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Ecological Risk Assessment
Eastern Michaud Flats
Pocatello, Idaho

ARCS Region 10

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List of Acronyms

AVS	Acid Volatile Sulfide
BAF	Bioaccumulation Factor
BW	Body Weight
CEC	Cation Exchange Capacity
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
COPC	Contaminants of Potential Concern
CV	Coefficient of variation
E & E	Ecology and Environment, Inc.
ED	Exposure Duration
ELC	Ecological concern level
EMF	Eastern Michaud Flats
EPA	United States Environmental Protection Agency
EPC	Exposure Point Concentration
EE	Estimated Exposure
HHRA	Human Health Risk Assessment
IR	Ingestion Rate
IWW	Industrial Waste Water
LBV	Lower box value
LEL	Lowest effect level
MMD	Minimal detectable difference
NA	Not applicable
ND	Not detected
NOAEL	No observed adverse effect level
ORNL	Oak Ridge National Laboratory
PRP	Potentially Responsible Party
RI/FS	Remedial Investigation/Feasibility Study
SEM	Simultaneously Extracted Metals
SUF	Site Use Factor
TB	Toxicity Benchmarks
TRV	Toxicity Reference Value
UBV	Upper box value
UCL	Upper Confidence Limit
UF	Uptake Factors
USDA	United States Department of Agriculture
USDOI	United States Department of the Interior
USEPA	United States Environmental Protection Agency

USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey

Executive Summary

A baseline ecological risk assessment was conducted for the Eastern Michaud Flats Superfund Site (EMF Site) in Pocatello, Idaho, to evaluate the potential for effects of site-related contamination on the natural environment. The risk assessment was conducted by Ecology & Environment, Inc., (E & E) in accordance with regulatory guidance of the United States Environmental Protection Agency (EPA). The findings of the ecological risk assessment are presented in this report.

The EMF Site consists of two adjacent phosphate ore processing facilities. Both are active operating plants that have been in production since the 1940s. Important ecosystems occurring in the vicinity of the site include the riverine, open-water, and mudflat habitats of the Portneuf River and American Falls Reservoir. Extensive areas of native upland sagebrush steppe ecosystems also occur in the foothills and river plains adjacent to the site.

Releases of contaminants and migration from the site occur via movement in air, groundwater, and wastewater. Potential ecological risks of contamination in off-site surface soils, surface water, and sediment were addressed. Data collected during remedial investigations conducted from 1992 to 1994 were evaluated, and contaminants of potential concern (COPCs) were identified based on their potential toxicity to plants, wildlife, and aquatic life. The primary COPCs are cadmium, fluoride, and zinc in soils, and cadmium in river sediment. Because contaminated groundwater appears to be substantially diluted at the Portneuf River and spring discharge points, levels of COPCs in surface water are generally not of concern. Other inorganic contaminants were also identified as COPCs in soil and sediment, but only cadmium, fluoride, and zinc were subjected to detailed analysis to focus the risk assessment on the most critical issues.

Detailed ecological investigations of the EMF Site were conducted in September and October of 1994 to provide site-specific, supplementary data for the ecological risk assessment. Uptake of COPCs in terrestrial food chains was investigated by chemically

analyzing co-located samples of soil, sagebrush, grass (thickspike wheatgrass), and small mammals (deer mouse) in sagebrush-steppe habitats, and co-located samples of soil and shrubs (Russian olive) in riparian habitats. The nature and extent of sediment contamination was investigated in depositional areas of the Portneuf River delta at the American Falls Reservoir. Samples were chemically analyzed for cadmium, fluoride, zinc and other constituents. Laboratory toxicity testing was conducted with contaminated sediment collected from the Portneuf River at a location farther upstream near a facility outfall. All sampling activities were statistically designed to allow comparison of site-related contamination with unaffected reference areas.

The results of the aquatic investigations demonstrate that cadmium is elevated approximately 2.5 times background in depositional sediments of the Portneuf River delta. However, the chemical analysis showed that the majority of cadmium is strongly bound to sediments and, thus, is not in a bioavailable form. In addition, sediment from near the facility outfall was not toxic to laboratory test species of benthic invertebrates. Moreover, no other contaminants were found in Portneuf River delta sediment at levels significantly above background or levels of concern. Therefore, potential risks of adverse effects of sediment contamination on benthic life are expected to be minimal.

The results of the terrestrial investigations demonstrate that cadmium, fluoride, and zinc are elevated in riparian and upland soils and in plant tissue samples, and that cadmium and fluoride are elevated in small mammal tissue samples collected near the site.

- Average cadmium levels ranged up to 40 times background in soils; up to 7.3 times background in unwashed sagebrush foliage; up to 4.3 times background in grass stems and leaves; and up to 9.3 times background in whole bodies of deer mice. Average cadmium levels were 1.8 times background in Russian olive fruit.

- Average fluoride levels ranged up to 4.9 times background in soils; up to 6.1 times background in unwashed sagebrush foliage; up to 5.1 times background in grass; up to 19 times background in whole bodies of deer mice and up to 4.9 times background in femurs of deer mice. Average fluoride levels in Russian olive fruit could not be reliably determined, but all values were less than the method detection limit.

- Average zinc levels ranged up to 4.7 times background in soils; up to 1.3 times background in unwashed sagebrush foliage; up to 1.4 times background in grass; and were not distinguishable from background in deer mice. Average zinc levels in Russian olive fruit were 1.4 times background.

- Washing removed 13% to 22% of cadmium and 15% to 17% of zinc from sagebrush foliage. Fluoride levels in washed sagebrush foliage could not be reliably determined because of elevated detection limits.

In general, the data confirm that the mobility of cationic metals such as cadmium and zinc is limited by the arid, high-pH soils of the site vicinity. Hence, concentrations of COPCs are much reduced in the terrestrial food chain compared with their concentrations in soil. In addition, it is likely that soil contamination at the site is confined to the surficial soil horizon, where it is not readily accessible to plant roots.

The potential site-related exposure of terrestrial plants and wildlife to COPCs was quantitatively estimated. Exposure of aquatic and semi-aquatic birds and mammals to cadmium in river delta sediment was also quantitatively estimated. The following receptors of concern at the site were selected for evaluation:

- Sagebrush Steppe Habitat: shrubs (big sagebrush), grasses (thickspike wheatgrass), mammalian carnivores (coyote), small mammals (deer mouse), large herbivorous mammals (mule deer), upland game birds (sage grouse), raptors (red-tailed hawk), and songbirds (horned lark).

- Riparian Habitat: shrubs (Russian olive) and songbirds (cedar waxwing).

- River Delta Habitat: waterfowl (mallard), shorebirds (spotted sandpiper), and semi-aquatic herbivorous mammals (muskrat).

Cumulative exposure estimates were derived based on site-specific contaminant data and exposure parameters published in literature, such as dietary composition, home range, exposure duration, ingestion rate, and body weight. Both dietary exposure routes and incidental ingestion of contaminated media were quantitatively assessed. Estimated exposures to COPCs were greater for receptors at the EMF Site study areas compared to exposure for receptors at background locations. The importance of soil ingestion versus food as a percentage of total exposure varied with location, receptor, and COPC.

The potential toxic effects of COPCs were evaluated based on toxicity benchmarks derived from literature. Conservative assumptions were used where necessary to account for uncertainties of extrapolation from literature studies. Toxicity reference values derived in this manner are likely to encompass the broad range of wildlife sensitivity to COPCs.

For each receptor, the potential ecological risks of each COPC were estimated by calculating a hazard quotient (HQ), which is defined as the total estimated exposure received through all relevant pathways divided by the appropriate toxicity reference value. An HQ greater than 1 indicates a potential risk of adverse chronic effects resulting from exposure.

Potential risks of adverse effects of fluoride on resident plant and wildlife species of the sagebrush steppe ecosystem were identified. Potential site-related risks were not identified for cadmium or zinc in any of the habitats affected by the site. The estimated risks of fluoride are only marginally above the threshold for toxic effects, and by inference the species at risk may be marginally but not severely affected. Because the potential risks were quantified for effects on individual organisms using conservative assumptions to account for uncertainty, and because the upland species most likely to be impacted occur commonly throughout the region, widespread or significant ecological effects at the population and community levels are not expected.

Confidence in the results of the risk assessment is considered to be high. Maximal use was made of site-specific exposure data, thereby reducing a major source of uncertainty. Exposure estimates for plants and wildlife were based on statistically designed sampling; hence, the modeled exposure estimates have a high degree of reliability. Toxicity testing and chemical analysis of sediments provides adequate information to evaluate potential impacts of contaminants to the Portneuf River, which were judged to be minimal. In general, the risk assessment is more likely to overestimate rather than underestimate the risks of adverse effects of the site because of the conservative nature of the assumptions used.

Principal uncertainties and limitations of the risk assessment are related to selection of a limited number of COPCs and endpoint species for evaluation, deficiencies of the fluoride analyses, assumptions used to derive exposure estimates and toxicity reference values, the limited field verification of risks, and interpretation of the broader ecological significance of the hazard quotients.

Given the ongoing air emissions and cumulative toxicity of fluoride, the potential for impacts is expected to increase over time with continued air deposition. A reduction in fluoride loadings could allow for a reduction in the potential for harmful effects on the ecosystem in the future, as well as a reduction in current risks.

1 Introduction

Ecology and Environment, Inc., (E & E) has been assigned by the United States Environmental Protection Agency (EPA) to conduct a baseline ecological risk assessment for the Eastern Michaud Flats Superfund Site (EMF Site) in Pocatello, Idaho. This section provides an introduction to the ecological risk assessment. The remainder of the report presents the findings of the ecological risk assessment and provides conclusions to guide remedial planning at the site.

1.1 Statutory Framework

The ecological risk assessment for the EMF Site was conducted in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA). The statutory and technical requirements for ecological risk assessment are provided in *Risk Assessment Guidance for Superfund, Volume II: Environmental Evaluation Manual* (EPA 1989a). Further discussion of the basic principles of ecological risk assessment is presented in *Framework for Ecological Risk Assessment* (EPA 1992a), field and laboratory assessment methods are provided in *Ecological Assessment of Hazardous Waste Sites, A Field and Laboratory Reference* (EPA 1989b), and examples of risk assessments are provided in *A Review of Ecological Assessment Case Studies from a Risk Assessment Perspective* (EPA 1993).

1.2 Scope of the Ecological Risk Assessment

The EMF Site is a large, complex site (see Section 2). Remedial investigations (Bechtel Environmental, Inc. [BEI] 1994a) and other studies have indicated that terrestrial and aquatic ecosystems in the vicinity of the site are contaminated with metals, trace elements, and

radionuclides. Because of the variety of contaminants of potential concern (COPCs) and affected media, the complexity of contaminant behavior at the site, and uncertainties regarding the spatial extent of contamination in sensitive environments near the site, extensive planning was required to provide the necessary data for this assessment.

The objective of a baseline ecological risk assessment is to evaluate environmental samples for site-related contaminants and, in conjunction with evaluation of the results of toxicity testing and other studies, to estimate potential risks these contaminants pose to the natural environment. In accordance with EPA guidance, the ecological risk assessment for the EMF Site was conducted in phases. During Phase 1 of the Remedial Investigation/ Feasibility Study (RI/FS), sampling data were obtained for portions of the terrestrial and aquatic environments within a 3-mile radius of the site, and a site-survey of potentially impacted ecological resources was conducted. Based on a review of these data (E & E 1993a), EPA recommended that ecological studies be included in the RI/FS to further define the nature and extent of contamination and to provide site-specific ecological data for use in the risk assessment. Technical plans for these investigations were developed through the joint efforts of the Potentially Responsible Parties (PRPs), the EPA, and their respective consultants. Comments and recommendations of natural resource trustees, including the State of Idaho, the Shoshone-Bannock tribe, and the United States Fish and Wildlife Service (USFWS), also were considered in the planning process.

The technical plans for the ecological investigations at the EMF Site are presented in a Work Plan (E & E 1994a), Field Sampling Plan (E & E 1994b), and a Quality Assurance Project Plan (E & E 1994c). The investigations were carried out in September and October 1994. In January 1995, the data from these investigations were provided to the EPA in a series of data validation reports authored by BEI (BEI 1995a, 1995b, 1995c).

This report provides an assessment of the data collected in the Phase 1 and Phase 2 RI/FS, including the ecological investigations described in the above-referenced documents and relevant data in previously published reports.

Detailed agency guidance for calculating ecological risks of environmental contaminants at Superfund sites (analogous to the guidance for human health evaluation) was largely unavailable at the time this report was prepared. Consequently, professional judgement was used to define the best state-of-the-science approach for the EMF Site consistent with available guidance. Care is taken in this document to present the assumptions, data sources, and uncertainties of the assessment.

1.3 Organization of the Report

Consistent with EPA guidance (EPA 1992a), this ecological risk assessment is divided into five sections that correspond to the major components of the process: Problem Formulation (Section 2), Ecological Data Acquisition and Review (Section 3), Exposure Assessment (Section 4), Ecological Effects Assessment (Section 5), and Risk Characterization (Section 6).

- **Problem Formulation** identifies and describes the information evaluated during project scoping, including ecosystems and species of concern, potential stressors and pathways, and ecological endpoints. This section is largely based on E & E (1993a) as updated. In this section, the contaminant data collected during the RI/FS at the EMF Site are reviewed to select contaminants of potential concern. Based on this information, an ecological conceptual site model is presented.

- **Ecological Data Acquisition and Review** summarizes and evaluates the ecological data from the terrestrial and aquatic ecosystem studies conducted in September and October 1994.

- **Exposure Assessment** first describes the release, transport, and fate of contaminants in terrestrial and aquatic ecosystems. The exposure scenarios and pathways to be evaluated are then discussed, followed by derivation of quantitative estimates of exposure for selected wildlife species.

- **Ecological Effects Assessment** provides a review of the toxicity testing conducted on sediment samples at the EMF Site. In addition, toxicity benchmarks for the contaminants of concern are derived from published literature.

- **Risk Characterization** combines the information from the exposure assessment and the ecological effects assessment to obtain estimates of potential ecological risks. The ecological significance of these potential risks is discussed, and uncertainties of the risk assessment are summarized.

Section 7 presents the conclusions of the ecological risk assessment, and references are provided in Section 8.

In addition, sampling results of the Phase 1 and Phase 2 RIs are summarized in Appendix A; a summary of sample locations, analytical parameters, and the raw data of the ecological investigations is provided in Appendix B; the statistical approach used to analyze the data collected in the ecological investigations is presented in Appendix C; correspondence with state and federal agencies concerning endangered species in the site area is presented in

Appendix D; ecosystems and species of concern are described in Appendix E; previous studies of the site and areas near the site are discussed in Appendix F; Appendix G provides an analysis and review of information concerning contaminant fate and transport at the site; toxicity testing results are summarized in Appendix H; and Appendix I provides a brief toxicological summary of contaminants of concern.

The human health risk assessment for the EMF Site is presented in a separate volume. To avoid redundancy, reference is made to the human health evaluation where appropriate.

2 Problem Formulation

As stated in EPA guidance, "Problem formulation is the first phase of ecological risk assessment and establishes the goals, breadth, and focus of the assessment" (EPA 1992a, page 9). Examples of how problem formulation is applied can be found in EPA (1993). Problem formulation involves a series of interrelated steps to identify potential stressors, pathways, and ecological effects. Ecological endpoints appropriate for the site are then derived, and a conceptual model is articulated. The conceptual model is a set of working hypotheses regarding the potential effects of site-related stressors on ecosystems of concern to regulatory agencies.

2.1 Site Description

The EMF Site consists of two adjacent phosphate ore processing facilities. One facility is operated by FMC Corporation (FMC) and produces elemental phosphorus; the other facility is operated by J.R. Simplot Company (Simplot) and manufactures phosphate fertilizers. Both are active operating plants that have been in production since the 1940s. The EMF Site includes approximately 2,600 acres of industrial land contained within the plant boundaries and an unspecified area outside the plant property limits. Throughout this report, areas of concern outside plant property are referred to as 'off site' and areas on plant property are referred to as 'on site'.

The EMF Site is located in southeastern Idaho near the city of Pocatello (see Figure 2-1). The site is on the southern margin of the Eastern Michaud Flats at the base of the foothills of the Bannock Range. The Michaud Flats are situated on the Snake River Plain and are bounded to the north by the American Falls Reservoir, the largest of five major reservoirs on the upper Snake River. The ore processing facilities are within 1 mile of the Portneuf River, a tributary of the Snake River that empties to the Fort Hall Bottoms area of the

American Falls Reservoir approximately 4.5 miles from the site. Numerous springs occur in the Eastern Michaud Flats as a result of groundwater discharge, and groundwater seepage to the Portneuf River provides a significant fraction of its flow. The FMC portion of the site and much of the surrounding land are within the boundaries of the Fort Hall Indian Reservation.

2.2 Ecosystems and Species of Concern

A variety of ecosystems and species of concern occur in the vicinity of the EMF Site. A complete discussion of ecosystem types and wildlife is provided in Appendix E, which also includes identification and discussion of listed species and designated wetlands.

Native upland ecosystems characteristic of the semi-arid, temperate climate of southeastern Idaho are prevalent in the site area. The high plateau of the Michaud Flats and the foothills of the Bannock Range support sagebrush steppe communities dominated by sagebrush (*Artemisia* spp.) and a variety of other shrubs and grasses. This community is replaced with juniper woodlands and cliff/cave/canyon communities at higher elevations. Extensive cultivated agricultural areas are also located near the site, comprising approximately 40% of the EMF Site area.

Wildlife typical of sagebrush steppe are abundant in the site area and include small mammals such as the deer mouse (*Peromyscus maniculatus*), large herbivores such as the mule deer (*Odocoileus hemionus*), carnivores such as the coyote (*Canis latrans*), raptors such as the red-tailed hawk (*Buteo jamaicensis*), gallinaceous game birds such as the sage grouse (*Centrocercus urophasianus*), and numerous species of songbirds.

Aquatic and wetland communities are well-developed in the site vicinity. According to the National Wetland Inventory (NWI) maps of the United States Fish and Wildlife Service (USFWS), the Portneuf River channel, the river's associated riparian corridor, and the Fort Hall Bottoms are designated wetlands. Other wetlands include areas along Michaud Creek and other locations (see Appendix E). The Portneuf River supports an extensive riparian community dominated by willow (*Salix* spp.), red-osier dogwood (*Cornus sericea*), and other scrub/shrub riparian vegetation. This riparian zone is an important source of food, cover, and nesting sites for many wildlife species such as songbirds and piscivorous birds. The riverine, open-water, and mudflat habitats of the Portneuf River and American Falls Reservoir are significant nesting and wintering habitats for waterbirds. Thousands of individuals of numerous migratory bird species use areas in and near the site, particularly the Fort Hall

Bottoms. Common species of migratory birds include waterfowl such as ducks, geese, and swans; colonial birds such as pelicans, herons, shorebirds, and gulls; and raptors.

Eleven species of concern listed as endangered, threatened, and rare are reported to occur in the site area (see Appendix C for agency correspondence and Appendix E for discussion). One species of concern—a wintering population of bald eagle (*Haliaeetus leucocephalus*)—is listed by the State of Idaho and by the USFWS as endangered in Idaho. The remaining species of concern are identified as State of Idaho Special Concern species and/or are identified as federal Category 2 species, which indicates they are being considered for listing as a threatened or endangered species.

2.3 Identification of Contaminants of Potential Concern

This section identifies chemical stressors for each of the sample media by systematically reviewing the Phase 1 and Phase 2 RI/FS sampling data and selecting contaminants of potential concern (COPCs). A subset of these COPCs, representing those of greatest potential ecological significance, were identified and investigated further in field studies (see Section 3 and Appendix B).

2.3.1 Data Collection

Groundwater, soil, surface water, and sediment sampling were conducted from 1992 to 1994. The objectives of the RI/FS were to (1) characterize the nature and extent of contamination associated with the EMF Site and (2) to assess the topography, geology, hydrogeology, climate, land use, and ecology of the site in order to identify and evaluate potential migration and exposure pathways. The investigative activities performed to achieve these objectives are described in the RI report (BEI 1994). Discussion of the RI data collection also is provided in the Human Health Risk Assessment (HHRA) report (E & E 1995).

2.3.2 Data Evaluation

Issues regarding data validation, quantitation limits, data qualifiers, and data usability for the Phase 1 and Phase 2 RI/FS are discussed in the HHRA report (Section 2). The general methods of data evaluation described for the HHRA were followed for the ecological risk assessment. Because surface water and sediment data were not evaluated for the HHRA, however, a brief discussion is provided of the data evaluation specific to these media.

2.3.2.1 Data Validation

A summary of the general approach to data validation is provided in the HHRA report. A complete description of the database is found in the RI/FS Data Dictionary for the EMF Site (BEI 1993).

2.3.2.2 Quantitation Limits

Target quantitation limits for surface water and sediment analytical parameters were generally consistent with the contract-required quantitation limits (CRQLs) used in EPA's Contract Laboratory Program (CLP). Although the CRQLs are among the lowest quantitation limits that can reliably and reproducibly be obtained, concentrations of some chemicals below the CRQL could still pose significant ecological risks. If these chemicals were present in environmental media at concentrations below the media-specific quantitation limit but above their risk-based concentrations, significant ecological risks could exist that might be overlooked in the risk assessment. Therefore, it is important to compare the quantitation limits that were obtained to ecological risk-based concentrations to evaluate the adequacy of the quantitation limits.

The adequacy of the quantitation limits used in the RI/FS to analyze surface water were evaluated by comparing the quantitation limits to EPA freshwater chronic Ambient Water Quality Criteria (AWQC) or similar criteria derived from other sources. The adequacy of the quantitation limits for sediment analyses were evaluated by comparing the quantitation limits to Sediment Quality Guidelines of the Ontario Ministry of the Environment (OME). These ecological criteria and guidelines are discussed in more detail in Section 2.3.3. Tables 2-1 and 2-2 present the detection limits, criteria, and number of nondetects that exceeded ecological risk-based concentrations (RBCs) for surface water and sediment, respectively.

As discussed below, the sample detection limits for antimony, mercury, and silver in surface water exceeded EPA criteria (Table 2-1). The sample detection limits for PCBs (Aroclors 1016, 1248, 1254, and 1260), cadmium, and silver in sediment exceeded OME guidelines (Table 2-2).

Surface Water

Water quality criteria for antimony, mercury, and silver were exceeded in a number of surface water samples for which the analytical results were nondetect. The antimony freshwater chronic criterion of 0.03 mg/L and acute criterion of 0.088 mg/L are 'proposed'

criteria. According to EPA (1986), acute and chronic toxicity to freshwater aquatic life occurs at concentrations as low as 610 μg/L (0.610 mg/L). Since the maximum sample detection limit of antimony in surface water (0.44 mg/L; see Table 2-1) was below the lowest observed effect level (LOEL) reported by EPA (1986), from the information available it would appear that the detection limit for antimony was adequate to assess potential toxicity to aquatic life, despite being above the proposed criterion.

The EPA freshwater chronic criteria for mercury and silver are both less than 1 μg/L. Because specialized 'clean' or 'ultra-clean' methods of surface water sampling and analysis are required to reliably detect inorganic chemicals at these concentrations, and these methods generally require greater sophistication than standard CLP water sampling and analysis methods, it is not surprising that the detection limits used in the RI/FS were inadequate to evaluate the chronic toxicity of these chemicals.

The freshwater acute criteria for mercury (0.0024 mg/L) and silver (0.0041 mg/L at 100 mg/L hardness) were not exceeded by the maximum sample detection limits for mercury (0.0001 mg/L) or silver (0.004 mg/L), respectively. Therefore, the detection limits for mercury and silver in surface water were adequate to assess acute (but not chronic) toxicity to aquatic life.

Sediment

The OME guidelines for PCBs (Aroclors 1016, 1248, 1254, and 1260), cadmium, and silver in sediment were exceeded in a number of samples for which the analytical results were nondetect. The OME guideline for cadmium (see Table 2-2) is the lowest effect level (LEL) for effects on benthic life. The OME also provides an upper-bound threshold, called the Severe Effect Level (SEL). The cadmium SEL (10 mg/kg) was not exceeded by the maximum detection limit (MDL) for cadmium (0.94 mg/kg). Therefore, the detection limits for cadmium in sediment were adequate to assess severe toxicity to benthic life. However, the detection limits were inadequate to assess the lowest effect threshold toxicity to benthic life in four out of 11 samples.

The OME guideline for silver (see Table 2-2) is a provincial Open Water Disposal Guideline, not a toxicity-based LEL or SEL. Therefore, the toxicological significance of exceedances of this guideline is uncertain. However, because OME considers the Open Water Disposal Guidelines to be equivalent to LELs in terms of management decisions, for the purposes of the ecological risk assessment the detection limit for silver in sediment was

considered inadequate to evaluate the threshold toxicity of this chemical in seven out of 10 samples.

The guidelines for PCBs are 'tentative' guidelines, according to OME. SELs are also provided for these chemicals, based on normalization of bulk sediment chemical concentrations to organic carbon content of the sediment. In general, the PCBs detected at the EMF Site did not exceed the OME organic-carbon normalized SELs (see Appendix A). Therefore, the detection limits are considered inadequate to evaluate the lowest effect threshold toxicity of PCBs, but the detection limits appear to be adequate to evaluate severe effects.

2.3.2.3 Data Qualifiers and Data Usability

A detailed discussion of the evaluation of data qualifiers and data usability is provided in the HHRA report. Table 2-3 provides a summary of the data qualifiers and their effect on data use in the quantitative ecological risk assessment.

Because of blank contamination problems in mercury analyses from Phase 1 of the RI/FS, the Portneuf River was resampled for mercury. The results were provided in a June 1994 Data Validation Report (BEI 1994b). Problems encountered in Phase 1 surface water analyses were also encountered in the Phase 2 resampling. For most samples, a total mercury concentration of 0.0001 mg/L was reported, which is the MDL. Higher concentrations were reported for some samples and rinsate blanks; therefore, the mercury surface water data are considered unusable for evaluation of chronic toxicity due to the insensitivity of the method (see Section 2.3.2.2) and the presence of blank contamination. However, the sediment mercury sample detection limits were adequate for risk assessment purposes (see Table 2-2), and blank contamination was not a significant problem in these samples.

2.3.2.4 Background Concentrations

The HHRA report provides a discussion of the soil, groundwater, and air samples used to estimate natural background concentrations of inorganic chemicals and radionuclides. For the purposes of the ecological risk assessment, the groundwater background concentrations were used to identify COPCs in surface water, since groundwater discharge provides the majority of flow both for the springs and the Portneuf River channel downgradient from the site.

Surface water and sediment 'background' concentrations were also obtained by taking the maximum concentration of each chemical found in samples upstream from the site. These

samples were taken from locations upgradient of and adjacent to the city of Pocatello. Hence, they are likely to reflect local and regional anthropogenic impacts to the Portneuf River watershed, as well as natural background concentrations.

Background concentrations of chemicals and radionuclides could exceed risk-based standards because of the possibility of anthropogenic influences or high naturally occurring levels; therefore, each background data set was also evaluated by comparing detected concentrations to ecological risk-based criteria (see Appendix A).

2.3.3 Screening Criteria

COPCs were selected by comparing the chemical and radionuclide concentrations found in soil, surface water, and sediment to background concentrations and to available or derived risk-based standards and criteria. Background concentrations are discussed in Section 2.3.2.4. This section identifies and describes the ecological concern levels and criteria used to select COPCs from the Phase 1 and Phase 2 RI/FS data. It should be noted that the ecological criteria are intended only for use in screening the data for selection of COPCs, and are not meant to be indicative of clean up goals for remediation.

Certain on-site data were excluded from the screening process because of the low likelihood of frequent exposure for ecological receptors. On-site soils, surface water from the industrial waste water (IWW) ditch, and groundwater (excepting the springs) were not evaluated for COPCs. These data were examined, however, to identify the site as a potential source of COPCs detected in off-site media. In addition, the air data was not screened because of the general unavailability of ecological criteria for air contaminants.

2.3.3.1 Ecological Concern Levels, Standards, and Criteria

With the exception of some chemicals in surface water and several organics in sediment, national (or State of Idaho) standards to protect plants, wildlife, and aquatic life are unavailable. Therefore, for the purposes of this ecological risk assessment, a set of conservative, scientifically supportable ecological concern levels were obtained for screening chemicals in soil, sediment, and surface water for which national standards do not exist. The background and ecological risk-based screening criteria are summarized in Table 2-4.

Soil

The available international phytotoxicity standards (Kabata-Pendias and Pendias 1992) were used to identify potential inorganic contaminants in soil. Plants are directly exposed to contaminants in soils, have been well studied, and are sensitive to adverse effects of metals contamination. The phytotoxicity values used cannot be assumed to be protective of all terrestrial ecological receptors; however, they are generally below dietary No Observed Adverse Effect Levels (NOAELs) for wildlife and are therefore likely to be protective of wildlife as well as plants. Both a lower and an upper threshold concentration for phytoxicity were used for screening, if available.

Sediment

EPA sediment quality criteria do not exist for any organic or inorganic COPCs at the EMF Site. Agency guidance for evaluation of inorganic contaminants in sediments is being developed and will likely be consistent with some of the approaches described in Section 3 of this report, such as calculation of the molar ratio of "simultaneously extractable metals" and "acid volatile sulfide" (SEM/AVS), and toxicity testing of field-collected sediment. However, SEM/AVS analysis and toxicity testing were not done in Phases 1 and 2 of the RI/FS prior to the ecological investigations. Therefore, sediment quality criteria provided by the OME were used to select COPCs at the EMF Site. These criteria are considered by E & E to be the best, most comprehensive published screening concentrations for metals in freshwater sediments available, and their use is consistent with a protective approach. For inorganic and for some organic chemicals, the OME guidelines provide an LEL, which is defined as the level of contamination that has no effect on the majority of sediment-dwelling organisms, and an SEL, which is the level likely to affect the health of most sediment-dwelling organisms (Persaud *et al.* 1993).

Surface Water

EPA freshwater chronic and acute AWQC for the protection of aquatic life (EPA 1986, 1994) were used to identify COPCs in surface water. For chemicals without AWQC, a criterion was derived using the available aquatic toxicology literature, consistent with EPA methods (EPA 1985).

Radionuclides

To screen concentrations of radionuclides in various media at the EMF Site, an approach was used based on information provided in recent documents (NCRP 1991; IAEA 1992). Risk-based concentrations (RBCs) calculated from human health exposure models were used by NCRP and IAEA scientists to evaluate potential ecological risks of radionuclide exposure to aquatic and terrestrial life. These human health risk-based concentrations were shown by NCRP/IAEA to be equally protective of ecological receptors. The screening values are presented as "derived criteria" for the radionuclides evaluated in Appendix A.

2.3.3.2 Use of Screening Criteria in Selecting COPCs

Consistent with EPA Region 10 guidance (EPA 1989), the identification of COPCs for ecological receptors was based on the following considerations. For each of the affected media, the concentrations of chemicals detected at the site were compared to local background concentrations. Chemicals exceeding background were also compared with ecological risk-based criteria or concern levels. Chemicals not detected above these background or risk-based criteria were removed from consideration as COPCs. In addition, a low frequency of occurrence in environmental media, limited areal extent of contamination, and the absence of plausible exposure pathways were also considered to be reasons for eliminating chemicals from consideration as COPCs. To qualify as a potential COPC, chemicals generally met the following criteria:

- The substance was detected in at least 5% to 10% of the samples analyzed;
- The substance exceeded its background concentration in at least 5% to 10% of the samples;
- The substance exhibited a spatial distribution pattern consistent with site-related source(s); and
- The substance exceeded its lower ecological risk-based criterion or concern level in at least 10% to 20% of the samples and/or exceeded its higher criterion or concern level in at least 2% to 5% of the samples.

If a substance met all of these criteria, it was retained as a COPC. However, consideration was also given to the low potential toxicity and natural abundance of certain elements. Hence, chemicals such as aluminum, calcium, iron, and magnesium were not included as COPCs even if they met all of the criteria listed above.

2.3.4 Preliminary Summary of COPCs

A brief discussion of the screening results for contaminants from Phases 1 and 2 of the RI/FS is provided below. The data are summarized and complete results of screening for COPCs are provided in Appendix A.

2.3.4.1 Surface Soil COPCs

Seven inorganic trace elements were selected as COPCs for off-site soil locations—cadmium, chromium, fluoride, molybdenum, silver, vanadium, and zinc (see Table 2-5). Of these, cadmium, fluoride, and zinc appear to have the widest off-site distribution in soils at levels significantly above background or ecological criteria. The isopleths for cadmium, fluoride, and zinc indicate contamination gradients similar to the air circulation patterns in the area, suggesting airborne transport and deposition of contaminants (see HHRA report). It is noteworthy that the air pattern for cadmium, fluoride, and zinc suggests a lobe of downwind deposition along the Portneuf River; valley winds blowing from the upstream direction are a likely cause of this pattern.

Native upland soils are relatively alkaline in the vicinity of the EMF Site. Soil pH has an important effect on the potential mobility and bioavailability of trace elements such as cadmium. From examination of soil pH levels, it is apparent that soil pH is markedly reduced on site, but acidification of off-site soils is not evident. The uptake and mobility of cadmium, fluoride, and zinc in off-site ecosystems were investigated in September 1994 (see Section 3 and Appendix G). Further contaminant fate-and-transport analysis is provided in Appendix G to evaluate the effects of pH and other soil attributes on mobility and bioavailability of trace elements in EMF Site soils.

2.3.4.2 Sediment COPCs

Thirteen COPCs were identified in Portneuf River stream and spring sediment samples collected downgradient from the site—arsenic, beryllium, cadmium, chromium, copper, fluoride, lead-210, mercury, selenium, silver, thallium, vanadium, and zinc (see Table 2-5). Most of the sediment COPCs exceeded criteria at only one or a few locations. The greatest number of exceedances occurred at Sample Station 17, near the FMC outfall of the IWW ditch, indicating a probable link to the site for these sediment COPCs.

The contaminants of greatest concern in sediments appear to be cadmium, fluoride, mercury, and selenium because of their potential toxicity to fish and wildlife and tendency to

mobilize in the aquatic food chain. Sampling of the Portneuf River in the depositional areas of the river delta in the Fort Hall Bottoms was conducted in the ecological investigations to determine if contaminants from current or previous releases may have been transported to the bottoms, which is an area of concern for wildlife. Based on the evaluation of Portneuf River delta sediment data (see Section 3), only cadmium is selected as a sediment COPC for quantitative risk assessment.

2.3.4.3 Surface Water

Four trace elements detected in surface water were selected as being of potential concern to aquatic and semiaquatic biota—mercury, selenium, silver, and vanadium (see Table 2-5). Elevated levels of these COPCs were detected at various springs and Portneuf River locations. The location and sampling date of each exceedance are shown in Table 2-6.

The four surface water COPCs were also elevated in groundwater. Discharge of contaminated groundwater to surface water is a potentially important transport pathway at the EMF Site. In general, the concentrations of COPCs found in the on-site groundwater are higher than the concentrations of trace elements downgradient from the site in the Portneuf River and spring waters. Therefore, contaminated groundwater appears to be substantially diluted at the Portneuf River and spring discharge points.

High concentrations of trace elements, including the four COPCs, were also detected in at least one sampling round in the IWW ditch water, suggesting that runoff from on-site sources or resuspension of contaminated ditch sediments are possible sources of contamination to the Portneuf River.

Of the four surface water COPCs, mercury and selenium are of greatest concern because of historical information indicating bioaccumulation in fish and wildlife in the Portneuf River and American Falls Reservoir (see Appendix F). Artifacts of sampling and analytical methods may have influenced the levels of mercury reported in surface water. Further discussion of mercury in site surface water is provided in Section 6, Risk Characterization.

Surface waters at the site have high alkalinity and hardness. The effects of hardness on potential toxicity of trace elements to aquatic biota are accounted for in adjustments made to the AWQC (see Appendix A).

2.3.4.4 Summary

COPCs at the EMF Site include radionuclides and inorganic elements: seven COPCs occur in surface soil, 13 COPCs occur in sediment, and four COPCs occur in surface water. Several of these COPCs exceed ecological criteria at only a few locations, or they exceeded background but ecological criteria were not available to evaluate their potential toxicity to ecological receptors. E & E does not intend to quantitatively address the ecological risks of these 'minor' COPCs; rather, they will be addressed through qualitative discussion of their potential ecological significance. COPCs that are more widely distributed in the environment were further investigated (see Section 3) and will be addressed quantitatively in the ecological risk assessment. These COPCs include cadmium, fluoride, and zinc in surface soil, and cadmium in sediment.

2.4 Conceptual Site Model

2.4.1 Sources and Receiving Media

Contaminant types released by the phosphate facilities include numerous trace elements and radionuclides. However, based on the review of RI/FS and ecological data, only cadmium, fluoride, and zinc will be quantitatively evaluated in the remainder of the ecological risk assessment. These COPCs will be evaluated in terrestrial ecosystems at the EMF Site; only cadmium will be evaluated in aquatic ecosystems.

Soil, sediment, surface water, groundwater, air, and the aquatic and terrestrial food chains are all potentially affected media. Several ecologically relevant migration pathways for contaminants exist at the EMF Site. These pathways are illustrated in Figure 2-2 and include the following:

- Air deposition of contaminants to surface water, soil, and vegetation;
- Migration of contaminants in groundwater to discharge points at springs or within the channel of the Portneuf River;
- Surface water discharge to the Portneuf River at the IWW ditch outfall and from surface runoff; and
- Deposition of contaminants from surface water to sediments.

