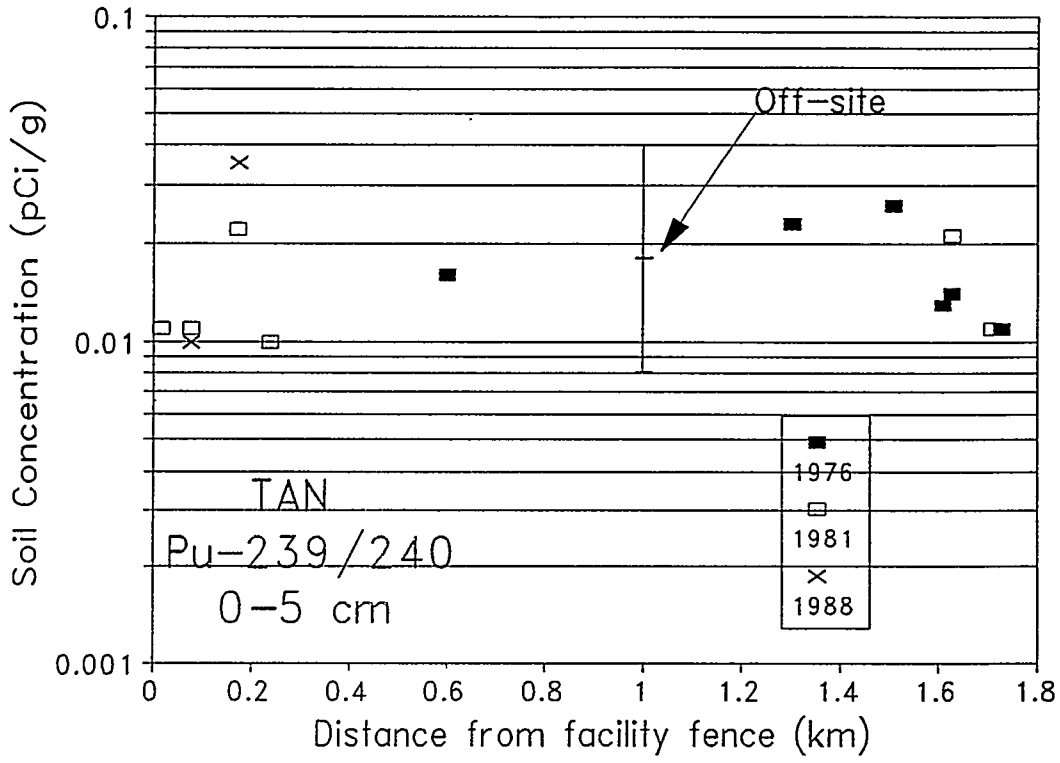


Figure C-I.16. Concentrations of $^{239,240}Pu$ in the soil surrounding facilities at TAN. Samples were taken at the soil surface down to 5 cm. The offsite error bar indicates the median background concentration ±1 GSD. The above-background concentration in the surface soil layer found at the farthest distance from the stack in each year is indicated by an arrow.

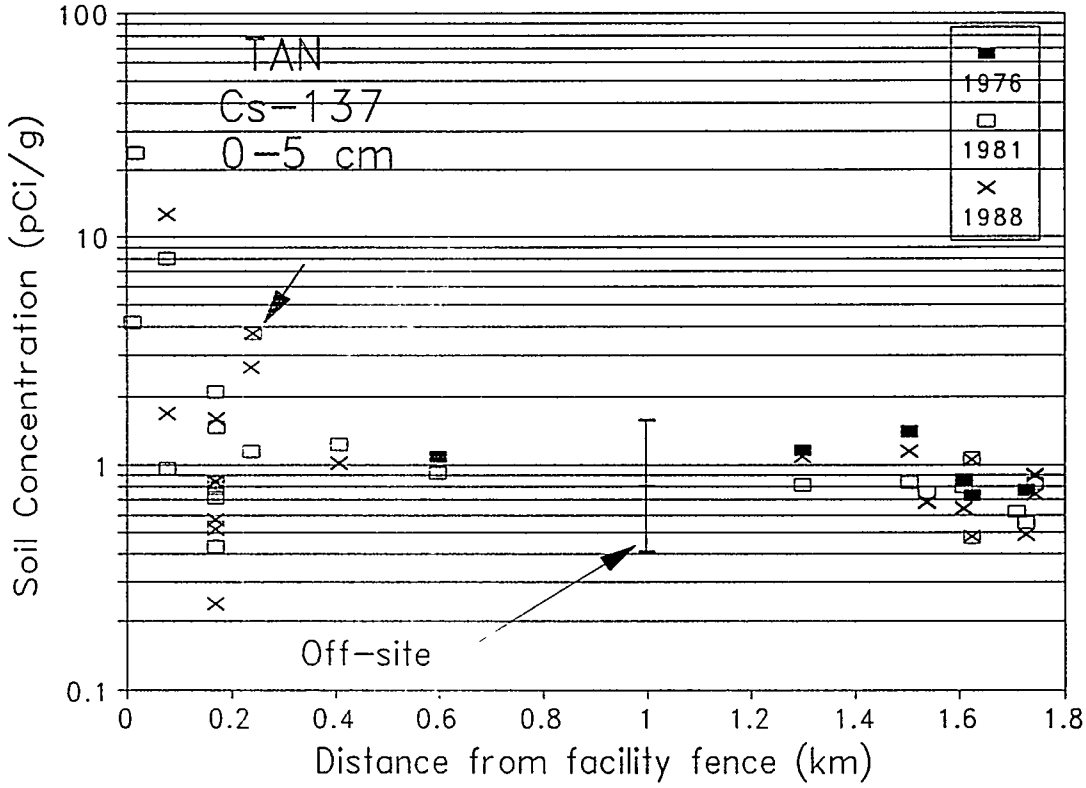


Figure C-I.17. Concentrations of ^{137}Cs in the soil surrounding facilities at TAN. Samples were taken at the soil surface down to 5 cm. The offsite error bar indicates the median background concentration ±1 GSD. The above-background concentration in the surface soil layer found at the farthest distance from the stack in each year is indicated by an arrow.

are soils, gamma-emitters in waterfowl, and ^{137}Cs in mourning doves. Surveys of the environment surrounding these facilities would allow determination of the potential for harmful contamination levels surrounding these facilities.

C-I-2. DISCUSSION

C-I-2.1 Extent of Contamination

The farthest distance from any facility to which ^{137}Cs or $^{239,240}Pu$ contamination was found at above background levels in soils was greater than 2 km but less than 10 km. This situation occurred at ICPP. Using the most recent values for the maximum extent of the plumes around the nine facilities examined in this report and assuming that each plume is an ellipse with the short axis half the length of the long axis, the total contaminated area onsite is approximately 160 km^2. This area is approximately 7% of the total area of the INEL.

There is evidence that contamination from INEL facilities, particularly ICPP, extends much farther. As indicated in the ICPP section above, ^{129}I has been detected in vegetation and mammal thyroids at great distances from the ICPP including areas well offsite. The source of this contamination and the mechanism of transport have not been conclusively demonstrated but it is presumed to be wind-borne contamination from ICPP (Markham 1974; Fraley and Bowman 1982; Markham et al. 1983; McGiff 1985).

C-I-2.2 Potential for Spread of Contamination

No evidence exists for increases in the horizontal extent of contamination plumes from any facility on the INEL. There is evidence, however, for very slow downward migration of ^{137}Cs, probably due to transport by water. This process is undoubtedly slow because of the tendency of ^{137}Cs to bind strongly to soils (Whicker and Schultz 1982) and the concentration is expected to decrease rapidly and nonlinearly with depth. The concentration of ^{137}Cs in the 5 to 10-cm soil layer is approximately 18% of that in the 0 to 5-cm soil layer.

Although the evidence is slight, there is a potential for radioactivity to be transported away from the soil contamination areas by animals. The potential exists for approximately 19,048 waterfowl y^{-1} using INEL ponds to transport 86 $\mu Ci\ y^{-1}$ (6.1 $pCi/g^{-1}/y^{-1}$) of gamma emitting radioactivity offsite. Seventy-seven percent of that activity was ^{137}Cs. This waterfowl transport is likely to be the most important single source of offsite transport of radioactivity from the INEL by biota (Hoff et al. 1991). However, this small amount of radioactivity, added to the soil when a waterfowl dies and decays offsite, would not add significantly to the background soil concentration of ^{137}Cs (Hoff et al. 1991). Thus, biotic transport of radioactivity offsite is likely not a concern at the INEL.

C-I-2.3 Potential for Harm to Human Receptors

The primary pathways by which humans could receive radiation dose from radioactivity in the INEL environment are through direct exposure to gamma radiation, ingestion or inhalation of contaminated soil, ingestion of contaminated vegetation, or ingestion of contaminated meat. Because the general public does not have access to the INEL and access to contaminated areas is tightly controlled for INEL workers, the first three pathways are generally not open. The final pathway, ingestion of contaminated meat, may be open for the general public because wildlife which become contaminated onsite may be hunted offsite.

Several authors have calculated potential doses to humans from consuming contaminated meats (Fraley and Bowman 1982; Markham and Halford 1982; Markham et al. 1982; Connelly and Markham 1983; Halford and Markham 1984; Halford 1987; Markham et al. 1988; Morris 1993; Morris et al. in preparation). In every case, the predicted potential doses have been found to be insignificant relative to DOE standards and background doses. For example, although the consumption of waterfowl using radioactive waste ponds on the INEL was the pathway which provided the greatest reported potential dose to humans from consuming contaminated wildlife (Hoff et al. 1991), the maximum potential committed effective dose equivalent from consumption of the most contaminated duck in the study, was 40 μSv (Morris 1993; Morris et al. in preparation). This value is 4% of the DOE annual limit for exposure of the public to effluents from normal operations (DOE 1990) and about 1% of the estimated annual effective dose equivalent due to natural background radiation at the INEL (Hoff et al. 1991).

Based on these results and the concentrations of radionuclides observed in environmental media throughout the site, it is very unlikely that any human individual could receive a dangerous dose from radioactivity deposited in the environment by INEL activities.

C-I-2.4 Potential for Harm to Nonhuman Receptors

When discussing the potential for harm to nonhuman receptors, it is important to distinguish between harm to individuals and harm to populations. In most cases, biologists are primarily concerned about harm to populations. For most populations, large numbers of individuals can suffer morbidity or mortality without affecting the viability of the population of which they are members. However, in the case of T&E species, where the viability of the population is already in question, harm to individuals becomes an issue.

Because of the limited data available, it is difficult to determine the potential for harm to individuals of INEL's T&E and C2 species from radioactive contaminants in the INEL environment.

For some of the T&E or C2 species on the INEL, data about distribution and home range size are insufficient to determine whether the species are potentially exposed to high levels of contamination. Projects are underway to provide such information for ferruginous hawks, Townsend's big-eared bats, and pygmy rabbits. Some limited distribution data are available for bald eagles and loggerhead shrikes from winter eagle counts and breeding bird surveys, respectively, but these data are not comprehensive. One study has been published on the ecology of pygmy rabbits on the site (Wilde 1978), but the distribution data in the study are very limited and dated.

In addition, data about contamination of the prey base (for the carnivores) or the individuals themselves are limited or nonexistent. Good (albeit dated) data are available for contamination of small mammals from SDA (Table C-I.3) and SL-1 (Table C-I.4). However, no data are available for small mammal contamination from other areas. No data are available for contamination of the prey base of loggerhead shrikes, and very limited data are available for contamination of the prey base of Townsend's big-eared bats.

On the basis of these limited data, one must conclude that all of INEL's T&E or C2 species are potentially exposed to above background levels of radioactive contamination. It is unlikely, but possible because of potential bioconcentration, that bald eagles and ferruginous hawks consume harmful concentrations of radioactive contaminants in their prey. No conclusions of this nature are possible for loggerhead shrikes, Townsend's big-eared bats, or pygmy rabbits.

Doses received by individual, nonhuman organisms provide a basis for determining the potential for harm to populations. A number of authors have calculated or estimated doses to nonhuman organisms from internal and external contamination received at the INEL (Craig et al. 1979; Fraley et al. 1982; Halford et al. 1982; Markham and Halford 1982; Markham et al. 1982; Halford and Markham 1984; Halford 1987a; Halford 1987b; Markham et al. 1988; Morris 1993; Morris et al. in preparation).

Halford and Markham (1978) found that some maximally exposed small mammals inhabiting the TRA radioactive waste pond basin received doses that had been found to reduce life expectancy in earlier studies (French et al. 1969). Arthur et al. (1986) found similar results for small mammals at SDA. In neither of these studies were the doses sufficient to cause observable population effects.

Millard et al. (1990) observed a statistically significant difference in growth rate between barn swallow nestlings exposed to contaminated sediments from the TRA radioactive waste percolation pond and control birds. However, the difference could not be definitely attributed to their exposure.

Evenson (1981) found statistically significant differences in several physiological parameters between deer mice inhabiting the TRA radioactive waste percolation pond basin, the SDA, and the control areas. However, she concluded that levels of radiation exposure were too low to cause somatic changes in the mice.

The four studies reported above were the only studies to report potential individual effects on organisms receiving radiation dose from INEL activities. In no case were the observed affects expressed as somatic changes in the organisms. All studies reported that doses to individual organisms were too low to cause any population level effect. Based on the concentrations of radionuclides observed in all media throughout the site, this is likely the case for all populations of all organisms.

C-I-3. CONCLUSIONS

None of the data examined in this report indicate that significant potential exists for harm to humans or nonhuman populations from radioactive contamination of the environment on the INEL. However, levels of contamination exist in some areas. These levels have been shown to cause physiological changes and reduced life expectancy in individuals of some nonhuman species.

There is little evidence that contamination from the INEL is spreading beyond currently contaminated areas. Further information needs to be collected, however, relative to ^{129}I concentrations in various media both on- and offsite to determine the source and means of transport of this radionuclide.

In some areas and for some media, insufficient data are available to determine environmental contamination levels. In addition, insufficient data are available to determine the potential for harmful levels of contamination in some of INEL's T&E or C2 species. This lack of data makes conclusions about the potential for harm to these species difficult.

C-I-4. BIBLIOGRAPHY

Arthur, W. J., III, 1982, "Radionuclide Concentrations in Vegetation at a Solid Radioactive Waste-Disposal Area in Southeastern Idaho," *Journal of Environmental Quality, 11,* pp. 394–399.

Arthur, W. J., and D. H. Janke, 1986, "Radionuclide Concentrations in Wildlife Occurring at a Solid Radioactive Waste Disposal Area," *Northwest Science, 60,* pp. 154–159.

Arthur, W. J., III, and O. D. Markham, 1982, "Radionuclide Export and Elimination by Coyotes at Two Radioactive Waste Disposal Areas in Southeastern Idaho," *Health Physics, 43,* pp. 493–500.

Arthur, W. J., III, and O. D. Markham, 1983, "Small Mammal Soil Burrowing as a Radionuclide Transport Vector at a Radioactive Waste Disposal Area in Southeastern Idaho," *Journal of Environmental Quality, 12,* pp. 117–122.

Arthur, W. J., J. C. Grant, and O. D. Markham, 1983, "Importance of Biota in Radionuclide Transport at the SL-1 Radioactive Waste Disposal Area," *Idaho National Engineering Laboratory Radioecology and Ecology Programs 1983 Progress Report,* DOE/ID-12098, Idaho Falls.

Arthur, W. J., et al., 1986, "Radiation Dose to Small Mammals Inhabiting a Solid Radioactive Waste Disposal Area," *Journal of Applied Ecology, 23,* pp. 13–26.

Arthur, W. J., et al., 1987, "Radionuclide Export by Deer Mice at a Solid Radioactive Waste Disposal in Southeastern Idaho," *Health Physics, 52,* pp. 45–53.

Blom, P. E., J. B. Johnson, and S. K. Rope, 1991, "Concentrations of ^{137}Cs and ^{60}Co in Nests of the Harvester Ant, *Pogonomyrmex salinus,* and Associated Soils Near Nuclear Reactor Waste Water Disposal Ponds," *American Midlands Naturalist, 126,* pp. 140–151.

Craig, T. H., D. K. Halford, and O. D. Markham, 1979, "Radionuclide Concentrations in Nestling Raptors Near Nuclear Facilities," *Wilson Bulletin, 91,* pp. 72–77.

Connelly, J. W., and O. D. Markham, 1983, "Movements and Radionuclide Concentrations of Sage Grouse in Southeastern Idaho," *Journal of Wildlife Management, 47,* pp. 169–177.

DOE, 1990, "Radiation Protection of the Public and the Environment," Order 5400.5, U.S. Department of Energy, Washington, DC.

Evenson, L. M., 1981, "Systemic Effects of Radiation Exposure on Rodents Inhabiting Liquid and Solid Radioactive Waste Disposal Areas," Thesis, Colorado State University, Fort Collins.

Fraley, L., Jr., et al., 1982, "Iodine-129 in Rabbit Thyroids Near a Nuclear Fuel Reprocessing Plant in Idaho," *Health Physics, 43,* pp. 251–258.

French, N. R., B. G. Maza, and H. W. Kaaz, 1969, "Mortality Rates in Irradiated Rodent Populations," D. J. Nelson and F. C. Evans (eds.), *Symposium on Radioecology: Washington, DC,* U.S. Atomic Energy Commission, Report 670503, pp. 46–52.

Halford, D. K., 1987a, "Density, Movement, and Transuranic Tissue Inventory of Small Mammals at a Liquid Radioactive Waste Disposal Area," *Proceedings of the Symposium on Environmental Research on Actinide Elements; 1983 November 7-11; Hilton Head, SC,* CONF-86008713, pp. 147–156.

Halford, D. K., 1987b, "Effect of Cooking on Radionuclide Concentrations in Waterfowl Tissues," *Journal of Environmental Radioactivity 5,* pp. 229–233.

Halford, D. K., and O. D. Markham, 1978, "Radiation Dosimetry of Small Mammals Inhabiting a Liquid Radioactive Waste Disposal Area," *Ecology, 59,* pp. 1047–1054.

Halford, D. K., and O. D. Markham, 1984, "Iodine-129 in Waterfowl Muscle from a Radioactive Leaching Pond Complex in Southeastern Idaho," *Health Physics, 46,* pp. 1259–1263.

Halford, D. K., O. D. Markham, and R. L. Dickson, 1982, "Radiation Doses to Waterfowl Using a Liquid Radioactive Waste Disposal Area," *Journal of Wildlife Management, 46,* pp. 905–914.

Halford, D. K., J. B. Millard, and O. D. Markham, 1981, "Radionuclide Concentrations in Waterfowl Using a Liquid Radioactive Waste Disposal Area and the Potential Radiation Dose to Man," *Health Physics, 40,* pp. 173–181.

Hoff, D. L., et al., 1991, *The Idaho National Engineering Laboratory Site Environmental Report for Calendar Year 1990,* DOE/ID-12082(90), Idaho National Engineering Laboratory, Idaho Falls.

Hoff, D. L., et al., 1992, *The Idaho National Engineering Laboratory Site Environmental Report for Calendar Year 1991,* DOE/ID-12082(91), Idaho National Engineering Laboratory, Idaho Falls.

Ibrahim, S., and T. Culp, 1989, "Plutonium Distribution and Oxidation States in a Reactor Leaching Ponds System," *Health Physics, 57,* pp. 607–614.

Janke, D. H., and W. J. Arthur, 1985, "Radionuclide Transport by Cottontail Rabbits at a Radioactive Waste Disposal Area," *Northwest Science, 59,* pp. 221–229.

Kuzo, G. B., et al., 1987, "Comparative Behavior and Distribution of Transuranium Nuclides in Selected Components of Test Reactor Leaching Ponds," *Proceedings of the Symposium on Environmental Research on Actinide Elements, 1983 November 7-11, Hilton Head, SC,* CONF-86008713, pp. 319–340.

Litteer, D. L., C. N. Peterson, and A. M. Sims, 1991, *Radioactive Waste Management Information for 1990 and Record-to-Date,* DOE/ID-10054(90), U.S. Department of Energy, Idaho Operations Office, Idaho Falls.

Markham, O. D., 1973, *National Reactor Testing Station Environmentally Related Publications,* IDO-12078, U.S. Atomic Energy Commission, Idaho Operations Office, Idaho Falls.

Markham, O. D., 1974, "Environmental and Radiological Monitoring at the National Reactor Testing Station During FY-1973 (July 1972-June 1973)," *Radiological Data Report, 15,* pp. 227–246.

Markham, O. D., 1976, "Radioactivity in Tumbling Weeds at the Radioactive Management Waste Complex on the INEL Site," O. D. Markham (ed.), *1975 Progress Report: Idaho National Engineering Laboratory Site Radioecology-Ecology Programs,* IDO-12080, U.S. Energy Research and Development Administration, Idaho Falls, ID, p. 49.

Markham, O. D., 1978, *Activation and Fission Products in the Environment Near the Idaho National Engineering Laboratory Radioactive Waste Management Complex,* IDO-12085, U.S. Department of Energy, Idaho Operations Office, Idaho Falls.

Markham, O. D., R. Autenrieth, and R. Hoskinson, 1976, "Concentrations of Radionuclides in Tissues of Antelope On and Near the INEL Site," R. Autenrieth (ed.), *Proceedings of the 7th Biennial Pronghorn Antelope Workshop, 1976 February 24–26, Twin Falls, ID,* Idaho Department of Fish and Game, Boise, pp. 63–65.

Markham, O. D., R. L. Dickson, and R. E. Autenrieth, 1979, "Plutonium in the Lungs of Pronghorn Antelope Near a Nuclear Fuel Reprocessing Plant," *Health Physics, 37,* pp. 398–400.

Markham, O. D., et al., 1983, "Iodine-129 in Mule Deer Thyroids in the Rocky Mountain West," *Health Physics, 45,* pp. 31–37.

Markham, O. D., and D. K. Halford, 1982, "Radionuclides in Mourning Doves Near a Nuclear Facility Complex in Southeastern Idaho," *Wilson Bulletin, 94,* pp. 185–197.

Markham, O. D., et al., 1982, "Radionuclides in Pronghorn Resulting from Nuclear Fuel Reprocessing and Worldwide Fallout," *Journal of Wildlife Management, 46,* pp. 30–42.

Markham, O. D., et al., 1988, "Plutonium, Am, Cm, and Sr in Ducks Maintained on Radioactive Leaching Ponds in Southeastern Idaho," *Health Physics, 55,* pp. 517–524.

Markham, O. D., K. W. Puphal, and T. D. Filer, 1978, "Plutonium and Americium Contamination Near a Transuranic Storage Area in Southeastern Idaho," *Journal of Environmental Quality, 7,* pp. 422–428.

Markham, O. D., and T. D. Reynolds, 1991, *Publications of the Idaho National Engineering Laboratory Radioecology and Ecology Program: 1974-1991,* DOE/ID-12125, U.S. Department of Energy, Idaho Operations Office, Idaho Falls.

McGiff, T. J., 1985, "Determination of ^{129}I and ^{127}I in Vegetation at the Idaho National Engineering Laboratory," Doctoral Dissertation, Colorado State University, Fort Collins.

Millard, J. B., F. W. Whicker, and O. D. Markham, 1990, "Radionuclide Uptake and Growth of Barn Swallows Nesting by Radioactive Leaching Ponds," *Health Physics, 58,* pp. 429–439.

Morris, R. C., 1993, "The Implications of Lined Radioactive Waste Ponds for Waterfowl Contamination," R. L. Kathren, D. H. Denham, and K. Salmon (eds.), *Environmental Health Physics, Proceedings of the Twenty-sixth Midyear Topical Meeting of the Health Physics Society, 1993, 24-28 January, Coeur d'Alene, Idaho,* Columbia Chapter, Health Physics Society, Richland, WA, pp. 147-155.

Morris, R. C., S. K. Rope, and O. D. Markham, in preparation, "Potential Radiation Dose to Human Waterfowl Hunters and Waterfowl Using Wastewater Ponds at the Idaho National Engineering Laboratory," *Journal of Environmental Radioactivity.*

Moseley, R., and C. Groves, 1992, "Rare, Threatened and Endangered Plants and Animals of Idaho," Conservation Data Center, Idaho Department of Fish and Game, Boise.

Overton, C. K., and D. W. Johnson, 1976, "Ecological Study of the Big Lost River with Emphasis on Environmental Impact," O. D. Markham (ed.), *1975 Progress Report: Idaho National Engineering Laboratory Site Radioecology-Ecology Programs,* IDO-12080, U.S. Energy Research and Development Administration, Idaho Falls, ID, pp. 166–180.

Whicker, F. W., and V. Schultz, 1982, *Radioecology: Nuclear Energy and the Environment,* CRC Press, Inc., Boca Raton, FL.

Wilde, D. B., 1978, "A Population Analysis of the Pygmy Rabbit (*Sylvilagus idahoensis*) on the INEL Site," Doctoral Dissertation, Idaho State University, Pocatello.

Appendix D

Ecological Components of the Idaho National Engineering Laboratory

Appendix D

Ecological Components of the Idaho National Engineering Laboratory

D-1. INTRODUCTION

T. A. Bensen, N. L. Hampton

Ecological risk assessment (ERA) at a site begins with site characterization, which involves identifying and understanding the importance of several ecosystem properties including biotic and abiotic properties and ecosystem structure and function. The biotic and abiotic components of the Idaho National Engineering Laboratory (INEL) are discussed in this appendix. Structure and function of the ecosystem are addressed in the screening-level ERA (SLERA) manual.

The approach designed for SLERA at the INEL uses the concept of ecological functional groups rather than individual species (with the exception of threatened and endangered species, which are addressed on an individual basis). This appendix is not intended to provide information to identify specific INEL ecological components of concern, but rather to provide broad information to help familiarize the ecological risk assessor with INEL systems. A broad understanding of INEL site ecology is important to accurately assess the potential ecological risk at a site.

Included in this appendix are general lists and descriptions as well as comprehensive species lists of the flora and fauna present at the INEL. Much of the information presented here has been taken and updated from the *Environmental Resource Document for the INEL* (Irving 1993). The scientific approach to the INEL WAG-wide SLERAs allows the emphasis in this appendix to be placed only on the most commonly occurring species and those that are threatened, endangered, or sensitive. The ecological components are described in the following sections:

- Floral communities as defined by remote sensing analysis (Section 2)
- Fauna (by family) compiled from 20 years of observation and research at the INEL (Section 3)
- Threatened, endangered, or sensitive species according to federal and state regulations or guidelines (Section 4)
- Abiotic components such as geology, soils, climatology, and topography (Section 5).

D-2. INEL ECOSYSTEM COMPONENTS OVERVIEW

The INEL is located in a cool desert ecosystem characterized by shrub-steppe vegetation communities. The flora and fauna are typical of the northern Great Basin and Columbia Plateau region (comprehensive species lists are included at the end of this appendix). For further information regarding regional ecological components, see West (1978). The surface of the INEL is relatively flat with several prominent volcanic buttes and numerous basalt flows that provide important habitat for small and large mammals, reptiles, and raptors. The elevation ranges from 1,460 m (4,790 ft) in the south to 1,650 m (5,913 ft) in the northeast, with the exception of the East, Middle and Big Southern buttes located in the southern portion of the site and to the south of the site which have elevations of 2,003 m (6,571 ft), 1,948 m (6,389 ft), and 2,304 m (7,557 ft), respectively. The shrub-steppe communities are dominated by sagebrush and provide habitat for numerous fauna such as sage grouse, pronghorn, and sage sparrows. Rabbitbrush, grasses and forbs, salt desert shrubs, and exotic/weed species comprise other communities. Juniper woodlands occur near the buttes and in the northwest portion of the INEL; these woodlands provide important habitat for raptors and big game animals. Limited riparian communities exist along intermittently flowing waters.

Microflora, bacteria, and fungi form extensive and critical communities in the desert ecosystem. Given the magnitude of mass and energy that cycles through the microbial biomass and of their associations with plant species, they are important components of all INEL communities. However, the microbiology of shrub-steppe ecosystems is not well understood and while work has been conducted in other arid ecosystems, detailed data describing the distribution and activities of microorganisms at the INEL are not available. Therefore, the microflora communities at the INEL will be only qualitatively addressed at sites not eliminated through the SLERA process.

D-3. BIOTIC COMPONENTS

INEL Flora

Sagebrush communities occupy the greater part of the INEL, but juniper-, crested wheatgrass-, and Indian ricegrass-dominated communities are also present and distributed throughout the INEL. Exotic plant species including cheatgrass *(Bromus tectorum),* halogeton *(Halogeton glomeratus),* and Russian thistle *(Salsola kali),* are established, particularly in disturbed areas. Crested wheatgrass *(Agropyron cristatum)*, a European annual seeded in the late 1950s dominates disturbed areas where it was used to provide cover and hold soils.

Most of the natural vegetation at the INEL consists of a shrub overstory with an understory of perennial grasses and forbs. The most common shrub is Wyoming big sagebrush *(Artemisia tridentata ssp. wyomingensis).* Basin big sagebrush (*Artemisia tridentata* ssp. *tridentata*) may dominate or be codominant with Wyoming big sagebrush on sites having deep soils or sand accumulations (Shumar and Anderson 1986). Big sagebrush communities occupy most of the central portions of the INEL. Green rabbitbrush (*Chrysothamnus viscidiflorus*) is the next most abundant shrub. Other common shrubs include winterfat (*Ceratoides lanata*), spiny hopsage [*Atriplex spinosa* (*Grayia spinosa*)], and gray rabbitbrush (*Chrysothamnus nauseosus*). Communities dominated by Utah juniper (*Juniperus osteosperma*), threetip sagebrush (*Artemisia tripartita*), and/or black sagebrush (*Artemisia nova*) are found along the periphery of the INEL on slopes of the buttes onsite and foothills of adjacent mountain ranges to the northwest.

The understory of grasses and forbs includes the rhizomatous thick-spiked wheatgrass (*Agropyron dasystachyum*) as the most abundant grass. Bottlebrush squirreltail (*Elymus elymoides*), Indian ricegrass (*Oryzopsis hymenoides*) and needle-and-thread (*Stipa comata*) are common bunchgrasses. Patches of creeping wildrye (*Elymus triticoides*) and western wheatgrass (*Agropyron smithii*) are locally abundant. Communities dominated by Great Basin wildrye (*Leymus cinereus*) are found in scattered depressions between lava ridges and in other areas having deep soils. Bluebunch wheatgrass (*Agropyron spicatum*) is common on slightly higher elevations in the southwest and east of the INEL. Prickly phlox (*Leptodactylon pungens*) is a common forb.

Limited riparian communities including cottonwood, willow, waterbirch, and chokecherry occur along the Big Lost River and Birch Creek. Intermittent natural wetlands include the rivers and creeks, playas that may fill in the spring, and the Big Lost River Sinks. Manmade wetlands include permanent evaporation ponds and drainage ditches as well as a series of spreading areas near the southwest corner of the site used to contain water diverted from the Big Lost River when high flows occur.

Fifteen cover classes of vegetation have been identified using satellite image analysis (Kramer et. al. 1992). Figure 3-2 (main document) presents these vegetation classes as they occur across the INEL. These classes are identified and the associated area, acreage, and percent cover per class are provided in Table D-1.

Table D-1. Expanded vegetation cover classes at the INEL and corresponding areas, acres, and percent cover.

Vegetation Cover Classes	Area (m^2)	Acres	Percent Cover
Juniper woodlands	15,750,193	3,892	0.68
Steppe	28,748,845	7,104	0.31
Sagebrush-Steppe off-lava	858,924,267	212,244	37.24
Sagebrush-Steppe on-lava	903,662,829	223,299	39.18
Sagebrush/Winterfat	92,080,343	22,753	3.99
Sagebrush-Rabbitbrush	142,919,566	35,316	6.20
Sage/Low-sage/Rabbitbrush off-lava	15,311,330	3,783	0.66
Salt Desert Shrub	71,835,822	17,751	3.11
Steppe-Small Sagebrush	3,329,476	823	0.14
Grassland	111,068,386	27,445	4.82
Basin Wildrye	7,130,973	1,762	0.31
Wetlands	2,410,200	596	0.10
Old-fields-disturbed seedings	11,878,201	2,935	0.52
Lava	15,792,439	3,902	0.68
Playa-bareground/gravel-borrow pits	17,698,089	4,373	0.77

For the purposes of INEL SLERAs, these 15 classes have been combined into eight broader cover classes. These classes are listed in Table D-2 (with the area, acreage, and percent cover per class) and also illustrated in Figure D-2. Considering these broader classes, the most prevalent cover class on the INEL is the Sagebrush/Rabbitbrush/Salt Desert Shrub class and the next most prevalent is the Sagebrush-Steppe on Lava cover class. Together, these classes comprise 90 percent of the vegetation of the INEL. Of the remaining classes, grasslands occupy nearly 6 percent of INEL land while the remaining four classes comprise the last 4 percent. Table D-3 provides an overview of each community, listing the dominant species in each and providing general comments for each community.

The vegetation map provides useful data for determining the ecological characteristics of the INEL, but has limitations. The use of satellite imagery to map vegetation is based on the assumption that vegetation communities have unique spectral properties. However, in arid regions where vegetation is sparse, the spectral signature of an area may depend largely on spectral characteristics of the soil surface and/or shadows cast by individual trees or shrubs (Tueller 1987). To the extent that soil spectral properties and vegetation are not related, limitations in the ability to map vegetation using satellite imagery are expected. The

Table D-2. Combined vegetation cover classes at the INEL and corresponding areas, acres, and percent cover.

Vegetation Cover Classes	Area (m^2)	Acres	Percent Cover
Juniper woodlands	18,015,939	4,452	0.78
Grasslands	127,853,347	31,593	5.54
Sagebrush/Rabbitbrush	1,194,742,785	295,226	51.81
Salt Desert Scrub	71,586,466	17,689	3.11
Sagebrush-Steppe on-lava	919,579,851	227,232	39.88
Lava	16,388,630	4,050	0.71
Wetlands	2,374,200	587	0.10
Playa-bareground/Disturbed areas	22,860,885	5,649	0.99
Facilities[a]	4,360,920	1,078	0.19

a. Not discussed in text; listed to account for all acreage mapped.

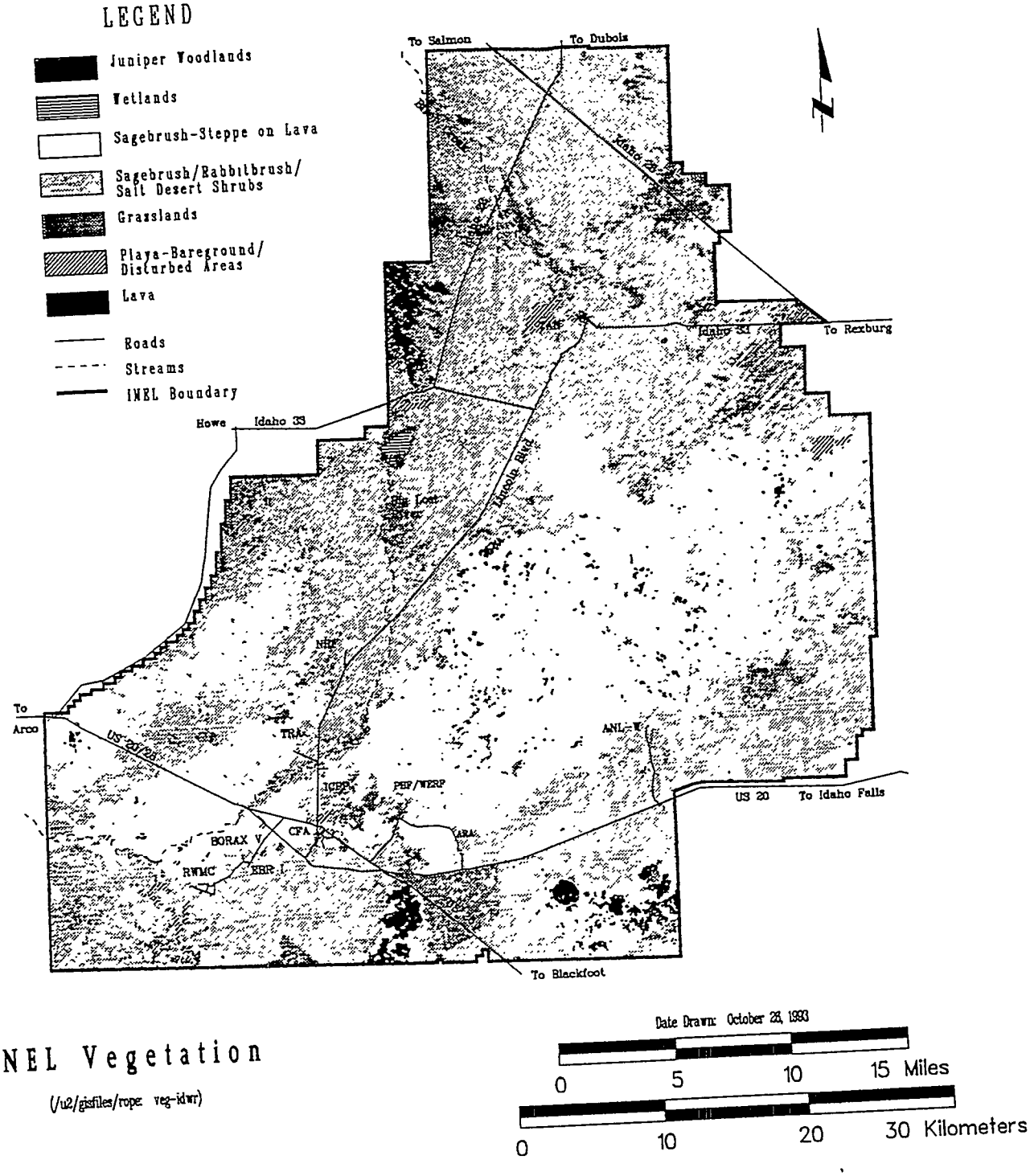
risk assessor should be aware that some differences may exist between the map and vegetation at the site until mapping has been verified by actual field surveys.

Juniper Woodlands

Utah juniper (*Juniperus osteosperma*) typically dominates this cover class, however some juniper woodlands are dominated by Wyoming big sagebrush (*Artemisia tridentata* ssp. *wyomingensis*) and black sagebrush (*Artemisia nova*). Even when not dominant in juniper stands, these two sagebrush species are still very abundant in juniper woodlands. Juniper trees have been occasionally associated with the "Lava" and the "Sagebrush-Steppe on Lava" cover classes. These individual or sparsely associated trees provide nesting sites for raptors and can be important habitat for other species.

Grasslands

The communities in this cover class are generally dominated by rhizomatous species such as thickspike wheatgrass (*Agropyron dasystachyum*) and douglas sedge (*Carex douglassi*) and characterized by the abundance of native graminoids and a sparse cover of shrubs. Nearly pure stands of the grass Great Basin wildrye (*Leymus cinereus*) occur in low-lying areas between lava ridges where deep soils and moisture accumulate. The shrubs, Wyoming big sagebrush and green rabbitbrush (*Chrysothamnus viscidiflorus*) or gray rabbitbrush (*Chrysothamnus nauseosus*) are also typically present on the perimeter of the nearly pure stands of Great Basin wildrye. Where these shrubs occur, tansey-mustard, or flixweed, (*Descurainia sophia*) is common in the understory. Steppe communities dominated by native bunchgrasses such as bottlebrush squirreltail (*Elymus elymoides*) or needle-and-thread grass (*Stipa comata*) are also present, commonly with the annuals



INEL Vegetation

(/u2/gisfiles/rope: veg-idwr)

Figure D-2. Vegetation map of the INEL showing combined cover classes.

Table D-3. SLERA combined vegetation cover class overviews (compiled from Anderson 1991).

Vegetation cover class	Dominant species	General comments
Juniper Woodlands	*Juniperus osteosperma* *Artemisia tridentata* ssp. *wyomingensis* *Leptodactylon pungens*	Unique habitat on the INEL; important raptor and other bird nesting/perching habitat, provides cover for deer and elk. Primarily located around Middle and East Buttes and NW portion of the INEL.
Grasslands	*Leymus cinereus* *Descurainia sophia* *Sisymbrium altissimum* *Agropyron dastachyum* *Artemisia tridentata* ssp. *wyomingensis* *Chrysothamnus viscidiflorus*	Common, but not abundant; provides good forage; primarily rhyzominous species. Located in small patches across the INEL. The *Leymus cinerus* communities provide unique habitat that are associated with basins, playas, and deeper soils, generally within the Sagebrush-Steppe on lava areas.
Sagebrush/ Rabbitbrush	*Artemisia tridentata* ssp. *wyomingensis* *Chrysothamnus viscidiflorus* *Bromus tectorum* *Sisymbrium altissimum* *Elymus elymoides*	Most abundant community on the INEL. Primarily located in northern and southern portions of the INEL. Winterfat is important forage.
Salt Desert Scrub	*Ceratoides lanata* *Atriplex nuttallii* *Atriplex confertifolia* *Atriplex canescens*	This cover class consists of several individual committees dominated by 1) *Atriplex nuttallii,* 2) *Atriplex confertifolia* and 3) *Ceratoides lanata.* Most of these communities have a high percentage of bareground.
Sagebrush-Steppe on Lava	*Artemisia tridentata* ssp. *wyomingensis* *Oryzopsis hymenoides* *Chrysothamnus viscidiflorus*	Second most abundant community on the INEL; relatively diverse habitat providing vegetation cover and cover from lava outcrops. Where significant sagebrush die off, *Bromus tectorum* can be dominant.
Lava	*Artemisia tridentata* ssp. *wyomingensis* *Chrysothamnus nauseosus*	Unique; lava outcrops provide good habitat for small and large mammals, raptors, and reptiles. These areas may also have juniper trees associated with them.
Wetlands	*Eleocharis palustris* *Typha latifolia* *Agropyron smithii*	Unique; Big Lost River and spreading areas are mapped by the USFWS as wetlands. The Big Lost River has significant vegetation (tree and shrub) and lava outcrops associated with it along the reach encompassed by the USFWS map.

Table D-3. (continued).

Vegetation cover class	Dominant species	General comments
Playa-Bareground/ Disturbed Areas	*Kochia scoparia* *Salsola kali* *Artemisia tridentata* ssp. *wyomingensis* *Chrysothamnus viscidiflorus*	Unique; playas may be associated with temporary flooding and considered ephemeral wetlands. Areas surrounding playa may include good forage.

cheatgrass (*Bromus tectorum*) and tumbleweed mustard (*Sisymbrium altissimum*), which are sometimes codominants in areas. Western stickseed (*Lappula redowskii*) and Western tansey-mustard (*Descurainia pinnata*) are common forbs in some areas.

Sagebrush/Rabbitbrush/Salt Desert Shrubs

This class occupies the largest percentage of the INEL (approximately 52%). The areas supporting this cover class are located off the lava flow that covers the central areas of the INEL, although some communities are found both on and off lava (e.g., Sagebrush-Steppe, Sagebrush/Rabbitbrush). These areas typically have deeper soils than on lava flows and are associated with the flood plain, alluvium deposits, sand dunes, or deposition zones for wind-blown materials. Several different vegetation communities are present in this class and include Basin Big Sagebrush-Steppe, Wyoming Sagebrush-Steppe, Sagebrush-Winterfat, Nuttall Saltbush, Shadscale, and Sagebrush/Rabbitbrush communities.

All communities in this class are similar in that a sagebrush species is present in nearly all. Basin Big Sagebrush-Steppe and Wyoming Sagebrush-Steppe communities represent 75% of this cover class. Basin big sagebrush is the only dominant species in the Basin Big Sagebrush-Steppe community whereas green rabbitbrush is codominant with Wyoming big sagebrush in the Wyoming Big Sagebrush-Steppe community. Aside from the dominance of basin big sagebrush, these communities do not have unique species compositions. Instead, they share a suite of subordinate species found in the other big sagebrush communities. Transitional stands codominated by both subspecies of big sagebrush are common between stands dominated by one subspecies or the other.

In the Sagebrush-Winterfat community, Wyoming big sagebrush is dominant or codominant with winterfat, and green rabbitbrush is also present. The Sagebrush/Rabbitbrush community is dominated by Wyoming big sagebrush, and green rabbitbrush is sometimes codominant. Both communities are rich in grasses. In fact, native perennial grasses such as Indian ricegrass (*Oryzopsis hymenoides*) comprise the understory in both communities. Cheatgrass has been observed in the Sagebrush/ Rabbitbrush community and is moderately to very abundant in most areas (Anderson 1991).

In the Nuttall Saltbush, Shadscale, and Winterfat communities, usually the only shrubs present are those for which the communities are named and much of the area within these communities is bare ground with little or no grasses or forbs present. Shrubby buckwheat

(*Eriogonum microthecum*) has been found with nuttall saltbush, and four-wing saltbush (*Atriplex canescens*) is common in the Winterfat community. Winterfat is a common shrub in all three communities.

Sagebrush-Steppe On Lava

This cover class is the second most prevalent on the INEL covering approximately 40% of the INEL. Two community types are found on lava at the INEL, Sagebrush/Low Sagebrush/Rabbitbrush on Lava and Sagebrush-Steppe on Lava.

The Sagebrush/Low Sagebrush/Rabbitbrush on Lava community is characterized by the presence of black sagebrush (*Artemisia nova*) though generally, it is not dominant. Green rabbitbrush and matchbrush, or snakeweed (*Gutierrezia sarothrae*) are common. Native grasses and forbs are commonly abundant.

Wyoming big sagebrush and basin big sagebrush are codominant in the Sagebrush-Steppe on Lava community. The communities which are named for these two sagebrush species off lava were discussed previously. The communities, as they occur off lava, are similar in species composition as they occur on lava.

Lava

Exposed lava outcrops and rubble largely comprise this cover class. The vegetation on lava is dominated by basin big sagebrush. Fern-bush (*Chamaebatiaria millefolia*) and gray rabbitbrush are common, but while fern-bush is common on lava flows and along desert canyon walls, it is rare over most of the INEL. Only four vascular plant species were recorded at the sample plots used for characterizing this cover class. Juniper trees are occasionally associated with lava. The cracks, crevices, and cliffs of the lava outcrops provide habitat for raptors, small and large mammals, and reptiles.

Wetlands

This cover class is found in areas south of the Big Lost River Sinks and includes intermittently flooded areas along the Big Lost River, Birch Creek, and playas that may fill in the spring. Man-made wetlands such as permanent evaporation ponds, drainage ditches, and spreading areas near the southwest corner of the INEL also exist. Common spike-rush is the dominant vegetation in wetland areas. Some locations were cattail marshes in the early- to mid-1980s; it is likely that these areas are recurring marshes during periods of above average precipitation. Western wheatgrass is also common in some areas.

Playa-Barcgound/Disturbed Areas

These areas are included on the INEL vegetation map, but are primarily barren of any vegetation. Some areas have been mapped as wetland habitat as part of the National Wetlands Inventory conducted by the U.S. Fish and Wildlife Service (Hampton et al. 1995).

D-4. INEL FAUNA

Numerous animal species have been observed on the INEL. Approximately 238 vertebrate species have been observed at the INEL including 37 mammal, 184 bird, nine reptile, six fish and two amphibian species. Approximately 154 of the 239 species occur as seasonal or migratory visitors, where the remaining 85 species are residents. A large number of the seasonal vertebrates are birds (Arthur et al. 1984). Raptors and songbirds are important ecological components and are some of the more visible occupants of the sagebrush-steppe community. The INEL is inhabited by 14 species of sparrows and allies; six species of swallows; 20 species of ducks and geese; and 24 species of raptors (Craig 1979; Arthur et al. 1984).

Thirty-four species observed at the INEL are considered game species. Of these species, waterfowl constitute the largest number of species present (22 species). Waterfowl use wetland and riparian habitat associated with the Big Lost River and ponds or impoundments at INEL facilities. However, the most common game species are the mourning dove, pronghorn, and sage grouse found in upland habitats. The INEL provides an important habitat for big game. Approximately 40% of Idaho's pronghorn population may use the INEL for winter range. In addition, a small population of elk has become resident on the INEL. Due to hunting restrictions, this herd of elk has grown dramatically from a very small number to its current size. In order to abate damage to crops on adjacent land, the INEL and the State of Idaho have implemented live-trap removal of a majority of the elk population (INEL News, April 1993). Some small mammal species such as the black-tailed jackrabbit exhibit large population fluctuations and influence the abundance, reproduction, and migration of predators such as the coyote, bobcat, and raptors.

The biological diversity of invertebrate fauna at the INEL has not been investigated extensively; however, 740 insect species have been collected and identified at the INEL. The harvester ant (*Pogonomyrmex salinus*), in particular, has received attention in recent studies because of its general importance in desert ecosystem energy cycling (Clark and Blom 1988; 1991). For comparison, a thorough inventory of invertebrates at the nearby Craters of the Moon National Monument lists 2,064 species (Horning 1966; Horning and Barr 1970), so it is possible that many more insect species are present at the INEL.

Six aquatic species have been observed on the INEL in years when water flow was sufficient in the Big Lost River. The river flows intermittently across about 50 km of the INEL, from southwest to north, before it terminates in the Big Lost River Sinks. Drought and upstream water diversion for agricultural and flood prevention purposes result in years when water flow does not reach the INEL section of the Big Lost River, and hence, aquatic species are not present.

Birds

A total of 184 avian species were recorded for the INEL in 1986 (Reynolds et al. 1986). Since then, 21 additional species have been recorded (T. D. Reynolds, personal communication, Feb. 23, 1994). A list of bird species recorded on the INEL is found on the species list. Additional species may be present but unaccounted for because more 216 avian species have been

reported in southeastern Idaho in habitats similar to those found on the INEL (Trost et al. 1977). Breeding bird surveys have been conducted through the Radiological and Environmental Sciences Laboratory to help determine which species are present and/or breeding on the INEL. Thirty-two species of game birds have been recorded on the INEL; 26 of these are waterfowl (including American coot and common snipe). Six upland game birds and 82 passerine species have been recorded on the INEL (Reynolds et al. 1986). The most common passerine species are the horned lark (*Eremophila alpestris*), black-billed magpie (*Pica pica*), American robin (*Turdus migratorius*), sage thrasher (*Oreoscoptes montanus*), Brewer's sparrow (*Spizella passerina*), sage sparrow (*Amphispiza belli*), and western meadowlark (*Sturnella neglecta*).

The INEL is an important nesting and wintering area for raptors. Twenty-two species of hawks, falcons, owls, or vultures have been observed (Reynolds et al. 1986) and ten species nest on or near the INEL. The most abundant breeding species are the American kestrel (*Falco sparverius*) and long-eared owl (*Asio otus*). American rough-legged hawks (*Buteo ragopus*), American kestrels, prairie falcons (*Falco mexicanus*), and golden eagles (*Aguila chrysactos*) are the most abundant raptors observed during the nonbreeding season. As many as 108 golden eagles and 15 bald eagles (*Haliaeetus leucocephalus*) have been observed on the INEL in a single mid-winter day (Watson 1984). The numbers of some wintering raptors are closely tied to fluctuation in black-tailed jackrabbit abundance, while others are closely tied to the population of small rodents. Two species, the bald eagle and the peregrine falcon (*Falco peregrinus*), are federally-listed endangered species. Six additional species are listed as Idaho special species of concern and/or sensitive by the Bureau of Land Management or the U.S. Forest Service.

Mammals

Thirty-seven species of mammals have been recorded on the INEL and are included in the species list. Fourteen of these species are rodents; four are lagomorphs; six are chiropterans; six are carnivores; and one belongs to the Insectivora family. The INEL supports resident populations of mule deer (*Odocoileus hemionus*), elk (*Cervus elaphus*), and pronghorn (*Antilocapra americana*). Moose (*Alces alces*), mountain sheep (*Oris canadensis*), and mountain lion (*Felis concolor*) have been reported, but are species that are not generally found on the INEL (Reynolds et al. 1986). Mule deer are considered uncommon and are generally concentrated in the southern and central portion of the INEL. They exist in greater numbers on the buttes and mountains surrounding the INEL. At least two herds of elk resided on the INEL in 1990, but were transplanted by the Idaho Department of Fish and Game in the winter of 1992 and 1993. A recent survey recorded the elk population at approximately 175 on the INEL (Personal communication, T. Reynolds, August, 1994). Home ranges for these elk herds encompass lands surrounding the INEL. Pronghorn are found throughout the INEL and are considered abundant; most pronghorn in southeastern Idaho are migratory. The Townsend's ground squirrel (*Spermophilus townsendii*), least chipmunk (*Tamius minimus*), Great Basin pocket mouse (*Pergnathus parvus*), Ord's kangaroo rat (*Dipodomys ordii*), western harvest mouse (*Reithrodontomys megalotis*), deer mouse (*Peromycus maniculatus*), bushy-tailed wood rat (*Neotoma cinerea*), and montane vole (*Microtus montanus*) are the most common small mammals on the INEL. Four species of leporids occur on the INEL and all but the white-tailed jackrabbit (*Lepus townsendii*) are considered abundant or common (Reynolds et al. 1986).

The number of black-tailed jackrabbits (*Lepus californicus*) on the INEL varies dramatically and periodically from less than 1 to more than 142 animals/km^2 (Stoddart 1983). Seven furbearing species have been recorded on the INEL (Reynolds et al. 1986). The muskrat (*Ondatra zibethicus*) and beaver (*Castor canadensis*) are confined to areas near water and are considered rare or vary local in distribution. The coyote (*Canis latrans*) and long-tailed weasel (*Mustela frenata*) are considered common species, while the bobcat (*Felis rufus*) and badger (*Taxidea taxus*) are considered uncommon. Bobcats and coyotes have both been studied on the INEL, and the abundance of these species depends, in part, on the abundance of jackrabbits (Knick 1990; MacCracken and Hansen 1987). The Western spotted skunk (*Spilogale gracilis*) is listed as a rare species on the INEL (Reynolds et al. 1986). Townsend's big-eared bat (*Plecotus townsendii*) and the pygmy rabbit (*Brachylagus idahoensis*) are Federally listed as Category 2 [candidate (C2)] species, and the Western pipstrelle (*Pipistrellus hesperus*) (a bat species), which may exist on the INEL (Reynolds et al. 1986), is listed as a species of special concern for the State of Idaho.

Amphibians and Reptiles

Two amphibian and 10 reptilian species have been recorded on the INEL and are listed on the species list (Reynolds et al. 1986). Of these species, five are considered common or abundant. There is only one confirmed record for the rubber boa (*Charina bottae*) and the western racer (*Coluber constrictor*) was only recently recorded on the INEL. The two amphibians recorded include the Great Basin spadefoot toad (*Spea intermontana*) and the Boreal Chorus Frog (*Hylidae pseudachris triceriatea*). The spadefoot toad is typically associated with the Big Lost River, the Big Lost River Sinks, and the spreading areas near the Radioactive Waste Management Complex (RWMC) (Reynolds et al. 1986) and because of drought, does not breed regularly on the INEL. Published ranges indicate that an additional four reptile species could possibly be found on the INEL (Nussbaum et al. 1983); however, of these species, it is likely that only the night snake (*Hypsiglena torquata*) exists on the INEL (personal communication with C. Peterson 1990). The night snake and the ringnecked snakes (*Diadophis punctatus*) are listed as sensitive species by the Bureau of Land Management.

Fish

Six species of fish have been identified in the portion of the Big Lost River that flows onto the INEL during the Big Lost River Salmonid Surveys (Overton 1977) and are listed on Table D-7 (Reynolds et al. 1986). Four of these were game species (salmonids) and two were nongame species. Additional game and nongame species may have been present but were not observed or are present only during some years of normal stream flow. Not since October 1986 has there been enough water in the Big Lost River to reach the INEL. That year, water flowed as far as the Big Lost Sinks. Since that time, low runoff, combined with upstream diversions, has prevented sustained flow and hence aquatic biota in the Big Lost River on the INEL.

Invertebrates

A total of 740 insect species have been collected on the INEL. A significant portion of these (226) have not been identified beyond the family level. The majority of the abundant species are Hymenoptera (wasps and ants), Diptera (flies), including parasitics and predatory

forms, and Coleoptera (beetles) (Stafford 1983, 1987; Stafford et al. 1986; Youdie 1986). A diverse insect community is associated with the sagebrush and great basin wildrye communities on the INEL, and these insects play an important role in the food chains of INEL ecosystems (Stafford 1983, 1987; Youdie 1986). A prominent feature of the area is harvester ant mounds, which are visible on aerial photographs. Ants of the INEL have been the subject of a number of recent studies (Clark and Blom 1988, 1991; Clark and Blom, in press), as have honeybees. No sensitive insect species have been identified on the INEL.

D-5. THREATENED, ENDANGERED, AND OTHERWISE REGULATED FLORA AND FAUNA

The scope of SLERAs requires that threatened, endangered, and/or other species of social value be specifically addressed. This section identifies the species that fall into these categories. Additionally, different listings are used by federal and state agencies and a species that occurs on a federal list may not be a state specie of concern, so this section also describes the listings by different agencies and culminates with a list of threatened, endangered, and/or sensitive species that may be present at the INEL.

Several state and federal agencies operating in Idaho have, as part of their goals and mandates, identified and established protection of rare species and their habitats. Federally, these agencies are the U.S. Fish and Wildlife Service (FWS), the U.S. Bureau of Land Management (BLM), and the U.S. Forest Service (USFS). Within the State of Idaho, the Departments of Fish and Game and Parks and Recreation administer such protection programs. The designation for a species is dependent on the classification of the organization recognizing it as such. These protection programs, classifications, and protected species are discussed further below.

Federal Flora and Fauna Protection Programs

The FWS administers the U.S. Endangered Species Act (Public Law 93-205) which provides federal protection for designated plant and animal species and their critical habitats. Under the Act, the Secretary of the Interior is authorized to develop and implement recovery plans for each listed species. Classifications for flora and fauna protected under the Act are listed endangered, listed threatened, or candidates for threatened or endangered status (Moseley and Groves 1992).

Listed endangered species are defined as those taxa in danger of extinction throughout all or a significant portion of their range. Listed threatened species are defined as taxa likely to be classified as endangered within the foreseeable future throughout all or a significant portion of their range. Candidates for threatened or endangered status are defined as taxa for which the FWS currently has substantial information on hand to support the biological appropriateness of proposing to list as endangered or threatened (referred to as C1 species); taxa for which information now in possession of the FWS indicates that proposing to list as endangered or threatened is possibly appropriate, but for which conclusive data on biological vulnerability and threat are not currently available to support proposed rules (C2 species); and taxa that were once being considered for listing as endangered or threatened, but are no longer receiving such consideration (Category 3 species).

The BLM has an internal program that acknowledges and designates for protection sensitive plant and animal species. The goals of the BLM Threatened and Endangered Species Program are to identify and count, monitor, prepare and implement plans to insure the maintenance and recovery of such species. It is BLM policy to manage candidate species and their habitats to insure that BLM actions do not contribute to the need to list any candidate species as threatened or endangered. Within this agency, protected species are classified as Sensitive Species.

State of Idaho Flora and Fauna Protection Mandates and Programs

In Idaho, two specific laws are in place for protection of flora and fauna. Idaho Code Section 18-3913 was established in 1967 to protect native Idaho wildflowers and gives the Idaho Department of Parks and Recreation authority to establish and amend a list of plants in need of protection because they may become extinct or because they affect the scenic beauty of public roads or public land. When this code was enacted, flora species selected for the listing were chosen primarily for political reasons. Therefore, of the 24 species listed in 1967, most are common northern Idaho forest herbs and shrubs (Moseley and Groves 1992). None of the Parks and Recreation department's listed species occur at the INEL.

The second law in place is Idaho Code Section 36-103 which mandates the Idaho Department of Fish and Game (F&G) to preserve, protect, perpetuate, and manage all wildlife. The F&G regulations classify wildlife into nine categories; those of relevance here are threatened or endangered wildlife, protected nongame species, and species of special concern. Some species found on the INEL are protected under the F&G policies and cannot be hunted, taken, or possessed except under special circumstances. These species include all federally-listed threatened or endangered wildlife including peregrine falcons and bald eagles; all State-protected nongame species such as chipmunks, all hawks, owls, eagles, and vultures; and all State-designated nongame birds except the European starling (*Sturnus vulgaris*), House sparrow (*Passer domesticus*), and feral pigeon (*Columba livia*).

In addition to these state laws, the F&G Conservation Data Center (CDC) has adopted the Idaho Native Plant Society (INPS) listing of rare flora native to Idaho. This list is updated annually at the INPS-sponsored Idaho Rare Plant Conference. Within this listing, the categories to classify rare Idaho flora are State Priority 1, State Priority 2, Sensitive, Monitor, Historical/Extirpated, and Review (Moseley and Groves 1992). Ten species on the CDC/INPS list are found at the INEL.

T/E Flora

An extensive survey for rare and endangered plant species was conducted by Cholewa and Henderson (1983, 1984) from 1980 to 1982. With the exception of vegetation communities associated with wetlands (see Section 2.3.2.6), no additional surveys have been conducted since for rare and endangered species. Work being conducted by Idaho State University will provide additional information on the INEL communities and the status of sensitive plant species. Currently, no plant species from the Cholewa and Henderson survey are considered threatened or endangered by the federal government, but most are considered sensitive by the BLM, USFS, or the INPS. Those species occurring at the INEL listed on the CDC/INPS rare plant list are listed in the T/E-sensitive species table.

T/E Fauna

The only species at the INEL currently recognized as threatened or endangered under the Endangered Species Act are the bald eagle, a winter visitor, and the peregrine falcon. Several species that are candidates for the Federal list are known to exist at the INEL and include the ferruginous hawk (*Buteo regalis*), loggerhead shrike (*Lanius excubitor*), white-faced ibis (*Plegadis*

chichi), black tern (*Childonia niger*), northern goshawk (*Accipiter gentilis*), pygmy rabbit, and the Townsend's big-eared bat (Arthur et al. 1984). The long-billed curlew (*Numenius americanus*) is currently considered to be more widespread than previously believed, or is not subject to identifiable threats, and therefore, has been removed from C2 status and is now designated 3C (no longer considered for listing) (Moseley and Groves 1992). Those listed species are provided in Table D-4.

Table D-4. Threatened, endangered, or sensitive species or species of special concern that may be found on the INEL.[a]

Common Name	Scientific Name	Status by Agency[b] Federal	State	BLM	USFS[e]	INPS
FLORA[c]						
Lemhi milkvetch	*Astragalus aquilonius*	—	—	S	S	S
Painted milkvetch	*Astragalus ceramicus* var. *apus*	3c	—	—	—	M
Plains milkvetch	*Astragalus gilviflorus*	NL	—	S	S	3
Winged-seed evening primrose	*Camissonia pterosperma*	NL	—	S	—	S
Nipple cactus	*Coryphantha missouriensis*	NL	—	S	—	M
Spreading gilia	*Ipomopsis (Gilia) polycladon*	NL	—	S	—	2
King's bladderpod	*Lesquerella kingii* var. *cobrensis*	—	—	—	—	M
Oxytheca	*Oxytheca dendroidea*	NL		S	—	S
Inconspicuous phalcelia[d]	*Phacelia inconspicua*	C2	SSC	S	—	S
Puzzling halimolobos	*Halimolobos perplexa* var. *perplexa*	—	—	—	—	M
BIRDS						
Peregrine Falcon	*Falco peregrinus*	LE	E	—	—	
Merlin	*Falco columbarius*	NL	—	S	—	
Gyrfalcon	*Falco rusticolus*	NL	SSC	S	—	
Bald eagle	*Haliaeetus leucocophalus*	LE	E	—	—	
Ferruginous hawk	*Buteo regalis*	C2	SSC	S	—	
Black tern	*Chlidonias niger*	C2	—	—	—	
Northern pygmy owl[d]	*Glaucidium gnoma*	—	SSC	—	—	
Burrowing owl	*Athene cunicularia*	NL	—	S	—	
Common loon	*Gavia immer*	—	SSC	—	—	
American white pelican	*Pelicanus erythrorhynchos*	—	SSC	—	—	
Great egret	*Casmerodius albus*	—	SSC	—	—	
White-faced ibis	*Plegadis chihi*	C2	—	—	—	
Long-billed curlew	*Numenius americanus*	3c	—	S	—	
Loggerhead shrike	*Lanius ludovicianus*	C2	NL	—	—	
Northern goshawk	*Accipiter gentilis*	C2	S	—	S	
Swainson's hawk	*Buteo swainsoni*	—	—	S	—	
Trumpeter swan	*Cygnus buccinator*	C2	SSC	S	S	
Sharptailed grouse	*Tympanuchus phasianellus*	C2	—	S	S	
Boreal owl	*Aegolius funereus*	—	SSC	S	S	
Flammulated owl	*Otus flammelous*	—	SSC	—	S	
MAMMALS						
Pygmy rabbit	*Brachylagus (Sylvilagus) idahoensis*	C2	NL	—	—	
Townsend's Western big-eared bat	*Plecotus townsendii*	C2	SSC	—	S	
Western pipistrelle[d]	*Pipistrellus hesperus*	NL	SSC	—	—	
Fringed myotis[d]	*Myotis thysanodes*	—	SSC	—	—	
California myotis[d]	*Myotis californicus*	—	SSC	—	—	
FISH						
Shorthead sculpin[d]	*Cottus confusus*	—	SSC	—	—	
REPTILES AND AMPHIBIANS						
Ringneck snake[d]	*Diadophis punctatus*	NL	SSC	S	—	
Night snake[d]	*Hypsiglena torquata*	—	—	S	—	

a. This list was compiled from the U.S. Fish and Wildlife Service (letter dated January 23, 1994) , the Idaho Department of Fish and Game Conservation Data Center threatened, endangered, and sensitive species for the State of Idaho (Moseley and Groves, 1992), and INEL RESL documentation (Reynolds, 1994; Reynolds et al., 1986).

b. Status codes: S=sensitive; 2=State Priority 2; 3c=no longer considered for listing; M=State monitor species; NL=not listed; 1=State Priority 1; LE=Listed endangered; E=endangered; SSC=species of special concern; and C2=Category 2 (defined in Moseley and Groves, 1992).

c. Recent update resulting from Idaho State Sensitive Species meeting (BLM, FWS, INPS, FS); (INPS, 1995).

d. No documented sighting on the INEL, howeverk, the range of this species overlaps the INEL and should be considered when conducting field surveys.

e. U.S. Forest Service Region 4.

D-6 ABIOTIC COMPONENTS

The topography of the INEL is flat to gently rolling with predominant relief manifested as volcanic buttes or unevenly surfaced basalt flows. With the exception of buttes, elevations range from 1,460 m (4,790 ft) in the south to 1,650 m (5,913 ft) in the northeast. The East, Middle, and Big Southern Buttes are located in the southern portion and to the south of the INEL and have elevations of 2,003 m (6,571 ft); 1,948 m (6,389 ft); and 2,304 m (7,557 ft) above sea level, respectively. The average elevation of the INEL is 1,526 m (5,000 ft) above sea level. A broad topographic ridge, which extends northward, separates the drainage of the mountain ranges northwest of the INEL from the Snake River.