Upon their release to the environment, site contaminants are persistent and may be transformed to more bioavailable forms and mobilized in the food chain. Mobilization of

contaminants in the aquatic food chain could occur through (1) root uptake or absorption from the water column by aquatic plants; (2) contact and absorption, incidental ingestion, and feeding on contaminated food by benthic invertebrates and fish exposed in surface water and sediment; and (3) bioconcentration from sediment and water by organisms at the base of the food chain and subsequent bioaccumulation in some herbivores, omnivores, predators, and piscivorous wildlife.

Mobilization in the terrestrial food chain also could occur. Plants in the vicinity of the EMF Site could be exposed via air deposition through either foliar uptake or root uptake from contaminated soil. Soil invertebrates could be exposed to contaminants through contact and absorption, incidental ingestion, and feeding on contaminated food. Terrestrial wildlife could be exposed through inhalation, contact and adsorption, incidental ingestion of contaminated media, ingestion of contaminated drinking water, and from ingestion of contaminated vegetation or animal prey.

Based on these pathways, the following general classes of ecological receptors might be potentially exposed to contaminants at the EMF Site:

- Aquatic and wetland biota in and near the Portneuf River and American Falls Reservoir;
- Semiaquatic wildlife and terrestrial wildlife that depend on the aquatic and wetland environments for a fraction of their food, drinking water, or habitat needs; and
- Upland plants and terrestrial wildlife downwind from the facilities.

2.4.2 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 ecological risk assessment 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. The following sections describe the selection of the assessment endpoints and identify the measurement endpoint species and measurement endpoints for the EMF Site.

2.4.2.1 Assessment Endpoints

Criteria used for the selection of assessment endpoints for site investigations include (1) regulatory and social significance, (2) ecological relevance, (3) amenability to measurement or prediction, and (4) 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, etc.). 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 the EMF Site could be considered as potential assessment endpoints. For example, species of regulatory or social significance 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, since these are important prey items for higher trophic levels. These receptors would also be highly susceptible to COPCs in soils due to their burrowing habits. 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, several representative categories of assessment endpoint species were selected for the terrestrial (Table 2-7) and aquatic (Table 2-8) ecosystems of the site. Because of the large numbers of species and the complexity of the ecosystem, a systematic method was used to identify assessment endpoint species. First, species likely to be found at the site were divided into major taxonomic groups. To reduce the number of wildlife to be considered as assessment endpoint species, the relative abundance of each species likely to occur at the site was evaluated. With the exception of the regulated species or other rare species identified as species of concern, only species known to be

abundant or common at the site were considered for selection as assessment endpoint species. Second, each taxonomic group was then divided into functional groups by combining species with similar potential for exposure to COPCs. This was done by defining the trophic level, the feeding habitat, and the nonfeeding habitat of each wildlife species expected to occur at the EMF Site. 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, only those groups presented in Tables 2-7 and 2-8 were selected for further analysis. These groups represent nine terrestrial assessment endpoint species groups—birds (raptors, upland game birds, and songbirds), mammals (small, large herbivorous, and carnivorous), and plants (upland shrubs, grasses, and riparian shrubs). For purposes of the risk assessment, 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 the EMF Site.

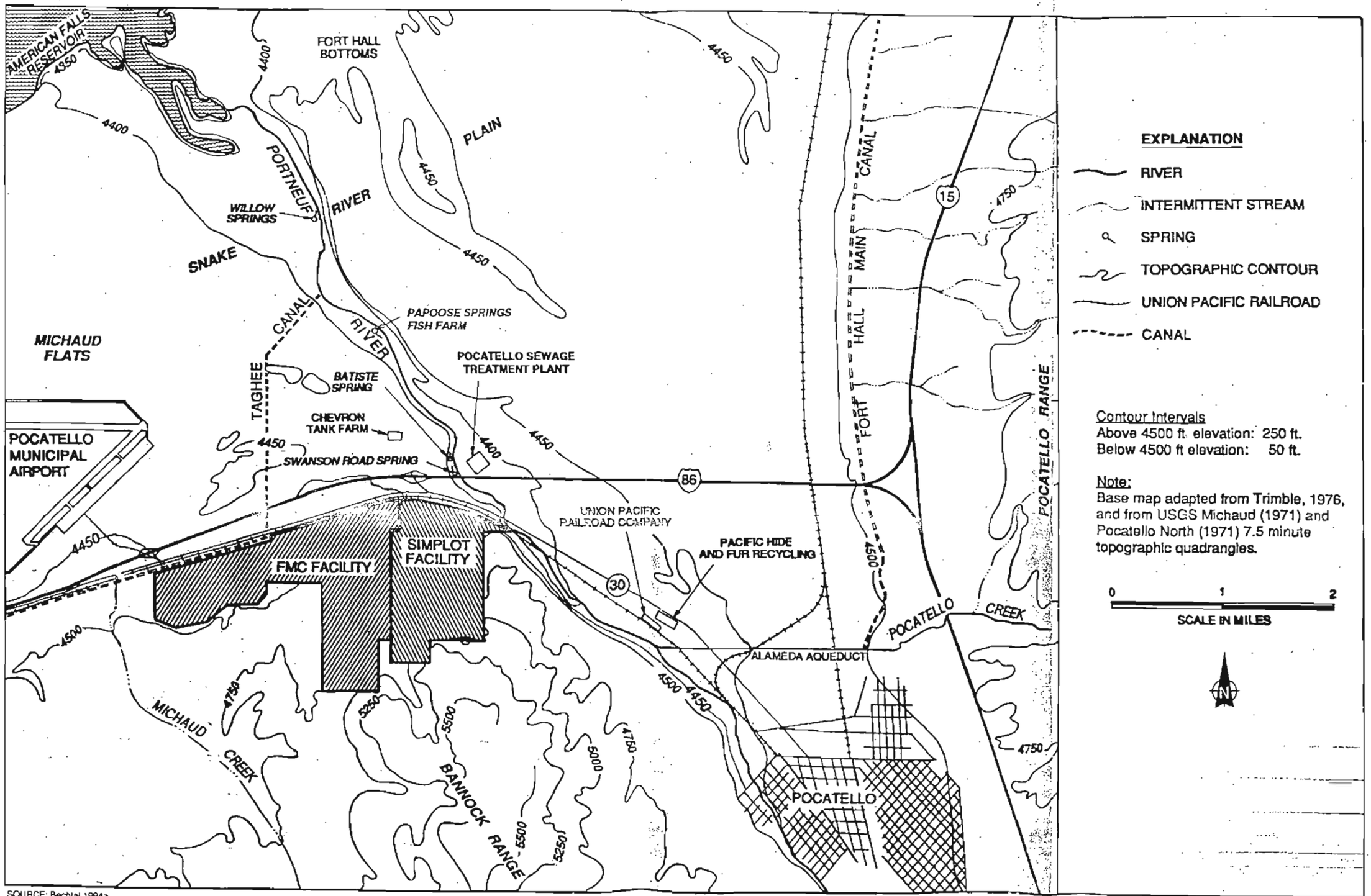
2.4.2.2 Measurement Endpoints

The assessment of all species inhabiting a potentially contaminated area is rarely feasible. Consequently, certain measurement endpoint species were selected to represent 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 the site.

Considerations for the selection of measurement endpoint species include (1) relevance to and consistency with the assessment endpoints; (2) rapidity and low variability of response, and sensitivity to area stressors; (3) diagnostic attributes of the response; and (4) ease of measurement (EPA 1992a). In selecting particular measurement endpoint species

from the functional groups listed in Tables 2-7 and 2-8, emphasis was placed on the availability of site-specific data and published toxicological information that would allow evaluation of exposure and effects. Other considerations for each of the measurement endpoint species selected for evaluation are shown in Tables 2-9 and 2-10.

Measurement endpoints are measurable responses to contaminants of the selected measurement endpoint species that can be related to the assessment endpoints. 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. These endpoints are expected to have a relationship to potential population-level effects on assessment endpoint species. However, the toxicological database is limited, and the actual measurement endpoints are determined by available data. The endpoints used in the risk assessment are identified in Section 5.



SOURCE: Bechtel 1994a

Figure 2-1 REGIONAL SETTING

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Table 2-1

COMPARISON OF SURFACE WATER SAMPLE DETECTION LIMITS TO WATER QUALITY CRITERIA
(mg/L)

Chemical	Target Detection Limit	Average Detection Limit	Maximum Detection Limit	EPA Freshwater Chronic Criteria[a]	Derived Criteria[b]	Number of Non-Detects Exceeding Criteria	Number of Nondetects	Total Number of Samples
Aluminum, total	0.2	0.03895	0.12000	0.087	NA	2	39	144
Antimony, total	0.06	0.07894	0.44000	0.03	NA	109	109	144
Arsenic, dissolved	0.01	0.00182	0.00232	0.18	NA	0	21	144
Arsenic, total	0.01	0.00175	0.00200	0.19	NA	0	24	144
Barium, total	0.2	0.02300	0.05000	NA	1.62	0	18	144
Beryllium, total	0.005	0.00125	0.00700	0.0053	NA	3	118	144
Boron, total	0.1	0.24567	0.35000	NA	1	0	3	143
Cadmium, dissolved	0.005	0.00085	0.00100	0.002209	NA	0	123	144
Cadmium, total	0.005	0.00091	0.00100	0.002598	NA	0	80	144
Chloride	0.5	1.00000	1.00000	230	NA	0	2	143
Chromium, dissolved	0.01	0.00081	0.00100	0.0105	NA	0	53	140
Chromium, total	0.01	0.00080	0.00102	0.011	NA	0	36	144
Cobalt, total	0.05	0.00509	0.03100	NA	0.05	0	119	144
Copper, dissolved	0.025	0.00368	0.00400	0.0248	NA	0	91	144

Key at end of table.

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Table 2-1

COMPARISON OF SURFACE WATER SAMPLE DETECTION LIMITS TO WATER QUALITY CRITERIA
(mg/L)

Chemical	Target Detection Limit	Average Detection Limit	Maximum Detection Limit	EPA Freshwater Chronic Criteria[a]	Derived Criteria[b]	Number of Non-Detects Exceeding Criteria	Number of Nondetects	Total Number of Samples
Copper, total	0.025	0.00365	0.00400	0.0291	NA	0	86	144
Fluoride	0.1	0.13750	0.20000	NA	2.63	0	8	143
Iron, total	0.1	0.04562	0.17800	1	NA	0	22	144
Lead, dissolved	0.003	0.00118	0.00280	0.003049	NA	0	103	144
Lead, total	0.003	0.00112	0.00200	0.0122	NA	0	77	144
Manganese, total	0.015	0.00904	0.03300	NA	75	0	46	144
Mercury, total	0.0005	0.00010	0.00010	0.000012	NA	49	49	181
Molybdenum, total	0.1	0.01928	0.08000	NA	0.043	10	123	144
Nickel, dissolved	0.04	0.01475	0.04000	0.327	NA	0	114	140
Nickel, total	0.04	0.01512	0.04600	0.0385	NA	1	115	144
Selenium, dissolved	0.005	0.00128	0.00500	NA	0.002	2	61	144
Selenium, total	0.005	0.00116	0.00290	0.005	NA	0	67	149
Silver, total	0.01	0.00311	0.00400	0.00012	NA	95	95	144
Thallium, total	0.01	0.00167	0.00400	0.04	NA	0	105	144

Key at end of table.

Table 2-1

COMPARISON OF SURFACE WATER SAMPLE DETECTION LIMITS TO WATER QUALITY CRITERIA
(mg/L)

Chemical	Target Detection Limit	Average Detection Limit	Maximum Detection Limit	EPA Freshwater Chronic Criteria[a]	Derived Criteria[b]	Number of Non-Detects Exceeding Criteria	Number of Nondetects	Total Number of Samples
Vanadium, total	0.05	0.00479	0.01500	NA	0.033	0	62	144
Zinc, dissolved	0.02	0.01051	0.04000	0.220	NA	0	35	144
Zinc, total	0.02	0.00907	0.02950	0.259	NA	0	31	144

[a] From EPA 1986, 1994. Hardness-dependent water quality criteria calculated based on a water hardness of 287.4 (average hardness of Portneuf River surface water samples).

[b] See Section 2.3.3.

Key:

NA = Not available.

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Table 2-2

COMPARISON OF SEDIMENT SAMPLE DETECTION LIMITS TO SEDIMENT QUALITY GUIDELINES (mg/kg)

Chemical	Target Detection Limit	Average Detection Limit	Maximum Detection Limit	Ontario Ministry of Environment Sediment Quality Guidelines[a]	Number of Non-Detects Exceeding Criteria	Number of Nondetects	Total Number of Samples
Aroclor 1016	NA	0.6268	0.65	0.007	27	28	33
Aroclor 1248	NA	0.6268	0.65	0.03	27	28	33
Aroclor 1254	NA	0.6284	0.65	0.06	29	30	33
Aroclor 1260	NA	0.6291	0.65	0.005	30	31	33
Arsenic, total	2	0.204	0.61	6	0	3	45
Cadmium, total	1	0.4835	0.94	0.6	4	11	45
Chromium, total	2	0.00495	0.01	26	0	4	45
Cobalt, total	10	2.648	6	50	0	20	45
Copper, total	5	0.003667	0.004	16	0	3	45
Iron, total	20	0.0405	0.069	20,000	0	2	42
Lead, total	0.6	1.4668	7.3	31	0	5	44
Manganese, total	3	0.003667	0.008	460	0	3	45
Mercury, total	0.2	0.07	0.09	0.2	0	8	80
Nickel, total	8	2.219	9.9	16	0	8	45
Silver, total	1	0.624	1.9	0.5	7	10	45

Key at end of table.

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Table 2-2

COMPARISON OF SEDIMENT SAMPLE DETECTION LIMITS TO SEDIMENT QUALITY GUIDELINES (mg/kg)

Chemical	Target Detection Limit	Average Detection Limit	Maximum Detection Limit	Ontario Ministry of Environment Sediment Quality Guidelines[a]	Number of Non-Detects Exceeding Criteria	Number of Nondetects	Total Number of Samples
Zinc, total	4	0.00899	0.00899	120	0	1	44

[a] From Persaud *et al.* 1993.

Key:

NA = Not Available.

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Table 2-3

DATA VALIDATION QUALIFIERS AND THEIR EFFECT ON DATA USE

Qualifier	Definition	Uncertain Identity?	Uncertain Concentration?	Include Data in Quantitative Risk Assessment?
Organic Chemical Data				
B	Analyte found in associated blank as well as in sample	No	Yes	Yes[a]
E	Concentration exceeds calibration range of GC/MS instrument	No	Yes	Yes
Inorganic and Organic Chemical Data				
J	Value is estimated, either for a TIC or when a compound is present (spectral identification criteria are not met, but the value is <CRQL)	No for TCL chemicals, Yes for TICs	Yes	Yes
U or <	Compound was analyzed for, but not detected	Yes	Yes	?
U6	Compound was analyzed for, but detected in field blanks	Yes	Yes	No
U7	Compound was analyzed for, but detected in lab blanks	Yes	Yes	No
R	Data are unusable (compound may or may not be present). Resampling and reanalysis are necessary for verification.	Yes	Yes	No

[a] Contaminant concentrations in site samples were considered as positive results only if the sample value was at least five times the blank value (10 times for common laboratory contaminants).

Key:

? = Determined on site-specific basis.
CRQL = Contract Required Quantitation Limit.
GC/MS = Gas Chromatography/Mass Spectrometry.
TCL = Target Compound List.
TIC = Tentatively identified compound.

Source: EPA 1992b; BEI 1993.

Table 2-4

CONTAMINANTS OF POTENTIAL ECOLOGICAL CONCERN SCREENING CRITERIA

Media	Background	Ecological Concern Levels	Source
Soil	Off-site shallow subsurface borings	Phytotoxicity guidelines	Kabata-Pendias and Pendias 1992
Surface water	Upstream surface water; upgradient groundwater	EPA Ambient Water Quality Criteria	EPA 1986, 1994
		Derived criteria	Various authors[a]
Sediment	Upstream sediments	Ontario Ministry of Environment Sediment Quality Guidelines	Persaud *et al.* 1993

[a] EA Engineering, Science and Technology, Inc., 1993 for barium; Eisler 1990 for boron; Diamond *et al.* 1992 for cobalt; Camargo and Tarazano 1991 for fluoride; Schweiger 1957 for manganese; EPA AQUIRE database for molybdenum, sodium, vanadium; Peterson and Nebeker 1992 for dissolved selenium; IAEA 1992 and NCRP 1991 for radionuclides.

Table 2-5

SUMMARY OF ECOLOGICAL COPCs BY MEDIA

Chemical	Soil	Sediment		Surface Water
		Portneuf River	Portneuf River Delta[a]	
Arsenic		X[b]		
Beryllium		X[c]		
Cadmium	X	X[b]	X	
Chromium	X	X		
Copper		X		
Fluoride	X	X[b]		
Lead-210		X[c]		
Mercury		X[b]		X[d]
Molybdenum	X			
Selenium		X[b, c]		X
Silver	X[c]	X		X
Thallium		X[c]		
Vanadium	X	X		X
Zinc	X	X[b]		
Total number of COPCs	7	13	1	4

[a] See Section 3.

[b] COPC selected for investigation in Portneuf River delta.

[c] Chemical exceeds background; ecological screening criteria not available.

[d] Mercury is considered a COPC in surface water due to the insensitivity of the analytical method (see Section 2.3.2.2) and the concern with mercury contamination of the aquatic food chain, raised from previous studies in American Falls Reservoir (see Appendix F).

Key:

COPC = Contaminant of Potential Concern.
▒ = COPC selected for quantitative risk analysis.

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Table 2-6

LOCATION OF SURFACE WATER EXCEEDANCES OF BACKGROUND AND CRITERIA[a]

Sample Number	Sample Type	Sample Location	Sample Date			
			July 1992	October 1992	February 1993	April 1993
SW-1	R	Downstream river mile 10	Vanadium	None	Silver	None
SW-2	S	Twenty Springs	Antimony	None	None	None
SW-3	R	Downstream near Siphon Road Spring	None	None	Silver	None
SW-4	S	Siphon Road Spring	Antimony	None	Antimony	None
SW-5	S	Papoose Spring drainage	Selenium (dissolved), vanadium	None	None	None
SW-6	S	Papoose Spring drainage	Selenium (dissolved), vanadium	None	None	None
SW-7	S	Papoose Spring	Selenium (dissolved), vanadium	None	None	None
SW-8	R	Downstream near FMC park	Selenium (dissolved), vanadium	None	Silver	None
SW-9	S	Spring-fed pond at FMC park	Selenium (dissolved), vanadium	None	None	None
SW-10	R	Downstream near Batiste Spring	Mercury, selenium (dissolved), vanadium	None	None	None

Key at end of table.

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Table 2-6

LOCATION OF SURFACE WATER EXCEEDANCES OF BACKGROUND AND CRITERIA[a]

Sample Number	Sample Type	Sample Location	Sample Date			
			July 1992	October 1992	February 1993	April 1993
SW-11	S	Batiste Spring drainage	Vanadium	None	None	None
SW-12	R	Downstream near STP	Vanadium	None	None	None
SW-13	S	Springs near STP	None	None	None	None
SW-14	S	Batiste Spring	Vanadium	None	None	Selenium (total and dissolved)
SW-15	S	Swanson Road Spring	Vanadium	None	None	None
SW-16	R	Downstream near Swanson Road Spring	Vanadium	None	None	None
SW-17	R	FMC outfall	Vanadium	None	Selenium, silver	None
SW-19	R	Downstream of gypstack	None	None	Silver (dissolved)	None
SW-20	R	Downstream of gypstack	None	None	None	None

[a] All chemicals are listed for total concentrations exceeding criteria, unless otherwise noted.

Key:

R = Portneuf River Channel.
S = Springs.

Table 2-7

**SAGEBRUSH STEPPE AND RIPARIAN HABITATS
ASSESSMENT ENDPOINT SPECIES**

Assessment Endpoint Species/Functional Group	Ecological Relevance	Regulatory or Social Significance	Susceptibility to COPCs	Measurability or Predictability
Native upland shrubs and grasses	Provide nesting sites, food, and cover for wildlife.	Potential importance as rangeland for grazing livestock. Habitat for game animals and other wildlife.	Vulnerable to exposure through root uptake and foliar deposition.	Levels of COPCs in soil and plant tissue were measured and can be related to published toxicity benchmarks for crops or native plants.
Riparian shrubs	Provide nesting sites, food, and cover for wildlife.	Habitat for game animals and other wildlife.	Vulnerable to exposure through root uptake and foliar deposition.	Levels of COPCs in soil and plant tissue were measured and can be related to published toxicity benchmarks for crops or native plants.
Small mammals	Base of food chain for raptors and carnivores. Occur in wide range of habitats, including disturbed areas.	Small mammals are important as a community because of significance as a food item for other species. The pygmy rabbit is a federal C2 species.	Susceptible to direct exposure due to burrowing habits, soil ingestion, consumption of contaminated food.	Levels of contaminants in soil and food items were measured and can be related to toxicity benchmarks derived from the literature.
Upland game birds	Important breeding wildlife in sagebrush steppe.	Game animals.	May ingest contaminated soil or food items.	Levels of contaminants in soil and food items were measured and can be related to toxicity benchmarks derived from the literature.

Table 2-7

**SAGEBRUSH STEPPE AND RIPARIAN HABITATS
ASSESSMENT ENDPOINT SPECIES**

Assessment Endpoint Species/Functional Group	Ecological Relevance	Regulatory or Social Significance	Susceptibility to COPCs	Measurability or Predictability
Large herbivorous mammals	Significant consumers of vegetation in terms of biomass and abundance.	Game animals.	May ingest contaminated soil or forage.	Levels of contaminants in soil and food items were measured and can be related to toxicity benchmarks derived from the literature.
Raptors	Top avian predator in terrestrial food chain.	Of recreational and aesthetic importance. Several species of raptors are state species of special concern. Federally protected under the Migratory Bird Treaty Act and Eagle Protection Act.	Could be exposed through consumption of contaminated food items.	Levels of contaminants in soil and food items were measured and can be related to toxicity benchmarks derived from the literature.
Mammalian carnivores	Top mammalian predator in terrestrial food chain.	Of recreational and aesthetic importance. The wolverine is a federal C2 species.	Could be exposed through consumption of contaminated food items.	Levels of contaminants in soil and food items were measured and can be related to toxicity benchmarks derived from the literature.
Songbirds	Common breeding wildlife in riparian and upland habitats.	Federally protected under the Migratory Bird Treaty Act. Songbirds are classified as protected nongame wildlife species under Idaho law.	May ingest contaminated food or soil.	Levels of contaminants in soil and food items were measured and can be related to toxicity benchmarks derived from the literature.

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Table 2-8

AQUATIC HABITATS
ASSESSMENT ENDPOINT SPECIES

Assessment Endpoint Species/Functional Group	Ecological Relevance	Regulatory or Social Significance	Susceptibility to COPCs	Measurability or Predictability
Semi-aquatic herbivorous mammals	Important herbivores. Base of food chain for carnivores and raptors.	Fur-bearers.	Could be exposed through consumption of contaminated food, sediment ingestion, and direct contact with the sediments.	Levels of contaminants in sediment were measured and can be related to toxicity benchmarks derived from the literature.
Aquatic invertebrates	Base of the aquatic food chain.	Water and sediment quality criteria are frequently based on toxicity testing of aquatic invertebrates.	Sensitive indicators of surface water or sediment contamination.	Levels of contaminants in sediment and surface water were measured and can be related to toxicity benchmarks derived from the literature or regulatory criteria. Toxicity testing of sediment at the IWW ditch outfall also provides measurement endpoints.
Waterfowl	Important breeding and wintering wildlife in the Portneuf River delta.	Game animals. Waterfowl are protected under the Migratory Bird Treaty Act.	Could be exposed through consumption of contaminated food and sediment ingestion.	Levels of contaminants in sediment were measured and can be related to toxicity benchmarks derived from the literature.

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Table 2-8

AQUATIC HABITATS
ASSESSMENT ENDPOINT SPECIES

Assessment Endpoint Species/Functional Group	Ecological Relevance	Regulatory or Social Significance	Susceptibility to COPCs	Measurability or Predictability
Shorebirds	Important breeding wildlife in the Portneuf River delta.	Shorebirds protected under the Migratory Bird Treaty Act. The black tern is a federal C2 species. Several species of shorebirds are state species of special concern.	Could be exposed through consumption of contaminated food, sediment ingestion, and direct contact with the sediments	Levels of contaminants in sediment were measured and can be related to toxicity benchmarks derived from the literature.

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Table 2-9

**SAGEBRUSH STEPPE AND RIPARIAN HABITATS
MEASUREMENT ENDPOINT SPECIES**

Measurement Endpoint Species	Relevance to Assessment Endpoints	Responsiveness and Diagnostic Attributes	East of Measurement
Thickspike wheatgrass, sagebrush	Dominant species of native shrubs and grasses in the sagebrush steppe habitat.	Rooting plants are in direct contact with contaminated soil and can be sensitive indicators of toxic metal contamination.	Published toxicological information is available for similar species of grasses and shrubs. Levels of COPCs in tissues were measured.
Russian olive	Common species of shrub in the riparian habitat.	Rooting plants are in direct contact with contaminated soil and can be sensitive indicators of toxic metal contamination.	Published toxicological information is available for similar species of shrubs. Tissue levels of COPCs were measured.
Deer mouse	Most common small mammal in study area.	Representative of exposure for small mammals. Prolific breeding and short life span allow for rapid response to COPCs.	Extensive toxicological database available for related species of rodents. Tissue levels of COPCs were measured.
Sage grouse	Important upland game bird.	Feeds mainly on sagebrush foliage.	Can predict dietary intake from measured soil and plant tissue concentrations.
Mule deer	Common large herbivorous mammal.	Migratory animal winters in the sagebrush steppe. Ungulates are sensitive to the effects of fluoride, possibly because of the long period of time food is held in their digestive tracts.	Can predict dietary intake from measured soil and plant tissue concentrations.

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Table 2-9

**SAGEBRUSH STEPPE AND RIPARIAN HABITATS
MEASUREMENT ENDPOINT SPECIES**

Measurement Endpoint Species	Relevance to Assessment Endpoints	Responsiveness and Diagnostic Attributes	East of Measurement
Red-tailed hawk	Common raptor.	Consumption of small vertebrates as primary food item and year-round presence in study area are representative of worst-case exposure for raptors.	Can predict dietary intake from measured mouse tissue concentrations.
Coyote	Common carnivore.	Consumption of small vertebrates as primary food item and year-round presence in study area are representative of worst-case exposure for terrestrial carnivores.	Cam predict dietary intake from measured mouse tissue concentration.
Cedar waxwing	Common songbird of the riparian habitat.	Feeds mainly on fruits.	Can predict dietary intake from measured soil and plant tissue concentrations.
Horned lark	Common songbird of the sagebrush steppe habitat.	Feeds mainly on seeds; present in the study area year-round.	Can predict dietary intake from measured soil and plant tissue concentrations.

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Table 2-10

AQUATIC HABITATS
MEASUREMENT ENDPOINT SPECIES

Measurement Endpoint Species	Relevance to Assessment Endpoints	Responsiveness and Diagnostic Attributes	Ease of Measurement
Mallard	Common waterfowl species that utilizes the Portneuf River delta during breeding and migration; also over winters.	Juveniles and egg-laying females feed primarily on benthic invertebrates; the male and non-egg producing females feed primarily on macrophytes. Feeds by dabbling and filtering through the sediments.	Relatively extensive toxicological database exists for mallards. Dietary intake can be estimated using macrophyte and benthic invertebrate data from Low and Mullins 1990, or estimated from sediment data.
Spotted sandpiper	Common shorebird that utilizes the mud flat habitat in the Portneuf River Delta.	Insectivore that feeds mainly on benthic invertebrates. Ingests relatively large amount of sediment as a result of mud-probing feeding habits.	Dietary intake can be estimated using benthic invertebrate data from Low and Mullins 1990, or estimated from sediment data.
Muskrat.	Common mammalian species that utilizes the Portneuf River.	Feed primarily on roots and basal portions of aquatic vegetation. A major consumer of aquatic vegetation. Also digs for food on river bottoms.	Dietary intake can be estimated using macrophyte data from Low and Mullins 1990, or estimated from sediment data.
Hyallela azteca, *Chironomus tentans*	Representative of the benthic macroinvertebrate community.	Both are standard toxicity test organisms with known sensitivity to metals.	Measurement of growth and survival following short-term exposure to sediment provides statistically defensible effects data.

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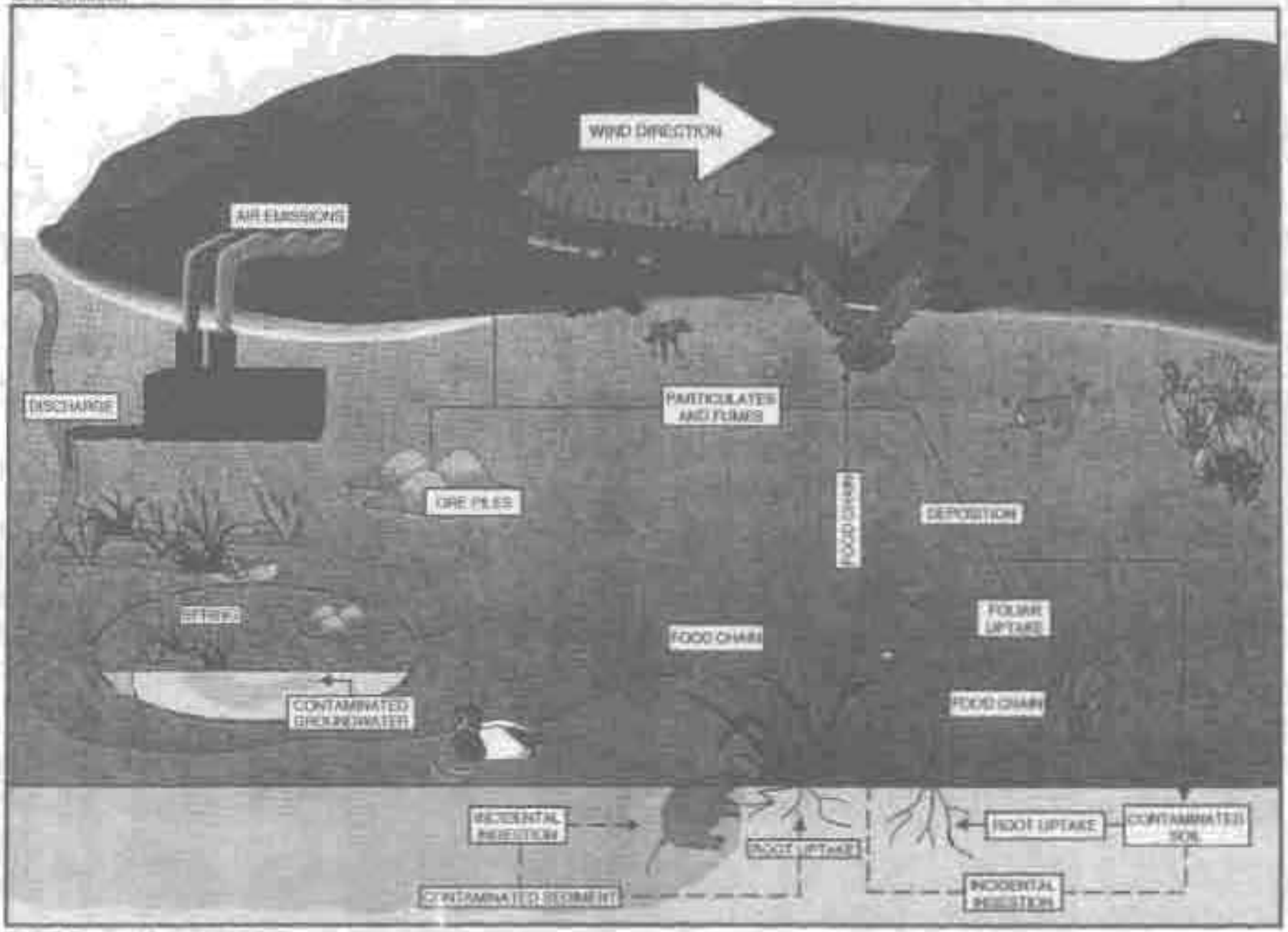

SOURCE: Ecology and Environment, Inc. 1990

Figure 2-2 POTENTIAL EXPOSURE PATHWAYS FOR ECOLOGICAL RECEPTORS AT THE EMF SITE

3 Ecological Data Acquisition and Review

This section provides a summary and evaluation of the data collected as part of the ecological investigations of the EMF Site conducted in September and October 1994. A description of the sampling locations, media, and analytical parameters, and the complete analytical results are presented in Appendix B.

3.1 Data Collection

The objectives of the ecological assessment investigations are described in the Ecological Assessment Work Plan and Field Sampling Plan (E & E 1994a, 1994b). Field investigations were conducted to obtain sufficient site-specific data to evaluate potential site-related impacts to principal ecosystems in the vicinity of the site, including upland sagebrush steppe habitats of the Michaud Flats and Bannock Hills, and riparian and aquatic habitats of the Portneuf River. Vegetation, small mammal, and soil samples were collected from sagebrush steppe habitats, and vegetation and soil samples (but not small mammals) were collected from the riparian zone bordering the Portneuf River. Sediment and benthos from the Portneuf River and its delta at American Falls Reservoir were evaluated as indicators of potential site-related impacts to aquatic habitats. These studies were not designed to characterize the spatial extent of contamination of soils and plants. However, an objective of the ecological assessment was to delineate the nature and spatial extent of inorganic contaminants in sediments of the Portneuf River delta and to estimate the threat of this contamination to aquatic biota and wildlife.

The specific objectives of these studies were to collect data that allow site-specific estimates of bioavailability, uptake, food-chain transfer, and media toxicity of COPCs. The studies were designed to fill several data gaps, including:

- Concentration, forms, and bioavailability of COPCs in soil and sediment;
- COPC concentrations in vegetation and small mammals; and
- Toxicity to aquatic biota of sediment from the Portneuf River.

A variety of contaminant investigations were to be performed in the ecological assessment. However, not all of the planned investigations were completed. Rather, a subset of the planned studies were conducted, and the performance of the remainder of the planned studies was contingent upon review of the initial findings. This modification of the sampling plan was agreed to by the EPA. The following studies are pending: (1) the mineralogical studies, which were intended to determine the mineral form and oxidation state of inorganic chemicals in site soils; (2) additional studies of site-related contamination in the Portneuf River delta, including sediment toxicity testing and chemical analysis of fish and benthic macroinvertebrates; and (3) surface water sampling for mercury and selenium using ultra-clean methods and low detection limits.

It should be noted that the review of initial findings of the ecological investigations was done concurrently with the preparation of this ecological risk assessment report. Therefore, an additional objective of this ecological risk assessment report is to identify and recommend if any of the pending Phase 2 ecological investigations are warranted based on the findings of the field investigations conducted to date.

3.2 Data Evaluation

This section discusses the adequacy of the data collected during the ecological investigations for use in risk assessment. Because of the care taken in planning the ecological field studies, nearly all data collected were usable for the ecological risk assessment. Minor exceptions are noted below.

3.2.1 Data Validation

All data validation reports were reviewed for adequacy and found to be acceptable. No discrepancies or inconsistencies were noted between the hard copy of the analytical results found in the validation reports and the electronic copy supplied to E & E.

3.2.2 Quantitation Limits

During development of the Field Sampling Plan (FSP) (E & E 1994b), target quantitation limits were selected that were less than the expected analyte concentrations in the sediment, soil, vegetation, and deer mice that were collected for the ecological assessment. Analytical methods were then chosen that could attain these limits. The target quantitation limits and analytical methods were presented in the FSP and Quality Assurance Project Plan (QAPjP) (E & E 1994c) for the EMF ecological assessment. The analytical work was performed by EA Engineering, Science and Technology, Inc., a contract laboratory selected by FMC and Simplot. With two exceptions, the laboratory's MDLs were found to be adequate, i.e., the MDLs were less than or equal to the requested quantitation limits and/or were less than contaminant levels in the samples.

The two exceptions were for analysis of fluoride in Russian olive fruit and washed sagebrush foliage. The laboratory's MDL was approximately five times greater than the requested quantitation limit of 10 mg/kg for both sample types, and fluoride was reported as not detected in the samples. Consequently, it was not possible to determine the fraction of fluoride removed from sagebrush foliage by washing, or to determine if fluoride was elevated in Russian olive fruit collected near the facilities. The maximum concentrations reported as not detected were 174 mg/kg in washed sagebrush foliage and 24.9 mg/kg in Russian olive fruit, respectively.

3.2.3 Data Qualifiers and Data Usability

The usability of the data for risk assessment was determined using established EPA guidelines (EPA 1992b). Several types of data qualifiers were associated with the analytical data collected for the ecological assessment, as shown in Table 2-3 and Appendix B. All data for the ecological assessment and any associated qualifiers are tabulated in Appendix B. The most common qualifiers are briefly discussed below.

If a sample fell outside the QC limits for an analysis as defined in the QAPjP (E & E 1994c), the reported concentration was described as "estimated" or biased and was "J-flagged" in the database. Guidance on data usability for risk assessment recommends that estimated values be included in the risk assessment: although they may not be as reliable as data meeting all QA/QC criteria, they represent the best available estimate of the analyte's concentration in the sample. Therefore, J-flagged values in the ecological assessment database were used in the risk assessment. However, it should be noted that nearly all fluoride values

in the database were J-flagged, often as a result of low matrix spike recovery or poor performance on the laboratory control sample.

When a chemical was not detected in a sample, the laboratory's MDL was reported in the database accompanied by a U-flag to indicate that the chemical was not detected at that concentration. When nondetect (U-flagged) results were used in statistical calculations or to calculate exposure-point concentrations, a value equal to one-half the MDL was used.

Several analytes that were detected at low levels in site samples also were detected in the associated blanks. In accordance with EPA guidance, contaminant concentrations in site samples were considered as positive results only if the sample value was at least five times the blank value (10 times for common laboratory contaminants). Analytical values less than five or ten times the blank value were indicated with a U-flag and a qualifier code of 6 or 7 in the database and were not used in the ecological risk assessment.

Analytical values rejected in the data validation process (R-flagged values) also were not used for the ecological risk assessment.

3.2.4 Background Concentrations

The inorganic analytes investigated as part of the ecological assessment also are natural constituents of sediment, soil, and organisms. Therefore, it was necessary to determine background (or reference) concentrations in order to determine whether concentrations in samples were consistent with background or were the result of contamination. In addition to the collection of samples from locations near the facilities, the aquatic and terrestrial ecological investigations included the collection of samples from distant locations, which were used to determine background concentrations (see Appendix B). Samples from locations near the facilities were compared with those from the designated reference sites to identify contamination resulting from site activities. The comparisons were made following the statistical approach described in Appendix C.

3.3 Evaluation of Contaminants of Potential Concern

This section compares levels of suspected contaminants in physical and biological media with background concentrations to evaluate levels of COPCs in terrestrial food chains, and to finalize selection of COPCs in Portneuf River sediment. For the terrestrial ecological investigations, cadmium, fluoride, and zinc were identified as COPCs in soil from the Phase 1 RI/FS data (see Section 2.3.4.1). The purpose of the terrestrial ecological investigations was

to evaluate levels of these contaminants in vegetation and small mammals for use in the quantitative ecological risk assessment. For the aquatic investigations, sediment samples from the Portneuf River delta had not previously been sampled in the RI/FS. Therefore, the primary purpose of these investigations was to identify COPCs in the delta sediments.

3.3.1 Terrestrial Investigations

The results of the terrestrial ecological investigations of sagebrush steppe and riparian areas at the EMF Site are discussed below.

3.3.1.1 Surface Soil

Cadmium, fluoride, and zinc levels in surface soil from the three sagebrush steppe and two riparian sample locations are shown on Figure 3-1, and statistical comparisons are summarized in Table 3-1. For both habitat types, the difference in soil contaminant levels between the potentially impacted sites and reference site are statistically significant. The three terrestrial sample locations close to the facilities (Bannock Hills SW sagebrush steppe, Michaud Flats sagebrush steppe, and Portneuf River riparian) had elevated levels of cadmium, fluoride, and zinc compared with the two reference sites (Ferry Butte sagebrush steppe and Snake River riparian). This is not surprising since, based on the RI data, these sites are located in areas believed to be affected by the facilities. As shown in Figure 3-1, cadmium, fluoride, and zinc levels in soil also were more variable at the impacted sites compared with the reference sites.

3.3.1.2 Vegetation

Cadmium, fluoride, and zinc levels in washed and unwashed sagebrush foliage from the two potentially impacted sagebrush steppe sites (Bannock Hills SW and Michaud Flats) and one reference site (Ferry Butte) are shown on Figure 3-2, and statistical comparisons between the sites are summarized in Table 3-2. Cadmium and fluoride levels in unwashed sagebrush foliage were elevated at the Bannock Hills SW and Michaud Flats sites compared with the reference site. Zinc levels in washed and unwashed sagebrush foliage were elevated at the Michaud Flats site, but not at the Bannock Hills site, compared with the reference site.

Washing resulted in a decrease in the measured levels of cadmium and zinc in sagebrush foliage; the average decrease was 22% for cadmium and 17% for zinc at the Bannock Hills SW site, and 13% for cadmium and 15% for zinc at the Michaud Flats site. This result

suggests that COPCs were largely assimilated into the sagebrush foliage and were not predominantly surface contaminants. The fraction of fluoride removed by washing could not be accurately quantified because of the high fluoride detection limit for washed samples (see Section 3.2.2 and Appendix B).

Cadmium, fluoride, and zinc levels in stems and leaves of thickspike wheatgrass from the two potentially impacted sagebrush steppe sites (Bannock Hills SW and Michaud Flats) and one reference site (Ferry Butte) are shown on Figure 3-3, and statistical comparisons are summarized in Table 3-2. Cadmium, fluoride, and zinc levels in grass were elevated at the Bannock Hills SW and Michaud Flats sites compared with the reference site.

Cadmium and zinc levels in Russian olive fruit from the Portneuf and Snake River riparian sites are shown on Figure 3-4, and statistical comparisons are summarized in Table 3-2. Cadmium and zinc levels in Russian olive fruit were elevated at the potentially impacted Portneuf River riparian site compared with the Snake River reference site. The single cadmium value of 0.66 mg/kg detected in Russian olive fruit at the Snake River riparian location (Figure 3-4a) was judged to be an outlier and was excluded from the statistical comparison between the sites. A meaningful statistical comparison between the two riparian sites for fluoride could not be made because all reported values from both locations were less than the MDL.

3.3.1.3 Small Mammals

Cadmium, fluoride, and zinc levels in whole deer mice, and fluoride in deer mouse femurs, at the three sagebrush steppe sites are shown on Figure 3-5, and statistical comparisons are summarized in Table 3-3. Cadmium and fluoride levels (whole body and femur) in deer mice collected from the two sites near the facilities (Bannock Hills SW and Michaud Flats) were elevated compared with the Ferry Butte reference site. Zinc levels in deer mice were similar between the three locations.

3.3.1.4 Summary

Table 3-4 summarizes the comparisons between the potentially impacted locations and the reference location for cadmium, fluoride, and zinc levels for all terrestrial sample types. All three COPCs were elevated in soils at the potentially impacted sites compared with background. However, exposure of raptors and carnivores to zinc through consumption of

small mammals is not of concern at the site, because zinc levels were not elevated in deer mouse tissues.

3.3.2 Portneuf River Delta Sediment Investigation

This section summarizes data on suspected contaminants (arsenic, cadmium, mercury, selenium, zinc, and fluoride) and other parameters in sediment collected from the Portneuf River and Snake River deltas during the October 1994 Portneuf River delta study. The complete data set for the study is presented in Appendix B. The data were evaluated to identify COPCs and/or the need for Phase 2 studies. Briefly, the evaluation consisted of the following:

- Comparison of contaminant levels in Portneuf River delta sediment to background (i.e., Snake River delta, Portneuf River upstream from the facilities, and regional background [if available]);
- Evaluation of results of SEM/AVS analyses;
- Comparison of contaminant levels in Portneuf River delta sediment to available ecological concern levels;
- Consideration of additional relevant factors, such as the tendency of some site contaminants to be biomagnified in aquatic food chains; and
- An approach for integrating this information into a weight-of-evidence judgement to identify COPCs.

Table 3-5 summarizes the weight-of-evidence approach for the six suspected contaminants. Based on this evaluation, only cadmium was designated as a COPC in the Portneuf River delta.

3.3.2.1 Comparison to Background

The first and most important step in the weight-of-evidence approach is the comparison to background. Cadmium, fluoride, and zinc had higher average (and median) concentrations in Portneuf River delta sediment compared with Snake River delta sediment (see Table 3-6 and Figures 3-6b through 3-6f). For every chemical except cadmium, however, the differences can be explained by the higher natural occurrence of aluminum-containing minerals (i.e., clay minerals) in Portneuf River delta sediment (see Figure 3-6a). The trace-metal content of sediment often covaries with the aluminum content because of the inclusion

of certain metals as impurities in the crystal lattice of clay minerals and from adsorption of metal ions on clay-mineral exchange sites. Indeed, the average element-to-aluminum ratios for the suspected contaminants are higher in Snake River delta sediment compared with the Portneuf River delta sediment, with the exception of cadmium, which is significantly greater in Portneuf River delta sediment (Table 3-6). The relationship of cadmium to aluminum in sediment is shown graphically on Figure 3-7; it can be seen that for a given aluminum concentration, cadmium concentrations are higher in the Portneuf River. Also shown on Figure 3-7 is the relationship of zinc to aluminum in sediment, which shows that for a given aluminum concentration, zinc concentrations are higher in the Snake River. This result suggests that there is a source of cadmium to the Portneuf River delta sediment other than natural weathering of rock and soil. Since cadmium has been shown to be elevated in soil at the EMF Site and in sediment in the IWW ditch outfall, the site is a potential source of the contamination.

Also shown on Figure 3-6 are levels of aluminum, arsenic, cadmium, fluoride, selenium, and zinc in sediment upstream from the FMC and Simplot facilities (Portneuf River stations 21 through 25). Levels of aluminum, arsenic, fluoride, selenium, and zinc were similar in sediments from the Portneuf River delta and upstream locations. Only cadmium was significantly elevated in Portneuf River delta sediment compared with upstream sediment (Figure 3-6c). This finding agrees with the comparisons made for these contaminants between the two river deltas and further suggests that the facilities have contributed cadmium to sediment in the Portneuf delta.

Finally, it should be noted that a formal statistical comparison for mercury in sediment could not be conducted because most sample concentrations were below the MDL. E & E judged that mercury levels in sediments from the Portneuf River and Snake River deltas were similar. Therefore, since the reported mercury levels in both systems, though highly qualified, were generally less than the MDL (approximately 0.1 mg/kg), mercury was not considered a COPC in the Portneuf River delta.

3.3.2.2 Evaluation of SEM/AVS Ratio

Bioavailability of metals in sediment is influenced by the extent to which metals bind to the sediment's solid phase. Metals that are strongly bound have very low aqueous phase (pore water) concentrations and exhibit little or no toxicity. Conversely, metals that are weakly bound have comparatively higher pore water concentrations and are potentially toxic.

The AVS phase in anoxic sediments has been shown to be important in ameliorating heavy-metal toxicity because it forms very insoluble sulfide precipitates with several potentially toxic heavy metals (cadmium, copper, mercury, nickel, lead, and zinc). The molar ratio of SEM to AVS can be used to predict the bioavailability and toxicity of heavy metals in sediment (DiToro *et al.* 1990). If the molar ratio of SEM to AVS is less than 1, the six divalent heavy metals listed above most likely are bound to AVS and therefore are *not* bioavailable. Conversely, if the molar ratio of SEM to AVS exceeds 1, there is insufficient AVS to bind the metals and some heavy metal ions may be bioavailable.

This section focuses on cadmium, since it is the only SEM metal that is a COPC in Portneuf River delta sediment. In brief, the results of the SEM/AVS analysis suggest that cadmium in Portneuf River delta sediment is not bioavailable; the ratio of SEM-cadmium to AVS was < 1 for Portneuf River delta sediment (average ratio = 0.00035 for bank and channel samples combined). The six SEM metals have different affinities for AVS; mercury, copper, and zinc bind more strongly with AVS than cadmium, while zinc and nickel bind less strongly (DiToro *et al.* 1992). Nevertheless, there was ample AVS in Portneuf River delta sediment to bind SEM-cadmium even if SEM-mercury, SEM-copper, and SEM-lead were bound first (average ratio of SEM-cadmium/[AVS - (SEM-mercury + SEM-copper + SEM-lead)] = 0.022 for bank and channel sediment combined; all values in μmol/g).

3.3.2.3 Comparison to Ecological Concern Levels

Comparisons of sediment levels of arsenic, cadmium, mercury, and zinc to OME sediment quality criteria are presented in Table 3-7. Cadmium exceeded the LEL in five of 20 Snake River delta samples, and in 18 of 20 Portneuf River delta samples. The higher frequency of LEL exceedance for the Portneuf River compared with the Snake River suggests a greater potential for adverse effects of cadmium on benthic communities in the Portneuf River delta. None of the other suspected contaminants exceeded the LEL in either the Snake or Portneuf River sediments in more than one sample in either location, and the few exceedances were of low magnitude. There were no exceedances of the OME SEL in either location.

3.3.2.4 Other Relevant Factors

The most pertinent related data available to help decide whether to consider cadmium a COPC are the results from the toxicity tests conducted with Portneuf River sediment

collected near the IWW ditch outfall (see Section 5.2 and Appendix H). No toxicity to the amphipod *Hyalella azteca* or the midge *Chironomus tetans* was observed in these tests, even though cadmium levels in sediment near the outfall were greater than those in Portneuf River delta sediment. This result suggests that cadmium in Portneuf River sediment is largely not bioavailable.

3.3.2.5 Summary

Cadmium was designated as a COPC in Portneuf River delta sediment because it is significantly elevated at this location compared with sediment from the Snake River delta and Portneuf River upstream from the facilities. The levels of arsenic, fluoride, mercury, selenium, and zinc in the Portneuf River delta sediment are not elevated above background. Although sediment levels of cadmium from the Portneuf River delta exceeded the OME sediment quality criteria for cadmium in 18 of 20 samples, the SEM/AVS data and results from toxicity tests with river sediment collected near the IWW ditch outfall suggest that cadmium in Portneuf River sediment is not bioavailable and/or toxic to benthic organisms. Consequently, the likelihood of adverse effects of cadmium on benthic life in the Portneuf River delta is considered low. However, cadmium in Portneuf River delta sediment is selected as a COPC for quantitative risk analysis of exposure and effects on other ecological receptors such as water birds and mammals.

Table 3-1

TERRESTRIAL ECOLOGICAL INVESTIGATIONS
SUMMARY OF STATISTICAL COMPARISON TO BACKGROUND FOR SOIL (mg/kg)

Habitat	Chemical	Location	Frequency of Detection	Minimum Detected Concentration	Maximum Detected Concentration	Average Concentration	Is Impacted Area Significantly Greater Than Background Area?[a]
Sagebrush steppe	Cadmium	Bannock Hills SW	10/10	18.6	34.1	27.2	Yes
		Michaud Flats	10/10	9.4	31.1	21.0	Yes
		Ferry Butte[b]	10/10	0.47	1.2	0.68	—
	Fluoride	Bannock Hills SW	10/10	1,100	1,840	1,454	Yes
		Michaud Flats	10/10	850	3,200	1,793	Yes
		Ferry Butte[b]	10/10	330	421	363	—
	Zinc	Bannock Hills SW	10/10	183	342	256	Yes
		Michaud Flats	10/10	88.4	219	156	Yes
		Ferry Butte[b]	10/10	49.4	64.1	56.5	—
Riparian	Cadmium	Portneuf	10/10	0.64	27.6	10.3	Yes
		Snake[b]	10/10	0.17	0.4	0.26	—
	Fluoride	Portneuf	10/10	321	2,930	1,073	Yes
		Snake[b]	10/10	175	298	245	—
	Zinc	Portneuf	10/10	47.5	197	114	Yes
		Snake[b]	10/10	15.5	31.5	24.1	—

[a] Average concentrations were compared ($p < 0.2$). Appendix C discusses the statistical approach and tests used.
[b] Background area.

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Table 3-2

TERRESTRIAL ECOLOGICAL INVESTIGATIONS
SUMMARY OF STATISTICAL COMPARISON TO BACKGROUND FOR VEGETATION (mg/kg)

Habitat	Chemical	Vegetation	Location	Frequency of Detection	Minimum Detected Concentration	Maximum Detected Concentration	Average Concentration	Is Impacted Area Significantly Greater Than Background Area[a]
Sagebrush steppe	Cadmium	Sagebrush foliage (unwashed)	Bannock Hills SW	10/10	0.81	1.2	0.99	Yes
			Michaud Flats	10/10	0.97	1.7	1.27	Yes
			Ferry Butte[b]	5/10	0.2	0.35	0.17	—
		Sagebrush foliage (washed)	Bannock Hills SW	10/10	0.59	1.2	0.77	Yes
			Michaud Flats	10/10	0.61	1.5	1.10	Yes
			Ferry Butte[b]	4/10	0.21	0.34	0.17	—
		Thickspike wheatgrass (stems and leaves)	Bannock Hills SW	10/10	0.33	0.88	0.54	Yes
			Michaud Flats	10/10	0.33	0.59	0.46	Yes
			Ferry Butte[b]	2/10	0.14	0.40	0.12	—
	Fluoride	Sagebrush foliage (unwashed)	Bannock Hills SW	18/20	47.3	122	74.2	Yes[c]
			Michaud Flats	19/20	25.5	114	55.6	Yes[c]
			Ferry Butte[b]	0/20	—	—	12.1[d]	—
		Sagebrush foliage (washed)	Bannock Hills SW	0/20	—	—	—	—[e]
			Michaud Flats	0/20	—	—	—	—[e]
			Ferry Butte[b]	0/20	—	—	—	—

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Table 3-2

TERRESTRIAL ECOLOGICAL INVESTIGATIONS
SUMMARY OF STATISTICAL COMPARISON TO BACKGROUND FOR VEGETATION (mg/kg)

Habitat	Chemical	Vegetation	Location	Frequency of Detection	Minimum Detected Concentration	Maximum Detected Concentration	Average Concentration	Is Impacted Area Significantly Greater Than Background Area[a]
		Thickspike wheatgrass (stems and leaves	Bannock Hills SW	10/10	39.6	111	62.1	Yes[c]
			Michaud Flats	4/10	25.0	51.1	22.4	Yes[c]
			Ferry Butte[b]	0/10	—	—	12.2[e]	—
	Zinc	Sagebrush foliage (unwashed)	Bannock Hills SW	10/10	26.1	39.8	31.2	No
			Michaud Flats	10/10	30.6	49.1	38.3	Yes
			Ferry Butte[b]	10/10	22.7	44.1	30.2	—
		Sagebrush foliage (washed)	Bannock Hills SW	10/10	22.4	31.5	26.0	No
			Michaud Flats	10/10	15.0	43.9	32.7	Yes
			Ferry Butte[b]	10/10	23.5	40.7	27.6	—
		Thickspike wheatgrass (stems and leaves)	Bannock Hills SW	10/10	6.5	16.5	11.5	Yes
			Michaud Flats	10/10	7.9	15.1	10.8	Yes
			Ferry Butte[b]	10/10	5.2	10.5	8.2	—
Riparian	Cadmium	Russian olive (fruit)	Portneuf	5/10	0.2	0.33	0.18	Yes[c]
			Snake[b]	1/10	0.66[f]	0.66[f]	0.10	—

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Table 3-2

TERRESTRIAL ECOLOGICAL INVESTIGATIONS
SUMMARY OF STATISTICAL COMPARISON TO BACKGROUND FOR VEGETATION (mg/kg)

Habitat	Chemical	Vegetation	Location	Frequency of Detection	Minimum Detected Concentration	Maximum Detected Concentration	Average Concentration	Is Impacted Area Significantly Greater Than Background Area[a]
	Fluoride	Russian olive (fruit)	Portneuf	0/10	—	—	12.0[d]	—[e]
			Snake[b]	0/10	—	—	11.9[d]	—
	Zinc	Russian olive (fruit)	Portneuf	10/10	7.3	13.3	10.2	Yes
			Snake[b]	10/10	5.4	9.4	7.2	—

[a] Average concentrations were compared ($p < 0.2$). Appendix C discusses the statistical approach and tests used.
[b] Background area.
[c] Meaningful statistical comparison to background area not possible because all background samples were less than method detection limit. Potentially impacted area judged to be elevated because of high frequency of detects compared with background area.
[d] One-half of detection limit.
[e] Meaningful statistical comparisons not possible; all reported values were less than method detection limit.
[f] Outlier.

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Table 3-3

TERRESTRIAL ECOLOGICAL INVESTIGATIONS
SUMMARY OF STATISTICAL COMPARISON TO BACKGROUND FOR DEER MICE (mg/kg)

Chemical	Tissue	Location	Frequency of Detection	Minimum Detected Concentration	Maximum Detected Concentration	Average Concentration	Is Impacted Area Significantly Greater than Reference Area[a]
Cadmium	Whole body	Bannock Hills SW	10/10	0.24	1.2	0.61	Yes
		Michaud Flats	10/10	0.08	0.42	0.22	Yes
		Ferry Butte[b]	10/10	0.02	0.15	0.07	—
Fluoride	Whole body	Bannock Hills SW	10/10	93.8	173	128	Yes[c]
		Michaud Flats	10/10	50.4	135	90.9	Yes[c]
		Ferry Butte[b]	0/10	—	—	6.8[d]	—
	Femur	Bannock Hills SW	7/10	196	760	297	Yes
		Michaud Flats	10/10	291	1,030	633	Yes
		Ferry Butte[b]	3/10	195	301	130	—
Zinc	Whole body	Bannock Hills SW	10/10	31.7	48.1	38.5	No
		Michaud Flats	10/10	33	43.5	37.6	No
		Ferry Butte[b]	10/10	28.2	48.3	38.6	—

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Table 3-3 (Cont.)

[a] Average concentrations were compared ($p < 0.2$). Appendix C discusses the statistical approach and tests used.
[b] Background area.
[c] Meaningful statistical comparison to background area not possible because all background samples were less than the method detection limit. Potentially impacted area judged to be elevated because of high frequency of detects compared with background area.
[d] One-half of method detection limit.

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Table 3-4

SUMMARY OF STATISTICAL COMPARISON TO BACKGROUND FOR ALL TERRESTRIAL SAMPLE TYPES

Habitat	Chemical	Location	Elevated Above Background?[a]					
			Soil	Sagebrush (unwashed)	Sagebrush (washed)	Thickspike Wheatgrass	Deer Mouse	Russian Olive
Sagebrush steppe	Cadmium	Bannock Hills SW	Yes	Yes	Yes	Yes	Yes	—[b]
		Michaud Flats	Yes	Yes	Yes	Yes	Yes	—[b]
	Fluoride	Bannock Hills SW	Yes	Yes	?[c]	Yes	Yes[d]	—[b]
		Michaud Flats	Yes	Yes	?[c]	Yes	Yes[d]	—[b]
	Zinc	Bannock Hills SW	Yes	No	No	Yes	No	—[b]
		Michaud Flats	Yes	Yes	Yes	Yes	No	—[b]
Riparian	Cadmium	Portneuf	Yes	—[b]	—[b]	—[b]	—[b]	Yes
	Fluoride	Portneuf	Yes	—[b]	—[b]	—[b]	—[b]	?[c]
	Zinc	Portneuf	Yes	—[b]	—[b]	—[b]	—[b]	Yes

a See Tables 3-1, 3-2, and 3-3.
b Not collected from this location.
c Data not sufficient to evaluate.
d Both whole body and femur.

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Table 3-5

**PORTNEUF RIVER DELTA SEDIMENT INVESTIGATION
SUMMARY OF THE WEIGHT-OF-EVIDENCE APPROACH**

Evaluation Criteria	Suspected Contaminants[a]					
	Arsenic	Cadmium	Fluoride	Mercury	Selenium	Zinc
Comparison to background(s)[b]	–	+	–	–	–	–
Evaluation of SEM/AVS ratio	NA	–	NA	–	NA	–
Comparison to ECL(s)	–	+	NA	+	NA	–
Other relevant factors	–	–	+	+	+	+
COPC?	No	Yes	No	No	No	No

a A "+" implies an exceedance of background, an SEM to AVS ratio > 1, an exceedance of an ecological concern level, or the presence of a compelling additional factor.

b Integrates comparison of contaminant levels in Portneuf River delta sediment to those in the Snake River delta, those in upstream Portneuf River sediment, and those in regional background sediments (if available).

Key:

AVS = Acid volatile sulfide.
COPC = Contaminant of potential concern.
ECL = Ecological Concern Level.
NA = Not applicable.
SEM = Simultaneously extracted metals.

Table 3-6

**PORTNEUF RIVER DELTA SEDIMENT INVESTIGATION
SUMMARY OF STATISTICAL COMPARISON TO BACKGROUND**

Element	Average Concentration (mg/kg)		Is Portneuf Significantly Greater than Snake?[a]	Element/Aluminum Ratio		Is Portneuf Significantly Greater than Snake?[a]
	Snake	Portneuf		Snake	Portneuf	
Aluminum	5,050	8,100	Yes	NA	NA	NA
Arsenic	3.11	2.89	No	2.30×10^{-4}	1.36×10^{-4}	No
Cadmium	0.369	0.934	Yes	1.70×10^{-5}	2.94×10^{-5}	Yes
Fluoride	247	345	Yes	7.79×10^{-2}	6.92×10^{-2}	No
Selenium	0.622	0.812	No	4.55×10^{-5}	3.37×10^{-5}	No
Zinc	35.2	42.9	Yes	3.05×10^{-3}	2.23×10^{-3}	No

[a] Average concentrations were compared ($p < 0.2$). Appendix C discusses the statistical approach and tests used.

Key:

NA = Not applicable.

Table 3-7

PORTNEUF RIVER DELTA SEDIMENT INVESTIGATION
COMPARISONS OF CHEMICAL CONCENTRATIONS WITH SEDIMENT QUALITY GUIDELINES

Chemical	Location	Detection Frequency	Minimum Detected Concentration (µg/g)	Maximum Detected Concentration (µg/g)	LEL[a] (µg/g)	Frequency of Exceedance of LEL
Aluminum	Snake[b]	20/20	1,950	11,500	NA	NA
	Portneuf	20/20	4,610	15,100	NA	NA
Arsenic	Snake[b]	20/20	1.7	11.3	6	1/20
	Portneuf	19/19	1.9	4.6	6	0/20
Cadmium	Snake[b]	15/20	0.19	0.79	0.6	5/20
	Portneuf	20/20	0.51	1.6	0.6	18/20
Fluoride	Snake[b]	20/20	114	389	NA	NA
	Portneuf	20/20	250	529	NA	NA
Iron	Snake[b]	20/20	4,630	19,000	NA	NA
	Portneuf	20/20	5,940	18,000	NA	NA
Mercury	Snake[b]	0/15	ND	ND	0.2	0/15
	Portneuf	2/5	0.19	0.46	0.2	1/5
Selenium	Snake[b]	19/20	0.30	1.1	NA	NA
	Portneuf	18/20	0.37	1.7	NA	NA
Zinc	Snake[b]	20/20	18.9	70.9	120	0/20
	Portneuf	20/20	27.7	68.8	120	0/20

[a] From Persaud *et al.* 1993.
[b] Background location.

Key:

LEL = Lowest Effect Level, Ontario Ministry of Environment.
NA = Not Applicable.
ND = Not detected.

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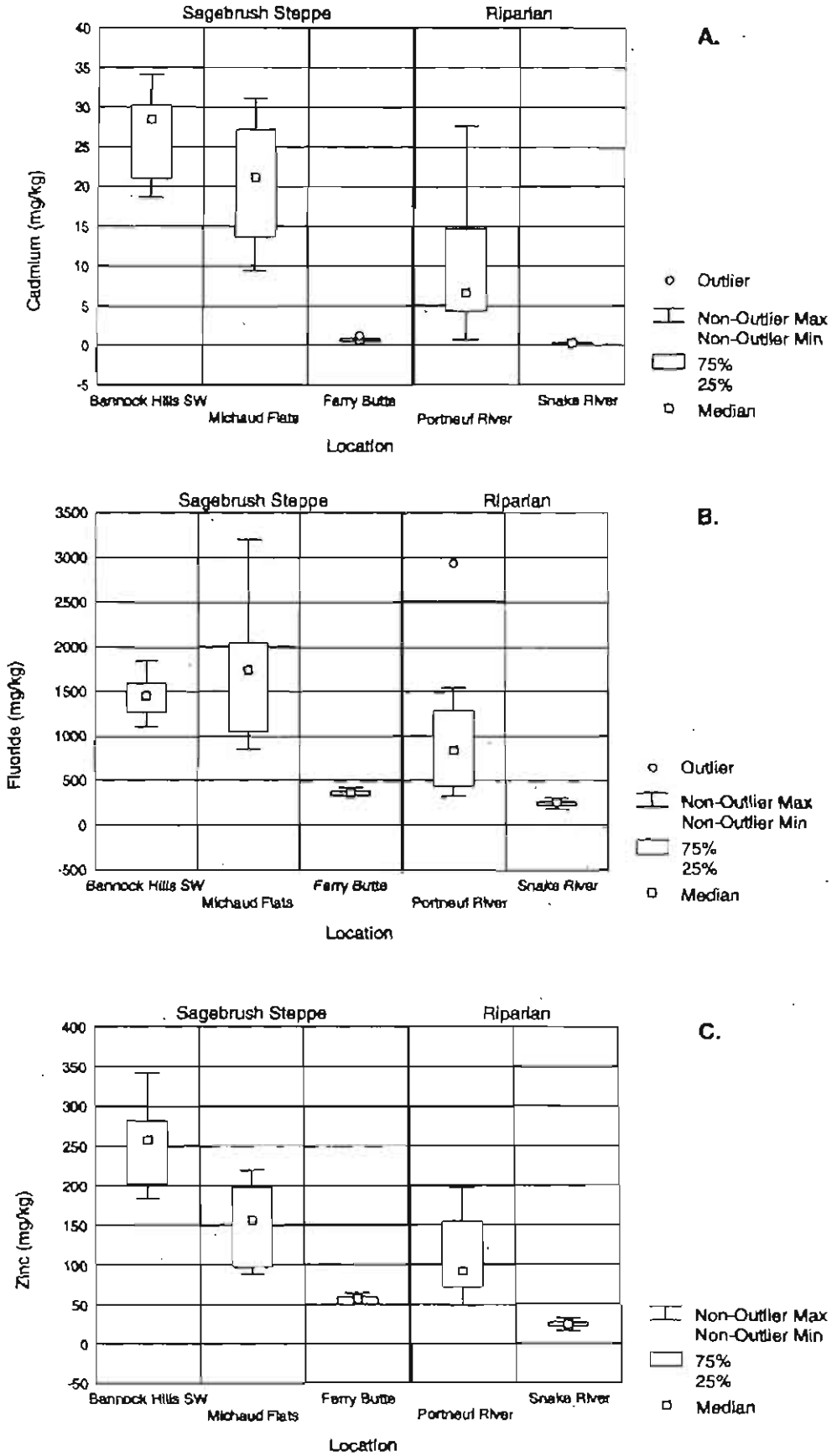
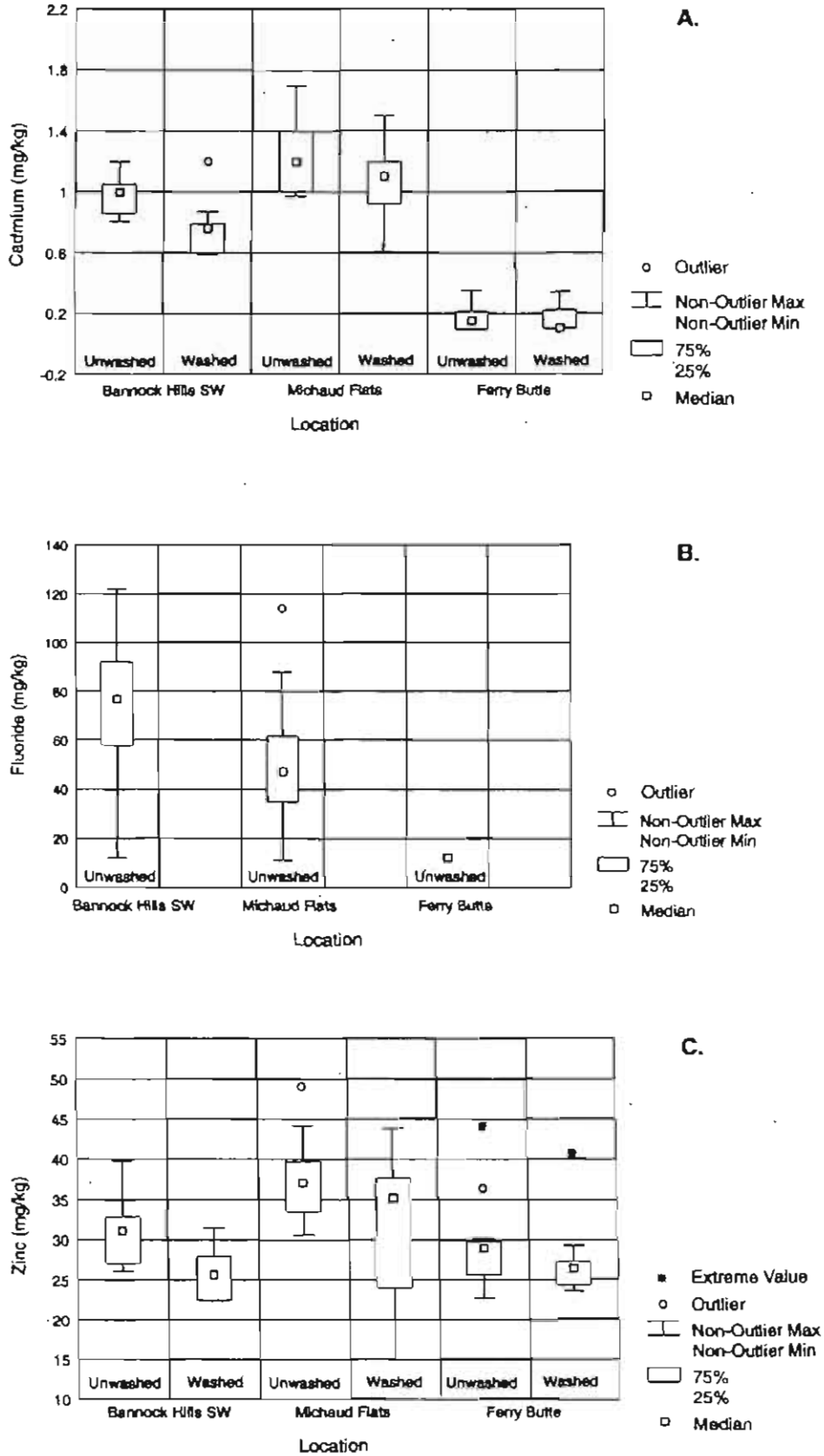


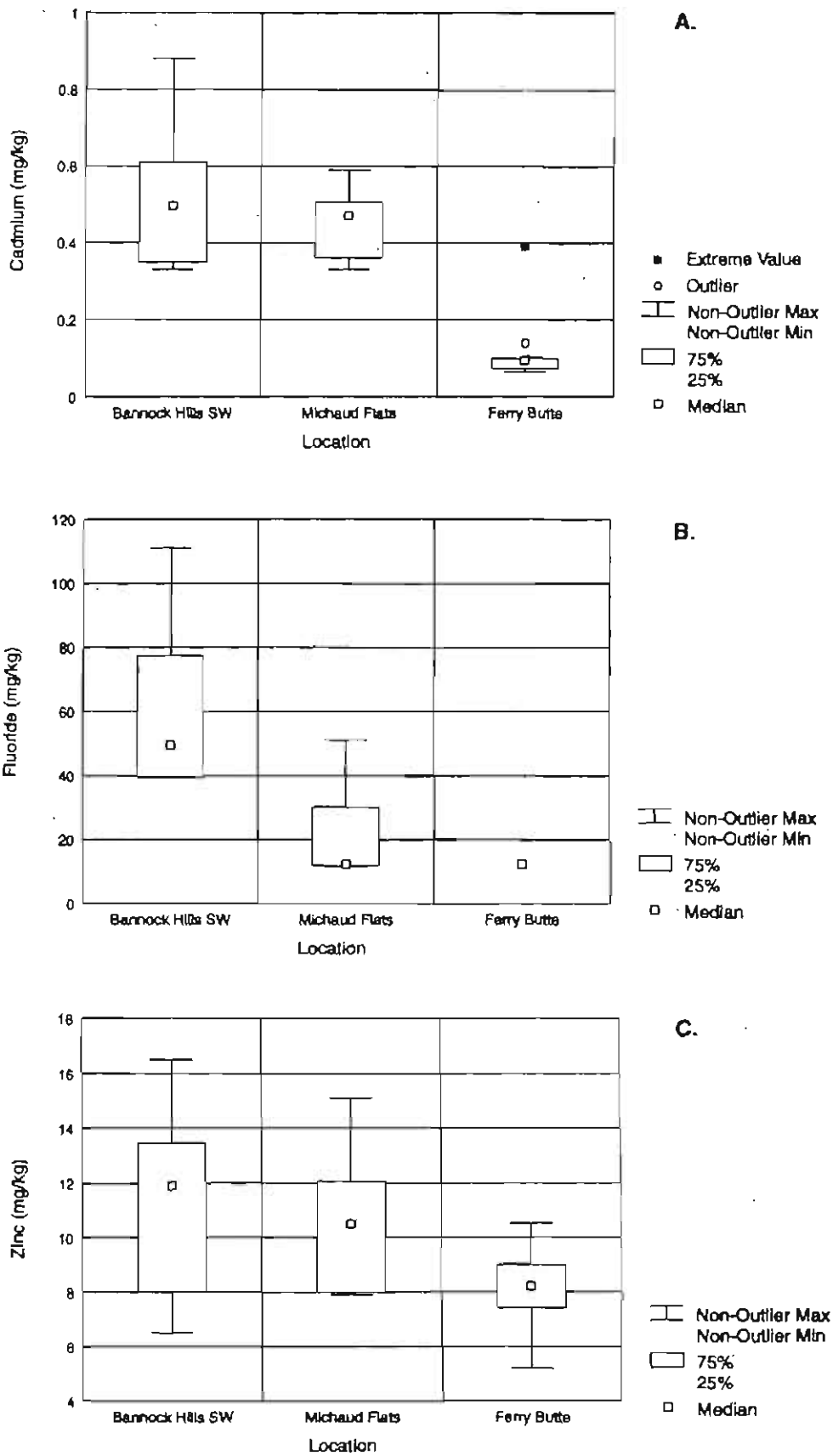
SOURCE: Ecology and Environment, Inc. 1995