The INEL can be divided into three physical subdivisions: a central alluvial trough that extends from southwest to northeast through the INEL; the Lost River, Lemhi, and Bitterroot mountains to the north and northwest; and a lava ridge to the southeast. The alluvial (riverine) trough has been formed by the Big Lost River, which enters the southwestern corner of the INEL, flows north, and percolates into the Snake River Plain Aquifer at the Big Lost River Sinks near Howe, Idaho. The three mountain ranges are composed primarily of Paleozoic limestone and are within the Basin and Range Province. They are all faulted on their west sides, and were uplifted 10,000 to 15,000 ft during block-faulting activities about 10 million years ago. The lava flows on the INEL are undulating. The East and Big Southern Buttes are rhyolite domes, formed from viscous lava from volcanic eruptions while Middle Butte is composed of basalt, possibly with rhyolite underneath it (Martin et al. 1992).

In general, INEL soils have formed as a result of alluvial or aeolian (wind-blow) deposition over basalt lava flows and are derived from silicic volcanic and Paleozoic limestones from nearby mountains and buttes. In the southern part of the INEL, soils are gravely to rocky. Rock outcrops are common and some soils are relatively shallow. The northern portion of the INEL is covered by lake and eolian deposits, mostly composed of unconsolidated clay, silt, and sand. Thirteen soil series are know to occur at the INEL; ten of the soil series are loames and the remaining three are sands. In general, the soils in the central and northern portions of the INEL are deep, while soils in the southern portion of the site are generally rocky and shallow (Martin et al. 1992).

D-7. CLIMATOLOGY

The climate of the area is characterized by large diurnal and seasonal temperature fluctuations. Winters are cold, with 2 to 3 months of mean temperatures below freezing. Topsoils usually remain frozen from mid-to-late November through mid-February or early March. Snow cover typically persists for two to three months or more. The average annual temperature is 5.4°C (41.7°F) and the average maximum temperatures in the summer and winter are 28°C (83°F) and -0.5°C (31°F). The frost-free period in this region is about 90 days.

The INEL lies in the rain shadow of the numerous mountain ranges of south-central Idaho. Mean annual precipitation is 22.20 cm (8.74 in.). On average, over one-third of the precipitation falls early in the growing season during April, May, and June. Melting snow and spring rains account for virtually all of the annual recharge of moisture in the soil profile (Anderson et al. 1987). Annual snowfall at the INEL ranges from a low of about 30 cm (12 in.) to a high of about 102 cm (40 in.) and an average of 66 cm (26 in.). Normal winter snowfall occurs from November through April, although occasional snow storms occur in May, June, and October.

Wind patterns at the INEL can be quite complex. The orientations of the surrounding mountain ranges and the ESRP play an important part in determining the wind regime. The INEL is in the belt of prevailing westerly winds, which are channeled within the ESRP to produce a west-southwest or southwest wind approximately 40% of the time. Local mountain valley features exhibit a strong influence on the wind flow under other meteorological conditions as well. At the mouth of Birch Creek, the northwest to southeast orientation of this valley channels strong north-northwest winds into the TAN weather station areas. Average wind speeds recorded at CFA and TAN meteorological stations at 20 ft were 9.3 mph and 9.5 mph, respectively. These speeds were recorded in mid-spring, while in mid-winter, the average speeds recorded at the same stations were 5.1 mph at CFA and 4.6 mph at TAN (Irving 1993). A wind rose based on wind direction and speed data collected by the National Oceanic and Atmospheric Administration (NOAA) from the CFA meteorological station from 1987 through 1991 is provided in Figure D-3 (Bensen 1992).

Source: NOAA

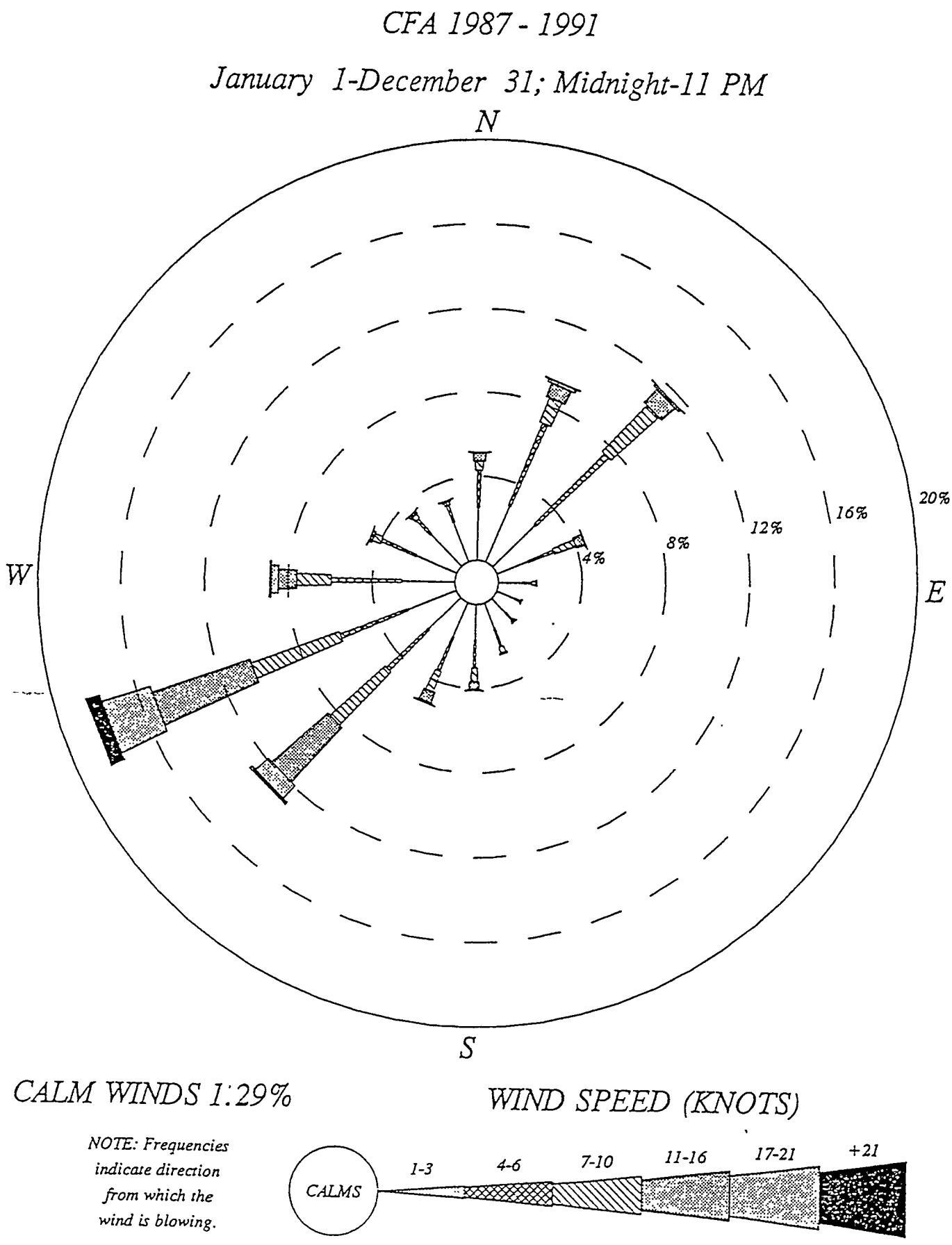


Figure D-3. Wind rose for the INEL.

D-8. HYDROLOGY

Stream flows on the INEL are very infrequent. Three streams that occasionally flow onto the INEL are the Big Lost River, Little Lost River, and Birch Creek. The Big Lost River is the major surface water feature on the INEL and its waters are impounded and regulated by Mackay Dam, which is located approximately 6.4 km (4 mi) northwest of Mackay, Idaho. Upon leaving the dam, waters of the Big Lost River flow southeastward through the Big Lost River Basin past Arco and onto the Eastern Snake River Plain (ESRP). When flow in the Big Lost River actually reaches the INEL, it is either diverted at the INEL Diversion Dam or flows northward across the INEL in a shallow channel to its terminus at the Lost River Sinks, where its flow is lost to evaporation and infiltration. Flow in the Big Lost River has not reached the INEL since 1993.

The Little Lost River drains from the slopes of the Lemhi and Lost River ranges and the flows are diverted for irrigation north of Howe, Idaho. Water from the Little Lost River has not reached the INEL in recent years. Birch Creek receives water from springs below Gilmore Summit in the Beaverhead Mountains of the Bitterroot range and drainage from the surrounding basin. Water in Birch Creek is diverted for irrigation and hydropower in the summer months before it reaches the INEL. In the winter months, when water is not used for irrigation, water is returned to a man-made channel on the INEL 6.4 km (4 mi) north of TAN where it infiltrates into channel gravels, recharging the aquifer (Irving, 1993).

Subsurface hydrology at the INEL consists of the vadose zone, perched water, and the saturated zone, referred to as the Snake River Plain Aquifer. The vadose zone extends from land surface down to the water table. An extensive vadose zone exists at the INEL ranging in thickness from 61 m (200 ft) in the north to greater than 274 m (900 ft) in the south. It consists of surface sediments, relatively thin horizontal basalt flows, and occasional interbedded sediments. Perched water forms in the vadose zone as discontinuous saturated lenses. It occurs when water migrates vertically, and to a lesser extent, laterally from the source until an impeding layer is encountered. Perched water at the INEL has been detected at the ICPP, the TRA, TAN, and RWMC facilities. Its occurrence is generally related to the presence of disposal ponds or other surface water sources. The Snake River Plain Aquifer exists at depths up to hundreds of feet beneath the ESRP. It is considered one of the largest aquifers in the United States. The aquifer is recharged by infiltration and snowfall that occurs within the drainage basin that surrounds the ESRP and from deep percolation of irrigation water. Annual recharge rates are dependent on precipitation, but in general, recharge in the vicinity of the INEL is somewhat less than discharge (Irving, 1993).

D-9. REFERENCES

Anderson, J. E., 1991, *Final Report, Vegetation Studies to Support the NPR Environmental Impact Statement,* Subcontract No. C85-110421, Task Order No. 72, EG&G Idaho, Inc., Idaho Falls, Idaho.

Arthur, W. J., J. W. Connelly, D. K. Halford, and T. D. Reynolds, 1984, *Vertebrates of the Idaho National Engineering Laboratory*, DOE/ID-12099.

Bensen, T. A. 1992, "Meteorlogical Data for the Central Facilities Area and Radioactive Waste Management Complex and Sources of Additional Data," Engineering Design File, ERD-WED-91, October.

Cholewa, A. F. and D. M. Henderson, 1983, "Noteworthy collections–Idaho: *Lesquerilla kingii* S. wats, var. *cobrenses* Roll. and Shaw, *Astragalus kentrophyta* Gray var. *jessiae* (Peck) Barneby, *Gilia polycladon* Torrey," *Madrono,* 30:63-64.

Cholewa, A. F. and D. M. Henderson, 1984 *A Survey and Assessment of the Rare Vascular Plants of the Idaho National Engineering Laboratory Site,* Radiological and Environmental Sciences Laboratory, DOE/ID-12100, Idaho Falls, Idaho, pp. 45.

Clark, W. H. and P. Blom, 1988, "Observations on the Relationship Between Ants (Hymenoptera: Formicidae: Myrmicinae, Dorylinae) and Areaoschizus (Coleoptera: Tenebrionidae)," *Journal of the Idaho Academy of Sciences, 24,* pp. 35-37.

Clark, W. H. and P. Blom, 1991, "Observations of Ants (Hymenoptera: Formicidae: Myrmicinae, Formicinae, Dolichoderinae) Utilizing Carrion," *Southwestern Naturalist, 36,* pp. 140-142.

Clark, W. H., and P. E. Blom, in press, "Chemotaxonomic Study of an Undescribed Species of *Myrmica* Ant from Idaho," *Journal of Chemical Ecology.*

Craig, T. H., 1979, *Raptors of the INEL,* U. S. Department of Energy Idaho Operations Office, Idaho Falls, ID IDO-12089.

EG&G Idaho, 1985, *INEL Environmental Characterization Report*, EGG-NPR-6688, 3 Vol., EG&G Idaho, Inc., Idaho Falls, ID, January.

Irving, J. S., 1993, *Environmental Characterization Document for the Idaho National Engineering Laboratory,* EGG-WMO-10279, 2 vol., EG&G Idaho, Inc., Idaho Falls, ID, July.

Hampton, N. L., Rope, R. C., Glennon, J. M., and Moor, K. S., 1995, *A Preliminary Survey of National Wetlands Inventory as Mapped for the Idaho National Engineering Laboratory,* INEL-95/0101.

Horning, D. S., 1966, *Insects of Craters of the Moon National Monument, Idaho,* Master's Thesis, University of Idaho, Moscow, Idaho.

Horning, D. S., Jr. and W. F. Barr, 1970, *Insects of Craters of the Moon National Monument, Idaho,* University of Idaho College of Agriculture Miscellaneous Series No. 8, Moscow, Idaho.

INEL News, 1993, "Elk Herds Moved From Site," August.

Knick, S. T., 1990, "Ecology of Bobcats Relative to Exploitation and a Prey Decline in Southeastern Idaho," *Wildlife Monographs, 108*, 42 p.

Kramber, W. J., R. C. Rope, J. Anderson, J. Glennon, and A. Morse, 1992, "Producing a Vegetation Map of the Idaho National Engineering Laboratory Using Lands at Thematic Mapper Data," proceedings of ASPRS 1992 Annual Meeting, Albuquerque, NM, March.

MacCracken, J. G. and R. M. Hansen, 1987, "Coyote Feeding Strategies in Southeastern Idaho: Optimal Foraging by an Opportunistic Predator?" *Journal of Wildlife Management, 51,* pp. 278-285.

Martin, K. L., et al. 1992, *Preliminary Assessment of Surface Soils at Active EG&G Idaho Facilities Data Document,* EGG-ESQ-9225, Rev. 1, EG&G Idaho, Inc., Idaho Falls, ID, May.

Moseley, R. and C. Groves, 1992, *Rare, Threatened, and Endangered Plants and Animals of Idaho,* Conservation Data Center Nongame and Endangered Wildlife Program, Idaho Department of Fish and Game, Boise, Idaho.

Nussbaum, P. A., E. D. Brodie, Jr., and R. M. Storm, 1983, *Amphibians and Reptiles of the Pacific Northwest*, University Press of Idaho, Moscow, Idaho, 330 p.

Overton, C. K., 1977, "Description, Distribution and Density of the Big Lost River Salmonid Populations," Unpublished thesis, Idaho State University, Pocatello, Idaho.

Peterson, C., 1990, Personnal communication.

Reynolds, T. D., J. W. Connelly, D. K. Halford, and W. J. Arthur, 1986, "Vertebrate Fauna of the Idaho National Environmental Research Park," *Great Basin Naturalist, 46,* pp. 513-527.

Reynolds, T. D., 1994, Personnal communication, February.

Shumar, M. L. and J. E. Anderson, 1986, "Gradient Analysis of Vegetation Dominated by Two Subspecies of Big Sagebrush," *Journal of Range Management*, 39, pp. 156-160.

Stafford, M. P., 1983, *Surface-dwelling Coleoptera inhabiting sagebrush communities in southeastern Idaho,* Master's Thesis, University of Idaho, Moscow, Idaho.

Stafford, M. P., 1987, *Insect interactions with four species of sagebrush* (Artemisia) *in a southeastern Idaho high desert rangeland,* Ph.D. Dissertation, University of Idaho, Moscow, Idaho.

Stafford, M. P., W. F. Barr, and J. B. Johnson, 1986, "Coleoptera of the Idaho National Engineering Laboratory Site: An annotated checklist," *Great Basin Naturalist*, 46:287-293.

Stoddart, L. C., 1983, *Relative Abundance of Coyotes, Lagomorphs, and Rodents on the Idaho National Engineering Laboratory, 1983 Progress Report*, DOE/IDO-12098, Idaho National Engineering Laboratory Radioecology and Ecology Programs, O. D. Markham (ed.), National Technical Information Service, Springfield, VA, pp. 268-277 and 434.

Trost, C. H., S. L. Findholt, and T. D. Rich, 1977, *Field Check List*, Department of Biology, Idaho State University, Pocatello, Idaho.

Tueller, P. T., 1987, "Remote Sensing of Science Applications in Arid Environments," *Remote Sensing of Environments,* 23, pp. 143–154.

Watson, J. W., 1984, *Rough-legged hawk winter ecology in southeastern Idaho,* Master's Thesis, Montana State University, Bozeman, Montana.

West, N. E., 1978, (ed. 1983), Ecosystems of the World 5, Temperate Deserts and Semi-Deserts, Amsterdam, Netherlands: Elsevier Scientific Publishing Co.

Youdie, B. A., 1986, *The Insect Fauna Associated with Great Basin Wildrye in Southern Idaho,* Master's Thesis, University of Idaho, Moscow, Idaho.

COMPREHENSIVE SPECIES LISTS
FOR THE IDAHO NATIONAL ENGINEERING LABORATORY

Flora Recorded for the INEL

Family
Genus species, Common Name

Aceraceae - Maple Family

Acer glabrum Torr. - Rocky Mountain Maple
Acer negundo L. - Box Elder

Alismaceae - Water Plantain Family

Alisma gramineum Gmel. - Water Plantain

Amaranthaceae - Amaranth Family

Amaranthus albus L. - White Pigweed
Amaranthus californicus (Moq.) Wats. - California Amaranth
Amaranthus hybridus L. - Pigweed
Amaranthus retroflexus L. - Redroot

Anacardiaceae - Sumac Family

Rhus trilobata Nutt. - Squawbush, Skunkbush

Apocynaceae - Dogbane Family

Apocynum cannabinum L. - Dogbane

Asclepiadaceae - Milkweed Family

Asclepias speciosa Torr. - Showy Milkweed, Greekweed

Betulaceae - Birch Family

Betula occidentalis Hook. - Western Water Birch

Boraginaceae - Borage Family

Amsinckia menziesii (Lehm.) Nels. and Macb. - Small-flowered Fiddleneck
Asperugo procumbens L. - Catchweed, Madwort
Cryptantha ambigua (Gray) Greene - Obscure Cryptantha
Cryptantha circumsicissa (H. and A.) Johnst. - Matted Cryptantha
Cryptantha fendleri (Gray) Greene - Fendler's Cryptantha
Cryptantha interrupta (Greene) Pays. - Bristly Cryptantha
Cryptantha kelseyana Greene - Kelsey's Cryptantha
Cryptantha scoparia Nels - Desert Cryptantha
Cryptantha watsoni - Watson's Cryptantha
Hackelia jessicae (McGregor) Brand - Blue Stickseed, Wild Forget-Me-Not
Lappula echinata Gilib. - Stick-tights, Beggar Ticks
Lappula redowskii (Hornem.) Greene - Western Stickseed, Beggar's Ticks
Lithospermum ruderale Dougl. - Gromwell, Western Gromwell, Columbia Puccoon
Mertensia oblongifolia (Nutt.) G. Don - Leafy Bluebells
Myosotis laxa Lehm. - Small-flowered Forget-Me-Not

Family

Genus species, Common Name

Cataceae - Cactus Family

Opuntia polyacantha Haw. - Starvation Cactus, Prickly Pear

Capparidaceae - Caper Family

Clemone lutea Hook. - Yellow Bee Plant

Caprifoliaceae - Honeysuckle Family

Sambucus cerulea Raf. - Elderberry
Symphoricarpos oreophilus Gray. - Snowberry

Caryophyllaceae - Pink Family

Arenaria congesta Nutt. - Capitate Sandwort, Ballhead Sandwort
Arenaria franklinii Dougl. - Franklin's Sandwort
Arenaria kingii M. E. Jones - King's Sandwort
Arenaria nuttallii Pax. - Nuttall's Sandwort
Lychnis apetala L. - Catchfly, Campion
Silene douglasii Hook. - Catchfly, Wild Pink
Silene menziesii Hook. - Catchfly, Wild Pink

Chenopodiaceae - Goosefoot Family

Atriplex canescens (Pursh) Nutt. - Wingscale
Atriplex confertifolia - Shadscale, Spiny Saltbush
Atriplex nuttallii - Saltsage, Moundscale
Atriplex rosea - Red Orache
Atriplex spinosa (Hook.) Collotzi - Spiny Hopsage
Chenopodium album L. - White Goosefoot, Lamb's Quarter, White Pigweed
Chenopodium fremontii Wats. - Fremont's Goosefoot
Chenopodium leptophyllum (Mog.) Wats. - Slimleaf Goosefoot, Lamb's Quarter
Chenopodium rubrum L. - Red Goosefoot
Eurotia lanata (Pursh) Mog. - Winterfat, White Sage, Winter Sage
Halogeton glomeratus C. A. Meyer - Halogeton
Kochia scoparia (L.) Schrad. - Summer Cypress, Red Belvedere
Monolepis nuttalliana (Schultes) Greene - Povertyweed, Prostrate Monolepsis
Salsola kali L. - Windwitch, Tumbleweed, Russian Thistle
Sarcobatus vermiculatus (Hook.) Torr. - Greasewood, Chico

Asteraceae - Composite or Sunflower Family

Achillea millefolium L. - Common Yarrow
Agoseris glauca (Pursh) Raf. - False Dandelion
Agoseris retrorsa (Benth.) Greene - Spear-leafed Agoseris
Ambrosia artemisiifolia L. - Ragweed
Antennaria dimorpha - Dwarf Pussy-toes, Low Pussy-toes
Antennaria microphylla Rydb. - Rosy Pussy-toes
Arctium minus (Hill) Bernh. - Common Burdock
Arnica cordifolia hook - Heart-leaved Arnica
Artemisia arbuscula Nutt. - Low Sage, Dwarf Sage
Artemisia biennis Willd. - Biennial Wormwood
Artemisia drancunculus L. - Dragon Sage
Artemisia frigida Willd. - Pasture Sagebrush, Fringed Sagebrush
Artemisia ludoviciana Nutt. - Silver Sage, Prairie Sage
Artemisia spinescens Eat. - Spiny Sage

Family	Genus species, Common Name

Asteraceae - Composite or Sunflower Family (Continued)

Artemisia tridentata Nutt. - Big Sage
Artemisia tripartita Rydb. - Threetip Sage
Aster scopulorum Gray - Crag Aster, Lava Aster
Balsamorhiza hookeri Nutt. - Hooker's Balsamroot
Balsamorhiza sagittata (Pursh) Nutt. - Arrowleaf Balsamroot
Bidens cernua L. - Nodding Beggar-ticks
Carduus nutans L. - Musk Thistle, Milk Thistle
Centaurea maculosa Lam. - Spotted Knapweed
Centaurea repens L. - Russian Knapweed
Chaenactis douglasii (Hook.) H. and A. - Hoary False-yarrow
Chrysothamnus nauseousus (Pall.) Britt. - Gray Rabbit brush
Chrysothamnus vicidiflorus (Hook.) Nutt. - Green Rabbit-brush
Cirsium arvense (L.) Scop. - Canada Thistle, Creeping Thistle
Cirsium magnificum (A. Nels.) Petrah. - Showy Thistle
Cirsium subniveum Rydb. - Jackson's Hole Thistle
Cirsium utahense Petr. - Utah Thistle
Cirsium vulgare (Savi) Airy-Shaw - Bull-Thistle
Conyza canadensis (L.) Cronq. - Horseweed, Canada Fleabane
Conyza floribunda H. B. K. Nov. - Horseweed
Crepis acuminata Nutt. - Longleaved Hawksbeard
Crepis atrabarba Heller - Slender Hawksbeard
Crepis barbigera Leib. - Bearded Hawksbeard
Crepis modocensis Greene - Low Hawksbeard
Crepis occidentalis Nutt. - Western Hawksbeard
Erigeron caespitosus Nutt. - Tufted Fleabane, Gray Daisy
Erigeron corymbosus Nutt. - Longleaf Fleabane
Erigeron gabellus Nutt. - Fleabane Daisy
Erigeron pumilus Nutt. - Shaggy Fleabane
Gnaphalium palustre Nutt. - Lowland Cudweed, Everlasting
Grindelia squarrosa (Pursh) Dunal - Gumweed, Resin-Weed
Gutierrezia sarothrae (Pursh) Britt. and Rusby - Matchbrush, Broom Shrub, Snakeweed
Haplopappus resinosus (Nutt.) Gray - Columbia Goldenweed
Haplopappus acaulis (Nutt.) Gray - Stemless Goldenweed, Strawflower
Helenium autumnale L. - Sneezeweed
Helianthus annuus L. - Annual Sunflower, Common Sunflower
Helianthus petriolaris Nutt. - Prairie Sunflower
Hymenopappus filifolius Hook. - Hymenopappus
Iva axillaris Pursh - Povery Weed
Iva xanthifolia Nutt. - Tall Marsh Elder
Lactuca pulchellus (Pursh) D. C. - Blue Lettuce
Lactuca serriola L. - Prickly Wild Lettuce
Lygodesmia grandiflora (Nutt.) T. and G. - Skeleton Weed, Rush Pink
Lygodesmia spinosa Nutt. - Spiny Skeleton Week
Machaerantha canscens (Pursh) Gray - Hoary Aster
Matricaria maritima L. - Scentless May-Weed
Scenecio canus Hook. - Wooly Groundsel
Scenecio integerimus Nutt. - Western Groundsel, One-stemmed Butterweed
Senecio serra Hook. - Tall Butterweed
Senecio vulgaris L. - Common Grounsel
Solidago canadensis L. - Canada Goldenrod, Meadow Goldenrod
Solidago occidentalis (Nutt.) T. and G. - Goldenrod, Western Goldenrod
Sonchus asper (L.) Hill - Prickley Sow Thistle
Stephanomeria exigua Nutt. - Small Wirelettuce
Stephanomeria tenuifolia (Torr.) Hall - Narrow-leaved Skeletonweed, Wirelettuce
Tanacetum valgare L. - Tansey, Common Tansey
Taraxacum officinale Webber - Common Dandelion

Family

Genus species, Common Name

Asteraceae - Composite or Sunflower Family (Continued)

Tetradymia canescens D. D. - Gray Horsebrush
Tetradymia spinosa H. and A. - Spiny Horsebrush
Townsendia florifer (Hook.) Gray - Showy Townsendia
Tragopogon dubius Scop. - Goat's Beard, Yellow Salsify
Xanthium strumarium L. - Common Cocklebur

Brassicaceae - Mustard Family

Alyssum desertorum Stapf. - Desert Alyssum
Arabis cobrensis Jones - Cobre Rockcress
Arabis holboellii Hornem. - Holboell's Rockcress
Arabis lignifera A. Nels. - Rockcress, Woody-branched Rockcress
Arabis microphylla Nutt. - Littleleaf Rockcress
Arabis nuttallii Robin - Rockcress, Nuttall's Rockcress
Bassica juncea (L.) Coss. - Chinese Mustard
Capsella bursa-pastoris (L.) Medic - Sheperd's Purse
Chorispora tenella (Pall.) D. C. - Purple Carpet, Purple Mustard, Blue Mustard
Descurainia pinnata (Walt.) Britt. - Western Tansey Mustard
Descurainia sophia (L.) Webb. - Tansey-mustard, Flixweed
Draba obligosperma Hook. var. oligosperma - Whitlow Grass
Erysisum inconspicuum (Wats.) McMillan - Wallflower, Small Wallflower
Lepidium densiflorum Schard. - Peppergrass, Common Peppergrass
Lepidium perfoliatum L. - Pepperweed, Clasping Peppergrass
Lepidium virginicum L. - Peppergrass, Tall Peppergrass
Lesquerella ludoviciana (Nutt.) Watts. - Silvery Bladderpod
Phoenicaulis cheiranthoides Nutt. - Daggerpod
Rorippa curvisiliqua (Hook.) Bessey - Yellow watercress, Marsh Yellowcress
Rorippa islandica (Oed.) Borbas - Yellow watercress, Marsh Yellowcress
Rorippa obtusa (Nutt.) Britt. - Yellow Watercress, Blunt-leaved Yellowcress
Schoenocrambe linifolia (Nutt.) Greene - Perrennial Mustard, Flaxleaved Plains Mustard
Sisymbrium altissimum L. - Jim Hill Mustard, Tumbleweed Mustard
Sisymbrium loeselii L. - Loesel Tumbleweed
Stanleya viridiflora Nutt. - Prince's Plume, Perennial Stanleya
Thelypodium laciniatum (Hook.) Endl. - Thick-leaved Thelypody
Thlaspi arvense L. - Penny-cress, Fanweed

Convolvulaceae - Morning Glory Family

Convolvulus arvensis L. - Field Morning Glory, Small Bindweed

Cornaceae - Dogwood Family

Cornus stolonifera Michx. - Red-stemmed Dogwood, Red-osier Dogwood

Crassulaceae - Stonecrop Family

Sedum stenopetalum Pursh - Wormleaf Stonecrop

Cupressaceae - Cypress Family

Juniperus osteosperma (Torr.) Little - Utah Juniper
Juniperus scopulorum Sarg. - Rocky Mountain Juniper

Family	Genus species, Common Name

Cyperaceae - Sedge Family

Carex douglasii - Douglas Sedge
Eleocharis palustris (L.) R. and S. - Spikerush, Common Spikerush, Creeping Spikerns
Scirpus acutus Muhl. - Hardstem Bulrush
Scirpus maritimus L. - Seacoast Bulrush

Euphorbiaceae - Spurge Family

Euphorbia esula L. - Esula spurge
Euphorbia glyptosperma Engelm. - Corrugate-seeded Spurge

Gentianaceae - Gentian Family

Fraseria albicaulis Dougl. - White-stemmed Fraseria

Poaceae - Grass Family

Agropyron x Elymus - Wheatgrass/Ryegrass Cross
Agropyron caninum (L.) Beauv. - Awned Wheatgrass, Bearded Wheatgrass
Agropyron cristatum (L.) Gaerth. - Crested Wheatgrass
Agropyron dasystachyum (Hook.) Scribn. - Thickspike Wheatgrass
Agropyron smithii Rydb. - Western Wheatgrass
Agropyron spicatum (Pursh) Scribn. and Smith - Bluebunch Wheatgrass
Agrostis alba L. - Bentgrass
Alopecurus aequalis Sobol. - Shortawn Foxtail, Little Meadow-Foxtail
Aristida fendleriana Stend. - Three-awn
Beckmannia syzigachne (Steud.) Fern. - Slough Grass
Bromus carinatus Hook. and Arn. - California Bromegrass
Bromus inermis Leys. - Smooth Bromegrass
Bromus tectorum L. - Cheatgrass, Downy Chess, June Grass
Dactylis glomerata L. - Orchard Grass
Distichlis stricta (Torr.) Rydb. - Desert Saltgrass
Echinochloa crusgalli (L.) Beauv. - Barnyard Grass
Elymus ambiguus Vasey and Scribn. - Ryegrass
Elymus cinereus Scribn. and Merill - Giant Wildrye
Elymus flavescens Scribn. and Smith - Golden Wildrye
Elymus triticoides Buckl. - Creeping Wildrye, Beardless Wildrye
Festuca idahoensis Elmer - Idaho Fescue
Festuca octoflora Walt. - Six-weeks fescue
Glyceria grandis Wats. - American Mannagrass
Hesperochloa kingii (Wats.) Rydb. - Spike Fescue
Hordeum jubatum L. - Foxtail Barley
Koeleria cristata Pers. - Prairie June Grass
Melica bulbosa Geyer - Oniongrass
Oryzopsis hymenoides (R. and S.) Ricker - Indian Ricegrass
Panicum capillare L. - Witchgrass, Panic grass
Phalaris arundinacea L. - Reed Canary Grass
Phleum pratense L. - Timothy, Common Timothy
Poa bulbosa L. - Bulbous Bluegrass
Poa fendleriana (Steud.) Vasey - Muttongrass
Poa nevadensis Vasey - Nevada Bluegrass
Poa pratensis L. - Kentucky Bluegrass
Poa sandbergii Vasey - Sandberg's Bluegrass
Poa scabrella (Thurb.) Benth. - Pine Bluegrass
Setaria viridis (L.) Breauv. - Green Bristle-grass
Sitanion hystrix (Nutt.) J. G. Smith - Bottlebrush, Squirreltail

Family
Genus species, Common Name

Poaceae - Grass Family (Continued)

Sporobolus cryptandrus (Torr.) Gray - Western Dropseed
Stipa commata Trin. and Rupr. - Needle-and Thread Grass
Stipa occidentalis Thurb. - Western Needlegrass
Stipa thurberiana Piper - Thurber's Needlegrass
Triticum aestivum L. - Common Wheat

Grossulariaceae - Currant or Gooseberry Family

Ribes aureum Pursh. - Golden Current
Ribes cereum Dougl. - Squaw Currant
Ribes setosum Lindl. - Gooseberry, Missouri Gooseberry

Hydrophyllaceae - Waterleaf Family

Hesperochiron californicus (Benth.) Wats. - California Hesperochiron
Hesperochiron pumilus (Griseb.) Porter - Dwarf Hesperochiron
Phacelia glandifera Piper - Glandular Phacelia
Phacelia glandulosa Nutt. - Silky Phacelia
Phacelia hastata Dougl. - Silverleaf Phacelia
Phacelia humilis T. and G. - Low Phacelia

Iridaceae - Iris Family

Sisyrinchium angustifolium Mill - Blue-eyed-grass, Blue star

Juncaceae - Rush Family

Juncus balticus Willd. - Baltic Rush

Labiatae - Mint Family

Agastache cusikii (Greene) Heller - Horsemint
Agastache urticifolia (Benth.) Kuntze - Giant Hyssop
Mentha arvensis L. - Field mint

Leguminosae - Pea Family

Astragalus agrestis Dougl. - Purple Milkvetch
Astragalus calycosa Torr. - Matted Milkvetch
Astragalus canadensis L. - Canada Milkvetch
Astragalus ceramicus Sheld. - Painted Milkvetch
Astragalus cibarius Sheld. - Browse Milk-vetch
Astragalus convallarius Greene - Lesser Rushy Milkvetch
Astragalus curvicarpus (A. Hell.) Macbr. - Curvepod Milkvetch
Astragalus filipes Torr. - Basalt Milkvetch, Threadstock Milkvetch
Astragalus lentiginosus Dougl. - Freckled Milkvetch
Astragalus miser Dougl. - Weedy Milkvetch
Astragalus purshii Dougl. - Loco Weed, Woolly-pod Milkvetch
Astragalus terminales Wats. - Railhead Milkvetch
Glycyrrhiza lepidota Pursh. - Licorice, Licorice-root
Hedysarum occidentale Nutt. - Western Hedysarum
Lupinus argenteus Pursh - Silvery Lupine
Lupinus pusillus Pursh - Tiny Peavine
Lupinus sericeus - Silky Lupine
Lupinus wyethii Wats. - Wyeth's Lupine
Medicago lupulina L. - Black Medic, Hop Clover

Family	Genus species, Common Name

Leguminosae - Pea Family (Continued)

Medicago sativa L. - Alalfa
Melilotus alba Desr. - White Sweet Clover
Melilotus officinalis (L.) Lam. - Common Yellow Sweet Clover
Oxytropis lagopus Nutt. - Rabbit-foot Crazyweed
Oxytropis sericea Nutt. - Silky Crazyweed
Petalostemun ornatum Dougl. - Western Prairie Clover
Psoralea lanceolata Pursh. - Lance-leaved Scurf-pea
Thermopsis montana Nutt. - Mountain Thermopsis, False-Lupine, Buck-bean
Trifolium pratense L. - Red Clover
Trifolium repens L. - White Clover, Dutch Clover
Vicia sativa L. - Common Vetch

Liliaceae - Lily Family

Allium acuminatum Hook. - Hooker's Onion
Allium geyeri Wats. - Geyer's Onion
Allium textile Nels. and Macbr. - Textile Onion
Calochortus brueaunis Nels. and Macbr. - Mariposa Lily
Calochortus macrocarpus Dougl. - Sagebrush Mariposa, Green-banded Star-Tulip
Fritillaria atropupurea Nutt. - Leopard Lily
Fritillaria pudica (Pursh.) Spreng. - Yellowbell, Fritillary
Smilacina stellata (L.) Desf. - False Solomon's Seal
Zigadenus paniculatus (Nutt.) Wats. - Foothills Death-Camas
Zigadenus venenosus Wats. - Death-Camas, Meadow Death-Camas

Loasaceae - Blazing-Star Family

Mentzelia albicaulis Dougl. - White-Stemmed Mentzelia, Little Blazing-Star
Mentzelia laevicaulis (Dougl.) T. and G. - Blazing-Star

Malvaceae - Mallow Family

Sphaeralcea munroana (Dougl.) Spach. - White-stemmed Globemallow

Marsileaceae - Pepperwort Family

Marsilea vestita Hook and Grev. - Pepperwort, Clover-fern

Nyctaginaceae - Four-o'clock Family

Abronia mellifera Dougl. - Sand Verbena, White Sand Verbena

Onagraceae - Evening-primrose Family

Epilobium angustifolium L. - Fireweed, Blooming Sally
Epilobium paniculatum Nutt. - Autumn Willow-Herb, Tall Annual Willow-Herb
Epilobium watsonii Barbey - Watson's Willow-Herb
Gayophytum nuttallii T. and G. - Nuttall's Gayophytum
Gayophytum racemosum T. and G. - Racemed Groundsmoke
Gayophytum ramosissium Nutt. - Hairstem Gayophytum
Oenothera andina Nutt. - Obscure Evening Primrose
Oenothera biennis L. - Common Evening Primrose
Oenothera caespitosa Nutt. - Evening Primrose
Oenothera minor (A. Nels) Munz - Small Flowered Evening Primrose
Oenothera pallida Lindl. - White-stemmed Evening Primrose

Family	Genus species, Common Name
Onagraceae - Evening-primrose Family (Continued)	
	Oenothera scapoidea Nutt. - Naked-stemmed Evening Primrose
Orchidaceae - Orchid Family	
	Corallorhiza maculata Raf. - Spotted Coral-Root
Orobanchaceae - Broomrape Family	
	Orobanche californica Cham. and Schlecht. - California Broomrape
	Orobanche fasciculata Nutt. - Clustered Broomrape
Pinaceae - Pine Family	
	Pinus contorta Dougl. - Lodgepole Pine
	Pinus flexilis James - Limber Pine
	Pseudotsuga menziesii (Mirbel.) Franco - Douglas Fir
Plantaginaceae - Plantain Family	
	Plantago major L. - Common Plantain
	Plantago patagonica Jacq. - Desert Plantain, India-wheat
Polemoniaceae - Phlox Family	
	Collomia linearis Nutt. - Narrow-leaf Collomia
	Eriastrum sparsiflorum (Eastw.) Mason - Few-Flowered Eriastrum
	Gilia aggregata (Pursh) Spreng. - Scarlet Gilia
	Gilia congesta Hook. - Many-flowered Gilia
	Gilia leptomeria Gray - Great Basin Gilia
	Gilia minutiflora Benth. - Small Flowered Gilia
	Gilia sinuata Doug. 1 - Sinuate Gilia
	Gymnosteris nudicaulis (H. and A.) Greene - Large Flowered Gymnosteris
	Gymnosteris parvula (Rydb.) Heller - Small-flowered Gymnosteris
	Langloisia setosissima (T. and G.) Greene - Bristly Langloisia
	Leptodactylon pungens (Torr.) Nutt. - Prickly Phlox
	Leptodactylon watsoni (Gray) Rydb. - Watson's Prickly Phlox
	Linanthus septentrionalis Mason - Northern Linanthus
	Phlox aculeata A. Nels. - Prickly-Leaved Phlox
	Phlox hoodii Rich. - Hood's Phlox
	Phlox longifolia Nutt. - Longleaf Phlox
Polygonaceae - Buckwheat Family	
	Eriogonum caespitosum Nutt. - Mat Buckwheat
	Eriogonum cernuum Nutt. - Nodding Buckwheat
	Eriogonum heracleoides Nutt. - Parsnip-flowered Buckwheat
	Eriogonum mancum Rydb. - Imperfect Buckwheat
	Eriogonum marifolium T. and G. - Slender Bush Buckwheat
	Eriogonum microthecum Nutt. - Shrubby Buckwheat
	Eriogonum ovalifolium Nutt. - Cushion Buckwheat
	Eriogonum umbellatum Torr. - Sulfurflower Buckwheat
	Oxytheca dendroidea Nutt. - Oxytheca
	Polygonum aviculare L. - Doorweed, Prostrate Knotweed
	Polygonum persicaria L. - Heartweed, Spotted Ladysthumb
	Polygonum ramosissimum Michx. - Yellow Flowered Knotweed
	Rumex crispus L. - Curley Dock

Family	Genus species, Common Name

Polygonaceae - Buckwheat Family (Continued)

Rumex salicifolius Weinm. - Willow-leaved Dock
Rumex maritimus L. - Seaside Dock
Rumex venosus - Wild Begonia

Polypodiaceae - Common Fern Family

Woodsia oreganna D. C. Eat. - Woodsia (Fern)

Ranunculaceae - Buttercup Family

Aquilegia formosa Fisch. - Red Columbine
Clematis ligusticifolia Nutt. - Virgin's Bower
Delphinium andersonii Gray - Desert Larkspur
Delphinum nuttallianum Pritz. - Upland Larkspur
Ranunculus andersonii Gray - Anderson Buttercup
Ranunculus aquatilis L. - Water Corwfoot
Ranunculus cymbalaria Pursh - Shore Buttercup
Ranunculus glaberrimus Hook. - Sagebrush Buttercup
Ranunculus macounii Britt. - Macoun's Buttercup
Ranunculus testiculatus Crantz. - Bur Buttercup

Rhamnaceae - Buckthorn Family

Ceanothus velutinus L. - Snowbrush, Mountain Laurel

Rosaceae - Rose Family

Amelanchier alnifolia Nutt. - Western Serviceberry
Cercocarpus ledifolius Nutt. - Mountain Mahagony
Chamaebatiaria millefolium (Torr.) Maxim. - Fernbrush, Tanseybush
Geum macrophyllum Willd. - Large-leaved Avens
Holodiscus dumosus (Hook.) Heller - Ocean Spray
Physocarpus alternans (M. E. Jones) J. T. Howell - Ninebark
Potentilla anserina L. - Common Silverweed
Potentilla biennis Greene - Biennial Cinquefoil
Potentilla norvegica L. - Norwegian Cinquefoil
Prunus virginiana L. - Common Chokecherry
Purshia tridentata (Pursh) D. C. - Bitterbrush, Antelope-brush
Rosa woodsii Lindl. - Wood's Rose
Rubus ideaus L. - Red Raspberry

Rubiaceae - Madder Family

Galium bifolium Wats. - Thin-leaved Bedstraw
Galium multiflorum Kell. - Shrubby Bedstraw

Salicaceae - Willow Family

Populus angustifolia James - Narrow-leaved Cottonwood
Populus tremuloides Michx. - Quaking Aspen
Salix exigua Nutt. - Western Sandbar Willow
Salix lasiandra Benth. - Whiplash Willow
Salix phylicifolia L. - Tea-leaved Willow
Salix scouleriana Barratt - Scouler's Willow

INEL Flora (Continued)

Family	Genus species, Common Name
Santalaceae - Sandalwood Family	
	Comandra umbellata (L.) Nutt. - False Toadflax
Saxifragaceae - Saxifrage Family	
	Heuchera parvifolia Nutt. - Common Alumroot
	Lithophragma bulbifera Rydb. - Star Flower
	Lithophragma parviflora (Hook.) Nutt. - Star Flower
Scrophulariaceae - Figwort Family	
	Castelleja angustifolia (Nutt.) G. Don. - Desert Paintbrush
	Castelleja longispica A. Nels. - White Paintbrush
	Collinsia parviflora Lindle. - Blue-eyed Mary
	Cordylanthus ramosus Nutt. - Bushy Birdbeak
	Limosella aquatica L. - Mudwort
	Linaria dalmatica (L.) Mill. - Dalmation Toadflax
	Linaria vulgaris Hill - Butter-and-eggs
	Purshia tridentata (Pursh) D. C. - Bitterbrush, Antelope-brush
	Mimulus breviflorus Piper - Short Flowered Monkey Flower
	Minulus nanus H. and A. - Purple Monkey Flower
	Penstemon cyaneus Pennell - Dark-blue Penstemon
	Penstemon deustus Dougl. - Hot-rock Penstemon
	Penstemon humilis Nutt. - Lowly Penstemon
	Penstemon pumilus Nutt. - Dwarf Penstemon
	Penstemon radicosus A. Nels - Matroot Penstemon
	Verbascum thapsus L. - Common Mullein, Hairy Mullein
	Veronica americana Schewin. - American Brookline, Speedwell
	Veronica anagallis-aquatica L. - Water Speedwell
Solanaceae - Nightshade Family	
	Hyoscyamus niger L. - Black Henbane
	Nicotiana attenuata Torr. - Coyote Tobacco
	Solanum dulcamara L. - Bittersweet
Typhaceae - Cattail Family	
	Typha latifolia L. - Common Cattail
Umbelliferae - Parsley Family	
	Cymopterus acaulis (Pursh) Raf. - Biscuit-Root
	Cymopterus terebinthinus (Hook.) T. and G. - Turpentine Cymopterus
	Lomatium dissectum (Nutt.) Math. and Const. - Fern-leaved Desert Parsley
	Lomatium foeniculaceum (Nutt.) Coult. and Rose - Fennel-leaved Desert Parsley
	Lomatium triternatum (Pursh) Coult. and Rose - Nine-leaf Lomatium
	Osmorhiza chilensis H. and A. - Sweet Cicely
Urticaceae - Nettle Family	
	Urtica dioica L. - Stinging Nettle
Verbenaceae - Verbena Family	
	Purshia tridentata (Pursh) D. C. - Bitterbrush, Antelope-brush
	Verbena bracteata Lag. and Rodg. - Bracted Verbena

INEL Flora (Continued)

Family	Genus species, Common Name
Violaceae - Violet Family	
	Viola nuttallii Pursh. - Yellow Violet

Avifauna Recorded on the INEL

Taxa	Abundance,[a] Season, and Breeding Status[b]	Habitat[c]
GAVIIFORMES		
Gaviidae		
Common Loon, *Gavia immer*[d]	M5	w
PODICIPEDIFORMES		
Podicipedidae		
Pied-billed Grebe, *Podilymbus podiceps*	S5, M5	w
Horned Grebe, *Podiceps auritus*	M5	w
Eared Grebe, *P. nigricollis*	B5, M3, W3	w
Western Grebe, *Aechmophorus occidentalis*	S5, M5	w
PELECANIFORMES		
Pelecanidae		
American White Pelican, *Pelecanus erythrorhynchos*[d]	M5	w
Phalacrocoracidae		
Double-crested Cormorant, *Phalacrocorax auritus*	U6	w
CICONIIFORMES		
Ardeidae		
American Bittern, *Botaurus lentiginosus*	S5, M5	w
Great Blue Heron, *Ardea herodias*	S5, M5	w
Snowy Egret, *Egretha thula*	U6	w
Great Egret, *Casmerodius albus*[d]	S5, M5	w
Cattle Egret, *Bubulcus ibis*	U6	w
Green-backed Heron, *Butorides striatus*	S6, M6	w
Threskiornithidae		
White-faced Ibis, *Plegadis chihi*[d]	S5, M5	w
ANSERIFORMES		
Anatidae		
Tundra Swan, *Cygnus columbianus*	M5	w
Trumpeter Swan, *C. buccinator*[d]	U6	w
Snow Goose, *Chen caerulescens*	M5	w
Ross' Goose, *Chen rossii*	U6	w
Canada Goose, *Branta canadensis*	S3, M3	w
White-fronted Goose, *Anser albifrons*	U6	w
Wood Duck, *Aix sponsa*	S6, M5	w
Green-winged Teal, *Anas crecca*	S5, M5	w
Mallard, *A. platyrhynchos*	B2, M2, W3	w
Northern Pintail, *A. acuta*	S3, M3	w
Blue-winged Teal, *A. discors*	B2, M3	w
Cinnamon Teal, *A. cyanoptera*	S3, M3	w
Northern Shoveler, *A. clypeata*	B3, M3	w
Gadwall, *A. strepera*	S3, M3	w

INEL Avifauna (Continued)

Taxa	Abundance,[a] Season, and Breeding Status[b]	Habitat[c]
ANSERIFORMES Anatidae (Continued)		
American Wigeon, *A. americana*	S3, M3	w
Canvasback, *Aythya valisineria*	B5, M5	w
Redhead, *A. americana*	S5, M5, W5	w
Ring-necked Duck, *A. collaris*	S5, M5	w
Lesser Scaup, *A. affinis*	S5, M3, W3	w
Common Goldeneye, *Bucephala clangula*	S5, M3, W3	w
Barrow's Goldeneye, *B. islandica*	S6, M5	w
Bufflehead, *B. albeola*	S5, M3	w
Surf Scoter, *Melanitta perspicillata*	U6	w
Common Merganser, *Mergus merganser*	S3, M5	w
Hooded Merganser, *Lophodytes cucullatus*	U6	w
Ruddy Duck, *Oxyura jamaicensis*	B5, M3	w
FALCONIFORMES		
Cathartidae		
Turkey Vulture, *Cathartes aura*	S3, M3, W6	sw
Accipitridae		
Osprey, *Pandion haliaetus*	M5	w
Bald Eagle, *Haliaeetus leucocephalus*[e]	M5, W3	sw
Northern Harrier, *Circus cyaneus*	R2	sw
Sharp-shinned Hawk, *Accipiter striatus*	S5, M5, W5	sw
Cooper's Hawk, *A. cooperii*	S3, M5, W5	sw
Northern Goshawk, *A. gentilis*	S5, M5, W5	sw
Swainson's Hawk, *Buteo swainsoni*	B3, M3, W5	sw
Red-tailed Hawk, *B. jamaicensis*	B3, M3, W5	sw
Ferruginous Hawk, *B. regalis*[d]	B3, M3, W5	sw
Rough-legged Hawk, *B. lagopus*	S6, M2, W2	sw
Golden Eagle, *Aquila chrysaetos*	B3, M4, W2	sw
Falconidae		
American Kestrel, *Falco sparverius*	B2, M2, W3	sw
Merlin, *F. columbarius*[d]	R5	sw
Peregrine Falcon, *F. peregrinus*[e]	S5, M5, W5	sw
Gyrfalcon, *F. rusticolus*	M6	sw
Prairie Falcon, *F. mexicanus*	R3	sw
GALLIFORMES		
Phasianidae		
Gray Partridge, *Perdix perdix*	R3	g, ss, f
Chukar, *Alectoris chukar*	R3	g, ss
Ring-necked Pheasant, *Phasianus colchicus*	R3	g, ss
Blue Grouse, *Dendragapus obscurus*	S6	f
Sage Grouse, *Centrocercus urophasianus*	R2	ss, g, f
GRUIFORMES		
Gruidae		
Sandhill Crane, *Grus canadensis*	U6	U

INEL Avifauna (Continued)

Taxa	Abundance,[a] Season, and Breeding Status[b]	Habitat[c]
GRUIFORMES (Continued)		
Rallidae		
Sora, *Porzana carolina*	B5, M5	w, f
American Coot, *Fulica americana*	R3	w
CHARADRIIFORMES		
Charadriidae		
Killdeer, *Charadrius vociferus*	B2, M2	sw
Semipalmated Plover, *C. semipalmatus*	U6	w
Mountain Plover, *Eupoda montana*	U6	U
Recurvirostridae		
American Avocet, *Recurvirostra americana*	S2, M3	w
Black-necked stilt, *Himantopus mexicanus*	U6	w
Scolopacidae		
Greater Yellowlegs, *Tringa melanoleuca*	M5	w
Lesser Yellowlegs, *T. flavipes*	S5, M5	w
Solitary Sandpiper, *T. solitaria*	S5, M3	w
Willet, *Catoptrophorus semipalmatus*	S3, M3	w, ss
Spotted Sandpiper, *Actitis macularia*	S3, M3	w
Long-billed Curlew, *Numenius americanus*[d]	S3, M3	w, ss
Marbled Godwit, *Limosa fedoa*	S3, M5	w
Least Sandpiper, *Calidris minutilla*	S5, M5	w
Long-billed Dowitcher, *Limnodromus scolopaceus*	M5	w
Western Sandpiper, *Ereunetes mauri*	U6	w
Baird's Sandpiper, *Erolia bairdii*	U6	w
Common Snipe, *Gallinago gallinago*	S5, M5	w
Wilson's Phalarope, *Phalaropus tricolor*	S3, M3	w
Red-necked Phalarope, *P. lobatus*	M5	w
Laridae		
Franklin's Gull, *Larus pipixcan*	S3, M3	w, ss
Bonaparte's Gull, *L. philadelphia*	M5	w
Ring-billed Gull, *L. delawarensis*	S3, M3	w, ss,g
California Gull, *L. californicus*	S5, M3	w, ss
Herring Gull, *L. argentatus*	S3, M3	w, ss, g
Black-legged Kittiwake, *Rissa tridactyla*	W6	w
Caspian Tern, *Sterna caspia*	M5	w
Forster's Tern, *S. forsteri*	S5	w
Black Tern, *Childonias niger*	S5, M5	w
COLUMBIFORMES		
Columbidae		
Rock Dove, *Columba livia*	R2	sw
Mourning Dove, *Zenaida macroura*	B1, M3, W5	sw

INEL Avifauna (Continued)

Taxa	Abundance,[a] Season, and Breeding Status[b]	Habitat[c]
STRIGIFORMES		
Strigidae		
Great Horned Owl, *Bubo virginianus*	R3	sw
Snowy Owl, *Nyctea scandiaca*	W5	sw
Burrowing Owl, *Athene cunicularia*	B3, M3, W6	ss, g
Long-eared Owl, *Asio otus*	B4, M4	d
Short-eared Owl, *A. flammeus*	B3, M3	ss, g
Northern Saw-whet Owl, *Aegolius acadicus*	S6, M6, W6	sw
CAPRIMULGIFORMES		
Caprimulgidae		
Common Nighthawk, *Chordeiles minor*	B2, M3	sw
Common Poor-will, *Phalaenoptilus nuttalii*	U6	j
APODIFORMES		
Apodidae		
White-throated Swift, *Aeronautes saxatalis*	S5	d
Trochilidae		
Rufous Hummingbird, *Selasphorus rufus*	S3, M3	d
CORACIIFORMES		
Alcedinidae		
Belted Kingfisher, *Ceryle alcyon*	S3, M3	w
PICIFORMES		
Picidae		
Downy Woodpecker, *Picoides pubescens*	B5, M5	d
Northern Flicker, *Colaptes auratus*	B3, M3	d
Lewis' Woodpecker, *Asyndesmus lewis*	U6	U
Red-naped Sapsucker, *Sphyrapicus nuchalis*	U6	U
PASSERIFORMES		
Tyrannidae		
Olive-sided Flycatcher, *Contopus borealis*	S5, M5	d
Western Flycatcher, *Empidonax difficilis*	S5	d
Say's Phoebe, *Sayornis saya*	B3, M3	ss,d,f,j
Ash-throated Flycatcher, *Myiarchus cinerascens*	S5	d
Western Kingbird, *Tyrannus verticalis*	B3, M3	f,d,j
Eastern Kingbird, *T. tyrannus*	B3, M3	f,d,j
Alaudidae		
Horned Lark, *Eremophila alpestris*	R2	g,ss

INEL Avifauna (Continued)

Taxa	Abundance,[a] Season, and Breeding Status[b]	Habitat[c]
PASSERIFORMES (Continued)		
Hirundinidae		
Tree Swallow, *Tachycineta bicolor*	B3, M3	d,j
Violet-green Swallow, *T. thalassina*	B4, M4	d,j
Northern Rough-winged Swallow, *Stelgidopteryx serripennis*	B3, M3	d,j
Bank Swallow, *Riparia riparia*	B5, M3	d,j
Cliff Swallow, *Hirundo pyrrhonota*	B2, M2	d,j
Barn Swallow, *H. rustica*	B2, M3	d,j
Corvidae		
Blue Jay, *Cyanocitta cristata*	U6	U
Clark's Nutcracker, *Nucifraga columbiana*	S4, M4, W5	j
Black-billed Magpie, *Pica pica*	R2	sw
American Crow, *Corvus brachyrhynchos*.	R3	sw
Common Raven, *C. corax*	R3	sw
Troglodytidae		
Rock Wren, *Salpinctes obsoletus*	B3, M3	ss
Canyon Wren, *Catherpes mexicanus*	S5, M5	ss
House Wren, *Troglodytes aedon*	R3	d
Muscicapidae		
Ruby-crowned Kinglet, *Regulus calendula*	M3, W6	d
Western Bluebird, *Sialia mexicana*	S5, M5	ss
Mountain Bluebird, *S. currucoides*	S3, M3	ss
Townsend's Solitaire, *Myadestes townsendi*	S5, M5	d
American Robin, *Turdus migratorius*	B2, M2	sw
Varied Thrush, *Ixoreus naevius*	W6	ss
Swainson's Thrush, *Hylocichla ustulata*	U6	U
Mimidae		
Northern Mockingbird, *Mimus polyglottos*	S6	j
Sage Thrasher, *Oreoscoptes montanus*	B2, M2	ss
Polioptilidae		
Blue-gray Gnatcatcher, *Polioptila caerulea*	U6	U
Motacillidae		
Water Pipit, *Anthus spinoletta*	M5	ss
Bombycillidae		
Bohemian Waxwing, *Bombycilla garrulus*	S3, M2, W3	f,d
Cedar Waxwing, *B. cedrorum*	S5, M3, W5	f,d
Laniidae		
Northern Shrike, *Lanius excubitor*	M3, W5	sw
Loggerhead Shrike, *L. ludovicianus*	B3	ss

INEL Avifauna (Continued)

Taxa	Abundance,[a] Season, and Breeding Status[b]	Habitat[c]
PASSERIFORMES (Continued)		
Sturnidae		
European Starling, *Sturnus vulgaris*	R3	sw
Vireonidae		
Warbling Vireo, *Vireo gilvus*	S5, M5	d
Emberizidae		
Black-and-White Warbler, *Mniotilta varia*	U6	U
Yellow Warbler, *Dendroica petechia*	B5, M3	d
Yellow-rumped Warbler, *D. coronata*	S3, M3	d
Townsend's Warbler, *D. townsendi*	M5	d
American Redstart, *Setophaga ruticilla*	M6	f
Common Yellowthroat, *Geothlypis trichas*	S5	d
Wilson's Warbler, *Wilsonia pusilla*	S5, M5	d
Orange-crowned Warbler, *Bermivora celata*	U6	U
Yellow-breasted Chat, *Icteria virens*	S5	d
MacGillivray's Warbler, *Oporornis tolmiei*	U6	U
Western Tanager, *Piranga ludoviciana*	S3, M3	d
Black-headed Grosbeak, *Pheucticus melanocephalus*	S5, M5	sw
Lazuli Bunting, *Passerina amoena*	S5, M5	d
Green-tailed Towhee, *Pipilo chlorurus*	S3, M3	ss
Rufous-sided Towhee, *P. erythrophthalmus*	S3, M3	sw
Chipping Sparrow, *Spizella passerina*	M5	f,d,ss
Brewer's Sparrow, *S. breweri*	B2, M2	ss
Vesper Sparrow, *Pooecetes gramineus*	B3, M3	g, ss
Lark Sparrow, *Chondestes grammacus*	S3, M5	sw
Black-throated Sparrow, *Amphispiza bilineata*	S5, M5	ss
Sage Sparrow, *A. belli*	B2, M2	ss
Lark Bunting, *Calamospiza melanocorys*	S5, M5	ss
Savannah Sparrow, *Passerculus sandwichensis*	S5, M3	d,g
Song Sparrow, *Melospiza melodia*	S5, M3	d
White-crowned Sparrow, *Zonotrichia leucophrys*	M4	ss
Dark-eyed Junco, *Junco hyemalis*	M3	sw
Snow Bunting, *Plectrophenax nivalis*	W5	g,ss
Red-winged Blackbird, *Agelaius phoeniceus*	B3, M3	w, ss
Western Meadowlark, *Sturnella neglecta*	B2, M2, W3	g,ss
Yellow-headed Blackbird, *Xanthocephalus xanthocephalus*	B4, M3	w,d
Brewer's Blackbird, *Euphagus cyanocephalus*	B2, M2, W5	sw
Brown-headed Cowbird, *Molothrus ater*	B3, M3	ss
Northern Oriole, *Icterus galbula*	S3, M3	d
Orchard Oriole, *Icterus spuris*	U6	U
Fringillidae		
Rosy Finch, *Leucosticte arctoa*	M5, W5	ss
House Finch, *Carpodacus mexicanus*	S3, M3	f,d
Pine Siskin, *Carduelis pinus*	S5, M3	f,d
American Goldfinch, *C. tristis*	M5	d,ss
Evening Grosbeak, *Coccothraustes vespertinus*	S5, M3	d
Passeridae		
House Sparrow, *Passer domesticus*	B2, M1, W3	f,d

a. Abundance code (all abundance classes assume a qualified biologist exerted a reasonable effort to search or sample the proper habitat at the appropriate time of year):

1. Abundant - very numerous and certain to be seen or sampled.
2. Common - likely but not certain to be observed or sampled.
3. Uncommon - found in limited numbers, not likely to be sampled or observed.
4. Occasional or local - a species that is not always present or is restricted in distribution.
5. Rare - a species that has a range including all or part of the INEL, but has been documented $\leq$ seven times on the INEL.
6. Vagrant or accidental- a species that is not expected to occur on the INEL, but has been recorded there.

b. Breeding and seasonal code:

R Breeder and year-round resident.
B Summer breeder.
M Migrant.
W Winter visitor.
S Summer visitor: no breeding records.
U Unknown.

in descending order of preference):

w On or near water
ss Shrub-steppe
d Deciduous or riparian
j Juniper woodland
g Grassland
sw Sitewide
f Facility complexes.
U Unknown

d. Candidate Species for List of Threatened or Endangered Species (White-faced Ibis; Ferruginous Hawk; Long-billed Curlew) or Idaho State Species of Special Concern (Moseley and Groves 1990).

e. Endangered (Federal Register 1990).Fish Recorded on the INEL (from Reynolds et al. 1986).

Fish Recorded for the INEL

Taxa	Distribution	Abundance
SALMONIFORMES		
Salmonidae		
Kokanee Salmon, *Oncorhynchus nerka*	Big Lost River	Uncommon
Rainbow Trout, *Salmo gairdneri*	Big Lost River	Common
Brook Trout, *Salvelinus fontinalis*	Big Lost River	Uncommon
Mountain Whitefish, *Prosopium williamsoni*	Big Lost River	Common
CYPRINIFORMES		
Cyprinidae		
Speckled Dace, *Rhinichthys osculus*	Big Lost River	Uncommon
PERCIFORMES		
Cottidae		
Shorthead Sculpin, *Cottus confusus*	Big Lost River	Common

a. See Table F-1 for definitions of abundance terms.

Reptiles and Amphibians Recorded On The INEL

Taxa	Distribution and Habitat	Abundance
ANURA		
Pelobatidae		
Great Basin Spadefoot Toad, *Spea intermontana*[b]	Big Lost River and sinks	Common
Hylidae		
Boreal Chorus Frog, *Pseudacris triseriata*		Uncommon
SQUAMATA		
Iguanidae		
Leopard Lizard, *Gambelia wislizenii*[a]	NE INEL; sandy areas	Local
Short-horned Lizard, *Phrynosoma douglassi*	Sitewide; shrub-steppe	Abundant
Sagebrush Lizard, *Sceloporus graciosus*	Sitewide; shrub-steppe	Abundant
Scincidae		
Western Skink, *Eumeces skiltonianus*	South INEL	Rare
Boidae		
Rubber Boa, *Charina bottae*	Unknown	Accidental
Colubridae		
Desert Striped Whipsnake, *Masticophis taeniatus*	NE INEL; shrub-steppe	Uncommon
Gopher Snake, *Pituophis melanoleucus*	Sitewide; shrub-steppe	Common
Western Garter Snake, *Thamnophis elegans*	Sitewide; all habitats	Uncommon
Western Racer, *Coluber constrictor*	Unknown	Accidental
Viperidae		
Western Rattlesnake, *Crotalus viridis*	Sitewide; shrub-steppe	Common

a. Collins et al. (1978) list this as *Scaphiophus intermontanus*.
b. Collins et al. (1978) place this in the genus *Crotaphytus*.
See Avifauna listing for definition of abundance terms.