Figure 3-1 CADMIUM, FLUORIDE, AND ZINC IN SURFACE SOIL



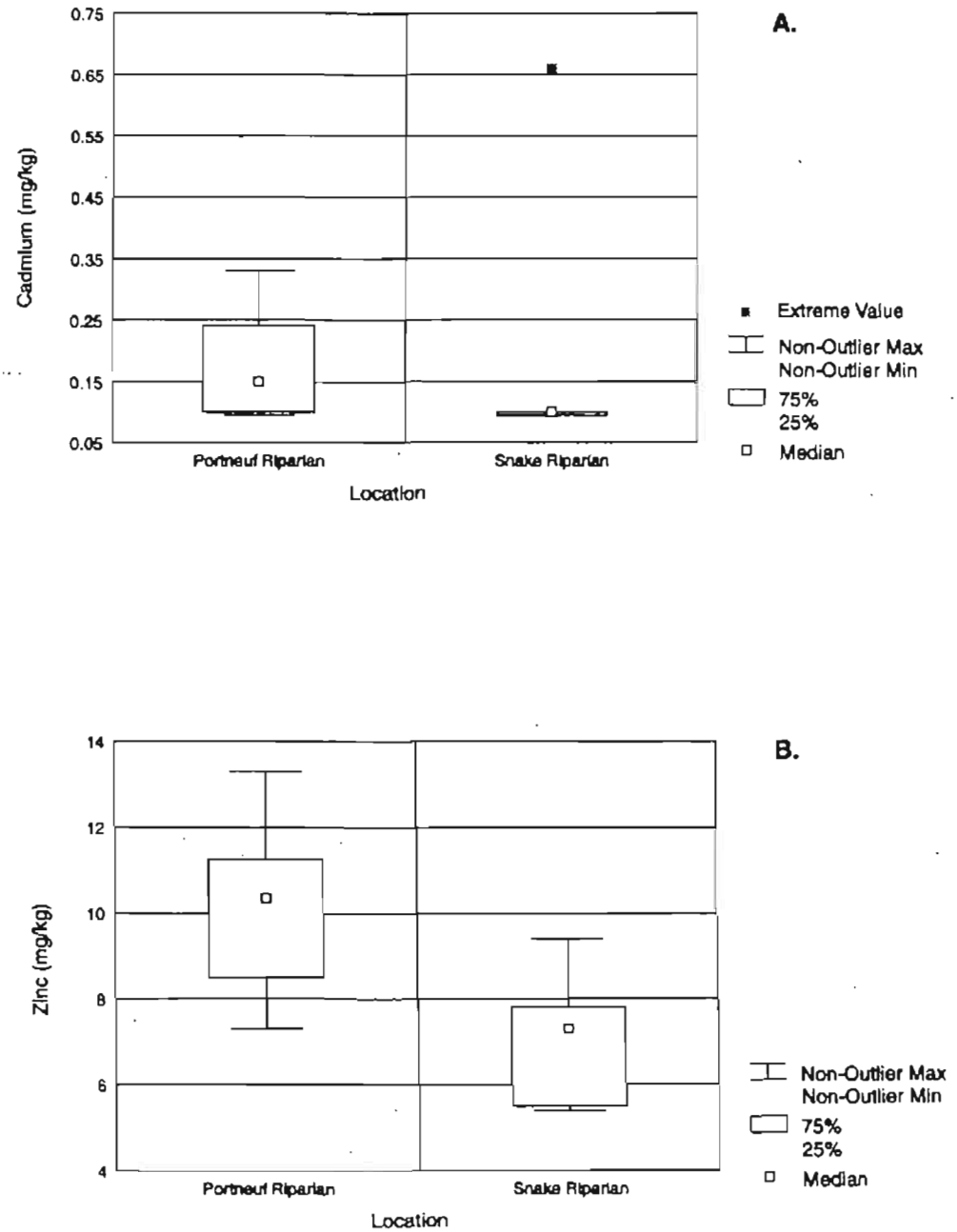
SOURCE: Ecology and Environment, Inc. 1995

Figure 3-2 CADMIUM, FLUORIDE, AND ZINC IN SAGEBRUSH FOLIAGE



SOURCE: Ecology and Environment, Inc. 1995

Figure 3-3 CADMIUM, FLUORIDE, AND ZINC IN STEMS AND LEAVES OF THICKSPIKE WHEATGRASS



SOURCE: Ecology and Environment, Inc. 1995

Figure 3-4 CADMIUM AND ZINC IN RUSSIAN OLIVE FRUIT

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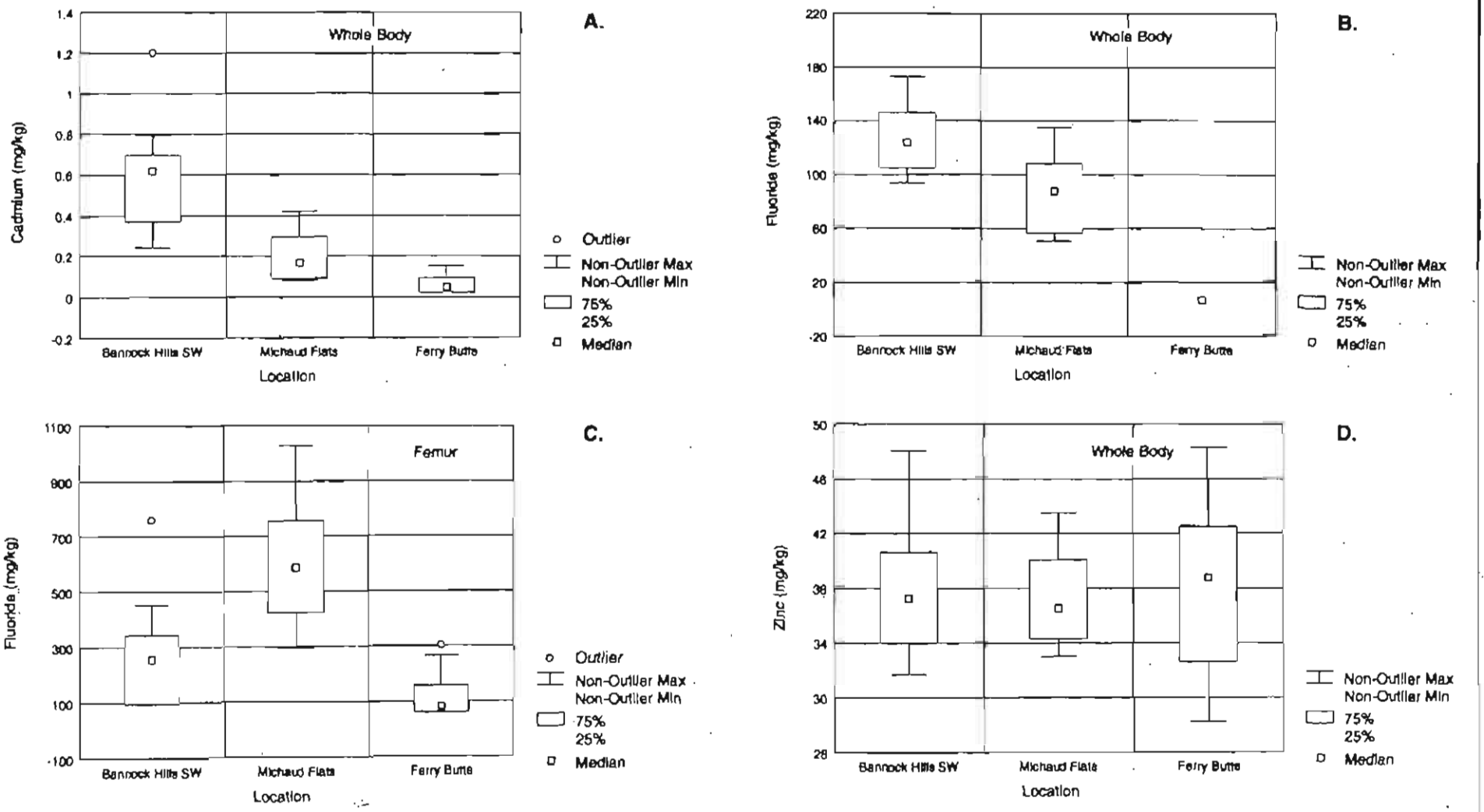
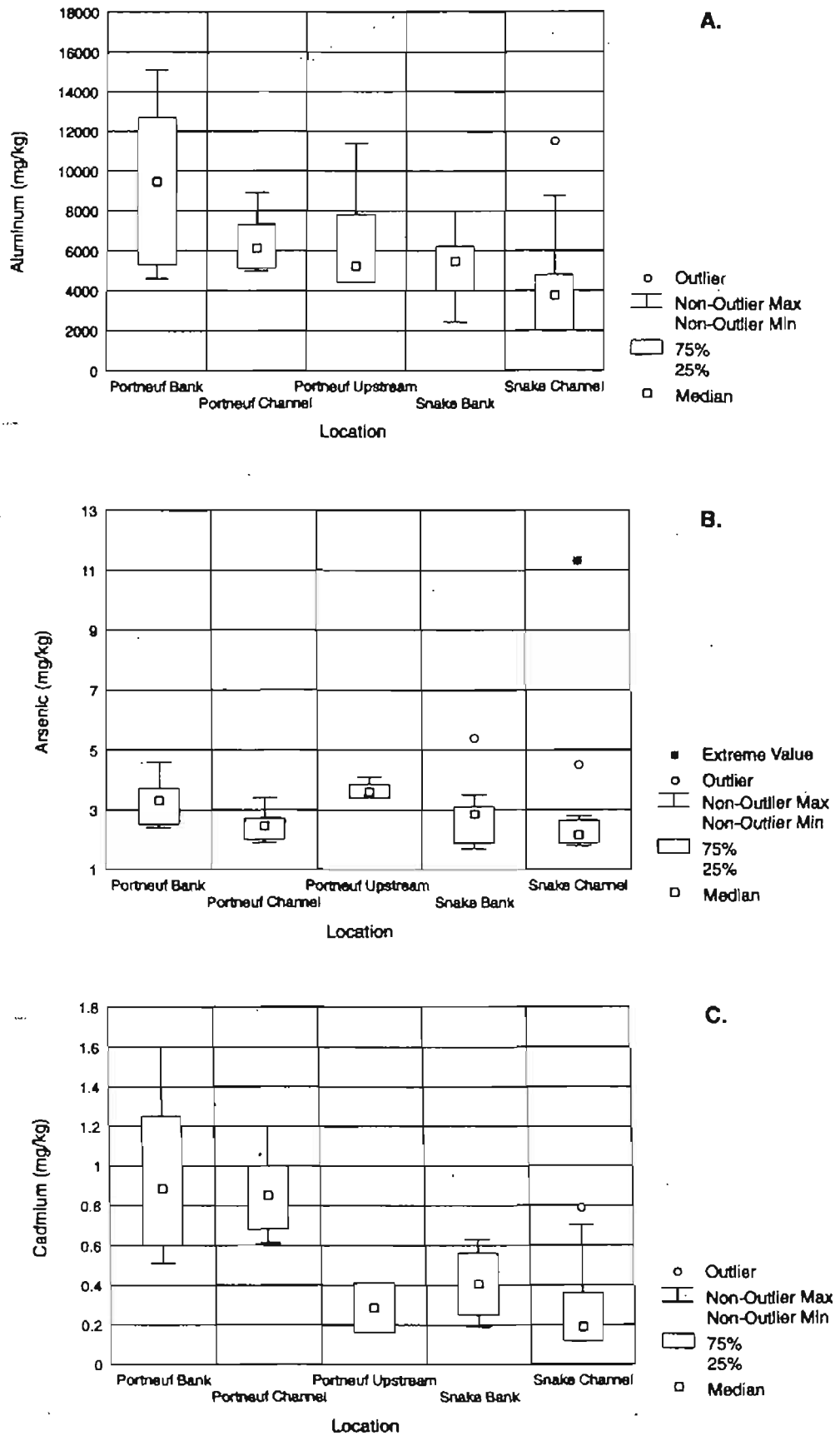


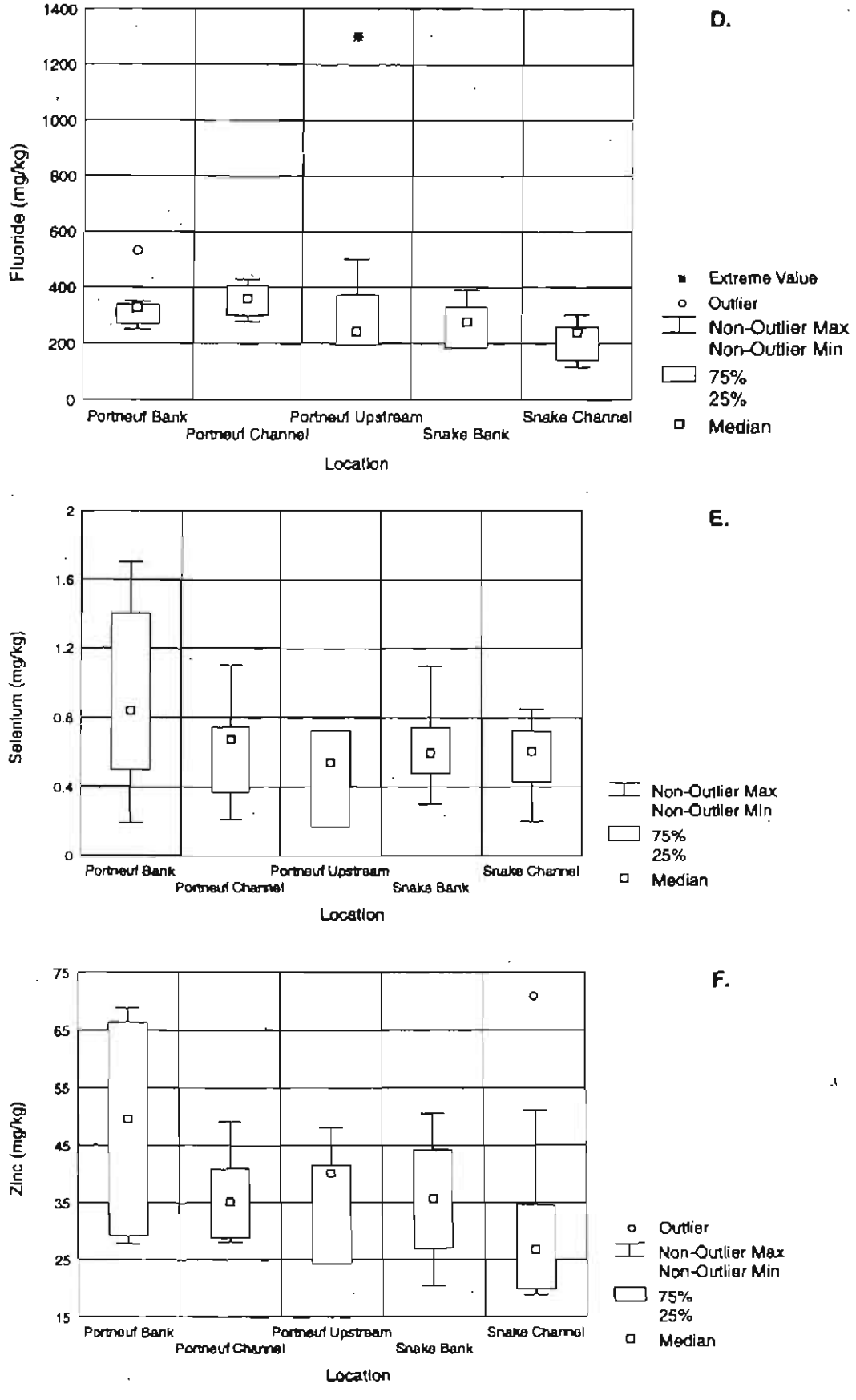
SOURCE: Ecology and Environment, Inc. 1995

Figure 3-5 CADMIUM, FLUORIDE, AND ZINC IN DEER MICE



SOURCE: Ecology and Environment, Inc. 1995

Figure 3-6 ALUMINUM, ARSENIC, CADMIUM, FLUORIDE, SELENIUM, AND ZINC IN SEDIMENT



SOURCE: Ecology and Environment, Inc. 1995

Figure 3-6 (Cont.) ALUMINUM, ARSENIC, CADMIUM, FLUORIDE, SELENIUM, AND ZINC IN SEDIMENT

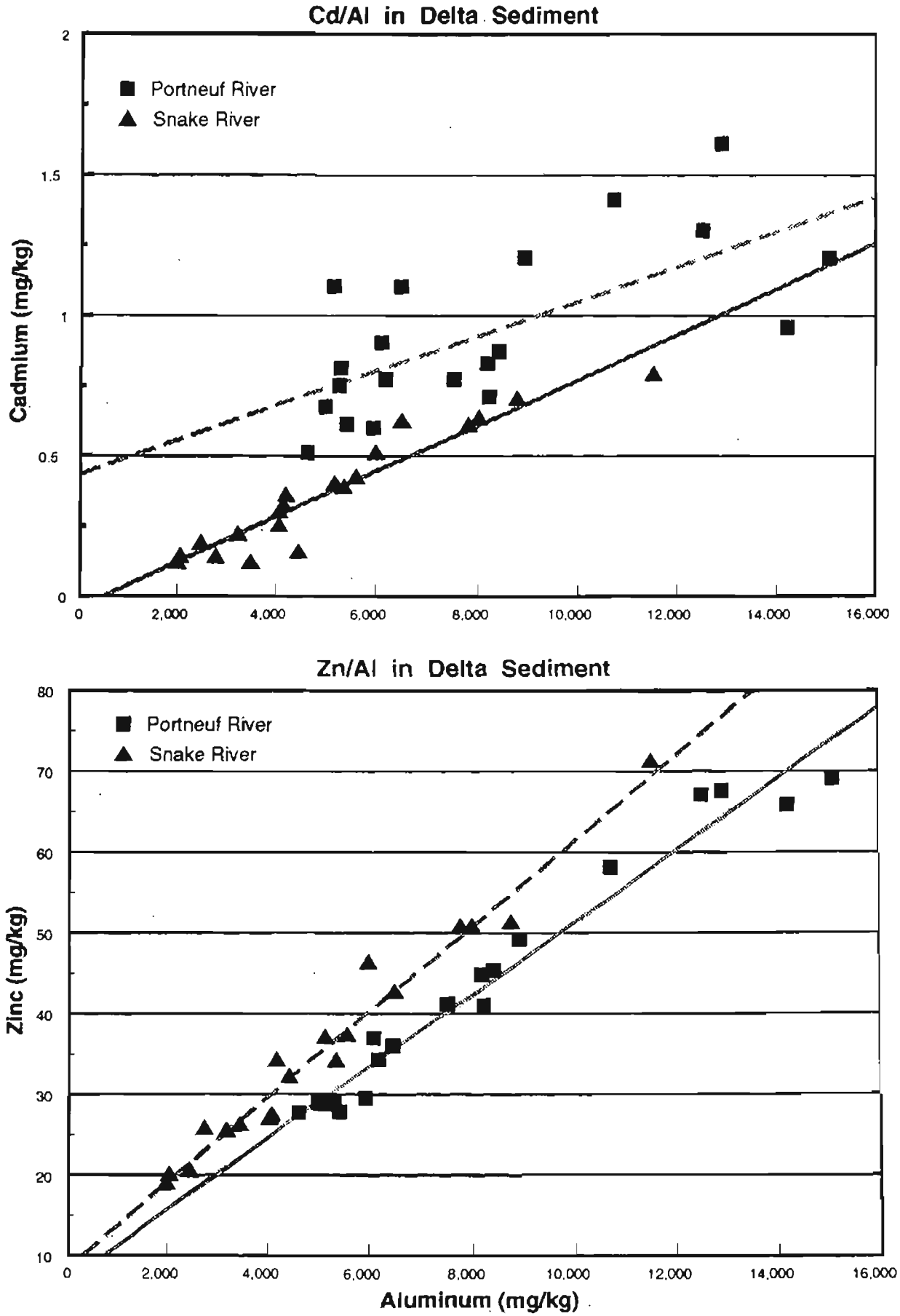


Figure 3-7 RELATIONSHIP OF CADMIUM AND ZINC TO ALUMINUM IN SEDIMENT

4 Exposure Assessment

This section describes the approach for obtaining exposure estimates for ecological receptors at the EMF Site and summarizes the estimates of exposure. In addition, the transport and fate of contaminants is summarized in this section to provide general background information for the exposure assessment.

4.1 Contaminant Release, Migration, and Fate

A detailed overview of the fate and transport of COPCs at the EMF Site is provided in the HHRA report. In addition, Appendix G provides an evaluation of issues pertinent to the ecological risk assessment, including an analysis of the soil geochemical data collected in the September 1994 ecological investigations, and a review of the bioavailability of the COPCs and their potential for bioaccumulation in the terrestrial food chain. This section provides a brief summary of the information provided in Appendix G and the HHRA report as it relates to the exposure assessment for the ecological risk assessment.

4.1.1 Terrestrial Investigations

COPCs investigated in detail at the EMF Site include cadmium, fluoride, and zinc. The potential for mobilization of these three COPCs in the terrestrial food chain was investigated by sampling vegetation and small mammals at two sagebrush steppe habitat locations (Bannock Hills SW and Michaud Flats) adjacent to the site facilities and vegetation at a riparian habitat location (Portneuf River) adjacent to the site facilities (see Appendix B). Cadmium and fluoride were found to be significantly elevated in plant and animal tissues sampled from these locations, in comparison with samples collected from background locations (see Section 3).

These findings indicate that historic and/or ongoing air deposition of contaminants to vegetation and soil in the vicinity of the site is an important migration pathway at the EMF Site. However, the data also show that COPCs are not readily mobilized in the terrestrial food chain: uptake factors (UF, the ratio of plant tissue concentrations to soil concentrations) for cadmium and zinc are significantly lower at the site compared with background locations (see Appendix G). It is likely that soil contamination at the site is confined to the upper surface horizon of the soil, where it is not readily accessible to plant roots. In addition, based on considerations of the site geochemistry (i.e., arid, high-pH soils), cationic metals such as cadmium and zinc are not expected to be very mobile. This expectation is confirmed by the higher plant UFs for cadmium and zinc found at the Michaud Flats sampling location (average soil pH = 7.00) compared with the Bannock Hills SW sampling location (average soil pH = 7.83; see Appendix G).

The degree of bioavailability and plant uptake of fluoride is less equivocal. Unfortunately, fluoride levels in plants were not accurately measured at the background locations (see Section 3). However, unlike cadmium and zinc, fluoride is expected to be somewhat more mobile at higher pH. This expectation is confirmed by the higher fluoride UFs found at the more alkaline Bannock Hills SW location compared with the Michaud Flats location (see Appendix G).

The deer mouse data also show greater concentration factors (CF, the ration of mouse tissue concentration to soil concentrations) of COPCs at the background location compared with the site. However, the mouse data do not correspond to the plant data with regard to showing consistent differences between Bannock Hills SW and Michaud Flats locations (see Appendix G). The mouse data may be confounded by adherence of soil contaminants to the animal's fur (i.e., the whole-body analysis reflects incidental contamination as well as bioconcentration in tissues).

4.1.2 Aquatic Investigations

Contaminant metals and fluoride may be transported from the facilities to the Portneuf River by migration in contaminated groundwater, direct discharge at outfalls, and air deposition. After entering the river, the contaminants may be deposited near the point of discharge or transported downstream to the Portneuf River delta at American Falls Reservoir. This section focuses on contaminants in sediment because sediments are the most important repository for contaminants in aquatic systems.

Metal contamination at the site is largely a result of phosphate ore particles and slag. Two lines of evidence suggest that these relatively immobile, nonbioavailable mineral forms also may be the predominant forms of metals in Portneuf River sediment. First, although concentrations of several metals (i.e., cadmium, chromium, vanadium, and zinc) are elevated in sediment near the IWW ditch outfall, the levels are not toxic to benthic invertebrates (see Appendix H). Secondly, SEM-cadmium and SEM-zinc, which are labile forms of metals determined by acid digestion with 6N HCl, were a much lower percentage of total cadmium and zinc in Portneuf River delta sediment compared with Snake river delta sediment. This would be expected if contaminant metals had been introduced to the Portneuf River as insoluble ore or slag particles and transported to the delta by advective flow. For example, SEM-cadmium averaged 23% of total cadmium in Portneuf River delta sediment compared with 60% for Snake River delta sediment. This result suggests that contaminant metals are present in sediment from the Portneuf River and its delta in a relatively refractory form.

No data are available on the form of fluoride in Portneuf River sediment. However, because fluoride is a major component of the ore used by the facilities, a fraction of the fluoride in sediment likely is the result of ore particles transported from the site.

4.2 Exposure Scenarios and Pathways

This section presents the exposure scenarios for the different habitats and receptors being evaluated, and summarizes the important exposure media and exposure routes. The exposure scenarios are based on the pathways and endpoint species identified and described in the conceptual site model (see Section 2.5). The main emphasis in the ecological risk assessment is placed on current conditions and evaluation of off-site ecosystems. It is unlikely that any realistic alternative future uses of the site would allow for significant recolonization by wildlife, and wildlife contact and use of the facility grounds at present is minimal due to the disturbed nature of the site. However, continuing releases of contaminants to groundwater, as well as stack emissions and downwind fallout, are of potential concern at the site. Future conditions cannot be accurately quantified with the available data, but will be discussed in the Risk Characterization (Section 6).

Table 4-1 lists the two plant scenarios and six wildlife scenarios that were selected for the quantitative ecological risk assessment in the sagebrush steppe habitat. The vegetation scenarios chosen for evaluation are a native shrub (big sagebrush) and grass (thickspike wheatgrass). The wildlife scenarios selected for quantitative evaluation include a small

mammal (deer mouse), a mammalian carnivore (coyote), a large herbivorous mammal (mule deer), an omnivorous songbird (horned lark), an upland gamebird (sage grouse), and a raptor (red-tailed hawk). Also listed in Table 4-1 are the scenarios chosen for the riparian habitat, which include a shrub (Russian olive) and a songbird (cedar waxwing) that feeds on the fruit of riparian shrubs. Table 4-2 lists the scenarios for the aquatic habitats. The scenarios selected for quantitative evaluation in the aquatic habitat of the Portneuf River delta include a waterfowl (mallard), a shorebird (spotted sandpiper), and an aquatic mammal (muskrat).

For the vegetation scenarios, the important exposure routes are root uptake of COPCs from soil and foliar uptake from the air. These combined pathways were evaluated using plant foliage tissue concentrations measured at the site. For the wildlife scenarios, the potential exposure routes include direct contact and ingestion of contaminated media (soil, sediment, surface water), inhalation of airborne contaminants, and consumption of contaminated food. The relative importance of the various exposure routes are discussed in Section 4.3.2 (Exposure Estimates). In general, the ingestion of soil or sediment and consumption of contaminated food items were evaluated using soil, sediment, plant, and small mammal tissue concentrations measured at the site.

4.3 Quantification of Exposure

This section describes how quantitative exposure estimates were obtained for the exposure scenarios identified in Section 4.2. Exposure point concentrations (EPCs) are presented in Section 4.3.1. Section 4.3.2 describes the method for calculating exposure estimates and summarizes the estimated exposures.

4.3.1 Exposure Point Concentrations

The exposure media sampled during the ecological investigations include sediment, surface soil, sagebrush, thickspike wheatgrass, deer mice, and Russian olive fruit. Exposure point concentrations (EPCs) were calculated for each COPC from these data, as described below. EPCs for the sagebrush steppe and riparian habitats are listed in Table 4-3, and EPCs for the river delta habitat are listed in Table 4-4.

4.3.1.1 Exposure Areas

The area potentially affected by site contamination is large, and the extent of contamination is not accurately known. However, the two potentially impacted sagebrush

steppe sampling locations (Bannock Hills SW and Michaud Flats) and the single potentially impacted riparian sampling location (Portneuf River) were all located within 1 mile downwind of the site facilities, in areas of known soil contamination. The average concentrations of COPCs in soils at these locations (see Section 3) were approximately the same as the average site-wide concentrations of COPCs in soils (see Appendix A). Therefore, the exposure of plants and wildlife to COPCs at these sampling locations is likely to be representative of the average exposure for sagebrush steppe and riparian receptors at the EMF Site. For risk evaluation purposes, the EMF Site is considered to encompass all of the potentially impacted sampling locations and the areas of soil contamination identified in Phase 1 of the RI/FS (i.e., the area within a 3-mile radius of the facilities).

Because of the apparent differences in concentrations and mobility of COPCs noted at the two potentially impacted sagebrush steppe locations (see Section 4.1), each location was treated as a separate exposure area. In addition, the background sagebrush steppe sampling location (Ferry Butte) and background riparian sampling location (Snake River) were evaluated separately as exposure areas. Background exposure was calculated for these areas to allow evaluation of incremental site-related risks to background risks for the COPCs, each of which occurs naturally at detectable concentrations.

4.3.1.2 Exposure Point Concentrations - Calculations

Consistent with EPA guidance for risk assessment (EPA 1989c), the 95% upper confidence limit (UCL) of the arithmetic mean concentration was used as a conservative estimate of the average concentration in an exposure area for the purpose of estimating exposure and risks.

When a data set was normally or lognormally distributed, the 95% UCL on the mean was calculated as described in Gilbert (1987) and EPA (1992b). The distribution of each data set was determined as described in Appendix C.

Several data sets were not normally or lognormally distributed. When this resulted from a large number of 'nondetects', the EPC was set equal to the non-outlier maximum, or the average of the detected concentrations. In cases where the COPC was detected in all samples but the data were not normally or lognormally distributed, the third quartile (75th percentile) was used as the EPC. These cases are noted in Table 4-3.

Because COPCs in macrophytes and benthic invertebrates were not measured as part of the ecological investigations, EPCs for these exposure media were taken from the literature

or calculated from the sediment cadmium data as described below. The EPC for cadmium in macrophytes in the Portneuf River delta was taken from Low and Mullins (1990). These authors measured cadmium in horned pondweed from the river below the facilities (see Table 4-4). To arrive at a cadmium level in macrophytes for the Snake River delta, the EPC for cadmium in Snake delta sediment was multiplied by a sediment-to-macrophyte bioaccumulation factor (BAF). The BAF (2.19) was derived from Portneuf River data by dividing the cadmium level in horned pondweed (2.3 mg/kg dry weight) by the cadmium EPC in sediment (1.05 mg/kg dry weight).

Cadmium levels in benthic invertebrates from the Portneuf River also were taken from Low and Mullins (1990); these authors measured cadmium in mayfly nymphs and caddisfly larvae from the river below the facilities (see Table 4-4). Because cadmium data were not available for benthic invertebrates from the Snake River delta, cadmium levels in benthic invertebrates also were estimated from the sediment data using the approach described in EPA (1994). The approach was developed by the EPA from experimental data and recommends using a cadmium bioaccumulation factor of 1.5 for benthic invertebrates when the sediment has an SEM/AVS ratio less than 1. Consequently, EPCs for cadmium in sediment were multiplied by 1.5 to arrive at tissue levels in 'model' benthic invertebrates (see Table 4-4). Of the three benthic invertebrate values listed in Table 4-4 for the Portneuf River delta, the highest value (5.39 mg/kg dry weight) was used in the exposure assessment to provide a conservative estimate of risk.

4.3.2 Exposure Estimates

The cumulative dietary exposure for ecological receptors was 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). Dietary exposure is represented mathematically as:

$$EE_{diet} = \frac{\sum_{1 \to n} \left[(P_1 \times T_1) + (P_2 \times T_2) + \ldots (P_n \times T_n) \right] \times SUF \times ED \times IR}{BW}$$

where: EE_{diet} = Estimated Exposure from diet (mg/kg BW · day);

P_n = Percentage of diet represented by prey item ingested;

T_n = Tissue concentration in prey item n (mg/kg dry weight);

SUF = Site use factor (unitless);

ED = Exposure duration (unitless), equal to the fraction of the year spent in the region;

IR = Ingestion rate of receptor (kg/day in dry weight); and

BW = Body weight of receptor (kg in fresh weight).

Dietary, home range, and body weight information for the endpoint species are listed in Table 4-5 for the sagebrush steppe and riparian habitats, and in Table 4-6 for the river delta habitat. Sources include EPA (1993) and other publications on wildlife natural history, as indicated in the footnotes of the tables. Food ingestion rates were calculated from the intake formulas of Nagy (1987) as presented in EPA (1993); the equations are listed in Table 4-7.

Tissue concentrations in wildlife food items were: (1) measured directly as part of the ecological investigation, (2) taken from other published studies at the site, (3) calculated by multiplying the COPC concentration in the affected media by a BAF, or (4) arrived at using conservative assumptions. Items 1 through 3 were discussed in the previous section, and the EPCs in wildlife food are listed in Tables 4-3 and 4-4. For scenarios including forbs and shrubs as wildlife food items, the EPCs for thickspike wheatgrass and sagebrush, respectively, were used. Because data on COPC levels in terrestrial insects from the EMF site are not available, and insects are a common dietary item of the horned lark and deer mouse, insect EPCs were conservatively assumed to be the same as in thickspike wheatgrass, a food source for common insects at the site (e.g., grasshoppers).

Because COPC concentrations in surface water from the site were several orders of magnitude lower than in soil, sediment, or food items, COPC exposure from the drinking of surface water was assumed to be negligible compared with other sources. For example, drinking exposure to fluoride (the COPC with the highest concentration in surface water) was calculated to be less than 3.5% of total exposure for the mule deer, the species with the greatest drinking rate. Fluoride exposure from drinking water was generally < 1% of total exposure for receptor at the Bannock Hills SW and Michaud Flats exposure areas. A COPC exposure from inhalation was also assumed to be negligible compared with other sources.

An ED value of 1.0 was used for receptor species that are year-round residents of Idaho; a value between 0 and 1.0 was used for migratory species, based on the fraction of the

year spent in the state. Because a precise estimate of the area affected by the facilities is not available, but appears large based on the extent of soil contamination (E & E 1993), the SUF was assumed to be one (1.0) for all wildlife receptors. This assumption implies that the entire home range of a receptor is in an area affected by the facilities. The uncertainties of this and other assumptions made in the exposure assessment are discussed in Section 6.

Receptor exposure to chemicals from ingestion of soil or sediment was estimated by multiplying the soil EPC by the percentage of soil in the diet of each receptor, multiplying by the SUF, ED, and IR, and dividing by BW. Soil ingestion data for wildlife were taken from Beyer *et al.* (1994).

The total exposure of a receptor to a chemical was calculated as the sum of the diet and soil (or sediment) dosages:

$$EE_{total} = EE_{diet} + EE_{soil/sediment}$$

where:

EE_{total} = Total exposure (mg/kg BW · day);

EE_{diet} = Estimated exposure from diet (mg/kg BW · day);

$EE_{soil/sediment}$ = Estimated exposure from soil (or sediment) ingestion (mg/kg BW · day);

For the wildlife scenarios, EE_{total}, EE_{diet}, and $EE_{soil/sediment}$ values are summarized in Table 4-8 for the sagebrush steppe and riparian habitats, and in Table 4-9 for the river delta habitat. Tables 4-8 and 4-9 also list the contribution of EE_{diet} and $EE_{soil/sediment}$ to EE_{total} on a percent basis. Estimated exposures to COPCs were greater for measurement endpoint species from the impacted sites compared with the reference sites. This is not surprising since the measured COPC levels in soil, sediment, and wildlife food items were elevated near the facilities. Because COPC levels in soil and sediment were more highly elevated than in wildlife food items near the facilities, $EE_{soil/sediment}$ was generally a greater percentage of EE_{total} at the impacted sites compared with the reference sites.

For the plant species being quantitatively evaluated, estimated exposures are based on the measured tissue concentration EPCs reported in Table 4-3. The significance of the exposure estimates is discussed in the following sections.

Table 4-1

SAGEBRUSH STEPPE AND RIPARIAN HABITAT EXPOSURE SCENARIOS

Assessment Endpoint Species/Functional Group	Measurement Endpoint Species	Exposure Media	Potentially Important Exposure Routes
Sagebrush Steppe Habitat			
Shrubs	Big sagebrush	Soil	Root uptake
		Air	Foliar uptake
Grasses	Thickspike wheatgrass	Soil	Root uptake
		Air	Foliar uptake
Mammalian carnivores	Coyote	Soil	Incidental ingestion
		Small mammals	Dietary
Upland game birds	Sage grouse	Soil	Incidental ingestion
		Sagebrush foliage and forbs	Dietary
Raptors	Red-tailed hawk	Soil	Incidental ingestion
		Small mammals	Dietary
Songbirds	Horned lark	Soil	Incidental ingestion
		Seeds of grasses and shrubs	Dietary
Small mammals	Deer mouse	Soil	Incidental ingestion
		Seeds, foliage of grasses and shrubs	Dietary
Large herbivorous mammals	Mule deer	Soil	Incidental ingestion
		Foliage of grasses and shrubs	Dietary
Riparian Habitat			
Shrubs	Russian olive	Soil	Root uptake
		Air	Foliar uptake
Songbirds	Cedar waxwing	Soil	Incidental ingestion
		Russian olive fruit	Dietary

Table 4-2

RIVER DELTA HABITAT EXPOSURE SCENARIOS

Assessment Endpoint Species/Functional Group	Measurement Endpoint Species	Exposure Media	Potentially Important Exposure Routes
Waterfowl	Mallard	Sediment	Incidental ingestion
		Macrophytes and benthic invertebrates	Dietary
Shorebirds	Spotted sandpiper	Sediment	Incidental ingestion
		Benthic invertebrates	Dietary
Semi-aquatic herbivorous mammals	Muskrat	Sediment	Incidental ingestion
		Macrophytes	Dietary

Table 4-3

EXPOSURE POINT CONCENTRATIONS OF COPCs IN SAGEBRUSH STEPPE AND RIPARIAN HABITATS (mg/kg)

Exposure Medium	Location	COPC		
		Cadmium EPC	Fluoride EPC	Zinc EPC
Surface soil	Ferry Butte[a]	0.81	381	59.2
	Michaud Flats	25.5	2,207	184
	Bannock Hills SW	30.1	1,585	283
	Snake riparian[a]	0.30	264	26.7
	Portneuf riparian	15.2	1,860[b]	144
Sagebrush (unwashed)	Ferry Butte[a]	0.35[d]	12.1	33.9[b]
	Michaud Flats	1.42	60.8	41.4
	Bannock Hills SW	1.06	85.7	33.6
Sagebrush (washed)	Ferry Butte[a]	0.34[d]	NA	28[d]
	Michaud Flats	1.24	NA	37.8
	Bannock Hills SW	0.86[b]	NA	28
Thickspike Wheatgrass (stems and leaves)	Ferry Butte[a]	0.27[e]	12.2[e]	9.05
	Michaud Flats	0.51	38.1[e]	12.5[f]
	Bannock Hills SW	0.65	86.9[f]	13.4
Russian olive (fruit)	Snake riparian[a]	0.10[e]	11.9[e]	8.0
	Portneuf riparian	0.25[e]	12.0[e]	11.3
Deer mouse (whole body)	Ferry Butte[a]	0.21	6.8[e]	42.4
	Michaud Flats	0.29	108	39.8
	Bannock Hills SW	0.77	144	41.4
Deer mouse (femur)	Ferry Butte[a]	NA	214[b]	NA
	Michaud Flats	NA	761	NA
	Bannock Hills SW	NA	524[b]	NA

Key at end of table.

Table 4-3 (Cont.)

[a] Background locations.
[b] 95% UCL of lognormal distribution.
[c] One-half detection limit.
[d] Non-outlier maximum.
[e] Average of detected concentrations.
[f] Third quartile (75th percentile) used because the 10 detected values were not normally or lognormally distributed.

Key:

COPC = Contaminant of potential concern
NA = Not available.
UCL = Upper confidence limit.
EPC = Exposure point concentration.

Table 4-4

EXPOSURE POINT CONCENTRATIONS OF CADMIUM IN RIVER DELTA HABITAT (mg/kg)

Exposure Medium	Location	Cadmium EPC
Sediment	Snake[a]	0.45
	Portneuf	1.05
Horned pondweed	Snake[a]	1.0[b]
	Portneuf	2.3[c]
"Model" benthic invertebrate	Snake[a]	0.68[b]
	Portneuf	1.58[b]
Caddisfly larvae	Portneuf	0.73[c]
Mayfly nymphs	Portneuf	5.39[c,d]

[a] Background location.
[b] Calculated as described in text.
[c] Low and Mullins (1990).
[d] Selected as the EPC for benthic invertebrates in the Portneuf River Delta; see text.

Key:

EPC = Exposure point concentration.

Table 4-5

EXPOSURE PARAMETERS FOR WILDLIFE IN SAGEBRUSH STEPPE AND RIPARIAN HABITATS

Assessment Endpoint Species/functional Group	Measurement Endpoint Species	Percent of Diet[a]					Home Range[c] (acres)	Exposure Duration[d]	Ingestion Rate[e] (kg/day)	Body Weight[f] (kg)
		Shrubs	Forbs	Insects	Small Mammals	Soil[b]				
Upland game birds	Sage grouse	74	26	0	0	9	890[g], 2.47	1	0.105	2.47
Raptors	Red-tailed hawk	0	0	0	100	2	4,374	1	0.060	1.056
Songbirds	Horned lark	0	80	20	0	2	2.0	1	0.0075	0.031
Small mammals	Deer mouse	21.5	42.8	35.7	0	2	0.32	1	0.0035	0.021
Large mammalian herbivores	Mule deer	75	25	0	0	2	90	0.5	2.25	87.2
Mammalian carnivores	Coyote	0	0	0	100	2	6,968	1	0.59	13.6
Riparian songbirds	Cedar waxwing	100	0	0	0	2	0.23	1	0.0076	0.032

[a] Martin *et al.* (1951) for mule deer, horned lark, cedar waxwing, and sage grouse; EPA (1993) for red-tailed hawk and deer mouse.

[b] Beyer *et al.* (1994) for grouse, hawk, and mouse; 2 percent assumed for other receptors.

[c] Burt and Grossenheider (1976) for mule deer; Connelly (1988) for sage grouse; EPA (1993) for red-tailed hawk and deer mouse; DeGraaf and Rudis (1986) for horned lark and cedar waxwing; Laundre and Keller (1984) for coyote.

[d] Fraction of time spent in area, 0 to 1 (unitless).

[e] See Table 4-7 for calculation.

[f] Burt and Grossenheider (1976) for mule deer; Dunning (1993) for sage grouse, horned lark, and cedar waxwing; EPA (1993) for red-tailed hawk and deer mouse; Godin (1977) for coyote.

[g] Larger number indicates distance traveled between summer and winter range (Connelly 1988); smaller number is size of breeding range (Connelly 1981).

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Table 4-6

EXPOSURE PARAMETERS FOR WILDLIFE IN RIVER DELTA HABITAT

Assessment Endpoint Species/Functional Group	Measurement Endpoint Species	Percent of Diet[a]			Home Range[a] (acres)	Exposure Duration[c]	Ingestion Rate[d] (kg/day)	Body Weight[a] (kg)
		Macrophytes	Invertebrates	Sediment or Soil[b]				
Semi-aquatic mammals	Muskrat	100	0	3.3	25	1	0.028	0.87
Shorebirds	Spotted sandpiper	0	100	18	0.62	0.66	0.061	1.068
Waterfowl	Mallard	92	8	3.3	1,156	1	0.110	1.153

a From EPA (1993).

b Beyer *et al.* (1994) for sandpiper and mallard; muskrat assumed to be same as mallard.

c Fraction of time spent in area, 0 to 1 (unitless).

d See Table 4-7 for calculation.

Table 4-7

FOOD INTAKE FORMULAS FOR WILDLIFE

Wildlife Group	Food Intake Formula[a] (g/day)
Placental mammals	$0.235(bw)^{0.822}$
Rodents	$0.621(bw)^{0.564}$
Herbivores	$0.577(bw)^{0.727}$
Nonpasserine birds	$0.648(bw)^{0.651}$
Passerine birds	$0.398(bw)^{0.850}$

[a] Dry-weight basis.

Key:

bw = Body weight (g), fresh weight.

Source: Nagy 1987, as presented in EPA 1993.

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Table 4-8

ESTIMATED EXPOSURE OF WILDLIFE TO COPCs IN SAGEBRUSH STEPPE AND RIPARIAN HABITATS

Measurement Endpoint Species	COPC	Location	EE_{diet} mg/kg bw/d	Diet-Percent of EE_{total}	EE_{soil} mg/kg bw/d	Soil-Percent of EE_{total}	EE_{total} mg/kg bw/d
Sage grouse	Cadmium	Ferry Butte[a]	0.014	82.4	0.003	17.6	0.017
		Michaud Flats	0.050	33.8	0.098	66.2	0.148
		Bannock Hills SW	0.040	25.6	0.116	74.4	0.156
	Fluoride	Ferry Butte[a]	0.515	26.1	1.455	73.9	1.9
		Michaud Flats	2.330	21.6	8.47	78.4	10.8
		Bannock Hills SW	3.660	37.7	6.06	62.3	9.72
	Zinc	Ferry Butte[a]	1.17	84.2	0.22	15.8	1.39
		Michaud Flats	1.44	67.3	0.70	32.7	2.14
		Bannock Hills SW	1.21	52.8	1.08	47.2	2.29
Red-tailed hawk	Cadmium	Ferry Butte[a]	0.012	92.3	0.001	7.7	0.013
		Michaud Flats	0.016	35.6	0.029	64.4	0.045
		Bannock Hills SW	0.044	56.4	0.034	43.6	0.078
	Fluoride	Ferry Butte[a]	0.368	44.9	0.451	55.1	0.819
		Michaud Flats	6.14	71.1	2.50	28.9	8.64
		Bannock Hills SW	8.16	81.8	1.81	18.2	9.97
	Zinc	Ferry Butte[a]	2.41	97.2	0.07	2.8	2.48
		Michaud Flats	2.26	91.5	0.21	8.5	2.47

Key at end of table.

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Table 4-8

ESTIMATED EXPOSURE OF WILDLIFE TO COPCs IN SAGEBRUSH STEPPE AND RIPARIAN HABITATS

Measurement Endpoint Species	COPC	Location	EE_{diet} mg/kg bw/d	Diet-Percent of EE_{total}	EE_{soil} mg/kg bw/d	Soil-Percent of EE_{total}	EE_{total} mg/kg bw/d
		Bannock Hills SW	2.35	88.0	0.32	12.0	2.67
Horned lark	Cadmium	Ferry Butte[a]	0.065	94.2	0.004	5.8	0.069
		Michaud Flats	0.124	50.2	0.123	49.8	0.247
		Bannock Hills SW	0.157	51.8	0.146	48.2	0.303
	Fluoride	Ferry Butte[a]	2.95	61.5	1.85	38.5	4.80
		Michaud Flats	9.22	46.3	10.68	53.7	19.9
		Bannock Hills SW	21.0	73.2	7.70	26.8	28.7
	Zinc	Ferry Butte[a]	2.19	88.7	0.28	11.3	2.47
		Michaud Flats	3.02	77.2	0.89	22.8	3.91
		Bannock Hills SW	3.24	70.3	1.37	29.7	4.61
Deer mouse	Cadmium	Ferry Butte[a]	0.048	94.1	0.003	5.9	0.051
		Michaud Flats	0.117	57.6	0.086	42.4	0.203
		Bannock Hills SW	0.123	55.2	0.100	44.8	0.223
	Fluoride	Ferry Butte[a]	2.03	61.5	1.27	38.5	3.30
		Michaud Flats	7.16	49.4	7.34	50.6	14.5
		Bannock Hills SW	14.4	73.1	5.3	26.9	19.7
	Zinc	Ferry Butte[a]	2.40	92.3	0.20	7.7	2.60

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Table 4-8

ESTIMATED EXPOSURE OF WILDLIFE TO COPCs IN SAGEBRUSH STEPPE AND RIPARIAN HABITATS

Measurement Endpoint Species	COPC	Location	EE_{diet} mg/kg bw/d	Diet-Percent of EE_{total}	EE_{soil} mg/kg bw/d	Soil-Percent of EE_{total}	EE_{total} mg/kg bw/d
		Michaud Flats	3.12	83.6	0.61	16.4	3.73
		Bannock Hills SW	2.96	75.9	0.94	24.1	3.90
Mule deer	Cadmium	Ferry Butte[a]	0.0042	93.3	0.0003	6.7	0.0045
		Michaud Flats	0.015	68.2	0.007	31.8	0.022
		Bannock Hills SW	0.012	60.0	0.008	40.0	0.020
	Fluoride	Ferry Butte[a]	0.156	61.2	0.099	38.8	0.255
		Michaud Flats	0.711	55.5	0.569	44.5	1.28
		Bannock Hills SW	1.11	73.0	0.41	27.0	1.52
	Zinc	Ferry Butte[a]	0.357	96.0	0.015	4.0	0.372
		Michaud Flats	0.441	90.4	0.047	9.6	0.488
		Bannock Hills SW	0.368	83.4	0.073	16.6	0.441
Coyote	Cadmium	Ferry Butte[a]	0.0091	91.0	0.0009	9.0	0.010
		Michaud Flats	0.013	37.1	0.022	62.9	0.035
		Bannock Hills SW	0.033	55.0	0.027	45.0	0.060
	Fluoride	Ferry Butte[a]	0.295	47.2	0.330	52.8	0.625
		Michaud Flats	4.69	71.1	1.91	28.9	6.60
		Bannock Hills SW	6.23	81.9	1.38	18.1	7.61

Key at end of table.

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Table 4-8

ESTIMATED EXPOSURE OF WILDLIFE TO COPCs IN SAGEBRUSH STEPPE AND RIPARIAN HABITATS

Measurement Endpoint Species	COPC	Location	EE_{diet} mg/kg bw/d	Diet-Percent of EE_{total}	EE_{soil} mg/kg bw/d	Soil-Percent of EE_{total}	EE_{total} mg/kg bw/d
	Zinc	Ferry Butte[a]	1.84	97.4	0.05	2.6	1.89
		Michaud Flats	1.73	91.5	0.16	8.5	1.89
		Bannock Hills SW	1.80	88.2	0.24	11.8	2.04
Cedar waxwing	Cadmium	Snake riparian[a]	0.024	96.0	0.001	4.0	0.025
		Portneuf riparian	0.059	45.0	0.072	55.0	0.131
	Fluoride	Snake riparian[a]	2.83	69.4	1.25	30.6	4.08
		Portneuf riparian	2.85	24.4	8.83	75.6	11.69
	Zinc	Snake riparian[a]	1.90	94.1	0.12	5.9	2.02
		Portneuf riparian	2.68	79.5	0.69	20.5	3.37

[a] Background location.

Key:

bw = Body weight.
COPC = Contaminant of potential concern.
EE = Estimated exposure.

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Table 4-9

WILDLIFE ESTIMATED EXPOSURE TO COPCS IN RIVER DELTA HABITAT

Measurement Endpoint Species	COPC	Location	EE_{diet} mg/kg BW/d	Diet-Percent of EE_{total}	$EE_{sediment}$ mg/kg BW/d	Sediment-Percent of EE_{total}	EE_{total} mg/kg BW/d
Muskrat	Cadmium	Snake Delta[a]	0.032	97.0	0.001	3.0	0.033
		Portneuf Delta	0.074	98.7	0.001	1.3	0.075
Spotted sandpiper	Cadmium	Snake Delta[a]	0.026	89.7	0.003	10.3	0.029
		Portneuf Delta	0.203	96.7	0.007	3.3	0.210
Mallard	Cadmium	Snake Delta[a]	0.093	98.9	0.001	1.1	0.094
		Portneuf Delta	0.243	98.8	0.003	1.2	0.246

[a] Background location.

Key:

COPC = Contaminant of potential concern.
EE = Estimated exposure.

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5 Ecological Effects Assessment

This ecological effects assessment describes the potential toxic effects associated with the identified COPCs in each medium of concern. The toxicological evaluation involves characterizing the inherent toxicity of the COPCs and establishing toxicity benchmarks (TBs) for each endpoint species and COPC. The TB is a concentration or dose representative of the expected 'no observed adverse effect level' (NOAEL) or 'lowest observed adverse effect level' (LOAEL) for any given receptor and COPC.

TBs are drawn from published dose response studies, which typically involve the use of standard laboratory or domestic test species of plants and animals. Extrapolation of these benchmarks to wild populations is uncertain; thus, a conservative approach is taken to avoid underestimating potential toxicity. These uncertainties and their relevance to the ecological risk assessment are discussed further in this section and in the risk characterization (Section 6).

For any given receptor or COPC being evaluated in the risk assessment, the TB selected for evaluation is termed a Toxicity Reference Value (TRV). The derivation of TRVs for the EMF site is provided in Section 5.1.

While the ecological effects assessment for the EMF site is largely based on extrapolation from published toxicological studies, field investigations can also provide evidence of ecological effects related to the site. The only formal investigation of this type conducted at the site was the toxicity testing of Portneuf River sediment at the IWW ditch outfall (see Appendix H). The toxicity test results are summarized, along with other field observations pertinent to the evaluation of ecological effects, in Section 5.2. In addition, a review of the pertinent ecotoxicological literature for fluoride is provided in Appendix I.

5.1 Derivation of Toxicity Reference Values

TRVs were derived for plants and wildlife using the procedures outlined below.

5.1.1 Terrestrial Plants

The TRV used to evaluate phytotoxicity of a given COPC was the NOAEL or LOAEL of plant tissue concentrations, estimated from literature. The TRVs for endpoint species of shrubs and grasses are provided in Table 5-1. In general, the critical concentration in sensitive species of plants and/or the lowest concentration considered excessive or toxic in plant tissues was selected as the TRV (Kabata-Pendias and Pendias 1992).

5.1.2 Wildlife

Potential impacts to wildlife at estimated exposure doses were evaluated using published toxicological data for mammalian and avian species (Opresko *et al.* 1994) and other sources. From these data, a test species NOAEL or LOAEL was selected as a TB for each COPC (see Table 5-2). Toxicity data reported as dietary or drinking water 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 body weights of test animals (see Table 5-3). Toxicity benchmarks were drawn from studies that considered reproductive and developmental effects, or other critical effects indicative of overt impacts to individual organisms that may affect population size. Studies incorporating chronic exposure durations, multiple exposure levels, and statistical evaluation of test results were preferred.

Uncertainty arises when using published benchmarks to estimate wildlife toxicity and includes the following:

- Extrapolation from acute or subchronic exposures to chronic exposure durations;
- Extrapolation from LOAELs to NOAELs;
- Extrapolation across different species of varying taxonomic relatedness, feeding habits, and body size;
- Extrapolation to sensitive or protected species; and

- Consideration of bioavailability, assimilation, and relative toxicity of forms of contaminants used in toxicity testing versus forms occurring in nature.

Uncertainty and scaling factors associated with each of these extrapolations are provided in Opresko *et al.* (1994) and other references, and discussed below.

5.1.2.1 Uncertainty Factors

Ecological risk assessment guidance provides a variety of approaches to the selection of uncertainty factors for extrapolating from acute or subchronic exposure durations, or for extrapolating from LOAELs to NOAELs. The uncertainty factors applied to either case can vary—for example, from an overall factor of 0.1 to a factor of 0.01 to extrapolate from an acute or subchronic LOAEL to a chronic NOAEL (Suter 1993). E & E selected chronic NOAELs as TBs, if available; otherwise, uncertainty factors were applied on a case-by-case basis.

There were only two instances where the use of uncertainty factors was a consideration. First, the mammalian TB for cadmium is a chronic LOAEL estimated to be 2.518 mg/kg/day (see Table 5-2). The use of an uncertainty factor of 0.1 to 0.01 is not warranted in this case, because doses of less than approximately 0.25 mg/kg-bw/day are within the normal range of dietary intake for mammalian receptors. Therefore, the LOAEL multiplied by 0.5 was considered to be sufficiently conservative in this case. Second, the avian TB for zinc is a subchronic LOAEL (Table 5-2), since mortality was observed at all dose levels and the study did not encompass critical lifestages (Opresko *et al.* 1994). Therefore, an uncertainty factor of 0.1 was used to derive the TB of 30 mg/kg-bw/day (see Table 5-2). Doses less than 30 mg/kg/day could be within the normal range of dietary intake for birds, and since zinc is an essential nutrient, it is not warranted to extrapolate within or below the range of normal exposure.

In all other cases, the TB selected from published studies was a chronic NOAEL, and extrapolation to account for exposure duration or sensitivity of the endpoint was unnecessary.

5.1.2.2 Body Size Scaling

Extrapolation of TBs from test species to taxonomically unrelated species of wildlife introduces uncertainty. For this reason, TBs were derived separately for birds and mammals to minimize the uncertainty of extrapolating between broadly defined groups of animals.

Within any group of animal species, the remaining major source of variation in sensitivity to toxic effects of contaminants is varying body size (Opresko *et al.* 1994). In general, smaller organisms are more tolerant of toxins as a result of their higher rate of metabolism and greater detoxification capability. To account for this source of variation in sensitivity, the TBs were adjusted to estimate species-specific wildlife TRVs using the approach described by Opresko *et al.* (1994). Dose equivalency for organisms of varying body sizes was estimated by adjusting for differences in body size between test species and endpoint species, as follows:

$$TRV_w = TB_t \times (BW_t / BW_w)^{(1/3)}$$

Where:

TRV_w = Toxicity reference value for endpoint species (mg/kg-bw/day).
TB_t = Toxicity benchmark for the test species (mg/kg-bw/day).
BW_w = Body weight of endpoint species (kg).
BW_t = Body weight of test species (kg).

The body weight scaling factors are presented in Table 5-4.

5.1.2.3 Other Sources of Uncertainty

Other uncertainties in dose extrapolation include the evaluation of potential effects on sensitive or protected species, and consideration of the bioavailability and toxicity of the forms of the chemicals used in toxicity tests versus the forms of COPCs occurring at the EMF Site.

Effects on sensitive or protected species are of concern at the EMF Site primarily for the Portneuf River delta, because this is a location where several rare species and numerous migratory waterfowl are expected to come in contact with site contaminants (see Appendix E). In addition, the riparian habitat along the Portneuf River is significant ecologically and is a designated wetland. In general, the sagebrush habitats adjacent to the site are representative of the region and do not warrant special consideration.

Contaminant levels are greatest adjacent to the site, in the least important of the habitat types described above (i.e., sagebrush habitat is more contaminated than the Portneuf River delta). Therefore, no attempt was made to quantitatively adjust the toxicity benchmarks to account for sensitive or protected species. However, in the risk characterization (Section 6) the exceedances of TRVs are qualitatively evaluated in light of the varying ecological and social importance of the site ecosystems.

Finally, forms of inorganic chemicals used in toxicity tests are typically soluble salts that are more soluble, readily absorbed, and toxic than the forms of COPCs contacted and ingested by wildlife at the site. Since this leads to an inherently conservative bias in the risk assessment, quantitative adjustment is deemed unnecessary, although risks may be overestimated. This is particularly true of ingestion of soil, where insoluble mineral forms of COPCs are likely to predominate (see Section 4.1). Furthermore, contaminants such as fluoride are localized in bone tissue, which is unlikely to be entirely digested by predators consuming prey such as deer mice. These factors are also taken into account in the evaluation of risks and uncertainties presented in Section 6.

5.1.2.4 Toxicity Reference Values

The TRVs for endpoint species of wildlife are listed in Table 5-5. The TRVs are presented as dose estimates, in units of mg/kg-bw/day, to allow direct comparison with the exposure estimates derived in Section 4. From examination of the values shown in Table 5-5, it can be seen that TRVs vary greatly among COPCs. Cadmium TRVs are generally lowest (0.05 to 4.84 mg/kg-bw/day) and zinc TRVs are highest (23.4 to 408 mg/kg-bw/day), with fluoride TRVs (2.94 to 46.3 mg/kg-bw/day) generally intermediate to the cadmium and zinc TRVs. In general, this corresponds to the known toxicity of these COPCs (i.e., cadmium toxicity > fluoride > zinc). It is also clear from Table 5-5 that smaller organisms such as the deer mouse have significantly higher TRVs than larger organisms such as the mule deer, as would be expected from the adjustment for body size described in Section 5.1.2.2. Overall, the TRVs are likely to encompass the broad range of wildlife sensitivity to COPCs at the EMF Site.

5.2 Field Evidence of Ecological Effects

Laboratory toxicity testing was conducted on sediment collected from the IWW ditch outfall in the Portneuf River (see Appendix H). Two benthic invertebrate species, *Hyallela azteca* (an amphipod) and *Chironomus tentans* (a midge larva) were tested in 10-day exposures to contaminated and uncontaminated control sediment. Neither species' growth or survival was adversely affected. The lack of toxicity of Portneuf River sediments is likely a result of the low bioavailability of the mineral forms of metals in the sediment. Since benthic

organisms were not affected at the elevated concentrations of metals detected at the IWW ditch outfall, impacts of these site contaminants on aquatic life are expected to be minimal.

Previous studies of benthic life in the Portneuf River have also indicated that impacts of the site are negligible (see Appendix F). No other studies of effects of site contamination on aquatic or terrestrial ecosystems are known to have been conducted. No observations of overt ecological effects were documented during field surveys conducted for the RI (BEI 1994).

Table 5-1

TOXICITY REFERENCE VALUES FOR PLANT TISSUES (mg/kg)

Chemical	Deficient	Sufficient or Normal	Critical Concentration in Sensitive Species	Excessive or Toxic
Cadmium	—	0.05 - 0.2	5[a] - 10	5 - 30
Fluoride	—	5 - 30	—	50[a] - 500
Zinc	10 - 20	27 - 150	150[a] - 200	100 - 400

[a] Selected as the TRV for plant tissue concentrations: sagebrush foliage, thickspike wheatgrass stems and leaves, and Russian olive fruit.

Key:

TRV = Toxicity Reference Value

Source: Kabata-Pendias and Pendias 1992.

Table 5-2

DERIVATION OF TEST SPECIES TOXICITY BENCHMARKS

Chemical	Test Species	Form	Exposure Duration and Exposure Route	Endpoint and Concentration	Critical Effect(s)	Test Species TB (mg/kg/day)	Reference
Cadmium	Mallard	Soluble salt	90 days; oral in diet	NOAEL 15.2 ppm	Reproduction	1.45	White and Finley 1978
	Mouse	Cadmium chloride	2 generations; oral in water (plus incidental in food)	LOAEL[a] 10 ppm in water and 0.1 ppm in diet	Reproduction	1.26	Schroeder and Mitchner 1971
Fluoride	Screech owl	Sodium fluoride	5 to 6 months; oral in diet	NOAEL 56.5 ppm	Reproduction	7.8	Pattee *et al.* 1988
	Mink	Sodium fluoride	7 to 8 months; oral in diet	NOAEL 125 ppm in diet and 0.3 ppm in water	Bone structure	12.8	Shupe *et al.* 1987
Zinc	Mallard	Zinc carbonate	60 days; oral in diet	LOAEL[b] 3,000 ppm	Mortality, body weight, blood	30	Gasaway and Buss 1972
	Rat	Zinc oxide	1 to 16 days during gestation; oral in diet	NOAEL 2,000 ppm	Reproduction	160	Schlicker and Cox 1968

[a] Uncertainty factor of 0.5 was used to obtain TB.
[b] Uncertainty factor of 0.1 was used to obtain TB.

Key at end of table.

Table 5-2 (Cont.)

Key:

LOAEL = Lowest observed adverse effect level.
NOAEL = No observed adverse effect level.
TB = Toxicity benchmark.

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Table 5-3

AVIAN AND MAMMALIAN INGESTION RATES AND BODY WEIGHTS

Species	Food Ingestion Rate (kg/day)	Reference	Body Weight (kg)	Reference
Mammals				
Laboratory mouse	0.0055	EPA 1988[a]	0.030	EPA 1985
Laboratory rat	0.028	EPA 1988[a]	0.35	EPA 1985
Mink	0.137	Bleavins and Aulerich 1981	1.0	EPA 1993a
Deer mouse	0.0035	Nagy 1987[b]	0.021	Millar 1989
Mule deer	2.25	Nagy 1987[b]	87.175	Burt and Grossenheider 1952
Coyote	0.587	Nagy 1987[b]	13.6	Godin 1977
Muskrat	0.028	Nagy 1987[b]	0.87	Reeves and Williams 1956
Birds				
Mallard	0.110	White and Finley 1978	1.153	White and Findley 1978
Screech owl	0.025	Opresko *et al.* 1994	0.181	Dunning 1993
Sage grouse	0.105	Nagy 1987[a]	2.468	Dunning 1993
Red-tailed hawk	0.0602	Nagy 1987[a]	1.056	EPA 1993b
Horned lark	0.0075	Nagy 1987[a]	0.0311	Dunning 1993
Cedar waxwing	0.0076	Nagy 1987[a]	0.032	Dunning 1993
Spotted sandpiper	0.061	Nagy 1987[a]	1.068	EPA 1993b

[a] Laboratory Mammals: $F = 0.056(BW)^{0.6611}$

[b] Food ingestion rates are based on the body weight of the organism in grams:
Rodents: $F = 0.621(BW)^{0.564}$
Herbivores: $F = 0.577(BW)^{0.727}$
Placental mammals: $F = 0.235(BW)^{0.822}$
Nonpasserine birds: $F = 0.648(BW)^{0.651}$
Passerine birds: $F = 0.398(BW)^{0.850}$

Key:

BW = Body weight.
F = Food ingestion rate.

Table 5-4

BODY SIZE SCALING FACTORS FOR SELECTED SPECIES

Test Species		Endpoint Species		
Species	Body Weight (BW_t) (kg)	Species	Body Weight (BW_w) (kg)	Scaling Factor[a] $(BW_t/BW_w)^{1/3}$
Mouse	0.03	Deer mouse	0.021	1.13
Mouse	0.03	Mule deer	87.175	0.07
Mouse	0.03	Coyote	13.6	0.13
Mouse	0.03	Muskrat	0.87	0.33
Rat	0.35	Deer mouse	0.021	2.55
Rat	0.35	Mule deer	87.175	0.16
Rat	0.35	Coyote	13.6	0.30
Rat	0.35	Muskrat	0.87	0.74
Mink	1.0	Deer mouse	0.021	3.62
Mink	1.0	Mule deer	87.175	0.23
Mink	1.0	Coyote	13.6	0.42
Mink	1.0	Muskrat	0.87	1.05
Mallard	1.153	Sage grouse	2.468	0.78
Mallard	1.153	Red-tailed hawk	1.056	1.03
Mallard	1.153	Horned lark	0.031	3.34
Mallard	1.153	Mallard	1.153	1.00
Mallard	1.153	Spotted sandpiper	1.068	1.03
Mallard	1.153	Cedar waxwing	0.032	3.30
Screech owl	0.181	Sage grouse	2.468	0.42
Screech owl	0.181	Red-tailed hawk	1.056	0.56
Screech owl	0.181	Horned lark	0.031	1.91
Screech owl	0.181	Mallard	1.153	0.54
Screech owl	0.181	Spotted sandpiper	1.068	0.55
Screech owl	0.181	Cedar waxwing	0.032	1.78

[a]From Opresko *et al.* 1994. For source of body weights see Table 5-3.

Table 5-5

TOXICITY REFERENCE VALUES FOR WILDLIFE

Chemical	Test Species	Test Species TB[a] (mg/kg/day)	Endpoint Species	Estimated Wildlife TRV[b] (mg/kg/day)
Cadmium	Mouse	1.26	Deer mouse	1.42
			Mule deer	0.09
			Coyote	0.16
			Muskrat	0.42
	Mallard	1.45	Sage grouse	1.13
			Red-tailed hawk	1.49
			Horned lark	4.84
			Mallard	1.45
			Spotted sandpiper	1.49
			Cedar waxwing	4.79
Fluoride	Mink	12.8	Deer mouse	46.3
			Mule deer	2.94
			Coyote	5.38
			Muskrat	13.4
	Screech owl	7.8	Sage grouse	3.28
			Red-tailed hawk	4.37
			Horned lark	14.9
			Mallard	4.21
			Spotted sandpiper	4.29
			Cedar waxwing	13.9
Zinc	Rat	160	Deer mouse	408
			Mule deer	25.6
			Coyote	48.0
			Muskrat	118
	Mallard	30	Sage grouse	23.4
			Red-tailed hawk	30.9

Key at end of table.

Table 5-5

TOXICITY REFERENCE VALUES FOR WILDLIFE

Chemical	Test Species	Test Species TB[a] (mg/kg/day)	Endpoint Species	Estimated Wildlife TRV[b] (mg/kg/day)
			Horned lark	100
			Mallard	30
			Spotted sandpiper	30.9
			Cedar waxwing	99

[a] See text for derivation of test species TB.
[b] Calculated by multiplying test species TB by a body weight scaling factor (see text and Table 5-4).

Key:

TB = Toxicity benchmark.
TRV = Toxicity reference value.

6 Risk Characterization

In this section, the potential ecological risks posed by COPCs at the EMF Site are identified and discussed. To identify risks, the estimated exposures derived in Section 4 and the TRVs derived in Section 5 are compared and evaluated for each of the COPCs and measurement endpoint species under consideration. The ecological significance of the identified risks is then discussed in terms of the spatial, temporal, and biological scale of potential adverse effects on site ecosystems. Measurement endpoints and assessment endpoints are linked to provide a framework for interpretation of the ecological risks. In addition, the principal uncertainties of the risk assessment are enumerated and possible limitations of the assessment are identified and discussed. Estimates of risk are provided in Section 6.1; the ecological significance of the risks is discussed in Section 6.2; and the uncertainties are reviewed in Section 6.3.

6.1 Risk Estimation

The potential risks of COPCs were estimated by calculating an overall hazard quotient (HQ_{total}) for each COPC and measurement endpoint species. HQ_{total} was calculated from the total exposure (EE_{total}) received through all relevant pathways for each receptor, divided by the TRV for that receptor:

$$HQ_{total} = EE_{total}/TRV$$

where:

HQ_{total} = Hazard quotient, all pathways;
EE_{total} = Estimated exposure, all pathways (see Section 4); and
TRV = Toxicity reference value (see Section 5).

If $HQ_{total} > 1$, a potential risk of adverse chronic effects resulting from exposure was presumed for a given COPC, ecological receptor, and critical effect. If risks of adverse effects arising from total exposure were identified, the risks of exposure through individual pathways were examined to partition and evaluate the potential sources of risk. For example, the percentages of total risk due to exposure through dietary ingestion (EE_{diet}) and exposure through incidental soil ingestion (EE_{soil}) were calculated for terrestrial wildlife with HQs greater than 1.

Potential risks to plants in the sagebrush steppe and riparian habitats are shown in Table 6-1. Fluoride was found to pose a potential risk to sagebrush (based on tissue concentrations in unwashed foliage) at the Michaud Flats and Bannock Hills SW sampling locations. Fluoride also posed a risk to thickspike wheatgrass at Bannock Hills SW. It was not possible to evaluate risks of fluoride to sagebrush (based on tissue concentrations in washed foliage) because of poor data quality (see Sections 3 and 4). Moreover, no phytotoxicity risks of fluoride to Russian olive were identified in the riparian habitat. No phytotoxicity risks of cadmium or zinc were identified for any of the plant measurement endpoint species.

Potential risks to mammals in the sagebrush steppe habitat are shown in Table 6-2. Fluoride was found to pose a potential risk to coyote at the Michaud Flats and Bannock Hills SW sampling locations. No other risks of fluoride were identified for mammals, and no risks of cadmium or zinc were identified for mammals in the sagebrush steppe habitat. The absence of risks of fluoride for the deer mouse are confirmed by comparison of femur fluoride concentrations to the effects threshold of 2,000 mg/kg dry weight (see Appendix I). Concentrations of fluoride in deer mouse femurs at all locations (see Section 4) were lower than 2,000 mg/kg, indicating that accumulation of fluoride to toxic levels in deer mouse tissues is not occurring at the EMF site.

Potential risks to birds in sagebrush steppe and riparian habitats are shown in Table 6-3. Fluoride was found to pose a potential risk to the horned lark, the red-tailed hawk, and the sage grouse at the Michaud Flats and Bannock Hills SW sampling locations. Risks of

fluoride to the cedar waxwing were not evident in the riparian habitat. No risks of cadmium or zinc were identified for birds in the sagebrush steppe or riparian habitats.

Potential risks of cadmium to mammals and birds in the river delta habitat are shown in Table 6-4. No risks of adverse effects were identified for any of the measurement endpoint species in the river delta habitat.

No risks of adverse effects were identified for any of the background locations. The incremental risks due to the site can be calculated by subtracting background HQs from HQ_{total}, for each of the endpoint species found to be at risk from total exposure. HQs calculated in this manner are all greater than 1, indicating that exposure at background levels of COPCs does not account for a meaningful fraction of the total risks.

To summarize, potential risks of adverse effects arising from exposure to fluoride were identified for the following measurement endpoint species in sagebrush steppe habitat: sagebrush, thickspike wheatgrass, coyote, horned lark, red-tailed hawk, and sage grouse. No risk potential arising from exposure to cadmium or zinc was identified for plants or wildlife in any of the habitat types at the EMF Site. No potential risks due to any of the COPCs were identified for measurement endpoint species in the riparian or the river delta habitats.

6.2 Ecological Significance

Based on the findings of the studies conducted for the RI/FS and the ecological investigations, the EMF Site is a potential source of metals and fluoride contamination to soil and terrestrial food chains in the vicinity of the site facilities. The site is also a potential source of environmental contamination affecting sediment and surface water at the site, including the Portneuf River delta sediments at the Fort Hall Bottoms of American Falls Reservoir. The ecological significance of contamination of site ecosystems is discussed in this section.