Mammals Recorded on the INEL

Taxa	Distribution and Habitat	Abundance[a]
INSECTIVORA		
Soricidae		
Merriam Shrew, *Sorex merriami*	Sitewide; sagebrush-steppe	Uncommon
CHIROPTERA		
Vespertilionidae		
Little Brown Myotis, *Myotis lucifugus*	Sitewide; roosts in buildings	Common
Small-footed Myotis, *M. leibii*	Sitewide; rocky outcrops and lava	Abundant
Long-eared Myotis, *M. evotis*	SE INEL; junipers	Common
Big-brown Bat, *Eptesicus fuscus*	Sitewide; roosts in buildings and caves	Common
Hoary Bat, *Lasiurus cinereus*	Patchy; riparian and junipers	Uncommon
Townsend's Big-eared Bat, *Plecotus townsendii*	Sitewide; caves and lava tubes	Abundant
LAGOMORPHA		
Leporidae		
White-tailed Jackrabbit, *Lepus townsendii*	Sitewide; sagebrush-steppe	Occasional
Black-tailed Jackrabbit, *L. californicus*	Sitewide; sagebrush-steppe	Abundant-occasional (cyclic)
Nuttall's Cottontail, *Sylvilagus nuttallii*	Sitewide; sagebrush-steppe facilities	Common
Pygmy Rabbit, *S. idahoensis*	Patchy; sagebrush-steppe and rocky outcrops	Common
RODENTIA		
Sciuridae		
Least Chipmunk, *Tamias minimus*	Sitewide; sagebrush-steppe	Abundant

INEL Mammals (Continued)

Taxa	Distribution and Habitat	Abundance[a]
RODENTIA Sciuridae (Continued)		
Yellow-bellied Marmot, *Marmota flaviventris*	Sitewide; rocky outcrops	Uncommon
Townsend's Ground Squirrel, *Spermophilus townsendii*	Sitewide; sagebrush-steppe facilities	Common
Geomyidae		
Northern Pocket Gopher, *Thomomys talpoides*	Patchy; sagebrush-steppe	Occasional
Heteromyidae		
Great Basin Pocket Mouse, *Perognathus parvus*	Sitewide; sagebrush-steppe	Uncommon
Ord's Kangaroo Rat, *Dipodomys ordii*	Sitewide; sagebrush-steppe and grassland	Common
Castoridae		
Beaver, *Castor canadensis*	Patchy; Big Lost River	Local
Cricetidae		
Western Harvest Mouse, *Reithrodontomys megalotis*	Sitewide; sagebrush-steppe and grassland	Common
Deer Mouse, *Peromyscus maniculatus*	Sitewide; all habitats	Abundant
Northern Grasshopper Mouse, *Onychomys leucogaster*	Sitewide; sagebrush-steppe	Occasional
Bushy-tailed Woodrat, *Neotoma cinerea*	Sitewide; rocky outcrops	Common
Montane Vole, *Microtus montanus*	Sitewide; grassland and facilities	Abundant-occasional
Sagebrush Vole, *Lagurus curtatus*	Patchy; sagebrush-steppe	Uncommon
Muskrat, *Ondatra zibethicus*	Patchy; aquatic	Rare (cyclic)

INEL Mammals (Continued)

Taxa	Distribution and Habitat	Abundance[a]
Muridae		
Norway Rat, *Rattus norvegicus*	NW and NE INEL; near agricultural areas	Rare
House Mouse, *Mus musculus*	Patchy; facilities	Rare
Erethizontidae		
Porcupine, *Erethizon dorsatum*	Patchy; riparian and juniper	Uncommon
CARNIVORA		
Canidae		
Coyote, *Canis latrans*	Sitewide; all habitats	Common
Mustelidae		
Long-tailed Weasel, *Mustela frenata*	Sitewide; sagebrush-steppe	Common
Badger, *Taxidea taxus*	Sitewide; all habitats	Uncommon
Western Spotted Skunk, *Spilogale gracilis*	Sitewide; rocky outcrops	Rare
Felidae		
Mountain Lion, *Felis concolor*	Sitewide; transient	Vagrant
Bobcat, *F. rufus*	Sitewide; sagebrush-	Uncommon
ARTIODACTYLA		
Cervidae		
Elk, *Cervus elaphus*	Sitewide; transient	Vagrant
Mule Deer, *Odocoileus hemionus*	Sitewide; sagebrush-steppe, grassland	Uncommon
Moose, *Alces alces*	Sitewide; transient	Vagrant
Antilocapridae		
Pronghorn, *Antilocapra americana*	Sitewide; sagebrush-steppe, facilities	Abundant

INEL Mammals (Continued)

Taxa	Distribution and Habitat	Abundance[a]
ARTIODACTYLA Bovidae (Continued)		
Mountain Sheep, *Ovis canadensis*	North INEL; transient	Vagrant

a. See Avifauna listing for definition of abundance terms.

Appendix E

Ecological Grouping Methods for SLERA

Appendix E

Ecological Grouping Methods for SLERA

N. L. Hampton and R. C. Morris

E-1. INTRODUCTION

A "functional grouping" methodology has been developed and applied to screening-level risk assessment (SLERA) at the Idaho National Engineering Laboratory (INEL). The approach is based on grouping species having similarities that are defined in terms of SLERA goals to aid in analyzing the effects of stressors on INEL ecosystem components.

The primary purpose for functional grouping is to apply existing data from one or more species within the group to assess the risk to the group as a whole. Identification of every species inhabiting all sites of contamination within individual WAGs is difficult. Functional groups are used to perform a limited evaluation of exposures for all potential receptors and provide a mechanism for focusing subsequent baseline ERAs on receptors that best characterize potential contaminant effects.

A second purpose for applying the functional group concept is to lend a consistent, systematic approach to defining and selecting SLERA assessment and measurement endpoints and communicating SLERA results. The use of functional grouping allows a repeatable process for identifying and screening numerous contaminants and potential receptors associated with INEL waste area groups (WAGs) and produces comparable results for multiple assessments..

Some basic considerations associated with the use of functional groups that must be addressed in the SLERA process include:

- Groups are assumed to have biological functions similar enough to allow all members to be represented by surrogate species within that functional group.
- Modification of exposure as a result of behavioral response to contaminant effects is not addressed (Suter, 1993).
- Issues such as seasonal variation in diet and habitat use must be specifically addressed in the SLERA analysis.
- Subjectivity exists in the grouping process and criteria for grouping must be well defined.

This appendix presents the methodology for deriving functional groups based on the needs of INEL SLERA and for incorporating those groups into processes performed in the SLERA problem formulation, screening analysis, and screening-level evaluation phases.

E-2. SLERA FUNCTIONAL GROUP STRUCTURE

The criteria for grouping individuals for contaminant exposure must result in a structural organization that allows use of surrogate measurements or groups of individual measurements to represent a functional group as a whole. To address potential exposure and effects for INEL site-related contamination, species are combined into functional groups that demonstrate:

- Shared potential for contaminant exposure
- Similar biological response to that exposure.

Functional grouping can be applied for all biotic ecosystem components, including vegetation, wildlife, insects, and microorganisms. Grouping criteria may differ for assessments addressing risk in terms of habitat change or impacts. For example, physiological responses may not be as important as habitat usage if effects to species are measured in terms of habitat loss or degradation. Although the development of functional groups would be the same, criteria for their structure would be refined to emphasize habitat assessment goals.

E-2.1 Wildlife

Vertebrates. The primary division for developing wildlife functional groups for contaminant effects assessment is by taxon or Class. Class is a level of taxonomic organization within the hierarchical system by which organisms are classified (in zoology Kingdom, Phylum, Class, Order, Family, Genus, and Species). The grouping criteria for the SLERA uses this fundamental separation to establish biological similarity. The highest level at which organism physiological and biochemical responses are assumed to be similar is within taxonomic Class. The six Classes (Taxa) represented by INEL wildlife species are listed on Table E-1.

A second level of division defines group relationships based on the potential for contaminant exposure. Shared dietary and physical exposure pathways are established by developing a "functional group index" for each species. The index incorporates three parameters (elements) to characterize potential exposure through dietary and physical routes based on the habits and habitat of the individual species:

- Trophic level
- Feeding habitat
- Non-feeding habitat.

The criteria for assigning trophic, feeding and non-feeding codes for INEL vertebrate species are summarized on Table E-2. A secondary trophic level assignment may be added to address seasonal food/prey usage for some species.

Table E-1. Classes represented by INEL wildlife species.

Class (Taxon)
Birds (Aves)
Mammals (Mammalia)
Reptiles (Reptilia)
Amphibians (Amphibia)
Fishes (Osteichthyes)
Insects (Insecta)

These codes, in combination, represent the functional group index for an individual species. Table E-3 shows the functional group indicies for several INEL species.

Trophic level is a "functional classification of taxa within a community that is based on feeding relationships (e.g., aquatic and terrestrial green plants comprise the first trophic level and herbivores comprise the second)" (EPA, 1992). Five trophic categories are used to define primary contaminant exposure through dietary routes, including contaminant intake from live prey, vegetation, soil, sediments and water: 1) Herbivores, 2) Insectivores, 3) Carnivores, 4) Omnivores, and 5) Detritivores.

Primary feeding and non-feeding habitats are grouped into four representative categories: 1) air, 2) terrestrial, 3) terrestrial/aquatic interface, and 4) aquatic categories. These categories incorporate vertical habitat stratification (Short, 1982) to establish physical proximity to contaminated media, including exposure incurred as a result of feeding and non-feeding (breeding and loafing) behaviors. While feeding habitat codes incorporate additional detail for dietary uptake, the non-feeding code accounts for physical transfer across animal surfaces from various media, including inhalation of air- and vapor-borne contamination. For terrestrial analyses, effects of dermal contact are primarily of importance for invertebrates and soil dwelling organisms (Peterle, 1991).

Functional grouping criteria for all INEL species are contained in the INEL species database (Attachment 1) and can be used to sort each species into appropriate functional groups. Grouping criteria several INEL species are shown on Table E-3. A four way, ascending order sort can performed to combine species by 1) trophic category, 2) feeding-habitat index 3) non-feeding habitat index and 4) Class. Functional groups developed for the INEL are presented on Table E-4.

For ease of discussion, individual functional groups have been assigned a unique code consisting of one or two letters to indicate taxon (A = Amphibia, AV = Aves, M = Mammalia, R = Reptilia), and a three digit number derived from the combination of trophic category and the feeding habitat index. For example, AV122 represents the group of bird species that are herbivorous (trophic category = 1) whose feeding habitat is terrestrial surface and/or understory (feeding habitat index = 2.2).

Table E-2. Criteria for defining INEL wildlife functional groups (Short, 1982).

	DEFINITION	CODE	COMMENTS
TROPHIC CATEGORY	"Primary" feeding habits (based on >50% of prey/food consumed).	1 HERBIVORE 2 INSECTIVORE 3 CARNIVORE 4 OMNIVORE 5 DETRITIVORE	Some re-definition is required for species having prey/food sources that differ according to season.
FEEDING HABITAT	"Primary" feeding habitat (based on location of >50% food or prey items).	1.0 AIR 2.0 TERRESTRIAL 2.1 Vegetation canopy 2.2 Surface/understory 2.3 Subsurface 2.4 Vertical habitat 3.0 TERRESTRIAL/ AQUATIC INTERFACE 3.1 Vegetation canopy 3.2 Surface/understory 3.3 Subsurface 3.4 Vertical habitat 4.0 AQUATIC 4.1 Surface water 4.2 Water column 4.3 Bottom	Used for all species, regardless of abundance or seasonal status. Vertical habitat includes manmade structures (e.g. power poles, buildings), cliff faces, etc.
NON-FEEDING HABITAT	For species breeding at the INEL (residents and summer breeders), "primary" breeding habitat. For seasonal visitors, transients, etc. "primary" loafing/resting habitat.	1.0 AIR 2.0 TERRESTRIAL 2.1 Vegetation canopy 2.2 Surface/understory 2.3 Subsurface 2.4 Vertical habitat 3.0 TERRESTRIAL/AQUATIC INTERFACE 3.1 Vegetation canopy 3.2 Surface/understory 3.3 Subsurface 3.4 Vertical habitat 4.0 AQUATIC 4.1 Surface water 4.2 Water column 4.3 Bottom	Vertical habitat includes manmade structures (e.g. power poles, buildings), cliff faces, etc.

Table E-3. Functional group indicies for example INEL wildlife species.

Common name	Functional grouping criteria		
	Trophic* Category	Feeding** Habitat Index	NonFeeding** Habitat Index
Great Basin Spadefoot Toad	2	3.2	3.3
Western Meadowlark	2	2.2	2.1
Brewer's Sparrow	2	2.2	2.1
Peregrine Falcon	3	1.0	2.4
Bobcat	3	2.2	2.3
Least Chipmunk	4	2.2	2.3
Coyote	4	2.2	2.3

* 1 = Herbivore, 2 = Insectivore, 3 = Carnivore, 4 = Omnivore, 5 = Detritivore

**
- 1.0 AIR
- 2.0 TERRESTRIAL
  - 2.1 Vegetation canopy
  - 2.2 Surface/understory
  - 2.3 Subsurface
  - 2.4 Vertical habitat
- 3.0 TERRESTRIAL/AQUATIC INTERFACE
  - 3.1 Vegetation canopy
  - 3.2 Surface/understory
  - 3.3 Subsurface
  - 3.4 Vertical habitat
- 4.0 AQUATIC
  - 4.1 Surface water
  - 4.2 Water column
  - 4.3 Bottom

Table E-4. INEL wildlife functional groups.

CLASS	FG	TAXONOMIC NAME	COMMON NAME	T	F-H	NF-H	DIST/ STATUS	ABUNDANCE/ SEASON
AMPHIBIA	A232	Spea intermontana*	Great Basin Spadefoot Toad	2	3.2	3.3	w	R2
AMPHIBIA		Pseudacris triseriata	Boreal Chorus Frog	2	3.2	3.3	w	R4
AVES	AV121	Carduelis pinus	Pine Siskin	1	2.1	2.1	f,d	S5, M3
AVES		Carduelis tristis	American Goldfinch	1	2.1	2.1	d,ss	M5
AVES		Coccothraustes vespertinus	Evening Grosbeak	1	2.1	2.1	d	S5, M3
AVES		Bombycilla cedrorum	Cedar Waxwing	1	2.1	2.1	f,d	S5,M3,W5
AVES	AV122	Passer domesticus	House Sparrow	1	2.2	2	f,d	B2, M1, W3
AVES		Selasphorus rufus	Rufous Hummingbird	1	2.2	2.1	d	S3, M3
AVES		Archilochus alexandri	Black-chinned Hummingbird	1	2.2	2.1	ag,d	I7
AVES		Stellula calliope	Calliope Hummingbird	1	2.2	2.1	ag,d	I6
AVES		Selasphorus platycercus	Broad-tailed Hummingbird	1	2.2	2.1	ag,d	I7
AVES		Zenaida macroura	Mourning Dove	1	2.2	2.1	sw	B1, M3, W5
AVES		Chondestes grammacus	Lark Sparrow	1	2.2	2.1	sw	S3, M5
AVES		Plectrophenax nivalis	Snow Bunting	1	2.2	2.1	g,ss	W5
AVES		Leucosticte arctoa	Rosy Finch	1	2.2	2.1	ss	M5, W5
AVES		Carpodacus mexicanus	House Finch	1	2.2	2.1	f,d	S3, M3
AVES		Perdix perdix	Gray Partridge	1	2.2	2.2	g, ss, f	R3
AVES		Alectoris chukar	Chukar	1	2.2	2.2	g, ss	R3
AVES		Dendragapus obscurus	Blue Grouse	1	2.2	2.2	f	S6
AVES		Tympanuchus phasianellus	Sharp-tailed Grouse	1	2.2	2.2		I6
AVES		Centrocercus urophasianus	Sage Grouse	1	2.2	2.2	ss, g, f	R2
AVES		Eremophila alpestris	Horned Lark	1	2.2	2.2	g,ss	R2
AVES		Junco hyemalis	Dark-eyed Junco	1	2.2	2.2	sw	M3
AVES		Columba livia	Rock Dove	1	2.2	2.4	sw	R2
AVES	AV132	Porzana carolina	Sora	1	3.2	3.2	w, f	B5, M5
AVES	AV142	Chen caerulescens	Snow Goose	1	4.2	4.1	w	M5
AVES		Anas crecca	Green-winged Teal	1	4.2	4.1	w	S5, M5
AVES		Aythya americana	Redhead	1	4.2	4.1	w	S5, M5, W5
AVES		Aythya collaris	Ring-necked Duck	1	4.2	4.1	w	S5, M5
AVES	AV143	Cygnus columbianus	Tundra Swan	1	4.3	4.1	w	M5
AVES		Cygnus buccinator	Trumpeter Swan	1	4.3	4.1	w	I6
AVES		Chen rossii	Ross' Goose	1	4.3	4.1	w	I6
AVES		Branta canadensis	Canada Goose	1	4.3	4.1	w	S3, M3
AVES		Anser albifrons	White-fronted Goose	1	4.3	4.1	w	I6
AVES		Anas platyrhynchos	Mallard	1	4.3	4.1	w	B2, M2, W3
AVES		Anas acuta	Northern Pintail	1	4.3	4.1	w	S3, M3

Table E-4. (continued).

CLASS	FG	TAXONOMIC NAME	COMMON NAME	T	F-H	NF-H	DIST/ STATUS	ABUNDANCE/ SEASON
AVES		Anas discors	Blue-winged Teal	1	4.3	4.1	w	B2, M3
AVES		Anas cyanoptera	Cinnamon Teal	1	4.3	4.1	w	S3, M3
AVES		Anas clypeata	Northern Shoveler	1	4.3	4.1	w	B3, M3
AVES		Anas strepera	Gadwall	1	4.3	4.1	w	S3, M3
AVES		Anas americana	American Wigeon	1	4.3	4.1	w	S3, M3
AVES		Aythya valisineria	Canvasback	1	4.3	4.1	w	B5, M5
AVES	AV210	Childonias niger	Black Tern	2	1	1	w	S5, M5
AVES		Contopus borealis	Olive-sided Flycatcher	2	1	2.1	d	S5, M5
AVES		Contopus sordidulus	Western Wood-Peewee	2	1	2.1	d	I6
AVES		Empidonax difficilis	Western Flycatcher	2	1	2.1	d	S5
AVES		Myiarchus cinerascens	Ash-throated Flycatcher	2	1	2.1	d	S5
AVES		Tyrannus verticalis	Western Kingbird	2	1	2.1	f,d,j	B3, M3
AVES		Empidonax traillii	Willow Flycatcher	2	1	2.1	d	I7
AVES		Empidonax oberholseri	Dusky Flycatcher	2	1	2.1	d	I7
AVES		Empidonax wrightii	Gray Flycatcher	2	1	2.1	g,ss,j	I6
AVES		Tyrannus tyrannus	Eastern Kingbird	2	1	2.1	f,d,j	B3, M3
AVES		Tachycineta bicolor	Tree Swallow	2	1	2.1	d,j	B3, M3
AVES		Tachycineta thalassina	Violet-green Swallow	2	1	2.1	d,j	B4, M4
AVES		Myadestes townsendi	Townsend's Solitaire	2	1	2.1	d	S5, M5
AVES		Chordeiles minor	Common Nighthawk	2	1	2.2	sw	B2, M3
AVES		Phalaenoptilus nuttalii	Common Poor-will	2	1	2.2	j	I6
AVES		Aeronautes saxatalis	White-throated Swift	2	1	2.4	d	S5
AVES		Sayornis saya	Say's Phoebe	2	1	2.4	ss,d,f,j	B3, M3
AVES		Stelgidopteryx serripennis	Northern Rough-winged swallow	2	1	2.4	d,j	B3, M3
AVES		Riparia riparia	Bank Swallow	2	1	2.4	d,j	B5, M3
AVES		Hirundo pyrrhonota	Cliff Swallow	2	1	2.4	d,j	B2, M2
AVES		Hirundo rustica	Barn Swallow	2	1	2.4	d,j	B2, M3
AVES	AV221	Parus atricapillus	Black-capped Chickadee	2	2.1	2.1	d,j	I6
AVES		Parus gambeli	Mountain Chickadee	2	2.1	2.1	d,j	I7
AVES		Sitta canadensis	Red-breasted nuthatch	2	2.1	2.1		
AVES		Regulus calendula	Ruby-crowned Kinglet	2	2.1	2.1	d	M3, W6
AVES		Sialia mexicana	Western Bluebird	2	2.1	2.1	ss	S5, M5
AVES		Hylocichla ustulata	Swainson's Thrush	2	2.1	2.1	U	I6
AVES		Polioptila caerulea	Blue-gray Gnatcatcher	2	2.1	2.1	U	B6
AVES		Bombycilla garrulus	Bohemian Waxwing	2	2.1	2.1	f,d	S3, M2, W3
AVES		Vireo gilvus	Warbling Vireo	2	2.1	2.1	d	S5, M5
AVES		Dendroica petechia	Yellow Warbler	2	2.1	2.1	d	B5, M3
AVES		Dendroica coronata	Yellow-rumped Warbler	2	2.1	2.1	d	S3, M3
AVES		Dendroica townsendi	Townsend's Warbler	2	2.1	2.1	d	M5
AVES		Setophaga ruticilla	American Redstart	2	2.1	2.1	f	M6
AVES		Geothlypis trichas	Common Yellowthroat	2	2.1	2.1	d	S5
AVES		Wilsonia pusilla	Wilson's Warbler	2	2.1	2.1	d	S5, M5

Table E-4. (continued).

CLASS	FG	TAXONOMIC NAME	COMMON NAME	T	F-H	NF-H	DIST/ STATUS	ABUNDANCE/ SEASON
AVES		Icteria virens	Yellow-breasted Chat	2	2.1	2.1	d	S5
AVES		Piranga ludoviciana	Western Tanager	2	2.1	2.1	d	S3, M3
AVES		Pheucticus melanocephalus	Black-headed Grosbeak	2	2.1	2.1	sw	S5, M5
AVES		Icterus galbula	Northern Oriole	2	2.1	2.1	d	S3, M3
AVES		Picoides pubescens	Downy Woodpecker	2	2.1	2.1	d	B5, M5
AVES		Colaptes auratus	Northern Flicker	2	2.1	2.1	d	B3, M3
AVES		Asyndesmus lewis	Lewis' Woodpecker	2	2.1	2.1	U	I6
AVES		Sphyrapicus nuchalis	Red-naped Sapsucker	2	2.1	2.1	U	I6
AVES		Picoides villosus	Hairy Woodpecker	2	2.1	2.1	ag,d	I7
AVES		Mniotilta varia	Black-and-White Warbler	2	2.1	2.2	d	I6
AVES		Bermivora celata	Orange-crowned Warbler	2	2.1	2.2	U	I6
AVES		Oporornis tolmiei	MacGillivray's Warbler	2	2.1	2.2	U	I6
AVES	AV222	Larus pipixcan	Franklin's Gull	2	2.2	1	w, ss	S3, M3
AVES		Larus californicus	California Gull	2	2.2	1	w, ss	S5, M3
AVES		Sturnus vulgaris	European Starling	2	2.2	2	sw	R3
AVES		Troglodytes aedon	House Wren	2	2.2	2.1	d	R3
AVES		Sialia currucoides	Mountain Bluebird	2	2.2	2.1	ss	S3, M3
AVES		Turdus migratorius	American Robin	2	2.2	2.1	sw	B2, M2
AVES		Ixoreus naevius	Varied Thrush	2	2.2	2.1	ss	W6
AVES		Mimus polyglottos	Northern Mockingbird	2	2.2	2.1	j	S6
AVES		Oreoscoptes montanus	Sage Thrasher	2	2.2	2.1	ss	B2, M2
AVES		Passerina amoena	Lazuli Bunting	2	2.2	2.1	d	S5, M5
AVES		Spizella passerina	Chipping Sparrow	2	2.2	2.1	f,d,ss	M5
AVES		Spizella breweri	Brewer's Sparrow	2	2.2	2.1	ss	B2, M2
AVES		Amphispiza bilineata	Black-throated Sparrow	2	2.2	2.1	ss	S5, M5
AVES		Amphispiza belli	Sage Sparrow	2	2.2	2.1	ss	B2, M2
AVES		Passerculus sandwichensis	Savannah Sparrow	2	2.2	2.1	d,g	S5, M3
AVES		Zonotrichia leucophrys	White-crowned Sparrow	2	2.2	2.1	ss	M4
AVES		Melospiza lincolnii	Lincoln's Sparrow	2	2.2	2.1		I6
AVES		Calcrius lapponicus	Lapland Longspur	2	2.2	2.1	g,ss	I7
AVES		Sturnella neglecta	Western Meadowlark	2	2.2	2.1	g,ss	B2, M2, W3
AVES		Euphagus cyanocephalus	Brewer's Blackbird	2	2.2	2.1	sw	B2, M2, W5
AVES		Molothrus ater	Brown-headed Cowbird	2	2.2	2.1	ss	B3, M3
AVES		Otus flammeolus	Flammulated Owl	2	2.2	2.1		I6
AVES		Charadrius vociferus	Killdeer	2	2.2	2.2	sw	B2, M2
AVES		Catharus guttatus	Hermit Thrush	2	2.2	2.2		I6
AVES		Anthus spinoletta	Water Pipit	2	2.2	2.2	ss	M5
AVES		Pipilo chlorurus	Green-tailed Towhee	2	2.2	2.2	ss	S3, M3
AVES		Pipilo erythrophthalmus	Rufous-sided Towhee	2	2.2	2.2	sw	S3, M3
AVES		Pooecetes gramineus	Vesper Sparrow	2	2.2	2.2	g, ss	B3, M3
AVES		Calamospiza melanocorys	Lark Bunting	2	2.2	2.2	ss	S5, M5
AVES		Melospiza melodia	Song Sparrow	2	2.2	2.2	d	S5, M3
AVES		Zonotrichia querula	Harris' Sparrow	2	2.2	2.2		I6
AVES		Salpinctes obsoletus	Rock Wren	2	2.2	2.3	ss	B3, M3

Table E-4. (continued).

CLASS	FG	TAXONOMIC NAME	COMMON NAME	T	F-H	NF-H	DIST/ STATUS	ABUNDANCE/ SEASON
AVES		Catherpes mexicanus	Canyon Wren	2	2.2	2.3	ss	S5, M5
AVES		Athene cunicularia	Burrowing Owl	2	2.2	2.3	ss, g	B3, M3, W6
AVES	AV232	Icterus spuris	Orchard Oriole	2	3	3	U	I6
AVES		Charadrius semipalmatus	Semipalmated Plover	2	3.2	2.2	w	I6
AVES		Eupoda montana	Mountain Plover	2	3.2	2.2	U	I6
AVES		Agelaius phoeniceus	Red-winged Blackbird	2	3.2	3.1	w, ss	B3, M3
AVES		Xanthocephalus xanthocephalus	Yellow-headed Blackbird	2	3.2	3.1	w,d	B4, M3
AVES		Actitis macularia	Spotted Sandpiper	2	3.2	3.2	w	S3, M3
AVES		Calidris minutilla	Least Sandpiper	2	3.2	3.2	w	S5, M5
AVES		Ereunetes mauri	Western Sandpiper	2	3.2	3.2	w	I6
AVES		Erolia bairdii	Baird's Sandpiper	2	3.2	3.2	w	I6
AVES		Rallus limicola	Virginia Rail	2	3.2	3.2	w	I7
AVES		Cistothorus palustris	Marsh Wren	2	3.2	3.2	w	I7
AVES	AV233	Himantopus mexicanus	Black-necked stilt	2	3.3	3.2	w	I6
AVES		Tringa solitaria	Solitary Sandpiper	2	3.3	3.2	w	S5, M3
AVES		Catoptrophorus semipalmatus	Willet	2	3.3	3.2	w, ss	S3, M3
AVES		Numenius americanus	Long-billed Curlew	2	3.3	3.2	w, ss	S3, M3
AVES		Limosa fedoa	Marbled Godwit	2	3.3	3.2	w	S3, M5
AVES		Limnodromus scolopaceus	Long-billed Dowitcher	2	3.3	3.2	w	M5
AVES		Gallinago gallinago	Common Snipe	2	3.3	3.2	w	S5, M5
AVES		Egretha thula	Snowy Egret	2	3.3	3.2	w	I6
AVES		Bubulcus ibis	Cattle Egret	2	3.3	3.2	w	I6
AVES		Plegadis chihi	White-faced Ibis	2	3.3	3.2	w	S5, M5
AVES	AV241	Aix sponsa	Wood Duck	2	4.1	3.1	w	S6, M5
AVES		Phalaropus lobatus	Red-necked Phalarope	2	4.1	3.2	w	M5
AVES		Phalaropus tricolor	Wilson's Phalarope	2	4.1	4.1	w	S3, M3
AVES	AV242	Aythya affinis	Lesser Scaup	2	4.2	3.2	w	S5, M3, W3
AVES		Bucephala clangula	Common Goldeneye	2	4.2	3.2	w	S5, M3, W3
AVES		Bucephala islandica	Barrow's Goldeneye	2	4.2	3.2	w	S6, M5
AVES		Oxyura jamaicensis	Ruddy Duck	2	4.2	3.2	w	B5, M3
AVES		Tringa flavipes	Lesser Yellowlegs	2	4.2	3.2	w	S5, M5
AVES		Larus philadelphia	Bonaparte's Gull	2	4.2	3.2	w	M5
AVES		Bucephala albeola	Bufflehead	2	4.2	4.1	w	S5, M3
AVES		Melanitta perspicillata	Surf Scoter	2	4.2	4.1	w	I6
AVES		Podilymbus podiceps	Pied-billed Grebe	2	4.2	4.1	w	S5, M5
AVES		Podiceps auritus	Horned Grebe	2	4.2	4.1	w	M5
AVES		Podiceps nigricollis	Eared Grebe	2	4.2	4.1	w	B5, M3, W3

Table E-4. (continued).

CLASS	FG	TAXONOMIC NAME	COMMON NAME	T	F-H	NF-H	DIST/ STATUS	ABUNDANCE/ SEASON
AVES	AV310	Accipiter striatus	Sharp-shinned Hawk	3	1	2.1	sw	S5, M5, W5
AVES		Accipiter cooperii	Cooper's Hawk	3	1	2.1	sw	S3, M5, W5
AVES		Accipiter gentilis	Northern Goshawk	3	1	2.1	sw	S5, M5, W5
AVES		Falco columbarius	Merlin	3	1	2.1	sw	R5
AVES		Falco peregrinus	Peregrine Falcon	3	1	2.4	sw	S5, M5, W5
AVES		Falco mexicanus	Prairie Falcon	3	1	2.4	sw	R3
AVES		Falco rusticolus	Gyrfalcon	3	1	3	sw	M6
AVES	AV322	Nyctea scandiaca	Snowy Owl	3	2.2	2	sw	W5
AVES		Haliaeetus leucocephalus	Bald Eagle	3	2.2	2.1	sw	M5, W3
AVES		Falco sparverius	American Kestrel	2	2.2	2.1	sw	B2, M2, W3
AVES		Circus cyaneus	Northern Harrier	3	2.2	2.1	sw	R2
AVES		Buteo swainsoni	Swainson's Hawk	3	2.2	2.1	sw	B3, M3, W5
AVES		Buteo jamaicensis	Red-tailed Hawk	3	2.2	2.1	sw	B3, M3, W5
AVES		Buteo regalis	Ferruginous Hawk	3	2.2	2.1	sw	B3, M3, W5
AVES		Lanius excubitor	Northern Shrike	3	2.2	2.1	sw	M3, W5
AVES		Lanius ludovicianus	Loggerhead Shrike	3	2.2	2.1	ss	B3
AVES		Bubo virginianus	Great Horned Owl	3	2.2	2.1	sw	R3
AVES		Asio otus	Long-eared Owl	3	2.2	2.1	d	B4, M4
AVES		Asio flammeus	Short-eared Owl	3	2.2	2.1	ss, g	B3, M3
AVES		Aegolius acadicus	Northern Saw-whet Owl	3	2.2	2.1	sw	S6, M6, W6
AVES		Aegolius funerlus	Boreal Owl	3	2.2	2.1		I6
AVES		Otus kennicottii	Western Screech-Owl	3	2.2	2.1	d	I6
AVES		Glaucidium gnoma	Northern Pygmy Owl	3	2.2	2.1	d	I7
AVES		Aquila chrysaetos	Golden Eagle	3	2.2	2.2	sw	B3, M4, W2
AVES		Cathartes aura	Turkey Vulture	3	2.2	2.4	sw	S3, M3, W6
AVES		Buteo lagopus	Rough-legged Hawk	3	2.2	2.4	sw	S6, M2, W2
AVES	AV333	Tringa melanoleuca	Greater Yellowlegs	3	3.3	3.2	w	M5
AVES		Nycticorax nycticorax	Black-crowned Night Heron	3	3.3	3.2	w	I6
AVES		Butorides striatus	Green-backed Heron	3	3.3	3.2	w	S6, M6
AVES	AV342	Ceryle alcyon	Belted Kingfisher	3	4.2	3.1	w	S3, M3
AVES		Pandion haliaetus	Osprey	3	4.2	3.1	w	M5
AVES		Sterna caspia	Caspian Tern	3	4.2	3.2	w	M5
AVES		Sterna forsteri	Forster's Tern	3	4.2	3.2	w	S5
AVES		Botaurus lentiginosus	American Bittern	3	4.2	3.2	w	S5, M5
AVES		Ardea herodias	Great Blue Heron	3	4.2	3.2	w	S5, M5
AVES		Rissa tridactyla	Black-legged Kittiwake	3	4.2	3.4	w	W6
AVES		Mergus merganser	Common Merganser	3	4.2	4.1	w	S3, M5
AVES		Mergus serrator	Red-breasted Merganser	3	4.2	4.1	w	I6
AVES		Lophodytes cucullatus	Hooded Merganser	3	4.2	4.1	w	I6

Table E-4. (continued).

CLASS	FG	TAXONOMIC NAME	COMMON NAME	T	F-H	NF-H	DIST/ STATUS	ABUNDANCE/ SEASON
AVES		Gavia immer	Common Loon	3	4.2	4.1	w	M5
AVES		Pelecanus erythrorhynchos	American White Pelican	3	4.2	4.1	w	M5
AVES		Phalacrocorax auritus	Double-crested Cormorant	3	4.2	4.1	w	I6
AVES		Aechmophorus occidentalis	Western Grebe	3	4.2	4.1	w	S5,M5
AVES	AV422	Cyanocitta cristata	Blue Jay	4	2.2	2.1	d,f	I6
AVES		Aphelocoma coerulescens	Scrub Jay	4	2.2	2.1		
AVES		Nucifraga columbiana	Clark's Nutcracker	4	2.2	2.1	j	S4, M4, W5
AVES		Pica pica	Black-billed Magpie	4	2.2	2.1	sw	R2
AVES		Corvus brachyrhynchos	American Crow	4	2.2	2.1	sw	R3
AVES		Quiscalus quiscula	Common Grackle	4	2.2	2.1		I6
AVES		Phasianus colchicus	Ring-necked Pheasant	4	2.2	2.2	g, ss	R3
AVES		Corvus corax	Common Raven	4	2.2	2.4	sw	R3
AVES		Larus argentatus	Herring Gull	4	2.2	3.2	w, ss, g	S3, M3
AVES	AV432	Recurvirostra americana	American Avocet	4	3.2	3.2	w	S2, M3
AVES		Larus delawarensis	Ring-billed Gull	4	3.2	3.2	w, ss, g	S3, M3
AVES		Casmerodius albus	Great Egret	4	3.3	3.2	w	S5, M5
AVES		Grus canadensis	Sandhill Crane	4	3.3	3.2	U	I6
AVES	AV442	Fulica americana	American Coot	4	4.2	3.2	w	R3
MAMMALIA	M121	Erethizon dorsatum	Porcupine	1	2.1	2.3	r,f	I4
MAMMALIA	M122	Lepus townsendii	White-tailed Jackrabbit	1	2.2	2.2	sw,ss	R4
MAMMALIA		Lepus californicus	Black-tailed Jackrabbit	1	2.2	2.2	sw,ss	R1,R4 (cyclic)
MAMMALIA		Reithrodontomys megalotis	Western Harvest Mouse	1	2.2	2.2	sw,ss,g	R2
MAMMALIA		Cervus elaphus	Elk	1	2.2	2.2	sw	T (?)
MAMMALIA		Odocoileus hemionus	Mule Deer	1	2.2	2.2	sw,ss,g	R3
MAMMALIA		Alces alces	Moose	1	2.2	2.2	sw	T6
MAMMALIA		Antilocapra americana	Pronghorn	1	2.2	2.2	sw,ss,f	R1
MAMMALIA		Ovis canadensis	Mountain Sheep	1	2.2	2.2	No. INE	T6
MAMMALIA	M122A	Sylvilagus nuttallii	Nuttall's Cottontail	1	2.2	2.3	sw,ss,f	R2
MAMMALIA		Sylvilagus idahoensis*	Pygmy Rabbit	1	2.2	2.3	ss,ro	R2
MAMMALIA		Marmota flaviventris	Yellow-bellied Marmot	1	2.2	2.3	sw,ro	R3
MAMMALIA		Spermophilus townsendii	Townsend's Ground Squirrel	1	2.2	2.3	sw,ss,f	R2
MAMMALIA		Perognathus parvus	Great Basin Pocket Mouse	1	2.2	2.3	sw,ss	R3
MAMMALIA		Dipodomys ordii	Ord's Kangaroo Rat	1	2.2	2.3	sw,ss,g	R2
MAMMALIA		Neotoma cinerea	Bushy-tailed Woodrat	1	2.2	2.3	sw,ro	R2

Table E-4. (continued).

CLASS	FG	TAXONOMIC NAME	COMMON NAME	T	F-H	NF-H	DIST/ STATUS	ABUNDANCE/ SEASON
MAMMALIA		Microtus montanus	Montane Vole	1	2.2	2.3	sw,g,f	R1,R4 (cyclic)
MAMMALIA		Lagurus curtatus*	Sagebrush Vole	1	2.2	2.3	ss	R3
MAMMALIA	M123	Thomomys talpoides	Northern Pocket Gopher	1	2.3	2.3	ss	R4
MAMMALIA	M132	Castor canadensis	Beaver	1	3.2	3.3	w	R4,S,W
MAMMALIA		Ondatra zibethicus	Muskrat	1	3.2	3.3	w	S5,W5 (cyclic)
MAMMALIA	M210	Myotis evotis	Long-eared Myotis	2	1	2.1	SE INEL,	U2
MAMMALIA		Lasiurus cinereus	Hoary Bat	2	1	2.1	d,j	U3
MAMMALIA		Lasionycteris noctivagans	Silver-haired Bat	2	1	2.1	sw	M4
MAMMALIA	M210A	Myotis leibii	Small-footed Myotis	2	1	2.3	sw,ro	R2
MAMMALIA		Eptesicus fuscus	Big-brown Bat	2	1	2.3	sw,f,c	R3
MAMMALIA		Plecotus townsendii	Townsend's Big-eared Bat	2	1	2.3	sw,c	R2
MAMMALIA		Myotis lucifugus	Little Brown Myotis	2	1	2.4	sw,f	I2
MAMMALIA		Myotis californicus	California Myotis	2	1	2.3	sw	U2
MAMMALIA		Myotis yumanensis	Yuma Myotis	2	1		sw	I7
MAMMALIA		Myotis volans	Long-legged Myotis	2	1		sw	I7
MAMMALIA		Myotis thysanodes	Fringed Myotis	2	1		sw	I7
MAMMALIA		Pipistrellus hesperus	Western Pipistrelle	2	1	2.4	sw	I7
MAMMALIA		Antrozous pallidus	Pallid Bat	2	1		sw	I7
MAMMALIA	M222	Sorex merriami	Merriam Shrew	2	2.2	2.3	sw,ss	R4
MAMMALIA		Onychomys leucogaster	Northern Grasshopper Mouse	2	2.2	2.3	sw,ss	R4
MAMMALIA	M322	Felis concolor	Mountain Lion	3	2.2	2.2	sw	T6
MAMMALIA		Mustela frenata	Long-tailed Weasel	3	2.2	2.3	sw,ss	R2
MAMMALIA		Taxidea taxus	Badger	3	2.2	2.3	sw	R3
MAMMALIA		Felis rufus	Bobcat	3	2.2	2.3	sw,ss,j	R4
MAMMALIA		Vulpes vulpes	Red Fox	3			ag,d	I7
MAMMALIA		Mustela erminea	Short-tailed Weasel (Ermine)	3			ag,d	I7
MAMMALIA		Mephitis mephitis	Striped Skunk	3			ag,d	I7
MAMMALIA	M422	Tamias minimus	Least Chipmunk	4	2.2	2.3	sw,ss	R1
MAMMALIA		Peromyscus maniculatus	Deer Mouse	4	2.2	2.3	sw	R1
MAMMALIA		Rattus norvegicus	Norway Rat	4	2.2	2.3	NW/NE I	R5 (?)
MAMMALIA		Mus musculus	House Mouse	4	2.2	2.3	f	R5 (?)
MAMMALIA		Spilogale gracilis	Western Spotted Skunk	4	2.2	2.3	sw,ro	R5
MAMMALIA		Procyon lotor	Racoon	4	2.2		ag,d	I7

Table E-4. (continued).

CLASS	FG	TAXONOMIC NAME	COMMON NAME	T	F-H	NF-H	DIST/ STATUS	ABUNDANCE/ SEASON
MAMMALIA	M422A	Canis latrans	Coyote	4	2.2	2.3	sw	R2
OSTEICHTHYES	O242	Cottus confusus	Shorthead Sculpin	2	4.2	4.3	w	R2
OSTEICHTHYES	O243	Rhinichthys osculus	Speckled Dace	2	4.3	4.3	w	R3
OSTEICHTHYES		Prosopium williamsoni	Mountain Whitefish	2	4.3	4.3	w	R2
OSTEICHTHYES		Gila atraria	Utah Chub	2			w	I7
OSTEICHTHYES		Salmo gairdneri	Rainbow Trout	3	4.2	4.3	w	R2
OSTEICHTHYES		Salvelinus fontinalis	Brook Trout	3	4.2	4.3	w	R3
OSTEICHTHYES		Salvelinus malma	Dolly Varden	3			w	I7
OSTEICHTHYES		Salmo clarkii	Cutthroat Trout	3			w	I7
OSTEICHTHYES		Oncorhynchus nerka	Kokanee Salmon	4	4.2	4.3	w	R3
REPTILIA	R222	Gambelia wislizenii*	Leopard Lizard	2	2.2	2.3	NE INEL	R4
REPTILIA		Phrynosoma douglasii	Short-horned Lizard	2	2.2	2.3	sw,ss	R1
REPTILIA		Sceloporus graciosus	Sagebrush Lizard	2	2.2	2.3	sw,ss	R1
REPTILIA		Eumeces skiltonianus	Western Skink	2	2.2	2.3	South IN	R5
REPTILIA	R322	Charina bottae	Rubber Boa	3	2.2	2.3	U	I6
REPTILIA		Masticophis taeniatus	Desert Striped Whipsnake	3	2.2	2.3	NE INEL	R3
REPTILIA		Pituophis melanoleucus	Gopher Snake	3	2.2	2.3	sw,ss	R2
REPTILIA		Thamnophis elegans	Western Garter Snake	3	2.2	2.3	sw	R3
REPTILIA		Coluber constrictor	Western Racer	3	2.2	2.3	sw	I5
REPTILIA		Crotalus viridis	Western Rattlesnake	3	2.2	2.3	sw,ss	R2
REPTILIA		Diadophis punctatus	Ringneck Snake	3			sw	I7
REPTILIA		Hypsiglena torquata	Night Snake	3			sw	I7
REPTILIA		Thamnophis sirtalis	Common Garter Snake	3			sw	I7

Note: FG = functional group
T = trophic level
F-H = feeding habitat
NF-H = non-feeding habitat
DIST = distribution

In some cases, more specific grouping criteria may be required to meet assessment goals. For example, the criteria presented on Table E-2 produces two INEL mammalian functional groups that include both surface dwelling and burrowing species (M122 and M210). For contaminant assessment, these groups should be subdivided according to the non-feeding habitat index, creating two additional groups designated M122A and M210A. Assessment specific grouping criteria must be clearly defined in the SLERA documentation.

Insects. Currently, information to support the creation or assessment of functional groups for INEL insects and microorganisms is insufficient. As an alternative, a simple trophic level/vertical habitat grouping that does not specify taxonomic associations may allow these components to be represented in the assessment. For example, "canopy dwelling phytophagous insects" or "subsurface microbial detritivores" might each represent a functional group. These groups could be individually associated with exposure pathways for contaminated media within each WAG.

Because insect species are too numerous to consider individually, a coarse grouping at the Family level could be performed using the same trophic and feeding habitat categories as those for vertebrate species. The non-feeding habitat code is eliminated and life-form distinctions designated by flight, non-flight or both (this could also be oriented to other life-stage processes) are substituted as the third code. Because identification of insect species is incomplete for the INEL, professional judgement must be applied to estimate families that are most likely represented at the INEL. Suggested criteria for functional grouping for INEL insects are described on Table E-5.

E-2.2 Vegetation

Fifteen vegetation communities have been identified as part of the development of the INEL vegetation map (Kramber et al., 1992) (see Section 3.2.3 and Appendix D). The cover classes identified for the map have been combined into 8 functional groups for use in the SLERA process. These functional groups are described on Table E-6.

Ideally, potential risk to vegetation could be approached using functional grouping similar to that for fauna. Biological similarity might be established through physiotype, life-form or other grouping criteria. Soil type/plant associations could be used to establish similar exposure through root uptake, physiognomic and/or growth characteristics that affect deposition, retention, and uptake by foliage, and physical proximity of the vegetation to the contaminant. The two or three dominant species could be considered as representatives for each group. Insufficient data currently exist to support assessment of effects to vegetation (especially individual species) based on contaminant behavior in different soil types (INEL soil characterization is also inadequate). However, the concept of soil/vegetation units is offered here as a potential for future investigation of risk to vegetation.

For SLERA, primary pathways for direct effects are identified as root and, to a lesser extent, stomatal uptake. Indirect stressor effects resulting from soil matrix/chemical alteration, removal of pollinating species or destruction of symbionts is beyond the scope of the SLERA.

Table E-5. Suggested criteria for defining INEL insect functional groups (Short, 1983).

	DEFINITION	CODE	COMMENTS
TROPHIC CATEGORY	"Primary" feeding habits (based on >50% of prey/food consumed).	1 HERBIVORE (Phytophagous) 2 INSECTIVORE(Entomophagous) 3 CARNIVORE(Zoophagous) 4 OMNIVORE 5 DETRITIVORE (Spaprophagous)	Some re-definition is required for species having prey/food sources that differ according to life stage.
NON-FEEDING HABITAT	"Primary" physical habitat	1.0 AIR 2.0 TERRESTRIAL 2.1 Vegetation canopy 2.2 Tree bole 2.3 Surface/understory 2.4 Subsurface 3.0 TERRESTRIAL/AQUATIC INTERFACE 3.1 Vegetation canopy 3.2 Tree bole 3.3 Surface/understory 3.4 Subsurface 4.0 AQUATIC 4.1 Surface water 4.2 Water column 4.3 Bottom	
LIFE FORM	To be defined	1 Flying 2 Non-Flying 3 Both	

Table E-6. SLERA Vegetation Functional Group Summary.

Functional group	INEL vegetation cover classes	Dominant species
Juniper Woodlands	Juniper Woodlands	*Juniperus osteosperma* *Artemisia tridentata* ssp. *wyomingensis* *Leptodactylon pungens*
Grasslands	Steppe Basin Wildrye Grassland	*Leymus cinereus* *Descurainia sophia* *Sisymbrium altissimum* *Agropyron dasytachyum* *Elymus elymoides* *Artemisia tridentata* ssp. *wyomingensis* *Chrysothamnus viscidiflorus*
Sagebrush/Rabbitbrush	Sagebrush-Steppe off Lava Sagebrush-Winterfat Sagebrush-Rabbitbrush	*Artemisia tridentata* ssp. *wyomingensis* *Chrysothamnus viscidiflorus* *Bromus tectorum* *Sisymbrium altissimum* *Oryzopsis hymenoides*
Salt Desert Shrub	Salt Desert Shrub	*Atriplex confertifolia* *Atriplex nutallii* *Atriplex canescens* *Ceratoides lanata*
Sagebrush-Steppe on Lava	Sagebrush-Steppe on Lava	*Artemisia tridentata* ssp. *wyomingensis* *Oryzopsis hymenoides* *Chrysothamnus viscidiflorus*
Lava	Sage, Low sage, Rabbitbrush on Lava Lava	*Artemisia tridentata* ssp. *wyomingensis* *Chrysothamnus nauseosus*
Wetlands	Wetlands	*Eleocharis palustris* *Typha latifolia* *Agropyron smithii*
Playa-Bareground/Disturbed Areas	Playa-bareground/gravel borrow pits Old fields, disturbed areas, seedings	*Kocchia scoparia* *Salsola kali* *Artemisia tridentata* ssp. *wyomingensis* *Chrysothamnus viscidiflorus*

E-3. FUNCTIONAL GROUPS IN THE SLERA PROCESS

Once developed, functional groups can be used throughout the SLERA problem formulation process including receptor characterization, assessment and measurement endpoint definition, screening analysis and interpretation of SLERA results.

The first step in compiling functional groups for a SLERA is to identify ecosystems represented in the WAG assessment area and develop a list of functional groups expected to inhabit that area. The list can be created using wildlife habitat preference, abundance and distribution data from the site characterization process and data contained in the INEL wildlife species database (see Attachment I) to identify the spatial orientation, size, vegetation, geology, soil and other aspects that can be used to associate species with WAG assessment area.

Although detailed data for habitat characteristics and wildlife usage for each of the individual sites have not been collected, existing information on species habitat and dietary preference and relative abundance on the INEL was used to associate individual functional groups with general vegetation communities. Table E-8 presents the vegetation associations for INEL wildlife functional groups.

E-3.1 Receptor Characterization

Individual assessment site functional groups must be screened for potential exposure to each route identified by the SLERA pathway/exposure models (Section 3.2.5). For fauna, this process can be expedited by using summarized potential pathway exposures for site functional groups. Exposure matricies have been developed for INEL birds (Table E-9), mammals (Table E-10), and fish and herpetiles (Table E-11). Primary exposure pathways were derived by interpreting the functional group index with regard to dietary and physical habits of each group of species. Functional groups from Table E-4 that have potential for dietary and physical exposure to contamination for media and routes identified from the pathways model (e.g., surface soil, subsurface soil, and surface water) should be identified and summarized as shown on Table E-12. For example, group AV122 (Table E-9) shows potential for both dietary and physical exposure to vegetation and surface soil, but not for exposure to subsurface soil. Functional groups that are not in an exposure pathway are eliminated from the screening analysis.

The vegetation functional groups represented on the WAG site should be identified and assessed separately for potential effects as a result of exposure to WAG contaminants.

Table E-8. Summary of INEL Functional Groups Associated with SLERA Vegetation Types.

	Habitat type[b]								
Functional group	1	2	3	4	5	6	7	8	9
AV232							X		
AV121			X		X				
AV122		X	X	X	X				X
AV132							X		X
AV142							X		X
AV143							X		x
AV210	X	X	X	X	X		X		X
AV221			X	X	X		X		X
AV222	X	X	X	X	X		X		X
AV232			x	x	x		X		x
AV233			x	x	x		X		x
AV241							X		x
AV242							X		x
AV310	X	X	X	X	X	X	X		X
AV322	X	X	X	X	X	X	X		X
AV333							X		x
AV342							X		X
AV422	X	X	X	X	X	X	X		X
AV432		X	X	X	X		X		
AV433		x	x	x	x		X		
AV422							X		x
M121							X		x
M122		X	X	X	X	X			x
M122A		X	X	X	X	X			x
M123			X	X	X				
M132							X		
M210	X								X
A210A			X	X	X	X			X
M222			X	X	X	X			X
M322	X	X	X	X	X	X	X		X
M422	X	X	X	X	X	X	X		x
M422A	X	X	X	X	X	X	X		x
R222	X	X	X	X	X	X	X		x
R322	X	X	X	X	X	X	X		x

a. Individual species for each functional group are listed in Table D-4, Appendix D.

b. 1 = Juniper woodlands, 2 = Grasslands, 3 = Sagebrush/Rabbitbrush, 4 = Salt Desert Shrub, 5 = Sagebrush-Steppe on Lava, 6 = Lava, 7 = Wetlands, 8 = Playa, bareground/disturbed areas (not completed), 9 = Facilities. See Table 3-5 for cover class descriptions. Small (x) = where appropriate habitat exists (e.g., wetland species frequent facility waste ponds).

Table E-9. Summary of potential exposure pathways for INEL Avian Functional Groups.

EXPOSURE PATHWAY	AVIAN FUNCTIONAL GROUP																				
	AV 121	AV 122	AV 132	AV 142	AV 143	AV 210	AV 221	AV 222	AV 222A	AV 232	AV 233	AV 241	AV 242	AV 312	AV 322	AV 333	AV 342	AV 422	AV 432	AV 433	AV 442
DIETARY																					
Water	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D
Sediments			D								D		D			D			D	D	D
Vegetation	D	D	D	D	D													D	D	D	D
Surf. Soil		D						D	D						D			D			
Subs. Soil									D												
Prey						I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I
PHYSICAL																					
Air	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D
Water			D	D	D						D	D	D			D	D		D	D	D
Sediment					D				D	D	D		D			D			D	D	D
Vegetation	D	D				D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D
Surf. Soil		D				D								D	D			D			
Subs. Soil																					

D = Direct
I = Indirect

Table E-10. Summary of potential exposure pathways for INEL Mammalian Functional Groups.

EXPOSURE PATHWAY	MAMMALIAN FUNCTIONAL GROUP										
	M121	M122	M122A	M123	M132	M210	M210A	M222	M322	M422	M422A
DIETARY											
Water	D	D	D	D	D	D	D	D	D	D	D
Sediments					D						
Vegetation	D	D	D	D	D					D	
Surf. Soil	D	D	D	D				D	D	D	D
Subs. Soil	D		D	D				*	*	*	*
Prey						I	I	I	I	I	I
PHYSICAL											
Air	D	D	D	D	D	D	D	D	D	D	D
Water					D						
Sediment					D						
Vegetation	D	D	D	D		D					
Surf. Soil	D	D	D	D	D			D	D	D	D
Subs. Soil	D		D	D				D	D	D	D

D = Direct
I = Indirect

Table E-11. Summary of potential exposure pathways for INEL Fish, Reptilian, and Amphibian Functional Groups.

EXPOSURE PATHWAY	FUNCTIONAL GROUP					
	REPTILES		AMPHIBIANS	FISHES		
	R222	R322	A232	O222	O322	O422
DIETARY						
Water	D	D	D	D	D	D
Sediments			D			
Vegetation						
Surf. Soil	D	D	D			
Subs. Soil	D	D	D			
Prey	I	I	I		I	I
PHYSICAL						
Air	D	D	D			
Water			D	D	D	D
Sediment			D			
Vegetation						
Surf. Soil	D	D	D			
Subs. Soil	D	D	D			

D = Direct
I = Indirect

Table E-12. Example summary of potential exposure pathways for WAG functional wildlife groups.

Exposure medium	Exposure route	Potential receptors (functional groups)[a]
Subsurface soil (Direct)	Ingestion (dietary)	AV222A, M121, M122A, M123, M222, M322, M422, M422A, R222, R322, A232, terrestrial invertebrates, microorganisms, individual plan species
	Physical contact	AV222A, M121, M122A, M123, M222, M322, M422, M422A, R222, R322, A232
	Inhalation	Not addressed
Surface soil (Direct)	Ingestion (dietary)	AV122, AV222, AV222A, AV322, AV422, M121, M122, M122A, M123, M222, M322, M422, M422A, R222, R322, A232, terrestrial invertebrates, microorganisms, individual plant species
	Physical contact	AV122, AV210, AV310, AV322, AV422, M121, M122, M122A, M123, M132, M222, M322, M422, M422A, R222, R322, terrestrial invertebrates, microorganisms, individual plant species
	Inhalation	Not addressed
Vegetation (Direct)	Ingestion	AV121, AV122, AV132, AV142, AV143, AV422, AV432, M122, M122A, M123, M132, M422, phytophagous insects
	Physical contact	AV121, AV122, AV132, AV142, AV210, AV222, AV222A, AV233, AV241, AV242, AV310, AV322, AV333, AV342, AV422, AV432, AV433, AV442, M121, M122, M122A, M123, M210, terrestrial invertebrates, individual plant species
Surface water (Direct)	Ingestion (dietary)	AV121, AV122, AV132, AV142, AV143, AV210, AV221, AV222A, AV222, AV232, AV233, AV241, AV242, AV310, AV322, AV333, AV342, AV422, AV432, AV433, AV442, M121, M122, M122A, M210A, M222, M322, M422, M422A, R222, R322, A232, aquatic microfauna
	Physical contact	AV132, AV142, AV143, AV232, AV233, AV241, AV242, AV333, AV432, AV433, AV442, M123, M132, M210, M132, A232, aquatic microflora/fauna

Table E-12. (continued).

Exposure medium	Exposure route	Potential receptors (functional groups)[a]
Sediments (Direct)	Ingestion (dietary)	AV132, AV233, AV242, AV333, AV432, AV433, AV442, M132, A232, benthic invertebrates
	Physical contact	AV143, AV232, AV233, AV242, AV333, AV432, AV433, AV442, benthic invertebrates
	Physical contact	AV143, AV232, AV233, AV242, AV333, AV432, AV433, AV442, benthic invertebrates
	Inhalation	Not addressed
Prey (Indirect)	Ingestion	A232, AV210, AV221, AV222, AV222A, AV232, AV233, AV241, AV242, AV310, AV322, AV333, AV342, AV422, AV432, AV433, AV442, M210A, M210, M222, M322, M422, M422A, R222, R322, entomophagous, zoophagous, and saprophagous insects

a. Individual species associated with these groups are listed on Table D-4.

E-3.2 Screening Analysis and Evaluation

Functional groups, as defined for SLERA, are positioned in ecological hierarchy as shown:

ECOSYSTEM
|
COMMUNITY
|
GUILD
|
FUNCTIONAL GROUP
|
POPULATION
|
INDIVIDUAL

SLERA assessment endpoints are defined in terms of functional groups and T/E or candidate species that have potential for exposure to WAG contaminants (Section 3.2.7). An indicator of risk or SLQ (Section 3.4) is used to semi-quantitatively determine potential risk for each functional group and species of concern. An SLQ value greater than 1.0 for an individual group is interpreted as potential risk to all individuals within the functional group, hence potential risk to populations of individual species. Conversely, SLQ values less than 1.0 are interpreted as

indication of low likelihood for potential risk to individuals and populations for all members of the group. While used with conservative assumptions with regard to individual contaminant exposures for SLERA, extrapolation of population effects from one species to another is not appropriate in higher level assessments.
Contaminant effects resulting in altered behavioral responses (e.g. avoidance behavior), are also not addressed by SLERA exposure/effects analyses.

Measurement species, as defined for SLERA, are those species for which exposure/effects model input values data are obtained (Section 3.2.8). A major challenge to risk assessors in conducting both ERAs and SLERAs is to identification of existing ecological and toxicological data that can serve as data with which to address assessment endpoints.

For SLERA, measurement endpoint values that are required as input for include NOAELs, and LOAELs to support calculation of TRVs (Section 3.3.2.1) and dietary composition, home range, temporal and spatial habitat use data (site use factors and exposure duration), soil ingestion rate, food digestion rate and body weights to support calculation of EBSLs (Section 3.3.1.3.) The primary source for these data is the published literature.

All species within WAG functional groups identified as having potential for exposure to WAG in the receptor characterization have potential for serving as measurement species for the assessment. All threatened and/or endangered (T/E) and species potentially present at the WAG must be addressed by the SLERA and are, therefore, prime candidates for use as SLERA measurement species.

All resident and other breeding species that are abundant or common (abundance codes 1 or 2, Table E-4) should be included for consideration as measurement species since they can be assumed to best represent site communities. Less common species (abundance codes >2), including rare and non-breeding species, should not be considered for use as measurement species except in cases where no alternative exists for accomplishing assessment goals. Functional group members not selected, including those for which little or no ecological data exist, are represented in the assessment by the measurement species.

Functional groups eliminated from consideration because no member of the group has abundance code less than 3 must be reviewed separately to ensure that individual species requiring specific consideration in the SLERA (e.g., sensitive or societally valued species) have not been overlooked. Group AV310 is an example where the group is eliminated from most of the potential pathways of exposure at the INEL. However, the group contains species of particular importance (hawks). If assessment endpoints or risk management goals cannot be adequately addressed, additional species should be evaluated and included as needed. A final screen of potential measurement species should be conducted to isolate the most representative species for each functional group.

E-4. REFERENCES

EPA, 1992, Framework for Ecological Risk Assessment, EPA/630/R-92/001, PB93-102192, U.S. Environmental Protection Agency, ORD/Risk Assessment Forum, February, 55 pp.

Kramber, W.J., R.C. Rope, J.E. Anderson, J.M. Glennon, and A. Morse, 1992, "Producing a Vegetation Map of the Idaho National Engineering Laboratory Using LANDSAT Thematic Mapper Data," In: *Proceedings of ASPRS 1992 Annual Meeting*, Albuquerque, NM, March.

Peterle, T. J., 1991, *Wildlife Toxicology,* Van Nostrand Reinhold, New York, NY.

Short, H. L., 1982, "Development and Use of a Habitat Gradient Model to Evaluate Wildlife Habitat," *Proceedings of the North American Wildlands Natural Resources Conference No. 47,* pp. 57–72.

Suter, G. W. II, 1993, Ecological Risk Assessment, Lewis Publishers, Ann Arbor, MI, 538 pp.

Attachment I

The INEL Species Database

Attachment I

The INEL Species Database

E-I-1. INEL WILDLIFE SPECIES DATABASE DESCRIPTION AND KEY

This database was developed to support the WAG-wide Ecological Risk Assessment and includes basic information regarding wildlife species found at the INEL. The purpose of the database is to allow convenient sorting and manipulation of criteria for species guild construction and risk assessment modeling.

The database is formatted for EXCEL, however, will be uploaded to the ERIS ORACLE system via ASCII format. Once the contents have been verified and corrections completed, the database will be generally available in EXCEL or ASCII formats. In the future, the ORACLE based version could be linked to databases containing more detailed profiles (not yet developed) for species habitat, diet composition, and contaminant response.

The database currently includes:

- SPECIES IDENTIFICATION:

  - **Class** - taxonomic class name
  - **Order**[1] - taxonomic order name
  - **Family**[1] - taxonomic family name

  - **Taxonomic Name**[1]—Species taxonomic name --including information on different taxonomic identification (*)

  - **Species Code**[2] (SPCODE)—A unique, four letter identifier compiled from the first two letters of genus and species.

  - **Common Name**[1]—species common name

- FUNCTIONAL GROUP ASSOCIATION:

  - **Trophic Category**[3] (TROPH)—1 = Herbivore, 2 = Insectivore, 3 = Carnivore, 4 = Omnivore, 5 = Detritivore

  - **Feeding Habitat**[5] (F-H)—

    1.0 AIR

    2.0 TERRESTRIAL
    2.1 Vegetation canopy

2.2 Surface/understory
2.3 Subsurface
2.4 Vertical habitat (natural/manmade)

3.0 TERRESTRIAL/AQUATIC INTERFACE
3.1 Vegetation canopy
3.2 Surface/understory
3.3 Subsurface
3.4 Vertical habitat

4.0 AQUATIC
4.1 Surface water
4.2 Water column
4.3 Bottom

- **Non-Feeding Habitat**[5] (NF-H) -

1.0 AIR

2.0 TERRESTRIAL
2.1 Vegetation canopy
2.2 Surface/understory
2.3 Subsurface
2.4 Vertical habitat (natural/manmade)

3.0 TERRESTRIAL/AQUATIC INTERFACE
3.1 Vegetation canopy
3.2 Surface/understory
3.3 Subsurface
3.4 Vertical habitat

4.0 AQUATIC
4.1 Surface water
4.2 Water column
4.3 Bottom

- **ABUNDANCE AND DISTRIBUTION INFORMATION:**

- **Habitat**[1]—(listed in descending order of preference):

w On or near water
ss Shrub-steppe
d Deciduous or riparian
j Juniper woodland
g Grassland
sw Sitewide
f Facility complexes

c Cave
ro Rocky outcrop
U Unknown.

- **Abundance and Season**[1]—Abundance code (all abundance classes assume a qualified biologist exerted a reasonable effort to search or sample the proper habitat at the appropriate time of year):

1. Abundant - very numerous and certain to be seen or sampled.

2. Common - likely but not certain to be observed or sampled.

3. Uncommon - found in limited numbers, not likely to be sampled or observed.

4. Occasional or local - a species that is not always present or is restricted in distribution.

5. Rare - a species that has a range including all or part of the INEL, but has been documented $\leq$ seven times on the INEL.

6. Vagrant or accidental- a species that is not expected to occur on the INEL, but has been recorded there.

7. Possible occurrence - species for which sightings have been unverified or geographical range overlaps the INEL (and preferred habitat occurs on the INEL).

- **Breeding and seasonal code:**

R Breeder and year-round resident
B Summer breeder
M Migrant
W Winter visitor
S Summer visitor: no breeding records
U Unknown
I Incidental
T Transient.

- **REGULATORY STATUS**[4]—Species management codes for Federal (FED), Bureau of Land Management (BLM), U. S. Forest Service Region 4 (USFS), and Audubon Blue List (AUDBL: C2 = category 2 species; 3c = no longer considered for listing; E = endangered species; NL = not listed; SSC = species of special concern; T = threatened species; S = sensitive.

- **Notes**[1]—General comments and information.

(Information Sources)

1 Reynolds, T. et al. 1986; Aurthur et al., 1984; Reynolds, T. 1994 updates)

2 Compiled from species taxonomic name.

3 Ehrlich, P.R., et al. (1988)

4 Reynolds, T. et al. (1986), Mosely and Groves (1992)

5 Short (1982)

CLASS	ORDER	FAMILY	TAXONOMIC NAME	CODE	COMMON NAME	TROP	HI	F-H	NF-H	DIST/STATUS	ABUNDANCE/SEASON/STATUS	FED	STATE	BLM	USFS	AUDBL
AVES	GAVIIFORMES	Gaviidae	Gavia immer	GAIM	Common Loon	3		4.2	4.1	w	M5		SSC			
AVES	PODICIPEDIFORMES	Podicipedidae	Podilymbus podiceps	POPO	Pied-billed Grebe	2	3	4.2	4.1	w	S5, M5					
AVES	PODICIPEDIFORMES	Podicipedidae	Podiceps auritus	POAU	Horned Grebe	2	3	4.2	4.1	w	M5					
AVES	PODICIPEDIFORMES	Podicipedidae	Podiceps nigricollis	PONI	Eared Grebe	2	3	4.2	4.1	w	B5, M3, W3					
AVES	PODICIPEDIFORMES	Podicipedidae	Aechmophorus occidentalis	AEOC	Western Grebe	3		4.2	4.1	w	S5,M5					X
AVES	PELECANIFORMES	Pelecanidae	Pelecanus erythrorhynchos	PEER	American White Pelican	3		4.2	4.1	w	M5		SSC			
AVES	PELECANIFORMES	Phalacrocoracidae	Phalacrocorax auritus	PHAU	Double-crested Cormorant	3		4.2	4.1	w	I6					
AVES	CICONIIFORMES	Ardeidae	Botaurus lentiginosus	BOLE	American Bittern	3		4.2	3.2	w	S5, M5					
AVES	CICONIIFORMES	Ardeidae	Ardea herodias	ARHE	Great Blue Heron	3		4.2	3.2	w	S5, M5					
AVES	CICONIIFORMES	Ardeidae	Egretta thula	EGTH	Snowy Egret	2	3	3.3	3.2	w	I6					
AVES	CICONIIFORMES	Ardeidae	Casmerodius albus	CAAL	Great Egret	4		3.3	3.2	w	S5, M5		SSC			
AVES	CICONIIFORMES	Ardeidae	Bubulcus ibis	BUIB	Cattle Egret	2	3	3.3	3.2	w	I6					
AVES	CICONIIFORMES	Ardeidae	Nycticorax nycticorax	NYNY	Black-crowned Night Heron	3	2	3.3	3.2	w	I6					
AVES	CICONIIFORMES	Ardeidae	Butorides striatus	BUCH	Green-backed Heron	3	2	3.3	3.2	w	S6, M6					
AVES	CICONIIFORMES	Threskiornithidae	Plegadis chihi	PLCH	White-faced Ibis	2	3	3.3	3.2	w	S5, M5	C2				
AVES	ANSERIFORMES	Anatidae	Cygnus columbianus	CYCO	Tundra Swan	1	2	4.3	4.1	w	M5					
AVES	ANSERIFORMES	Anatidae	Cygnus buccinator	CYBU	Trumpeter Swan	1	2	4.3	4.1	w	I6	C2	SSC	S	S	
AVES	ANSERIFORMES	Anatidae	Chen caerulescens	CHCA	Snow Goose	1	2	4.2	4.1	w	M5					
AVES	ANSERIFORMES	Anatidae	Chen rossii	CHRO	Ross' Goose	1	2	4.3	4.1	w	I6					
AVES	ANSERIFORMES	Anatidae	Branta canadensis	BRCA	Canada Goose	1	2	4.3	4.1	w	S3, M3					
AVES	ANSERIFORMES	Anatidae	Anser albifrons	ANAL	White-fronted Goose	1	2	4.3	4.1	w	I6					
AVES	ANSERIFORMES	Anatidae	Aix sponsa	AISP	Wood Duck	2	1	4.1	3.1	w	S6, M5					
AVES	ANSERIFORMES	Anatidae	Anas crecca	ANCR	Green-winged Teal	1	2	4.2	4.1	w	S5, M5					
AVES	ANSERIFORMES	Anatidae	Anas platyrhynchos	ANPL	Mallard	1	2	4.3	4.1	w	B2, M2, W3					
AVES	ANSERIFORMES	Anatidae	Anas acuta	ANAC	Northern Pintail	1		4.3	4.1	w	S3, M3					
AVES	ANSERIFORMES	Anatidae	Anas discors	ANDI	Blue-winged Teal	1	2	4.3	4.1	w	B2, M3					
AVES	ANSERIFORMES	Anatidae	Anas cyanoptera	ANCY	Cinnamon Teal	1	2	4.3	4.1	w	S3, M3					
AVES	ANSERIFORMES	Anatidae	Anas clypeata	ANCL	Northern Shoveler	1	2	4.3	4.1	w	B3, M3					
AVES	ANSERIFORMES	Anatidae	Anas strepera	CNST	Gadwall	1	2	4.3	4.1	w	S3, M3					
AVES	ANSERIFORMES	Anatidae	Anas americana	ANAM	American Wigeon	1	2	4.3	4.1	w	S3, M3					
AVES	ANSERIFORMES	Anatidae	Aythya valisineria	AYVA	Canvasback	1		4.3	4.1	w	B5, M5					
AVES	ANSERIFORMES	Anatidae	Aythya americana	AYAM	Redhead	1	2	4.2	4.1	w	S5, M5, W5					
AVES	ANSERIFORMES	Anatidae	Aythya collaris	AYCO	Ring-necked Duck	1	2	4.2	4.1	w	S5, M5					
AVES	ANSERIFORMES	Anatidae	Aythya affinis	AYAF	Lesser Scaup	2	1	4.2	3.2	w	S6, M3, W3					
AVES	ANSERIFORMES	Anatidae	Bucephala clangula	BUCL	Common Goldeneye	2		4.2	3.2	w	S5, M3, W3					
AVES	ANSERIFORMES	Anatidae	Bucephala islandica	BUIS	Barrow's Goldeneye	2		4.2	3.2	w	S6, M5					
AVES	ANSERIFORMES	Anatidae	Bucephala albeola	BUAL	Bufflehead	2		4.2	4.1	w	S5, M3					
AVES	ANSERIFORMES	Anatidae	Melanitta perspicillata	MEPE	Surf Scoter	2		4.2	4.1	w	I6					
AVES	ANSERIFORMES	Anatidae	Mergus merganser	MEME	Common Merganser	3		4.2	4.1	w	S3, M5					
AVES	ANSERIFORMES	Anatidae	Mergus serrator	MERG	Red-breasted Merganser	3		4.2	4.1	w	I6					
AVES	ANSERIFORMES	Anatidae	Lophodytes cucullatus	LOCU	Hooded Merganser	3		4.2	4.1	w	I6					
AVES	ANSERIFORMES	Anatidae	Oxyura jamaicensis	OXJA	Ruddy Duck	2	1	4.2	3.2	w	B5, M3					
AVES	FALCONIFORMES	Cathartidae	Cathartes aura	CAAU	Turkey Vulture	3	4	2.2	2.4	sw	S3, M3, W6					
AVES	FALCONIFORMES	Accipitridae	Pandion haliaetus	PAHA	Osprey	3		4.2	3.1	w	M5					
AVES	FALCONIFORMES	Accipitridae	Haliaeetus leucocephalus	HALE	Bald Eagle	3		2.2	2.1	sw	M5, W3	LE	E			
AVES	FALCONIFORMES	Accipitridae	Circus cyaneus	CICY	Northern Harrier	3		2.2	2.1	sw	R2					

CLASS	ORDER	FAMILY	TAXONOMIC NAME	CODE	COMMON NAME	TROP	HI	F-H	NF-H	DIST/STATUS	ABUNDANCE/SEASON/STATUS	FED	STATE	BLM	USFS	AUDBL
AVES	FALCONIFORMES	Accipitridae	Accipiter striatus	ACST	Sharp-shinned Hawk	3		1	2.1	sw	S5, M5, W5					X
AVES	FALCONIFORMES	Accipitridae	Accipiter cooperii	ACCO	Cooper's Hawk	3		1	2.1	sw	S3, M5, W5					
AVES	FALCONIFORMES	Accipitridae	Accipiter gentilis	ACGE	Northern Goshawk	3		1	2.1	sw	S5, M5, W5	C2	S		S4	
AVES	FALCONIFORMES	Accipitridae	Buteo swainsoni	BUSW	Swainson's Hawk	3		2.2	2.1	sw	B3, M3, W5			S		
AVES	FALCONIFORMES	Accipitridae	Buteo jamaicensis	BUJA	Red-tailed Hawk	3		2.2	2.1	sw	B3, M3, W5					
AVES	FALCONIFORMES	Accipitridae	Buteo regalis	BURE	Ferruginous Hawk	3		2.2	2.1	sw	B3, M3, W5	C2	SSC	S		
AVES	FALCONIFORMES	Accipitridae	Buteo lagopus	BULA	Rough-legged Hawk	3		2.2	2.4	sw	S8, M2, W2					
AVES	FALCONIFORMES	Accipitridae	Aquila chrysaetos	AQCH	Golden Eagle	3		2.2	2.2	sw	B3, M4, W2					
AVES	FALCONIFORMES	Falconidae	Falco sparverius	FASP	American Kestrel	2	3	2.2	2.1	sw	B2, M2, W3					
AVES	FALCONIFORMES	Falconidae	Falco columbarius	FACO	Merlin	3		1	2.1	sw	R5	NL		S		
AVES	FALCONIFORMES	Falconidae	Falco peregrinus	FAPE	Peregrine Falcon	3		1	2.4	sw	S5, M5, W5	LE	E			
AVES	FALCONIFORMES	Falconidae	Falco rusticolus	FARU	Gyrfalcon	3		1	3	sw	M6	NL	SSC	S		
AVES	FALCONIFORMES	Falconidae	Falco mexicanus	FAME	Prairie Falcon	3		1	2.4	sw	R3					
AVES	GALLIFORMES	Phasianidae	Perdix perdix	PEPE	Gray Partridge	1		2.2	2.2	g, ss, f	R3					
AVES	GALLIFORMES	Phasianidae	Alectoris chukar	ALCH	Chukar	1	2	2.2	2.2	g, ss	R3					
AVES	GALLIFORMES	Phasianidae	Phasianus colchicus	PHCO	Ring-necked Pheasant	4		2.2	2.2	g, ss	R3					
AVES	GALLIFORMES	Phasianidae	Dendragapus obscurus	DEOB	Blue Grouse	1	2	2.2	2.2	f	S6					
AVES	GALLIFORMES	Phasianidae	Tympanuchus phasianellus	TYPH	Sharp-tailed Grouse	1	2	2.2	2.2		I6					
AVES	GALLIFORMES	Phasianidae	Centrocercus urophasianus	CEUR	Sage Grouse	1	2	2.2	2.2	ss, g, f	R2					
AVES	GRUIFORMES	Gruidae	Grus canadensis	GRCA	Sandhill Crane	4		3.3	3.2	U	I6					
AVES	GRUIFORMES	Rallidae	Porzana carolina	PORZ	Sora	1	2	3.2	3.2	w, f	B5, M5					
AVES	GRUIFORMES	Rallidae	Fulica americana	FUAM	American Coot	4		4.2	3.2	w	R3					
AVES	GRUIFORMES	Rallidae	Rallus limicola	RALI	Virginia Rail	2	1	3.2	3.2	w	I7					
AVES	CHARADRIIFORMES	Charadriidae	Charadrius vociferus	CHVO	Killdeer	2		2.2	2.2	sw	B2, M2					
AVES	CHARADRIIFORMES	Charadriidae	Charadrius semipalmatus	CJSE	Semipalmated Plover	2	1	3.2	2.2	w	I6					
AVES	CHARADRIIFORMES	Charadriidae	Eupoda montana	EUMO	Mountain Plover	2		3.2	2.2	U	I6					
AVES	CHARADRIIFORMES	Recurvirostridae	Recurvirostra americana	REAM	American Avocet	4		3.2	3.2	w	S2, M3					
AVES	CHARADRIIFORMES	Recurvirostridae	Himantopus mexicanus	HIME	Black-necked stilt	2		3.3	3.2	w	I6					
AVES	CHARADRIIFORMES	Scolopacidae	Tringa melanoleuca	TRME	Greater Yellowlegs	3	2	3.3	3.2	w	M6					
AVES	CHARADRIIFORMES	Scolopacidae	Tringa flavipes	TRFL	Lesser Yellowlegs	2	3	4.2	3.2	w	S5, M5					
AVES	CHARADRIIFORMES	Scolopacidae	Tringa solitaria	TRSO	Solitary Sandpiper	2		3.3	3.2	w	S5, M3					
AVES	CHARADRIIFORMES	Scolopacidae	Catoptrophorus semipalmatus	CASE	Willet	2		3.3	3.2	w, ss	S3, M3					
AVES	CHARADRIIFORMES	Scolopacidae	Actitis macularia	ACMA	Spotted Sandpiper	2		3.2	3.2	w	S3, M3					
AVES	CHARADRIIFORMES	Scolopacidae	Numenius americanus	NUAM	Long-billed Curlew	2		3.3	3.2	w, ss	S3, M3					X
AVES	CHARADRIIFORMES	Scolopacidae	Limosa fedoa	LIFE	Marbled Godwit	2		3.3	3.2	w	S3, M5					
AVES	CHARADRIIFORMES	Scolopacidae	Calidris minutilla	CAMI	Least Sandpiper	2	1	3.2	3.2	w	S5, M5	3c		S		
AVES	CHARADRIIFORMES	Scolopacidae	Limnodromus scolopaceus	LISC	Long-billed Dowitcher	2	1	3.3	3.2	w	M5					
AVES	CHARADRIIFORMES	Scolopacidae	Ereunetes mauri	ERMA	Western Sandpiper	2		3.2	3.2	w	I6					
AVES	CHARADRIIFORMES	Scolopacidae	Erolia bairdii	ERBA	Baird's Sandpiper	2		3.2	3.2	w	I6					
AVES	CHARADRIIFORMES	Scolopacidae	Gallinago gallinago	GAGA	Common Snipe	2		3.3	3.2	w	S5, M5					
AVES	CHARADRIIFORMES	Scolopacidae	Phalaropus tricolor	PHTR	Wilson's Phalarope	2	1	4.1	4.1	w	S3, M3					
AVES	CHARADRIIFORMES	Scolopacidae	Phalaropus lobatus	PHLO	Red-necked Phalarope	2	1	4.1	3.2	w	M5					
AVES	CHARADRIIFORMES	Laridae	Larus pipixcan	LAPI	Franklin's Gull	2		2.2	1	w, ss	S3, M3					
AVES	CHARADRIIFORMES	Laridae	Larus philadelphia	LAPH	Bonaparte's Gull	2		4.2	3.2	w	M5					
AVES	CHARADRIIFORMES	Laridae	Larus delawarensis	LADE	Ring-billed Gull	4		3.2	3.2	w, ss, g	S3, M3					
AVES	CHARADRIIFORMES	Laridae	Larus californicus	LACA	California Gull	2	3	2.2	1	w, ss	S5, M3					

CLASS	ORDER	FAMILY	TAXONOMIC NAME	CODE	COMMON NAME	TROP	HI	F-H	NF-H	DIST/STATUS	ABUNDANCE/SEASON/STATUS	FED	STATE	BLM	USFS	AUDBL
AVES	CHARADRIIFORMES	Laridae	Larus argentatus	LAAR	Herring Gull	4		2.2	3.2	w, ss, g	S3, M3					
AVES	CHARADRIIFORMES	Laridae	Rissa tridactyla	RITR	Black-legged Kittiwake	3		4.2	3.4	w	W6					
AVES	CHARADRIIFORMES	Laridae	Sterna caspia	STCA	Caspian Tern	3	2	4.2	3.2	w	M5					
AVES	CHARADRIIFORMES	Laridae	Sterna forsteri	STFO	Forster's Tern	3	2	4.2	3.2	w	S5					
AVES	CHARADRIIFORMES	Laridae	Childonias niger	CHNI	Black Tern	2	3	1	1	w	S5, M5	C2				
AVES	COLUMBIFORMES	Columbidae	Columba livia	COLI	Rock Dove	1		2.2	2.4	sw	R2					
AVES	COLUMBIFORMES	Columbidae	Zenaida macroura	ZEMA	Mourning Dove	1	2	2.2	2.1	sw	B1, M3, W6					
AVES	STRIGIFORMES	Strigidae	Bubo virginianus	BUVI	Great Horned Owl	3		2.2	2.1	sw	R3					
AVES	STRIGIFORMES	Strigidae	Nyctea scandiaca	NYSC	Snowy Owl	3		2.2	2	sw	W6					
AVES	STRIGIFORMES	Strigidae	Athene cunicularia	ATCU	Burrowing Owl	2	3	2.2	2.3	ss, g	B3, M3, W6	NL		S		
AVES	STRIGIFORMES	Strigidae	Asio otus	ASOT	Long-eared Owl	3		2.2	2.1	d	B4, M4					
AVES	STRIGIFORMES	Strigidae	Asio flammeus	ASFL	Short-eared Owl	3	2	2.2	2.1	ss, g	B3, M3					X
AVES	STRIGIFORMES	Strigidae	Aegolius acadicus	AEAC	Northern Saw-whet Owl	3	2	2.2	2.1	sw	S6, M6, W6					
AVES	STRIGIFORMES	Strigidae	Aegolius funerlus	AEFU	Boreal Owl	3	2	2.2	2.1		I6					
AVES	STRIGIFORMES	Strigidae	Otus kennicottii	OTKE	Western Screech-Owl	3	2	2.2	2.1	d	I6					
AVES	STRIGIFORMES	Strigidae	Otus flammeolus	OTFL	Flammulated Owl	2		2.2	2.1		I6					
AVES	STRIGIFORMES	Strigidae	Glaucidium gnoma	GLGN	Northern Pygmy Owl	3	2	2.2	2.1	d	I7		SSC			
AVES	CAPRIMULGIFORMES	Caprimulgidae	Chordeiles minor	CHMI	Common Nighthawk	2		1	2.2	sw	B2, M3					
AVES	CAPRIMULGIFORMES	Caprimulgidae	Phalaenoptilus nuttalii	PHNU	Common Poor-will	2		1	2.2	j	I6					
AVES	APODIFORMES	Apodidae	Aeronautes saxatalis	AESA	White-throated Swift	2		1	2.4	d	S5					
AVES	APODIFORMES	Trochilidae	Selasphorus rufus	SELA	Rufous Hummingbird	1	2	2.2	2.1	d	S3, M3					
AVES	APODIFORMES	Trochilidae	Archilochus alexandri	ARAL	Black-chinned Hummingbird	1	2	2.2	2.1	ag,d	I7					
AVES	APODIFORMES	Trochilidae	Stellula calliope	STCA	Calliope Hummingbird	1	2	2.2	2.1	ag,d	I6					
AVES	APODIFORMES	Trochilidae	Selasphorus platycercus	SEPL	Broad-tailed Hummingbird	1	2	2.2	2.1	ag,d	I7					
AVES	CORACIIFORMES	Alcedinidae	Ceryle alcyon	CEAL	Belted Kingfisher	3		4.2	3.1	w	S3, M3					
AVES	PICIFORMES	Picidae	Picoides pubescens	PIPU	Downy Woodpecker	2		2.1	2.1	d	B5, M5					
AVES	PICIFORMES	Picidae	Colaptes auratus	COAU	Northern Flicker	2		2.1	2.1	d	B3, M3					
AVES	PICIFORMES	Picidae	Asyndesmus lewis	ASLE	Lewis' Woodpecker	2	1	2.1	2.1	U	I6					
AVES	PICIFORMES	Picidae	Sphyrapicus nuchalis	SPNU	Red-naped Sapsucker	2	1	2.1	2.1	U	I6					
AVES	PICIFORMES	Picidae	Picoides villosus	PIVI	Hairy Woodpecker	2		2.1	2.1	ag,d	I7					
AVES	PASSERIFORMES	Tyrannidae	Contopus borealis	COBO	Olive-sided Flycatcher	2		1	2.1	d	S5, M5					
AVES	PASSERIFORMES	Tyrannidae	Contopus sordidulus	COSO	Western Wood-Peewee	2		1	2.1	d	I6					
AVES	PASSERIFORMES	Tyrannidae	Empidonax difficilis	EMDI	Western Flycatcher	2		1	2.1	d	S5					
AVES	PASSERIFORMES	Tyrannidae	Sayornis saya	SASA	Say's Phoebe	2	1	1	2.4	ss,d,f,j	B3, M3					
AVES	PASSERIFORMES	Tyrannidae	Mylarchus cinerascens	MYCI	Ash-throated Flycatcher	2	1	1	2.1	d	S5					
AVES	PASSERIFORMES	Tyrannidae	Tyrannus verticalis	TYVE	Western Kingbird	2	1	1	2.1	f,d,j	B3, M3					
AVES	PASSERIFORMES	Tyrannidae	Empidonax traillii	EMTR	Willow Flycatcher	2	1	1	2.1	d	I7					
AVES	PASSERIFORMES	Tyrannidae	Empidonax oberholseri	EMOB	Dusky Flycatcher	2		1	2.1	d	I7					
AVES	PASSERIFORMES	Tyrannidae	Empidonax wrightii	EMWR	Gray Flycatcher	2		1	2.1	g,ss,j	I6					
AVES	PASSERIFORMES	Tyrannidae	Tyrannus tyrannus	TYTY	Eastern Kingbird	2	1	1	2.1	f,d,j	B3, M3					
AVES	PASSERIFORMES	Alaudidae	Eremophila alpestris	ERAL	Horned Lark	1	2	2.2	2.2	g,ss	R2					
AVES	PASSERIFORMES	Hirundinidae	Tachycineta bicolor	TABI	Tree Swallow	2	1	1	2.1	d,j	B3, M3					
AVES	PASSERIFORMES	Hirundinidae	Tachycineta thalassina	TATH	Violet-green Swallow	2		1	2.1	d,j	B4, M4					
AVES	PASSERIFORMES	Hirundinidae	Stelgidopteryx serripennis	STSE	Northern Rough-winged swallow	2		1	2.4	d,j	B3, M3					
AVES	PASSERIFORMES	Hirundinidae	Riparia riparia	RIRI	Bank Swallow	2		1	2.4	d,j	B5, M3					
AVES	PASSERIFORMES	Hirundinidae	Hirundo pyrrhonota	HIPY	Cliff Swallow	2		1	2.4	d,j	B2, M2					

CLASS	ORDER	FAMILY	TAXONOMIC NAME	CODE	COMMON NAME	TROP	HI	F-H	NF-H	DIST/STATUS	ABUNDANCE/SEASON/STATUS	FED	STATE	BLM	USFS	AUDBL
AVES	PASSERIFORMES	Hirundinidae	Hirundo rustica	HIRU	Barn Swallow	2		1	2.4	d,j	B2, M3					
AVES	PASSERIFORMES	Corvidae	Cyanocitta cristata	CYCR	Blue Jay	4		2.2	2.1	d,f	I6					
AVES	PASSERIFORMES	Corvidae	Aphelocoma coerulescens	APCO	Scrub Jay	4		2.2	2.1							
AVES	PASSERIFORMES	Corvidae	Nucifraga columbiana	NUCO	Clark's Nutcracker	4		2.2	2.1	j	S4, M4, W5					
AVES	PASSERIFORMES	Corvidae	Pica pica	PIPI	Black-billed Magpie	4		2.2	2.1	sw	R2					
AVES	PASSERIFORMES	Corvidae	Corvus brachyrhynchos	COBR	American Crow	4		2.2	2.1	sw	R3					
AVES	PASSERIFORMES	Corvidae	Corvus corax	COCO	Common Raven	4		2.2	2.4	sw	R3					
AVES	PASSERIFORMES	Paridae	Parus atricapillus	PAAT	Black-capped Chickadee	2	1	2.1	2.1	d,j	I6					
AVES	PASSERIFORMES	Paridae	Parus gambeli	PAGA	Mountain Chickadee	2	1	2.1	2.1	d,j	I7					
AVES	PASSERIFORMES	Sittidae	Sitta canadensis	SITT	Red-breasted nuthatch	2		2.1	2.1							
AVES	PASSERIFORMES	Certhiidae	Salpinctes obsoletus	SAOB	Rock Wren	2		2.2	2.3	ss	B3, M3					
AVES	PASSERIFORMES	Certhiidae	Catherpes mexicanus	CAME	Canyon Wren	2		2.2	2.3	ss	S5, M6					
AVES	PASSERIFORMES	Certhiidae	Troglodytes aedon	TRAE	House Wren	2		2.2	2.1	d	R3					
AVES	PASSERIFORMES	Certhiidae	Cistothorus palustris	CIPA	Marsh Wren	2		3.2	3.2	w	I7					
AVES	PASSERIFORMES	Muscicapidae	Regulus calendula	RECA	Ruby-crowned Kinglet	2	1	2.1	2.1	d	M3, W6					
AVES	PASSERIFORMES	Muscicapidae	Sialia mexicana	SIME	Western Bluebird	2	1	2.1	2.1	ss	S5, M5					X
AVES	PASSERIFORMES	Muscicapidae	Sialia currucoides	SICU	Mountain Bluebird	2		2.2	2.1	ss	S3, M3					
AVES	PASSERIFORMES	Muscicapidae	Myadestes townsendi	MUTO	Townsend's Solitaire	2	1	1	2.1	d	S5, M6					
AVES	PASSERIFORMES	Muscicapidae	Turdus migratorius	TUMI	American Robin	2	1	2.2	2.1	sw	B2, M2					
AVES	PASSERIFORMES	Muscicapidae	Catharus guttatus	CAGU	Hermit Thrush	2	1	2.2	2.2		I6					
AVES	PASSERIFORMES	Muscicapidae	Ixoreus naevius	IXNA	Varied Thrush	2	1	2.2	2.1	ss	W6					
AVES	PASSERIFORMES	Muscicapidae	Hylocichla ustulata	HYUS	Swainson's Thrush	2	1	2.1	2.1	U	I6					
AVES	PASSERIFORMES	Mimidae	Mimus polyglottos	MIPO	Northern Mockingbird	2	1	2.2	2.1	j	S6					
AVES	PASSERIFORMES	Mimidae	Oreoscoptes montanus	ORMO	Sage Thrasher	2	1	2.2	2.1	ss	B2, M2					
AVES	PASSERIFORMES	Polioptilidae	Polioptila caerulea	POCA	Blue-gray Gnatcatcher	2		2.1	2.1	U	B6					
AVES	PASSERIFORMES	Motacillidae	Anthus spinoletta	ANSP	Water Pipit	2	1	2.2	2.2	ss	M5					
AVES	PASSERIFORMES	Bombycillidae	Bombycilla garrulus	BOGA	Bohemian Waxwing	2	1	2.1	2.1	f,d	S3, M2, W3					
AVES	PASSERIFORMES	Bombycillidae	Bombycilla cedrorum	BOCE	Cedar Waxwing	1	2	2.1	2.1	f,d	S5, M3, W5					
AVES	PASSERIFORMES	Laniidae	Lanius excubitor	LAEX	Northern Shrike	3	2	2.2	2.1	sw	M3, W5					
AVES	PASSERIFORMES	Laniidae	Lanius ludovicianus	LALU	Loggerhead Shrike	3	3	2.2	2.1	ss	B3	C2	NL			X
AVES	PASSERIFORMES	Sturnidae	Sturnus vulgaris	STVU	European Starling	2	1	2.2	2	sw	R3					
AVES	PASSERIFORMES	Vireonidae	Vireo gilvus	VIGI	Warbling Vireo	2	1	2.1	2.1	d	S5, M5					
AVES	PASSERIFORMES	Emberizidae	Mniotilta varia	MNVA	Black-and-White Warbler	2		2.1	2.2	d	I6					
AVES	PASSERIFORMES	Emberizidae	Dendroica petechia	DEPE	Yellow Warbler	2	1	2.1	2.1	d	B5, M3					X
AVES	PASSERIFORMES	Emberizidae	Dendroica coronata	DECO	Yellow-rumped Warbler	2		2.1	2.1	d	S3, M3					
AVES	PASSERIFORMES	Emberizidae	Dendroica townsendi	DETO	Townsend's Warbler	2		2.1	2.1	d	M5					
AVES	PASSERIFORMES	Emberizidae	Setophaga ruticilla	SERU	American Redstart	2		2.1	2.1	f	M6					
AVES	PASSERIFORMES	Emberizidae	Geothlypis trichas	GETR	Common Yellowthroat	2		2.1	2.1	d	S6					
AVES	PASSERIFORMES	Emberizidae	Wilsonia pusilla	WIPU	Wilson's Warbler	2		2.1	2.1	d	S5, M5					
AVES	PASSERIFORMES	Emberizidae	Bermivora celata	BECE	Orange-crowned Warbler	2	1	2.1	2.2	U	I6					
AVES	PASSERIFORMES	Emberizidae	Icteria virens	ICVI	Yellow-breasted Chat	2	1	2.1	2.1	d	S5					
AVES	PASSERIFORMES	Emberizidae	Oporornis tolmiei	OPTO	MacGillivray's Warbler	2		2.1	2.2	U	I6					
AVES	PASSERIFORMES	Emberizidae	Piranga ludoviciana	PILU	Western Tanager	2	1	2.1	2.1	d	S3, M3					
AVES	PASSERIFORMES	Emberizidae	Pheucticus melanocephalus	PHME	Black-headed Grosbeak	2	1	2.1	2.1	sw	S5, M5					
AVES	PASSERIFORMES	Emberizidae	Passerina amoena	PAAM	Lazuli Bunting	2	1	2.2	2.1	d	S5, M5					
AVES	PASSERIFORMES	Emberizidae	Pipilo chlorurus	PICH	Green-tailed Towhee	2	1	2.2	2.2	ss	S3, M3					

CLASS	ORDER	FAMILY	TAXONOMIC NAME	CODE	COMMON NAME	TROP	HI	F-H	NF-H	DIST/STATUS	ABUNDANCE/SEASON/STATUS	FED	STATE	BLM	USFS	AUDBL
AVES	PASSERIFORMES	Emberizidae	Pipilo erythrophthalmus	PIER	Rufous-sided Towhee	2	1	2.2	2.2	sw	S3, M3					
AVES	PASSERIFORMES	Emberizidae	Spizella passerina	SPPA	Chipping Sparrow	2	1	2.2	2.1	f,d,ss	M5					
AVES	PASSERIFORMES	Emberizidae	Spizella breweri	SPBR	Brewer's Sparrow	2	1	2.2	2.1	ss	B2, M2					
AVES	PASSERIFORMES	Emberizidae	Pooecetes gramineus	POGR	Vesper Sparrow	2	1	2.2	2.2	g, ss	B3, M3					
AVES	PASSERIFORMES	Emberizidae	Chondestes grammacus	CHGR	Lark Sparrow	1	2	2.2	2.1	sw	S3, M5					
AVES	PASSERIFORMES	Emberizidae	Amphispiza bilineata	AMBI	Black-throated Sparrow	2	1	2.2	2.1	ss	S5, M5					
AVES	PASSERIFORMES	Emberizidae	Amphispiza belli	AMBE	Sage Sparrow	2	1	2.2	2.1	ss	B2, M2					
AVES	PASSERIFORMES	Emberizidae	Calamospiza melanocorys	CAME	Lark Bunting	2	1	2.2	2.2	ss	S5, M5					
AVES	PASSERIFORMES	Emberizidae	Passerculus sandwichensis	PASA	Savannah Sparrow	2	1	2.2	2.1	d,g	S5, M3					
AVES	PASSERIFORMES	Emberizidae	Melospiza melodia	MELO	Song Sparrow	2	1	2.2	2.2	d	S5, M3					
AVES	PASSERIFORMES	Emberizidae	Zonotrichia querula	ZOQU	Harris' Sparrow	2	1	2.2	2.2		I6					
AVES	PASSERIFORMES	Emberizidae	Zonotrichia leucophrys	ZOLE	White-crowned Sparrow	2	1	2.2	2.1	ss	M4					
AVES	PASSERIFORMES	Emberizidae	Melospiza lincolnii	MELI	Lincoln's Sparrow	2	1	2.2	2.1		I6					
AVES	PASSERIFORMES	Emberizidae	Junco hyemalis	JUHY	Dark-eyed Junco	1	2	2.2	2.2	sw	M3					
AVES	PASSERIFORMES	Emberizidae	Calcrius lapponicus	CALC	Lapland Longspur	2	1	2.2	2.1	g,ss	I7					
AVES	PASSERIFORMES	Emberizidae	Plectrophenax nivalis	PLNI	Snow Bunting	1		2.2	2.1	g,ss	W5					
AVES	PASSERIFORMES	Emberizidae	Agelaius phoeniceus	AGPH	Red-winged Blackbird	2	1	3.2	3.1	w, ss	B3, M3					
AVES	PASSERIFORMES	Emberizidae	Sturnella neglecta	STNE	Western Meadowlark	2	1	2.2	2.1	g,ss	B2, M2, W3					
AVES	PASSERIFORMES	Emberizidae	Xanthocephalus xanthocephalus	XAXA	Yellow-headed Blackbird	2	1	3.2	3.1	w,d	B4, M3					
AVES	PASSERIFORMES	Emberizidae	Euphagus cyanocephalus	EUCY	Brewer's Blackbird	2	3	2.2	2.1	sw	B2, M2, W5					
AVES	PASSERIFORMES	Emberizidae	Molothrus ater	MOAT	Brown-headed Cowbird	2	3	2.2	2.1	ss	B3, M3					
AVES	PASSERIFORMES	Emberizidae	Quiscalus quiscula	QUQU	Common Grackle	4		2.2	2.1		I6					
AVES	PASSERIFORMES	Emberizidae	Icterus galbula	ICGA	Northern Oriole	2	1	2.1	2.1	d	S3, M3					
AVES	PASSERIFORMES	Emberizidae	Icterus spuris	ICSP	Orchard Oriole	2	1	3	3	U	I6					
AVES	PASSERIFORMES	Fringillidae	Leucosticte arctoa	LEAR	Rosy Finch	1	2	2.2	2.1	ss	M5, W5					
AVES	PASSERIFORMES	Fringillidae	Carpodacus mexicanus	CARP	House Finch	1		2.2	2.1	f,d	S3, M3					
AVES	PASSERIFORMES	Fringillidae	Carduelis pinus	CAPI	Pine Siskin	1	2	2.1	2.1	f,d	S5, M3					
AVES	PASSERIFORMES	Fringillidae	Carduelis tristis	CATR	American Goldfinch	1	2	2.1	2.1	d,ss	M5					
AVES	PASSERIFORMES	Fringillidae	Coccothraustes vespertinus	COVE	Evening Grosbeak	1	2	2.1	2.1	d	S5, M3					
AVES	PASSERIFORMES	Passeridae	Passer domesticus	PADO	House Sparrow	1	2	2.2	2	f,d	B2, M1, W3					
AMPHIBIA	ANURA	Pelobatidae	Spea intermontana*	SPIN	Great Basin Spadefoot Toad	2		3.2	3.3	w	R2					
AMPHIBIA	ANURA	Hylidae	Pseudacris triseriata	PSTR	Boreal Chorus Frog	2		3.2	3.3	w	R4					
AMPHIBIA	ANURA	Ranidae	Rana pipiens	RAPI	Northern Leopard Frog	2				w	I7					
AMPHIBIA	ANURA	Bufonidae	Bufo boreas	BUBO	Western Toad	2				w,d	I7					
AMPHIBIA	CAUDATA	Ambystomidae	Ambystoma tigrinum	AMTI	Tiger Salamander	2				w	I7					
REPTILIA	SQUAMATA	Iguanidae	Crotaphytus bicinctores	CRBI	Mojave Black-collared Lizard	2				sw	I7		SSC			
REPTILIA	SQUAMATA	Iguanidae	Gambelia wislizenii*	GAWI	Leopard Lizard	2	3	2.2	2.3	NE INEL	R4					
REPTILIA	SQUAMATA	Iguanidae	Phrynosoma douglasii	PHDO	Short-horned Lizard	2		2.2	2.3	sw,ss	R1					
REPTILIA	SQUAMATA	Iguanidae	Sceloporus graciosus	SCGR	Sagebrush Lizard	2		2.2	2.3	sw,ss	R1					
REPTILIA	SQUAMATA	Scincidae	Eumeces skiltonianus	EUSK	Western Skink	2		2.2	2.3	South INEL	R5					
REPTILIA	SQUAMATA	Boidae	Charina bottae	CHBO	Rubber Boa	3		2.2	2.3	U	I6					
REPTILIA	SQUAMATA	Colubridae	Masticophis taeniatus	MATA	Desert Striped Whipsnake	3		2.2	2.3	NE INEL, ss	R3					
REPTILIA	SQUAMATA	Colubridae	Pituophis melanoleucus	PIME	Gopher Snake	3		2.2	2.3	sw,ss	R2					
REPTILIA	SQUAMATA	Colubridae	Thamnophis elegans	THEL	Western Garter Snake	3		2.2	2.3	sw	R3					
REPTILIA	SQUAMATA	Colubridae	Coluber constrictor	COLU	Western Racer	3		2.2	2.3	sw	I5					
REPTILIA	SQUAMATA	Colubridae	Diadophis punctatus	DIPU	Ringneck Snake	3				sw	I7	NL	SSC			

CLASS	ORDER	FAMILY	TAXONOMIC NAME	CODE	COMMON NAME	TROP	HI	F-H	NF-H	DIST/STATUS	ABUNDANCE/SEASON/STATUS	FED	STATE	BLM	USFS	AUDBL
REPTILIA	SQUAMATA	Colubridae	Hypsiglena torquata	HYTO	Night Snake	3				sw	I7			S		
REPTILIA	SQUAMATA	Colubridae	Thamnophis sirtalis	THSI	Common Garter Snake	3				sw	I7					
REPTILIA	SQUAMATA	Viperidae	Crotalus viridis	CRVI	Western Rattlesnake	3		2.2	2.3	sw,ss	R2					
OSTEICHTHYES	SALMONIFORMES	Salmonidae	Oncorhynchus nerka	ONNE	Kokanee Salmon	4		4.2	4.3	w	R3					
OSTEICHTHYES	SALMONIFORMES	Salmonidae	Salmo gairdneri	SAGA	Rainbow Trout	3		4.2	4.3	w	R2					
OSTEICHTHYES	SALMONIFORMES	Salmonidae	Salvelinus fontinalis	SAFO	Brook Trout	3		4.2	4.3	w	R3					
OSTEICHTHYES	SALMONIFORMES	Salmonidae	Prosopium williamsoni	PRWI	Mountain Whitefish	2		4.3	4.3	w	R2					
OSTEICHTHYES	SALMONIFORMES	Salmonidae	Salvelinus malma	SAMA	Dolly Varden	3				w	I7					
OSTEICHTHYES	SALMONIFORMES	Salmonidae	Salmo clarkii	SACL	Cutthroat Trout	3				w	I7					
OSTEICHTHYES	CYPRINIFORMES	Cyprinidae	Rhinichthys osculus	RHOS	Speckled Dace	2		4.3	4.3	w	R3					
OSTEICHTHYES	CYPRINIFORMES	Cyprinidae	Rhinichthys cataractae	RHCA	Longnose Dace	2				w	I7					
OSTEICHTHYES	CYPRINIFORMES	Cyprinidae	Gila atraria	GIAT	Utah Chub	2				w	I7					
OSTEICHTHYES	PERCIFORMES	Cottidae	Cottus confusus	COTT	Shorthead Sculpin	2		4.2	4.3	w	R2					
MAMMALIA	INSECTIVORA	Soricidae	Sorex merriami	SOME	Merriam Shrew	2		2.2	2.3	sw,ss	R4					
MAMMALIA	CHIROPTERA	Vespertilionidae	Myotis californicus	MYCA	California Myotis	2				sw	I2		SSC			
MAMMALIA	CHIROPTERA	Vespertilionidae	Myotis lucifugus	MYLU	Little Brown Myotis	2		1	2.4	sw,f	I2					
MAMMALIA	CHIROPTERA	Vespertilionidae	Myotis leibii	MYLE	Small-footed Myotis	2		1	2.3	sw,ro	R2					
MAMMALIA	CHIROPTERA	Vespertilionidae	Myotis evotis	MYEV	Long-eared Myotis	2		1	2.1	SE INEL,j	I2					
MAMMALIA	CHIROPTERA	Vespertilionidae	Eptesicus fuscus	EPFU	Big-brown Bat	2		1	2.3	sw,f,c	R3					
MAMMALIA	CHIROPTERA	Vespertilionidae	Lasiurus cinereus	LACI	Hoary Bat	2		1	2.1	d,j	I3					
MAMMALIA	CHIROPTERA	Vespertilionidae	Plecotus townsendii	PLTO	Townsend's Big-eared Bat	2		1	2.3	sw,c	R2	C2	SSC		S2	
MAMMALIA	CHIROPTERA	Vespertilionidae	Myotis yumanensis	MYYU	Yuma Myotis	2				sw	I7					
MAMMALIA	CHIROPTERA	Vespertilionidae	Myotis volans	MYVO	Long-legged Myotis	2				sw	I7					
MAMMALIA	CHIROPTERA	Vespertilionidae	Myotis thysanodes	MYTH	Fringed Myotis	2				sw	I7		SSC			
MAMMALIA	CHIROPTERA	Vespertilionidae	Lasionycteris noctivagans	LANO	Silver-haired Bat	2		1	2.1	sw	M4					
MAMMALIA	CHIROPTERA	Vespertilionidae	Pipistrellus hesperus	PIHE	Western Pipistrelle	2				sw	I7	C2	SSC	S		
MAMMALIA	CHIROPTERA	Vespertilionidae	Antrozous pallidus	ANPA	Pallid Bat	2				sw	I7					
MAMMALIA	LAGOMORPHA	Leporidae	Lepus townsendii	LETO	White-tailed Jackrabbit	1		2.2	2.2	sw,ss	R4					
MAMMALIA	LAGOMORPHA	Leporidae	Lepus californicus	LECA	Black-tailed Jackrabbit	1		2.2	2.2	sw,ss	R1,R4 (cyclic)					
MAMMALIA	LAGOMORPHA	Leporidae	Sylvilagus nuttallii	SYNU	Nuttall's Cottontail	1		2.2	2.3	sw,ss,f	R2					
MAMMALIA	LAGOMORPHA	Leporidae	Sylvilagus idahoensis*	SYID	Pygmy Rabbit	1		2.2	2.3	ss,ro	R2	C2	NL			
MAMMALIA	RODENTIA	Sciuridae	Tamias minimus	TAMI	Least Chipmunk	4		2.2	2.3	sw,ss	R1					
MAMMALIA	RODENTIA	Sciuridae	Marmota flaviventris	MAFL	Yellow-bellied Marmot	1		2.2	2.3	sw,ro	R3					
MAMMALIA	RODENTIA	Sciuridae	Spermophilus townsendii	SPTO	Townsend's Ground Squirrel	1		2.2	2.3	sw,ss,f	R2					
MAMMALIA	RODENTIA	Geomyidae	Thomomys talpoides	THTA	Northern Pocket Gopher	1		2.3	2.3	ss	R4					
MAMMALIA	RODENTIA	Heteromyidae	Perognathus parvus	PEPA	Great Basin Pocket Mouse	1		2.2	2.3	sw,ss	R3					
MAMMALIA	RODENTIA	Heteromyidae	Dipodomys ordii	DIOR	Ord's Kangaroo Rat	1		2.2	2.3	sw,ss,g	R2					
MAMMALIA	RODENTIA	Castoridae	Castor canadensis	CACA	Beaver	1		3.2	3.3	w	R4,S,W					
MAMMALIA	RODENTIA	Cricetidae	Reithrodontomys megalotis	REME	Western Harvest Mouse	1		2.2	2.2	sw,ss,g	R2					
MAMMALIA	RODENTIA	Cricetidae	Peromyscus maniculatus	PEMA	Deer Mouse	4		2.2	2.3	sw	R1					
MAMMALIA	RODENTIA	Cricetidae	Onychomys leucogaster	ONLE	Northern Grasshopper Mouse	2		2.2	2.3	sw,ss	R4					
MAMMALIA	RODENTIA	Cricetidae	Neotoma cinerea	NECI	Bushy-tailed Woodrat	1		2.2	2.3	sw,ro	R2					
MAMMALIA	RODENTIA	Cricetidae	Microtus montanus	MIMO	Montane Vole	1		2.2	2.3	sw,g,f	R1,R4 (cyclic)					
MAMMALIA	RODENTIA	Cricetidae	Lagurus curtatus*	LACU	Sagebrush Vole	1		2.2	2.3	ss	R3					
MAMMALIA	RODENTIA	Cricetidae	Ondatra zibethicus	ONZI	Muskrat	1		3.2	3.3	w	S6,W6 (cyclic)					
MAMMALIA	RODENTIA	Muridae	Rattus norvegicus	RANO	Norway Rat	4		2.2	2.3	NW/NE INEL; ag	R6 (?)					

CLASS	ORDER	FAMILY	TAXONOMIC NAME	CODE	COMMON NAME	TROP	HI	F-H	NF-H	DIST/STATUS	ABUNDANCE/SEASON/STATUS	FED	STATE	BLM	USFS	AUDBL
MAMMALIA	RODENTIA	Muridae	Mus musculus	MUMU	House Mouse	4		2.2	2.3	f	R5 (?)					
MAMMALIA	RODENTIA	Erethizontidae	Erethizon dorsatum	ERDO	Porcupine	1		2.1	2.3	r,f	I4					
MAMMALIA	CARNIVORA	Canidae	Canis latrans	CALA	Coyote	4		2.2	2.3	sw	R2					
MAMMALIA	CARNIVORA	Canidae	Vulpes vulpes	VUVU	Red Fox	3				ag,d	I7					
MAMMALIA	CARNIVORA	Mustelidae	Mustela frenata	MUFR	Long-tailed Weasel	3		2.2	2.3	sw,ss	R2					
MAMMALIA	CARNIVORA	Mustelidae	Mustela erminea	MUER	Short-tailed Weasel (Ermine)	3				ag,d	I7					
MAMMALIA	CARNIVORA	Mustelidae	Taxidea taxus	TATA	Badger	3		2.2	2.3	sw	R3					
MAMMALIA	CARNIVORA	Mustelidae	Mephitis mephitis	MEPH	Striped Skunk	3				ag,d	I7					
MAMMALIA	CARNIVORA	Mustelidae	Spilogale gracilis	SPGR	Western Spotted Skunk	4		2.2	2.3	sw,ro	R5					
MAMMALIA	CARNIVORA	Felidae	Felis concolor	FECO	Mountain Lion	3		2.2	2.2	sw	T6					
MAMMALIA	CARNIVORA	Felidae	Felis rufus	FERU	Bobcat	3		2.2	2.3	sw,ss,j	R4					
MAMMALIA	CARNIVORA	Procyonidae	Procyon lotor	PRLO	Racoon	4				ag,d	I7					
MAMMALIA	ARTIODACTYLA	Cervidae	Cervus elaphus	CEEL	Elk	1		2.2	2.2	sw	~~T-(?)~~ R4					
MAMMALIA	ARTIODACTYLA	Cervidae	Odocoileus hemionus	ODHE	Mule Deer	1		2.2	2.2	sw,ss,g	R3					
MAMMALIA	ARTIODACTYLA	Cervidae	Alces alces	ALAL	Moose	1		2.2	2.2	sw	T6					
MAMMALIA	ARTIODACTYLA	Antilocapridae*	Antilocapra americana	ANTI	Pronghorn	1		2.2	2.2	sw,ss,f	R1					
MAMMALIA	ARTIODACTYLA	Bovidae	Ovis canadensis	OVCA	Mountain Sheep	1		2.2	2.2	No. INEL	T6					

Appendix F

Development of Contaminant Database

Appendix F

Development of Contaminant Database

Karl L. Smith
Shannon M. Rood

F-1. INTRODUCTION

This appendix presents a summary of the efforts to obtain contaminant data for performance of a screening-level ecological risk assessment (SLERA). The Department of Energy's (DOE) response to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), was to put a substantial effort in developing comparable and consistently well-documented data sets for areas contaminated with hazardous materials. Most of these data are produced through Idaho National Engineering Laboratory (INEL) contractor studies (rather than DOE or other federal agency/agency contractors), and essentially all of the data generated for CERCLA response is tracked using two database software systems, the Environmental Restoration Information System (ERIS) and the INEL Environmental Data Management System (IEDMS). These two databases capture the sampling and analysis information required for developing sampling and analysis reports that are admissible as legal evidence. These data are readily accessible for use in the performance of a SLERA.

The data available from IEDMS although easily accessible required sorting and analysis before it could be summarized in a form useful for SLERAs. From these samples for each contaminant, descriptive statistics were computed (i.e., minimum, maximum, and average) and the frequency of detection and frequency of exceedance were calculated.

F-1.1 Approach to ERIS Data

The ERIS data structure was examined for the purpose of establishing how the data are characterized in the database, as well as the initial data screening criteria presented in Table F-1. Each of the ERIS database fields listed below were used to further summarize the data.

- Matrix (media)
- Type location, location, and sample data
- Depth range
- Concentration
- Units of measurement
- Data quality flags

Table F-1. Initial data screening criteria.

Factor	Level (criteria)	Keep	Delete	Action/comment
Type location	Aquifer Well		yes	Eliminate ground water sample.
Type location	Perchd well (Perched well)		yes	Eliminate perched well if greater than 10 feet in depth. Other considerations on a site may necessitate including deeper sites.
Type location	QC (quality control)		yes	Eliminate QC. These are Quality Control flags such as field blanks.
Matrix (medium)	Soil	yes		Sample depth will be broken into two major categories; namely, sub-surface and surface (i.e., see Table E.1).
Concentration	Zero (0) concentration values		yes	Eliminate any sample with zero values unless it is for a radionuclide. Zero values have no meaning for the risk analysis.
Concentration	Reported radionuclide concentrations	yes		Convert to picoCuries per gram for solid media, and to microCuries per milliliter for liquids.
Concentration	Reported inorganic and organic concentrations	yes		Convert to micrograms per gram for solid media, and to micrograms per liter for aqueous media.
Concentration	Soil sample values measured in micrograms per liter		yes	Eliminate any soil sample with concentration measured in micrograms per liter because of uncertain unit conversion.
Depth range	Depths greater than 10 ft.		yes	Eliminate any samples taken at depths greater than 10 feet.
Data quality flags	See associated Tables F-4 & F-5			

- Compound (contaminant)
- Analysis.

F-1.1.1 Matrix (Media)

For specified database fields the ERIS database can be queried to determine what combinations of entries exist in the database. For example, for the field "Matrix" the entries include; MSOIL, NWATER, SLUDGE, SOIL, SUBSUR, SUR, WATER, and BLANK. These were used to sort the data based on the media for the pathway analysis.

F-1.1.2 Type Location, Location, and Sample Date

It was noted that the OPERABLE UNITS and SITE CODE designations specified in the Action Plan for the Implementation of the Federal Facility Agreement and Consent Order (FFA/CO) were not classification factors in the ERIS database. Consequently, if possible, it is necessary to link Operable Units and site codes with the type location, location, sample date, and other factors that appear in the ERIS database. Table F-2 provides the translation matrix which links the Operable Units and CERCLA process tracks that was used for the development of the WAG 2 ERIS database. The method for linking is based on previous work performed to establish the Maximum and Plume databases.[a]

F-1.1.3 Depth Range

A fundamental criteria used in this study was the categorization of sample depth as "surface" or "subsurface." The surface samples were defined as those that were taken at a depth of less than or equal to 15 cm (0.5 ft). The subsurface samples were defined as those that were taken at depths greater than 15 cm (0.5 ft) but less than or equal to 3 m (10 ft). The ERIS database generally uses feet for measurement and therefore these units are presented in Table F-3. There were samples that overlapped these depths and a binning process (based on ecological judgement) was used to place the sample depths into the surface or subsurface bin.

The ERIS database was queried to determine the various entries in the Depth Range field. Table F-3 indicates the depth levels that appear in the ERIS database. The depths are grouped into the indicated three categories. Only the ERIS data that meet the "surface" and "subsurface" criteria are retained for further analysis. Screening the ERIS data by depth generally greatly reduced the amount of data (i.e., in the case of WAG 2 from over 43,000 individual samples to approximately 13,500).

---

a. EG&G Idaho, Inc. Memo to E. C. Miller from S. M. Rood, dated April 11, 1994, Subject: "Transmittal of Maximum and Plum Databases".

Table F-2. Translation matrix for Operable Units and CERCLA Process Tracks Versus ERIS Database Type Location and Location Factors.

OPER_U	SITE_COD	Sites Within Operable Units (Table E.2)	indx	ERIS TYPE LOCATION	ERIS LOCATION
2-05	TRA-15	TRA Hot Waste Tanks #2, #3, #4 at TRA-613	1	FIELD COMPOSITE	BOREHOLE 3
			2	FIELD COMPOSITE	BOREHOLE 1
			3	FIELD COMPOSITE	BOREHOLE 2
			4	UST SITE	BOREHOLE 3
2-09	TRA-13	TRA Final Sewage Leach Ponds (2) by TRA-732	5	SLP-50 CELL	SLP-06
			6	SLP-50 CELL	SLP-09
			7	SLP-50 CELL	SLP-11
			8	SLP-50 CELL	SLP-08
			9	SLP-50 CELL	SLP-12
			10	SLP-50 CELL	SLP-05
			11	SLP-50 CELL	SLP-04
			12	SLP-50 CELL	SLP-07
			13	SLP-65 CELL	SLP-02
			14	SLP-65 CELL	SLP-01
			15	SLP-65 CELL	SLP-03
			16	SLP-65 CELL	SLP-10
2-10			17	CELL 52	SS-03
			18	CELL 52	SS-02
			19	CELL 52	SS-13
			20	CELL 52	SS-01

Table F-2. (continued).

OPER_U	SITE_COD	Sites Within Operable Units (Table E.2)	indx	ERIS TYPE LOCATION	ERIS LOCATION
2-10			21	CELL 52	SS-04
			22	CELL 57	SS-07
			23	CELL 57	SS-05
			24	CELL 57	SS-08
			25	CELL 57	SS-06
			26	CELL 64	SS-09
			27	CELL 64	SS-11
			28	CELL 64	SS-10
			29	CELL 64	SS-12
2-13	TRA-06	Wag 2 Comprehensive RI/FS, including: TRA Chemical Waste Pond (TRA-701).	30	BIASED	DRAINPIPE OUTLT
			31	BIASED	TRUCK RAMP
			32	BIASED	GRAVEL FAN
			33	RANDOM	GRAVEL/MAINPOND
			34	RANDOM	PRECIP/MAINPOND
			35	REPLICATE	QC
2-99*		No operating unit (OPER_U) and site code (SITE COD) correspondence with WAG 2 ERIS samples.	36	BACKGROUND	SW BACKGROUND
			37	BACKGROUND	N BACKGROUND
			38	BIASED	BACKGROUND
			39	COOLING TOWER	LOCATION 4
			40	COOLING TOWER	BOREHOLE
			41	COOLING TOWER	LOCATION 3
			42	COOLING TOWER	LOCATION 6

Table F-2. (continued).

OPER_U	SITE_COD	Sites Within Operable Units (Table E.2)	indx	ERIS TYPE LOCATION	ERIS LOCATION
2-99*		No operating unit (OPER_U) and site code (SITE COD) correspondence with WAG 2 ERIS samples.	43	COOLING TOWER	LOCATION 5
			44	COOLING TOWER	LOCATION 7
			45	COOLING TOWER	LOCATION 2
			46	COOLING TOWER	LOCATION 1
			47	EAST OVERTOPPING	WARM WASTE POND
			48	FAR EAST OVERTOPPING	WARM WASTE POND
			49	SOIL BORING	SB09
			50	SOIL BORING	SB01
			51	SOIL BORING	SB04
			52	SOIL BORING	SB08
			53	SOIL BORING	SB05
			54	SOIL BORING	SB03
			55	SOIL BORING	SB07
			56	SOIL BORING	SB06
			57	SOIL BORING	SB02
			58	WEST OVERTOPPING	WARM WASTE POND

* The 2-99 code is assigned to facilitate ERIS risk assessment data processing, this code is not a "true" operating unit code. This group of data must associated with site by analyst.

Table F-3. Depth range screening criteria specification.

Depth range	Category code	Delete	Comment
SURFACE			
0-0.3	1	no	OK
0-0.5	1	no	OK
0.0.5 [0-0.5]	1	no	OK
0.2-0.5	1	no	OK
0-12"	1	no	OK
0-12 [0-12"]	1	no	OK [correct to inches]
SUBSURFACE			
0.5-0.7	2	no	OK
0-2	2	no	Put in sub-surface
0-2'	2	no	Put in sub-surface
1	2	no	OK
1-1.3	2	no	OK
12-24"	2	no	OK
12-24 [12-24"]	2	no	OK [correct to inches]
1-3	2	no	OK
2-3	2	no	OK
2-3.5	2	no	OK
2-4	2	no	OK
3	2	no	OK
3.6-3.8	2	no	OK
3-5	2	no	OK
3.5-4	2	no	OK
4-5	2	no	OK
5-7	2	no	OK
8-10	2	no	OK
9	2	no	OK
10	2	no	OK
ELIMINATE			
27-31	3	yes	OK
27-29	3	yes	OK
31-33	3	yes	OK
26-28'	3	yes	OK
32-34'	3	yes	OK
28-30	3	yes	OK
30-32	3	yes	OK
31-35	3	yes	OK
24-26	3	yes	OK
23-25	3	yes	OK

Table F-3. (continued).

Depth range	Category code*	Delete	Comment
22-24	3	yes	OK
40-42	3	yes	OK
25-27	3	yes	OK
32-34	3	yes	OK
26-27.5	3	yes	OK
29-31	3	yes	OK
21-23	3	yes	OK
39-41	3	yes	OK
21-25	3	yes	OK
34-36	3	yes	OK
20-22'	3	yes	OK
35-42	3	yes	OK
211-213	3	yes	OK
45-47	3	yes	OK
50-52	3	yes	OK
42-44	3	yes	OK
37-39	3	yes	OK
34-35	3	yes	OK
33-35	3	yes	OK
34-36.5	3	yes	OK
35-37	3	yes	OK
35-38	3	yes	OK
35-37'	3	yes	OK
33-34.5	3	yes	OK
12-14	3	yes	OK
11-16	3	yes	OK
120	3	yes	OK
0-38	3	yes	Spans all categories
37.5'	3	yes	OK
486	3	yes	OK
L3-35 [l3-35]	3	yes	OK
20-22	3	yes	OK
476	3	yes	OK
37-38.3	3	yes	OK
0-35.8	3	yes	Spans all categories
30.532.5 [30.5-32.5]	3	yes	OK
N/A	3	yes	Don't know depth
PHASE I	3	yes	Don't know depth
490	3	yes	OK

Table F-3. (continued).

Depth range	Category code*	Delete	Comment
34.536.5 [34.5-36.5]	3	yes	OK
30.5-32.5	3	yes	OK
36.5-38.5	3	yes	OK
44-53	3	yes	OK
80	3	yes	OK
17-19	3	yes	OK
15-17.5	3	yes	OK
15-17	3	yes	OK
18-20	3	yes	OK
19-21	3	yes	OK
10-12'	3	yes	OK
0-37	3	yes	Spans all categories
14-15	3	yes	OK
15-17'	3	yes	OK
75	3	yes	OK
10-11	3	yes	OK
14-16	3	yes	OK
9-11	3	yes	Spans category 2
10-12	3	yes	OK
13-15	3	yes	OK
15-16	3	yes	OK
11-12	3	yes	OK

* CATEGORY CODE:

1 Surface—Depth less than or equal to 1.0 ft (i.e., 0 to and including 12 in.).
2 Sub-surface—Depth greater than 0.5 ft but less than or equal to 10 ft.
3 Depth greater than 10 ft.

F-1.1.4 Concentration and Unit of Measurement

It was necessary to appropriately convert all contaminant concentration values for soils to either µg/g or pCi/g so that they could ultimately be averaged across all the samples. This conversion lead to the elimination of sample concentrations measured in mg/L, since the conversion of such concentrations to µg/g is uncertain.

F-1.1.5 Data Quality Flags

The ERIS data qualifier flags differ for either organic, inorganic, or radiological analysis. Table F-4 defines appropriate data qualifiers for organic types of analysis as included in the ERIS database. Table F-4 shows the codes used to indicate whether a compound concentration was either a "detect" or "non-detect" and indicates which codes are used to delete samples from the database for use in the risk analysis. Samples were eliminated for several reasons as listed. Attachment 1, "Control of Nonconforming Analytical Data", contains a detailed description of the data qualifiers used in organic analysis.

Table F-5 defines the appropriate data qualifiers for inorganic types of analysis. Inorganic data qualifiers are more complex. The data qualifier specifications information consists of three fields designating concentration, Q qualifier, and method. These flags in combination explain in some detail the laboratory results of each sample in some detail. The first field reported is the concentration field. This is one column and is designated as either a B, U or a blank. A B flag is entered if the reported value was obtained from a reading that was less than the Contract Required Detection Limit (CRDL) but greater than or equal to the Instrument Detection Limit (IDL). A U flag is entered if the analyte was analyzed for but not detected. A blank is entered if there are no data quality flag restrictions. Data qualifier flags were resolved according to appropriate definitions for organic and radiological data and for inorganic. The second field reported is the Q Qualifier field, which is 6 columns of alpha and symbolic characters that qualifies the laboratory results. The third field is the method qualifier, which is 2 columns of alpha characters that describe the analytic method used for the analysis. Attachment 1, "Control of Nonconforming Analytical Data", contains a detailed description of the data qualifiers used in inorganic analysis.

Table F-6 defines the appropriate data qualifiers for radiological analysis. Attachment 1, "Control of Nonconforming Analytical Data", contains a detailed description of the data qualifiers used in radiological analysis.

Table F-4. Data qualifier specification for organic analyses.

Data qualifier	Analysis type	Delete?	Detection?
"blank"[a]	PESTS-CLP	no	yes
"blank"	SEMIS-CLP	no	yes
"blank"	VOAS-BOA	no	yes
"blank"	VOAS-CLP	no	yes
A[b]	VOAS-BOA	no	yes
B	"organic"		yes
BJ	SEMIS-BOA	yes	
D	"organic"	no	yes
J	PCBS-CLP	no	yes
J	SEMIS-BOA	no	yes
J	VOAS-BOA	no	yes
J	VOAS-CLP	no	yes
JB	SEMIS-CLP	no	yes
JN	SEMIS-CLP	no	yes
JN	VOAS-BOA	no	yes
JN	VOAS-CLP	no	yes
JR	SEMIS-CLP	yes	
JR	VOAS-CLP	yes	
N	"organic"	no	yes
NJ	"organic"	no	yes
R	SEMIS-CLP	yes	
R	VOAS-BOA	yes	
R	VOAS-CLP	yes	
U	OC-HERBS-TCLP	no	no
U	OC-PESTS-BOA	no	no
U	OC-PESTS-BOA	no	no
U	PCBS-CLP	no	no
U	PESTS-CLP	no	no

Table F-4. (continued).

Data qualifier	Analysis type	Delete?	Detection?
U	SEMIS-BOA	no	no
U	SEMIS-CLP	no	no
U	VOAS-BOA	no	no
U	VOAS-CLP	no	no
UD	PESTS-CLP	no	yes
UJ	OC-HERBS-BOA	no	no
UJ	OC-PESTS-BOA	no	no
UJ	SEMIS-CLP	no	no
UJ	VOAS-BOA	no	no
UJ	VOAS-CLP	no	no
UR	SEMIS-CLP	yes	
UR	VOAS-BOA	yes	
UR	VOAS-CLP	yes	
UX	PESTS-CLP	yes	
X	"organic"	yes	

a. No data qualifier was required.

b. Attachment 1, "Control of Nonconforming Analytical Data", Organic Analysis

Table F-5. Data qualifier specification for inorganic analyses.

Concentration data qualifier	Method data qualifier	Delete?	Detection
"blank"[a]	F[b]	no	yes
"blank"	P	no	yes
"blank"	CV	no	yes
"blank"	A	no	yes
"blank"		no	yes
"blank"	CV	no	yes
"blank"	CV	no	yes
"blank"	F	no	yes
"blank"	CV	no	yes
"blank"	P	no	yes
"blank"	F	no	yes
"blank"	P	no	yes
"blank"	P	no	yes
"blank"	F	no	yes
"blank"	CV	no	yes
"blank"	F	no	yes
"blank"		no	yes
"blank"		no	yes
"blank"	P	no	yes
"blank"	F	no	yes
"blank"	P	no	yes
"blank"		yes	
"blank"	F	yes	
"blank"	F	no	no
"blank"	F	no	no
"blank"	NR	yes	
"blank"	F	no	no

Table F-5. (continued).

Concentration data qualifier	Method data qualifier	Delete?	Detection
"blank"		yes	
"blank"	CV	yes	
"blank"	F	no	yes
"blank"	F	no	yes
"blank"	F	no	yes
"blank"	F	no	no
"blank"	P	no	no
"blank"	F	no	no
"blank"		no	no
"blank"	F	no	no
B	F	no	yes
B	P	no	yes
B	A	no	yes
B	CV	no	no
B	P	no	yes
B	CV	no	yes
B	P	no	yes
B	F	no	yes
B	P	no	yes
B	F	no	no
B	F	no	no
B	F	no	yes
B	F	no	no
B	P	no	no
B	F	no	no
B	F	no	yes

Table F-5. (continued).

Concentration data qualifier	Method data qualifier	Delete?	Detection
B	F	no	no
J	C	no	yes
J		no	yes
U	P	no	no
U		no	no
U	CV	no	no
U	F	no	no
U	CV	no	yes
U	F	no	no
U	P	no	no
U		no	no
U		yes	
U	F	yes	
U	P	no	no
U	F	yes	
U	F	no	no
U	P	no	no
U	F	no	no
U	F	no	no

a. No data qualifier was required.

b. Attachment 1, "Control of Nonconforming Analytical Data", Inorganic Analysis

Table F-6. Data qualifier specification for radionuclide analyses.

Data qualifier	Analysis type	Delete?	Detection?
"blank"[a]	RAD	no	yes
U[b]	RAD	no	no
UJ	RAD	yes	no

a. No data qualifier was required.

b. Attachment 1, "Control of Nonconforming Analytical Data", Radiological Analysis

F-2 REFERENCES

Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual (Part A), Chapter 5.4 Evaluation of Qualified and Coded Data, Exhibit 5-4 (CLP Laboratory Data Qualifiers and Their Potential Use In Quantitative Risk Assessment, Page 5-12), and Exhibit 5-5 (Validation Data Qualifiers and Their Potential Use In Quantitative Risk Assessment, Page 5-14, Interim Final, EPA/540/1-89/002, December 1989.

EG&G Idaho Inc., Environmental Restoration Program (ERP), Program Directives, Title: "Control of Nonconforming Analytical Data," Appendix A, Data Qualifier (Flags) Definitions for Data Users, page PD 5.8.

Legend sheet qualifier flags for Inorganic Analysis Data Flags, Methods, and Inorganic Validation Data Qualifiers, EG&G Idaho, Inc., Personal Communication notes from Debi Jones (Statistical and Reliability Analysis) to Robin Vanhorn (Chemical and Radiological Risk Assessment), April 5, 1994.

Attachment I

Control of Nonconforming Analytical Data

LOCKHEED IDAHO TECHNOLOGIES COMPANY **PROGRAM DIRECTIVE** ENVIRONMENTAL RESTORATION	Title: CONTROL OF NONCONFORMING ANALYTICAL DATA	No.: PD 5.8 Rev: 02 Page: 1 of 10 Date: 12/23/94
	Approved:	Legend | = Change
Reviewed by: Original signatures appear on DRR# ER-1476, release date 12/22/94.		

1. PURPOSE AND SCOPE

This Environmental Restoration (ER) Program Directive (PD) establishes the policy, procedures, requirements, and responsibilities to control analytical data that do not conform to the quality requirements specified in the method used for the analysis. This PD implements those Quality Assurance (QA) requirements of References 1 through 5 regarding nonconforming item control.

2. DEFINITIONS

Analytical Method Data Validation or Validation: Review of measurements and analytical results against a set of criteria to assess limitations on the use of the data.

Chemical Analysis: The analysis of samples of environmental media (air, soil, or water) or wastes for organic or inorganic nonradiological constituents including analyses performed using United States Environmental Protection Agency (EPA) approved methods as well as nonstandard methods.

Data Limitations and Validation (L&V) Report: Report written by an analytical chemist or other technical expert performing analytical method data validation. The report documents any deficiencies in the data identified during the validation process. The report also indicates the level of validation performed on the data.

Data Qualifier Flag: A label, usually in the form of one or multiple letters of the alphabet or some other symbol, such as "+" or "*," that is used to document nonconformances and/or limitations with an analytical result. The same letter(s) designate different attributes to the data depending on the analysis being validated.

Geochemical Analysis: The analysis of geologic materials (soil or rock) for chemical properties (e.g., mineralogy, cation exchange capacity).

Invalid Analytical Data: Data produced from chemical, physical property, or radiological analyses of environmental samples that because of the magnitude of the nonconformance(s) are qualified as unusable by the data validator.

Nonconformance: A deficiency in characteristic, documentation, or procedure which renders the quality of an item unacceptable or indeterminate. Examples of nonconformances include physical defects, test failures,

2. DEFINITIONS (continued)

incorrect or inadequate documentation, and deviations from prescribed processing, inspection, or test procedures.