6.2.1 Ecological Significance of Cadmium, Fluoride, and Zinc Contamination

Potential risks of adverse effects of fluoride were identified for measurement endpoint species representing the following assessment endpoint species and functional groups in the sagebrush steppe habitat: shrubs and grasses, carnivores, raptors, upland game birds, and songbirds. Overall, these species represent a broad cross-section of the plant and animal communities in the site vicinity. However, the estimated risks are only marginally above the

threshold for the measurement endpoint species, and by inference the assessment endpoint communities at risk may be marginally but not severely affected. As the potential risks were quantified for affects on individual organisms using conservative assumptions to account for uncertainty (as discussed below in Section 6.3), and because the upland species most likely to be impacted occur commonly throughout the region, widespread or significant ecological effects at the population and community levels are not expected. However, the threshold risks predicted for fluoride do not leave a margin of safety to accommodate a large range of uncertainty.

The potential risks due to fluoride are a result of exposure through dietary exposure and/or incidental soil ingestion. The relative importance of these exposure pathways varies among receptors (see Section 6.3). In general, fluoride is mobilized in terrestrial food chains through air deposition and absorption across plant leaf surfaces, and subsequent consumption of plants by herbivores. Plant uptake of fluoride from contaminated soil and incidental ingestion of soil by wildlife is likely to contribute to the overall exposure, and in some cases could be a major source of the total risk. The relative importance of existing soil contamination versus ongoing air deposition of fluoride, however, is not known with certainty.

The areal extent of fluoride contamination of sagebrush steppe habitat in the vicinity of the site is not clearly definable, but soil contamination appears to extend beyond the boundaries of the 3-mile radius of the RI/FS study area. In general, the numbers of individuals and species affected will be a function, in part, of the areal extent of contamination. Sagebrush steppe habitat is extensive in the Bannock Hills to the south of the site facilities, whereas adjacent land to the north of the facilities is largely agricultural and disturbed. Therefore, any potential effects of fluoride on the sagebrush steppe ecosystem is likely to have greatest significance in the Bannock Hills.

Potential impacts of fluoride to the sagebrush steppe ecosystem are likely to be related, in part, to ongoing air emissions from the EMF Site facilities. Average concentrations of fluoride, measured in air at monitoring stations located adjacent to the site are greater than 2 times background (see HHRA report). Given the ongoing air emissions, and the cumulative toxicity of fluoride, potential impacts are expected to increase over time with continued air deposition. A reduction in fluoride loadings could allow for long-term recovery of the ecosystem and a consequent reduction in the potential risks.

It is noteworthy that potential site-related risks were not identified for the riparian, riverine, and mudflat habitats associated with the Portneuf River. These are the habitats of greatest ecological and regulatory concern at the site.

6.2.2 Ecological Significance of Other COPCs

The ecological risk assessment focused on three COPCs with the greatest likelihood of potential effects—cadmium, fluoride, and zinc. Based on the findings of the risk analysis for these three COPCs in terrestrial ecosystems, other COPCs in soil (see Section 2) are presumed to be of marginal ecological significance. In addition, it is worth noting that there is no evidence of significant acidification of soils adjacent to the site, either from the pH data or from evaluation of cation exchange capacity and other soil parameters (see Appendix G).

Although 13 COPCs were identified in Portneuf River sediment (see Section 2), toxicity testing of the sediment collected at the IWW ditch outfall indicates that these contaminants are not likely to pose a risk to the benthic community. Moreover, only cadmium was found to be elevated in the Portneuf River delta at the Fort Hall Bottoms. Based on the toxicity testing conducted at the IWW ditch outfall and the results of SEM/AVS analysis, cadmium and other COPCs occur in a chemical form that is largely unavailable and nontoxic to aquatic life. Moreover, as shown in the quantitative risk analysis, wildlife exposure to cadmium through the food chain or through incidental ingestion of sediment is unlikely to pose a risk.

Mercury was identified as a COPC in surface water largely on the basis of poor analytical data quality (see Section 2). Since mercury was not found to be significantly elevated in Portneuf River delta sediments, and deposition of water-borne mercury contamination would be expected to occur in the delta, the site is not considered likely to be a significant source of mercury in surface water. Moreover, naturally occurring mercury has been found in regional sediments associated with gold deposits (see Appendix F), indicating that historical observations of mercury contamination in the American Falls Reservoir can be explained in part by the occurrence of natural geological sources of mercury. Silver is also associated with natural deposits in the area, and elevated levels of silver in Portneuf River surface water are considered likely to result from these sources. In addition, for both silver and mercury, EPA freshwater acute quality criteria were not exceeded. Selenium was also not found to be elevated in Portneuf River delta sediment; therefore, the site is not likely to be a significant source of surface water selenium contamination.

6.2.3 Potential Risks to Species of Concern

Listed and candidate species, unique natural ecosystems, and jurisdictionally designated wetlands that may be present within an approximately 10-mile radius of the EMF Site are described in Section 2.2 and Appendix E. The vulnerability of these species and ecosystems of concern to site COPCs was evaluated, and assessment endpoints were selected to allow a determination of the potential risks of adverse effects on protected and/or rare species and their habitat. Potential risks associated with fluoride to these assessment endpoints were identified as follows:

- Common species of raptors likely to occur at the site, such as the red-tailed hawk, were found to be at risk primarily through dietary exposure. Although there are no federal or state-listed species of raptors known to occur in the sagebrush steppe habitat where risks for the red-tailed hawk were identified, many common migratory raptors are federally protected under the Migratory Bird Treaty Act (MBTA), and all raptors are classified as Protected Nongame Species by the Idaho Department of Fish and Game (IDFG) (Moseley and Groves 1992).

- Songbirds such as the horned lark were found to be at risk from the combined effects of dietary exposure and incidental ingestion of soil. The State Special Concern yellow-billed cuckoo (*Coccyzus americanus*) has a probable nesting occurrence in the area (Stephens 1993) and could be at risk. However, the breeding range of this species falls primarily outside of the state, and it is therefore classified as a Category B - Peripheral Species (Moseley and Groves 1992). Other, more common songbird species are more likely to be affected by exposure to fluoride in the sagebrush steppe habitat of the EMF Site. As with the raptors, many songbirds are federally protected under the MBTA, and are classified as Protected Nongame Species by the IDFG (Moseley and Groves 1992).

- Common species of upland game birds such as the sage grouse were found to be at risk primarily through incidental ingestion of soil. All game species in Idaho are regulated by IDFG (Moseley and Groves 1992).

- Common species of carnivorous mammals likely to occur at the site, such as the coyote, were found to be at risk primarily through dietary exposure. Another carnivore, the wolverine (*Gulo gulo luscus*), is a Federal Candidate species and State Special Concern species. The wolverine is known from a single recent sighting in the Fort Hall Bottoms (Stephens 1993), but based on its limited occurrence in the area, exposure is considered unlikely. Common carnivores likely to occur in the sagebrush steppe habitat of the EMF Site are of

ecological, recreational, and aesthetic significance but have no known protected status.

- Common species of shrubs and grasses such as sagebrush and thickspike wheatgrass were found to be at risk from exposure through root uptake or foliar absorption of fluoride. These dominant species of sagebrush steppe are not themselves protected, but they form the base of the food chain and provide cover and nesting sites for wildlife species that have protected status (e.g., raptors, songbirds, upland gamebirds). The slick-spot peppergrass (*Lipidium papilliterum*) is a Federal Candidate species known from an old (1949) collection (Stephens 1993). Based on its limited occurrence in the site area, significant exposure of this species is considered unlikely.

In general, the species at greatest risk of effects from exposure to fluoride at the EMF Site are common species of sagebrush steppe, which nonetheless may have protected status under various State and Federal statutes. As previously stated, based on risk evaluation of benthic invertebrates, waterfowl, shorebirds, songbires, semi-aquatic mammals, and shrubs, potential site-related risks were not identified for the jurisdictional wetlands or listed species of riparian, riverine, and mudflat habitats associated with the Portneuf River.

6.3 Uncertainties of the Risk Assessment

In this section, the principal uncertainties of the risk assessment are evaluated and interpreted. To the extent possible, an estimate of the magnitude of the uncertainties is also provided.

6.3.1 Uncertainties of the Problem Formulation

1. **COPC Selection.** The uncertainties of COPC selection include the lack of sensitivity of analysis for mercury and silver in surface water and the lack of ecological risk-based screening for many of the site contaminants and media of concern. The detection limits for mercury and silver in surface water were adequate to address acute but not chronic toxicity to aquatic life. However, the method sensitivity for mercury and silver is not expected to be a major issue in addressing risks, for the reasons described above in Section 6.2. The lack of screening criteria is an inherent limitation of ecological risk assessment. In general, contaminants found at levels well above background were evaluated in the risk assessment, even if screening criteria were unavailable (e.g., fluoride in soil).

2. **Endpoint Selection.** The selection of endpoints appropriate for the site is uncertain because it is not feasible to evaluate all of the species and communities potentially at risk. The ecological endpoints selected for evaluation at the EMF Site are felt to represent the broadest possible range of receptors that could be addressed with sufficient certainty to provide a basis for regulatory decisions. Certain potential endpoints were left out of the assessment, however, because of the lack of good toxicological or other relevant information. These include: bats, reptiles, terrestrial invertebrates, and soil microbes. Other potential receptors such as piscivorous birds were left out of the assessment because COPCs (e.g., cadmium in sediment for piscivorous birds) were not expected to accumulate in their food items to a level likely to pose a significant risk.

6.3.2 Uncertainties of the Exposure Assessment

1. **Plant Exposure Estimates.** Potential risks of fluoride to plants were identified on the basis of chemical analysis of unwashed foliage (see Table 6-1). Washed foliage concentrations provide a better estimate of the biologically incorporated (and hence, potentially phytotoxic) fraction of fluoride. Washed sagebrush foliage generally had lower concentrations of cadmium and zinc than unwashed foliage, and 13% to 22% of the cadmium and zinc measured in sagebrush foliage was estimated to be surface contamination (see Section 3). The detection limits for fluoride analyses of washed foliage were elevated, however, and it is not possible to reliably estimate the biologically-incorporated tissue concentrations of fluoride in sagebrush.

2. **Predator Exposure Estimates.** The potential risk of fluoride to the coyote and the red-tailed hawk in the sagebrush steppe habitat is largely a result of dietary exposure, which constitutes >70% of the estimated total exposure for these predators (see Tables 6-2 and 6-3). The diets of the coyote and the red-tailed hawk were assumed to consist entirely of small mammals (see Section 4). Greater than 90% of the fluoride in mouse tissues is incorporated in bone, and bioavailability of fluoride in bone is <50%, as compared with >75% bioavailability of other dietary sources of fluoride (NRC 1993). Therefore, the dietary exposure of the coyote and the red-tailed hawk could be overestimated by a factor of approximately 2. In addition, the soil fluoride incidentally ingested by these receptors is likely to be in a relatively unavailable mineral form (see Appendix G).

3. **Herbivore Exposure Estimates.** The potential risks of fluoride to the horned lark and the sage grouse in the sagebrush steppe habitat are also subject to uncertainty as a result of the simplifying assumptions used to estimate exposure. The sage grouse was assumed to ingest 9% of its dietary intake as soil (see Section 4), a higher percentage than the other receptors. This soil ingestion rate is based

on data for other large upland game birds, since species specific estimates of soil ingestion for the sage grouse are unavailable. However, as stated above for the coyote and the red-tailed hawk, the form of fluoride likely to occur in soil at the EMF Site has a low bioavailability. In addition, the diet of the horned lark consists of seeds and invertebrates; as a conservative assumption, the fluoride concentrations of these food items were set equal to the concentrations of fluoride in stems and leaves of thickspike wheatgrass (see Section 4). Seeds tend to have lower tissue concentrations of fluoride compared with vegetative parts of plants, perhaps by as much as a factor of 10 (Baes *et al.* 1984). Therefore, the dietary exposure of the horned lark and the sage grouse could be substantially overestimated.

4. **Assumption of Site Use Factor (SUF) = 1.** The levels of COPCs measured at Bannock Hills SW and Michaud Flats sampling locations were felt to be representative of the average site-wide levels of these COPCs. However, there is a clear gradient of diminishing concentrations with distance from the site. Wide-ranging receptors such as the coyote and the red-tailed hawk would be expected to have home-ranges only partially overlapping the areas of highest contamination close to the site, and their exposure is likely to be overestimated by setting SUF = 1.

5. **Analytical Uncertainties.** In addition to the problems with fluoride analysis of washed sagebrush foliage noted above, matrix spike recoveries were generally low for fluoride analyses (see Section 3). Matrix spike recoveries and laboratory control sample recoveries for vegetation and deer mouse analyses were as low as 44.8% and 47%, respectively. Given the high frequency of J-qualified fluoride determinations, poor spike recovery, and elevated detection limits, uncertainties due to deficiencies in the analyses could result in underestimation of risks by a factor of approximately 2.

6.3.3 Uncertainties of the Ecological Effects Assessment

1. **Extrapolation of Laboratory-Derived TBs for Wildlife Risks.** Principal uncertainties of the extrapolation methods used to derive TBs benchmarks were identified and discussed in Section 5.

2. **Field Verification of Potential Adverse Effects on Plants and Wildlife.** The toxic effects of fluoride on plants and animals can be determined through a number of diagnostic features. Field effects studies were not undertaken in the RI/FS, however, and risks are predicted based largely on extrapolation methods. The uncertainty of the predicted effects could be reduced, and expectations of marginal effects of fluoride could be verified through further field investigation of terrestrial plant and animal communities in the site vicinity.

3. **Potential Additive Effects and Interactions of Trace Elements.** The combined effects of COPCs on ecological receptors could be either additive, antagonistic, or synergistic. Antagonism is a combined toxic effect that is less than the sum of independent effects. Synergism is a combined toxic effect that is greater than the sum of the independent effects. Alternatively, effects of exposure to multiple contaminants could be simply additive for a given critical effect. In general, the potential additive and interactive effects of COPCs are difficult to quantitatively evaluate because, for a given receptor, the measurement endpoints are not the same for various COPCs. Therefore, these potential effects are a source of uncertainty in the risk estimates. However, there are reports both of antagonistic and synergistic zinc-cadmium interactions in plants (Kabata-Pendias and Pendias 1992), and simultaneous administration of zinc and cadmium has been shown to inhibit tumor development in laboratory rodents (Eisler 1985). Also of potential importance at the site are the possible antagonistic effects of calcium and phosphorus on the toxicity of cadmium, fluoride, and zinc, although synergistic effects of phosphorus uptake on fluoride phytotoxicity have also been observed (Kabata-Pendias and Pendias 1992).

6.3.4 Uncertainties of the Risk Characterization

In general, the risk characterization is more likely to overestimate rather than underestimate the risks of adverse ecological effects at the site, because of the conservative nature of the assumptions used. For COPCs with estimated exposures less than the TRVs, the probability of significant ecological risks is very low. Potential risks due to fluoride for plants, birds, and mammals cannot be eliminated from consideration, although the marginal exceedance of the TRVs does not imply any particular level of risk at the population or the community level.

6.3.4.1 Sensitivity Analysis

Because fluoride was the only COPC to exceed an HQ of 1 in the ecological risk assessment, it is perhaps of interest to provide a quantitative estimate of the sensitivity of the fluoride risk estimates to the uncertainties of the exposure assessment. Adjusted HQs are provided in Table 6-5. The adjusted HQs were derived by first calculating an adjusted EE (EE_{adj}) for the coyote, red-tailed hawk, horned lark, and sage grouse (all species with unadjusted HQ > 1 for fluoride). The adjusted HQ (HQ_{adj}) was then calculated by dividing EE_{adj} by the TRV.

For the coyote and red-tailed hawk, the adjustment entailed dividing the small mammal component of the diet by 2 to account for the bioavailability of fluoride in bone (see Section 6.3.2, No. 2), and multiplying by 2 to account for analytical uncertainties (see Section 6.3.2, No. 5). Since the adjustment factors for bioavailability and analytical uncertainty cancel each other, there is no net change in the HQ for the coyote and red-tailed hawk (see Table 6-5).

The adjustment for the horned lark entailed dividing the forb component of its diet by a factor of 10 to account for the lower tissue concentrations in seeds (see Section 6.3.2, No. 3), and multiplying by 2 to account for analytical uncertainties (see Section 6.3.2, No. 5). The net effect of the adjustments is to lower the horned lark exposure and risks by approximately 20% at Michaud Flats and 32% at Bannock Hills SW (see Table 6-5). However, despite these adjustments, the HQ_{adj} for both locations is still greater than 1, indicating that a potential risk remains for the horned lark.

For the sage grouse, the adjustment entailed multiplying the shrub and forb components of its diet by a factor of 2 to account for analytical uncertainties (see Section 6.3.2, No. 5). The net effect of the adjustment is to increase the sage grouse exposure and risks by approximately 20% at Michaud Flats and 38% at Bannock Hills SW (see Table 6-5).

No other quantitative adjustments were made to account for the uncertainties identified in Section 6.3.2. Although the bioavailability of fluoride in soil is likely to be overestimated, site-specific information on the form of fluoride in soil is needed to make quantitative adjustments in the exposure estimates. Because of its high assumed soil ingestion rate, the sage grouse is the receptor whose risk estimates are most sensitive to changes in bioavailability of soil fluoride. However, even if the soil fluoride bioavailability were to be reduced to the same extent as estimated for the bioavailability of fluoride in bone (i.e., a bioavailability of 50%), HQ_{adj} would still exceed 2 for the sage grouse at both Bannock Hills SW and Michaud Flats locations. Therefore, adjustments for bioavailability of fluoride in soil are not likely to have a meaningful effect on the identification of potential risks.

To summarize, quantitative adjustments of the fluoride exposure estimates for birds and mammals at the EMF Site were made to evaluate the sensitivity of risk estimates to uncertainties of the exposure assessment. These adjustments produce marginal shifts in the risk estimates, either increasing the risk (sage grouse), decreasing the risk (horned lark), or having no net change in the risk (coyote and red-tailed hawk). In general, the conclusions of the risk assessment are not affected by quantitative adjustments of risk.

Table 6-1

HAZARD QUOTIENTS FOR PLANTS IN SAGEBRUSH STEPPE AND RIPARIAN HABITATS

Measurement Endpoint Species	Chemical	Location	EE (mg/kg)	TRV (mg/kg)	HQ
Sagebrush Steppe Habitat					
Sagebrush (washed)	Cadmium	Ferry Butte[a]	0.34	5	0.07
		Michaud Flats	1.24	5	0.25
		Bannock Hills SW	0.86	5	0.17
	Fluoride	Ferry Butte[a]	NA	50	NA
		Michaud Flats	NA	50	NA
		Bannock Hills SW	NA	50	NA
	Zinc	Ferry Butte[a]	28	150	0.19
		Michaud Flats	37.8	150	0.25
		Bannock Hills SW	28	150	0.19
Sagebrush (unwashed)	Cadmium	Ferry Butte[a]	0.35	5	0.07
		Michaud Flats	1.42	5	0.28
		Bannock Hills SW	1.06	5	0.21
	Fluoride	Ferry Butte[a]	12.1	50	0.24
		Michaud Flats	60.8	50	1.22
		Bannock Hills SW	85.7	50	1.71
	Zinc	Ferry Butte[a]	33.9	150	0.23
		Michaud Flats	41.4	150	0.28
		Bannock Hills SW	33.6	150	0.22
Thickspike wheatgrass	Cadmium	Ferry Butte[a]	0.27	5	0.05
		Michaud Flats	0.51	5	0.10
		Bannock Hills SW	0.65	5	0.13
	Fluoride	Ferry Butte[a]	12.2	50	0.24
		Michaud Flats	38.1	50	0.76
		Bannock Hills SW	86.9	50	1.74

Key at end of table.

Table 6-1

HAZARD QUOTIENTS FOR PLANTS IN SAGEBRUSH STEPPE AND RIPARIAN HABITATS

Measurement Endpoint Species	Chemical	Location	EE (mg/kg)	TRV (mg/kg)	HQ
	Zinc	Ferry Butte[a]	9.05	150	0.06
		Michaud Flats	12.5	150	0.08
		Bannock Hills SW	13.4	150	0.09
Riparian Habitat					
Russian olive	Cadmium	Snake River[a]	0.1	5	0.02
		Portneuf River	0.25	5	0.05
	Fluoride	Snake River[a]	11.9	50	0.24
		Portneuf River	12.0	50	0.24
	Zinc	Snake River[a]	8	150	0.05
		Portneuf River	11.3	150	0.08

[a] Background location.

Key:

EE = Estimated exposure.
HQ = Hazard quotient.
TRV = Toxicity reference value.
▒ = HQ > 1, potential risk identified.

Table 6-2

HAZARD QUOTIENTS FOR MAMMALS IN SAGEBRUSH STEPPE HABITAT

Measurement Endpoint Species	Chemical	Location	EE_{total} (mg/kg/d)	TRV (mg/kg/d)	HQ_{total}	Diet %	Soil %
Coyote	Cadmium	Ferry Butte[a]	0.01	0.16	0.06	–	–
		Michaud Flats	0.035	0.16	0.22	–	–
		Bannock Hills SW	0.06	0.16	0.38	–	–
	Fluoride	Ferry Butte[a]	0.625	5.38	0.12	–	–
		Michaud Flats	6.6	5.38	1.23	71.1%	28.9%
		Bannock Hills SW	7.61	5.38	1.41	81.9%	18.1%
	Zinc	Ferry Butte[a]	1.89	48	0.04	–	–
		Michaud Flats	1.89	48	0.04	–	–
		Bannock Hills SW	2.04	48	0.04	–	–
Deer mouse	Cadmium	Ferry Butte[a]	0.051	1.42	0.04	–	–
		Michaud Flats	0.203	1.42	0.14	–	–
		Bannock Hills SW	0.223	1.42	0.16	–	–
	Fluoride	Ferry Butte[a]	3.3	46.3	0.07	–	–
		Michaud Flats	14.5	46.3	0.31	–	–
		Bannock Hills SW	19.7	46.3	0.43	–	–
	Zinc	Ferry Butte[a]	2.6	408	0.01	–	–
		Michaud Flats	3.73	408	0.01	–	–
		Bannock Hills SW	3.9	408	0.01	–	–
Mule deer	Cadmium	Ferry Butte[a]	0.0045	0.09	0.05	–	–
		Michaud Flats	0.022	0.09	0.24	–	–
		Bannock Hills SW	0.02	0.09	0.22	–	–
	Fluoride	Ferry Butte	0.255[a]	2.94	0.09	–	–
		Michaud Flats	1.28	2.94	0.44	–	–
		Bannock Hills SW	1.52	2.94	0.52	–	–
	Zinc	Ferry Butte[a]	0.372	25.6	0.01	–	–
		Michaud Flats	0.488	25.6	0.02	–	–

Key at end of table.

Table 6-2

HAZARD QUOTIENTS FOR MAMMALS IN SAGEBRUSH STEPPE HABITAT

Measurement Endpoint Species	Chemical	Location	EE_{total} (mg/kg/d)	TRV (mg/kg/d)	HQ_{total}	Diet %	Soil %
		Bannock Hills SW	0.441	25.6	0.02	—	—

[a] Background location.

Key:

EE_{total} = Estimated exposure.
HQ_{total} = Hazard quotient.
TRV = Toxicity reference value.
— = Not calculated.
▒▒ = HQ > 1, potential risk identified.

Table 6-3

HAZARD QUOTIENTS FOR BIRDS IN SAGEBRUSH STEPPE AND RIPARIAN HABITATS

Measurement Endpoint Species	Chemical	Location	EE_{total} (mg/kg/d)	TRV (mg/kg/d)	HQ_{total}	Diet %	Soil %
Sagebrush Steppe Habitat							
Horned lark	Cadmium	Ferry Butte[a]	0.069	4.84	0.01	–	–
		Michaud Flats	0.247	4.84	0.05	–	–
		Bannock Hills SW	0.303	4.84	0.06	–	–
	Fluoride	Ferry Butte[a]	4.8	14.9	0.32	–	–
		Michaud Flats	19.9	14.9	1.34	46.3%	53.7%
		Bannock Hills SW	28.7	14.9	1.93	73.2%	26.8%
	Zinc	Ferry Butte[a]	2.47	100	0.02	–	–
		Michaud Flats	3.91	100	0.04	–	–
		Bannock Hills SW	4.61	100	0.05	–	–
Red-tailed hawk	Cadmium	Ferry Butte[a]	0.013	1.49	0.01	–	–
		Michaud Flats	0.045	1.49	0.03	–	–
		Bannock Hills SW	0.078	1.49	0.05	–	–
	Fluoride	Ferry Butte[a]	0.819	4.37	0.19	–	–
		Michaud Flats	8.64	4.37	1.98	71.1%	28.9%
		Bannock Hills SW	9.97	4.37	2.28	81.8%	18.2%
	Zinc	Ferry Butte[a]	2.48	30.9	0.08	–	–
		Michaud Flats	2.47	30.9	0.08	–	–
		Bannock Hills SW	2.67	30.9	0.09	–	–
Sage grouse	Cadmium	Ferry Butte[a]	0.017	1.13	0.02	–	–
		Michaud Flats	0.148	1.13	0.13	–	–
		Bannock Hills SW	0.156	1.13	0.14	–	–
	Fluoride	Ferry Butte[a]	1.9	3.28	0.58	–	–
		Michaud Flats	10.8	3.28	3.29	21.6%	78.4%
		Bannock Hills SW	9.72	3.28	2.96	37.7%	62.3%

Key at end of table.

Table 6-3

HAZARD QUOTIENTS FOR BIRDS IN SAGEBRUSH STEPPE AND RIPARIAN HABITATS

Measurement Endpoint Species	Chemical	Location	EE_{total} (mg/kg/d)	TRV (mg/kg/d)	HQ_{total}	Diet %	Soil %
	Zinc	Ferry Butte[a]	1.39	23.4	0.06	—	—
		Michaud Flats	2.14	23.4	0.09	—	—
		Bannock Hills SW	2.29	23.4	0.10	—	—
Riparian Habitat							
Cedar waxwing	Cadmium	Snake River[a]	0.025	4.79	0.01	—	—
		Portneuf River	0.131	4.79	0.03	—	—
	Fluoride	Snake River[a]	4.08	13.9	0.29	—	—
		Portneuf River	11.69	13.9	0.84	—	—
	Zinc	Snake River[a]	2.02	99	0.02	—	—
		Portneuf River	3.37	99	0.03	—	—

[a] Background location.

Key:

EE_{total} = Estimated exposure.
HQ_{total} = Hazard quotient.
TRV = Toxicity reference value.
— = Not calculated.
▒▒ = HQ > 1, potential risk identified.

Table 6-4

HAZARD QUOTIENTS FOR MAMMALS AND BIRDS IN RIVER DELTA HABITAT - CADMIUM

Measurement Endpoint Species	Location	EE_{total} (mg/kg/d)	TRV (mg/kg/d)	HQ_{total}
Mallard	Snake River[a]	0.094	1.45	0.06
	Portneuf River	0.246	1.45	0.17
Muskrat	Snake River[a]	0.033	0.42	0.08
	Portneuf River	0.075	0.42	0.18
Spotted sandpiper	Snake River[a]	0.029	1.49	0.02
	Portneuf River	0.21	1.49	0.14

[a] Background location.

Key:

EE_{total} = Estimated exposure.
HQ_{total} = Hazard quotient.
TRV = Toxicity reference value.

Table 6-5

ADJUSTED HAZARD QUOTIENTS FOR MAMMALS AND BIRDS IN SAGEBRUSH STEPPE HABITAT - FLUORIDE

Measurement Endpoint Species	Location	EE_{adj} (mg/kg/d)	TRV (mg/kg/d)	HQ_{adj}
Coyote	Michaud Flats	6.6	5.38	1.23
	Bannock Hills SW	7.61	5.38	1.41
Horned Lark	Michaud Flats	15.8	14.9	1.06
	Bannock Hills SW	19.4	14.9	1.30
Red-tailed hawk	Michaud Flats	8.64	4.37	1.98
	Bannock Hills SW	9.97	4.37	2.28
Sage grouse	Michaud Flats	13.1	3.28	3.99
	Bannock Hills SW	13.4	3.28	4.09

Key:

EE_{adj} = Estimated exposure adjusted as described in text.
HQ_{adj} = Hazard quotient, equal to EE_{adj}/TRV.
TRV = Toxicity reference value.

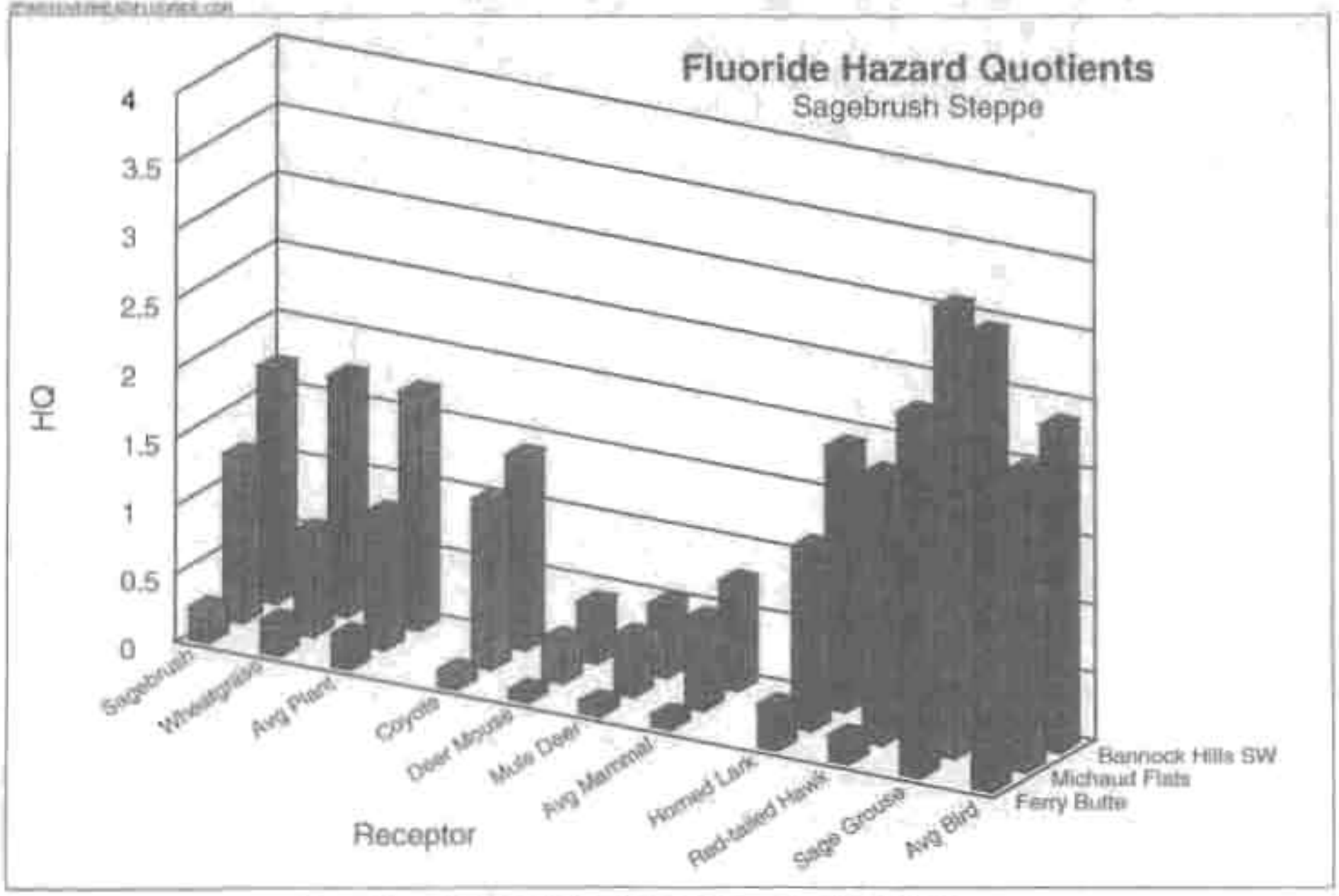

Figure 6-1 FLUORIDE HAZARD QUOTIENTS - SAGEBRUSH STEPPE

7 Conclusions

The ecological risk assessment for the EMF Site identified potential risks of adverse effects of fluoride on resident plant and wildlife species of the sagebrush steppe ecosystem at sampling locations within 1 mile of the facilities. These locations are thought to be representative of a larger area extending approximately 3 miles from the facilities. The fluoride risks are considered to have only a marginal likelihood of resulting in adverse effects on population size or community composition of species in the affected areas because (1) the estimated risks of fluoride are only marginally above the threshold for toxic effects, (2) the potential risks were quantified for effects on individual organisms using conservative assumptions to account for uncertainty, and (3) the upland species most likely to be impacted occur commonly throughout the region. However, because sensitivity analysis indicates that risk estimates exceed a Hazard Quotient of 1 even when adjustments are made to account for possible overestimation of the risk, there is scant margin of safety to allow for the uncertainties of inferring marginal potential impacts on site ecology. Ongoing air deposition of fluoride from facility operations is one potential source of contamination affecting the sagebrush steppe ecosystem.

Based on risk evaluation of benthic invertebrates, waterfowl, shorebirds, songbirds, semi-aquatic mammals, and shrubs, potential site-related risks were not identified for the riparian, riverine, or mudflat habitats associated with the Portneuf River. These are the ecosystems of greatest ecological and regulatory concern in the site vicinity.

Confidence in the results of the risk assessment is considered to be high. Maximal use was made of site-specific exposure data for the risk assessment, thereby reducing a major source of uncertainty. Fluoride exposure estimates for wildlife were based on statistically designed sampling and analysis of representative food items, hence the modeled dose estimates are considered to have a high degree of reliability. Toxicity testing and SEM/AVS analysis of sediments provides adequate information to evaluate potential impacts of

contaminants to the Portneuf River, which were judged to be minimal. In general, with the exception of analytical uncertainties for fluoride, the conservative assumptions used in the risk assessment are more likely to overestimate rather than underestimate the risks of adverse effects of the site.

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A

A Summary of RI/FS Sampling Results

This appendix summarizes chemical and radiological analytical results reported in the Remedial Investigation/Feasibility Study (RI/FS) of the Eastern Michaud Flats Superfund Site in Pocatello, Idaho. The appendix tables provide a statistical summary and screening of the results (through July 1994) that are pertinent to the ecological risk assessment. Appendix B provides the raw data collected for the ecological assessment in investigations conducted in September and October 1994.

The data summarized in this appendix were provided to the United States Environmental Protection Agency (EPA), Region 10, in correspondence received from the J.R. Simplot Company and FMC Corporation prior to January 1995. In addition to the investigation sample results, the database includes quality assurance/quality control (QA/QC) sample results (duplicate, matrix spike, rinsate, and blank samples).

The data has been organized to facilitate interpretation. Separate tables are presented for soil, sediment, and surface water data. In addition, separate tables are presented for various functional groupings of the data, as indicated by table title. For each matrix, the first table presented is the data regarded as the background data set for that matrix (see Section 2.3). The summary information included for each grouping of data includes the name of the chemical or parameter; units of measurement; detection frequency (number of times the chemical was found above the detection limit); the minimum concentration found; the maximum concentration found; and the arithmetic average of the concentrations.

The screening criteria selected for each sample matrix are described in Section 2.3 of the report. For each grouping of the data, a screening table is provided that includes: the name of the chemical or parameter; units of measurement; the value of the criterion used for screening; and the frequency of exceedance (number of times the chemical was found above the criterion).

Specific steps taken in the organization and manipulation of the database were as follows:

- QA/QC data (e.g., matrix spikes, rinsates, and blanks) were removed, with the exception of duplicates;
- For duplicate samples, the average value was taken;
- Values with the qualifier "R," "U6," or "U7" were removed;
- Values with the qualifier "U" were divided by 2;

- Surface water and sediment files were divided into separate files for Portneuf River samples upstream of the site (locations 21 through 25, A1, and A2), downstream river channel samples (locations 1, 3, 8, 10, 12, 16 through 20, 7E, B1, C1, C2, and C4), and downstream spring samples (locations 2, 4, 5, 6, 7, 9, 11, 13, 14, and 15) based on locational information provided in BEI (1994);

- Groundwater background samples were from wells 101, 102, 106, 147, 158, 301, 305, 510 through 514, 516, IDAHO POWER, PEI-1, PEI-6, and TW-105; and

- Radiological data files were combined with nonradiological data files (this step was taken to reduce the number of tables).