Nonconforming Analytical Data: Data produced from chemical, physical property or radiological analyses of environmental samples (a) that were produced when the measurement system was not within the quality control (QC) limits specified by the analytical method, or (b) with insufficient documentation to judge the adequacy of the data. These data do not conform to the method requirements but may still be of some use to the data user depending upon the Data Quality Objectives (DQO) required for data use and/or data interpretation.

Physical Property Analysis: The analysis of samples of environmental media (soil, air, water) or wastes for physical or geologic properties (e.g., viscosity, pour point, flash point, particle size distribution, porosity, hydraulic conductivity) including analyses performed using EPA approved methods and American Society for Testing and Materials (ASTM) methods as well as nonstandard methods.

Radiological Analysis (RAD): The analysis of samples of environmental media (air, soil, or water) or wastes for specific radionuclides or total radiation (i.e., gross alpha, gross beta).

3. POLICY

Data that do not conform to analytical method requirements shall be controlled by labeling the data to prevent inappropriate use. Data that are invalid shall be labeled with an "R" flag so that it may be segregated to prevent its inappropriate use in decision making. Controls shall provide for identification, documentation, evaluation, segregation, and disposition of nonconforming and invalid data. All Statements of Work (SOWs) for subcontracted analytical services are Quality Level B documents. Thus, all nonconforming data produced from these services are subject to this PD.

4. PROCEDURES

Sample Management Office (SMO)	.1	Ensures that the flags used for nonconforming analytical data provide for identification, documentation, evaluation, segregation (if necessary), disposition, and notification to affected data users.
	.2	Establishes controls in the form of data labels or "flags" to prevent inadvertent or inappropriate use of data. Each analysis type shall have a defined set of

4. PROCEDURES (continued)

SMO (continued)		flags associated with that data (Appendix A).
	.3	If the nonconforming data can be corrected by communication with the laboratory; ensures the laboratory submits to SMO Field Data Coordinator (FDC) documentation of the communication, the nature of the nonconformance, and the corrective action taken to ensure the nonconformance will not continue.
	.4	If the nonconformance cannot be corrected in process, and represents an irreconcilable difference between the requirements of the laboratory's Statement of Work and what was performed by the laboratory, issues a nonconformance report to the Project Manager (PM) per the requirements of Company Procedure 9.7.
PM	.5	Ensures nonconformance report is evaluated and closed out per the requirements of Company Procedure 9.7.
SMO	.6	If the nonconforming analytical data are such that payment for the analytical services should be withheld, informs subcontract administrator in writing of the nonconformance and requests payment be withheld.
	.7	Produces Limitations & Validation (L&V) Reports and distributes to the analytical laboratory that produced the data, the project manager that requested the data, Integrated Environmental Data Management System (IEDMS) personnel, the project files, and Administrative Record and Document Control (ARDC).
	.8	Ensures that all data qualifier flags (Appendix A) assigned to the nonconforming data by the SMO are entered into the IEDMS data base and are

4. PROCEDURES (continued)

SMO (continued)		subsequently uploaded to Environmental Restoration Information System.
	.9	Ensures that a copy of all L&V Reports are present with or referenced on all copies of data that have been validated.
	.10	Ensures that all data forms that have the original markings of the person performing the validation are returned to ARDC for permanent storage.
Environmental Restoration Information System Manager	.11	Ensures that access to nonconforming analytical data is controlled and all data flag definitions (Appendix A) are available for the data users.

5. REFERENCES/BIBLIOGRAPHY

1. EG&G Idaho, Inc., Quality Program Plan for the Environmental Restoration Program, QPP-149.

2. EG&G Idaho, Inc., Quality Manual, QP-15, "Control of Nonconforming Items."

3. EG&G Idaho, Inc., Procurement Standard Practice Manual, PSP 5.11, "Nonconforming Materials, Supplier Disposition Requests, and Conditional Releases."

4. American Society of Mechanical Engineers (ASME), Quality Assurance Program Requirements for Nuclear Facilities, NQA-1, 1989.

5. EG&G Idaho, Inc., Company Procedures Manual, CP-9.7, "Nonconformances."

Guidance for Data Usability In Risk Assessment, EPA/540/G-90/008, October 1990.

APPENDIX A

DATA QUALIFIER (FLAGS) DEFINITIONS FOR DATA USERS

Organic Analysis

The following definitions are intended to assist the data user by providing an explanation of the qualifiers (flags) appended to organic analysis results by the laboratory and/or data reviewer. The purpose is to facilitate appropriate data use, consistent with the project objectives.

U - The analyte was analyzed for and is definitely not present above the level of the numerical value listed to the left of the flag on the laboratory's data reporting form. The numerical value indicates the approximate concentration necessary to detect the analyte in this sample.

If a decision requires quantitation of the analyte below the listed numerical level, reanalysis or alternative analytical methods should be considered. The SMO technical staff is available to discuss available options.

J - The analyte was analyzed for and was positively identified, but the associated numerical value may not be consistent with the amount actually present in the environmental sample. The data should be seriously considered for decision-making and are usable for many purposes.

UJ - A combination of the "U" and the "J" qualifier. The analyte was analyzed for and was not present above the level of the associated value. The associated numerical value may not accurately or precisely represent the concentration necessary to detect the analyte in this sample.

If a decision requires quantitation of the analyte close to the associated numerical level, reanalysis or alternative analytical methods should be considered.

A subscript may be appended to the "J" (whether the "J" flag is being used in combination with the "U" flag or not) or an "R" that indicates which of the following quality control criteria were not met:

1 Blank contamination: indicates possible high bias and/or false positives

2 Calibration range exceeded: indicates possible low bias

3 Holding times not met: indicates low bias for most analytes with the possible exception of common laboratory contaminants (i.e., acetone, methylene chloride).

4 Other QC outside control limits: bias not readily determined.

APPENDIX A (continued)

R - The data are unusable for all purposes. The analyte was analyzed for, but the presence or absence of the analyte has not been verified.

Resampling and reanalysis are necessary to confirm or deny the presence of the analyte. Data may be usable depending on project specific DQOs. Severe limitations on use of "R" flagged data is recommended.

N - The analysis indicates that an analyte is present, and there are strong indications that the identity is correct.

Confirmation of the analyte requires further analysis.

NJ - A combination of the "N" and the "J" qualifier. The analysis indicates that the analyte is "tentatively identified" and the associated numerical value may not be consistent with the amount actually present in the environmental sample.

A subscript may be appended to the "NJ" that indicates which of the following situations applies:

NJ_1 DDT/Endrin breakdown evident

NJ_2 Interference by other sample components

NJ_3 Non-Target Compound List (TCL) compounds (Confirmation is necessary using specific target compound methodology to accurately determine the concentration and identity of the detected compounds).

NJ_4 A confirmation analysis was missing or quality control criteria were not met for the confirmation analysis.

D - This flag identifies all compounds identified in an analysis at a secondary dilution factor. If a sample or extract is reanalyzed at a higher dilution factor, as in the "E" flag below, the "DL" suffix is appended to the sample number on the Form I for the diluted sample, and all concentration values reported on that Form I are flagged with the "D" flag.

E - This flag identifies compounds whose concentrations exceed the calibration range of the gas chromatograph/mass spectrometry (GC/MS) instrument for that specific analysis. This flag will not apply to pesticides/ polychlorinated biphenyls (PCBs) analyzed by GC/Environmental Checklist (EC) methods.

APPENDIX A (continued)

B - This flag is used when the analyte is found in the associated blank as well as in the sample. It indicates possible/probable blank contamination and warns the data user to take appropriate action. This flag must be used for a tentatively identified compound (TIC) as well as for a positively identified TCL compound.

C - This flag applies to pesticide results where the identification has been confirmed by GC/MS. Single component pesticides $\geq$10 ng/μl in the final extract shall be confirmed by GC/MS.

A - This flag indicates that a TIC is a suspected aldol-condensation product.

X - Other specific flags may be required for the laboratory to properly define the results. If used, they should be fully described and such description attached to the Sample Data Summary Package and the Case Narrative. Laboratories typically begin by using "X." If more than one flag is required, laboratories may use "Y" and "Z," as needed. If more than five qualifiers are required for a sample result, laboratories may use the "X" flag to combine several flags, as needed. For instance, the "X" flag might combine with "A," "B," and "D" flags for some sample.

Inorganic Analysis

Laboratories that perform inorganic analyses under ER's analytical services master subcontract are required to follow USEPA Contract Laboratory Program (CLP) protocol whenever applicable. CLP protocol stipulates that data be reported on a standard set of forms. Sample results for CLP type analyses (e.g., analytes determined by inductively coupled plasma atomic emission spectroscopy "ICPAES", graphite furnace atomic absorption spectroscopy "GFAAS", and cold vapor atomic absorption spectroscopy "CVAAS") are reported on CLP FORM I-IN, while sample results for non-CLP type inorganic analyses (alkalinity, chloride, nitrate, etc.) are reported on a modified version of CLP FORM I-IN. The inorganic analysis data sheets (i.e., CLP FORM I-IN and all modified versions of CLP FORM I-IN) have three columns (labeled "C", "Q", and "M") in which analytical laboratory personnel enter qualifying flags (hereafter, flags applied by laboratory personnel shall be referred to as laboratory flags) in accordance with CLP protocol. Descriptions of laboratory flags are as follows:

- C (Concentration) qualifier -- Specified entries and their meanings are as follows:

  B - The reported valve was obtained from a reading that was less than the contract required detection limit (CRDL) but greater than or equal to the instrument detection limit (IDL).

  U - The analyte was analyzed for and was not detected.

- Q qualifier -- Specified entries and their meanings are as follows:

APPENDIX A (continued)

E - The reported value is estimated because of the presence of interference. An explanatory note shall be included under Comments on the Cover Page (if the problem applies to all samples) or on the specific inorganic analysis data sheet (if it is an isolated problem).

M - Duplicate injection precision was not met.

N - Spiked sample recovery was not within the control limits.

S - The reported value was determined by the method of standard additions (MSA).

W - Post-digestion spike for GFAAS analysis is out of the control limits (85-115%), while sample absorbance is less than 50% of spike absorbance.

* - Duplicate analysis was not within the control limits.

\+ - Correlation coefficient for the MSA is less than 0.995.

Entering "S", "W", or "+" is mutually exclusive. No combination of these qualifiers can appear in the same field for an analyte.

- M (Method) qualifier -- Enter:

  - "P" for ICPAES
  - "M" for ICP mass spectrometry (ICPMS)
  - "A" for flame atomic absorption spectrometry (FAAS)
  - "F" for GFAAS
  - "PM" for ICPAES when microwave digestion is used
  - "MM" for ICPMS when microwave digestion is used
  - "FM" for GFAAS when microwave digestion is used
  - "AM" for FAAS when microwave digestion is used
  - "CV" for manual CVAAS
  - "AV" for automated CVAAS
  - "CA" for midi-distillation spectrophotometric
  - "AS" for semi-automated spectrophotometric
  - "C" for manual spectrophotometric
  - "T" for titrimetric
  - "NR" if the analyte is not required to be analyzed.

APPENDIX A (continued)

For analytes in which none of the listed method qualifier codes are applicable, the analytical laboratory is required to either; (a) develop, and define within the confines of each applicable data package, a new method qualifier code, or (b) list the analytical method number rather than a method qualifier code.

Upon request by ER project management, an inorganic laboratory data package is subjected to method validation. Inorganic data validators apply qualifying flags (hereafter, flags assigned by data validators shall be referred to as validation flags) in accordance with SMO-SOP-12.1.5. Descriptions of validation flags are as follows:

U - The material was analyzed for, but was not detected above the level of the associated value. The associated value is either the sample quantitation limit or the sample detection limit. In most instances, a "U" validation flag will be accompanied by a "B" laboratory flag.

UJ - The material was analyzed for, but was not detected. The associated value is an estimate and may not accurately reflect the IDL in the sample matrix.

J - The analyte was analyzed for and was positively identified, but the associated numerical value may not be consistent with the amount actually present in the environmental sample

R - The accuracy of the data is so questionable that it is recommended the data not be used.

Radiological Analysis

The following are definitions of the data qualifier flags applied to radiological analysis results.

U - Analysis was performed and the result is below two times the associated uncertainty for the analysis. The analyte of interest is not considered to be present at the 95% confidence level.

J - Analysis was performed and a true positive result was obtained (result is greater than two times the associated uncertainty), but the result is considered to be an estimated quantity due to quality control problems. The analyte of interest is considered to be present at the 95% confidence level.

UJ - The analysis result obtained is below two times the associated uncertainty for the analysis and is considered to be an estimated quantity due to quality control problems. Analyte of interest may or may not be present at the 95% confidence level.

APPENDIX A (continued)

R - The analysis result obtained is unusable due to major problems with the sample analysis or the supporting quality control information.

N/A - The indicated analysis was not performed on this sample.

The following definitions are for the validation flags that are applied to the individual validation parameters evaluated during the radiological data validation process.

I - Parameter is in control, there are no problems with the sample results data.

Q - Parameter is questionable, there may be minor problems with the sample results data.

O - Parameter is out of control, there may be major problems with the sample results data.

N/A - Parameter is not applicable to the analysis type being validated.

End of Procedure

Appendix G

Correlation Study of Background Soil Sampling

Appendix G

Correlation Study of Background Soil Sampling

C. S. Staley, G. J. White

Concurrent with the sitewide INEL background study (Rood, 1995), the INEL-wide ecological risk assessment was also evaluating background concentrations of metals and radionuclides in the soil. The purpose of the ecological background investigation, in part, was to determine if the concentration of metals and radionuclides are correlated with soil type and the concentration of other metals and radionuclides in soil. The results of this investigation are presented in this section. The data used in this section. The data used in this section are the offsite data only from both the Martin and NPR studies. See Rood et al. (1995) for detail presentation of this data.

The initial approach used involved application of stepwise regression analysis to the available data for certain key metals and radionuclides. Concentrations (or activities) of these metals and radionuclides were regressed on soil characteristics such as pH, cation exchange capacity, organic carbon, and percent sand, silt, and clay. The purpose of this initial assessment was to detect obvious trends relating these metals and radionuclides with soil characteristics. This was done first for aluminum and magnesium, non-pollutants that would be expected to correlate strongly with certain soil characteristics. Cesium-137 was then chosen because it represents a globally-distributed pollutant deposited atmospherically. Correlations between Cs-137 activities and soil characteristics would not be expected to be as strong. Two metals, lead and cadmium, were also used.

Finally, problems in assessing the data available are discussed. Recommendations are provided for how to better assess offsite background for contaminants at the INEL.

G-1. STEPWISE REGRESSION

The initial evaluation of these data involved performance of stepwise regression of selected metals against soil characteristics. This was applied to the data set that included the 18 data points for which concentrations of metals, activities of radionuclides, and measurements of soil characteristics were available. The purpose of this initial cursory look was to see if expected relationships between materials and soil characteristics could be observed.

G-1.1 Aluminum

This metal represents an important constituent of soil, and is not generally associated with environmental contamination. A strong correlation between aluminum concentrations and certain soil characteristics was therefore expected.

Aluminum concentrations in the 18 soil samples considered was regressed on all six measured soil characteristics (% sand, % silt, % clay, pH, CEC, and TOC). This multiple

regression yielded a correlation coefficient (r) of 0.98, indicating strong correlation. Because sand, silt, and clay are not entirely independent of one another, only one of the three was used in the stepwise regressions.

Regressing aluminum concentrations against each of the three soil textures individually yielded the following:

- Sand: r = 0.94
- Silt: r = 0.89
- Clay: r = 0.88.

This indicates that aluminum concentration is more highly correlated with sand content than clay content of the soil. However, when aluminum concentration is regressed on a single soil type in combination with the other three soil characteristics (i.e., CEC, pH, and TOC), the results indicate that clay content is more closely correlated with aluminum. The conclusion regarding aluminum is that, as expected, soil aluminum concentrations are highly correlated with soil characteristics, especially those related to soil type such as percent clay, sand, or silt.

G-1.2 Magnesium

A similar stepwise regression was performed on magnesium. Again, this element represents a natural component of the soil and would therefore be expected to be associated with certain soil characteristics such as clay content. As with aluminum, concentrations of magnesium in the background soil samples were highly correlated with soil characteristics (especially clay content). These results can now be used as a benchmark against materials that are not natural constituents of the soil.

G-1.3 Cesium-137

Similar analyses of the Cs-137 data were then performed. This radionuclide was chosen specifically because it represents a pollutant of strictly anthropogenic origin which, is dispersed globally through atmospheric deposition. As such, Cs-137 represents the opposite situation as was observed with aluminum and magnesium, with soil concentrations not expected to be well correlated with soil characteristics.

Results of single variable regressions of Cs-137 concentration vs. the various soil characteristics are as follows:

- Sand: r = 0.3
- Silt: r = 0.3
- Clay: r = 0.3

- CEC: r = 0.2
- TOC: r = 0.4
- pH: r = 0.2.

Stepwise regression of Cs-137 on organic C, clay and sand, CEC and pH indicate that Cs-137 concentrations in background soils do not correlate well with any soil characteristic measured. This is likely due to the fairly uniform deposition of this material from globally-dispersed material.

G-1.4 Lead

Moving to non-radioactive pollutants, lead was the next material analyzed. Again, because this material is deposited atmospherically, relatively low correlations are anticipated. Single variable regression of lead concentration versus the six soil characteristics yielded the following:

- Sand: r = 0.5
- Clay: r = 0.4
- CEC: r = 0.6
- TOC: r = 0.1
- pH: r = 0.3.

Stepwise regression of lead soil concentrations and sand content, CEC, TOC, and pH indicate the relative importance of cation-exchange capacity. Still, this correlation is low (r = 0.6), and probably indicates that once deposited on the surface, mobility of lead is reduced somewhat by high CEC.

G-1.5 Cadmium

Finally, cadmium was chosen as another example of potential pollutant. Single variable regressions of cadmium concentration on soil characteristics yielded much higher correlation coefficients than observed with lead:

- Sand: r = 0.8
- Silt: r = 0.8
- Clay: r = 0.5
- CEC: r = 0.8

- TOC: $r = 0.7$
- pH: $r = 0.3$.

Stepwise regressions of cadmium soil concentrations on CEC, sand, TOC, and pH indicate the relatively high correlation between cadmium concentration and several of the soil characteristics may indicate the potential use of soil properties as a tool for predicting distribution of cadmium contamination. However, it is also possible that the variation seen in cadmium content and the association between cadmium and soil characteristics reflects the presence of natural cadmium in these soils.

G-2. SYSTEMATIC APPROACH TO CORRELATION ANALYSIS

Following this cursory look at selected contaminants, a more systematic approach was applied. This involved calculating correlation coefficients for each chemical element and each radionuclide against one another as well as against each soil characteristic. Because atmospherically derived pollutants often exhibit a log-normal distribution, this process was conducted for the log of the concentration of each material as well. Only the values of the materials being regressed against the other parameters were converted to log values—the independent variables were not transformed. Transformation of both dependent and independent variable represent a possible next step in the data analysis.

Once all the single variable regressions were performed, a modified stepwise regression was performed for each material. This involved identifying the top 10 and the top three parameters (soil characteristics or other soil elemental constituents) and performing multiple regressions on these sets of independent variables. As with the stepwise regressions above, either sand or clay content was used, but not both.

The general conclusion that may be drawn is that reasonable predictions of metal and radionuclide relationships with soil characteristics and constituents may be possible if enough parameters are available. The practicality of this is questionable, at best.

Ideally, strong relationships would be observed between metals or radionuclides and some subset of the six soil characteristics evaluated. In most cases, these regressions yielded very weak correlations. This is especially true of the radionuclides, which showed no correlation coefficients in excess of 0.44 for either non-transformed or log-transformed data. Some strong relationships appear in the metal data, although many of these are likely due to the natural component of the material in question.

Regarding log transforms, it can be seen that correlation coefficients did not improve substantially upon transformation of the data except in the cases of cadmium and Cs-137. The distribution of atmospherically deposited materials such as Cs-137 would be expected to be log-normal. Other transformation may be more useful, but none were evaluated.

In addition, Cs-137, K-40, Th-232, and U-238 were repressed against one another. As before, both non-transformed and log-transformed data are used for the dependent variables whereas the independent variables were not transformed. Cs-137 activities are not correlated with

the other radionuclides. This is expected, because unlike the other three, this nuclide is of anthropogenic origin and is dispersed globally in the atmosphere as the result of atomic weapons testing. Thorium, uranium, and K-40 are all naturally-occurring radionuclides. The weak correlation between K-40 with Th-232, and U-238 remains unexplained. Th-232 and U-238 are typically found together in parent geological materials, so the high correlations between these nuclides is not unusual.

G-3. RESL DATA SET RADIONUCLIDE CONCENTRATIONS

A second data set consisting of analytical data from six sampling sites collected by RESL was also evaluated. These samples were analyzed for radionuclide concentrations, and were collected from offsite locations where data on soil characteristics was also available. These six sampling sites were Atomic City, Carey, Howe, Monteview, Mud Lake, and Reno Ranch.

The data set provided for this evaluation contained radionuclide levels and soil characteristic data from three samples form each site. Two of the three samples were taken from the "surface" layer of the soil, while the third was taken from the second soil horizon. The second horizon sample and one of the surface samples were collected as part of the same sampling effort. The second surface sample was collected at a different time and/or by different individuals at presumably the same site.

However, RESL radionuclide data were available for these six sites, plus an additional six sites: Mud Lake (2), Crystal Ice Caves, FAA Tower, Butte City, Blackfoot, and St. Anthony. No soil characteristics data have been located for these second six locations nor the depths of sample collection and it is not known whether the soil characteristics data are from "Mud Lake 1" or "Mud Lake 2". Initially the assumption was made that the Mud Lake sample was from "Mud Lake 1". Regressions of radionuclide activities vs. the different soil characteristics were performed based on this assumption, with each nuclide regressed individually on each soil characteristic. These regressions were repeated substituting radionuclide data for Mud Lake 2.

The regression results are provided in Table G-1. The first value in each cell of the table is the correlation coefficients for the data using Mud Lake 1 data, while the second is for with the substitution of Mud Lake 2. The final values in each column are the correlation coefficients for a combination of three of the six soil characteristics. These three characteristics included either clay or sand, whichever provided the highest individual correlation coefficients, along with CEC and organic carbon. As mentioned above, sand, silt, and clay are not entirely independent of one another, so should not all be included in the multiple regression. Silt was not considered simply because it represents a mid-range in soil particle size. Organic matter was also not included because it is not independent of organic carbon. This is apparent in the R^2 values shown in Table 26, which are identical for both organic matter and organic carbon.

The regression results shown in Table G-1 imply a much higher correlation between the radionuclide data using Mud Lake 2 radionuclide data rather than Mud Lake 1. The differences are greatest for Cs-137. Am-241 was not included as it was noted that all six data points were in effect equal. It was determined that because the correlation was better with Mud Lake 2 data, the radionuclide data from this site likely coincided with the soil characteristic data provided for Mud Lake.

Table G-1. Correlation coefficients for radionuclides with both soil horizons combined.

	Am-241		Cs-137		Pu-239/240		Sr-90	
	ML[a]-1	ML-2	ML-1	ML-2	ML-1	ML-2	ML-1	ML-2
% Sand	0.6	—	0.4	0.7	0.8	0.8	0.8	0.8
% Silt	0.5	—	0.4	0.7	0.8	0.9	0.9	0.8
% Clay	0.6	—	0.5	0.6	0.7	0.7	0.7	0.7
CEC	0	—	0	0.3	0.5	0.6	0.7	0.7
TOC	0.5	—	0.6	0.8	0.9	1	0.6	0.6
Org. Matter	0.5	—	0.6	0.8	0.9	1	0.6	0.6
TOP 3 factors	0.9	—	0.9	1	1	1	1	1

— No data available.

a. Mud Lake.

Next, these correlations were re-run using only the surface soil samples. The third set of soil characteristics, listed as being for the second horizon, were omitted in determining the mean value for each characteristic. The results of these regressions are provided in Table G-2.

Table G-2. Correlation coefficients for radionuclides with individual soil horizons.[a]

	Cs-137		Pu-239/240		Sr-90	
	Surface	Both horizons	Surface	Both horizons	Surface	Both horizons
% Sand	0.7	0.7	0.8	0.8	0.8	0.8
% Silt	0.7	0.7	0.8	0.9	0.8	0.8
% Clay	0.7	0.6	0.9	0.7	0.7	0.7
CEC	0.5	0.3	0.7	0.6	0.7	0.7
TOC	0.9	0.8	1	1	0.4	0.6
Org. Matter	0.9	0.8	1	1	0.4	0.6
TOP 3 factors	0.9	1	1	1	0.9	1

a. Mud Lake 2 data were used.

Appendix H

Example of the Use of Functional Groups for TRV, EBSL, and SLQ Calculations

Appendix H

Example of the Use of Functional Groups for TRV, EBSL, and SLQ Calculations

R. L. VanHorn

This appendix will include an example of the exposure and analysis sections of the screening level ecological risk assessment (SLERA) methodology. This includes the devlopment of TRVs for INEL functional groups for two contaminants, and the calculation of ecologically-based screening levels (EBSLs) for the contaminant/functional group combinations. These EBSLs will then be used with a hypothetical contaminant concentration to calculate screening level quotients (SLQs).

H-1. TOXICITY REFERENCE VALUE DEVELOPMENT

As discussed in Section 3.3.2, TRV development is initiated by reviewing the available toxicological literature and relevant data bases for each contaminant. Based on each study selected, six adjustment factors for extrapolation from experimental studies to field exposures at INEL are defined as shown in Table H-1. Using these AFs the algorithm used for deriving a TRV is:

$$TRV = \frac{QCE}{AF} \tag{1}$$

where

QCE = quantified critical exposure level

AF = [I] x [R] x [Q_1] x [Q_2] x [Q_3] x [U] x [M].

Table H-2 presents the development of the TRVs for chromium VI and lead. Information used to derive TRVs for non-radioactive inorganic contaminants and non-radioactive organic contaminants is summarized. The TRVs for each contaminant/functional group combination are presented in tabular form in Tables H-3 and H-4. Shading in these tables corresponds to TRVs chosen for each functional group to use in the analysis. When the test organism and the members of the functional group were in the same taxonomic order and trophic category (R = 1), the corresponding TRV was chosen, as shown in heavier shading. Otherwise, the minimum TRV for each contaminant was chosen for all mammalian or avian receptors. If a TRV can not be developed, this is considered a data gap and the functional group cannot be analyzed. The final TRVs chosen from Tables H-3 and H-4 should be summarized in a final TRV table as shown in Table H-5. Note that the plant TRVs were taken from the literature.

Table H-1. AF values and criteria for their use in developing TRVs for INEL.

Adjustment Factor	Qualitative Ranking	Value	Criteria
I	Low	1	Variability is low
	Medium	2	Variability is moderate or average
	High	3	Variability is high, or information on variability is inadequate
R	Low	1	Test organism and receptor are in same taxonomic order and trophic category
	Medium	2	Test organism and receptor are in same trophic category but different taxa
	High	3	Test organism and receptor are in different trophic categories
Q_1	Low	0.1	Experimental endpoint is highly unlikely to occur in the field
	Medium	0.5	Experimental endpoint is moderately unlikely to occur in the field
	High	1	Experimental endpoint is likely to occur in the field
Q_2	Low	1	Study was of chronic duration
	Medium	2	Study was of subchronic duration
	High	3	Study was of acute duration
Q_3	Low	1	NOAEL
	Medium	2	LOAEL
	High	3	Adverse effect level or frank effect level
U	Low	1	High quality studies
	Medium	2	Studies of reasonable quality
	High	3	Studies with flawed design or incomplete information
M	--	0.5	Soluble metal salt administered in drinking water
	--	1	Exposure medium comparable to those at INEL

Table H-2. Example of toxicity reference value development for functional groups at the INEL.

COPC: **Chromium (VI)** CAS 7440-47-3

Test Organisms: Dog
Exposure Medium: Water
Test Endpoint: NOAEL
References: Steven, J.D., L.J. Davies, E.K. Stanley, R.A. Abbott, M. Ihnat, L. Bidstrup, and J.F. Jaworski, 1976, *Effects of Chromium in the Canadian Environment,* NRCC No. 15017, National Resources Council, Ottawa, Canada.

Eisler, R., 1986, *Chromium Hazards to Fish, Wildlife, and Invertebrates: A Synoptic Review,* U.S. Fish and Wildlife Service Biological Report, 85(1.6).

QCE: 0.30 mg/kg-day

Adjustment Factors (AF)				Justification for adjustment factor
R	1	2	3	R = 1 is AF for same order and trophic level R = 2 is AF for different order or trophic level R = 3 is AF for different order and trophic level
I	3	3	3	No information (secondary source)
Q_1	1	1	1	No endpoint observed
Q_2	1	1	1	Chronic duration (4 years)
Q_3	1	1	1	NOAEL
U	3	3	3	Secondary source
M	0.5	0.5	0.5	Chromium administered in water
Total AF	4.5	9.0	13.5	$R * I * Q_1 * Q_2 * Q_3 * U * M$ = Total AF
QCE (mg/kg-day)	0.30	0.30	0.30	QCE = quantified critical endpoint
TRV	0.07	0.03	0.02	Toxicity Reference Value = QCE/Total AF

Appropriate Functional Groups:

R Value	TRV (mg/kg-day)	Justification	Appropriate Functional Group
1	0.07	Test organism is in the same order and trophic level as the functional group members	M422A
2	0.03	Test organism is in a different order or trophic level from the functional group members	M322, M422
3	0.02	Test organism is in a different order and trophic level from the functional group members	M121, M122, M122A, M123, M210, M210A, M222

Table H-2. (continued).

COPC:	**Chromium (VI)** CAS 7440-47-3
Test Organisms:	Mice
Exposure Medium:	Water
Test Endpoint:	FEL-r
Reference:	Trivedi, B., D.K. Saxena, R.C. Murthy, and S.V. Chandra, 1989, *Embroyotoxicity and Fetotoxicity of Orally Administered Hexavalent Chromium in Mice,* Reproductive Toxicology, 3(4);275-278.
QCE:	59 mg/kg-day

Adjustment Factors (AF)				Justification for adjustment factor
R	1	2	3	R = 1 is AF for same order and trophic level R = 2 is AF for different order or trophic level R = 3 is AF for different order and trophic level
I	1	1	1	Adequate numbers, variability assessed appropriately and not high.
Q_1	1	1	1	Ecologically relevant endpoint
Q_2	2	2	2	Subchronic exposure duration
Q_3	3	3	3	FEL endpoint
U	2	2	2	Well designed study, appropriate endpoints well characterized, but no NOAEL identified.
M	0.5	0.5	0.5	Cr administered in water
Total AF	6	12	18	$R * I * Q_1 * Q_2 * Q_3 * U * M$ = Total AF
QCE (mg/kg-day)	59	59	59	QCE = quantified critical endpoint
TRV	9.83	4.92	3.28	Toxicity Reference Value = QCE/Total AF

Appropriate Functional Groups:

R Value	TRV (mg/kg-day)	Justification	Appropriate Functional Group
1	9.8	Test organism is in the same order and trophic level as the functional group members	none
2	4.9	Test organism is in a different order or trophic level from the functional group members	M121, M123, M422, M422A
3	3.3	Test organism is in a different order and trophic level from the functional group members	M122, M122A, M210, M210A, M222, M322

Table H-2. (continued).

COPC: **Chromium (VI)** CAS 7440-47-3
Test Organisms: Chicken
Exposure Medium: Diet
Test Endpoint: NOAEL
Reference: Rosomer, G.L., W.A. Dudley, L.J. Machlin, and L. Loveless, 1961, *Toxicity of Cadmium and Chromium for the Growing Chick,* Poultry Science, 40:1171-1173.
QCE: 49 mg/kg-day

Adjustment Factors (AF)				Justification for adjustment factor
R	1	2	3	R = 1 is AF for same order and trophic level R = 2 is AF for different order or trophic level R = 3 is AF for different order and trophic level
I	3	3	3	Secondary source
Q_1	1	1	1	No endpoint observed
Q_2	2	2	2	Subchronic exposure duration
Q_3	1	1	1	NOAEL endpoint
U	3	3	3	Old study described in secondary source
M	1	1	1	Appropriate exposure medium for INEL
Total AF	18	36	54	R * I * Q_1 * Q_2 * Q_3 * U * M = Total AF
QCE (mg/kg-day)	49	49	49	QCE = quantified critical endpoint
TRV	2.72	1.36	0.91	Toxicity Reference Value = QCE/Total AF

Appropriate Functional Groups:

R Value	TRV (mg/kg-day)	Justification	Appropriate Functional Group
1	2.7	Test organism is in the same order and trophic level as the functional group members	none
2	1.4	Test organism is in a different order or trophic level from the functional group members	AV422, AV432, AV433,AV442
3	0.91	Test organism is in a different order and trophic level from the functional group members	AV121, AV122, AV132, AV142, AV143, AV210, AV210A, AV221, AV222, AV222A, AV232, AV233, AV241, AV242, AV310, AV322, AV333, AV342

Table H-3. Summary of toxicity reference values (TRVs in mg/kg-day) for mammalian functional groups.

Chemical	TRV for M121	TRV for M122	TRV for M122A	TRV for M123	TRV for M210	TRV for M210A	TRV for M222	TRV for M322	TRV for M422	TRV for M422A
Chromium (VI) (dog)	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.07
Chromium (VI) (mouse)	4.9	3.3	3.3	4.9	3.3	3.3	3.3	3.3	4.9	4.9
Lead (cattle)	0.08	0.08	0.08	0.08	0.06	0.06	0.06	0.06	0.06	0.06
Lead (dog)	0.0089	0.0089	0.0089	0.0089	0.0089	0.0089	0.0089	0.013	0.013	0.027
Lead (rat)	0.05	0.03	0.03	0.05	0.03	0.03	0.03	0.03	0.05	0.05

Table H-4. Summary of toxicity reference values (TRVs in mg/kg-day) for avian functional groups.

Chemical	TRV for AV121	TRV for AV122	TRV for AV132	TRV for AV142	TRV for AV143	TRV for AV210	TRV for AV210A	TRV for AV221	TRV for AV222	TRV for AV222A	TRV for AV232
Chromium-VI (chicken)	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91
Lead (chicken)	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48
Lead (European starling)	0.04	0.03	0.03	0.03	0.03	0.04	0.08	0.04	0.04	0.04	0.04
Lead (mallard duck)	0.93	0.93	0.93	1.9	1.9	0.62	0.62	0.62	0.62	0.62	0.62

Chemical	TRV for AV233	TRV for AV241	TRV for AV242	TRV for AV310	TRV for AV322	TRV for AV333	TRV for AV342	TRV for AV422	TRV for AV432	TRV for AV433	TRV for AV442
Chromium-VI (chicken)	0.91	0.91	0.91	0.91	0.91	0.91	0.91	1.4	1.4	1.4	1.4
Lead (chicken)	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.72	0.72	0.72	0.72
Lead (European starling)	0.04	0.04	0.04	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Lead (mallard duck)	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62

Table H-5. Toxicity reference values (TRVs) for nonradionuclides (mg/kg-d).

Functional groups	*Antimony*	*Cadmium*	*Chromium VI*	*Copper*	*Lead*
Avian herbivores (AV121)	—	1.80E-01	9.10E-01	6.70E-01	4.00E-02
Avian herbivores (AV122)	—	1.80E-01	9.10E-01	6.70E-01	3.00E-02
Avian herbivores (AV132)	—	1.80E-01	9.10E-01	6.70E-01	3.00E-02
Avian herbivores (AV142)	—	1.80E-01	9.10E-01	6.70E-01	1.90E+00
Avian herbivores (AV143)	—	1.80E-01	9.10E-01	6.70E-01	1.90E+00
Avian insectivores (AV210)	—	1.80E-01	9.10E-01	6.70E-01	4.00E-02
Avian insectivores (AV210A)	—	1.80E-01	9.10E-01	6.70E-01	8.00E-02
Avian insectivores (AV221)	—	1.80E-01	9.10E-01	6.70E-01	4.00E-02
Avian insectivores (AV222)	—	1.80E-01	9.10E-01	6.70E-01	4.00E-02
Avian insectivores (AV222A)	—	1.80E-01	9.10E-01	6.70E-01	4.00E-02
Avian insectivores (AV232)	—	1.80E-01	9.10E-01	6.70E-01	4.00E-02
Avian insectivores (AV233)	—	1.80E-01	9.10E-01	6.70E-01	4.00E-02
Avian insectivores (AV241)	—	1.80E-01	9.10E-01	6.70E-01	4.00E-02
Avian insectivores (AV242)	—	1.80E-01	9.10E-01	6.70E-01	4.00E-02
Avian carnivores (AV312)	—	1.80E-01	9.10E-01	6.70E-01	4.00E-03
Avian carnivores (AV322)	—	1.80E-01	9.10E-01	6.70E-01	3.00E-02
Avian carnivores (AV333)	—	1.80E-01	9.10E-01	6.70E-01	3.00E-02
Avian omnivores (AV422)	—	2.70E-01	1.40E+00	1.00E+00	3.00E-02
Avian omnivores (AV432)	—	2.70E-01	1.40E+00	1.00E+00	3.00E-02
Avian omnivores (AV433)	—	2.70E-01	1.40E+00	1.00E+00	3.00E-02
Avian omnivores (AV442)	—	2.70E-01	1.40E+00	1.00E+00	3.00E-02
Mammalian herbivores (M121)	1.80E-01	3.10E-01	2.00E-02	1.30E+00	8.90E-03
Mammalian herbivores (M122)	1.20E-01	2.10E-01	2.00E-02	1.30E+00	8.90E-03
Mammalian herbivores (M122A)	1.20E-01	2.10E-01	2.00E-02	1.30E+00	8.90E-03
Mammalian herbivores (M123)	1.80E-01	3.10E-01	2.00E-02	1.30E+00	8.90E-03
Mammalian insectivores (M210)	1.20E-01	2.10E-01	2.00E-02	1.30E+00	8.90E-03
Mammalian insectivores (M210A)	1.20E-01	2.10E-01	2.00E-02	1.30E+00	8.90E-03
Mammalian insectivores (M222)	1.20E-01	2.10E-01	2.00E-02	1.30E+00	8.90E-03
Mammalian carnivore (M322)	1.20E-01	2.10E-01	3.00E-02	4.00E+00	1.30E-02
Mammalian omnivores (M422)	1.80E-01	3.10E-01	3.00E-02	1.30E+00	1.30E-02
Mammalian omnivores (M422A)	1.80E-01	3.10E-01	7.00E-02	2.00E+00	2.70E-02
Reptilian insectivores (R222)	—	—	—	—	—
Reptilian carnivores (R322)	—	—	—	—	—
plants	5.00E+00	2.00E+00	2.00E+00	4.00E+01	5.00E+01

Note --- no toxicity references available

H-2. DEVELOPING ECOLOGICALLY-BASED SCREENING LEVELS (EBSLS)

Estimating EBSLs for contaminants provides a rational, consistent approach for screening of sites that may require further investigation or remedial action, and prioritization of sites based on comparison of concentrations of contaminants with EBSLs. EBSLs are ecologically-based target concentrations of contaminants in soil derived from site-specific exposure scenarios for relevant ecological receptors (functional groups). The exposure equations are rearranged to calculate EBSLs in different media from target intakes and default exposure assumptions (Section 3.3.1.3). EBSLs will have to be developed for each media exposure as appropriate.

Each of the functional groups was evaluated individually. Quantification of exposures used species-specific numerical exposure factors including body weight, ingestion rate, fraction of diet composed of vegetation or prey, and soil consumed from the affected area. Species parameters used to model intakes by the functional groups are summarized in Table H-6. These parameters are used to develop EBSLs for each functional group. Potential exposures for each species within a functional group was determined based on the species' life history and feeding habits. From these species values within a functional group, the maximum percent prey, maximum percent soil, maximum exposure duration, and minimum body weight, and the minimum home ranges were chosen to represent the functional group because they result in the calculation of the most conservative EBSL.

Exposure duration (ED) estimates represent the fraction of the year animals spend in the affected area. For year-round residents, ED is assumed to be 1 (i.e., receptors spend 100% of their time on the WAG 2 assessment area). For migratory receptors that only spend one season (e.g., summer or winter) onsite, ED is assumed to be 0.50.

Food intake rates (g dry weight/day) for passerine birds, non-passerine birds, rodents, herbivores, all other mammals, and insectivorous reptiles are estimated using allometric equations (Section 3.3.1.2), if actual data is not available. The allometric equations contain body weight in their calculation. Body weight to ingestion rate is a ratio in the EBSL calculation. Due to the size ranges in certain functional groups, it is assumed that the smallest body weight will be used in the EBSL equation. The smallest body weight yields the smallest body weight to ingestion rate ratio which yields the most conservative EBSL.

Plant uptake factors (PUF) and bioaccumulation factors will be developed as discussed in Section 3.3.1.2. For these calculations the PUF for chromium VI and lead was taken from the literature. The BAF for these contaminants was set at the default of 1.0.

Site-wide EBSLs are developed using best available estimates for species-specific exposure parameters and TRVs. These site-wide EBSLs are modified for application at each WAG by dividing by the site use factor (SUF). The SUF is the assessment area (in ha) divided by the species' home range (in ha) to a maximum of 1. For this example the assessment area will be assumed to be 1000 ha. The EBSLs for the surface soil pathway, for an assessment area of 1000 ha. are presented in Table H-7. Note that chromium VI and lead are included.

Table H-6. Species parameters for use in exposure calculations.

	PP	PV	PS	ED	IR (kg/day)	BW (kg)	Home range (Ha)
Avian herbivores (AV121)	0.00E+00	9.80E-01	2.00E-02	5.00E-01	3.48E-03	1.32E-02	1.00E-03
Avian herbivores (AV122)	0.00E+00	9.07E-01	9.30E-02	1.00E+00	1.46E-03	3.50E-03	5.18E+00
Avian herbivores (AV132)	0.00E+00	9.80E-01	2.00E-02	1.00E+00	9.51E-03	6.19E-02	1.00E-03
Avian herbivores (AV142)	0.00E+00	9.18E-01	8.20E-02	1.00E+00	3.01E-02	3.64E-01	1.00E-03
Avian herbivores (AV143)	0.00E+00	9.18E-01	8.20E-02	1.00E+00	3.24E-02	4.08E-01	6.20E+02
Avian insectivores (AV210)	9.80E-01	0.00E+00	2.00E-02	5.00E-01	2.90E-03	1.00E-02	3.04E-01
Avian insectivores (AV210A)	9.80E-01	0.00E+00	2.00E-02	5.00E-01	3.71E-03	1.46E-02	1.00E-03
Avian insectivores (AV221)	9.80E-01	0.00E+00	2.00E-02	5.00E-01	2.28E-03	6.90E-03	2.02E-01
Avian insectivores (AV222)	9.27E-01	0.00E+00	7.30E-02	1.00E+00	3.07E-03	1.09E-02	4.20E-01
Avian insectivores (AV222A)	9.27E-01	0.00E+00	7.30E-02	5.00E-01	3.37E-03	1.26E-02	6.00E+00
Avian insectivores (AV232)	9.27E-01	0.00E+00	7.30E-02	5.00E-01	5.02E-03	2.32E-02	2.50E-01
Avian insectivores (AV233)	9.27E-01	0.00E+00	7.30E-02	5.00E-01	4.78E-03	2.15E-02	1.00E-03
Avian insectivores (AV241)	8.90E-01	0.00E+00	1.10E-01	5.00E-01	6.55E-03	3.49E-02	1.00E-03
Avian insectivores (AV242)	8.90E-01	0.00E+00	1.10E-01	5.00E-01	1.13E-02	8.10E-02	8.90E+01
Avian carnivores (AV310)	9.80E-01	0.00E+00	2.00E-02	1.00E+00	1.67E-02	1.47E-01	1.01E+03
Avian carnivores (AV322)	9.80E-01	0.00E+00	2.00E-02	1.00E+00	7.99E-03	4.74E-02	6.00E+01
Avian carnivores (AV333)	9.80E-01	0.00E+00	2.00E-02	5.00E-01	1.84E-02	1.71E-01	1.00E-03
Avian omnivores (AV422)	4.90E-01	4.17E-01	9.30E-02	1.00E+00	1.13E-02	8.02E-02	1.00E-03
Avian omnivores (AV432)	4.90E-01	4.17E-01	9.30E-02	5.00E-01	2.75E-02	3.16E-01	1.00E-03
Avian omnivores (AV433)	4.90E-01	4.17E-01	9.30E-02	5.00E-01	5.57E-02	9.35E-01	1.00E-03
Avian omnivores (AV442)	4.90E-01	4.17E-01	9.30E-02	5.00E-01	4.71E-02	7.24E-01	1.00E-03
Mammalian herbivores (M121)	0.00E+00	9.37E-01	6.30E-02	1.00E+00	5.55E-01	1.27E+01	1.00E-03
Mammalian herbivores (M122)	0.00E+00	9.37E-01	6.30E-02	1.00E+00	2.41E-03	1.70E-02	6.07E+00
Mammalian herbivores (M122A)	0.00E+00	9.37E-01	6.30E-02	1.00E+00	3.64E-03	2.80E-02	2.51E-03
Mammalian herbivores (M123)	0.00E+00	9.37E-01	6.30E-02	1.00E+00	1.28E-02	1.30E-01	1.00E-03
Mammalian insectivores (M210)	9.80E-01	0.00E+00	2.00E-02	5.00E-01	1.69E-03	1.10E-02	1.00E-03
Mammalian insectivores (M210A)	9.80E-01	0.00E+00	2.00E-02	1.00E+00	1.50E-03	9.50E-03	1.00E-03
Mammalian insectivores (M222)	9.37E-01	0.00E+00	6.30E-02	1.00E+00	1.02E-03	6.00E-03	2.00E-01
Mammalian carnivore (M322)	9.72E-01	0.00E+00	2.80E-02	1.00E+00	2.83E-02	3.40E-01	1.42E+01
Mammalian omnivores (M422)	4.90E-01	4.82E-01	2.80E-02	1.00E+00	2.98E-03	2.20E-02	9.29E-03
Mammalian omnivores (M422A)	4.90E-01	4.82E-01	2.80E-02	1.00E+00	9.04E-01	2.30E+01	6.48E+03
Reptilian insectivores (R222)	9.80E-01	0.00E+00	2.00E-02	1.00E+00	9.76E-05	7.00E-03	6.00E-02
Reptilian carnivores (R322)	9.80E-01	0.00E+00	2.00E-02	1.00E+00	1.98E-03	2.51E-01	3.00E+00
plants							

PP = percent prey
PV = percent vegetation
PS = percent soil
SUF = site use factor
BW = body weight
ED = exposure duration
IR = ingestion rate

Table H-7. Ecologically-based screening level (EBSLs) values for surface soil pathway.

Functional groups	Antimony	Cadmium	Chromium VI	Copper	Lead
Avian herbivores (AV121)	NTD	NTD	2.53E+02	1.24E+01	4.74E+00
Avian herbivores (AV122)	NTD	NTD	2.18E+01	3.51E+00	5.36E-01
Avian insectivores (AV210)	NTD	NTD	6.27E+00	4.62E+00	2.76E-01
Avian insectivores (AV210A)	NTD	NTD	7.16E+00	5.27E+00	6.29E-01
Avian insectivores (AV221)	NTD	NTD	5.51E+00	4.06E+00	2.42E-01
Avian insectivores (AV222)	NTD	NTD	3.23E+00	2.38E+00	1.42E-01
Avian insectivores (AV222A)	NTD	NTD	6.80E+00	5.01E+00	2.99E-01
Avian carnivores (AV310)	NTD	NTD	8.09E+00	5.96E+00	2.67E-01
Peregrine falcon & northern goshawk	NTD	NTD	4.05E+00	2.98E+00	1.33E-01
Avian carnivores (AV322)	NTD	NTD	5.40E+00	3.98E+00	1.78E-01
Bald eagle, ferruginous hawk, & loggerhead shrike	NTD	NTD	2.70E+00	1.99E+00	8.90E-02
Avian carnivores (AV333)	NTD	NTD	1.69E+01	1.24E+01	5.57E-01
Avian omnivores (AV422)	NTD	NTD	1.70E+01	9.51E+00	3.55E-01
Avian omnivores (AV432)	NTD	NTD	5.50E+01	3.07E+01	1.15E+00
Avian omnivores (AV442)	NTD	NTD	7.34E+01	4.10E+01	1.53E+00
Mammalian herbivores (M121)	5.76E+01	1.23E+01	6.53E+00	6.79E+01	1.94E+00
Mammalian herbivores (M122)	1.18E+01	2.56E+00	2.01E+00	2.09E+01	5.96E-01
Mammalian herbivores (M122A)	1.29E+01	2.80E+00	2.20E+00	2.29E+01	6.52E-01
Pygmy rabbit	6.46E+00	1.40E+00	1.10E+00	1.14E+01	3.26E-01
Mammalian herbivores (M123)	2.55E+01	5.42E+00	2.89E+00	3.01E+01	8.57E-01
Mammalian insectivores (M210)	5.48E+00	2.74E+00	2.61E-01	1.70E+01	1.16E-01
Townsend's western big-eared bat	2.74E+00	1.37E+00	1.30E-01	8.48E+00	5.80E-02
Mammalian insectivores (M210A)	2.67E+00	1.33E+00	1.27E-01	8.26E+00	5.65E-02
Mammalian insectivores (M222)	2.46E+00	1.23E+00	1.17E-01	7.61E+00	5.21E-02
Mammalian carnivore (M322)	5.04E+00	2.52E+00	3.60E-01	4.80E+01	1.56E-01
Mammalian omnivores (M422)	7.56E+00	2.92E+00	4.24E-01	1.35E+01	1.78E-01
Mammalian omnivores (M422A)	1.69E+02	6.52E+01	2.21E+01	4.63E+02	8.24E+00
Reptilian insectivores (R222)	NTD	NTD	NTD	NTD	NTD
Reptilian carnivores (R322)	NTD	NTD	NTD	NTD	NTD
Plants	5.00E+00	2.00E+00	2.00E+00	4.00E+01	5.00E+01

NTD no toxicity determined

H-3. CALCULATING SCREENING LEVEL QUOTIENTS (SLQS)

The SLQ is the ratio of the contaminant concentration to EBSL for each contaminant and is used as an indicator of potential risk to the ecosystem. SLQs are derived for all contaminants and functional groups or for the threatened and endangered species identified as present at an WAG. If there were no data available to derive TRVs or no required parameters (body weights, home ranges, percent intake of vegetable, prey, or soil), no EBSL was derived for that particular contaminant and/or functional group species. Thus, no SLQ was estimated and these data gaps are indicated as blanks. If a particular pathway was not of concern it will be indicated. SLQs are calculated using the following equation.

$$SLQ = \frac{CS}{EBSL} \tag{2}$$

where

SLQ = Screening level quotient;

CS = Average concentration of contaminant (mg/kg or pCi/g);

EBSL = Minimum ecologically-based screening level (mg/kg or pCi/g)

A SLQ less than the risk factor (traditionally one) implies little or no potential effect from that contaminant. SLQs for each pathway of exposure should be presented, Table H-8 presents the SLQs for the surface pathways using the EBSLs presented in Table H-7 and hypothetical surface soil contaminant concentrations. The SLQs can be summed across the pathways by functional group and/or T/E species, but it is important to use care with this method as discussed in Section 3.4.

Table H-8. Screening level quotients (SLQs) for surface soil pathway.

Concentration term	1.98E-03	5.18E+00	3.27E-03	9.84E-02	1.70E+03
Functional groups	Antimony	Cadmium	Chromium VI	Copper	Lead
Avian herbivores (AV121)	NTD	NTD	1.29E-05	7.97E-03	3.58E+02
Avian herbivores (AV122)	NTD	NTD	1.50E-04	2.80E-02	3.17E+03
Avian insectivores (AV210)	NTD	NTD	5.21E-04	2.13E-02	6.16E+03
Avian insectivores (AV210A)	NTD	NTD	4.56E-04	1.87E-02	2.70E+03
Avian insectivores (AV221)	NTD	NTD	5.93E-04	2.43E-02	7.01E+03
Avian insectivores (AV222)	NTD	NTD	1.01E-03	4.14E-02	1.20E+04
Avian insectivores (AV222A)	NTD	NTD	4.80E-04	1.97E-02	5.68E+03
Avian carnivores (AV310)	NTD	NTD	4.04E-04	1.65E-02	6.37E+03
Peregrine falcon & northern goshawk	NTD	NTD	8.07E-04	3.30E-02	1.27E+04
Avian carnivores (AV322)	NTD	NTD	6.05E-04	2.48E-02	9.54E+03
Bald eagle, ferruginous hawk, & loggerhead shrike	NTD	NTD	1.21E-03	4.95E-02	1.91E+04
Avian carnivores (AV333)	NTD	NTD	1.93E-04	7.91E-03	3.05E+03
Avian omnivores (AV422)	NTD	NTD	1.92E-04	1.04E-02	4.78E+03
Avian omnivores (AV432)	NTD	NTD	5.94E-05	3.21E-03	1.48E+03
Avian omnivores (AV442)	NTD	NTD	4.45E-05	2.40E-03	1.11E+03
Mammalian herbivores (M121)	3.44E-05	4.08E-01	5.00E-04	1.45E-03	8.77E+02
Mammalian herbivores (M122)	1.68E-04	1.96E+00	1.62E-03	4.70E-03	2.85E+03
Mammalian herbivores (M122A)	1.53E-04	1.79E+00	1.49E-03	4.30E-03	2.61E+03
Pygmy rabbit	3.07E-04	3.58E+00	2.97E-03	8.61E-03	5.21E+03
Mammalian herbivores (M123)	7.78E-05	9.23E-01	1.13E-03	3.28E-03	1.98E+03
Mammalian insectivores (M210)	3.62E-04	1.83E+00	1.25E-02	5.81E-03	1.46E+04
Townsend's western big-eared bat	7.24E-04	3.66E+00	2.50E-02	1.16E-02	2.93E+04
Mammalian insectivores (M210A)	7.43E-04	3.75E+00	2.57E-02	1.19E-02	3.00E+04
Mammalian insectivores (M222)	8.06E-04	4.07E+00	2.79E-02	1.29E-02	3.26E+04
Mammalian carnivore (M322)	3.93E-04	1.99E+00	9.07E-03	2.05E-03	1.09E+04
Mammalian omnivores (M422)	2.62E-04	1.72E+00	7.70E-03	7.30E-03	9.56E+03
Mammalian omnivores (M422A)	1.17E-05	7.68E-02	1.48E-04	2.12E-04	2.06E+02
Reptilian insectivores (R222)	NTD	NTD	NTD	NTD	NTD
Reptilian carnivores (R322)	NTD	NTD	NTD	NTD	NTD
Plants	3.96E-04	2.50E+00	1.63E-03	2.46E-03	3.40E+01

NTD no toxicity determined

Appendix I

INEL WAG-Wide Screening Level Ecological Risk Assessment Case Study

ACKNOWLEDGMENTS

Ecology and Environment, Inc., (E & E) prepared this document in a cooperative effort with assistance from ecologists, risk assessors, and project managers at DOE-ID and Lockheed Idaho. Donald K. Vernon, Jr. was the E & E task manager. Steven C. Peterson was the technical lead ecological risk assessor. Contributing authors at E & E included Rone Brewer, Matt Kim, Carl Mach, and Herbert Pirela. A working group consisting of Robin VanHorn and others at Lockheed Idaho and Randy Morris at the Environmental Science and Research Foundation helped to formulate the approach, provided data and interpretation, and critiqued earlier drafts of this report.

Appendix I

INEL WAG-Wide Screening Level Ecological Risk Assessment Case Study

S. C. Peterson, R. Brewer, M. Kim, C. Mack, H. Pirela

I-1. INTRODUCTION

This report presents a case study approach to explore the application of screening-level ecological risk assessments (ERAs) to Waste Area Groups (WAGs) at the U.S. Department of Energy, Idaho Operations Office (DOE-ID) Idaho National Engineering Laboratory (INEL) in southeastern Idaho. This case study was designed as an example of the use of procedures delineated within the Screening-level Ecological Risk Assessment Guidance Manual (manual). The use of a case study approach is integral to the development of the manual [Ecology and Environment, Inc. (E & E) 1993]. The case study was developed using current federal ecological risk assessment guidance [U.S. Environmental Protection Agency (EPA) 1992a].

I-1.1 Statutory and Regulatory Background

Under the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), as amended by the Superfund Amendment and Reauthorization Act of 1986 (SARA), defines EPA's responsibility to establish the National Priorities List (NPL) to classify hazardous waste sites within the United States with regard to the need for remediation. The NCP calls for the identification and mitigation of environmental impacts at CERCLA sites and selection of remedial actions protective of human health and the environment.

In 1989, the INEL was added to the NPL, which required the hazardous waste sites at the INEL to be investigated and potentially remediated. In December 1991, the Federal Facilities Agreement and Consent Order (FFA/CO) was signed by U.S. Environmental Protection Agency (EPA), the State of Idaho Department of Health and Welfare (IDHW), and DOE-ID. The FFA/CO integrates the responsibilities of the involved agencies and the regulations enforced by each. It attempts to establish the appropriate lines of communication between the agencies and to minimize duplication of effort. The FFA/CO also provides the framework for future investigation and remediation.

Under the FFA/CO Action Plan, procedures were described to investigate and narrow the scope of any potential investigation and remediation. The initial screening included placing each suspected area of contamination into operable units (OUs) and each OU into a specific WAG. Preliminary Track 1 Scoping reduced the number of OUs that may have required investigation. Preliminary Track 2 Scoping involved limited sampling to further characterize the remaining OUs and remove as many as possible from consideration of further action. Screening-level ERAs, as described in this case study, are part of the WAG-wide Remedial Investigation/Feasibility Study (RI/FS) scoping process and are intended to further reduce the number of WAGs requiring

detailed ecological investigation and to describe data needs which may be fulfilled during the RIs. Following RI/FS scoping, the FFA/CO Action Plan calls for the RI/FS process to be completed, a Record of Decision (ROD) executed between the FFA/CO parties, and subsequent remediation of hazardous areas where necessary.

Some federal and state laws and regulations that aid this process are termed "applicable or relevant and appropriate requirements" (ARARs), or requirements "To Be Considered" (TBCs). Examples of potential ecological ARARs include the Endangered Species Act, the Clean Water Act, and the Migratory Bird Treaty Act. Consideration of these regulations was given in the development of the case study. The TBCs are non-promulgated or non-enforceable guidelines or criteria that may be relevant to the assessment. Both ARARs and TBCs must be considered in any CERCLA action.

I-1.2 Objectives

The primary objective of the case study is to provide an example of the application of screening-level ERA methods to a hypothetical WAG. These methods can then be used for real WAG-wide screening-level ERA in support of the RI/FS scoping process at the INEL. Other objectives of the case study include:

- Providing a possible template for future screening-level ERAs conducted at the INEL.
- Allowing for the exploration of appropriate screening-level ERA methods applicable to the INEL ERA needs.

The development of a case study for screening-level ERA at the INEL will provide several benefits to future users of this guidance. The first benefit is that risk assessors will have examples of the procedures outlined in the manual. These examples will enhance understanding of the screening-level ERA process, and will promote better communication among risk assessors, site managers, DOE-ID, and other involved parties. Risk assessors and managers will also be able to prepare better schedule and budget projections for the risk assessments. Second, problems encountered during the case study can be expected during assessment of the WAGs, and some specific problem-solving methodologies may be developed. This process will promote efficient screening-level ERAs with fewer decision points that may require time-consuming discussions regarding appropriate approaches. Finally, the case study should promote better understanding of the approach to be applied across sites at the INEL. This understanding will promote easier interpretation and should facilitate public and agency/trustee approval of the methods and results of the screening-level ERAs.

I-1.3 Scope

The case study was developed in parallel with the manual and served as a template for testing screening-level ERA approaches and methods. The procedures outlined herein are considered screening-level because the potential risks are determined with simple calculation methods using data that are already available from previous investigations. During the case study an attempt was made not to duplicate all pertinent information provided in the manual or in

other guidance. However, because the case study is intended to be read with minimal reference to the manual, relevant information from the manual was included.

For the case study to be most useful as a prototype for the WAG-wide screening-level ERAs, it was considered desirable to evaluate a variety of contaminants, contaminated areas, and ecological endpoints on a spatial scale representative of the WAGs. Because evaluation of a real WAG was not within the scope of the case study, a hypothetical WAG (WAG H) was assembled from several areas previously investigated at the INEL. Data from contaminated sites within OUs in real WAGs were used. Following a review of Track 2 sites listed in the FFA/CO, three sites were selected as representative of a broad array of ecological concerns at the INEL. Each of these sites was labeled as an OU at WAG H. The identity of the WAG H OUs and the general site types represented are described in Table I-1. Further description of WAG H is provided in Section 2 of the case study.

The scope of the case study was carefully limited to meet the objectives identified in Section I-1.2. With this in mind, only a few representative contaminants of concern, pathways, and endpoints were selected for evaluation. The examples presented in the case study are not intended to be a comprehensive coverage of all possible ecological risk assessment procedures; however, they represent a technically achievable and reasonable screening approach for conservatively assessing ecological risks of chemical and radiological contamination at the INEL. The data set used in the Case Study, while based on real data, is an example data set used to illustrate the screening-level ecological risk assessment process.

The selection of the contaminants of concern, exposure pathways, endpoints, and calculations of potential risks are presented formally as if WAG H were a real site. However, even though data from previous investigations at the INEL are used in the case study, no conclusions can be drawn concerning real or potential ecological risks at the INEL because the case study is only meant to illustrate the application of screening-level ERA methods.

Table I-1. Identity of the Operable Units[a] used for the WAG H Site types.

Operable Unit number	Site name	Site type
1-03	Technical Service Facility Burn Pit	Burn Pit
2-10, 2-11	Test Reactor Area Warm Waste Pond Complex	Liquid Radioactive Waste Pond
7-10	Pit 9	Waste Burial Pit

a. *Federal Facility Agreement and Consent Order for the Idaho National Engineering Laboratory*, December 4, 1991.

I-1.4 Technical Approach

The technical approach for the case study is consistent with the principles and organization of the manual, which in turn is based on EPA's *Framework for Ecological Risk Assessment* (EPA 1992a), DOE-ID's *INEL WAG-Wide Baseline Ecological Risk Assessment Interim Guidance* (E & E 1993), other pertinent guidance (EPA 1986b, 1989a, 1989b), and published ecological risk information (Bartell et al. 1992, Calabrese and Baldwin 1993, Suter 1993). The three phases of the EPA's framework include Problem Formulation, Analysis, and Risk Characterization; and these phases represent the three main sections of the case study.

I-1.4.1 Problem Formulation

The goals, breadth, and focus of the ecological risk assessment are established in "Problem Formulation" (Section 2). Problem Formulation first presents the physical site description and a summary of previous ecological investigations. This phase provides background information for understanding the nature of the site, the sources of contamination, and the contaminants that might pose ecological risks. Data from previous investigations are then reviewed to determine the contaminants of potential concern (COPCs). This effort involves an initial data review to locate, assemble, and determine the usability of the available data. Following this review, concentrations of organic, inorganic, and radionuclide contaminants are compared to local, regional, or national background concentrations to remove those that are not elevated above background. This comparison results in a reduction in the numbers of contaminants to be considered as COPCs for WAG H.

Next, a risk-based screening is implemented to further screen contaminant concentrations. This procedure compares available ecological effects criteria or benchmarks for specific media to WAG H contaminant concentrations. The risk-based screening concentrations are obtained from agency guidance and open literature. Those contaminants with concentrations greater than the criteria or benchmarks are considered for selection as COPCs.

To focus the risk assessment on the most significant components, important ecological aspects are described at the regional, local, and area-specific scales. The presence of legally protected threatened, endangered, sensitive, or rare species is discussed; and their potential for exposure at the site is evaluated. Potential pathways of contaminant release, migration, and exposure are then identified; and potential ecological effects of the COPCs are also described. As a result of this understanding of the site ecosystems and the potential vulnerability of ecological receptors to COPCs, ecological endpoints appropriate for evaluation at the site are selected. The Problem Formulation phase concludes with a conceptual model, which includes a set of working hypotheses that relate contaminants to potential effects for specific ecological endpoints at the site.

I-1.4.2 Analysis

Exposure estimates for selected receptor species and the toxicity of COPCs are presented in the Analysis Phase (Section 3). To estimate exposure, an average concentration is calculated for each selected COPC using available data from all sampled areas within the WAG. The average

concentrations are then used as the exposure point concentrations for the risk assessment. The use of the average concentration of all available data across the WAG to calculate the exposure point concentrations is conservative since sampling data at the WAGs have been collected in areas of known or suspected contamination. This approach results in estimated exposure doses that are most likely higher than the actual doses received by most ecological receptors at the site. Therefore, the average COPC concentrations are used to estimate a reasonable maximum exposure (RME) for populations of receptors inhabiting the WAG. Exposure doses are then calculated in various exposure media (e.g., soil, sediment, surface water, and selected biota) using conservative estimates. The toxicity reference values (TRVs) for each of the COPCs are also derived from the ecotoxicological literature. The TRVs are dosages of specific contaminants, which are associated with significant toxic responses.

I-1.4.3 Risk Characterization

In "Risk Characterization" (Section 4), the estimated exposure doses are compared to the TRVs. Doses higher than the TRVs indicate a potential for ecological risks at the WAG and so further investigation may be warranted. The screening-level ERA process culminates in a review of the potential significance of ecological risks at the site. Ecological risk management must take into account contaminant concentrations or exposure doses which exceed regulatory criteria or TRVs, respectively. However, these alone do not indicate the need for further investigation. Consideration must also be given to the significance of the risks and to the uncertainties of the risk assessment. If a review of these factors indicates that the exposure and/or toxic effects will not significantly affect wildlife or plant populations (or individuals of a threatened, endangered, or sensitive species), then the potential risks may not be sufficient to require further ecological assessment. If potential risks are indicated, however, a decision may be made to proceed to a more detailed assessment to better define the risks and the need for remediation.

I-2. PROBLEM FORMULATION

Problem Formulation is the first step in the screening-level ERA process and establishes the goals, breadth, and focus of the assessment. These are presented in the following sections by identifying and describing the physical nature of the site (Section I-2.1); gaining knowledge about the site through previous investigations (Section I-2.2); determining the COPCs and other stressors (Section I-2.3); identifying the ecosystem components (Section I-2.4); describing the potential contaminant transport pathways (Section I-2.5) and ecological effects of the COPCs (Section I-2.6); and selecting the assessment and measurement endpoints (Section I-2.7). Finally, this information is integrated into a conceptual model (Section I-2.8), which describes a set of working hypotheses regarding the ecosystems potentially at risk and the exposure pathways to be examined for the case study. An overview of the Problem Formulation phase is shown in Figure I-1.

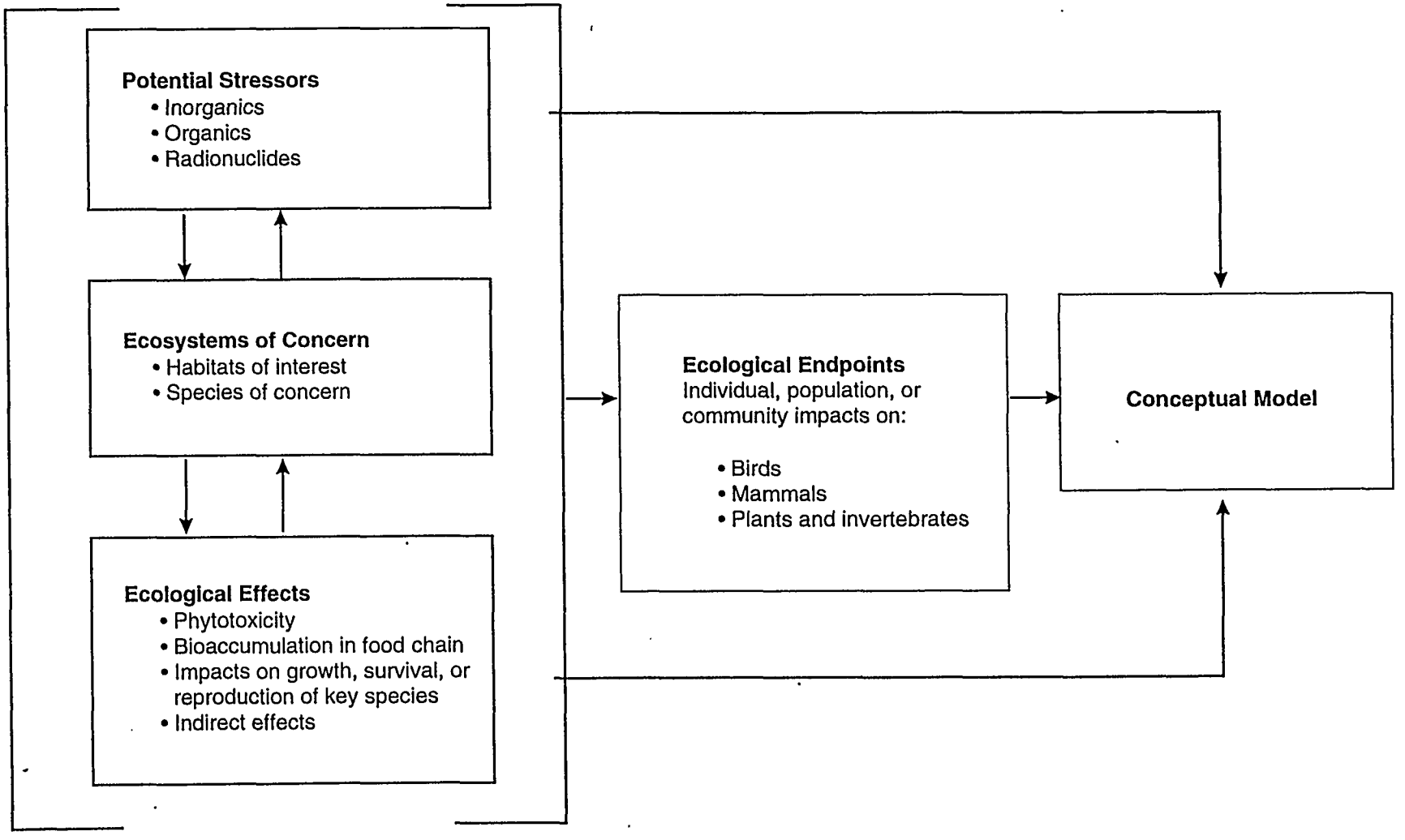
I-2.1 Site Description

The DOE-ID's 2,305 km^2 INEL site is located on the Upper Snake River Plain in southeastern Idaho (Figure I-2). The primary missions of the INEL include reactor fuel reprocessing, breeder reactor research, fuel and structural material testing, radioactive waste management, and nuclear reactor testing. The INEL is located in portions of Butte, Bonneville, Bingham, Jefferson, and Clark counties. The nearest city is Idaho Falls, approximately 100 km to the east. The INEL is bounded to the west and northwest by three mountain ranges that run toward the northwest: the Lost River, the Lemhi, and the Bitterroot. To the east and south lies the Snake River Plain. The Big Lost River is the largest natural waterway on the INEL. The Big Lost River enters the INEL at the southwest corner and flows toward the northeast. Flow of the river is intermittent dependent upon annual precipitation, but historically flowed more consistently and supported diverse populations of aquatic organisms. For the past several years high flows have been diverted before reaching INEL facilities to prevent flooding.

WAG H is assumed to consist of an operating nuclear reactor testing facility that has been in operation since the 1950s. The central complex of buildings (facilities), which covers approximately 64 ha, is surrounded by a fence. The total area of WAG H is approximately 506 ha. Three OUs are assumed to be at WAG H: OU-1 (the waste burial pit), OU-2 (the burn pit), and OU-3 (the liquid radioactive waste pond). These are located within 500 m outside the fenced facility area, to the east or southeast (Figure I-3).

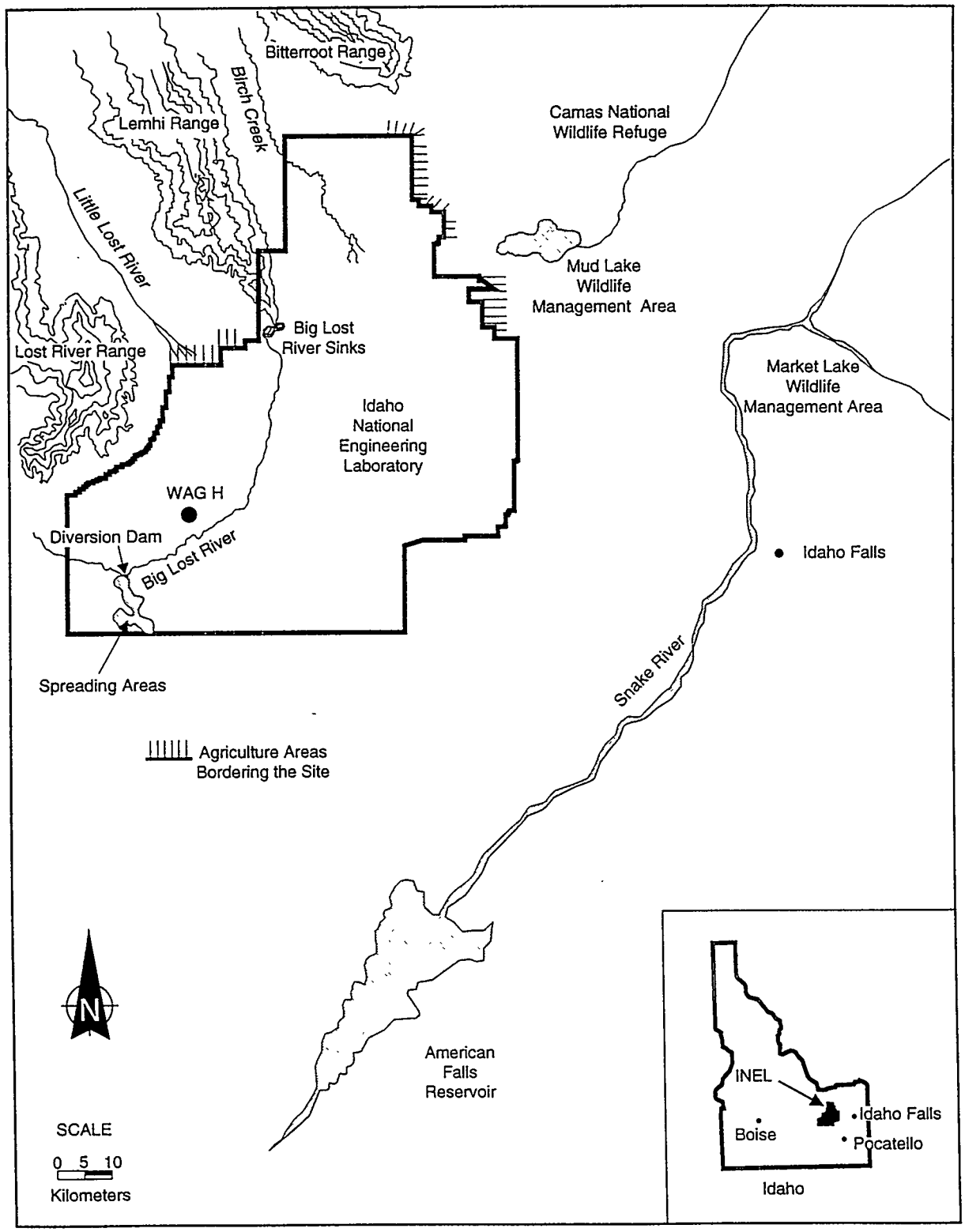
The waste burial pit (OU-1) operated from November 1967 to June 1969. The 40 × 120-m (0.48 ha) burial pit is located 400 m east of the northeast corner of the facilities and contains approximately 4,270 m^3 of buried waste. Eighty percent of the waste was transported to the pit from other sites. The estimated 3,921 drums and 2,029 boxes of radioactive and other mixed wastes in the pit are currently covered with 1.8 m of soil. Grassland vegetation has been established on the soil cap, and a fence surrounds OU-1 to limit human and wildlife access.

The burn pit (OU-2) is an 8 × 20-m area (0.016 ha) located 450 m east of the southeast corner of the complex. It was used for the open burning of combustible waste from 1953 to 1958. This included refuse, construction debris, and combustible liquids including oils and solvents. No records were kept regarding the volumes of burned materials. Likely contaminants include



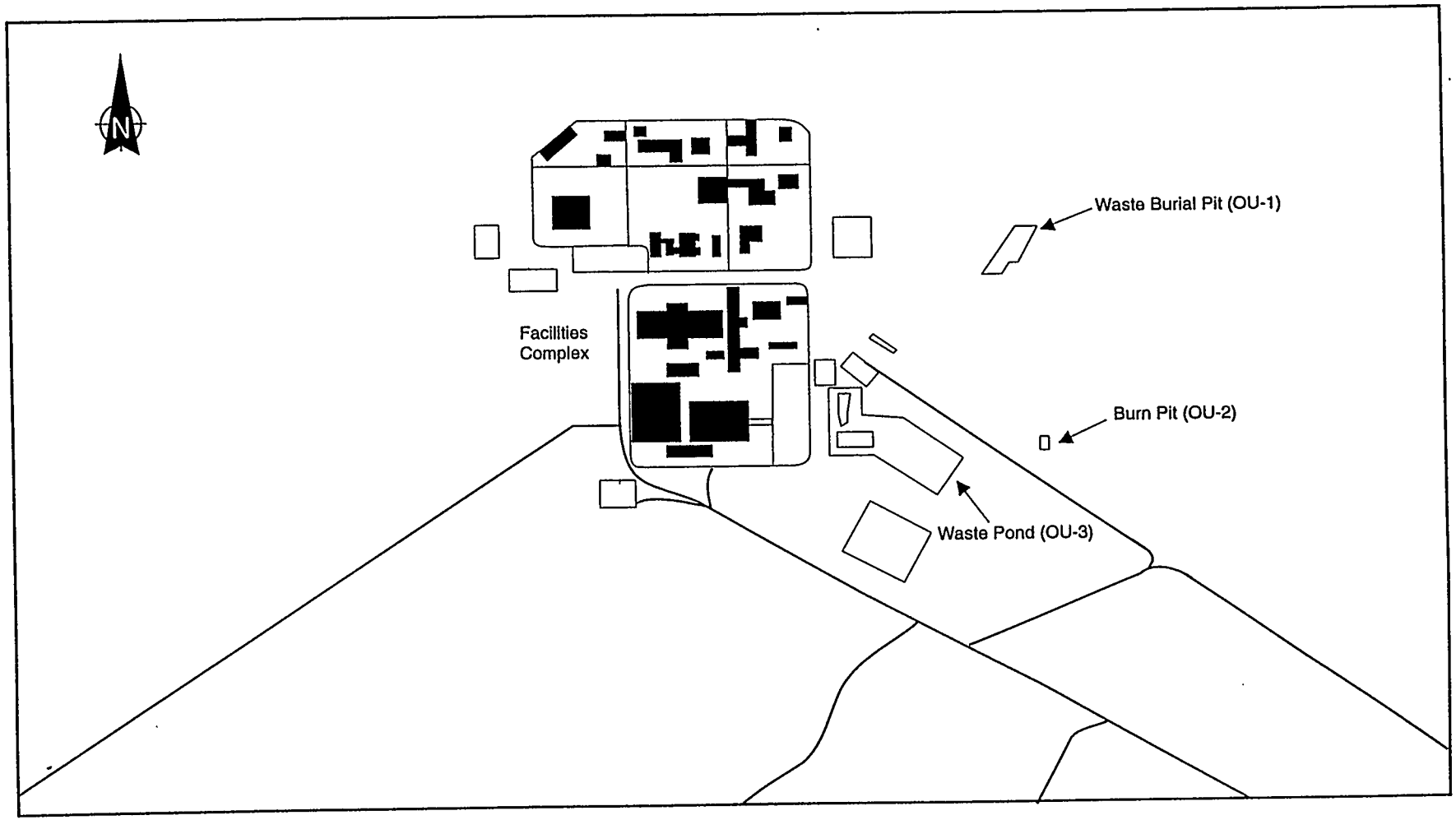
SOURCE: Ecology and Environment, Inc. 1993

Figure I-1. Problem formulation phase.



SOURCE: Ecology and Environment, Inc. 1994.

Figure I-2. WAG H location map.



SOURCE: Ecology and Environment, Inc. 1994.

Figure I-3. WAG H and associated OUs.

metals, volatile organic compounds (VOCs), and possibly radionuclides. This OU is not covered with a soil cap, nor is it fenced.

The liquid radioactive waste pond (OU-3) is an artificial pond used for disposal of low-level liquid radioactive wastes from light-water moderated and cooled reactors. The pond was created in 1952 and was used until 1991, when new lined ponds were created. The pond is 46 × 76 m (0.35 ha) and averages 4.6 m in depth. Approximately 46,400 curies of beta-gamma activity, primarily activation and fission products, were released to the pond from 1952 to 1976. No estimates of radioactive waste releases were available after 1976. The pond drains by percolation into the subsurface soil and is fenced to limit human and wildlife access.

In addition to these three OUs, WAG H is assumed to encompass other potentially contaminated areas outside of the three OUs described above, including sites removed from further consideration during preliminary Track 1 and Track 2 scoping, but for which limited sampling information may be available. Because of the limited extent of these areas, they are not described in detail in the case study, but the maximum contaminant concentrations from the areas were used to further characterize WAG H.

I-2.2 Previous Ecological Investigations

The evaluation of pertinent literature is an important aspect of the screening-level ERA because the available information can provide a better understanding of the issues posed by the site. In addition, some of the data provided in previous publications may be usable for estimating exposure or effects in the screening-level ERAs. Because of this, a literature review was conducted of documents with information relevant to the case study. The documents reviewed included published articles related to the potential for exposure of wildlife to contaminants and the potential effects of the contaminants on the wildlife and vegetation of the INEL. While many articles were reviewed, for brevity only those specific to the WAG H OUs are presented below as background information which may be useful in the weight of evidence approach used for determining the potential for ecological risks at WAG H. Site characteristics of the three OUs evaluated in the case study have changed significantly since many of the studies were published. For example, the cap of the waste burial pit has been thickened, and the waste pond has been drained and capped. These physical changes in site characteristics are important to take into account when evaluating the relevance of historical information at the INEL. However, for the purposes of the case study, the OUs are assumed to exist as described in the articles.

I-2.2.1 INEL-Wide Investigations

DOE-ID has supported ecological research at the INEL for more than 20 years. These studies include investigations of the basic ecology of the species inhabiting INEL, the exposure of these species to contaminants, and the transport and fate of contaminants. Nearly 300 publications were collected regarding the ecology and ecotoxicology of the INEL (summaries of these publications are presented in Appendix F of the manual).

This information was used qualitatively to identify receptors and to develop exposure models for representative species at WAG H. In certain instances, the ecological investigations also provided quantitative contaminant data of potential use for the screening-level risk assessments. For example, published studies at various INEL sites provide data on body burdens and uptake of

radionuclides for various ecological receptors. This type of data is not generally available from the Track 1 and Track 2 scoping investigations. The review of studies presented in the Literature Evaluation discusses usability of the published ecological data for risk assessment purposes. It is important to note that even though there are many investigations of the INEL, there still may be many data gaps at any given area. Some studies pertinent to each of the WAG H OUs are outlined below.

I-2.2.2 Waste Burial Pit (OU-1)

Arthur, 1982. The concentrations of ^{238}Pu, $^{239,240}Pu$, and ^{241}Am in crested wheatgrass [*Agropyron cristatum* (L.) Gaertn] and Russian thistle (*Salsola kali* L.) growing on or near the site were significantly greater than those in control vegetation. However, the total inventory of radionuclides in site vegetation was not significantly greater than the control area. This lack of a significant difference between the site and the control area was a result of the fact that 90% or more of the radioactivity in vegetation was attributed to ^{90}Sr and ^{137}Cs, and concentrations of these radionuclides were not significantly elevated in vegetation at the site. Russian thistle concentrated more radionuclides than crested wheatgrass, presumably as a result of its deeper rooting and spreading growth characteristics. Radionuclide transport through vegetation was also investigated and was not considered to be a major transport pathway at the site.

Arthur and Janke, 1986. Eighteen wildlife species were sampled for radionuclides from the waste burial pit area over a 24-month period. Deer mouse (*Peromyscus maniculatus*) carcasses and hides had the highest concentrations of radionuclides (^{90}Sr, ^{137}Cs, ^{238}Pu, $^{239,240}Pu$, and ^{241}Am). These concentrations were significantly higher than control values. Cottontail (*Sylvalagus nuttallii*) carcasses also had ^{241}Am levels above background. Horned lark (*Eremophila alpestris*), sage grouse (*Centrocercus urophasianus*), and mourning dove (*Zenaida macroura*) tissue samples did not have radionuclide concentrations above control levels, and all radionuclides except ^{241}Am were below control levels in coyote feces.

Arthur et al., 1986. Deer mice and kangaroo rats [*Dipodomys ordii* (Woodhouse)] were live trapped intermittently for 14 months from the cap of the waste burial pit. Deer mice were the most numerous. Thermoluminescent dosimeters (TLDs) were implanted in a representative sample of the trapped small mammals, and 53% of the TLDs were recovered. An estimated 49% of the deer mice and 20% of the kangaroo rats were exposed to areas of buried waste and/or contaminated soil.

Dose rates to small mammals on or near the waste burial pit were significantly higher than those in a control area. Also during the winter, dose rates were higher, and a higher percentage of the small mammals at the burial pit received doses greater than control mammals. This was thought to be due to more time spent in the subsurface soils during the colder months.

Groves and Keller, 1983. Species composition, diversity, biomass, and densities of small mammal populations were examined over a 15-month period in crested wheatgrass and Russian thistle on the waste burial pit area and on a sagebrush (*Artemisia tridentata*) control area. The deer mouse was the most numerous species in all habitats. Species diversity was highest in the

control sagebrush habitat, but overall densities and biomass did not vary significantly among the three vegetation types or between the waste burial pit area and the control area.

I-2.2.3 Burn Pit (OU-2)

No previous investigations of OU-2 were located.

I-2.2.4 Liquid Radioactive Waste Pond (OU-3)

Halford and Markham, 1978. Small mammals were live trapped in a dry liquid radioactive waste pond and had TLDs implanted. Upon recapture of the animals, the TLDs were removed and dose rates were determined. Sixty-five percent of the TLDs were recovered. Deer mice were the most numerous species trapped. All species captured onsite received significantly greater doses than control species. The mean deer mouse dose equivalent rate was 279 mrem/day, and the highest dose equivalent rate was 982 mrem/day, which was 356 times the dose rate received by control deer mice. Deer mice also had the highest radionuclide concentrations in whole body tissues, compared to the other species of small mammals trapped during the investigation.

Halford and Markham, 1984. Wild free-ranging waterfowl were collected from the liquid radioactive waste pond and on control areas to determine the $^{129}I/^{127}I$ ratios in muscle tissue. Wing-clipped mallards (*Anas platyrhynchos*) were also released on test and control areas for two to 156 days before collection and testing.

The mean iodine ratios for wild waterfowl were not significantly different between test and control areas. However, the wing-clipped waterfowl iodine ratios from the waste pond were significantly higher than all the other tested birds. Although no significant correlation emerged between time spent on the waste pond and iodine ratios, the authors felt it was the most likely reason for the higher iodine ratios in wing-clipped mallards. The total whole-body dose from ^{129}I ranged from 1.0×10^{-5} mrad for control waterfowl to 3.0×10^{-5} mrad for waste pond waterfowl.

Halford and Millard, 1978. An inventory of the terrestrial vertebrate fauna and the seasonal occurrence of each species was determined for the radioactive waste pond. The pond was found to be a food, water, and habitat source for many species. Three reptile, 11 mammal, and 94 bird species were identified over a four-year period.

The bull snake (*Pituophis melanoleucus*) was the only reptile commonly seen at the pond. The most abundant small mammal was the deer mouse. Mule deer (*Odocoileus hemionus*) were observed drinking from the pond on several occasions. Four raptor species were seen at the pond. Northern harriers (*Circus cyaneus*) nested near the site each year of the study and were common. Kestrels (*Falco sparverius*) were the only other common raptor seen at the pond. Game birds frequenting the pond included mourning doves, sage grouse, and waterfowl. Other birds commonly using the pond area were killdeer (*Charadrius vociferous*), spotted sandpipers (*Actitis macularia*), and barn swallows (*Hirundo rustica*).

Ibrahim and Culp, 1989. Concentrations of ^{239}Pu, ^{240}Pu, and ^{238}Pu were determined in water, net plankton, suspended particulates, and sediment. The oxidation states of plutonium were also

measured and found to be mostly Pu^{+3} and Pu^{+4}, unlike larger natural water bodies which usually support plutonium in the +5 and +6 oxidation states. The highest plutonium concentrations were found in net plankton, but sediments were found to be the main reservoir for plutonium in the pond. The lowest plutonium concentrations were in filtered water. This indicates that the plutonium is taken up by or bound to the plankton in the water column, which eventually settles to the bottom sediments.

Millard et al., 1990. Concentrations and potential effects of radionuclides on barn swallows were examined. The swallows were found to feed on pond arthropods and use contaminated mud for nest building. More than 20 radionuclides were detected in immature and adult birds. ^{51}Cr was found in the highest concentrations and 72% of the total dose resulted from ^{24}Na. Total mortality rate of the swallows was not found to be different from control populations, but the first clutch of young swallows was found to have lower growth rates and lower body weights than controls. These depressed growth factors were not found to be below the normal range of values, however, and could not be attributed to exposure to radioactivity.

I-2.2.5 Summary

The studies reviewed in this section demonstrate that some radionuclides are present in the soils, vegetation, and wildlife of two of the three WAG H OUs at levels above control sites. It has also been shown that many species of wildlife utilize habitats on or near WAG H. The common species include deer mice, kangaroo rats, cottontail, killdeer, spotted sandpipers, barn swallows, waterfowl, northern harriers, kestrels, and bull snakes. The majority of concern has centered around the radionuclides ^{241}Am, ^{51}Cr, ^{129}I, ^{24}Na, ^{137}Cs, ^{238}Pu, $^{239,240}Pu$, and ^{90}Sr. Animals in direct or prolonged contact with contaminated subsurface soil or sediments appear to have the greatest exposure, including year-round resident and nesting species. Potential effects of exposure have been suggested but not demonstrated in barn swallows. Other authors have qualitatively addressed potential effects on exposed populations. In general, the radionuclide exposure of plants and wildlife at these sites has not been considered to pose a significant threat to populations. Appendix F of the manual presents a more in-depth review of the INEL literature.

Even though a considerable amount of literature confirms the exposure of wildlife to radionuclides at the INEL, few field studies have been conducted to evaluate effects. Also, few published data are available on wildlife exposure to and effects of nonradionuclide contaminants.

I-2.3 Potential Stressors at WAG H

The major chemical stressors of concern at the INEL are the radionuclides and other wastes generated by the operations of nuclear reactor testing and materials production processes. Other important stressors may result from the physical disturbances of habitat during operations, maintenance, construction, demolition and remediation at each of the facilities. These actions may result in destruction and loss of habitat and invasion of exotic plant species which may, in turn, affect the natural faunal populations of the area. However, these physical stressors are not usually evaluated in ERAs conducted for CERCLA sites; therefore their effects are not assessed in the screening-level ERA presented in the case study. Remedial activities conducted under CERCLA regulation can cause physical disturbance of habitats, which could result in more harm to the environment than if contaminants were left in place. The potential ecological impacts of

remedial actions should be carefully considered in all risk management decisions. The following sections of the case study describe the selection of those chemical and radiological stressors most likely to be associated with ecological risks at INEL and briefly discuss potential physical stressors that may contribute to the risk.

I-2.3.1 Chemical and Radiological Stressors

This section identifies the COPCs that will be evaluated in the WAG H screening-level ERA. The methodology described herein reflects national and regional risk assessment guidance (EPA, 1992b). The selection of COPCs for ecological risk assessment involves the following steps: initial data quality review, review of the spatial distribution of sampling sites and evaluation of the frequency of detection (FOD) and range of concentrations, comparisons of chemical and radionuclide concentrations with natural background levels, and comparisons of concentrations to risk-based criteria or benchmarks. The temporal distribution of sampling data was not considered for the case study. The general process for selecting COPCs is outlined in Figure I-4.

I-2.3.1.1 Initial Data Review. The sampling data evaluated for the WAG H screening-level ERA were collected during investigations of the three OUs and other areas outside of the three OUs. Digital data were gathered from the Environmental Restoration Information System (ERIS), the Radiological and Environmental Sciences Laboratory (RESL), and from other sources suggested by EG&G Idaho, Inc. personnel. Additional sources of data were investigated through the EG&G Idaho, Inc. Center for Integrated Environmental Technologies (CIET) and other personnel involved in environmental monitoring at the INEL. In some cases, data were found in hard copy format and had to be entered into ERIS or another database (Microsoft ACCESS) compatible with the risk assessment software (Microsoft EXCEL).

Data sets from separate investigations were grouped by OU and sorted by medium (surface water, sediment, and soil) and by type of contaminant (organics, inorganics, and radionuclides). No contaminant concentration data were found for biota. While such biota data would be helpful, it does not necessarily represent a data gap for screening-level ERA because these concentrations can be conservatively modeled if necessary. The formats (column headers, column order, etc.) of each data set were standardized to reduce the complications of joint evaluation of the data sets. All reported concentrations of inorganics and organics in the databases were converted to micrograms per gram (μg/g) for solid media and to micrograms per liter (μg/L) for aqueous media. For radionuclides, concentration units are picocuries per gram (pCi/g) for solid media and microcuries per milliliter (μCi/mL) for aqueous media.

Quality assurance/quality control (QA/QC) information was gathered for each of the data sets. This information was needed to assess the usability of the data and to interpret data qualifiers. In general, ERIS data sets present a reported validation level associated with each sample. Validation levels of A or B [as defined in EG&G Program Directive 3.7 (1993)], had Limitations and Validation (L and V) reports that provided the QA/QC information. Data from ERIS with Level C validation had Status Reports for the QA/QC information. Level A and B validations were intended to meet EPA Contract Laboratory Program (CLP) standards, while Level C validation was not so rigorous. If no L and V or Status Reports were available for a data set, an attempt was made to gather QA/QC and data validation information from the WAG manager, project manager, and the laboratory reports. Regardless of the level of QA/QC or

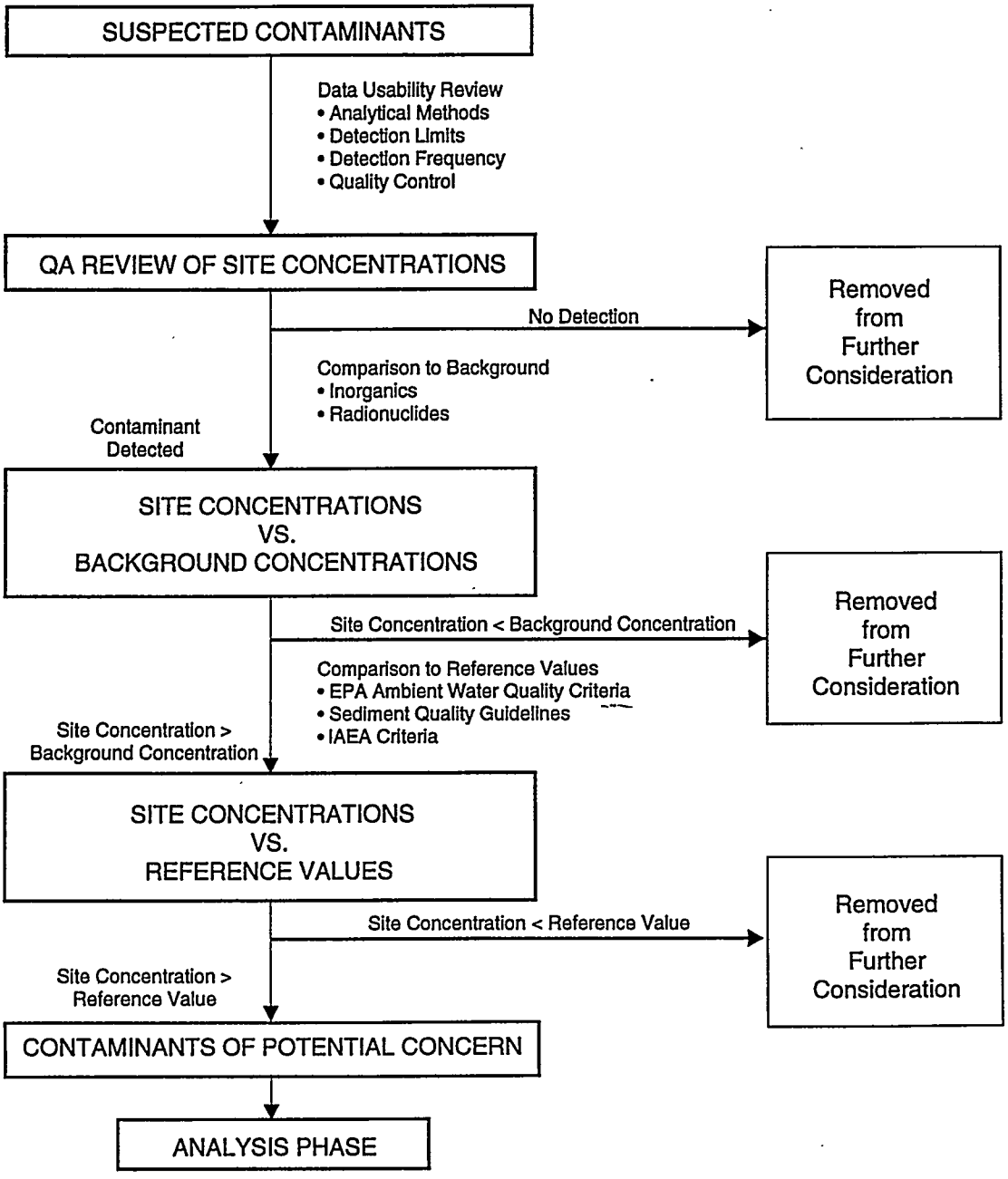


Figure I-4. Selection process for contaminants of potential concern.

validation, data qualifier definition was verified for each data set because of the potential for variability between data sets. The data qualifiers and their definitions are provided in Table I-2.

Information from the L and V reports was used to assure that blank contamination, recovery rates, and data qualifiers were appropriately documented in the digital data. Since data qualifiers may vary depending upon the laboratory and the investigators, data qualifier definitions were also checked to assure the appropriate data were used. All data to be used for risk assessment were carefully reviewed with the L and V reports or other QA/QC reports whenever possible before any data manipulation was undertaken.

Following standard EPA protocols (EPA, 1992b), contaminants were not included in the screening evaluation if the substance was an artifact of sampling or analysis, as determined by comparison with method and field blanks ("JB" or "UJB" qualifiers for organic contaminants). These included common laboratory contaminants detected at concentrations 10 times or less than the maximum concentrations reported in any method or field blanks. Common laboratory contaminants may include acetone, methylene chloride, 2-butanone, toluene, and phthalate esters. Any other contaminants detected at five times or less than the maximum blank concentrations were also considered artifacts of sampling and analysis. Any data qualified with a "B" was included in the analysis because, even though it was found in the blank, it was at concentrations more than 10 times the maximum blank concentration for common laboratory contaminants, or more than five times the maximum blank concentration for other contaminants.

Data were also not used if the qualifier indicated the data should be rejected ("R" qualifier). This qualifier indicated difficulties in the analytical procedures other than blank contamination, which disallowed accurate results.

Contaminant concentrations qualified as estimated values ("J" qualifier) were included in the evaluation of COPCs. Estimated values resulted when the detected concentration of a contaminant was below the quantitation limit but above the detection limit of the instrument, or the detected concentration was outside the range of the standards used to calibrate the instrument.

All the data that was qualified as not detected ("U," "UD," "UJ," and "UW" qualifiers for organics and radionuclides, and "U" or "BU" for inorganic contaminants) resulted in taking one-half the detection limit for the sample, in accordance with EPA guidance. The method quantitation limits were also scrutinized to assure that the range of detection was adequate for evaluation of ecological risks.

All data not removed from the assessment during the initial data quality review were selected for further screening. This included data from each of the three OUs and from WAG H sites outside these OUs. The media sampled at each source area are listed in Table I-3.

I-2.3.1.2 Spatial Representation and Frequency of Detection Screening. Available maps from summary reports were reviewed to examine the spatial representativeness of the sampling at each of the OUs. Any areas that are not adequately represented may require further investigation.

Table I-2. Data qualifiers.

Qualifier	Definition
B[a]	Concentration in sample is greater than 10 times the concentration in any blank for common laboratory contaminants or greater than 5 times the concentration in any blank for other contaminants.
J[a]	Sample concentration is below the instrument quantitation limit but above the instrument detection limit and is an estimate of the actual value.
JB[b]	Concentration in sample is less than 10 times the concentration found in any blank for common laboratory contaminants or less than 5 times the concentration in any blank for other contaminants. Concentration is greater than the instrument detection limit and is an estimate.
R[b]	Sample concentration results were rejected by the laboratory due to preparation or analysis difficulties.
U[a]	Sample concentration is below the instrument detection limit. Value is divided by 2 for use in the risk assessment.
UD, UJ, UW[a]	Sample concentration is below the instrument detection limit and is estimated. Value is divided by 2 for use in the risk assessment.
UJB[b]	Concentration in sample is less than 10 times the concentration found in any blank for common laboratory contaminants or less than 5 times the concentration in any blank for other contaminants. Concentration is below the instrument detection limit and is an estimate.

a. Data used in risk assessment.

b. Data not used in risk assessment.

Table I-3. Media sampled at each source area.

Source area	Soil	Sediment	Surface water	Biota[a]
Waste Burial Pit (OU-1)	Yes	No	No	Yes
Burn Pit (OU-2)	Yes	No	No	No
Waste Pond (OU-3)	No	Yes	Yes	Yes
WAG H areas outside the OUs	Yes	No	No	Yes

a. Biota were sampled for research, not as a component of remedial investigations; see Section 2.2.

The 24 soil sampling locations at the mixed waste burial pit are all located within 50 m around the perimeter of the pit. The sample locations were placed systematically; therefore, the spatial representativeness of the samples outside the perimeter is adequate for screening-level ecological risk assessment. However, the extent of contamination downwind (NE or SW) from the burial pit cannot be assessed with the available data and no samples were taken from the soil cap over the pit. This lack of downwind data is a data gap and since the studies reviewed in Section A-2.2.2 suggest that uptake by small mammals burrowing directly into the pit may be an important exposure pathway, the lack of samples from the cap represents another data gap. The samples collected from around the perimeter of the burial pit were taken at various depths but, for the purposes of the case study, sample depth was not considered and all data were considered as surface soil (0 to 12 inches below ground surface) data.

Potential soil contamination at the burn pit is represented by four soil sampling locations. These locations are in a linear pattern down the center of the OU and are not situated to characterize the spatial extent of potential ecological risks on or surrounding the OU. Downwind (SW or NE) migration of combustion by-products in aerial plumes is often an important migration pathway at burn pits and the lack of downwind sampling data represents a data gap. However, the current sample locations are likely to be in the most contaminated portion of the site and therefore may be used to conservatively estimate risks to ecological reports. The samples were taken at various depths but, as with the burial pit, all samples were considered to be collected from surface soil within the burn pit area.

The 12 sediment sampling locations at the liquid radioactive waste pond are placed in a pattern and in numbers adequate to assess the spatial extent of ecological risks due to sediment contamination. The three surface water sampling locations were used for multiple rounds of sampling at different times of the year. The locations were evenly distributed across the site but are too few in number to thoroughly address potential pond contamination. The small number of samples is a data gap in the assessment of ecological risks at the waste pond. The samples were all taken at depths between 0 and 12 inches deep and therefore do not fully characterize the different depths of the pond. However, the relatively homogeneous distribution of contaminants in water will allow adequate screening of ecological risks from the samples. No soil samples were taken from locations surrounding the waste pond where wind-blown contaminants may occur as a result of the pond's occasional dryness. However, because the pond occasionally dries out, exposing sediments as surface soil, the sediment data were also evaluated to identify potential soil COPCs as well as sediment COPCs. The lack of soil samples at the pond represents another data gap.

Soil samples were also included in the case study from a number of areas on WAG H located outside the three OUs. These areas were sampled at different times over the past five years for preliminary data screening; each area contained a number of sampling locations. Most of the areas are associated with suspected contaminated areas of WAG H. The sampling areas are well distributed across the facilities of the WAG, but few areas have been investigated outside the facility fence line.

For each contaminant within each medium at each of the source areas, the FOD and the range of concentrations were calculated (see Tables I-4 through I-8). Replicate and duplicate samples were considered as separate data points during this screening and throughout the risk

Table I-4. Summary of surface water samples—Waste Pond (OU-3).

Chemical	Frequency of detection[a]	Range		Background concentration[b]	Frequency of exceedance
		Minimum	Maximum		
Metals (μg/L)					
Chromium (III)	3/3	0.01	0.01	NA	NA
Sodium	25/25	26.6	147,000,000	NA	NA
Radionuclides (μCi/mL)					
Antimony-124	9/9	3E-07	9E-07	NA	NA
Antimony-125	1/1	6E-07	6E-07	5.4E-11	1/1
Barium-140	1/1	0.000016	0.000016	NA	NA
Cerium-141	9/9	3E-07	0.000009	NA	NA
Cerium-144	10/10	5.1E-07	0.000005	NA	NA
Cesium-134	16/16	1.3E-07	0.0000013	NA	NA
Cesium-137	69/69	1E-07	0.000015	4.1E-11	69/69
Cesium-141	1/1	0.000006	0.000006	NA	NA
Cesium-144	1/1	0.000006	0.000006	NA	NA
Chromium-51	66/66	0.000005	0.00042	NA	NA
Cobalt-57	2/2	9E-08	2.3E-07	NA	NA
Cobalt-58	22/22	1.4E-07	0.000006	NA	NA
Cobalt-60	67/67	2E-07	0.000055	NA	NA
Europium-152	3/3	3E-07	4E-07	NA	NA
Europium-154	1/1	2.3E-07	2.3E-07	NA	NA
Gross Alpha	1/1	4.3E-09	4.3E-09	NA	NA
Hafnium-175	3/3	2E-07	3.2E-07	NA	NA
Hafnium-181	28/28	2E-07	0.000004	NA	NA
Iodine-131	3/3	6E-07	0.000004	NA	NA
Iron-59	2/2	6E-07	0.000004	NA	NA
Lanthanum-140	2/2	6E-08	7E-08	NA	NA
Manganese-54	15/15	8E-08	0.0000023	NA	NA
Niobium-95	22/22	1.3E-07	9.7E-06	NA	NA
Potassium-40	1/1	6E-07	6E-07	NA	NA
Ruthenium-103	8/8	3E-07	0.000016	NA	NA
Ruthenium-106	1/1	0.0000044	0.0000044	NA	NA
Scandium-46	1/1	3E-07	3E-07	NA	NA
Selenium-124	1/1	3E-07	3E-07	NA	NA
Sodium-24	51/51	9E-09	0.000026	NA	NA
Strontium-90	68/68	2E-07	0.000009	6.8E-10	68/68
Tritium	68/68	0.000018	0.00791	3.2E-09	68/68
Yttrium-91	1/1	0.00016	0.00016	NA	NA
Zinc-65	4/4	5E-07	0.000002	NA	NA
Zirconium-95	18/18	3E-07	0.000013	NA	NA
Others					
Chloride (μg/L)	15/15	1,000,000	160,000,000	NA	NA
pH	68/68	2.7	9.8	NA	NA
Specific conductivity (mhos/cm)	1/1	0.00082	0.00082	NA	NA

a. The number of samples in which the contaminant was positively identified/the total number of samples analyzed.

b. From: Amiro (1993). Values reported in units of Bq/m^3 were converted to μCi/mL by multiplying the reported value times 27.03E-12.

Table I-5. Summary of sediment sample—Waste Pond (OU-3).

Chemical	Frequency of detection[a]	Range		Background concentration[b]	Frequency of exceedance
		Minimum	Maximum		
Metals (µg/g)					
Chromium (VI)	2/9	0.67	1	NA	NA
Radionuclides (pCi/g)					
Americium-241	25/28	0.337	215	0.005	25/28
Curium-244	26/28	0.145	121	0.005	26/28
Plutonium-238	26/28	0.145	104	0.003	26/28
Plutonium-239/240	26/28	0.412	309	0.024	26/28
Strontium-90	28/28	47.4	2860	0.3	28/28
Uranium-234	28/28	0.896	12.4	1.69	12/28
Uranium-235	2/28	0.0658	0.244	NA	NA
Uranium-238	28/28	0.831	2.2	1.56	3/28
Organics (µg/g)					
2,4-Dimethylphenol	4/35	0.34	3.3	NA	NA
2-Methylnaphthalene	4/36	0.26	1	NA	NA
4-Methylphenol	4/47	0.42	2.2	NA	NA
Acenaphthene	2/2	0.22	0.24	NA	NA
Acenaphthylene	1/35	1.1	1.1	NA	NA
Benzo(a)anthracene	1/34	0.98	0.98	NA	NA
Benzo(a)pyrene	1/37	1.4	1.4	NA	NA
Benzo(b)fluoranthene	1/36	1.9	1.9	NA	NA
Chloroform	15/48	0.001	0.01	NA	NA
Chrysene	3/36	0.97	1.3	NA	NA
Dibenzofuran	4/37	0.89	2.3	NA	NA
Fluoranthene	4/33	0.51	0.64	NA	NA
Fluorene	4/33	0.16	0.56	NA	NA
Indeno(1,2,3-cd)pyrene	1/34	0.85	0.85	NA	NA
Naphthalene	4/4	0.18	0.26	NA	NA
p,p-DDT	1/4	0.059	0.059	NA	NA
Phenanthrene	4/37	0.52	1.4	NA	NA
Pyrene	3/36	0.005	1.4	NA	NA
Trichloroethene	1/1	0.001	0.001	NA	NA

a. The number of samples in which the contaminant was positively identified/the total number of samples analyzed.

b. Anderson (1992), Martin et al. (1992), Berry et al. (1994), and Shacklette and Boerngen (1984).

Table I-6. Summary of soil samples—Waste Burial Pit (OU-1).

Chemical	Frequency of detection	Range		Background concentration[a]	Frequency of exceedance
		Minimum	Maximum		
Metals (μg/g)					
Aluminum	24/24	2,920	13,400	12,800	1/24
Antimony	2/24	6.8	6.9	2.2	2/24
Arsenic	24/24	2.4	7.1	5.9	3/24
Barium	24/24	55	256	190	13/24
Beryllium	24/24	0.3	1.2	1.4	0/24
Calcium	24/24	12,100	149,000	4,870	24/24
Chromium (III)	24/24	7.1	17.1	18	0/24
Cobalt	24/24	4.3	11.5	9.7	9/24
Copper	24/24	9.6	28.7	23.4	2/24
Iron	24/24	7,650	19,100	19,000	1/24
Lead	24/24	4.6	26	19.6	1/24
Magnesium	24/24	2,740	11,800	5,700	20/24
Manganese	24/24	164	617	645	0/24
Nickel	24/24	17.8	31.8	15.6	24/24
Potassium	24/24	449	3,070	4,110	0/24
Silver	1/24	2.1	2.1	0.23	1/24
Sodium	24/24	78.4	1,020	141	19/24
Vanadium	24/24	9.5	26.2	30.1	0/24
Zinc	24/24	32.4	107	78	1/24
Radionuclides (pCi/g)					
Americium-241	5/5	0.072	4	0.005	5/5
Plutonium-239	6/6	0.06	20.4	NA	NA
Thorium-228	21/21	0.53	1.59	NA	NA
Thorium-230	24/24	0.46	1.61	NA	NA
Thorium-232	24/24	0.57	1.5	11.5	0/24
Uranium-234	24/24	0.75	1.78	1.69	1/24
Uranium-238	24/24	0.78	1.43	1.56	0/24
Organics (μg/g)					
1,1-Dichloroethene	1/25	0.005	0.005	NA	NA
4-Chloro-3-methylphenol	1/25	0.42	0.42	NA	NA
Carbon Tetrachloride	1/1	0.002	0.002	NA	NA
Chloroform	5/25	0.002	0.006	NA	NA
Tetrachloroethene	5/25	0.001	0.003	NA	NA
Tributylphosphate	1/1	0.092	0.092	NA	NA
Trichloroethene	8/25	0.001	0.007	NA	NA

a. From: Anderson (1992), Martin et al. (1992), Berry et al. (1993), and Shacklette and Boerngen (1984).

Table I-7. Summary of soil samples—Burn Pit (OU-2).

Chemical	Frequency of detection	Range		Background concentration[a]	Frequency of exceedance
		Minimum	Maximum		
Metals (μg/g)					
Chromium (III)	9/10	25	174	18	9/10
Lead	10/10	23.4	2820	19.6	10/10
Mercury	5/10	0.17	10.9	0.06	5/10
Radionuclides (pCi/g)					
Cesium-137	1/1	0.0719	0.0719	0.073	0/1
Gross Alpha	1/1	20	20	NA	NA
Gross Beta	1/1	26	26	NA	NA
Uranium-234	1/1	0.5	0.5	1.69	0/1
Uranium-238	1/1	0.6	0.6	1.56	0/1
Organics (μg/g)					
Tetrachloroethene	6/7	0.001	0.13	NA	NA

a. Anderson (1992), Martin et al. (1992), Berry et al. (1993), and Shacklette and Boerngen (1984).

assessment. The FOD was determined as the number of samples in which a contaminant waspositively detected (no "U" qualifier), divided by the total number of samples analyzed for that chemical. If the FOD for a contaminant was less than 5%, it was eliminated from consideration as a COPC unless the maximum detected concentration was high enough to suggest a localized area of contamination ("hot spot"). Any potential hot spots were investigated further by checking the spatial distribution of samples around the hot spot. If other samples taken in the area did not indicate unusually high concentrations, the contaminant was removed from the risk assessment. If a hot spot was indicated by the maximum concentration and spatial distribution of other samples or no other samples were taken in the area, the contaminant was not eliminated. Each contaminant removed from further consideration during the ERA by the 5% FOD criteria was also qualitatively reviewed for toxicity to mammals, birds, and soil invertebrates, if possible. Those contaminants found to be potentially lethal at less than 50 mg/kg-BW (highly toxic [Klassen, 1986]), were further evaluated to determine whether their spatial distribution warranted their inclusion in the ERA.

I-2.3.1.3 Background Screening. Background concentrations for chemicals and radionuclides in surface water, sediment, and soil were obtained from various sources, as described below. This was an interim approach taken to allow progress in the case study, as research is continuing on selecting the background concentrations most appropriate for use at the INEL. Local background concentrations of contaminants were used whenever possible. However, the local background values were limited. When no local values were available, regional background contaminant concentrations were obtained. If no local or regional background concentrations were available, the national background elemental concentrations presented by Shacklette and Boerngen (1984) were used as default values.

Table I-8. Summary of soil sample WAG H maximums.

Chemical	Frequency of detection	Range		Background concentration[a]	Frequency of exceedance
		Minimum	Maximum		
Metals (μg/g)					
Aluminum	7/7	3,240	36,800	12,800	1/7
Antimony	1/1	20.7	20.7	2.2	1/1
Arsenic	11/11	0.0052	111	5.9	2/11
Barium	7/7	0.0576	3,830	190	4/7
Beryllium	11/11	0.00089	1.9	1.4	1/11
Cadmium	5/5	0.0014	101	2.5	4/5
Calcium	7/7	13.7	127,000	4,870	6/7
Chromium (III)	11/11	0.0093	1,580	18	9/11
Chromium (VI)	2/2	0.35	1	NA	NA
Cobalt	7/7	0.0047	20.6	9.7	1/7
Copper	7/7	0.0078	143	23.4	5/7
Iron	7/7	7.12	39,700	19,000	1/7
Lead	8/8	0.0063	225	19.6	7/8
Magnesium	12/12	3	16,800	5,700	1/12
Manganese	7/7	0.145	915	645	1/7
Mercury	8/8	0.00024	133	0.06	7/8
Nickel	7/7	0.0039	30.6	15.6	6/7
Potassium	6/6	0.719	1,530	4,110	0/6
Selenium	2/2	4	4	1	2/2
Silver	5/5	11.6	21.8	0.23	5/5
Sodium	5/5	151	184	141	5/5
Thallium	1/1	32.3	32.3	0.47	1/1
Vanadium	7/7	0.0217	54.8	30.1	2/7
Zinc	5/5	0.0326	795	78	4/5
Radionuclides (pCi/g)					
Americium-241	8/8	0.3	215	0.005	8/8
Antimony-125	1/1	72	72	NA	NA
Cerium-144	1/1	1,400	1,400	NA	NA
Californium-252	1/1	0.69	0.69	NA	NA
Curium-244	5/5	5.53	121	0.005	4/4
Cobalt-60	7/7	0.97	590	NA	NA
Cesium-134	4/4	0.27	29,000	NA	NA
Cesium-137	7/7	4.1	2,700	0.073	7/7
Europium-152	2/2	1.61	1.61	NA	NA
Europium-154	4/4	0.000018	0.845	NA	NA
Europium-155	1/1	110	110	NA	NA
Gross Alpha	2/2	0.005	23	NA	NA
Gross Beta	2/2	0.011	29	NA	NA
Plutonium-238	6/6	0.3	143	0.003	6/6
Plutonium-239	1/1	156	156	NA	NA
Plutonium-239/240	8/8	1.2	309	0.024	8/8
Strontium-90	10/10	2.38	4,200	0.3	10/10
Uranium-232	1/1	0.15	0.15	NA	NA
Uranium-234	9/9	0.99	12.4	1.69	8/9
Uranium-235	3/3	0.0658	0.41	NA	NA
Uranium-238	15/15	0.63	2.2	1.56	2/15
Organics (μg/g)					
Tetrachloroethene	1/1	0.007	0.007	NA	NA

a. Anderson (1992), Martin et al. (1992), Berry et al. (1993), and Shacklette and Boerngen (1984).

Local and regional background soil values for the INEL were obtained from publications of previously conducted background surface soil sampling (Berry et al. 1994; Martin et al. 1992; Anderson 1992). Background data for the Bingham West soil type was chosen from Martin et al. (1992) because this soil type most closely represents the soils at WAG H. For each contaminant, the lowest maximum of the background concentrations reported by these various authors for local or regional soils was selected as a reasonable screening-level. When no local or regional background data were available for a contaminant, background soil data for metals were qualitatively compared to the upper 95% limit on the range of published background values for the western United States (Table I-9) (Shacklette and Boerngen 1984). Regional background concentrations found to be above the western United States benchmark were not used because of the possibility of artifacts of contamination from sources such as agriculture. The available local background data are difficult to interpret and do not adequately represent the different soil types at the INEL. These difficulties and others related to background contaminant concentrations are discussed in the manual. The lack of a complete local elemental background concentration list for soils represents a data gap for the INEL and introduces some uncertainty into the assessment. This uncertainty is unmeasurable because the regional and national background concentrations could be above or below the actual local values.

For surface water, background data for a few radionuclides were obtained from a recently published review (Amiro 1993). Since no sediment background values were available, the soil background concentrations were used for screening of sediments. This approach assumes that the distribution of contaminants in the sediments is similar to that in the surface soils and was done to provide some means of screening the sediment contaminant concentration data during the case study. The process is based upon the fact that the waste ponds were created by digging unlined ponds from the natural soil. Therefore the soil/sediment at the bottom of the ponds is of the same origin as the surface soils. Also, the ponds often dry up leaving the sediments exposed as surface soil. The lack of sediment background data represents a data gap.

The concentrations of each contaminant from each site for each medium were compared to the background concentrations to calculate the frequency of exceedance. In addition, the magnitude of exceedance of background was examined. Contaminants that exceeded background at a low frequency (less than 5%) or that have maximum concentrations less than twice background were eliminated from consideration as COPCs. The results of this screening are provided in Tables I-4 through I-8.

For the waste pond surface water, the radionuclides ^{125}Sb, $1^{37}Cs$, ^{90}Sr, and ^{3}H were found to exceed background levels (see Table I-4). Background concentrations were not available for the other contaminants detected in the waste pond surface water; however, based on the exceedances observed for the four radionuclides that have background values, it appears likely that other radionuclides in surface water could also exceed background. The lack of background surface water concentrations for many contaminants represents a data gap in the assessment.

For the waste pond sediments, the radionuclides ^{241}Am, ^{244}Cm, ^{238}Pu, $^{239,240}Pu$, ^{90}Sr, and ^{234}U were found to significantly exceed background concentrations, and ^{238}U marginally exceeded background concentrations (Table I-5). Background values were not available for organics in sediments.

Table I-9. Background metals concentrations for the Western United States (µg/g).

Chemical	Lower limit[a]	Upper limit[a]
Aluminum	14,500	232,000
Antimony	0.10	2.2
Arsenic	1.4	21.6
Barium	197	1,716
Beryllium	0.13	3.6
Cadmium	NA	NA
Calcium	1,935	167,445
Chromium (III)	8.5	196.6
Chromium (VI)	NA	NA
Cobalt	1.8	27.6
Copper	4.9	90
Iron	5,523	79,853
Lead	5.2	55.1
Magnesium	1,515	36,142
Manganese	96.9	1,490
Mercury	0.0085	0.25
Nickel	3.4	66.2
Potassium	9,074	35,707
Selenium	0.039	1.4
Silver	NA	NA
Sodium	2,551	36,884
Thallium	4.1	20.2
Uranium	1.2	5.3
Vanadium	18.4	266
Zinc	17.2	176.2

a. Lower and upper limits of the expected range, calculated to encompass 95% of the distribution as described in Shacklette and Boerngen (1984).

For the waste burial pit soils, the following metals exceed background levels: calcium, magnesium, nickel, and sodium (Table I-6). The only radionuclide exceeding background levels is ^{241}Am. It appears that ^{239}Pu could also be elevated, although a background value was not available for this radionuclide.

For the burn pit soils, the chemicals exceeding background include the metals chromium, lead, and mercury (Table I-7). Radionuclides do not appear to exceed background at the burn pit, although only one sample was analyzed for radionuclides at OU-2. The lack of radionuclide sampling is an artifact of the sampling design which was not intended to look exhaustively for radionuclides because they were not expected at the burn pit. This expectation was based upon

an examination of the types of materials that were burned at the pit. Therefore, the lack of radionuclide data is not felt to represent a data gap at this OU.

As for the rest of WAG H, numerous metals and radionuclides appear to exceed background at one or more locations (Table I-8). These include the metals aluminum, antimony, arsenic, barium, cadmium, calcium, chromium, cobalt, copper, iron, lead, magnesium, mercury, selenium, silver, thallium, and zinc, and the radionuclides ^{241}Am, ^{244}Cm, ^{137}Cs, ^{238}Pu, $^{239,240}Pu$, ^{90}Sr, and ^{234}U.

Any contaminant which exceeded background concentrations, according to the procedures described above, was included in the assessment. All contaminants which had no background concentrations for comparison were also included in the assessment.

I-2.3.1.4 Risk-Based Screening. Risk-based criteria, standards, or benchmarks were used to further screen contaminants. For metals and organics in surface water, the EPA Ambient Water Quality Criteria (AWQC) were used. The AWQC are designed to be protective of most aquatic communities, except possibly where a locally important species is very sensitive (EPA 1986a). With the exception of a few organic contaminants, sediment criteria are not federally defined. Other reference values provided in Bennett and Cubbage (1991) were also used for screening purposes. Regulatory criteria for ecological risk-based screening of soils are not generally available for metals and organics. The lack of ecological risk-based screening benchmarks for many contaminants and media is a limitation of the ERA process.

To screen concentrations of radionuclides in various media for WAG H, the approach used was based on information provided in an International Atomic Energy Administration (IAEA) document (IAEA 1992) and a National Council on Radiation Protection (NCRP) document (NCRP 1991). In essence, the approach involves calculating risk-based concentrations for ecological health for a given radionuclide in a given medium, roughly based upon human health exposure models. The risk-based concentrations based upon these models are provided for a few radionuclides in IAEA (1992) and these are the values used for screening. These risk-based concentrations, though initially calculated for humans, have been shown by IAEA (1992) to be equally protective of some ecological receptors.

For the waste pond surface water, the radionuclides ^{137}Cs, ^{131}I, ^{90}Sr, and ^{3}H were found to exceed the IAEA risk-based criteria (Table I-10). Criteria were not available for most of the other radionuclides detected in surface water at OU-3. However, ^{60}Co did not exceed the IAEA criteria. Of the nonradiological contaminants in surface water, chloride exceeded EPA criteria. Both forms of chromium were below the EPA AWQC.

For the waste pond sediments, ^{90}Sr exceeded the IAEA criteria in two of 28 samples (Table I-11). ^{241}Am, ^{235}U, and ^{238}U did not exceed the criteria. The organics detected in pond sediment were generally below EPA or Wisconsin Department of Natural Resources criteria. The National Oceanic and Atmospheric Administration (NOAA) criteria were exceeded in a few cases but are not considered to be significant because the frequency of exceeding the criteria is low and the other criteria do not indicate a potential problem. The NOAA criteria are commonly used criteria in freshwater systems; however they were developed for use in marine or estuarine

Table I-10. Surface water comparison to ecological criteria—Waste Pond (OU-3).

Chemical	EPA ambient water quality chronic criteria[a]	Frequency of exceedance of chronic AWQC	EPA ambient water quality acute criteria[a]	Frequency of exceedance of acute AWQC	IAEA criteria[b]	Frequency of exceedance of IAEA criteria
Metals (µg/L)						
Chromium (VI)	11	0/3	16	0/3	NA	NA
Chromium (III)	207[c]	0/3	1,736[c]	0/3	NA	NA
Radionuclides (µCi/mL)						
Cesium-137	NA	NA	NA	NA	2.70E-09	69/69
Cobalt-60	NA	NA	NA	NA	0.00065	0/67
Iodine-131	NA	NA	NA	NA	8.38E-07	2/3
Strontium-90	NA	NA	NA	NA	5.68E-07	42/68
Tritium	NA	NA	NA	NA	0.00192	43/68
Others						
Chloride (µg/L)	230,000	15/15	860,000	15/15	NA	NA

a. EPA (1986a), as updated. Values are the freshwater acute and chronic criteria for the protection of aquatic life unless otherwise noted.

b. From: IAEA (1992). Values reported in units of Bq/L were converted to µCi/mL by multiplying the reported value times 27.03E-09.

c. Hardness-dependent criteria. 100 mg/L hardness used.

Table I-11. Sediments comparison to ecological criteria—Waste Pond (OU-3).

Chemical	WDNR[a] guidelines[b]	Frequency of exceedance of WDNR guidelines	NOAA ER-L concentrations[c]	Frequency of exceedance of NOAA ER-L guidelines	EPA interim criteria[d]	Frequency of exceedance of EPA criteria	IAEA criteria[e]	Frequency of exceedance of IAEA criteria
Radionuclides (pCi/g)								
Americium-241	NA	NA	NA	NA	NA	NA	414	0/28
Strontium-90	NA	NA	NA	NA	NA	NA	1,140	2/28
Uranium-235	NA	NA	NA	NA	NA	NA	270	0/28
Uranium-238	NA	NA	NA	NA	NA	NA	518	0/28
Organics (µg/g or µg/g OC, as noted)								
Acenaphthene	92	0/2	0.15	2/2	732	0/2	NA	NA
Benzo(a)pyrene	89	1/37	0.4	1/37	1,063	0/37	NA	NA
Chloroform	2.7	0/48	NA	NA	NA	NA	NA	NA
Chrysene	NA	NA	0.4	3/36	NA	NA	NA	NA
Fluoranthene	1,216	0/33	0.6	2/33	1,883	0/33	NA	NA
Fluorene	NA	NA	0.035	4/33	NA	NA	NA	NA
Naphthalene	1,240	0/4	0.34	0/4	NA	NA	NA	NA
p,p-DDT	NA	NA	0.001	1/4	NA	NA	NA	NA
Phenanthrene	NA	NA	0.225	4/37	139	0/37	NA	NA
Pyrene	NA	NA	0.35	2/36	1,311	0/36	NA	NA
Toluene	5,250	0/16	NA	NA	NA	NA	NA	NA

a. Wisconsin Department of Natural Resources.

b. From: Bennett and Cubbage (1991). Values shown are reference concentrations estimated using the equilibrium partitioning approach by WDNR, normalized for organic carbon.

c. From: Long and Morgan (1990). Values shown are the ER-L, defined as the lower 10 percentile of concentrations observed or predicted to be associated with biological effects. Note that the data used to estimate ER-L are principally from marine and estuarine environments.

d. From: EPA (1991). Values shown are derived from water criteria using the equilibrium partitioning approach and normalized for organic carbon.

e. From: IAEA (1992). Values reported in Bq/L were converted to pCi/g by multiplying the reported value times the sediment/water partition coefficient (Kd) times 27.03E-03.

systems. Therefore, they are not as appropriate and do not carry as much weight as the other listed criteria. They are presented to support a weight of evidence approach to the screening.

For the waste burial pit soils, both ^{241}Am and ^{239}Pu were below the IAEA criteria (Table I-12). Ecological criteria were not available for the metals detected above background or organics detected in soil at OU-1. Similarly, for the burn pit soils, no criteria were available for screening contaminants detected at the site. For the maximum concentrations of chemicals detected at other WAG H locations, only ^{137}Cs and ^{90}Sr exceeded the IAEA criteria (Table I-13).

^{241}Am and ^{239}Pu were below these criteria. Risk-based screening was not possible for most of the radionuclides and all the metals detected above background at these WAG H sites.

I-2.3.1.5 Summary of COPCs. The contaminants found to be above background and above the risk-based screening criteria were considered to be potential COPCs for the WAG H screening-level risk assessment. Those contaminants for which no background or risk-based screening concentrations were located, were also included in the assessment as COPCs. The essential or ubiquitous elements calcium, chloride, potassium, and sodium were eliminated from the ERA because they are not considered toxic to ecological receptors under normal circumstances. However, the maximum levels of sodium and chloride in surface water at the waste pond are notable, indicating a relatively saline environment that could adversely affect the freshwater aquatic community. Iron and magnesium were also eliminated because they are very common, ubiquitous elements and were only slightly above two times the background concentration and well within the upper background limit provided in Shacklette and Boerngen (1984). The results of the screening are summarized below and in Table I-14.

Of the radionuclides occurring in surface water, ^{125}Sb, ^{137}Cs, ^{131}I, ^{90}Sr, and ^{3}H were considered as COPCs for the case study. ^{125}Sb was analyzed in only one sample and ^{131}I was analyzed in three samples; therefore, the significance of these radionuclides is difficult to interpret. Of the other radionuclides (^{137}Cs, ^{90}Sr, and ^{3}H) listed in Table I-14, all three exceeded background and risk-based criteria in numerous samples. As noted in Section A-2.3.1.3, other radionuclides occur in surface water but neither background values nor criteria were

Table I-12. Soils comparison to ecological criteria—waste burial pit (OU-1).

Chemical	IAEA criteriaa	Frequency of exceedance of IAEA criteria
Radionuclides		
Americium-241	1,620	0/5
Plutonium-239	10,800	0/6

a. IAEA (1992). Values reported in units of Bq/kg were converted to pCi/g by multiplying the reported value times 27.03E-03.

Table I-13. Soils comparison to ecological criteria WAG H maximums (pCi/g).

Chemical	IAEA criteriaa	Frequency of exceedance of IAEA criteria
Radionuclides		
Americium-241	1,620	0/8
Cesium-137	1,890	1/7
Plutonium-239	10,800	0/1
Strontium-90	270	5/10

a. IAEA (1992). Values reported in units of Bq/kg were converted to pCi/g by multiplying the reported value times 27.03E-03.

available for screening. Additional research is required to derive screening values for these radionuclides, but this was not considered necessary for the case study. Other than chloride, no other chemicals in surface water exceeded the available criteria.

Similarly for sediment, five radionuclides exceeded background and/or screening criteria (Table I-14). However, of these, risk-based criteria were available only for ^{90}Sr. Based on the screening, metals and organics occurring in pond sediments do not appear to be of significant concern.

In soils, 14 metals were considered for evaluation as COPCs because these exceeded background at several sampling locations. Of the radionuclides in soils, several were considered as soil COPCs because of their presence in pond sediments and the potential for airborne transport to surrounding soils during periods of pond dryness. Most of these also occurred at WAG H sites other than the three OUs. Of the organics in soils, only tetrachloroethene was considered as a COPC.

To limit the scope of the case study, a single COPC was selected from each of the three main categories (metals, radionuclides, and organics) of contaminants for further evaluation. These COPCs are chromium, ^{90}Sr, and PCE. Chromium and ^{90}Sr were found at levels exceeding background and/or risk-based criteria at one or more locations in soils, and 90Sr was also found at elevated levels in surface water and sediment. PCE was found in soils at the burn pit and appears to be the most significant organic contaminant at WAG H.