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Table A-1

BACKGROUND SOIL SUMMARY
EASTERN MICHAUD FLATS SITE

Chemical	Units	Frequency of Detection	Minimum Detected Concentration	Maximum Detected Concentration	Average Concentration
Aluminum, total	mg/kg	85/85	4,270	15,600	10102.94
Antimony, total	mg/kg	15/80	5.6	20.5	4.660625
Arsenic, total	mg/kg	71/85	1.2	9	4.135824
Barium, total	mg/kg	85/85	73.2	2,240	174.1471
Beryllium, total	mg/kg	65/85	0.14	2	0.534471
Boron, total	mg/kg	82/84	0.78	91.7	5.788452
Cadmium, total	mg/kg	74/85	0.07	25.7	1.092294
Chromium, total	mg/kg	84/84	4.9	166	21.66429
Cobalt, total	mg/kg	65/85	2	11.3	4.61453
Copper, total	mg/kg	85/85	7.2	36	10.72118
Fluoride	mg/kg	85/85	190	3,320	505.4824
Iron, total	mg/kg	85/85	5,790	15,900	11,858.35
Lead, total	mg/kg	85/85	1.3	64.9	13.78588
Lithium, total	mg/kg	85/85	5.9	57.1	13.69412
Magnesium	mg/kg	2/2	10,500	22,000	16,250
Manganese, total	mg/kg	85/85	129	572	352.7294
Mercury, total	mg/kg	55/85	0.05	0.36	0.101588
Molybdenum, total	mg/kg	13/84	1.3	5.3	1.53869
Nickel, total	mg/kg	78/85	2.5	34.4	10.73353
Phosphorus, total	mg/kg	85/85	193	23,600	904.4471
Polonium-210	pCi/g	36/46	1.02	29.8	3.314935
Potassium-40	pCi/g	46/46	9.58	21.2	16.92783
Selenium, total	mg/kg	56/85	0.3	5.3	1.157294
Silver, total	mg/kg	69/85	0.28	3.4	1.074647
Thallium, total	mg/kg	49/83	0.03	0.89	0.125542
Uranium-238	pCi/g	1/46	5.42	5.42	5.00913

Table A-1

BACKGROUND SOIL SUMMARY
EASTERN MICHAUD FLATS SITE

Chemical	Units	Frequency of Detection	Minimum Detected Concentration	Maximum Detected Concentration	Average Concentration
Vanadium, total	mg/kg	83/85	19.3	220	35.17647
Zinc, total	mg/kg	85/85	28.9	296	46.33176

Table A-2

EASTERN MICHAUD FLATS SITE
BACKGROUND SOIL COMPARISON TO SCREENING CRITERIA

Chemical	Units	Lower Phytotoxicity Reference Value[a]	Frequency of Exceedance of Lower Reference Value	Upper Phytotoxicity Reference Value[a]	Frequency of Exceedance of Upper Reference Value
Aluminum, total	mg/kg	NA	NA	NA	NA
Antimony, total	mg/kg	5	15/80	10	10/80
Arsenic, total	mg/kg	15	0/85	50	0/85
Barium, total	mg/kg	NA	NA	NA	NA
Beryllium, total	mg/kg	10	0/85	10	0/85
Boron, total	mg/kg	25	1/84	100	0/84
Cadmium, total	mg/kg	3	4/85	8	2/85
Chromium, total	mg/kg	75	2/84	100	1/84
Cobalt, total	mg/kg	25	0/85	50	0/85
Copper, total	mg/kg	60	0/85	125	0/85
Fluoride	mg/kg	200	84/85	500	19/85
Iron, total	mg/kg	NA	NA	NA	NA
Lead, total	mg/kg	100	0/85	400	0/85
Lithium, total	mg/kg	NA	NA	NA	NA
Manganese, total	mg/kg	1,500	0/85	3,000	0/85
Mercury, total	mg/kg	0.3	4/85	5	0/85
Molybdenum, total	mg/kg	2	6/84	10	0/84
Nickel, total	mg/kg	100	0/85	100	0/85
Phosphorus, total	mg/kg	NA	NA	NA	NA
Polonium-210	mg/kg	NA	NA	NA	NA
Potassium-40	pCi/g	NA	NA	NA	NA
Selenium, total	pCi/g	5	1/85	10	0/85
Silver, total	mg/kg	NA	NA	NA	NA
Thallium, total	mg/kg	1	0/83	1	0/83
Uranium-238	mg/kg	NA	NA	NA	NA
Vanadium, total	pCi/g	50	6/85	150	1/85
Zinc, total	mg/kg	70	4/85	400	0/85

[8] From Kabata-Pendias and Pendias (1992); values are the minimum or maximum of the range of concentrations regarded as phytotoxic by various authors, as shown in Table 5 of the reference.

Key:

NA = Not available.

Table A-3

EASTERN MICHAUD FLATS SITE
OFF-SITE SURFACE SOIL SUMMARY

Chemical	Units	Frequency of Detection	Minimum Detected Concentration	Maximum Detected Concentration	Average Concentration
Aluminum, total	mg/kg	142/143	1150	18900	12520.21
Antimony, total	mg/kg	16/127	3.8	26.6	3.965354
Arsenic, total	mg/kg	128/137	1	18.4	5.388358
Barium, total	mg/kg	143/143	69.8	770	169.0336
Beryllium, total	mg/kg	125/138	0.14	2	0.772536
Boron, total	mg/kg	132/136	1.42	197	10.86493
Cadmium, total	mg/kg	135/139	0.32	189	22.08169
Calcium	mg/kg	36/37	4500	203000	57417.57
Chromium, total	mg/kg	143/143	9.3	608	81.84895
Cobalt, total	mg/kg	115/138	1.8	11.3	4.754493
Copper, total	mg/kg	143/143	8.7	84.4	21.51958
Fluoride	mg/kg	143/143	164	27200	2469.951
Fluoride, soluble	mg/kg	1/1	188	188	188
Iron, total	mg/kg	143/143	6040	20000	13066.29
Lead, total	mg/kg	143/143	0.8	2030	42.54937
Lead-210	pCi/g	76/94	0.441	50.8	6.775894
Lithium, total	mg/kg	143/143	6.1	65.6	13.44545
Magnesium	mg/kg	37/37	3590	15000	6654.054
Manganese, total	mg/kg	143/143	44.9	1330	428.321
Mercury, total	mg/kg	79/115	0.05	1.2	0.148348
Molybdenum, total	mg/kg	32/134	1.3	19.1	2.612687
Nickel, total	mg/kg	134/143	6.7	124	23.19545
Orthophosphate	mg/kg	142/143	0.59	154	14.4386
pH	Std. Units	143/143	5.25	9.87	7.697762
Phosphorus, total	mg/kg	143/143	300	84900	7853.105

Table A-3

EASTERN MICHAUD FLATS SITE
OFF-SITE SURFACE SOIL SUMMARY

Chemical	Units	Frequency of Detection	Minimum Detected Concentration	Maximum Detected Concentration	Average Concentration
Polonium-210	pCi/g	94/94	0.387	50.9	7.761202
Potassium	mg/kg	35/35	2350	4920	3640.857
Potassium-40	pCi/g	94/94	5.96	31.4	16.97106
Selenium, total	mg/kg	87/129	0.29	16.3	1.74876
Silver, total	mg/kg	100/139	0.2	10.8	1.721187
Sulfate	mg/kg	14/35	20	9730	429.8571
Thallium, total	mg/kg	117/137	0.02	3.9	0.480109
Total organic carbon	mg/kg	3/3	6100	8000	7033.333
Uranium-238	pCi/g	81/94	0.0111	26.9	3.974994
Vanadium, total	mg/kg	143/143	10.6	729	101.3832
Zinc, total	mg/kg	143/143	43.7	1540	223.2091

Table A-4

EASTERN MICHAUD FLATS SITE
OFF-SITE SURFACE SOIL COMPARISON TO SCREENING CRITERIA

Chemical	Units	Background[a]	Frequency of Exceedance of Background	Lower Phytotoxicity Reference Value[b]	Frequency of Exceedance of Lower Reference Value	Upper Phytotoxicity Reference Value[b]	Frequency of Exceedance of Upper Reference Value
Aluminum, total	mg/kg	13900	35/143	NA	NA	NA	NA
Antimony, total	mg/kg	2.2	16/127	5	15/127	10	9/127
Arsenic, total	mg/kg	7.7	22/137	15	7/137	50	0/137
Barium, total	mg/kg	188	24/143	NA	NA	NA	NA
Beryllium, total	mg/kg	1	25/138	10	0/138	10	0/138
Boron, total	mg/kg	12.8	28/136	25	13/136	100	1/136
Cadmium, total	mg/kg	1.9	104/139	3	91/139	8	56/139
Chromium, total	mg/kg	27.5	76/143	75	33/143	100	23/143
Cobalt, total	mg/kg	7.6	7/138	25	0/138	50	0/138
Copper, total	mg/kg	12.6	127/143	60	10/143	125	0/143
Fluoride	mg/kg	600	72/143	200	142/143	500	93/143
Iron, total	mg/kg	14400	41/143	NA	NA	NA	NA
Lead, total	mg/kg	29.1	46/143	100	3/143	400	1/143
Lead-210	pCi/g	3.03	52/94	NA	NA	NA	NA
Manganese, total	mg/kg	482	44/143	1500	0/143	3000	0/143
Mercury, total	mg/kg	0.16	19/115	0.3	13/115	5	0/115
Molybdenum, total	mg/kg	2.15	23/134	2	24/134	10	10/134

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Table A-4

EASTERN MICHAUD FLATS SITE
OFF-SITE SURFACE SOIL COMPARISON TO SCREENING CRITERIA

Chemical	Units	Background[a]	Frequency of Exceedance of Background	Lower Phytotoxicity Reference Value[b]	Frequency of Exceedance of Lower Reference Value	Upper Phytotoxicity Reference Value[b]	Frequency of Exceedance of Upper Reference Value
Nickel, total	mg/kg	15.5	55/143	100	4/143	100	4/143
Polonium-210	pCi/g	3.58	60/94	NA	NA	NA	NA
Potassium-40	pCi/g	20.5	17/94	NA	NA	NA	NA
Selenium, total	mg/kg	1.36	38/129	5	11/129	10	4/129
Silver, total	mg/kg	1.9	32/139	NA	NA	NA	NA
Thallium, total	mg/kg	0.27	51/137	1	11/137	1	11/137
Uranium-238	pCi/g	3.88	22/94	NA	NA	NA	NA
Vanadium, total	mg/kg	45.4	49/143	50	47/143	150	24/143
Zinc, total	mg/kg	52.8	139/143	70	108/143	400	21/143

[a] Estimated upper 95th percentile of off-site subsurface soil samples.

[b] From Kabata-Pendias and Pendias (1992); values are minimum or maximum of the range of concentrations regarded as phytotoxic by various authors, as shown in Table 5 of the reference.

Key:

NA = Not available.

Table A-5

EASTERN MICHAUD FLATS SITE
BACKGROUND SEDIMENT SUMMARY

Chemical	Units	Frequency of Detection	Minimum Detected Concentration	Maximum Detected Concentration	Average Concentration
Aluminum, total	mg/kg	7/7	4,450	14,600	8,875.7143
Antimony, total	mg/kg	0/3	ND	ND	5.3167
Aroclor 1016	mg/kg	0/5	ND	ND	0.3250
Aroclor 1221	mg/kg	0/5	ND	ND	0.3250
Aroclor 1232	mg/kg	0/5	ND	ND	0.3250
Aroclor 1242	mg/kg	0/5	ND	ND	0.3250
Aroclor 1248	mg/kg	0/5	ND	ND	0.3250
Aroclor 1254	mg/kg	0/6	ND	ND	0.3250
Aroclor 1260	mg/kg	0/6	ND	ND	0.3250
Arsenic, total	mg/kg	7/7	3.4	5.7	4.2714
Barium, total	mg/kg	7/7	87.3	174	125.1857
Beryllium, total	mg/kg	6/7	0.1	0.81	0.4179
Boron, total	mg/kg	7/7	3	13.2	6.5714
Cadmium, total	mg/kg	0/4	ND	ND	0.3625
Calcium	mg/kg	2/2	36,500	49,100	42,800.0000
Cesium-137	pCi/g	2/2	0.139	0.744	0.4415
Chromium, total	mg/kg	7/7	9.2	19.4	15.1143
Cobalt, total	mg/kg	7/7	3.7	6.4	5.1429
Copper, total	mg/kg	7/7	10.6	14.8	12.0429
Fluoride	mg/kg	7/7	193	1,300	468.8571
Fluoride, soluble	mg/kg	1/1	13	13	13.0000
Gross alpha	pCi/g	7/7	4.12	13.6	8.2900
Gross beta	pCi/g	7/7	10.2	25.3	15.8000
Iron, total	mg/kg	7/7	7,730	14,400	10,081.4286
Lead, total	mg/kg	7/7	12.1	71.9	28.8714

Table A-5

EASTERN MICHAUD FLATS SITE
BACKGROUND SEDIMENT SUMMARY

Chemical	Units	Frequency of Detection	Minimum Detected Concentration	Maximum Detected Concentration	Average Concentration
Lead-210	pCi/g	0/1	ND	ND	1.6700
Lithium, total	mg/kg	7/7	6	15.8	10.6714
Magnesium	mg/kg	2/2	5,020	5,510	5,265.0000
Manganese, total	mg/kg	7/7	216	522	329.7143
Manganese-54	pCi/g	1/1	0.0387	0.0387	0.0387
Mercury, total	mg/kg	3/6	0.09	0.55	0.1408
Molybdenum, total	mg/kg	1/4	2.5	2.5	1.3875
Nickel, total	mg/kg	7/7	4	13.9	8.1714
Orthophosphate (PO4 as P)	mg/kg	7/7	0.6	6.1	2.3000
pH	Std. units	7/7	7.2	8.1	7.7200
Phosphorus, total	mg/kg	7/7	158	531	357.0000
Potassium-40	pCi/g	7/7	8.08	18.4	12.6986
Selenium, total	mg/kg	2/3	0.54	0.72	0.4750
Silver, total	mg/kg	0/3	ND	ND	0.5017
Sodium-22	pCi/g	1/1	0.0519	0.0519	0.0519
Thallium, total	mg/kg	1/5	0.14	0.14	0.0850
Total organic carbon	mg/kg	2/2	7,995	9,729	8862.0000
Uranium-238	pCi/g	1/6	2.03	2.03	1.0082
Vanadium, total	mg/kg	7/7	18.1	32.1	25.6143
Zinc, total	mg/kg	7/7	24.3	55.3	41.9571

Key:

ND = Not detected.

Table A-6

EASTERN MICHAUD FLATS SITE
BACKGROUND SEDIMENT COMPARISON TO SCREENING CRITERIA

Chemical	Units	OME Guidelines—Lowest Effect Level[a]	Frequency of Exceedance of OME Lowest Effect Level	OME Guidelines—Severe Effect Level[a]	Frequency of Exceedance of OME Severe Effect Level
Aluminum, total	mg/kg	NA	NA	NA	NA
Antimony, total	mg/kg	NA	NA	NA	NA
Aroclor 1016	mg/kg	0.007	0/5	NA	NA
Aroclor 1221	mg/kg	NA	NA	NA	NA
Aroclor 1232	mg/kg	NA	NA	NA	NA
Aroclor 1242	mg/kg	NA	NA	NA	NA
Aroclor 1248	mg/kg	0.03	0/5	NA	NA
Aroclor 1254	mg/kg	NA	NA	NA	NA
Aroclor 1260	mg/kg	NA	NA	NA	NA
Arsenic, total	mg/kg	6	0/7	33	0/7
Barium, total	mg/kg	NA	NA	NA	NA
Beryllium, total	mg/kg	NA	NA	NA	NA
Boron, total	mg/kg	NA	NA	NA	NA
Cadmium, total	mg/kg	0.6	0/4	10	0/4

Key at end of table.

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Table A-6

EASTERN MICHAUD FLATS SITE
BACKGROUND SEDIMENT COMPARISON TO SCREENING CRITERIA

Chemical	Units	OME Guidelines—Lowest Effect Level[a]	Frequency of Exceedance of OME Lowest Effect Level	OME Guidelines—Severe Effect Level[a]	Frequency of Exceedance of OME Severe Effect Level
Calcium	mg/kg	NA	NA	NA	NA
Cesium-137	pCi/g	NA	NA	NA	NA
Chromium, total	mg/kg	26	0/7	110	0/7
Cobalt, total	mg/kg	50	0/7	NA	NA
Copper, total	mg/kg	16	0/7	110	0/7
Fluoride	mg/kg	NA	NA	NA	NA
Fluoride, soluble	mg/kg	NA	NA	NA	NA
Gross alpha	pCi/g	NA	NA	NA	NA
Gross beta	pCi/g	NA	NA	NA	NA
Iron, total	mg/kg	20,000	0/7	40,000	0/7
Lead-210	pCi/g	NA	NA	NA	NA
Lead, total	mg/kg	31	2/7	250	0/7
Lithium, total	mg/kg	NA	NA	NA	NA
Magnesium	mg/kg	NA	NA	NA	NA

Key at end of table.

Table A-6

EASTERN MICHAUD FLATS SITE
BACKGROUND SEDIMENT COMPARISON TO SCREENING CRITERIA

Chemical	Units	OME Guidelines—Lowest Effect Level[a]	Frequency of Exceedance of OME Lowest Effect Level	OME Guidelines—Severe Effect Level[a]	Frequency of Exceedance of OME Severe Effect Level
Manganese-54	pCi/g	NA	NA	NA	NA
Manganese, total	mg/kg	460	1/7	1,100	0/7
Mercury, total	mg/kg	0.2	1/6	2	0/6
Molybdenum, total	mg/kg	NA	NA	NA	NA
Nickel, total	mg/kg	16	0/7	75	0/7
Orthophosphate (PO4 as P)	mg/kg	NA	NA	NA	NA
Phosphorus, total	mg/kg	NA	NA	NA	NA
Potassium-40	pCi/g	NA	NA	NA	NA
Selenium, total	mg/kg	NA	NA	NA	NA
Silver, total	mg/kg	0.5	0/3	NA	NA
Sodium-22	pCi/g	NA	NA	NA	NA
Thallium, total	mg/kg	NA	NA	NA	NA
Total organic carbon	mg/kg	NA	NA	NA	NA
Uranium-238	pCi/g	NA	NA	NA	NA

Key at end of table.

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Table A-6

EASTERN MICHAUD FLATS SITE
BACKGROUND SEDIMENT COMPARISON TO SCREENING CRITERIA

Chemical	Units	OME Guidelines—Lowest Effect Level[a]	Frequency of Exceedance of OME Lowest Effect Level	OME Guidelines—Severe Effect Level[a]	Frequency of Exceedance of OME Severe Effect Level
Vanadium, total	mg/kg	NA	NA	NA	NA
Zinc, total	mg/kg	120	0/7	820	0/7

[a] From Persaud *et al.* (1993).

Key:

NA = Not available.
OME = Ontario Ministry of the Environment.

Table A-7

EASTERN MICHAUD FLATS SITE
DOWNSTREAM RIVER CHANNEL SEDIMENT SUMMARY

Chemical	Units	Frequency of Detection	Minimum Detected Concentration	Maximum Detected Concentration	Average Concentration
Aluminum, total	mg/kg	14/14	2,100	16,200	6,264.286
Antimony, total	mg/kg	0/12	ND	ND	13.4208
Aroclor 1016	mg/kg	0/11	ND	ND	0.3250
Aroclor 1221	mg/kg	0/11	ND	ND	0.3250
Aroclor 1232	mg/kg	0/11	ND	ND	0.3250
Aroclor 1242	mg/kg	0/11	ND	ND	0.3250
Aroclor 1248	mg/kg	0/11	ND	ND	0.3250
Aroclor 1254	mg/kg	1/13	0.46	0.46	0.3354
Aroclor 1260	mg/kg	0/13	ND	ND	0.3250
Arsenic, total	mg/kg	13/13	2.4	9.9	4.976923
Barium, total	mg/kg	14/14	68.7	183	117.1286
Beryllium, total	mg/kg	10/11	0.32	1.5	0.6714
Boron, total	mg/kg	13/13	2.5	15.2	6.115385
Cadmium, total	mg/kg	4/8	0.95	22.2	3.3919
Calcium	mg/kg	4/4	69,300	166,000	104,250
Chromium, total	mg/kg	14/14	5.6	80.8	19.50714
Cobalt, total	mg/kg	6/14	3.1	6.4	2.9679
Copper, total	mg/kg	14/14	4.8	85.9	17.07143
Fluoride	mg/kg	14/14	149	3,080	528.1429
Fluoride, soluble	mg/kg	1/1	26	26	26
Iron, total	mg/kg	14/14	4,970	16,100	7,616.429
Lead, total	mg/kg	14/14	6.7	61	19.7
Lithium, total	mg/kg	14/14	3.7	21.8	7.878571
Magnesium	mg/kg	4/4	4,920	8,370	6,182.5
Manganese, total	mg/kg	14/14	97.6	1,210	267.25

Table A-7

EASTERN MICHAUD FLATS SITE
DOWNSTREAM RIVER CHANNEL SEDIMENT SUMMARY

Chemical	Units	Frequency of Detection	Minimum Detected Concentration	Maximum Detected Concentration	Average Concentration
Mercury, total	mg/kg	7/9	0.06	1.1	0.1956
Molybdenum, total	mg/kg	0/14	ND	ND	0.9286
Nickel, total	mg/kg	12/14	2.7	16.1	6.6071
Orthophosphate (PO4 as P)	mg/kg	12/14	0.4	10.7	2.3929
pH	Std. Units	14/14	6.9	8	7.618571
Phosphorus, total	mg/kg	14/14	204	7,150	1,455.143
Selenium, total	mg/kg	5/5	1.2	5.2	3
Silver, total	mg/kg	9/13	0.44	4	1.4946
Thallium, total	mg/kg	9/9	0.14	0.73	0.307778
Total organic carbon	mg/kg	4/4	4,495	11,074	8501
Vanadium, total	mg/kg	14/14	10.5	87.8	25.48571
Zinc, total	mg/kg	14/14	20	251	55.22143
Cesium-137	pCi/g	6/7	0.046	0.144	0.0804
Europium-155	pCi/g	1/1	0.212	0.212	0.212
Gross alpha	pCi/g	12/14	6.03	29.2	9.2843
Gross beta	pCi/g	14/14	4.64	30	14.04857
Lead-210	pCi/g	2/2	1.9	2.81	2.355
Potassium-40	pCi/g	14/14	2.64	14.1	10
Uranium-238	pCi/g	2/9	0.829	1.33	0.7343

Key:

ND = Not detected.

Table A-8

EASTERN MICHAUD FLATS SITE
DOWNSTREAM RIVER CHANNEL SEDIMENT COMPARISON TO SCREENING CRITERIA

Chemical	Units	Background[a]	Frequency of Exceedance of Background	OME Guidelines - Lowest Effect Level[b]	Frequency of Exceedance of OME Lowest Effect Level	OME Guidelines - Severe Effect Level[b]	Frequency of Exceedance of OME Severe Effect Level
Aluminum, total	mg/kg	14,600	1/14	NA	NA	NA	NA
Antimony, total	mg/kg	ND	0/12	NA	NA	NA	NA
Aroclor 1016	mg/kg	ND	0/11	0.007	0/11	NA	NA
Aroclor 1221	mg/kg	ND	0/11	NA	NA	NA	NA
Aroclor 1232	mg/kg	ND	0/11	NA	NA	NA	NA
Aroclor 1242	mg/kg	ND	0/11	NA	NA	NA	NA
Aroclor 1248	mg/kg	ND	0/11	0.03	0/11	NA	NA
Aroclor 1254	mg/kg	ND	1/13	NA	NA	NA	NA
Aroclor 1260	mg/kg	ND	0/13	NA	NA	NA	NA
Arsenic, total	mg/kg	5.7	5/13	6	5/13	33	0/13
Barium, total	mg/kg	174	1/14	NA	NA	NA	NA
Beryllium, total	mg/kg	0.81	3/11	NA	NA	NA	NA
Boron, total	mg/kg	13.2	1/13	NA	NA	NA	NA
Cadmium, total	mg/kg	ND	4/8	0.6	4/8	10	1/8

Key at end of table.

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Table A-8

EASTERN MICHAUD FLATS SITE
DOWNSTREAM RIVER CHANNEL SEDIMENT COMPARISON TO SCREENING CRITERIA

Chemical	Units	Background[a]	Frequency of Exceedance of Background	OME Guidelines - Lowest Effect Level[b]	Frequency of Exceedance of OME Lowest Effect Level	OME Guidelines - Severe Effect Level[b]	Frequency of Exceedance of OME Severe Effect Level
Calcium	mg/kg	49,100	4/4	NA	NA	NA	NA
Chromium, total	mg/kg	19.4	4/14	26	1/14	110	0/14
Cobalt, total	mg/kg	6.4	0/14	50	0/14	NA	NA
Copper, total	mg/kg	14.8	3/14	16	3/14	110	0/14
Fluoride	mg/kg	1,300	1/14	NA	NA	NA	NA
Fluoride, soluble	mg/kg	13	1/1	NA	NA	NA	NA
Iron, total	mg/kg	14,400	1/14	20,000	0/14	40,000	0/14
Lead, total	mg/kg	71.9	0/14	31	2/14	250	0/14
Lithium, total	mg/kg	15.8	1/14	NA	NA	NA	NA
Magnesium	mg/kg	5,510	3/4	NA	NA	NA	NA
Manganese, total	mg/kg	522	1/14	460	1/14	1,100	1/14
Mercury, total	mg/kg	0.55	1/9	0.2	1/9	2	0/9
Molybdenum, total	mg/kg	2.5	0/14	NA	NA	NA	NA
Nickel, total	mg/kg	13.9	1/14	16	1/14	75	0/14

Key at end of table.

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Table A-8

EASTERN MICHAUD FLATS SITE
DOWNSTREAM RIVER CHANNEL SEDIMENT COMPARISON TO SCREENING CRITERIA

Chemical	Units	Background[a]	Frequency of Exceedance of Background	OME Guidelines - Lowest Effect Level[b]	Frequency of Exceedance of OME Lowest Effect Level	OME Guidelines - Severe Effect Level[b]	Frequency of Exceedance of OME Severe Effect Level
Orthophosphate (PO4 as P)	mg/kg	6.1	1/14	NA	NA	NA	NA
Phosphorus, total	mg/kg	531	9/14	NA	NA	NA	NA
Selenium, total	mg/kg	0.72	5/5	NA	NA	NA	NA
Silver, total	mg/kg	ND	9/13	0.5	8/13	NA	NA
Thallium, total	mg/kg	0.14	8/9	NA	NA	NA	NA
Vanadium, total	mg/kg	32.1	2/14	NA	NA	NA	NA
Zinc, total	mg/kg	55.3	3/14	120	1/14	820	0/14
Cesium-137	pCi/g	0.744	0/7	NA	NA	NA	NA
Europium-155	pCi/g	NA	NA	NA	NA	NA	NA
Gross alpha	pCi/g	13.6	1/14	NA	NA	NA	NA
Gross beta	pCi/g	25.3	1/14	NA	NA	NA	NA
Lead-210	pCi/g	ND	2/2	NA	NA	NA	NA
Potassium-40	pCi/g	18.4	0/14	NA	NA	NA	NA
Uranium-238	pCi/g	2.03	0/9	NA	NA	NA	NA

Key at end of table.

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Table A-8 (Cont.)

[a] Maximum of upstream sediment samples.
[b] From Persaud *et al.* 1993.

Key:

NA = Not Available.
ND = Not detected.
OME = Ontario Ministry of the Environment.

Table A-9

EASTERN MICHAUD FLATS SITE
SPRINGS SEDIMENT SUMMARY

Chemical	Units	Frequency of Detection	Minimum Detected Concentration	Maximum Detected Concentration	Average Concentration
Aluminum, total	mg/kg	9/9	2,530	8,600	4,994.45
Antimony, total	mg/kg	0/8	ND	ND	22.35
Aroclor 1016	mg/kg	0/9	ND	ND	0.325
Aroclor 1221	mg/kg	0/9	ND	ND	0.325
Aroclor 1232	mg/kg	0/9	ND	ND	0.325
Aroclor 1242	mg/kg	0/9	ND	ND	0.325
Aroclor 1248	mg/kg	0/9	ND	ND	0.325
Aroclor 1254	mg/kg	0/9	ND	ND	0.325
Aroclor 1260	mg/kg	0/9	ND	ND	0.325
Arsenic, total	mg/kg	8/9	1.5	13.8	5.82
Barium, total	mg/kg	9/9	52.1	324	110.23
Beryllium, total	mg/kg	7/7	0.35	2.2	1.00
Boron, total	mg/kg	8/8	3.4	5.9	4.54
Cadmium, total	mg/kg	3/3	0.35	1.5	0.74
Cesium-137	pCi/g	4/4	0.08	0.38	0.23
Chromium, total	mg/kg	9/9	9	54	18.43
Cobalt, total	mg/kg	1/8	2.1	2.1	1.41
Cobalt-57	pCi/g	1/1	0.04	0.04	0.04
Copper, total	mg/kg	9/9	5.3	13	8.49
Europium-155	pCi/g	2/2	0.31	0.49	0.40
Fluoride	mg/kg	9/9	75.3	800	251.81
Gross alpha	pCi/g	9/9	10	19.8	14.37
Gross beta	pCi/g	9/9	14.7	19.7	17.74
Iron, total	mg/kg	9/9	5,530	10,400	7,726
Lead, total	mg/kg	8/9	5.9	50.5	16.74

Table A-9

EASTERN MICHAUD FLATS SITE
SPRINGS SEDIMENT SUMMARY

Chemical	Units	Frequency of Detection	Minimum Detected Concentration	Maximum Detected Concentration	Average Concentration
Lead-210	pCi/g	4/4	2.73	4.05	3.21
Lithium, total	mg/kg	9/9	3.9	9.9	6.22
Manganese, total	mg/kg	9/9	22.7	405	136.09
Mercury, total	mg/kg	2/3	0.11	0.16	0.11
Molybdenum, total	mg/kg	0/9	ND	ND	0.95
Nickel, total	mg/kg	7/9	2.5	7.6	4.82
Orthophosphate (P04 as P)	mg/kg	6/9	0.5	4.9	1.55
pH	Std. Units	9/9	7.2	8.5	7.77
Phosphorus, total	mg/kg	9/9	64.5	3,950	846.50
Potassium-40	pCi/g	9/9	9.3	15.1	12.14
Ruthenium-106	pCi/g	1/1	0.306	0.306	0.306
Selenium, total	mg/kg	3/4	2.1	3.5	2.10
Silver, total	mg/kg	7/8	0.17	2.1	0.71
Thallium, total	mg/kg	3/4	0.14	0.3	0.16
Uranium-238	pCi/g	5/8	1.25	3.12	1.55
Vanadium, total	mg/kg	9/9	17.4	192	41.77
Zinc, total	mg/kg	9/9	15.4	107	37.82

Key:

ND = Not detected.

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Table A-10

EASTERN MICHAUD FLATS SITE
SPRINGS SEDIMENT COMPARISON TO SCREENING CRITERIA

Chemical	Units	Background[a]	Frequency of Exceedance of Background	OME Guidelines—Lowest Effect Level[b]	Frequency of Exceedance of OME Lowest Effect Level	OME Guidelines—Severe Effect Level[b]	Frequency of Exceedance of OME Severe Effect Level
Aluminum, total	mg/kg	14,600	0/9	NA	NA	NA	NA
Antimony, total	mg/kg	ND	0/8	NA	NA	NA	NA
Aroclor 1016	mg/kg	ND	0/9	0.007	0/9	NA	NA
Aroclor 1221	mg/kg	ND	0/9	NA	NA	NA	NA
Aroclor 1232	mg/kg	ND	0/9	NA	NA	NA	NA
Aroclor 1242	mg/kg	ND	0/9	NA	NA	NA	NA
Aroclor 1248	mg/kg	ND	0/9	0.03	0/9	NA	NA
Aroclor 1254	mg/kg	ND	0/9	NA	NA	NA	NA
Aroclor 1260	mg/kg	ND	0/9	NA	NA	NA	NA
Arsenic, total	mg/kg	5.7	4/9	6	4/9	33	0/9
Barium, total	mg/kg	174	1/9	NA	NA	NA	NA
Beryllium, total	mg/kg	0.81	3/7	NA	NA	NA	NA
Boron, total	mg/kg	13.2	0/8	NA	NA	NA	NA
Cadmium, total	mg/kg	ND	3/3	0.6	1/3	10	0/3
Cesium-137	pCi/g	0.744	0/4	NA	NA	NA	NA
Chromium, total	mg/kg	19.4	2/9	26	1/9	110	0/9

Key at end of table.

ecology and environment

Table A-10

EASTERN MICHAUD FLATS SITE
SPRINGS SEDIMENT COMPARISON TO SCREENING CRITERIA

Chemical	Units	Background[a]	Frequency of Exceedance of Background	OME Guidelines—Lowest Effect Level[b]	Frequency of Exceedance of OME Lowest Effect Level	OME Guidelines—Severe Effect Level[b]	Frequency of Exceedance of OME Severe Effect Level
Cobalt-57	pCi/g	NA	NA	NA	NA	NA	NA
Cobalt, total	mg/kg	6.4	0/8	50	0/8	NA	NA
Copper, total	mg/kg	14.8	0/9	16	0/9	110	0/9
Europium-155	pCi/g	NA	NA	NA	NA	NA	NA
Fluoride	mg/kg	1,300	0/9	NA	NA	NA	NA
Gross alpha	pCi/g	13.6	5/9	NA	NA	NA	NA
Gross beta	pCi/g	25.3	0/9	NA	NA	NA	NA
Iron, total	mg/kg	14,400	0/9	20,000	0/9	40,000	0/9
Lead-210	pCi/g	ND	4/4	NA	NA	NA	NA
Lead, total	mg/kg	71.9	0/9	31	1/9	250	0/9
Lithium, total	mg/kg	15.8	0/9	NA	NA	NA	NA
Manganese, total	mg/kg	522	0/9	460	0/9	1,100	0/9
Mercury, total	mg/kg	0.55	0/3	0.2	0/3	2	0/3
Molybdenum, total	mg/kg	2.5	0/9	NA	NA	NA	NA
Nickel, total	mg/kg	13.9	0/9	16	0/9	75	0/9

Key at end of table.

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Table A-10

EASTERN MICHAUD FLATS SITE
SPRINGS SEDIMENT COMPARISON TO SCREENING CRITERIA

Chemical	Units	Background[a]	Frequency of Exceedance of Background	OME Guidelines—Lowest Effect Level[b]	Frequency of Exceedance of OME Lowest Effect Level	OME Guidelines—Severe Effect Level[b]	Frequency of Exceedance of OME Severe Effect Level
Orthophosphate (PO4 as P)	mg/kg	6.1	0/9	NA	NA	NA	NA
Phosphorus, total	mg/kg	531	4/9	NA	NA	NA	NA
Potassium-40	pCi/g	18.4	0/9	NA	NA	NA	NA
Selenium, total	mg/kg	0.72	3/4	NA	NA	NA	NA
Silver, total	mg/kg	ND	7/8	0.5	4/8	NA	NA
Thallium, total	mg/kg	0.14	1/4	NA	NA	NA	NA
Uranium-238	pCi/g	2.03	4/8	NA	NA	NA	NA
Vanadium, total	mg/kg	32.1	1/9	NA	NA	NA	NA
Zinc, total	mg/kg	55.3	1/9	120	0/9	820	0/9

[a] Maximum of upstream sediment samples.
[b] From Persaud *et al.* 1993.

Key:

NA = Not Available.
ND = Not Detected.
OME = Ontario Ministry of the Environment.

Key at end of table.

ecology and environment

Table A-11

EASTERN MICHAUD FLATS SITE
BACKGROUND SURFACE WATER SUMMARY

Chemical	Units	Frequency of Detection	Minimum Detected Concentration	Maximum Detected Concentration	Average Concentration
Alkalinity, bicarbonate	mg/L	19/19	194	309	246.5263
Alkalinity, carbonate	mg/L	8/17	2	12	4.382353
Aluminum, dissolved	mg/L	2/18	0.0225	0.0848	0.035711
Aluminum, total	mg/L	15/18	0.0487	1.54787	0.485928
Ammonia (NH3as N)	mg/L	1/19	0.3	0.3	0.15
Antimony, dissolved	mg/L	0/19	ND	ND	0.067105
Antimony, total	mg/L	0/19	ND	ND	0.070526
Arsenic, dissolved	mg/L	11/12	0.00135	0.0047	0.003178
Arsenic, total	mg/L	12/17	0.00126	0.008	0.003639
Barium, dissolved	mg/L	14/19	0.0692	0.1067	0.07158
Barium, total	mg/L	14/19	0.08606	0.1281	0.079314
Beryllium, dissolved	mg/L	0/19	ND	ND	0.0005
Beryllium, total	mg/L	1/19	0.0019	0.0019	0.000574
Boron, dissolved	mg/L	17/17	0.0611	0.921	0.194967
Boron, total	mg/L	8/10	0.1129	0.535	0.19886
Cadmium, dissolved	mg/L	0/19	ND	ND	0.000382
Cadmium, total	mg/L	0/19	ND	ND	0.000405
Calcium	mg/L	18/19	29.8	83.9	58.6856
Calcium, dissolved	mg/L	14/14	58.29914	84.2	69.3298
Chloride	mg/L	19/19	33	59.3	46.34211
Chromium, dissolved	mg/L	7/19	0.0001	0.00136	0.000482
Chromium, total	mg/L	7/19	0.0002	0.00132	0.000508
Cobalt, dissolved	mg/L	0/19	ND	ND	0.002947
Cobalt, total	mg/L	1/19	0.0066	0.0066	0.002793
Copper, dissolved	mg/L	3/18	0.003	0.003	0.002028
Copper, total	mg/L	3/18	0.003	0.01099	0.002588

Key at end of table.