I-2.3.2 Physical Stressors

The major anthropogenic physical stressors at the INEL are the diversion of the Big Lost River and Birch Creek and habitat/wildlife disturbance near the WAGS due to operations. The diversion of major waterways resulted in the loss of habitat in riparian areas of the Big Lost River and Birch Creek. The habitat and wildlife disturbances near the WAGS may impact vegetation and wildlife inhabiting localized areas of the WAG. The placement of many of the WAGS in near proximity to each other may have altered the migration paths of some wildlife, but the presence of large areas for alternative routes alleviates the potential impact. Construction or

Table I-14. Contaminants of potential ecological concern—WAG H.

Chemical	Surface water	Sediment	Soil
Metals			
Aluminum			OU-1, WAG H
Antimony			OU-1, WAG H
Arsenic			OU-1, WAG H
Barium			OU-1, WAG H
Beryllium			WAG H
Cadmium			WAG H
Chromium	OU-3		
Chromium (III)[a]			OU-2, WAG H
Chromium (VI)[a]		OU-3	WAG H
Cobalt			OU-1, WAG H
Copper			OU-1, WAG H
Lead			OU-2, WAG H
Manganese			WAG H
Mercury			OU-2, WAG H
Nickel			OU-1, WAG H
Selenium			WAG H
Silver			WAG H
Thallium			WAG H
Vanadium			WAG H
Zinc			WAG H
Radionuclides			
Antimony-125	OU-3		WAG H
Barium-140	OU-3		
Californium-252			WAG H
Cerium-141	OU-3		
Cerium-144	OU-3		WAG H
Cesium-134	OU-3		
Cesium-134			WAG H
Cesium-137	OU-3		WAG H
Cesium-141	OU-3		
Cesium-144	OU-3		
Chromium-51	OU-3		
Cobalt-57	OU-3		
Cobalt-58	OU-3		
Cobalt-60			WAG H
Curium-244		OU-3	OU-3, WAG H
Europium-152	OU-3		WAG H
Europium-154	OU-3		WAG H

Table I-14. (continued).

Chemical	Surface water	Sediment	Soil
Europium-155			WAG H
Gross Alpha	OU-3		
Hafnium-175	OU-3		
Hafnium-181	OU-3		
Iodine-131	OU-3		
Iron-59	OU-3		
Lanthanum-140	OU-3		
Manganese-54	OU-3		
Niobium-95	OU-3		
Potassium-40	OU-3		
Plutonium-238		OU-3	OU-3, WAG H
Plutonium-239/240		OU-3	OU-3, WAG H
Ruthenium-103	OU-3		
Ruthenium-106	OU-3		
Scandium-46	OU-3		
Selenium-124	OU-3		
Sodium-24	OU-3		
Strontium-90a	OU-3	OU-3	OU-3, WAG H
Thorium-228			OU-1
Thorium-230			OU-1
Thorium-232			OU-1
Tritium	OU-3		
Uranium-232			WAG H
Uranium-234		OU-3	OU-3, WAG H
Uranium-235			WAG H
Uranium-238			WAG H
Yttrium-91	OU-3		
Zinc-65	OU-3		
Zirconium-95	OU-3		
Organics			
2,4-Dimethylphenol		OU-3	
2-Methylnaphthalene		OU-3	
4-Methylphenol		OU-3	
Acenaphthene		OU-3	
Acenaphthylene		OU-3	
Carbon Tetrachloride			OU-1
Chloroform		OU-3	OU-1
Dibenzofuran		OU-3	

Table I-14. (continued).

Chemical	Surface water	Sediment	Soil
Fluoranthene		OU-3	
Fluorene		OU-3	
Tetrachloroethene[a]			OU-1, OU-2
Tributylphosphate			OU-1
Trichloroethene		OU-3	OU-1
Others			
Chloride (μ/L)	OU-3		

a. Highlighted chemicals indicate those selected for evaluation in the case study. The OUs where each chemical is considered to be a COPC are indicated; "WAG H" refers to sites other than the three OUs.

destruction of facilities and/or any remedial activities may impose additional physical stress on wildlife and vegetation and could allow exotic floral species to invade and alter the natural ecosystems of the INEL.

These potential physical stressors may present significant impacts to the natural ecology of the INEL; however, the remedy for these physical stressors is not required under CERCLA regulation. Therefore physical stressors are considered outside the scope of screening-level ERA and are not addressed in the case study.

I-2.4 Ecosystem Components

This section outlines the ecological setting of WAG H. Descriptions of the regional and local ecology provide an understanding of the habitats and species of concern at WAG H and the behavior and effects of the COPCs as they are transported from their source through the abiotic and biotic environment.

I-2.4.1 Regional and Local Ecosystems

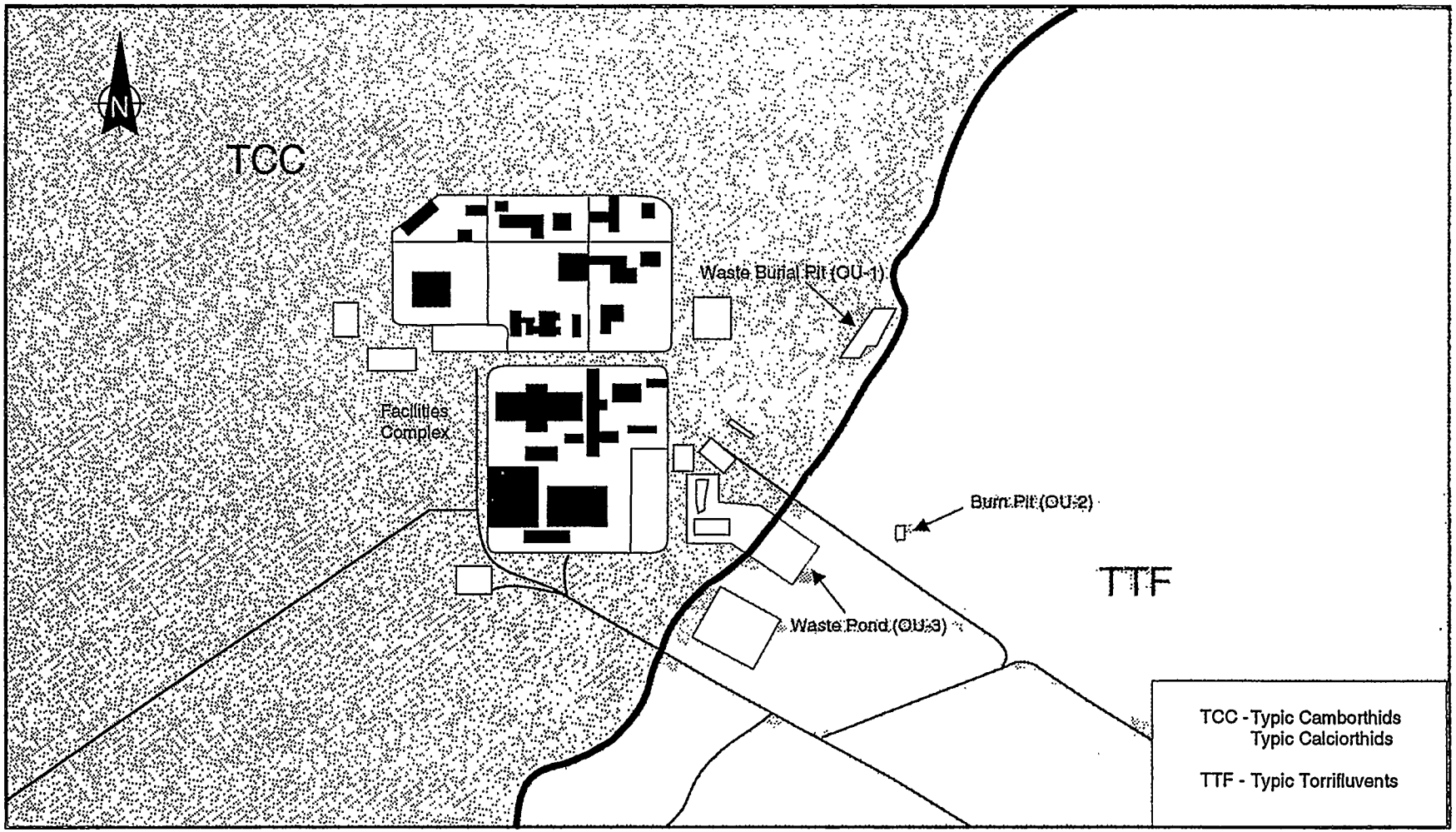
The INEL is located in the intermountain sagebrush ecoregion [U.S. Department of Agriculture (USDA) 1980] at the boundary of two physiographic provinces, the Great Basin and Range and the Columbia Plateau, a cool desert ecosystem characterized by hot summers and moderately cold winters with little precipitation. The temperature extremes are -44 to 38°C with an annual average of 11°C (Clawson et al. 1989). The mountains to the west of the INEL create a rain shadow that limits the annual precipitation to an average of 22 cm, falling mostly as snow in December and January with rain in May and June. Annual snowfall ranges from 17 to 152 cm per year and single event snowfall depths range to 51 cm. The predominant wind patterns are from the southwest during the day and from the northeast during the night. Storm events may bring winds of short duration from other directions.

The topography of INEL is generally flat or gently rolling, and the elevation is approximately 1,520 m above mean sea level. A few prominent buttes are located on and near the site. Although many different soil types occur within the boundaries of the INEL, most have similar

physical and chemical characteristics based upon origin. Only two soil types are found at WAG H. The northeast-southwest dividing line is east of the building complex (see Figure I-5). The majority of WAG H lies in the Typic Camborthids-Typic Calciorthids (TCC) soil type; however, two of the OUs lie on the dividing line between TCC and the Typic Torrifluvents type (TFF). Both of these soils are alluvium deposited by the Big Lost River; the TCC are older deposits and the TFF are newer deposits closer to the river. The TCC soils are loams or silty loams over gravelly or sandy loams, and the surface is frequently hardened due to the alkaline conditions. The TFF soils are loams or sandy loams over gravelly subsoils. Generally the gravel of the TFF soils is finer and more frequently found on the surface than the TCC soils. Both soils are often dry and are generally alkaline and saline, impermeable, erodible, and have little organic accumulation in the upper layer (USDA 1975, 1980). Spring thaws and intense rainstorms may lead to significant soil erosion.

The major type of vegetation at the INEL is sagebrush shrub-steppe characterized by sagebrush and perennial bunch grasses. Other important plants include shrubs (rabbit brush, winter fat, spiny hopsage) and grasses (bottlebrush wheat grass, Indian rice grass, and needle-and-thread). Scattered communities may be found to include Great Basin wild rye, blue bunch wheat grass, and prickly phlox. Limited riparian communities exist along the Big Lost River and Birch Creek beds. These riparian communities may include cottonwood, willow, water birch, chokecherry, and common spike-rush. A complete list of plant species likely to occur at INEL with their scientific names is provided in the manual.

The wildlife species of the cool desert ecosystem of the INEL include 184 birds, 37 mammals, 9 reptiles, 2 amphibians, and 6 fish (Reynolds 1986 as updated, Tim Reynolds, personal communication). A complete list of these species and their scientific names is presented in the manual. There are also diverse invertebrate populations characteristic of the region. Thirty-two of the bird species are game birds, most of which are waterfowl and upland birds. The most common resident game birds are the mourning dove and sage grouse. Mallards and blue-winged teal are common waterfowl breeders on the INEL. The most common passerine species are the horned lark, black-billed magpie, robin, sage thrasher, Brewer's sparrow, sage sparrow, and the western meadow lark.



SOURCE: Ecology and Environment, Inc. 1994.

Figure I-5. WAG H soils.

Pronghorn are the most common large game mammal on the INEL. Coyote and long-tailed weasel are two of the common predatory mammals. The deer mouse, harvest mouse, Great-Basin pocket mouse, mountain vole, Ord's kangaroo rat, bushy-tailed wood rat, least chipmunk, and Townsend's ground squirrel are all common small mammals at INEL. The black-tailed jackrabbit is also abundant periodically (Stoddard 1983). Several reptiles are commonly found at INEL. These include the short-horned lizard, sagebrush lizard, gopher snake, and western rattlesnake.

Fish are not expected to be found on the INEL, due to the dryness of the Big Lost River. Floodwaters likely to flow to the INEL are now diverted to spreading areas near the southwestern border of the area. This direction drastically limits any possibility of fish inhabiting the Big Lost River within the boundaries of the INEL.

A diverse terrestrial invertebrate community exists on the INEL. These species play important roles in nutrient cycling and in the food chain.

I-2.4.2 WAG H Ecosystems

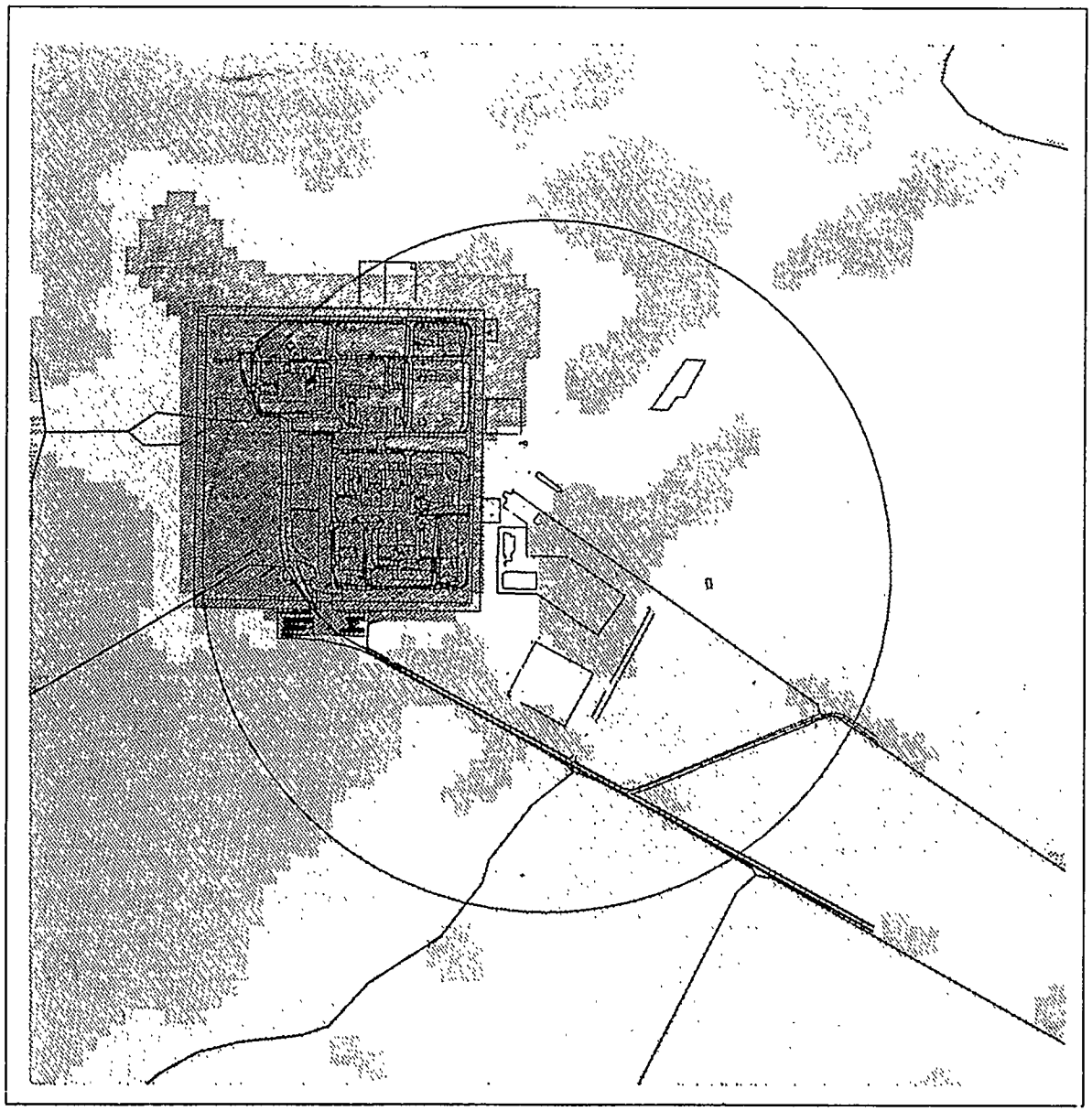
The vegetation types found on WAG H are a subset of those found across the INEL (Figure I-6). The ecosystem types and the percent of area they cover at WAG H are provided in Table I-15.

The waste burial pit (OU-1) is covered with planted crested wheatgrass, and Russian thistle has invaded disturbed areas of the pit cap. The area immediately surrounding the pit is dominated by big sagebrush, green rabbitbrush, and bluebunch wheatgrass. The habitat on and surrounding the waste burial pit provides habitat for numerous species of small mammals and food for herbivorous mammals, predatory mammals, and raptors. Fences surrounding the waste burial pit limit large wildlife access to the site. The burn pit (OU-2) is similar to the waste burial pit in vegetation cover and inhabiting species, but is much smaller.

The waste pond is an artificial aquatic system. No fish inhabit the pond, but aquatic free-swimming and benthic invertebrates and plankton are present. Some free-floating and rooted aquatic vegetation is also found. The principal invertebrates in the pond include dragonflies, damselflies, mayflies, water boatman, diving beetles, midges, and caddisflies. The principal planktonic species include *Navicula*, *Cyanthomonas*, *Pleurotaeium*, and *Achnanthes* spp. No identification of free-floating vegetation has been conducted but rooted aquatic vegetation includes small areas of sedges, bulrushes, and cattails.

I-2.4.3 Threatened, Endangered, and Sensitive or Rare Species of the INEL

Threatened, endangered, and sensitive or rare species may be categorized in Idaho by federal or state agencies such as the U.S. Fish and Wildlife Service (USFWS), U.S. Bureau of Land Management (BLM), U.S. Forest Service (USFS), Idaho Department of Fish and Game (IDFG), and Idaho Parks and Recreation (IPR). The Idaho Native Plant Society (INPS) sensitive plant listing has been adopted by the IDFG. Table I-16 provides a listing of the federal and state species of concern found at INEL.



Vegetation in the Vicinity of a Hypothetical Waste Area Group (WAG H)

Vegetation Classified from Landsat Thematic Mapper Data 8/17/89 and 5/8/87

N

- Sage Brush-Steppe on Lava
- Sagebrush/Rabbitbrush/ Salt Desert Shrubs
- Grassland
- Playa-Bareground/ Distrubed Areas
- Facilities

Assessment Area

Note:
An accuracy assessment of this map has not been conducted.

Structures depicted on this map have been altered for analytical purposes and do not accurately reflect INEL structures.

CENTER FOR INTEGRATED ENVIRONMENTAL TECHNOLOGIES

0 400 800 1200 Meters

Figure I-6. WAG H vegetation map.

Table I-15. WAG H ecosystem types.

Ecosystem typesa	Approximate area (ha)	Percent of WAG H area	Dominant cover types
Sagebrush/Rabbitbrush/Salt Desert Shrub	262	52	Sagebrush, green rabbitbrush, bunchgrasses, shrubs
Sagebrush Steppe on Lava	151	30	Sagebrush, desert shrubs, grasses, forbs
Facilities and Disturbed Areas	57	11	Lawns, planted shrubs and trees, annual grasses and weeds
Grassland	25	5	Grasses and forbs
Playa/Bare Ground	8	1.5	Naturally barren or disturbed areas
Waste Pond Complex	3	0.5	Surface water, bulrush, sedges, cattail

a. Based on preliminary inventory of wetlands and vegetation communities (Center for Environmental Monitoring and Assessment, INEL).

A survey for rare and endangered plants at the INEL was conducted by Cholewa and Henderson (1983, 1984). None of the species found by Cholewa and Henderson were federally listed as threatened or endangered. However, many were considered by the INPS and IDFG as sensitive species. These are listed in Table I-16. The association of these sensitive plants with particular vegetation communities was also investigated by Cholewa and Henderson (1984). None of the regulated/sensitive plant species found on the INEL are expected to occur at WAG H.

The bald eagle and peregrine falcon are the only federally threatened faunal species found on the INEL. These are also state endangered species. However, several species including the ferruginous hawk, northern goshawk, loggerhead shrike, black tern, pygmy rabbit, and Townsend's big-eared bat are all federal candidate species for listing (Arthur et al. 1984). The State of Idaho lists the common loon, American white pelican, ferruginous hawk, northern pygmy owl, California myotis, merlin, and great egret as species of special concern.

The threatened, endangered, and sensitive or rare plants and wildlife that are likely to be found within the boundaries of WAG H are highlighted in Table I-16. Eight wildlife species of concern considered likely to occur, other than as occasional transients, are the bald eagle, ferruginous hawk, burrowing owl, long-billed curlew, loggerhead shrike, Swainson's hawk, pygmy rabbit, and Townsend's big-eared bat.

I-2.5 Pathways of Contaminant Migration and Exposure

Contaminant types released from the WAG H complex include numerous trace elements, radionuclides, and organic compounds. The air, soils, surface water, groundwater, and biota are all potential avenues of contaminant transport and exposure. These are also the potentially affected media for WAG H. Transport of contaminants via groundwater is not considered in the case study because groundwater does not discharge to surface water at WAG H.

Table I-16. Threatened, endangered, or sensitive species that may be found at or near WAG H.[a]

Common name	Scientific name	Status					Abundance
		Federal	State	BLM	USFS	INPS	
Flora							
Lemhi milkvetch	*Astragalus aquilonius*	—	S	S	S	2	8
Painted milkvetch	*Astragalus ceramicus* var. *apus*	3c	—	—	—	M	8
Plains milkvetch	*Astragalus gilviflorus*	NL	S	S	S	1	8
Thistle milkvetch	*Astragalus kentrophyta* var. *jessiae*	NL	S	S	—	S	8
Winged-seed evening primrose	*Camissonia pterosperma*	NL	S	S	—	S	8
Nipple cactus	*Coryphantha missouriensis*	NL	S	S	—	M	8
Large-flowered gymnosteris	*Gymnosteris nudicaulis*	NL	—	—	—	M	8
Spreading gilia	*Ipomopsis (Gilia) polycladon*	NL	S	S	—	2	8
King's bladderpod	*Lesquirella kingii* var. *cobrensis*	—	—	—	—	M	8
	Oxytheca dendroidea	—	S	S	—	S	8
Birds							
Peregrine falcon	*Falco peregrinus*	LE	E	—	—	—	S5, M5, W5
Merlin	*Falco columbarius*	NL	—	S	—	—	R5
Gyrfalcon	*Falco rusticolus*	NL	SSC	S	—	—	8
Bald eagle[b]	*Haliaeetus leucocephalus*	LE	E	—	—	—	M5, W3
Ferruginous hawk[b]	*Buteo regalis*	C2	SSC	S	—	—	B3, M3, W5
Black tern	*Chlidonias niger*	C2	—	—	—	—	S5, M5
Northern pygmy owl[c]	*Glaucidium gnoma*	—	SSC	—	—	—	8
Burrowing owl[b]	*Athene cunicularia*	NL	—	S	—	—	B3, M3, W6
Common loon	*Gavia immer*	—	SSC	—	—	—	M5
American white pelican	*Pelicanus erythrorhyncos*	—	SSC	—	—	—	M5
Great egret	*Casmerodius albus*	—	SSC	—	—	—	S5, M5
White-faced ibis	*Plegadis chihi*	C2	—	—	—	—	S5, M5
Long-billed curlew[b]	*Numenius americanus*	3c	—	S	—	—	S3, M3
Loggerhead shrike[b]	*Lanius ludovicianus*	C2	NL	—	—	—	B3
Northern goshawk	*Accipiter gentilis*	C2	S	—	—	—	S5, M5, W5
Swainson's hawk[b]	*Buteo swainsoni*	—	—	S	—	—	B3, M3, W5
Trumpeter swan	*Cygnus buccinator*	C2	SSC	S	S	—	8

Table I-16. (continued).

Common name	Scientific name	Status					Abundance
		Federal	State	BLM	USFS	INPS	
Mammals							
Pygmy rabbit[b]	*Brachylagus (Sylvilagus) idahoensis*	C2	NL	—	—	—	R2
Townsend's Western big-eared bat[b]	*Plecotus townsendii*	C2	SSC	—	S	—	U1
Western pipistrelle[c]	*Pipistrellus hesperus*	NL	SSC	S	—	—	8
Fringed myotis[c]	*Myotis thysanodes*	—	SSC	—	—	—	8
California myotis[c]	*Myotis californicus*	—	SSC	—	—	—	8
Fish							
Shorthead sculpin[c]		—	SSC	—	—	—	8
Reptiles and Amphibians							
Spotted frog[c]	*Rana pretiosa*	C2	—	—	—	—	8
Mojave black-collared lizard[c]	*Crotophytus bicinctores*	—	SSC	—	—	—	8
Ringneck snake[c]	*Diadophis punctatus*	NL	SSC	S	—	—	8
Night snake[c]	*Hypsiglena torquata*	—	—	S	—	—	8

Key:

Status codes

1 = State Priority 1.
2 = State Priority 2.
3c = No longer considered for listing.
BLM = USDI Bureau of Land Management.
C2 = Federal candidate for listing.
E = State endangered.
IDFG = Idaho Department of Fish and Game.
INEL = Idaho National Engineering Laboratory.
INPS = Idaho Native Plant Society.
LE = Federally listed endangered.
M = State monitor species.
NL = Not listed.
S = Sensitive.
SSC = State species of special concern.
USFS = U.S. Forest Service.
USFWS = U.S. Fish and Wildlife Service.
WAG H = (hypothetical) Waste Area Group.

Abundance codes

B = Summer breeder.
M = Migrant.
R = Resident/breeder.
S = Summer visitor.
W = Winter visitor.
U = Unknown breeding status.
1 = Abundant.
2 = Common.
3 = Uncommon.
4 = Occasional or local.
5 = Rare.
6 = Vagrant/accidental.
7 = Possible.
8 = Not present.

a. Compiled from the USFWS, cross-checked and updated with the IDFG Conservation Data Center Threatened, Endangered, and Sensitive Species for the State of Idaho (Moseley and Groves 1992).

b. Highlighted species represent those expected to be found at WAG H.

c. No documented sightings at the INEL.

All areas within WAG H, including the OUs, may be contaminated with radionuclides due to past and ongoing operations and via atmospheric fallout from past nuclear detonations and accidents around the world. Releases of contaminants at each of the OUs may arise from materials transported to the burial pit or to the burn pit for disposal or effluents dispersed to the waste pond. The contaminants from WAG H source areas may then be transported to other areas or mobilized in the food chain as described below for each OU. These sections summarize the potential for contaminant migration and receptor exposure and present models for each OU that represent the most significant transport and exposure pathways. The number of pathways chosen was limited to be consistent with the scope of the case study. Further details on relevant aspects of transport and fate of specific COPCs at WAG H are provided in the "Analysis" (Section I-3).

I-2.5.1 Waste Burial Pit (OU-1)

Once contaminants have been released from the waste burial pit, several transport pathways may result in exposure to the biota of WAG H. These pathways are outlined on Figure I-7. The wastes buried in the pit may be released from leaking containers to the subsurface soil. Through plant uptake, burrowing mammal translocation, leaching and infiltration, and wind and water erosion, soil on and near the burial pit may also be contaminated. These soils may then become an exposure medium for biota inhabiting the burial pit and the surrounding area.

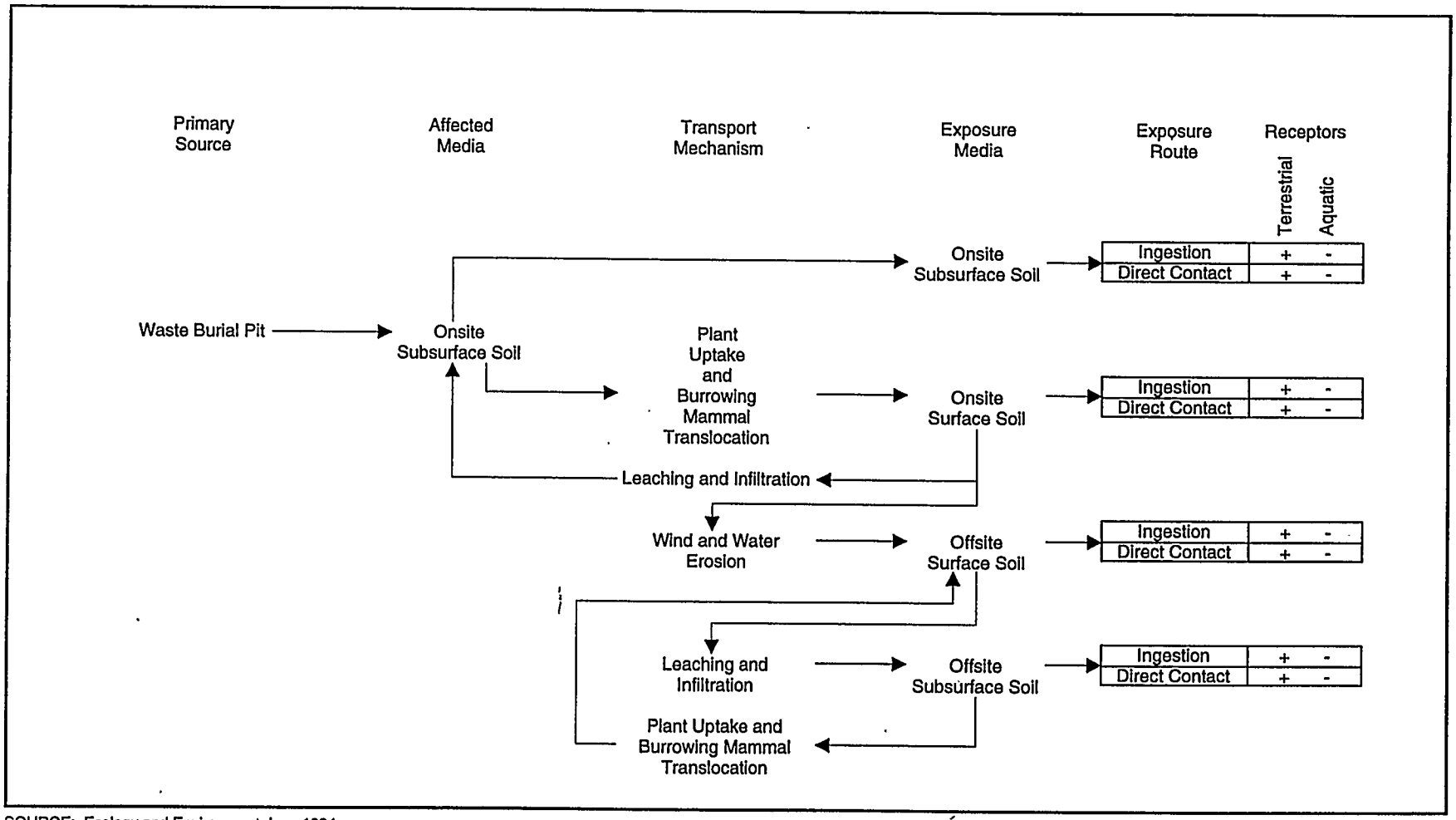
The major routes of exposure for biota may include ingestion of contaminated soil and food items, direct contact with contaminated soil, and plant uptake from contaminated soil with subsequent mobilization through the food chain via herbivorous biota. Inhalation is another potential pathway; however, it is not expected to be a large contributor to the total exposure of biota at the burial pit and will not be evaluated in the case study because the concentrations of VOCs are very low (<0.43 mg/kg).

I-2.5.2 Burn Pit (OU-2)

Transport and exposure pathways at the burn pit (Figure I-8) are similar to those of OU-1 except for the potential aerial transport of combusted materials. This pathway increases the potential for surface soil contamination in areas downwind from the site. Unlike the waste burial pit, the burn pit is assumed to be uncovered and unfenced, and surface contamination is, therefore, more directly accessible to plants and wildlife. Since the burn pit is no longer active, exposure through inhalation of combusted materials is not of concern. The lack of many volatile contaminants at the burn pit also supports the decision not to consider the inhalation pathway.

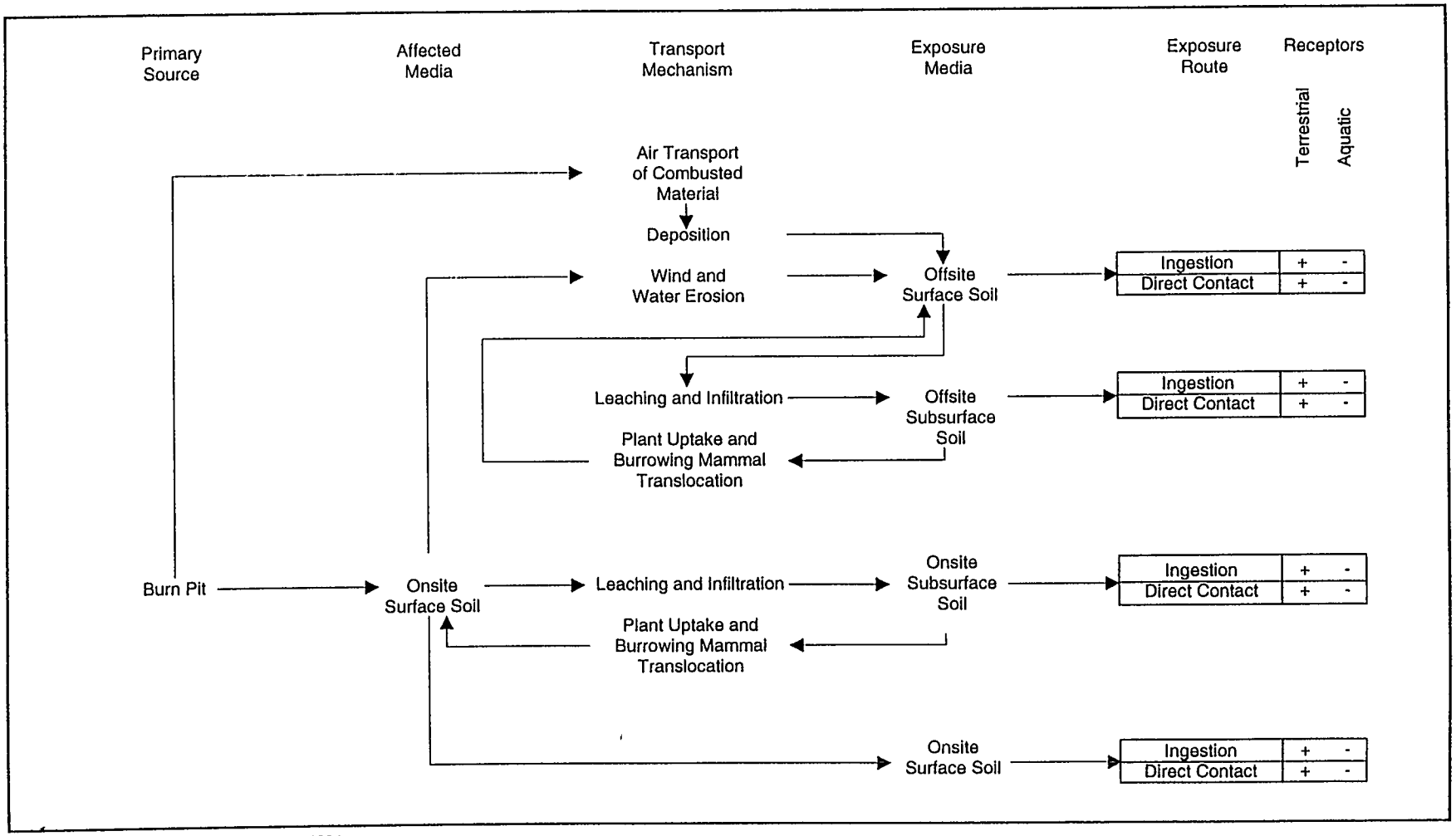
I-2.5.3 Liquid Radioactive Waste Pond (OU-3)

The major transport pathways for the waste pond include deposition from the water column to the sediments and leaching and infiltration of contaminants to the subsurface soils and groundwater. Wildlife using the pond could also translocate contaminants to other areas. In addition, burrowing mammal translocation and plant uptake may occur from the soils surrounding the pond or from dry areas of the pond itself (Figure I-9). Exposure routes include ingestion of and direct contact with pond water and aquatic and terrestrial plant uptake from the water.



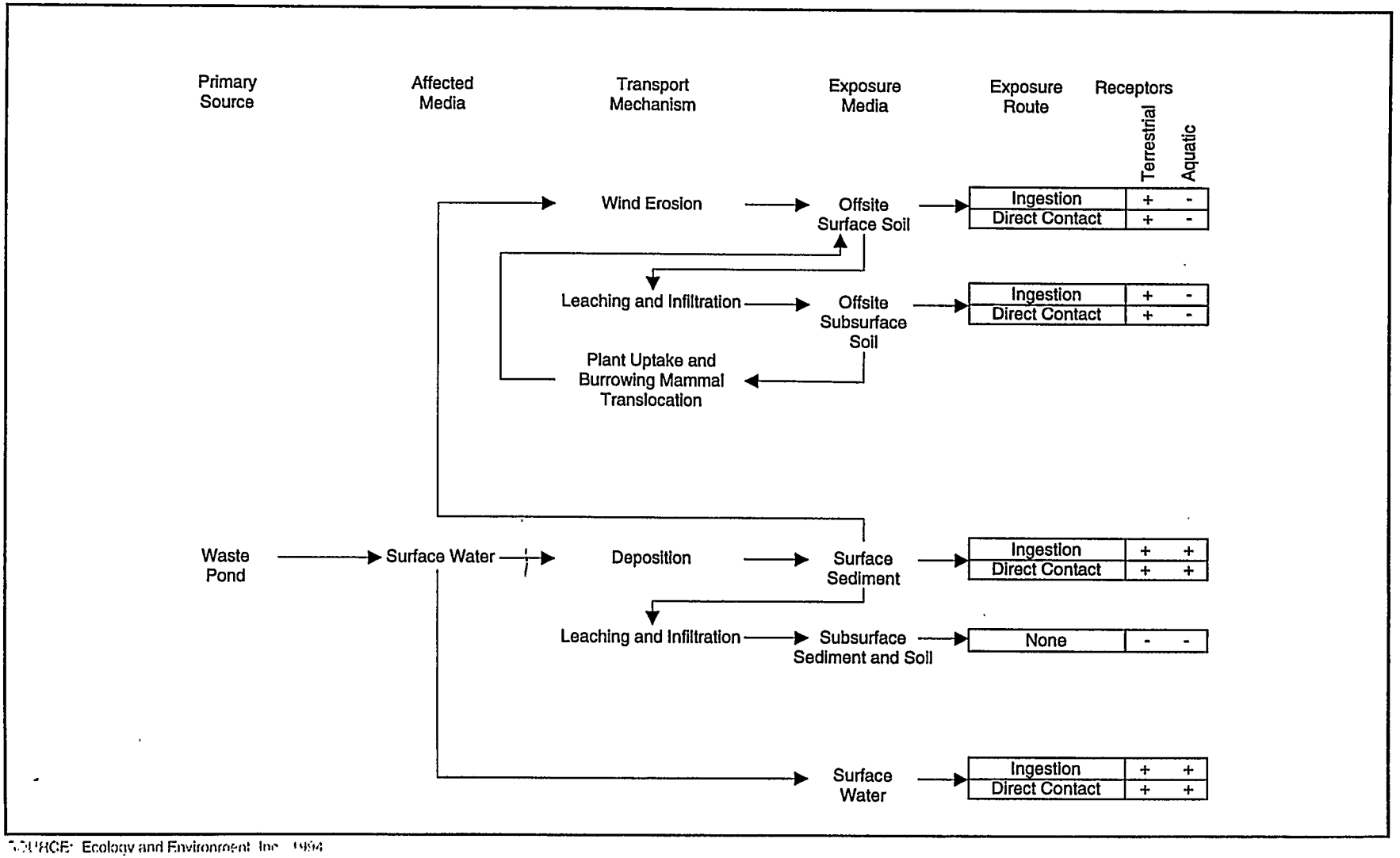
SOURCE: Ecology and Environment, Inc., 1994.

Figure I-7. Pathways of contaminant migration and exposure for the waste burial pit (OU-1).



SOURCE: Ecology and Environment, Inc., 1994.

Figure I-8. Pathways of contamination migration and exposure for burn pit (OU-2).



SOURCE: Ecology and Environment, Inc., 1994

Figure I-9. Pathways of contaminant migration and exposure for the waste pond (OU-3).

Ingestion of and direct contact with contaminants from soil and plant uptake from soil could also mobilize contaminants through the food chain. Inhalation is not expected to be a significant exposure route because of the lack of volatile contaminants.

I-2.5.4 Summary of Selected Pathways of Contaminant Migration and Exposure

The major contaminant migration pathways from each of the OUs include transport from the source to surrounding surface soils via wind and water erosion, plant uptake, and burrowing mammal translocation. Of these, the wind and water erosion are likely to be the most significant. Leaching and infiltration from surface soil to subsurface soils are other potential transport pathways. However, the limited rainfall and rapid evaporation of the INEL region will limit the depth of contaminant penetration except in areas of standing water such as the waste pond. The deposition of contaminants from surface water to sediments is another migration pathway at WAG H.

The most important exposure pathways were determined for the case study using professional judgment and analysis of the selected contaminant migration pathways. The presence of contaminants in surface soil, water, and sediments presents several significant routes of exposure to biota. These include ingestion of surface soil, water, and sediment and uptake of contaminants by vegetation. Direct contact with these media is also a likely pathway of exposure, but dermal uptake factor data are insufficient to measure this pathway. Finally, the exposure of biota that are prey for other biota provides the potential for exposure of the predator to COPCs. Therefore, ingestion of prey is another exposure pathway to be considered during the case study.

I-2.6 Ecological Effects

Available toxicological literature was reviewed to aid in the selection of ecological endpoints appropriate for WAG H. Details of the literature review are provided in Section I-3.2, but general ecological effects information is pertinent to endpoint selection and development of the conceptual model and is briefly described below.

I-2.6.1 Chromium

Chromium is an essential trace element in the diet of some animals and may also be beneficial to growth in plants at typical levels in the environment. At high environmental concentrations, however, chromium is a mutagen, teratogen, and carcinogen. More soluble forms of chromium tend to be more highly toxic. The toxicity of chromium is related to its chemical form. Biologically incorporated chromium is typically found in the trivalent state, and chromium (III) is considered less toxic than chromium (VI). Chromium (III) adversely affects normal metabolism at high dietary levels, and growth and survival can be reduced. The effects of chromium (VI) on mammals have been extensively reviewed and include liver and kidney damage. High doses can lead to failure of critical organs and death. Biomagnification of chromium has not been observed in food chains, and lower trophic levels usually have the highest concentrations. Chromium toxicity data for terrestrial invertebrates are sparse.

I-2.6.2 Strontium-90

The toxicity of elemental strontium is generally quite low at normal levels of calcium intake. Therefore, emphasis is placed on the toxic effects of radioactive ^{90}Sr. In the environment, ^{90}Sr is transferred to animal diets primarily through terrestrial pathways and is primarily retained in vertebrate organisms in bone. ^{90}Sr decays by beta emission and penetrates only a few millimeters in water or solid materials. For most species of wildlife, the internal radiation dose is a more significant source of exposure than the external dose. Sensitivity to chronic low-level radiation varies markedly among taxa. In general, mammals, birds, reptiles, and a few tree species appear to be the most sensitive receptors, and terrestrial species are more sensitive than aquatic organisms. Effects on reproduction, including gametogenesis and embryonic development, are likely to be the most critical endpoints in terms of populations.

I-2.6.3 Tetrachloroethene

Although extensive toxicological information is available for the effects of PCE on laboratory rodents, very little or no information is available for other receptors. Effects of exposure to PCE include liver damage and carcinogenesis in laboratory animals. The majority of PCE in surface soil evaporates into ambient air. Little is known of the phytotoxicity of PCE in soils. However, breakdown products of PCE are known to adversely affect plants.

I-2.6.4 Summary of Ecological Effects

A variety of potential ecological effects could occur as a result of exposure to COPCs at WAG H, affecting organisms at multiple trophic levels. However, both chromium and ^{90}Sr may affect the reproductive process and PCE appears to affect the liver. Good toxicological information is not available to evaluate potential effects of each of the COPCs on all the major groups of animals and plants. However, due to the variety of potential effects, a range of wildlife and plant species could be impacted and should be evaluated.

I-2.7 Ecological Endpoints

Ecological endpoints are receptors and their characteristics that may be adversely affected by environmental stressors. Ecological risk assessment guidance specifies two types of endpoints: assessment and measurement (EPA 1992a). Assessment endpoints are qualitative or quantitative expressions of environmental values to be protected from site-related stressors. The identification of assessment endpoints at any site is dependent upon several factors including the species that are considered to be of concern and the stressors that are present within the assessment area. Assessment endpoints link the ERA process to the risk management process. Measurement endpoints are characteristics of species or ecosystems that can be evaluated through ecological monitoring or other sampling activities and can be quantitatively or qualitatively related to the assessment endpoints. The measurement endpoints are generally determined for indicator species likely to inhabit the areas of contamination. In the case study, these species are termed measurement species. The following sections describe the selection of the assessment endpoints and identify the measurement endpoint species and measurement endpoints for WAG H.

I-2.7.1 Assessment Endpoints

Criteria used for the selection of assessment endpoints for site investigations include the following: regulatory and social significance, ecological relevance, amenability to measurement or prediction, and susceptibility to contaminants (EPA 1992a). Social significance indicates that the assessment endpoint has value to the public or to regulatory agencies (e.g., population abundance of game animals, viability of endangered species). Ecological relevance refers to the role of the assessment endpoint in the ecosystem or community. Measurability indicates that some measurement exists to allow evaluation of the endpoint. Susceptibility to contaminants indicates the potential for the assessment endpoint to be exposed and adversely affected by the site contaminants.

Numerous characteristics of species, communities, and ecosystems at WAG H could be considered as potential assessment endpoints. For example, species of regulatory or social significance such as the pygmy rabbit, pronghorn, or ferruginous hawk may occur at the areas of concern. These species could be susceptible to COPCs through ingestion of contaminated media or food items, and the COPCs could affect their growth, survival, or reproduction. In terms of ecological relevance, functional groups such as small mammals could also be considered, as these are important prey items for higher trophic levels. These receptors would also be highly susceptible to COPCs in surface or subsurface soils due to their burrowing habitats. The criterion of measurability is also an important consideration since toxicological data for native plants and wildlife are limited, and assessment endpoints must be carefully selected to allow evaluation.

Taking these considerations into account, a few representative categories of assessment endpoint species were selected for the terrestrial and aquatic ecosystems of WAG H (Table I-17). Because of the large numbers of species and the complexity of the ecosystem, a systematic method was developed to identify assessment endpoint species. Details of the methodology are provided in the manual. The application of the method to the case study proceeded as follows. All the species likely to be found at WAG H were divided into taxonomic groups as described in the manual. The groups were further segregated taxonomically into different orders and families. To reduce the number of wildlife to be considered as assessment endpoint species, the relative abundance of each species likely to occur at WAG H was evaluated. With the exception of the regulated species or other rare species identified as species of concern in Table I-16, only species known to be abundant or common at WAG H were considered for selection as assessment endpoint species.

Next, each taxonomic group was divided into functional groups by combining species with similar potential for exposure to COPCs. This grouping was done by defining the trophic level, the feeding habitat, and the nonfeeding habitat of each wildlife species expected to occur at WAG H. The trophic levels were generally defined as herbivore, insectivore, carnivore, omnivore, and detritivore. The feeding habitat and nonfeeding habitat types were air, terrestrial, terrestrial/aquatic interface, and aquatic. Each of the feeding and nonfeeding habitats may be further subdivided to represent different niches within each habitat. [To limit the number of functional groups for consideration at WAG H, only those groups presented in Table I-18 were selected for further analysis]. These groups represent five assessment endpoints species groups at WAG H including birds (raptors and waterfowl), mammals (small and large herbivorous), and

Table I-17. Assessment endpoint species—WAG H.

Assessment endpoint species categories	Ecological relevance	Regulatory or social significance	Susceptibility to COPCs	Measurability or predictability
Native shrubs and grasses	Provide nesting, food, and cover for wildlife.	Potential importance as rangeland for grazing livestock. Habitat for game animals.	Roots may penetrate to subsurface contamination. Contaminants in surface soil could also be mobilized and absorbed. Some COPCs are known to be phytotoxic.	Levels of COPCs in soils and plant tissues can be measured or predicted and related to published toxicity benchmarks for crops or native plants.
Small mammals	Base of the food chain for raptors and carnivores.	Small mammals are important as a community because of significance as a food item for other species of concern. Some species are utilized for game. The pygmy rabbit is a federal candidate for listing (C2 species).	Highly susceptible to exposure due to burrowing habits and occurrence in fenced and disturbed areas. Some mammals are sensitive to effects of radionuclides.	Dose rates can be estimated and related to published toxicity benchmarks. Toxicological information is relatively good for rodents due to widespread use as surrogates for testing effects of COPCs on humans.
Large herbivorous mammals	Significant consumers of vegetation in terms of biomass and abundance.	Game animals.	May ingest contaminated soil, forage, and drinking water. Some mammals are sensitive to effects of radionuclides.	Dose rates can be estimated and related to published toxicity benchmarks for domestic livestock, deer, or other mammals.
Raptors	Top predators in terrestrial food chain.	Of recreational and aesthetic importance. The bald eagle is federally endangered. The ferruginous hawk is a C2 species, and several species of raptors are state species of special concern.	Could be exposed through consumption of contaminated food items.	Dose rates can be estimated from small mammal tissue residues measured in previous ecological investigations of the site. Limited toxicological data are available for birds of prey.
Waterfowl	Important breeding wildlife at the waste pond.	Game animals. Waterfowl are protected under the Migratory Bird Treaty Act.	Could be exposed through consumption of contaminated food, sediment ingestion, and direct contact with and ingestion of water.	Dose rates can be estimated and related to published toxicity benchmarks for waterfowl or other birds.

Table I-18. Selected wildlife functional groups—WAG H.

Functional group	Common name	Trophic level	Feeding habitat	Non-feeding habitat	Abundance[a]
Raptors (Class Aves, Order Falconiformes)					
1	American kestrel	2/3	2.2	2.1	B2, M2, W3
	Northern harrier[b]	3	2.2	2.2	R2
	Ferruginous hawk	3	2.2	2.1	B3, M3, W5
	Rough-legged hawk	3	2.2	2.4	S6, M2, W2
	Golden eagle	3	2.2	2.1	B3, M4, W2
	Bald eagle	3	2.2	2.1	M5, W3
Raptors (Class Aves, Order Strigiformes)					
2	Burrowing owl	3	2.2	2.3	B3, M3, W6
Waterfowl (Class Aves, Order Anseriformes)					
3	Mallard[b]	1	4.3	4.1	B2, M2, W3
	Blue-winged teal	1	4.3	4.1	B2, M3
Small Mammals (Class Mammalia, Order Rodentia)					
4	Western harvest mouse	1	2.2	2.2	R2
	Montane vole	1	2.2	2.3	R1, R4 (cyclic)
	Bushy-tailed woodrat	1	2.2	2.3	R2
	Ord's kangaroo rat	1	2.2	2.3	R2
5	Townsend's ground squirrel	4	2.2	2.3	R2
	Least chipmunk	4	2.2	2.3	R1
	Deer mouse[b]	4	2.2	2.3	R1
Small Mammals (Class Mammalia, Order Lagomorpha)					
6	Black-tailed jackrabbit	1	2.2	2.2	R1, R4 (cyclic)
	Pygmy rabbit	1	2.2	2.3	R2
	Nuttall's cottontail	1	2.2	2.3	R2
Large Herbivorous Mammals (Class Mammalia, Order Artiodactyla)					
7	Pronghorn[b]	1	2.2	2.2	R1

Key:

Trophic Level codes:
- 1 = Herbivore.
- 2 = Insectivore.
- 3 = Carnivore.
- 4 = Omnivore.
- 5 = Detritivore.

Feeding and Non-Feeding Habitat codes:
- 1 = Aerial.
- 2 = Terrestrial.
- 2.1 = Canopy.
- 2.2 = Ground surface.
- 2.3 = Subsurface.
- 2.4 = Vertical.
- 3 = Semi-aquatic.
- 3.1 = Canopy.
- 3.2 = Ground or water surface.
- 3.3 = Subsurface.
- 3.4 = Vertical.
- 4 = Aquatic.
- 4.1 = Water surface.
- 4.2 = Water column.
- 4.3 = Bottom.

a. See Table I-16 for abundance codes.

b. Highlighted species are selected as measurement endpoint species.

plants. For purposes of the case study, each of the species in a functional group was considered representative of others in the same group with regard to potential exposure to COPCs and toxicological effects.

The selected assessment endpoint species are representative of concerns at the site, both from a regulatory point of view and from a broader ecological perspective. The assessment endpoint species are presented as major functional groups (e.g., raptors, small mammals) rather than as individual species. The assessment endpoints for these functional groups could be the predicted or measured effects of COPCs on survival, growth, or reproduction of individuals of important species within each group. However, with the exception of threatened or endangered species, adverse effects on populations or communities of these organisms are considered as the assessment endpoints for WAG H. Other assessment endpoints could be considered but will not be addressed for the purposes of the case study.

I-2.7.2 Measurement Species

The assessment of all species inhabiting a potentially contaminated area is rarely feasible. Therefore, certain measurement species were selected to reduce the time, energy, and expense involved in assessing the effects of site-related stressors on plants and wildlife. These species are considered indicators of potential ecological risks to other species within the same functional groups at WAG H. These measurement species may be surveyed, sampled, or otherwise measured for exposure or effects. For purposes of the screening-level ERAs, however, exposure of these measurement endpoint species is estimated from the available sampling data.

Considerations for the selection of measurement species include the following: relevance to and consistency with the assessment endpoints; rapidity and low variability of response, and sensitivity to area stressors; diagnostic attributes of the response; and ease of measurement (EPA 1992a). In selecting particular measurement species from those functional groups listed in Table I-19, emphasis was placed on the availability of toxicological information that would allow evaluation of effects. The selected species are widely used in monitoring at other locations in the western United States and are common enough at the INEL to be considered for use in future studies undertaken for detailed risk assessments. Other considerations included those shown in Table I-19. The measurement endpoint species selected for evaluation at WAG H are bunchgrass and sagebrush, deer mouse, northern harrier, pronghorn, and mallard (Table I-19).

I-2.7.3 Measurement Endpoints

Measurement endpoints are measurable responses to contaminants that can be related to the assessment endpoints. For the screening-level risk assessments, actual environmental effects to species are not measured. Therefore, the measurement endpoints are derived from published values of chronic and acute toxicity of COPCs in food, environmental media, or tissues of measurement endpoint species or their surrogates. The measurement endpoints vary but are generally selected to be indicative of significant effects on survival, reproduction, or growth of the measurement endpoint species. Given the ecological effects of the selected COPCs provided in Section A-2.6, effects on the reproduction and livers of the measurement species were preferred. However, the toxicological database is limited and the actual measurement endpoints are determined by available data. The particular endpoints used in the case study are identified in the "Analysis" (Section I-3).

Table I-19. Measurement endpoint species—WAG H

Measurement endpoint species	Relevance to assessment endpoints	Responsiveness and diagnostic attributes	Ease of measurement
Bunchgrass, Sagebrush	Dominant species of native shrubs and grasses.	Rooting plants are in direct contact with contaminated soils. Phytotoxic effects may include specific responses to COPCs.	Published toxicological information available for similar species of grasses and shrubs. Can be easily collected or surveyed for detailed studies.
Deer mouse	Most common small mammal at the site. Likely to occur in disturbed habitats at or near the OUs.	Herbivorous and burrowing habits are representative of worst-case exposure for small mammals. Prolific breeding and short lifespan allow for rapid response to COPCs.	Extensive toxicological database available for related species of rodents. Previously used for site monitoring.
Pronghorn	Most common large herbivore at the INEL.	Regarded as a transient at the site but could be exposed to wind-blown COPCs or via drinking water. Difficult to assess due to migratory behavior and large home range.	Toxicological data available for radionuclides in grazing food chain.
Northern harrier	Common raptor, breeds at the INEL near WAG H.	Consumption of small vertebrates as primary food item and year-round presence at the site are representative of worst-case exposure for raptors.	Commonly used as an indicator species for contaminant studies.
Mallard	Common waterfowl species, assumed to utilize the waste pond aquatic habitat during breeding and migration.	Literature indicates measurable uptake of radionuclides occurs over short durations of exposure.	Relatively extensive database of toxicological effects exists for mallards. Previously used for site monitoring.

If potential risks are determined to be present at WAG H, a detailed risk assessment may be initiated in which field investigations of exposure and effects could be conducted. In this event, WAG H specific measurement endpoints can be developed to guide the investigations.

I-2.8 Ecological Conceptual Site Model

Generally the ecological conceptual site model depicts all routes of contaminant migration and exposure at a given area. However, as applied to the final step of the problem formulation in screening-level ERA for WAG H, the model was used to clearly picture the most important aspects of the assessment which were delineated in the previous sections of the Problem Formulation and are to be examined further during the Analysis and Risk Characterization phases. As shown in Figure I-10, the case study will focus on the ingestion and uptake of contaminants by deer mice, pronghorn, northern harriers, mallards and plants from soil, water, sediments, plants and prey items. This ecological conceptual model for WAG H can be summarized in the following set of working hypotheses:

Hypothesis 1: Potential ecological risks are presented to the selected terrestrial receptors at WAG H as a result of their exposure to the selected COPCs in surface soils.

Soils at WAG H are contaminated with a variety of site-related constituents including chromium, ^{90}Sr, and PCE. Contaminants could affect the OUs and areas surrounding the OUs as a result of wind and water erosion, or translocation of contaminants by wildlife. These COPCs may be mobilized in the terrestrial food chain, and direct exposure may result via ingestion of soil by wildlife. In addition, uptake of COPCs from surface soil by vegetation of the sagebrush/steppe ecosystem may result in effects to the vegetation. Small and large herbivorous fauna that feed on the native vegetation and raptors that prey on small mammals represent other trophic levels that may be exposed to COPCs through the food chain.

Hypothesis 2: Potential ecological risks are presented to selected aquatic and terrestrial receptors at WAG H as a result of exposure to selected COPCs in surface water and sediments.

Surface water and sediments at the site are contaminated with site-related constituents including ^{90}Sr. Contaminants could migrate to the surface soils of the OUs and areas surrounding the OUs as a result of air deposition of windblown contaminants (during periods of pond dryness) or translocation of contaminants by wildlife. These COPCs may then be mobilized in the aquatic and terrestrial food chains, and exposure may result through ingestion of sediment, surface water, and nearby surface soils by wildlife. Since the pond is artificial, its integrity as an ecosystem is not of primary concern, but potential effects on waterfowl and other wildlife using the pond are of concern.

Each of these hypotheses are evaluated during the Analysis and Risk Characterization phases of the case study.

Figure I-10. Ecological conceptual site model for WAG H.

I-3. ANALYSIS

The analysis phase of screening-level ERA involves the evaluation of exposure to COPCs (see Section I-3.1) and potential effects of exposure (Section I-3.2). These activities are conducted interactively to ensure that the methods used to evaluate exposure and effects are compatible. Analysis of exposure and effects is based on the ecological endpoints and conceptual model derived during Problem Formulation (Section 2).

I-3.1 Exposure Assessment

The exposure assessment at WAG H involves estimating exposure to contaminants for the measurement endpoint species identified in Section 2. To derive these estimates, assumptions were made regarding ecological receptors' contact with and uptake of COPCs. When available, site-specific and species-specific exposure parameters were used to derive exposure estimates. Otherwise, exposure parameters were derived from published or readily available information, as described in this section. The exposure assessment is divided into the following sections:

- "Contaminant Transport and Fate" (Section I-3.1.1)
- "Exposure Point Concentrations" (Section I-3.1.2)
- "Exposure Scenarios and Pathways" (Section I-3.1.3)
- "Exposure Estimates" (Section I-3.1.4).

I-3.1.1 Contaminant Transport and Fate

In this section, information on the behavior of COPCs in environmental media at WAG H is qualitatively reviewed. No formal transport and fate modeling will be conducted for this screening-level ERA.

I-3.1.1.1 Chromium. Chromium is a multivalent element and can exist in the +2, +3, and +6 oxidation states. The latter two, chromium (III) and chromium (VI), are the most stable in the environment. In soils and sediments, chromium is influenced by oxidation/reduction reactions and can be adsorbed on the mineral and organic exchange complex or exist as a coating in iron and manganese hydrous oxides particles. Moreover, chromium can remain in solution in the porewater phase, become chelated by an organic ligand, or precipitated as sparingly soluble or highly insoluble (Adriano 1986; Bodek et al. 1988).

The adsorption of chromium (VI) by hydrous metal oxides and other soil mineral components decreases as pH increases. Therefore, in the alkaline soils of WAG H, chromium (VI) adsorption to soils may be low. The presence of other anions (e.g., sulfate and phosphate) significantly affects the extent of adsorption by competing for adsorption sites. Formation of ion pairs, such as dissolved calcium chromate, can also reduce the extent of adsorption. In contrast to chromium (VI), the adsorption of chromium (III) increases with pH. In general, it appears from laboratory studies that chromium (III) is adsorbed more strongly than chromium (VI). This may be especially true in the alkaline soils of WAG H. Organic material

may also be an important adsorbent in sediments and soils. The soils of WAG H are generally low in organic materials, which indicates a decreased potential for adsorption.

Typically, in normal, well-drained arid soils, the great majority of chromium is in the form of chromium (III) which may not be mobile in the WAG H soils. On average, chromium (VI) was found to be less than 1% of total chromium at WAG H so exposure to chromium (VI) is not expected to be widespread. Although the exposure to and concentrations of chromium (VI) are expected to be relatively low, this form of chromium is mobile in alkaline soils and is more toxic than chromium (III).

I-3.1.1.2 Strontium-90. Strontium is an alkaline earth element and is, therefore, chemically similar to calcium and barium. Strontium follows calcium through food chains from environment to organism, but some degree of discrimination exists against strontium (Kirchman et. al. 1993). Because strontium acts similarly to calcium in biota, it is retained in vertebrate organisms primarily in bone and in the hardshells of invertebrates.

^{90}Sr is a radionuclide formed during nuclear fission. It has a radioactive half-life of 29.1 years and decays by beta emission. Its daughter radionuclide, yttrium-90 (^{90}Y), also is radioactive. ^{90}Y has a half-life of 64 hours and decays by beta emission to the stable isotope zirconium-90 (^{90}Zr) (Shleien 1992).

During the 1950s and 1960s, large quantities of ^{90}Sr were released to the atmosphere in above-ground nuclear detonations and were subsequently dispersed throughout the world. In temperate latitudes, wet deposition from precipitation (rain and snow) accounts for 80 to 90% of the total ^{90}Sr in atmospheric fallout. Hence, some ^{90}Sr in the environment at the INEL may be fallout ^{90}Sr from above-ground nuclear testing.

Because ^{90}Sr is produced in the fuel of nuclear reactors, some ^{90}Sr in the environment at the INEL may be from the reactors operated there or from waste transported onto the site. The World Health Organization (WHO) (1983) reports that small amounts of ^{90}Sr produced in reactor fuel may reach the coolant through defects in the fuel cladding. In coolant purification or following coolant leakage, ^{90}Sr may reach the gaseous and/or liquid effluent streams and, in controlled amounts, be released to the environment.

In terrestrial ecosystems, 60 to 80% of ^{90}Sr from fallout is retained in the upper 5 cm of undisturbed soil (Horne 1978). The rate of movement of ^{90}Sr in soil typically is slow and depends on soil type; low cation exchange capacity, rapid water movement, and high electrolyte concentrations increase migration rates (WHO 1983). Plants acquire ^{90}Sr by root uptake and direct deposition onto foliage. Adsorption into the leaves is relatively slow, and superficial material is readily lost. Uptake from soil normally is the primary mode of ^{90}Sr entry into plants. The amount of exchangeable calcium in soil is a key factor in determining the extent of ^{90}Sr uptake by plants; uptake is greatest from soils of low calcium content. The relatively high levels of calcium found in WAG H soils may decrease the plant uptake of ^{90}Sr. ^{90}Sr in plants can be transferred to herbivorous animals and subsequently to higher trophic levels (WHO 1983; Kirchman et al. 1993).

In the aquatic environment, strontium, like calcium, exists primarily in ionic form (Sr^{2+}) and is not strongly sorbed by suspended particulate matter. Stable strontium concentrations in inland

waters in the United States range from 12 µg/L (Sebago Lake, Maine) to 2,100 µg/L (Great Salt Lake, Utah) (Horne 1978). Many aquatic organisms acquire strontium and calcium by direct uptake from water. Consequently, strontium accumulation in aquatic biota depends little on trophic level (WHO 1983).

^{90}Sr in the environment at the INEL most likely is from both atmospheric fallout and release from reactors onsite. ^{90}Sr in the environment is transferred to animal and human diets primarily through terrestrial pathways, is retained in vertebrate organisms primarily in bone, but also is retained in muscle tissue and various internal organs (Kirchman et al. 1993).

Because the ^{90}Sr beta particle penetrates only a few millimeters in water or solid materials (Shleien 1992), most organisms absorb 100% of the radiation dose from ^{90}Sr in their bones and soft tissues. The external radiation dose from low levels of ^{90}Sr in the environment is probably negligible for most birds and mammals because the ^{90}Sr beta particle travels only about 40 cm through air. However, soil invertebrates and small burrowing mammals may receive a significant external radiation dose from ^{90}Sr in soil.

Research has been conducted at the INEL on ^{90}Sr in soil, sediment, and water, and uptake by plants, mammals, birds, and invertebrates (Appendix F in the manual). For the case study, relevant INEL research was reviewed to identify qualitative and quantitative information useful for the exposure assessment at WAG H. Significant concentrations of ^{90}Sr are likely to be found in the soils, surface water, and sediment of WAG H.

I-3.1.1.2 Tetrachloroethene. Tetrachloroethene (C_2Cl_4; CAS number 127-18-4) is a nonflammable volatile organic compound that exists as a liquid between -22 and 121°C. The compound's water solubility is 150 mg/L at 20°C so, once transported to an aqueous medium, it is very soluble. Common synonyms for tetrachloroethene include carbon dichloride, ethylene tetrachloride, PCE, and tetrachloroethylene (WHO 1984). The compound is artificial and is not known to occur as a natural product.

Tetrachloroethene is mainly used in dry-cleaning and degreasing operations. At WAG H, the compound was found in soil from the burn pit, probably as a result of disposal of degreasing compounds at this location. Most (about 85%) tetrachloroethene disposed of on land evaporates into ambient air (WHO 1984). In the atmosphere, the compound is photodegraded in the presence of water, ultimately to form trichloroacetic acid (TCA), hydrochloric acid, and carbon dioxide. Some tetrachloroethene disposed of on land will infiltrate into soil and may possibly reach groundwater where it is moderately mobile (Fetter 1988). The compound can be relatively persistent in the subsurface environment and undergoes biodegradation only under anaerobic conditions (Parsons et al. 1984).

At WAG H tetrachloroethene is likely to evaporate rapidly from surface soils because of the warm dry climate. If it reaches surface soils, it may persist. In surface water tetrachlorethene is likely to remain in solution, with some volatilization and some deposition to sediments.

I-3.1.2 Exposure Point Concentrations

The exposure media of ecological concern at WAG H include surface water, sediment, and surface soil. For these media, the average exposure case was considered. Exposure point

concentrations (EPCs) calculated for the average exposure case are the average surface water, sediment, and soil concentrations of COPCs at WAG H (see Table I-20). The EPCs for surface water and sediment were estimated using data collected from the waste pond (OU-3). The EPCs for soil were conservatively estimated from surface and subsurface soil samples from the waste burial pit (OU-1) and burn pit (OU-2), and from the maximum concentrations detected at other WAG H locations outside the OUs. The use of the average concentrations to calculate EPCs is conservative since the sampling at WAG H is biased toward areas of known and suspected contamination. This approach results in estimated exposure doses that are most likely higher than the actual doses received by ecological receptors at the site. Therefore, the average COPC concentration in each of the affected media is considered to be an estimate of the RME for the case study.

I-3.1.3 Exposure Scenarios and Pathways

As discussed in Section 2, five functional groups were selected for the quantitative ecological risk assessment: a species of shrub or grass, a small mammal, a large herbivorous mammal, a raptor, and a waterfowl. Shrub and grass species are represented by bunchgrass or sagebrush; small mammals are represented by the deer mouse; large herbivorous mammals by the pronghorn; raptors by the northern harrier; and waterfowl by the mallard.

Each of the wildlife endpoint species was assumed to be exposed to COPCs via the following three pathways: the food chain (aquatic or terrestrial), incidental soil or sediment ingestion, and drinking water from the waste pond. Since the mallard was assumed to feed entirely from the aquatic food chain, ^{90}Sr (in surface water and sediment) and chromium (VI) (in sediment) are the COPCs to which the mallard is exposed. The deer mouse, northern harrier, and pronghorn are assumed to be exposed to all COPCs through the ingestion of soils and food as well as to ^{90}Sr through drinking water.

The exposure model for nonradiological contaminants (discussed in Section 3.1.4.1, below) allows for the determination of food-chain exposure through ingestion of multiple dietary items. The use of multiple dietary items is recommended for actual assessments; however, for the case study, each endpoint species' diet was assumed to be composed of a single food type. This assumption was made to simplify the presentation of calculations for food-chain exposure. The food item selected to represent the entire diet was the staple in the actual diet, as discussed in sources such as Martin et al. (1961) and DeGraaf and Rudis (1992). The mallard was assumed to obtain all its food from the waste pond aquatic food chain in the form of macrophytes. The deer mouse and pronghorn diets were assumed to be composed entirely of various terrestrial plants. The northern harrier's diet was assumed to be composed of various small mammals.

I-3.1.4 Exposure Estimates

This section discusses the methods used to quantitatively estimate the exposure of selected WAG H endpoint species to the COPCs. The calculations for total exposure of each of the endpoint species to nonradiological COPCs is discussed in Section 3.1.4.1. The calculations used to estimate terrestrial food-chain exposure are described in Section 3.1.4.2. Radionuclide dose estimates for the terrestrial measurement species are provided in Section 3.1.4.3. The exposure of the mallard to ^{90}Sr was assessed using a published computer model (CRITR2) and is discussed in Section 3.1.4.4.

Table I-20. Exposure point concentrations—WAG H.

COPC	Surface water		Sediment		Soil	
	Average concentration	N[a]	Average concentration	N	Average concentration	N
Chromium (III)	—	—	—	—	66.3 µg/g	45
Chromium (VI)	—	—	0.39 µg/g	9	0.44 µg/g	11
Strontium-90	1.58E-06 µCi/mL	68	314 pCi/g	28	534 pCi/g	38
PCE	—	—	—	—	0.035 µg/g	8

a. N = Number of samples.

I-3.1.4.1 Exposure Parameters and Formulas for Nonradiological Contaminants. Total exposure of each of the wildlife receptors to nonradiological chemicals was calculated as the sum of the dietary, soil (or sediment), and drinking water exposure estimates:

$$EE_{total} = EE_{food} + EE_{soil/sediment} + EE_{water} \quad (1)$$

where:

EE_{total} = Total exposure (mg/kg BW · day)

EE_{food} = Estimated exposure to COPCs from food ingestion (mg/kg BW · day)

$EE_{soil/sediment}$ = Estimated exposure to COPCs from soil ingestion (or sediment)(mg/kg BW · day)

EE_{water} = Estimated exposure to COPCs from drinking water ingestion (mg/kg BW · day).

The exposure estimates for the nonradioactive COPCs from dietary exposure and exposure from ingestion of soil, sediment, or surface water for each wildlife receptor were calculated by multiplying each prey species tissue concentration by the proportion of that prey in the diet; summing these values; multiplying by the receptor's site use factor (SUF), exposure duration (ED), and ingestion rate (IR); and dividing by the receptor's body weight (BW). The exposure parameters used for these calculations are provided in Table I-21 (with the exception of prey tissue concentrations, which are discussed below in Section 3.1.4.2). Dietary exposure is represented mathematically as:

$$EE_{food} = \frac{\left[\left(P_1 \times T_1\right) + \left(P_2 \times T_2\right) + \ldots \left(P_n \times T_n\right)\right] \times SUF \times ED \times IR}{BW} \quad (2)$$

where:

EE_{food} = Estimated exposure to COPCs from food ingestion (mg/kg BW · day).

P_n = Percentage of diet represented by food item ingested ($P_1 + P_2 + \ldots P_n$ must equal 100%).

Table I-21. Exposure parameters for measurement endpoint species.

Receptor	Percent of diet[a]			Home range[c] (acres)	Site use factor[d]	Exposure duration[e]	Drinking rate[f] (L/day)	Ingestion rate[f] (kg/day)	Body weight[c] (kg)
	Plants	Small mammals	Soil/ sediment[b]						
Mallard	100	—	2	192	1	1[g]	0.0986	0.061	1.08
Deer mouse	100	—	2	2	1	1	0.0060	0.004	0.027
Northern harrier	—	100	2	243	1	1	0.0482	0.033	0.42
Pronghorn	100	—	5	2,530	0.50	1	1.699	1.418	46.1

a. Approximate values assumed for simplicity. Values greater than 100% result from the soil/sediment intake being calculated as a percentage of and added to the food intake percentages.

b. Beyer et al. (1992).

c. DeGraaf and Rudis (1986) for mallard and northern harrier; Burt and Grossenheider (1976) for deer mouse and pronghorn.

d. Site use factor (unitless) is derived by dividing the site size (1,253 acres) by the receptor home range. Value is not to exceed 1.

e. Fraction of year spent in region, 0 to 1 (unitless).

f. See text for method for calculation.

g. For radionuclides, exposure duration was assumed to be 1 (365 days) for a resident mallard and 0.016 (6 days) for a migratory mallard (see text).

T_n = Tissue concentration in food item n (mg/kg), calculated by multiplying the chemical concentration in media (or food item) by a bioaccumulation factor (BAF).

SUF = Site use factor, equal to the area of WAG H (acres) divided by area of home range (acres) to a maximum of 1.0.

ED = Exposure duration (unitless), equal to the fraction of the year spent inhabiting WAG H.

IR = Ingestion rate of receptor [kg Dry Weight (DW)/day]

BW = Body weight of receptor (kg).

Literature sources of dietary information for the measurement species included Martin et. al. (1961) and DeGraaf and Rudis (1992). Home range sizes were taken from Burt and Grossenheider (1976) and DeGraaf and Rudis (1992). Food ingestion rates were calculated from the intake formulas presented in Suter (1993); the equations are listed in Table I-22. Literature sources for body weights of receptor species included Dunning (1993), DeGraaf and Rudis (1992), and Burt and Grossenheider (1976).

The SUF was calculated by dividing the WAG H area by the home-range area (to a maximum of 1.0). This process conservatively assumed the home ranges were centered on WAG H. An Exposure Duration (ED) value of 1.0 was used for receptor species that are year-round residents of the region, and a value between 0 and 1.0 was used for migratory species (mallard) based on the fraction of the year spent in the region. For the case study, each of the endpoint species was conservatively assumed to be a year-round resident, with the exception of the mallard (see Section 3.1.4.4).

Receptor exposure to chemicals from soil (or sediment) ingestion ($EE_{soil/sediment}$) was estimated by multiplying the soil concentration (mg/kg) by the percentage of soil in the diet of each receptor (kg/d); multiplying by the SUF, ED, and IR; and dividing by BW. Soil ingestion data as a percentage of diet were taken from Beyer et al. (1994).

Table I-22. Food intake formulas for wildlife.[a]

Wildlife group	Food intake formula[b] (g/day)
Rodents	$0.621(BW)^{0.564}$
Herbivorous mammals	$0.577(BW)^{0.727}$
Birds	$0.648(BW)^{0.651}$

a. Suter 1993.

b. Dry-weight basis.

To estimate drinking water intake for nonradionuclide COPCs, the following formula from Suter (1993) should be used:

$$\text{water intake (L/day)} = 0.093BW^{0.7584} \quad (3)$$

where:

BW = Body weight of receptor (kg).

The exposure to a COPC via water ingestion (EE_{water}) is then calculated by multiplying the water ingestion rate (L/day) by the concentration of the COPC in water (mg/L); multiplying by the SUF, and ED; and dividing by BW.

No nonradiological contaminants were selected for evaluation in surface water at WAG H. Therefore, the EE_{water}, as described here, was not utilized in the calculation of total exposure of the measurement species at WAG H. The drinking water exposure was calculated only for ^{90}Sr which requires a separate calculation process (see below).

I-3.1.4.2 Terrestrial Food-Chain Exposure Calculations. To calculate uptake of contaminants in the terrestrial food chain, contaminant transfer from environmental media or food to plant or animal tissues was estimated from published concentration factors. These contaminant-specific concentration factors are referred to as "uptake factors" for plants and "food-chain transfer factors" for wildlife. The plant uptake factor is generally described as the plant tissue concentration of a COPC divided by its soil or sediment concentration. The plant uptake factor was used to calculate the concentration of COPCs in plant tissues. The plant tissue concentration of the COPC was then used as T_n in Equation (2).

A plant uptake factor for chromium in soil was taken from Baes et al. (1984). Alternatively, site-specific plant uptake factors could be calculated using data in Arthur and Gates (1988). For PCE, the plant uptake factor was calculated from the octanol-water partition coefficient, using the approach described by Travis and Arms (1988). A site-specific plant uptake factor for ^{90}Sr of 1.11 was calculated from ^{90}Sr levels in soil and crested wheatgrass from the INEL, based on data from Arthur (1982). This uptake factor falls within the range of published ^{90}Sr plant uptake factors (0.13 to 2.3) for common crop plants reported by Kirchman et al. (1993). Plant uptake factors for nonradiological COPCs at WAG H sites are listed in Table I-23.

The food-chain transfer factor is the animal tissue concentration of a COPC divided by the concentration in its food. To estimate the tissue levels of COPCs in prey items of wildlife at different trophic levels, the food-chain transfer factors for each trophic level were multiplied together to derive a BAF, which is the concentration of a COPC in the tissues of an animal divided by the soil or sediment concentration. The BAF accounts for the transfer of contaminants at each trophic level up to the species of concern. For example, the BAF for an herbivorous small mammal is the plant uptake factor times the plant-to-herbivore transfer factor. The BAFs

Table 23. Uptake factors for plants—nonradiological contaminants.

Habitat	COPC	Uptake factor[a]	Remark	Reference
Terrestrial	Chromium (III)	0.0075	Vegetative parts.	Baes et al. (1984)
	PCE	1.22	Calculated from log K_{ow}.	Travis and Arms (1988)
Aquatic	Chromium (VI)	0.26	Sediment to macrophyte uptake factor. Calculated by dividing total chromium in macrophytes by total chromium in sediment; value is an average for cattail, bulrush, and pondweed.	Hoffman et al. (1990)

a. Dry weight basis; (plant DW concentration)/(soil or sediment DW concentration).

were used to estimate the tissue levels of a COPC in a particular small mammal by multiplying the small mammal BAF times the concentration of a COPC in the soil inhabited by the mammal. This tissue level may then be used to estimate exposure for predators of small mammals as T_n in Equation (2).

For animal receptors, BAFs and food-chain transfer factors for COPCs were taken from the literature or calculated from literature data. Data on chemical concentrations in wild animals, as opposed to domestic or laboratory animals, were used when available. Food-chain transfer factors for herbivores and birds are provided in Table I-24. Estimated tissue levels [T_n in equation (2)] in food-chain components are provided in Table I-25.

I-3.1.4.3 Radiation Dose Estimates for Terrestrial Receptors. Internal radiation dose estimates were calculated using the approach presented by IAEA (1992). Consistent with this approach, the steady-state concentrations of radionuclides in reproductive organs of animals were estimated. For the case study, these concentrations were assumed to be equal to the concentration in the whole body, although data on stable concentrations of strontium in tissues

Table I-24. Food-chain transfer factors for wildlife—nonradiological contaminants.

Animal group	COPC	Transfer factor	Remark	Reference
Herbivorous mammals	Chromium[a]	0.008	Determined in feeding studies with cotton rats.	Taylor (1980) as cited by Eisler (1986).
	PCE	1.6×10^{-4}	Calculated from log K_{ow} and an assumed muscle-tissue moisture content of 54%.	Travis and Arms (1988); Suter (1993) for tissue moisture.

a. Transfer factor used for both chromium (III) and chromium (VI).

Table 25. Bioaccumulation factors and estimated tissue levels—nonradiological contaminants.

	Plants		Macrophytes		Herbivorous mammals	
Chemical	Uptake factor	Tissue level (mg/kg)	Uptake factor	Tissue level (mg/kg)	BAF[a]	Tissue level (mg/kg)
Chromium (III)	0.0075	0.497	NC	NC	0.00006	0.00398
Chromium (VI)	0.0075	0.0033	0.262	0.102	0.00006	0.0000264
PCE	1.22	0.0427	NC	NC	0.000195	6.83E-06

a. Mammal BAF derived by multiplying plant to herbivore transfer factor by plant uptake factor.

could have been used to estimate reproductive tissue concentrations [International Commission on Radiological Protection (ICRP), 1959]. Dose rates were then calculated from the following equation:

Dose rate (Gy/day) =

$$\frac{[^{90}\text{Sr tissue level (Bq/kg)}] \cdot [\text{average decay energy (MeV/dis)}] \cdot [\text{fraction of decay energy absorbed}] \cdot [8.64 \times 10^4 \text{dis/day} \cdot \text{Bq}]}{[10^3 \text{g/kg}][6.25 \times 10^9 \text{ MeV/g} \cdot \text{Gy}]} \quad (4)$$

The ^{90}Sr tissue concentrations were derived by multiplying the concentration of radionuclides in soil for plants and in food items for fauna, by the concentration factors provided in Table I-26 and then multiplying by the SUF and the ED shown in Table I-27. The tissue levels are shown in Table I-27 in units of pCi/kg. Units were converted to Bq/kg by dividing the value by 27.03. The average decay energy for the ^{90}Sr β particle (0.1958 MeV/dis) was taken from Shleien (1992). The fraction of decay energy absorbed was assumed to be 1.0; this is a reasonable assumption given the short distance (<1 mm) that ^{90}Sr β particles can travel through solid materials (Shleien 1992). The last term in the numerator (8.64×10^4 dis/day · Bq) is a unit conversion factor and comes from the equality 1 Bq = 1 dis/sec. The two terms in the denominator of Equation (4) also are unit conversion factors; 6.25×10^{-9} MeV/g · Gy comes from the equality 1 Gy = 6.242×10^9 MeV/g (Shleien 1992). Table I-27 lists calculated internal dose rates from ^{90}Sr for the terrestrial receptors at WAG H.

Intake of ^{90}Sr for drinking water was calculated from Equation (3) and was compared to the intake from dietary sources for each of the measurement species. As the intake from drinking water was found to be 6 to 8 orders of magnitude less than intake from food, this source of exposure was negligible for terrestrial wildlife.

I-3.1.4.4 Radiation Dose Estimates for Semi-Aquatic Wildlife. To estimate radiation doses to the mallard from ^{90}Sr releases to the WAG H waste pond, the computerized exposure model CRITR2 was used. CRITR2 provides a simplified means of calculating radiation doses to semi-aquatic or aquatic biota from radionuclide concentrations in water and/or sediments, using a restricted number of parameters relating to the discharge and the receiving water body (NCRP 1991; Baker and Soldat 1992). Two exposure scenarios were simulated for the mallard. For the

Table I-26. Strontium-90 concentration factors.

Receptor	Concentration factor[a]	Remark	Reference
Bunchgrass/Sagebrush	1.11	Calculated by dividing the ^{90}Sr concentration in crested wheatgrass by the ^{90}Sr concentration in soil. Plant and soil data from INEL site.	Arthur (1982)
Deer mouse	1.07	Mouse BAF (carcass/soil). Calculated by dividing the ^{90}Sr activity in a deer mouse carcass from a background site by the ^{90}Sr levels in background soils surrounding the INEL site.	Arthur *et al.* (1987) for mouse tissue data; Arthur and Markham (1983) for soil data.
Pronghorn	1.54	Antelope BAF (carcass/soil). Calculated by dividing the ^{90}Sr activity in pronghorn bone ash from a background site by the ^{90}Sr activity in soil from the site. The resulting BAF was adjusted to a whole-carcass BAF by multiplying by 0.08. The animal's body composition was assumed to be 8% skeleton and 92% soft tissues.	Markham and Halford (1980) for ^{90}Sr data.
Northern harrier	1.10	Bird carcass/soil BAF. Conservative assumption.	None. No ^{90}Sr tissue data are available for raptors on or near the INEL site.

a. Dry weight basis (tissue DW concentration)/(soil DW concentration).

Table 27. Estimated internal dose rates to terrestrial endpoint Strontium-90 species.

Receptor	Concentration factor[a]	Site use factor[b]	Exposure duration[b]	Tissue level[c] (pCi/kg)	Internal dose rate[d] (Gy/day)
Bunchgrass/Sagebrush	1.11	1	1	592,740	5.94E-05
Deer mouse	1.07	1	1	571,380	5.73E-05
Northern harrier	1.10	1	1	534,000	5.35E-05
Pronghorn	1.54	0.5	1	822,360	4.12E-05

a. For bunchgrass and sagebrush, value is the plant uptake factor (see Table I-3.4); for kangaroo rat, northern harrier, and pronghorn, value is the BAF (see Table I-24).

b. See Table I-27.

c. Tissue level equals level in soil times the concentration factor times the site use factor times the exposure duration.

d. See text for explanation of calculation of internal dose rate from tissue concentration.

simulation for migratory mallards, calculations were done by hand following procedures described by Baker and Soldat (1992). The exposure parameters used in the simulations for the mallard are shown in Table I-28. The simulations performed for the waste pond assumed no dilution or recirculation.

I-3.1.4.5 Total Exposure Estimates. The total estimated exposure of the measurement species to the selected COPCs is presented in Table I-29. Exposure to nonradiological COPCs was assessed using Equations (1) and (2) for wildlife measurement species. For plants no exposure assessment was necessary for nonradionuclides because the soil concentrations of contaminants were used to determine the risks to plants. The exposure to radiological COPCs was estimated using Equation (4) for the bunchgrass/sagebrush, deer mouse, northern harrier and the pronghorn. The mallard was assessed for exposure to radionuclides using the CRITR2 model.

I-3.2 Ecological Effects Assessment

The purpose of the ecological effects assessment is to characterize the potential toxicity of the COPCs to the measurement species at WAG H. The assessment presents an overview of the sources of toxicological information and methods for evaluation and is divided into the following sections:

- "Toxicity Benchmark Values" (see Section I-3.2.1)
- "Uncertainty Factors" (see Section I-3.2.2)
- "Toxicity Reference Values" (see Section I-3.2.3).

The approach taken for ecological effects assessment is as follows. Toxicity benchmark values (TBVs) were selected from the ecotoxicological database. These TBVs served as the basis for developing TRVs, using selected uncertainty factors to relate the TBVs to the appropriate

Table I-28. Radionuclide exposure parameters used in the CRITR2 Model for the Mallard.

Receptor	Exposure duration (days)	Macrophytes in diet[a] (%)	Body weight[a] (kg)	Ingestion rate[a] (kg/day)	Equivalent radius[b] (cm)	Occupancy factor[b] (unitless)	Immersion[b] (unitless)	Proportion of time spent on surface water[b] (unitless)	Roughness[b] (unitless)
Mallard	365[c], 6[d]	100	1.08	0.061	5.0	0.20	0.30	0.5	0.2

a. See Table I-3.2.

b. Values are default parameters of the model.

c. Resident mallard scenario.

d. Migratory mallard scenario.

Table I-29. Total estimated exposure for measurement endpoint species—WAG H (mg/kg/BW-day).

Receptor	Chromium (III)	Chromium (VI)	PCE	Strontium-90 (Gy/day)
Bunchgrass	6.63E+01	4.40E-01	3.50E-02	5.94E-05
Mallard (resident)	NC	6.23E-03	NC	1.60E-02
Mallard (migratory)	NC	NC	NC	2.76E-04
Deer mouse	2.69E-01	1.79E-03	6.40E-03	5.73E-05
Northern harrier	1.05E-01	6.95E-04	5.56E-05	5.35E-05
Pronghorn	6.21E-02	4.12E-04	6.79E-04	4.12E-05

first scenario, year-round residence of the mallard at the waste pond was assumed. For the second scenario, ducks were assumed to be migratory and their exposure duration was limited to six days. This is the average waterfowl residence time at the waste pond estimated by Halford et al. (1982). Year-round residency is a default assumption of CRITR2; to perform the measurement endpoints and measurement species. The TRVs were expressed in terms of a dose (e.g., mg/kg-d) and were used in the assessment of risks to mammalian and avian measurement endpoint species. In the assessment of the potential effects of chromium and PCE on terrestrial plants, phytotoxicity TRVs are expressed in terms of soil concentrations rather than doses. The TRVs were derived from published information as described in this section.

I-3.2.1 Toxicity Benchmark Values

TBVs are doses from published toxicological studies that are considered to be the most conservative and defensible thresholds for adverse effects of COPCs on particular animal groups. A comprehensive literature and database search was performed to identify relevant TBVs for ecological receptors at WAG H. The principal data sources included:

- Primary literature sources (journal articles and scientific publications).
- Registry of Toxic Effects of Chemical Substances (RTECS) [U.S. National Institute of Occupational Safety and Health NIOSH) 1994].
- Hazardous Substances Database (HSDB) [National Library of Medicine (NLM) 1994].
- Integrated Risk Information System (IRIS) (EPA 1994).
- Toxicological Profile Series of the Agency for Toxic Substances and Disease Registry (ATSDR) [U.S. Department of Health and Human Services (HHS) 1992 1993].
- Phytotox Database (PHYTOTOX) (EPA 1992c).
- Chemical Evaluation Search and Retrieval System (CESARS) [Michigan Department of Natural Resources (MDNR) 1994].
- Oil and Hazardous Materials/Technical Assistance Database (OHM/TADS) (EPA 1994b).

Regardless of the source of the data, the primary reference was obtained whenever possible to fully interpret and review the data as presented by the authors of the original study.

Because toxicity data for the measurement endpoint species were often unavailable for the COPCs at WAG H, toxicity data for closely related species or species in the same functional group were used to identify TBVs. The threshold contaminant intake level is likely to fall between the Lowest Observed Effect Level (LOEL) and the No Observed Effect Level (NOEL). For the case study, a chronic NOEL was selected as the TBV, since it likely provides greater protection against potential adverse effects than a LOEL and is a conservative approach appropriate for screening-level ERA. Toxicity values representing the highest NOEL were

preferred, but other values such as the concentration that is a lethal dose to 50% of population (LD_{50}) were considered if a NOEL was not found. Data for chronic toxicity were chosen when available, but subchronic or acute data were used if no chronic data were found. If toxicity data were unavailable for a COPC, that COPC was not evaluated quantitatively in the screening-level ERA.

For most COPCs, several sources were available to select TBVs. These sources provide data associated with a variety of toxicological endpoints and critical effects. The process of selecting an appropriate toxicity endpoint for use as a TBV required assessment of the appropriateness of various endpoints. In general, data indicative of overt health effects to individual organisms that may result in population level effects, such as reproductive impacts, were preferred. Other less adverse effects data, such as changes in organ weight or subtle physiological effects, which are less likely to be directly associated with adverse population effects, were used only in the absence of the preferred toxicity data.

Toxicity data reported as dietary concentrations [i.e., parts per million (ppm) or mg/kg in food], were converted to a dose (i.e., mg/kg BW as an average daily intake] using data presented in the source study or from information on average ingestion rates and BWs of test animals. For each of the COPCs at WAG H, the pertinent toxicological data are reviewed and TBVs are derived, as follows. The TBVs are summarized in Table I-30.

I-3.2.1.1 Chromium (III). Rat and mouse oral LD_{50} values range from 260 mg/kg-BW as chromic nitrate to 2,369 mg/kg-BW for chromic acetate, and chronic NOELs for chromium range from 2.7 mg/kg-BW for chromic chloride to 1,400 mg/kg-BW for chromic oxide (MacKenzie and Hoppert 1958; Ivankovic and Preussman 1975). These data indicate the importance of the chemical form of chromium with regard to its toxicity. Given this importance, it is very difficult to choose the appropriate TBV without specific information on the form of the chromium compounds found in WAG H soils. However, since in general chromium (III) is less toxic than chromium (VI) and the majority of chromium in site soils is in the form of chromium (III), the subchronic NOEL of 1,400 mg/kg-BW (Ivankovic and Preussman 1975) was chosen as the chromium TBV for mammals. In addition, this NOEL is presented by the EPA in the integrated risk information system (IRIS) as the basis for the oral reference dose for human health risk assessment. The endpoints studied during the investigation included effects on hematology, liver, spleen, kidney, lung, heart, pancreas, stomach, small intestine, and bladder examination; food intake; weight changes; life expectancy; fertility; and reproduction (Ivankovic and Preussman 1975).

Avian species were represented in the literature by studies of black ducks, which were fed 4.75 mg/kg-BW over a 5-month period with no effects on survival or reproduction (Haseltine et al. 1985). Because this chronic NOEL was the only avian endpoint located, it was selected as the chromium TBV for the mallard and the northern harrier. As trivalent chromium is an essential trace element in the diet of birds and other animals, levels below this TBV could cause dietary deficiencies (Puls 1988), and this value is likely to be highly conservative in comparison to the NOEL for rats.

For chromium, potential phytotoxicity was addressed qualitatively by obtaining threshold soil concentrations of COPCs from the literature. A TBV of 75 µg/g chromium in soil was the

Table I-30. Summary of toxicity benchmark values—WAG H.

Chemical	Test organism	Exposure route-duration	Endpoint	Critical effects	TBV (mg/kg-BW)	Reference
PCE	Mouse	Oral-6 weeks	LOEL	Liver damage	100	Buben and Flaherty (1985)
	Oats	Root uptake from heavy soil	NOEL		1 μg/g	Adena and Henzen (1989)
	Black duck	Oral-5 months	NOEL	Survival, Reproduction	4.75	Haseltine et al. (1985)
	Plants	Root uptake from agricultural soils	LOEL	Adverse effects on crop yields	75 μg/g	Kabata-Pendiab and Pendiab (1992)
Chromium (III)	Rat	Oral-90 days	NOEL	Various organ and histopathological effects	1,400	Ivankovic and Preussman (1975)
	Black duck	Oral-5 months	NOEL	Survival, Reproduction	4.75	Haseltine et al. (1985)
	Plants	Root uptake from agricultural soils	LOEL	Adverse effects on crop yields	5 μg/g	Adriano (1986)
Chromium (VI)	Rat	Oral-1 year	NOEL	Body weight, Pathology	2.4	Mackenzie et al. (1958)
	Rabbit	Oral-6 weeks	LOEL	Liver damage	1.7	Tandon et al. (1978)
	Black duck	Oral-5 months	NOEL	Survival, Reproduction	4.75	Haseltine et al. (1985)
Strontium-90	Vole	Unspecified-Lifetime	NOEL	Survival	0.015 Gy/d	Mihok et al. (1985)
	Donkey	Unspecified-3 months	NOEL	General health, Mortality	0.001 Gy/d	Garner and Barber (1966)
	Swallow	Unspecified-Hatch to fledge	NOEL	Growth	0.006 Gy/d	Zack and Mayoh (1982)
	Plants	Unspecified-Lifetime	NOEL	Production, Leaf fall	0.010 Gy/d	IAEA (1992)

lowest threshold value found in a review of soil concentrations considered to be phytotoxic by various authors (Kabata-Pendias and Pendias 1992).

I-3.2.1.2 Chromium (VI). Acute LD_{50} values for chromium (VI) range from 5 mg/kg-BW for mice (Steven et al. 1976) to 22.5 mg/kg-BW for rats (ATSDR 1993). However, in another study, subchronic exposure at 98 mg/kg-BW only resulted in hypoactivity in rats (Diaz-Mayans et al. 1986). Hypoactivity was not seen at 9.8 mg/kg-BW during the same subchronic study, but this concentration was not considered to be an appropriate NOEL because other, more sensitive endpoints may exist.

MacKenzie and Hoppert (1958) found that chronic exposure of rats to chromium (VI) in drinking water at 2.4 mg/kg-BW per day resulted in no toxic symptoms. This research examined body weight, clinical blood chemistry, and gross and microscopic pathology. Other studies of rats found that approximately 50 mg/kg-BW in food resulted in a slight toxic effect indicating that chromium (VI) in food may be less toxic to rats than chromium (VI) in water. However, rabbits were affected (blood chemistry and liver damage) at 1.7 mg/kg-BW of chromium (VI) (Tandon et. al. 1978), indicating that rabbits may be more sensitive to chromium than rats, although comparisons across different studies are conjectural.

The rat NOEL of 2.4 mg/kg-BW was chosen as the TBV for the deer mouse in the case study, because the laboratory rat more closely resembles the deer mouse than does the rabbit. This value is also promoted by EPA as the basis for the oral reference dose for humans, which lends additional credence to this value. The rabbit LOEL of 1.7 mg/kg-BW was chosen as the TBV to represent the pronghorn. This value was selected as the most conservative approach given the lack of toxicity data for large herbivores. Moreover, due to the lack of chromium (VI) toxicity data for birds, the chromium TBV of 4.75 mg/kg-BW was selected for birds (see Section I-3.2.1.1).

For plants, a chromium (VI) TBV of 5 μg/g in soil was the lowest threshold considered to have adverse effects on plant growth (Adriano 1986). No avian effects data were located for chromium (VI).

I-3.2.1.3 Strontium-90. Effects of elemental strontium are not found except at high concentrations in the diet [>530 mg/kg-BW for mice (NLM 1994)] and LD_{50}s range from 2,629 mg/kg-BW for the rat to 8,100 mg/kg-BW for the mouse (NIOSH 1994). Because of the low toxicity of elemental strontium, the major effects at WAG H are expected to be due to the radioactivity of ^{90}Sr. Therefore, only radiological TBVs were calculated for strontium.

Acute LD_{50} values for small mammals range from approximately 5 Grays (Gy) to 11 Gy, and LD_1 values have been determined at 2 Gy (IAEA 1992). Mean litter sizes and number of pregnancies were also reduced in mice at 4.8 Gy (Whicker and Schultz 1982), and 0.25 Gy resulted in reductions in spleen weight and reduced platelet and leucocyte numbers in kangaroo rats (Haley et. al. 1960).

Chronic studies on the effects of radionuclides have shown that the rate of chronic exposure is more important than the total dose (IAEA 1992). In small mammals, decreased survival was detected at greater than 20 mGy/d; but at approximately 15 mGy/d, no population effects were

noted in a population of voles, and at 13 mGy/d, no reproductive effects were noted in albino rats. Chronic exposure of pigs and donkeys at 100 mGy/d resulted in death after several months, but 1 mGy/d was found to be a NOEL (Garner and Barber 1966). The highest NOEL presented in these data is 15 mGy/d and this value was chosen as the TBV for small mammals.

These data show that large mammals, such as donkeys, may be quite sensitive to radionuclides. Since the pronghorn is a large herbivorous mammal somewhat similar to the donkey, the TBV for the pronghorn was based upon the donkey toxicity data. A chronic NOEL of 1 mGy/d was chosen as the TBV for large herbivorous mammals.

The effects of irradiation on birds are not well documented. Several studies found 1 Gy/d down to 200 mGy/d resulted in reduced hatching success and embryonic mortality, respectively, for passerine species. A chronic NOEL was established for swallows and wrens exposed to 6 mGy (IAEA 1992) and was chosen to represent the avian TBV.

The most sensitive plant species was the pine tree; 20 mGy/d produced reduced litter production and leaf fall. Doses of <10 mGy/d were predicted to represent a NOEL for plant species (IAEA 1992) so 10 mGy/d was chosen as the TBV for plants.

I-3.2.1.4 Tetrachloroethene. The LD_{50} values for PCE range from 2,629 mg/kg-BW for the rat (NIOSH 1994) to 8,850 mg/kg-BW for the muskrat (EPA 1994b). Oral LD_{LO} concentrations were listed as 4,000 mg/kg-BW for the cat and dog, and 5,000 mg/kg-BW for the rabbit (NIOSH 1994). This information indicates that the rat was more sensitive to acute PCE exposure than other species that have been tested.

Subchronic studies listed in IRIS show that mice exposed at 100 mg/kg-BW or higher for six weeks had higher liver-to-body weight ratios and higher liver triglyceride concentrations (Buben and O'Flaherty 1985). A LOEL for rats based upon similar effects was listed as 400 mg/kg-BW (EPA 1994a). In the same study on rats, the next lowest dose below 400 mg/kg-BW was 14 mg/kg-BW, which was described as a NOEL. This large range between the LOEL and NOEL does not allow a clear definition of the effects threshold. Given the unknown effects between 14 and 400 mg/kg-BW and the fact that rats do not appear more sensitive to chronic exposure than mice, the mouse subchronic LOEL of 100 mg/kg-BW provided in Buben and O'Flaherty (1985) appears to represent the best estimate of a TBV for small mammals. Because data for large herbivorous mammals were unavailable, the small mammal TBV was used for the pronghorn.

No chronic studies were found for plant or animal exposure to PCE. Therefore, although the above studies are subchronic, they represent the best available information. No avian toxicity studies were located to establish TBVs for PCE for these receptors.

For plants, no studies were found on the phytotoxicity of PCE in soils. However, one of the breakdown products of PCE degradation is the compound TCA, which is highly phytotoxic and has been manufactured and widely used as an herbicide. Therefore, toxicity benchmarks for TCA were evaluated as surrogates for PCE. The lowest threshold TBV for TCA is 1.0 µg/g, which is a NOEL for oats grown in a loamy soil (Adema and Henzen 1989).

I-3.2.2 Uncertainty Factors

The toxicity data for wild, free-ranging wildlife are not as complete as those found for laboratory or domestic test species. Therefore, extrapolation of toxicity data from laboratory or domestic animal studies is often necessary to obtain TRVs for measurement endpoint species. Additional sources of uncertainty include extrapolation from acute or subchronic exposure doses to chronic doses, and extrapolation to sensitive or protected species. Because of the uncertainty associated with these extrapolations, uncertainty factors were applied to the TBVs to derive TRVs in an effort not to underestimate risks. The approach taken to derive TRVs for this assessment is provided in Table I-31. References for the chosen uncertainty factors are provided where possible; however, several of the uncertainty factors used in the case study are based upon professional judgment.

For those COPCs for which only acute lethal values (e.g., LD_{50}) were available, TRVs were derived by dividing the acute toxicity value by the appropriate uncertainty factors. Dividing by an uncertainty factor of 5, the LD_{50} was extrapolated to a value representative of an acute toxicity threshold. This uncertainty factor is based on an analysis of dose-response data for pesticides (EPA 1986b). In the case of acute LOELs, which would be expected to lie between an LD_{50} and an acute NOEL, a conservative uncertainty of 5 was also used to extrapolate to an acute NOEL. An uncertainty factor of 2 was used to extrapolate from the acute NOEL to a chronic NOEL. This procedure results in an overall uncertainty factor of 10 to extrapolate from an acute LOEL to a chronic NOEL (Newell et al. 1987). An uncertainty factor of 5 was used to extrapolate from a chronic LOEL to a chronic NOEL.

In cases where test species differed phylogenetically from the measurement endpoint species, an uncertainty factor of 2 was used to extrapolate between different families within the same order. A factor of 4 was used if the extrapolation was between different orders within the same class. Finally, an additional factor of 2 was used to provide more conservative TRV estimates for threatened, endangered, or other protected or sensitive species. These uncertainty factors were based on professional judgment and are consistent with factors used at other sites, such as at the Rocky Mountain Arsenal (Calabrese and Baldwin 1993).

An exception to this approach was taken for radionuclides, where extensive toxicity studies have been conducted and the threshold TRVs for the most sensitive species in various animal and plant groups have been established (see Section A-3.2.1.3). Hence, for radionuclides the chosen TBVs were not adjusted using uncertainty factors.

I-3.2.3 Toxicity Reference Values

The TRVs for the measurement species at WAG H are presented in Table I-32. The following summarizes the TRV calculations for each species.

Ingestion toxicity data were unavailable for the pronghorn, so other large herbivorous mammal data were used when available. If no data were found for large mammals, common laboratory rodent data were extrapolated to calculate a TRV.

Table I-31. Uncertainty factors for mammalian and avian receptors.

TBV	TRV (or intermediate)	Divide by (uncertainty factor)
Acute Lethal Dose (LD_{50})	Acute Toxicity Threshold (Acute LOEL)	5
Acute or Subchronic LOEL	Chronic NOEL	10
Chronic LOEL	Chronic NOEL	5
Different Family-Same Order	Nonprotected Species TRV	2
Different Order-Same Class	Nonprotected Species TRV	4
Nonprotected Species	Protected Species TRV	2

As an example in developing TRVs for an endangered, threatened, or rare species of rabbit when the only value available is an LD_{50} for a rat, the following steps would be taken:

Rat LD_{50} for COPC = 50 mg/kg BW

1. Acute lethality	---->	Acute toxicity threshold	$\frac{50 \text{ mg/kg BW}}{5}$ = 10 mg/kg BW
2. Acute toxicity threshold	---->	Chronic NOEL	$\frac{10 \text{ mg/kg BW}}{10}$ = 1 mg/kg BW
3. Different order Within Class	---->	Nonprotected species TRV	$\frac{1 \text{ mg/kg BW}}{4}$ = 0.25 mg/kg BW
4. Nonprotected species TRV	---->	Protected species TRV	$\frac{0.25 \text{ mg/kg BW}}{2}$ = 0.125 mg/kg BW

As 10 mGy/d was considered a NOEL for plant species, this value was chosen as the ^{90}Sr TRV for bunchgrass and sagebrush. Other TRVs were the soil concentrations provided in Table I-32.

Table I-32. Toxicity reference values for measurement species—WAG H.

COPC	Species	TBV (mg/kg-d)	Test species	Endpoint	LD_{50} to acute LOEL UF	Acute or subchronic LOEL or NOEL to chronic NOEL UF	Chronic LOEL to chronic NOEL UF	Phylogenetic UF	Combined UF	TRV (mg/kg-d)
PCE	Pronghorn	100	Mouse	LOEL	1	10	1	4	40	2.5
	Deer mouse	100	Mouse	LOEL	1	10	1	2	20	5
	Northern harrier	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Bunchgrass	1 μg/g	Oats	NOEC	1	1	1	1	1	1 μg/g
Chromium (III)	Pronghorn	1,400	Rat	NOEL	1	1	1	4	4	350
	Deer mouse	1,400	Rat	NOEL	1	1	1	2	2	700
	Northern harrier	4.75	Black duck	NOEL	1	1	1	4	4	1.19
	Bunchgrass	75 μg/g	Agricultural plants	LOEL	1	1	1	1	1	75 μg/g
Chromium (VI)	Pronghorn	1.7	Rabbit	LOEL	1	10	1	4	40	0.0425
	Kangaroo rat	2.4	Rat	NOEL	1	1	1	2	2	1.2
	Northern harrier	4.75	Black duck	NOEL	1	1	1	4	4	1.19
	Mallard	4.75	Black duck	NOEL	1	1	1	1	1	4.75
	Bunchgrass	5μg/g	Agricultural plants	NA	1	1	1	1	1	5μg/g
Strontium-90	Pronghorn	0.001 Gy/d	Mammals	NOEL	1	1	1	1	1	0.001 Gy/d
	Deer mouse	0.015 Gy/d	Vole	NOEL	1	1	1	1	1	0.015 Gy/d
	Northern harrier	0.006 Gy/d	Swallow	NOEL	1	1	1	4	4	0.0015 Gy/d
	Mallard	0.006 Gy/d	Swallow	NOEL	1	1	1	4	4	0.0015 Gy/d
	Bunchgrass	0.010 Gy/d	Plants	NOEL	1	1	1	1	1	0.010 Gy/d

For the deer mouse, the TRVs for nonradionuclide COPCs were extrapolated from laboratory mice and rats. The TRV for ^{90}Sr was calculated from an investigation of wild, free-ranging voles inhabiting a contaminated area.

Avian toxicity data are less complete than mammalian toxicity data. Species-specific toxicity data for the northern harrier and mallard were unavailable for any of the COPCs, and no PCE data were located for any avian species. The northern harrier and mallard TRVs were extrapolated from other available avian studies when available.

I-4. RISK CHARACTERIZATION

In this section, the ecological risks posed by COPCs at WAG H are identified and summarized. Risk characterization involves two major steps, risk estimation and risk description (EPA 1992a), as described below.

I-4.1 Risk Estimation

The risks of site contamination were estimated by calculating a hazard quotient (HQ) for each COPC and receptor. The HQs were calculated as follows:

$$HQ = EE/TRV \quad (5)$$

where:

HQ = Hazard quotient

EE = Estimated exposure

TRV = Toxicity reference value.

The estimated exposures were derived in the exposure assessment (Section 3.1). These exposures were based on the average concentration of COPCs in environmental media that were considered to be representative of the reasonable maximum exposure scenario because of the biased sampling which has occurred at WAG H. TRVs were derived in the ecological effects assessment (Section 3.2) and represent the concentration of a given contaminant that is considered to be toxic to the receptor of concern. A HQ greater than 1 would be considered presumptive evidence for a potential risk of adverse chronic effects of a chemical on a given ecological receptor for a given case, a given pathway, and a given critical effect.

Total hazard indices (THIs) were also calculated for all species (or contaminants) be assessed. These values are the additive results of each of the HQs across all COPCs. The addition of all HQs across the COPCs is considered a conservative approach to account for possible synergism due to exposure of a receptor to multiple COPCs. The conservatism results from the fact that actual synergism is likely to be less than 100% additive across all COPCs because some contaminants are expected to negate the effects of others. Therefore, the predicted. THIs are likely higher than the actual hazard indices would be.

I-4.1.1 Hazard Quotients

The HQs and THIs for measurement endpoint species at WAG H are presented in Table I-33. With one exception, all the HQs are less than 1, indicating that risks due to the individual COPCs are likely to be negligible for most COPCs and measurement species. The exception is the ^{90}Sr HQ for resident mallards, which was approximately equal to 11. Therefore, a potential risk may be posed as a result of exposure of the mallard to this radionuclide in the

Table I-32. Summary of wildlife hazard quotients.

	Mallard (resident)			Mallard (migratory)			Deer Mouse			Northern Harrier			Pronghorn		
Chemical[a]	EE_{total}	TRV	HQ	EE_{total}	TRV	HQ	EE_{total}	TRV	HQ	EE_{total}	TRV	HQ	EE_{total}	TRV	HQ
Chromium (III)	NC	NC	NC	NC	NC	NC	2.69E-01	7.00E+02	3.80E-04	1.05E-01	1.19E+00	8.82E-02	6.21E-02	3.50E+02	1.80E-04
Chromium (VI)	6.23E-03	4.75E+00	1.31E-03	NC	NC	NC	1.79E-03	1.2E+00	1.49E-03	6.95E-04	1.19E+00	5.84E-04	4.12E-04	4.25E-02	9.69E-03
Strontium-90	1.60E-02	1.5E-03	1.07E+01	2.76E-04	1.5E-03	1.84E-01	5.73E-05	1.50E-02	3.82E-03	5.35E-05	1.50E-03	3.57E-02	4.12E-05	1.00E-03	4.12E-02
PCE	NC	NC	NC	NC	NC	NC	6.40E-03	1.25E+01	1.28E-03	5.56E-05	NA	NA	6.79E-04	2.50E+00	2.72E-04
Total Hazard Indices			1.07E+01			1.84E-01			6.97E-03			1.24E-01			5.13E-02

a. Units are mg/kg BW-day for chromium, chromium (VI), and PCE, Gy/day for strontium-90.

Table I-33. Summary of plant hazard quotients.

Chemical[a]	EE_{total}	Bunchgrass/sagebrush TRV	HQ
Chromium	6.63E+01	7.50E+01	8.84E-01
Chromium (VI)	4.40E-01	5.00E+00	9.00E-02
Strontium-90	1.00E-02	1.00E-02	5.94E-03
PCE	3.5E-02	1.00E+00	3.5E-02
Total Hazard Index			1.01E+00

a. Units are mg/kg for chromium, chromium (VI), and PCE; Gy/day for strontium-90.

waste pond. Note that the HQ for migratory mallards was less than 1, indicating that only the resident portion of the waterfowl population is potentially exposed to harmful levels of radiation.

Table I-34 shows the HQs for plant receptors at WAG H. All HQs were less than one, but the THI was 1.01. This result indicates a slight potential for effects to plants due to the selected COPCs.

I-4.2 Risk Description

Risk description involves summarizing risks and their ecological significance. In addition, the uncertainties of the ecological risk assessment are discussed. A weight-of-evidence approach was used to determine whether the risks predicted using calculation methods are indicative of impacts to individuals, populations, communities, or ecosystems. This approach takes into account information outside of the risk assessment such as the literature regarding exposure, which was reviewed in the literature evaluation (Appendix F of the manual). The spatial and temporal scale of contamination was considered, along with corroborating evidence from field investigations.

I-4.2.1 Summary and Ecological Significance of Risks

Risks of adverse effects to plants and wildlife at WAG H were evaluated for contaminants found in soil, surface water, and sediment. For the purposes of providing an overview of the approach and methods for screening-level ERA, the numbers of potential receptors and contaminants were limited to a representative subset for use in the case study. The species selected for evaluation included terrestrial wildlife (raptors, small mammals, large herbivorous mammals), semi-aquatic wildlife (waterfowl), and terrestrial shrubs and grasses. The contaminants selected for evaluation were a metal (chromium), an organic (PCE), and a radionuclide (^{90}Sr). Exposure routes evaluated included ingestion of contaminated media and exposure through the food chain for selected wildlife measurement species and direct contact with, and uptake of, soil contaminants for plants.

Based on this evaluation, exposure of semi-aquatic wildlife (e.g., the mallard) to ^{90}Sr in the waste pond was identified as posing the most potential risk of adverse ecological effects.

Table 34. Summary of plant hazard quotients.

Chemical[a]	EE_{total}	Bunchgrass/sagebrush TRV	HQ
Chromium	6.63E+01	7.50E+01	8.84E-01
Chromium (VI)	4.40E-01	5.00E+00	9.00E-02
Strontium-90	1.00E-02	1.00E-02	5.94E-03
PCE	3.5E-02	1.00E+00	3.5E-02
Total Hazard Index			1.01E+00

a. Units are mg/kg for chromium, chromium (VI), and PCE; Gy/day for strontium-90.

However, this potential risk was calculated for a resident mallard. Since very few mallards reside on the pond during the full course of a year, the actual hazard to individual mallards is lower than predicted and the potential for any population effects is even lower yet.

The only other pathway evaluated with the likelihood of resulting in ecological effects was from surface soils to plants. The THI of 1.0 for plants suggests a slight potential for effects to vegetation of WAG H, but this is still a relatively low THI, and the potential effects to plants are not likely to be significant given the conservatism built into the assessment. The results may suggest the need for a more detailed investigation of the potential effects of COPCs on plants.

I-4.2.2 Uncertainties in the Assessment

Uncertainty can arise during any stage of the screening-level ERA. In the Problem Formulation phase of the case study, the principal uncertainties were related to the design of sampling activities and lack of data from several media at the OUs. Certain areas of potential contamination were not recently sampled, such as the soil and biota on the waste burial pit. Sampling the periphery of this OU is not likely to represent the worst-case exposure for ecological receptors. However, as the burial pit occupies a relatively small area of WAG H, the effects of contamination are likely to be restricted to a few individuals. Published ecological studies conducted at the waste burial pit could also be examined in detail to allow estimation of potential risks of buried radioactive waste.

In the Analysis phase, the principal uncertainties arise from the use of generic exposure parameters and toxicity reference values. Site-specific values were used whenever possible to reduce this uncertainty in the exposure assessment; however, the lack of exposure and toxicity values for wildlife and plants represents a significant data gap. In addition, soil sampling at WAG H was not designed to estimate exposure for ecological receptors at the appropriate spatial scale. This uncertainty was resolved by using a conservative approach to estimate the reasonable maximum exposure from the available data. For the ecological effects assessment, conservative assumptions and uncertainty factors were used to extrapolate from published toxicity benchmarks to avoid underestimating risks.

Numerous other uncertainties could be identified, but the general approach taken was to apply conservative worst-case assumptions in the screening-level ERA. As a consequence of the conservatism of this approach, ecological risks are more likely to be overestimated than underestimated at WAG H.

I-5. BIBLIOGRAPHY

Adriano, D. C., 1986, *Trace Elements in the Terrestrial Environment*, Springer-Verlag, New York.

Adema, D. M. M. and L. Henzen, 1989, "A Comparison of Plant Toxicities of Some Industrial Chemicals in Soil Culture and Soil-Less Culture," *Ecotoxicology and Environmental Safety, 18,* pp. 218–219.

Amiro, B. D., 1993, "Protection of the Environment from Nuclear Fuel Waste Radionuclides: A Framework Using Environmental Increments," *Science of the Total Environment, 128,* pp. 157–189.

Anderson, I. A., 1992, *Summary Report: Preliminary Assessment of Surface Soils at the Proposed New Production Reactor Site at the Idaho National Engineering Laboratory,* NPRD-92-024, EG&G Idaho, Inc., Idaho Falls.

Arthur, W. J., 1982, "Radionuclide Concentrations in Vegetation at a Solid Radioactive Waste-Disposal Area in Southeastern Idaho," *Journal of Environmental Quality, 11,* pp. 394–399.

Arthur, W. J., and O. D. Markham, 1983, "Small Mammal Burrowing as a Radionuclide Transport Vector at a Radioactive Waste Disposal Area in Southeastern Idaho," *Journal of Environmental Quality, 12,* pp. 117–122.

Arthur, W. J., et al., 1984, *Vertebrates of the Idaho National Engineering Laboratory,* DOE/ID-12099, U.S. Department of Energy, Idaho Operations Office, Radiological and Environmental Sciences Laboratory, Idaho Falls.

Arthur, W. J., and D. H. Janke, 1986, "Radionuclide Concentrations in Wildlife Occurring at a Solid Radioactive Waste Disposal Area," *Northwest Science, 60,* pp. 154–159.

Arthur, W. J., et al., 1986, "Radiation Dose to Small Mammals Inhabiting a Solid Radioactive Waste Disposal Area," *Journal of Applied Ecology, 23,* pp. 13–26.

Arthur, W. J., et al., 1987, "Radionuclide Export by Deer Mice at a Solid Radioactive Waste Disposal Area in Southeastern Idaho," *Health Physics, 52,* pp. 45–53.

Arthur, W. J., and R. J. Gates, 1988, "Trace Element Intake Via Soil Ingestion in Pronghorns and in Black-Tailed Jackrabbits," *Journal of Range Management, 41,* pp. 162–166.

Baes, C. F., et al., *1984, A Review and Analysis of Parameters for Assessing Transport of Environmentally Released Radionuclides Through Agriculture,* ORNL-5786, Oak Ridge National Laboratory, Oak Ridge, TN.

Baker, D. A., and J. K. Soldak, *1992, Methods for Estimating Doses to Organisms from Radioactive Materials Released into the Aquatic Environment,* PNL-8150, Pacific Northwest Laboratory, Richland, WA.

Bennett, S., and J. Cubbage, 1991, "Summary of Criteria and Guidelines for Contaminated Freshwater Sediments," Washington State Department of Ecology.

Berry, G. A., S. N. Stanisich, and M. J. Spry, 1994, *Interim Final Sampling and Analysis Plan/Quality Assurance Plan for the Naval Ordnance Disposal Area,* EGG-ESQ-107-33, MSE, Idaho Falls, ID.

Beyer, W. N., E. E. Connor, and S. Gerould, 1994, "Estimates of Soil Ingestion by Wildlife," *Journal of Wildlife Management, 58,* pp. 375–382.

Bodek, I., et al., 1988, *Environmental Inorganic Chemistry-Properties, Processes, and Estimation Methods,* Pergamon Press, New York.

Buben, J. A., and E. J. O'Flaherty, 1985, "Delineation of the Role of Metabolism in the Hepatotoxicity of Trichloroethylene and Perchloroethylene: A Dose-Effect Study," *Toxicology and Applied* pp. 105–122.

Burt, W. H., and R. P. Grossenheider, 1976, *A Field Guide to the Mammals of America North of Mexico*, Houghton Mifflin, Boston.

Calabrese, E. J., and L. A. Baldwin, 1993, *Performing Ecological Risk Assessments,* Lewis Publishers, Chelsea, MI.

Cholewa, A. F., and D. M. Henderson, 1983, *Noteworthy Collections of Idaho: Lesquerella kingii var. cobresis, Astragalus kentrophyta var. jesseiae, and Gilia polycladon, Madrono, 30,* pp. 63–64.

Cholewa, A. F., and D. M. Henderson, 1984, "A Survey and Assessment of the Rare Vascular Plants of the Idaho National Engineering Laboratory Site," *Great Basin Naturalist, 44,* pp. 140–144.

Clawson, K. L., G. E. Start, and N. R. Ricks, 1989, *Climatography of the Idaho National Engineering Laboratory*, 2nd ed., DOE/ID-12118, U.S. Department of Energy, Idaho Operations Office, Idaho Falls.

DeGraaf, R. M., and D. D. Rudis, 1992, *New England Wildlife Habitat, Natural History and Distribution*, General Technical Report NE-108, U.S. Department of Agriculture, Amherst, MA.

Diaz-Mayans, J., R. Laborda, and A. Nunez, 1986, "Hexavalent chromium effects on motor activity and some metabolic aspects of Wistar albino rats," *Comp. Biochem. Physiol., 83C,* pp. 191–195.

Dunning, J. B., Jr., 1993, *CRC Handbook of Avian Body Masses*, CRC Press, Boca Raton, FL.

Ecology & Environment, Inc., 1993, *WAG-Wide Baseline Ecological Risk Assessment, Interim Guidance,* Ecology & Environment, Idaho Falls, ID.

EG&G Idaho, Inc., 1993, "Data Characterization Process in Environmental Restoration," *Environmental Restoration Program*, Program Directive 3.7, EG&G Idaho, Idaho Falls.

Eisler, R., 1986, "Chromium Hazards to Fish, Wildlife, and Invertebrates: A Synoptic Review," *U.S. Fish and Wildlife Service Biological Report, 85*(1.6).

Fetter, C. W., 1988, *Applied Hydrogeology*, 2nd ed., Merrill Publishing, Columbus, OH.

Garner, R. J., and D. A. Barber, 1966, "Effects of Radioactive Substances on Animals and Plants," *Radioactivity and Human Diet*, R. S. Russell (ed.), Permagon Press, Oxford.

Groves, C. R., and B. L. Keller, 1983, "Ecological Characteristics of Small Mammals on a Radioactive Waste Disposal Area in Southeastern Idaho," *American Midland Naturalist, 109*, pp. 253–265.

Haley, T. J., et al., 1960, "Response of the Kangaroo Rat *(Dipodomys merriami Mearns)* to Single Whole-Body X-Irradiation," *Radiation Res., 42,* p. 331.

Halford, D. K., and O. D. Markham, 1978, "Radiation Dosimetry of Small Mammals Inhabiting a Liquid Radioactive Waste Disposal Area," *Ecology, 59*, pp. 1047–1054.

Halford, D. K., and O. D. Markham, 1984, "Iodine-129 in Waterfowl Muscle from a Radioactive Leaching Pond Complex in Southeastern Idaho," *Health Physics, 46,* pp. 1259–1263.

Halford, D. K., O. D. Markham, and R. L. Dickson, 1982, "Radiation Doses to Waterfowl Using a Liquid Radioactive Waste Disposal Area," *Journal of Wildlife Management, 46*, pp. 905–914.

Halford, D. K., and J. B. Millard, 1978, "Vertebrate Fauna of a Radioactive Leaching Pond Complex in Southeastern Idaho," *Great Basin Naturalist, 38,* pp. 64–70.

Haseltine, S. D., L. Sileo, D. J. Hoffman, and B. M. Mulhern, 1985, "Effects of Chromium on Reproduction and Growth of Black Ducks."

Hoffman, R. J., et al., 1990, "Reconnaissance Investigation of Water Quality, Bottom Sediment, and Biota Associated with Irrigation Drainage In and Near Stillwater Wildlife Management Area, Churchill County, Nevada, 1986–1987," *U.S. Geological Survey Water Resources Investigation Report,* 89-4105, U.S. Geological Survey, Carson City, NV.

Horne, R. A., 1978, *The Chemistry of Our Environment*, John Wiley and Sons, New York.

Ibrahim, S., and T. Culp, 1989, "Plutonium Distribution and Oxidation States in a Reactor Leaching Ponds System," *Health Physics, 57*, pp. 607–614.

International Atomic Energy Agency, 1992, "Effects of Ionizing Radiation on Plants and Animals at Levels Implied by Current Radiation Protection Standards," *Technical Reports Series* No. 332, International Atomic Energy Agency, Vienna, Austria.

International Commission on Radiological Protection, 1959, "Report of Committee 2 on Permissible Dose for Internal Radiation," *Health Physics, 3.*

Ivankovic, S., and R. Preussmann, 1975, "Absence of Toxic and Carcinogenic Effects After Administration of High Doses of Chromic Oxide Pigment in Subacute and Long-Term Feeding Experiments in Rats," *Food, Cosmetics, and Toxicology, 13,* pp. 347–351.

Kabata-Pendias, A., and H. Pendias, 1992, *Trace Elements in Soils and Plants,* 2nd ed. CRC Press, Boca Raton, FL.

Kirchman, R., et al., 1993, "Terrestrial Pathways," *Radioecology After Chernobyl,* E. E. Warner and R. M. Hamson (eds.), John Wiley and Sons, New York.

Klassen, C. D., 1986, "Principles of Toxicology," in *Casarett and Doull's Toxicology: The Basic Science of Poisons,* 3rd edition, C. D. Klassen, M. O. Amdur, and J. Doull (eds.), MacMillan Publishing, New York.

Long, E. R., and L. G. Morgan, 1990, "The Potential for Biological Effects of Sediment-Sorbed Contaminants Tested in the National Status and Trends Program," National Oceanic and Atmospheric Administration Technical Memorandum NOS OMA 52.

MacKenzie, R. D., and C. A. Hoppert, 1958, "Chronic Toxicity Studies: Hexavalent and Trivalent Chromium Administered in Drinking Water to Rats," *Archives of Industrial Health, 18,* pp. 232–234.

Markham, O. D., and D. K. Halford, 1980, "Strontium-90 Concentrations in Pronghorn Antelope Bones Near a Nuclear Fuel Reprocessing Plant," *Health Physics, 38,* pp. 811–816.

Martin, A. C., H. S. Zim, and A. L. Nelson, 1961, *American Wildlife and Plants, A Guide to Wildlife Food Habits,* Dover Publications, New York.

Martin, K. L., et al., 1992, *Preliminary Assessment of Surface Soils at Active EG&G Idaho Facilities Data Document,* EGG-ESQ-9225, EG&G Idaho, Idaho Falls, ID.

Michigan Department of Natural Resources, 1994, "Chemical Evaluation Search and Retrieval System," Lansing.

Mihok, S., B. Schwartz, and S. L. Iverson, 1985, "Ecology of Red-back Voles (*Clethrionomys gapperi*) in a Gradient of Gamma Radiation," *Annales Zoologici Fennici, 22,* p. 257.

Millard, J. B., F. W. Whicker, and O. D. Markham, 1990, "Radionuclide Uptake and Growth of Barn Swallows Nesting by Radioactive Leaching Ponds," *Health Physics, 4,* pp. 429–439.

Moseley, R., and C. Groves, 1992, "Rare, Threatened, and Endangered Plants and Animals of Idaho," Conservation Data Center, Idaho Department of Fish and Game, Boise.

National Council on Radiation Protection and Measurements, 1991, "Effects of Ionizing Radiation on Aquatic Organisms," *NCRP Report*, No. 109, Bethesda, MD.

National Institute for Occupational Safety and Health, 1994, "Registry of Toxic Effects of Chemical Substances," Chemical Information Systems, Baltimore, MD.

National Library of Medicine, 1994, "Toxicological Profile for Strontium," Hazardous Substances Database.

Newell, A. J., D. W. Johnson, and L. K. Allen, 1987, *Niagara River Biota Contamination Project: Fish Flesh Criteria for Piscivorous Wildlife,* Technical Report 87-3, Division of Fish and Wildlife, Bureau of Environmental Protection, New York State Department of Environmental Conservation.

Parsons, F., P. R. Wood, and J. Demarco, 1984, "Transformations of Tetrachloroethene and Trichloroethene in Microcosms and Groundwater," *Journal American Water Works Association, 76,* pp. 56–59.

Puls, R., 1988, "Mineral Levels in Animal Health," *Diagnostic Data*, Sherpa International, Clearbrook, BC.

Reynolds, T. D., 1994, Environmental Science and Research Foundation, Idaho Falls, ID, personal communication with Randy Morris, Environmental Science and Research Foundation, Idaho Falls, ID.

Reynolds, T. D., et al., 1986, "Vertebrate Fauna of the Idaho National Engineering Laboratory," *Great Basin Naturalist, 46*, pp. 513–527.

Shacklette, H. T., and J. G. Boerngen, 1984, *Element Concentrations in Soils and Other Surficial Material of the Conterminous United States,* U.S. Geological Survey Professional Paper 1270, Washington, DC.

Shleien, B., 1992, *The Health Physics and Radiological Health Handbook*, Scinta, Silver Springs, MD.

Steven, J. K. et al., 1976, *Effects of Chromium in the Canadian Environment,* NRCC 15017, Natural Resources Council Canada, Ottawa.

Stoddard, L. C., 1983, "Relative Abundance of Coyotes, Lagomorphs, and Rodents on the Idaho National Engineering Laboratory," *1983 Progress Report, INEL Radioecology and Ecology Programs,* DOE/IDO-12098, O. D. Markham (ed.), pp. 268–277.

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

Tandon, S. K., et al., 1978, "Comparative Toxicity of Trivalent and Hexavalent Chromium: Alterations in Blood and Liver," *Environmental Research, 15,* pp., 90–99.

Travis, C. C., and A. D. Arms, 1988, "Bioconcentration of Organics in Beef, Milk, and Vegetation." *Environmental Science and Technology, 22,* pp. 271–274.

U.S. Department of Agriculture, 1975, "A Basic System of Soil Classification for Making and Interpreting Soil Surveys," *Agricultural Handbook 436,* Washington, DC.

U.S. Department of Agriculture, 1980, "Description of the Ecoregions of the United States," Miscellaneous Publication No. 1391, Washington, DC.

U.S. Department of Health and Human Services, 1992, "Toxicological Profile for Tetrachloroethylene," Agency for Toxic Substances and Disease Registry (ATSDR), Atlanta.

U.S. Department of Health and Human Services, 1993, "Toxicological Profile for Chromium," Agency for Toxic Substances and Disease Registry (ATSDR), Atlanta.

U.S. Environmental Protection Agency, 1986a, *Quality Criteria for Water,* EPA/440/5-86-001, Office of Water Regulations and Standards, Washington, DC.

U.S. Environmental Protection Agency, Hazard Evaluation Division, 1986b, *Standard Evaluation Procedure, Ecological Risk Assessment,*" EPA 540/9-86/167, D. J. Urban and N. J. Cook, Office of Pesticide Programs, U.S. Environmental Protection Agency, Washington, DC.

U.S. Environmental Protection Agency, 1989a, *Ecological Assessment of Hazardous Waste Sites: A Field and Laboratory Reference*, EPA 600/3-89/013, W. Warren-Hicks, B. R. Parkhurst, and S. S. Baker (eds.), Washington DC.

U.S. Environmental Protection Agency, 1989b, *Risk Assessment Guidance for Superfund: Environmental Evaluation Manual*, EPA 540/1-89/001, Office of Emergency Response and Remedial Response, Washington DC.

U.S. Environmental Protection Agency, 1991, Water Quality Criteria Summary, Map, Office of Science and Technology, Health and Ecological Criteria Division, Washington, DC.

U.S. Environmental Protection Agency, 1992a, *Framework for Ecological Risk Assessment,* EPA 630/R-92/001, Risk Assessment Forum, Washington, DC.

U.S. Environmental Protection Agency, 1992b, "Guidance for Data Usability in Risk Assessment," Parts A and B, EPA publications 9285.7-09a, 9285.7-09b, Office of Emergency and Remedial. Response, Washington, DC.

U.S. Environmental Protection Agency, 1992c, PHYTOTOX, U.S. Environmental Protection Agency, Washington, DC.

U.S. Environmental Protection Agency, 1994a, Integrated Risk Information System, U.S. Environmental Protection Agency, Washington, DC.

U.S. Environmental Protection Agency, 1994b, Oil and Hazardous Materials/Technical Assistance Data System (OHM/TADS), U.S. Environmental Protection Agency, Washington, DC.

Whicker, F. W. and V. Schultz, 1982, *Radioecology*, CRC Press, Boca Raton, FL.

World Health Organization, 1983, "Selected Radionuclides," *Environmental Health Criteria, 25*, World Health Organization, Geneva, Switzerland.

World Health Organization, 1984, "Tetrachloroethylene," *Environmental Health Criteria, 31,* World Health Organization, Geneva, Switzerland.

Zack, R. and K. R. Mayoh, 1982, "Breeding Biology of Tree Swallows and House Wrens in a Gradient of Gamma Radiation," *Ecology, 63,* p. 1720.