Table A-11

EASTERN MICHAUD FLATS SITE
BACKGROUND SURFACE WATER SUMMARY

Chemical	Units	Frequency of Detection	Minimum Detected Concentration	Maximum Detected Concentration	Average Concentration
Dissolved oxygen	mg/L	19/19	6.3	17	10.94211
Fluoride	mg/L	19/19	0.2	0.382	0.293368
Iron, dissolved	mg/L	5/17	0.0217	0.08699	0.0299
Iron, total	mg/L	15/17	0.0497	1.6129	0.47251
Lead, dissolved	mg/L	1/19	0.0016	0.0016	0.000689
Lead, total	mg/L	7/13	0.00108	0.0024	0.001132
Lithium, dissolved	mg/L	16/16	0.01849	0.07099	0.051582
Lithium, total	mg/L	14/15	0.0463	0.07	0.052691
Magnesium	mg/L	19/19	22.5	40.7	31.1402
Magnesium, dissolved	mg/L	14/14	23.41813	39.8	32.86216
Manganese, dissolved	mg/L	3/14	0.0022	0.0317	0.003964
Manganese, total	mg/L	14/19	0.0045	0.0617	0.020471
Mercury, dissolved	mg/L	4/10	0.0002	0.0002	0.000115
Mercury, total	mg/L	6/13	0.0001	0.0002	0.000104
Molybdenum, dissolved	mg/L	0/19	ND	ND	0.007263
Molybdenum, total	mg/L	1/19	0.0166	0.0166	0.008321
Nickel, dissolved	mg/L	0/19	ND	ND	0.006763
Nickel, total	mg/L	1/18	0.01414	0.01414	0.008591
Nitrate (NO3 as N)	mg/L	14/19	0.15	1.17	0.455526
Orthophosphate (PO4 as P)	mg/L	10/19	0.02	0.09	0.022947
pH	Std. Units	19/19	8.03	8.74	8.452105
Phosphorus, total	mg/L	10/15	0.02	0.271	0.070667
Potassium	mg/L	19/19	5.18813	12	9.030071
Potassium, dissolved	mg/L	14/14	4.88782	11	8.426897
Selenium, dissolved	mg/L	0/14	ND	ND	0.000679

Key at end of table.

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Table A-11

EASTERN MICHAUD FLATS SITE
BACKGROUND SURFACE WATER SUMMARY

Chemical	Units	Frequency of Detection	Minimum Detected Concentration	Maximum Detected Concentration	Average Concentration
Selenium, total	mg/L	4/15	0.0015	0.0024	0.000935
Silver, dissolved	mg/L	0/15	ND	ND	0.0015
Silver, total	mg/L	0/15	ND	ND	0.0015
Sodium	mg/L	19/19	25.35322	56.3	41.51941
Sodium, dissolved	mg/L	14/14	25.54457	48.6	38.91661
Specific conductance	umhos/cm	19/19	522	1290	782.6842
Sulfate	mg/L	19/19	33.4	70.12	42.42368
Thallium, dissolved	mg/L	0/19	ND	ND	0.001039
Thallium, total	mg/L	0/19	ND	ND	0.001039
Total dissolved solids	mg/L	14/14	250	470	369.2857
Total Hardness	mg/L	3/3	308	325	318
Total suspended solids	mg/L	8/9	6	52	16
Vanadium, dissolved	mg/L	0/19	ND	ND	0.017974
Vanadium, total	mg/L	10/19	0.0031	0.04	0.007563
Zinc, dissolved	mg/L	7/13	0.0183	0.06	0.025937
Zinc, total	mg/L	7/12	0.0354	0.062	0.02854
Gross alpha	pCi/L	13/19	1.3	6.55	2.134211
Gross beta	pCi/L	18/19	5.15	13.8	7.956842
Radium-226	pCi/L	15/19	0.09	2.91	0.537368
Radium-228	pCi/L	15/19	0.5	7.5	1.5
Uranium-233/234	pCi/L	3/3	1.26	1.4	1.35
Uranium-235	pCi/L	2/3	0.055	0.0913	0.0536
Uranium-238	pCi/L	3/3	0.601	0.802	0.682

Key:

ND = Not detected.

Table A-12

EASTERN MICHAUD FLATS SITE
BACKGROUND SURFACE WATER COMPARISON TO SCREENING CRITERIA

Chemical	Units	EPA Freshwater Chronic Criteria[a]	Frequency of Exceedance of EPA Chronic Criteria	EPA Freshwater Acute Criteria[a]	Frequency of Exceedance of EPA Acute Criteria	Derived Freshwater Chronic Criteria[b]	Frequency of Exceedance of Derived Criteria
Alkalinity, bicarbonate	mg/L	NA	NA	NA	NA	NA	NA
Alkalinity, carbonate	mg/L	NA	NA	NA	NA	NA	NA
Aluminum, dissolved	mg/L	NA	NA	NA	NA	NA	NA
Aluminum, total	mg/L	0.087	13/18	0.75	5/18	NA	NA
Ammonia (NH3 as N)	mg/L	NA	NA	NA	NA	NA	NA
Antimony, dissolved	mg/L	NA	NA	NA	NA	NA	NA
Antimony, total	mg/L	0.03	0/19	0.088	0/19	NA	NA
Arsenic, dissolved	mg/L	0.18	0/12	0.34	0/12	NA	NA
Arsenic, total	mg/L	0.19	0/17	0.36	0/17	NA	NA
Barium, dissolved	mg/L	NA	NA	NA	NA	NA	NA
Barium, total	mg/L	NA	NA	NA	NA	1.62	0/19
Beryllium, dissolved	mg/L	NA	NA	NA	NA	NA	NA
Beryllium, total	mg/L	0.0053	0/19	0.13	0/19	NA	NA
Boron, dissolved	mg/L	NA	NA	NA	NA	NA	NA

Key at end of table.

Table A-12

EASTERN MICHAUD FLATS SITE
BACKGROUND SURFACE WATER COMPARISON TO SCREENING CRITERIA

Chemical	Units	EPA Freshwater Chronic Criteria[a]	Frequency of Exceedance of EPA Chronic Criteria	EPA Freshwater Acute Criteria[a]	Frequency of Exceedance of EPA Acute Criteria	Derived Freshwater Chronic Criteria[b]	Frequency of Exceedance of Derived Criteria
Boron, total	mg/L	NA	NA	NA	NA	1	0/10
Cadmium, dissolved	mg/L	0.00239	0/19	0.01229	0/19	NA	NA
Cadmium, total	mg/L	0.00281	0/19	0.01446	0/19	NA	NA
Calcium	mg/L	NA	NA	NA	NA	NA	NA
Calcium, dissolved	mg/L	NA	NA	NA	NA	NA	NA
Chloride	mg/L	230	0/19	860	0/19	NA	NA
Chromium, dissolved	mg/L	0.0105	0/19	0.01	0/19	NA	NA
Chromium, total	mg/L	0.011	0/19	0.016	0/19	NA	NA
Cobalt, dissolved	mg/L	NA	NA	NA	NA	NA	NA
Cobalt, total	mg/L	NA	NA	NA	NA	0.05	0/19
Copper, dissolved	mg/L	0.02701	0/18	0.04481	0/18	NA	NA
Copper, total	mg/L	0.03178	0/18	0.05272	0/18	NA	NA
Fluoride	mg/L	NA	NA	NA	NA	2.63	0/19
Gross alpha	pCi/L	NA	NA	NA	NA	NA	NA

Key at end of table.

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Table A-12

EASTERN MICHAUD FLATS SITE
BACKGROUND SURFACE WATER COMPARISON TO SCREENING CRITERIA

Chemical	Units	EPA Freshwater Chronic Criteria[a]	Frequency of Exceedance of EPA Chronic Criteria	EPA Freshwater Acute Criteria[a]	Frequency of Exceedance of EPA Acute Criteria	Derived Freshwater Chronic Criteria[b]	Frequency of Exceedance of Derived Criteria
Gross beta	pCi/L	NA	NA	NA	NA	NA	NA
Iron, dissolved	mg/L	NA	NA	NA	NA	NA	NA
Iron, total	mg/L	1	4/17	NA	NA	NA	NA
Lead, dissolved	mg/L	0.00347	0/19	0.17803	0/19	NA	NA
Lead, total	mg/L	0.01388	0/13	0.35606	0/13	NA	NA
Lithium, dissolved	mg/L	NA	NA	NA	NA	NA	NA
Lithium, total	mg/L	NA	NA	NA	NA	NA	NA
Magnesium	mg/L	NA	NA	NA	NA	NA	NA
Magnesium, dissolved	mg/L	NA	NA	NA	NA	NA	NA
Manganese, dissolved	mg/L	NA	NA	NA	NA	NA	NA
Manganese, total	mg/L	NA	NA	NA	NA	75	0/19
Mercury, dissolved	mg/L	NA	NA	0.0008	0/10	NA	NA
Mercury, total	mg/L	0.00002	6/13	0.0024	0/13	NA	NA

Key at end of table.

ecology and environment

Table A-12

EASTERN MICHAUD FLATS SITE
BACKGROUND SURFACE WATER COMPARISON TO SCREENING CRITERIA

Chemical	Units	EPA Freshwater Chronic Criteria[a]	Frequency of Exceedance of EPA Chronic Criteria	EPA Freshwater Acute Criteria[a]	Frequency of Exceedance of EPA Acute Criteria	Derived Freshwater Chronic Criteria[b]	Frequency of Exceedance of Derived Criteria
Molybdenum, dissolved	mg/L	NA	NA	NA	NA	NA	NA
Molybdenum, total	mg/L	NA	NA	NA	NA	0.043	0/19
Nickel, dissolved	mg/L	0.35662	0/19	3.20792	0/19	NA	NA
Nickel, total	mg/L	0.41956	0/18	3.77402	0/18	NA	NA
Nitrate (NO3 as N)	mg/L	NA	NA	NA	NA	NA	NA
Orthophosphate (PO4 as P)	mg/L	NA	NA	NA	NA	NA	NA
Phosphorus, total	mg/L	NA	NA	NA	NA	NA	NA
Potassium	mg/L	NA	NA	NA	NA	NA	NA
Potassium, dissolved	mg/L	NA	NA	NA	NA	NA	NA
Radium-226	pCi/L	NA	NA	NA	NA	6.2	0/19
Radium-228	pCi/L	NA	NA	NA	NA	NA	NA
Selenium, dissolved	mg/L	NA	NA	NA	NA	0.002	0/14
Selenium, total	mg/L	0.005	0/15	0.02	0/15	NA	NA

Key at end of table.

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ecology and environment

Table A-12

EASTERN MICHAUD FLATS SITE
BACKGROUND SURFACE WATER COMPARISON TO SCREENING CRITERIA

Chemical	Units	EPA Freshwater Chronic Criteria[a]	Frequency of Exceedance of EPA Chronic Criteria	EPA Freshwater Acute Criteria[a]	Frequency of Exceedance of EPA Acute Criteria	Derived Freshwater Chronic Criteria[b]	Frequency of Exceedance of Derived Criteria
Silver, dissolved	mg/L	NA	NA	0.02523	0/15	NA	NA
Silver, total	mg/L	0.00012	0/15	0.02969	0/15	NA	NA
Sodium	mg/L	NA	NA	NA	NA	78	0/19
Sodium, dissolved	mg/L	NA	NA	NA	NA	NA	NA
Sulfate	mg/L	NA	NA	NA	NA	NA	NA
Thallium, dissolved	mg/L	NA	NA	NA	NA	NA	NA
Thallium, total	mg/L	0.04	0/19	1.4	0/19	NA	NA
Total dissolved solids	mg/L	NA	NA	NA	NA	NA	NA
Total Hardness	mg/L	NA	NA	NA	NA	NA	NA
Total suspended solids	mg/L	NA	NA	NA	NA	NA	NA
Uranium-233/234	pCi/L	NA	NA	NA	NA	NA	NA
Uranium-235	pCi/L	NA	NA	NA	NA	100	0/3
Uranium-238	pCi/L	NA	NA	NA	NA	192	0/3
Vanadium, dissolved	mg/L	NA	NA	NA	NA	NA	NA

Key at end of table.

Table A-12

EASTERN MICHAUD FLATS SITE
BACKGROUND SURFACE WATER COMPARISON TO SCREENING CRITERIA

Chemical	Units	EPA Freshwater Chronic Criteria[a]	Frequency of Exceedance of EPA Chronic Criteria	EPA Freshwater Acute Criteria[a]	Frequency of Exceedance of EPA Acute Criteria	Derived Freshwater Chronic Criteria[b]	Frequency of Exceedance of Derived Criteria
Vanadium, total	mg/L	NA	NA	NA	NA	0.033	1/19
Zinc, dissolved	mg/L	0.2401	0/13	0.26509	0/13	NA	NA
Zinc, total	mg/L	0.28247	0/12	0.31187	0/12	NA	NA

[a] Criteria for total concentrations from EPA 1986, 1994. Criteria for dissolved concentrations adjusted based on EPA 1994. Hardness-dependent water quality criteria calculated based on a water hardness of 318.

[b] See Section 2.4.

Key:

NA = Not available.

Table A-13

EASTERN MICHAUD FLATS SITE
BACKGROUND GROUNDWATER SUMMARY

Chemical	Units	Frequency of Detection	Minimum Detected Concentration	Maximum Detected Concentration	Average Concentration
Aluminum, dissolved	mg/L	0/3	ND	ND	0.013833
Aluminum, total	mg/L	19/78	0.01675	1.38	0.075999
Ammonia (NH3 as N)	mg/L	2/90	0.73	0.8	0.205611
Antimony, dissolved	mg/L	0/4	ND	ND	0.03625
Antimony, total	mg/L	2/80	0.05795	0.17	0.031266
Arsenic, dissolved	mg/L	5/7	0.0036	0.01735	0.008193
Arsenic, total	mg/L	50/63	0.0019	0.0204	0.008106
Barium, dissolved	mg/L	6/8	0.05812	0.173	0.08981
Barium, total	mg/L	89/92	0.03513	0.27	0.120487
Beryllium, dissolved	mg/L	0/3	ND	ND	0.000667
Beryllium, total	mg/L	4/81	0.00043	0.003	0.000531
Boron, dissolved	mg/L	1/2	0.0784	0.0784	0.0517
Boron, total	mg/L	61/63	0.03309	0.671	0.119887
Cadmium, dissolved	mg/L	4/8	0.004	0.004	0.002313
Cadmium, total	mg/L	3/36	0.00013	0.0003	0.000068
Calcium	mg/L	96/96	36.1	107	70.46201
Calcium, dissolved	mg/L	2/2	49.81903	54.61044	52.21474
Chloride	mg/L	94/94	9	332	85.82553
Chromium, dissolved	mg/L	6/8	0.00135	0.013	0.007815
Chromium, total	mg/L	53/79	0.0004	0.1622	0.005506
Cobalt, dissolved	mg/L	0/4	ND	ND	0.00325
Cobalt, total	mg/L	4/86	0.00899	0.017	0.002701
Copper, dissolved	mg/L	4/8	0.004	0.004	0.00275
Copper, total	mg/L	3/71	0.0053	0.00899	0.002022
Fluoride	mg/L	101/102	0.2	1.3	0.425618
Iron, dissolved	mg/L	4/8	0.007	0.0371	0.018363

Key at end of table.

Table A-13

EASTERN MICHAUD FLATS SITE
BACKGROUND GROUNDWATER SUMMARY

Chemical	Units	Frequency of Detection	Minimum Detected Concentration	Maximum Detected Concentration	Average Concentration
Iron, total	mg/L	18/66	0.03239	1.05	0.094311
Lead, dissolved	mg/L	4/8	0.001	0.001	0.000875
Lead, total	mg/L	12/87	0.00061	0.035	0.001148
Lithium, dissolved	mg/L	1/2	0.01	0.01	0.0085
Lithium, total	mg/L	34/46	0.005	0.064	0.027976
Magnesium	mg/L	97/97	6	59.3	24.65128
Magnesium, dissolved	mg/L	2/2	13.92837	19.67331	16.80084
Manganese, dissolved	mg/L	5/8	0.001	0.0044	0.001801
Manganese, total	mg/L	11/67	0.0012	0.174	0.006454
Mercury, dissolved	mg/L	0/2	ND	ND	0.00009
Mercury, total	mg/L	12/38	0.00006	0.00116	0.00017
Molybdenum, dissolved	mg/L	0/4	ND	ND	0.00825
Molybdenum, total	mg/L	5/79	0.02	0.07	0.010585
Nickel, dissolved	mg/L	0/3	ND	ND	0.005167
Nickel, total	mg/L	1/75	0.03381	0.03381	0.006821
Nitrate (NO3 as N)	mg/L	98/98	0.17	6.26	2.137041
Orthophosphate (PO4 as P)	mg/L	59/82	0.02	0.24	0.034805
pH	Std. Units	102/102	6.91	9.57	7.460392
Phosphorus, total	mg/L	60/87	0.02	0.43	0.035023
Potassium	mg/L	101/101	0.6	19.3	7.970753
Potassium, dissolved	mg/L	2/2	6.19538	9.11928	7.65733
Selenium, dissolved	mg/L	4/7	0.002	0.0025	0.001843
Selenium, total	mg/L	34/66	0.00108	0.0071	0.002067
Silver, dissolved	mg/L	6/8	0.004	0.008	0.004375
Silver, total	mg/L	6/77	0.002	0.007	0.001849
Sodium	mg/L	96/96	11.9	83.3	35.61687

Key at end of table.

Table A-13

EASTERN MICHAUD FLATS SITE
BACKGROUND GROUNDWATER SUMMARY

Chemical	Units	Frequency of Detection	Minimum Detected Concentration	Maximum Detected Concentration	Average Concentration
Sodium, dissolved	mg/L	1/2	14.01181	14.01181	13.26912
Specific conductance	umhos/cm	102/102	293	1,073	723.3529
Sulfate	mg/L	100/100	8	75	46.8351
Thallium, dissolved	mg/L	1/2	0.001	0.001	0.00075
Thallium, total	mg/L	3/48	0.00071	0.00105	0.000447
Total dissolved solids	mg/L	93/94	230	3,150	513.7181
Total suspended solids	mg/L	1/1	71	71	71
Vanadium, dissolved	mg/L	4/5	0.005	0.00839	0.005718
Vanadium, total	mg/L	20/61	0.00278	0.00854	0.002869
Zinc, dissolved	mg/L	6/8	0.003	1.17	0.150431
Zinc, total	mg/L	11/49	0.00454	1.29	0.039495
Gross alpha	pCi/L	66/67	0.87	7.97	3.20194
Gross beta	pCi/L	61/62	2.93	2,210	142.2863
Radium-226	pCi/L	58/63	0.09	1.84	0.473175
Radium-228	pCi/L	41/69	0.5	139	9.985507

Key:

ND = Not detected.

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Table A-14

EASTERN MICHAUD FLATS SITE
BACKGROUND GROUNDWATER COMPARISON TO SCREENING CRITERIA

Chemical	Units	EPA Freshwater Chronic Criteria[a]	Frequency of Exceedance of EPA Chronic Criteria	EPA Freshwater Acute Criteria[a]	Frequency of Exceedance of EPA Acute Criteria	Derived Freshwater Chronic Criteria[b]	Frequency of Exceedance of Derived Criteria
Aluminum, dissolved	mg/L	NA	NA	NA	NA	NA	NA
Aluminum, total	mg/L	0.087	8/78	0.75	3/78	NA	NA
Ammonia (NH3 as N)	mg/L	NA	NA	NA	NA	NA	NA
Antimony, dissolved	mg/L	NA	NA	NA	NA	NA	NA
Antimony, total	mg/L	0.03	2/80	0.088	1/80	NA	NA
Arsenic, dissolved	mg/L	0.18	0/7	0.34	0/7	NA	NA
Arsenic, total	mg/L	0.19	0/63	0.36	0/63	NA	NA
Barium, dissolved	mg/L	NA	NA	NA	NA	NA	NA
Barium, total	mg/L	NA	NA	NA	NA	1.62	0/92
Beryllium, dissolved	mg/L	NA	NA	NA	NA	NA	NA
Beryllium, total	mg/L	0.0053	0/81	0.13	0/81	NA	NA
Boron, dissolved	mg/L	NA	NA	NA	NA	NA	NA
Boron, total	mg/L	NA	NA	NA	NA	1	0/63
Cadmium, dissolved	mg/L	0.002172	4/8	0.00895	0/8	NA	NA

Key at end of table.

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Table A-14

EASTERN MICHAUD FLATS SITE
BACKGROUND GROUNDWATER COMPARISON TO SCREENING CRITERIA

Chemical	Units	EPA Freshwater Chronic Criteria[a]	Frequency of Exceedance of EPA Chronic Criteria	EPA Freshwater Acute Criteria[a]	Frequency of Exceedance of EPA Acute Criteria	Derived Freshwater Chronic Criteria[b]	Frequency of Exceedance of Derived Criteria
Cadmium, total	mg/L	0.002556	0/36	0.010529	0/36	NA	NA
Calcium	mg/L	NA	NA	NA	NA	NA	NA
Calcium, dissolved	mg/L	NA	NA	NA	NA	NA	NA
Chloride	mg/L	230	1/94	860	0/94	NA	NA
Chromium, dissolved	mg/L	0.0105	3/8	0.01	3/8	NA	NA
Chromium, total	mg/L	0.011	3/79	0.016	3/79	NA	NA
Cobalt, dissolved	mg/L	NA	NA	NA	NA	NA	NA
Cobalt, total	mg/L	NA	NA	NA	NA	0.05	0/86
Copper, dissolved	mg/L	0.02477	0/8	0.034375	0/8	NA	NA
Copper, total	mg/L	0.024983	0/71	0.040442	0/71	NA	NA
Fluoride	mg/L	NA	NA	NA	NA	2.63	0/102
Gross alpha	pCi/L	NA	NA	NA	NA	NA	NA
Gross beta	pCi/L	NA	NA	NA	NA	NA	NA
Iron, dissolved	mg/L	NA	NA	NA	NA	NA	NA

Key at end of table.

ecology and environment

Table A-14

EASTERN MICHAUD FLATS SITE
BACKGROUND GROUNDWATER COMPARISON TO SCREENING CRITERIA

Chemical	Units	EPA Freshwater Chronic Criteria[a]	Frequency of Exceedance of EPA Chronic Criteria	EPA Freshwater Acute Criteria[a]	Frequency of Exceedance of EPA Acute Criteria	Derived Freshwater Chronic Criteria[b]	Frequency of Exceedance of Derived Criteria
Iron, total	mg/L	1	1/66	NA	NA	NA	NA
Lead, dissolved	mg/L	0.002424	0/8	0.124425	0/8	NA	NA
Lead, total	mg/L	0.009697	1/87	0.248851	0/87	NA	NA
Lithium, dissolved	mg/L	NA	NA	NA	NA	NA	NA
Lithium, total	mg/L	NA	NA	NA	NA	NA	NA
Magnesium	mg/L	NA	NA	NA	NA	NA	NA
Magnesium, dissolved	mg/L	NA	NA	NA	NA	NA	NA
Manganese, dissolved	mg/L	NA	NA	NA	NA	NA	NA
Manganese, total	mg/L	NA	NA	NA	NA	75	0/67
Mercury, dissolved	mg/L	NA	NA	0.0008	0/2	NA	NA
Mercury, total	mg/L	0.000012	12/38	0.0024	0/38	NA	NA
Molybdenum, dissolved	mg/L	NA	NA	NA	NA	NA	NA
Molybdenum, total	mg/L	NA	NA	NA	NA	0.043	1/79
Nickel, dissolved	mg/L	0.281069	0/3	2.528298	0/3	NA	NA

Key at end of table.

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Table A-14

EASTERN MICHAUD FLATS SITE
BACKGROUND GROUNDWATER COMPARISON TO SCREENING CRITERIA

Chemical	Units	EPA Freshwater Chronic Criteria[a]	Frequency of Exceedance of EPA Chronic Criteria	EPA Freshwater Acute Criteria[a]	Frequency of Exceedance of EPA Acute Criteria	Derived Freshwater Chronic Criteria[b]	Frequency of Exceedance of Derived Criteria
Nickel, total	mg/L	0.33067	0/75	2.974468	0/75	NA	NA
Nitrate (NO3 as N)	mg/L	NA	NA	NA	NA	NA	NA
Orthophosphate (PO4 as P)	mg/L	NA	NA	NA	NA	NA	NA
Phosphorus, total	mg/L	NA	NA	NA	NA	NA	NA
Potassium	mg/L	NA	NA	NA	NA	NA	NA
Potassium, dissolved	mg/L	NA	NA	NA	NA	NA	NA
Radium-226	pCi/L	NA	NA	NA	NA	6.2	0/63
Radium-228	pCi/L	NA	NA	NA	NA	NA	NA
Selenium, dissolved	mg/L	NA	NA	NA	NA	0.002	2/7
Selenium, total	mg/L	0.005	5/66	0.02	0/66	NA	NA
Silver, dissolved	mg/L	NA	NA	0.015552	0/8	NA	NA
Silver, total	mg/L	0.00012	6/77	0.018296	0/77	NA	NA
Sodium	mg/L	NA	NA	NA	NA	78	1/96
Sodium, dissolved	mg/L	NA	NA	NA	NA	NA	NA

Key at end of table.

ecology and environment

Table A-14

EASTERN MICHAUD FLATS SITE
BACKGROUND GROUNDWATER COMPARISON TO SCREENING CRITERIA

Chemical	Units	EPA Freshwater Chronic Criteria[a]	Frequency of Exceedance of EPA Chronic Criteria	EPA Freshwater Acute Criteria[a]	Frequency of Exceedance of EPA Acute Criteria	Derived Freshwater Chronic Criteria[b]	Frequency of Exceedance of Derived Criteria
Specific conductance	umhos/cm	NA	NA	NA	NA	NA	NA
Sulfate	mg/L	NA	NA	NA	NA	NA	NA
Thallium, dissolved	mg/L	NA	NA	NA	NA	NA	NA
Thallium, total	mg/L	0.04	0/48	1.4	0/48	NA	NA
Total dissolved solids	mg/L	NA	NA	NA	NA	NA	NA
Total suspended solids	mg/L	NA	NA	NA	NA	NA	NA
Vanadium, dissolved	mg/L	NA	NA	NA	NA	NA	NA
Vanadium, total	mg/L	NA	NA	NA	NA	0.033	0/61
Zinc, dissolved	mg/L	0.189166	1/8	0.208852	1/8	NA	NA
Zinc, total	mg/L	0.222549	1/49	0.245708	1/49	NA	NA

a Criteria for total concentrations from EPA 1986, 1994. Criteria for dissolved concentrations adjusted based on EPA 1994. Hardness-dependent criteria calculated using water hardness of 240.

b See Section 2.3.

Key:

NA = Not available.

Table A-15

EASTERN MICHAUD FLATS SITE
DOWNSTREAM RIVER CHANNEL SURFACE WATER SUMMARY

Chemical	Units	Frequency of Detection	Minimum Detected Concentration	Maximum Detected Concentration	Average Concentration
Alkalinity, bicarbonate	mg/L	40/40	175	301	244.075
Alkalinity, carbonate	mg/L	8/27	4	16	3.185185
Aluminum, dissolved	mg/L	8/38	0.0226	0.3	0.045166
Aluminum, total	mg/L	25/34	0.02	1.80202	0.465747
Ammonia (NH3 as N)	mg/L	13/40	0.5	6.2	0.5175
Antimony, dissolved	mg/L	2/40	0.0675	0.19	0.036263
Antimony, total	mg/L	2/39	0.0479	0.13	0.0331
Arsenic, dissolved	mg/L	18/23	0.00138	0.0099	0.003413
Arsenic, total	mg/L	25/30	0.0021	0.0108	0.004825
Barium, dissolved	mg/L	38/40	0.05	0.28	0.094664
Barium, total	mg/L	38/40	0.04	0.18	0.097527
Beryllium, dissolved	mg/L	6/37	0.0011	0.024	0.001832
Beryllium, total	mg/L	3/40	0.022	0.032	0.002513
Boron, dissolved	mg/L	28/28	0.06283	0.45	0.177523
Boron, total	mg/L	23/24	0.1089	0.59	0.19778
Cadmium, dissolved	mg/L	2/40	0.0001	0.0019	0.000469
Cadmium, total	mg/L	6/40	0.0003	0.0022	0.000545
Calcium	mg/L	40/40	37.6	92.1	65.93853
Calcium, dissolved	mg/L	30/30	59.02478	81.9	70.45486
Chloride	mg/L	40/40	20.9	68	44.665
Chromium, dissolved	mg/L	17/38	0.0001	0.00225	0.000807
Chromium, total	mg/L	23/40	0.0002	0.0035	0.000996
Cobalt, dissolved	mg/L	3/39	0.0038	0.0092	0.002889
Cobalt, total	mg/L	3/39	0.0037	0.00899	0.00275
Copper, dissolved	mg/L	10/38	0.003	0.0401	0.003935

Key at end of table.

Table A-15

EASTERN MICHAUD FLATS SITE
DOWNSTREAM RIVER CHANNEL SURFACE WATER SUMMARY

Chemical	Units	Frequency of Detection	Minimum Detected Concentration	Maximum Detected Concentration	Average Concentration
Copper, total	mg/L	7/33	0.003	0.023	0.003525
Dissolved oxygen	mg/L	40/40	5.5	14.1	9.3325
Fluoride	mg/L	40/40	0.2	0.7	0.3843
Gross alpha	pCi/L	32/40	1.7	10.8	2.61
Gross beta	pCi/L	40/40	2.4	12	7.551
Iron, dissolved	mg/L	14/36	0.0111	0.093	0.026346
Iron, total	mg/L	35/36	0.0172	1.72512	0.451881
Lead, dissolved	mg/L	3/36	0.0016	0.0046	0.000828
Lead, total	mg/L	10/36	0.001	0.0317	0.001784
Lithium, dissolved	mg/L	37/37	0.01825	0.2259	0.046703
Lithium, total	mg/L	30/31	0.02331	0.0564	0.043857
Magnesium	mg/L	40/40	17.5	41	28.63965
Magnesium, dissolved	mg/L	31/31	22.94698	39.4	30.53295
Manganese, dissolved	mg/L	19/35	0.00106	0.0352	0.004663
Manganese, total	mg/L	33/40	0.004	0.06231	0.01957
Mercury, dissolved	mg/L	8/28	0.0001	0.0004	0.000083
Mercury, total	mg/L	13/32	0.0001	0.0004	0.000095
Molybdenum, dissolved	mg/L	2/39	0.016	0.1796	0.013451
Molybdenum, total	mg/L	0/40	ND	ND	0.01
Nickel, dissolved	mg/L	3/38	0.011	0.0723	0.009745
Nickel, total	mg/L	3/40	0.01308	0.026	0.008352
Nitrate (NO3 as N)	mg/L	38/40	0.31	2.8	1.41325
Orthophosphate (PO4 as P)	mg/L	36/40	0.015	1.2	0.3352
pH	Std. Units	39/39	7.21	9.93	8.134872
Phosphorus, total	mg/L	36/37	0.02	1.45	0.437919

Key at end of table.

Table A-15

EASTERN MICHAUD FLATS SITE
DOWNSTREAM RIVER CHANNEL SURFACE WATER SUMMARY

Chemical	Units	Frequency of Detection	Minimum Detected Concentration	Maximum Detected Concentration	Average Concentration
Potassium	mg/L	40/40	5.12655	11	8.207743
Potassium, dissolved	mg/L	31/31	5.05138	11.1	8.219195
Radium-226	pCi/L	32/39	0.1	3.11	0.558205
Radium-228	pCi/L	17/38	0.8	5.9	0.897368
Selenium, dissolved	mg/L	7/30	0.001	0.0031	0.000882
Selenium, total	mg/L	10/27	0.0012	0.0053	0.001352
Silver, dissolved	mg/L	1/32	0.003	0.003	0.001578
Silver, total	mg/L	4/35	0.0024	0.0044	0.001743
Sodium	mg/L	40/40	25.18948	78.7	45.27579
Sodium, dissolved	mg/L	31/31	25.57935	60.68209	44.17747
Specific conductance, at 25° C	umhos/cm	39/39	497	2140	815.7949
Sulfate	mg/L	40/40	33.4	82	53.8225
Temperature	degrees C	39/39	0.27778	25.8333	13.50855
Thallium, dissolved	mg/L	0/18	ND	ND	0.000403
Thallium, total	mg/L	0/40	ND	ND	0.001081
Total dissolved solids	mg/L	33/33	260	540	408.7879
Total Hardness	mg/L	7/7	257	314	289.5714
Total suspended solids	mg/L	14/18	4	30	9.066667
Uranium-233/234	pCi/L	4/4	0.621	1.36	1.08275
Uranium-235	pCi/L	3/3	-0.0203	-0.00163	-0.009
Uranium-238	pCi/L	4/4	0.239	0.83	0.5855
Vanadium, dissolved	mg/L	15/40	0.0024	0.15	0.018782
Vanadium, total	mg/L	22/40	0.00285	0.08	0.012318
Zinc, dissolved	mg/L	14/26	0.003	0.052	0.017575
Zinc, total	mg/L	17/28	0.01636	0.06619	0.025373

Key at end of table.

Table A-15 (Cont.)

Key:

ND = Not detected.

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Table A-16

EASTERN MICHAUD FLATS SITE
DOWNSTREAM SURFACE WATER COMPARISON TO SCREENING CRITERIA

Chemical	Units	Groundwater Background[a]	Frequency of Exceedance of Groundwater Background	Surface Water Background[b]	Frequency of Exceedance of Surface Water Background	EPA Freshwater Chronic Criteria[c]	Frequency of Exceedance of EPA Chronic Criteria	EPA Freshwater Acute Criteria[c]	Frequency of Exceedance of EPA Acute Criteria	Derived Freshwater Chronic Criteria[d]	Frequency of Exceedance of Derived Criteria
Aluminum, dissolved	mg/l	ND	ND	0.0807	5/38	NA	NA	NA	NA	NA	NA
Aluminum, total	mg/l	0.4190	12/34	1.4841	3/34	0.0870	19/34	0.7500	11/34	NA	NA
Ammonia (NH3 as N)	mg/l	0.8	7/40	0.2550	13/40	NA	NA	NA	NA	NA	NA
Antimony, dissolved	mg/l	ND	ND	ND	2/40	NA	NA	NA	NA	NA	NA
Antimony, total	mg/l	0.17	0/39	ND	2/39	0.0300	2/39	0.0880	1/39	NA	NA
Arsenic, dissolved	mg/l	0.0174	0/23	0.0046	5/23	0.1800	0/23	0.3400	0/23	NA	NA
Arsenic, total	mg/l	0.0170	0/30	0.0078	5/30	0.1900	0/30	0.3600	0/30	NA	NA
Barium, dissolved	mg/l	0.173	1/40	0.1061	6/40	NA	NA	NA	NA	NA	NA
Barium, total	mg/l	0.2245	0/40	0.1130	3/40	NA	NA	NA	NA	1.6200	0/40
Beryllium, dissolved	mg/l	ND	ND	ND	6/37	NA	NA	NA	NA	NA	NA
Beryllium, total	mg/l	0.003	3/40	0.0006	3/40	0.0053	3/40	0.1300	0/40	NA	NA
Boron, dissolved	mg/l	0.0784	24/28	0.4530	9/28	NA	NA	NA	NA	NA	NA
Boron, total	mg/l	0.2400	5/24	0.4491	1/24	NA	NA	NA	NA	1.0000	0/24
Cadmium, dissolved	mg/l	0.0040	0/40	ND	2/40	0.0022	0/40	0.0110	0/40	NA	NA
Cadmium, total	mg/l	0.0003	5/40	ND	6/40	0.0026	0/40	0.0129	0/40	NA	NA
Calcium	mg/l	96.57	0/40	83.6300	2/40	NA	NA	NA	NA	NA	NA

Key at end of table.

ecology and environment

Table A-16

EASTERN MICHAUD FLATS SITE
DOWNSTREAM SURFACE WATER COMPARISON TO SCREENING CRITERIA

Chemical	Units	Groundwater Background[a]	Frequency of Exceedance of Groundwater Background	Surface Water Background[b]	Frequency of Exceedance of Surface Water Background	EPA Freshwater Chronic Criteria[c]	Frequency of Exceedance of EPA Chronic Criteria	EPA Freshwater Acute Criteria[c]	Frequency of Exceedance of EPA Acute Criteria	Derived Freshwater Chronic Criteria[d]	Frequency of Exceedance of Derived Criteria
Calcium, dissolved	mg/l	54.61	30/30	83.4850	0/30	NA	NA	NA	NA	NA	NA
Chloride	mg/l	177.9	0/40	58.4000	2/40	230	0/40	860	0/40	NA	NA
Chromium, dissolved	mg/l	0.0130	0/38	0.0013	9/38	0.0105	0/38	0.0100	0/38	NA	NA
Chromium, total	mg/l	0.0088	0/40	0.0011	17/40	0.0110	0/40	0.0160	0/40	NA	NA
Cobalt, dissolved	mg/l	ND	ND	ND	3/39	NA	NA	NA	NA	NA	NA
Cobalt, total	mg/l	0.017	0/39	0.0047	2/39	NA	NA	NA	NA	0.0500	0/39
Copper, dissolved	mg/l	0.0040	6/38	0.0030	9/38	0.0248	1/38	0.0407	0/38	NA	NA
Copper, total	mg/l	0.0090	3/33	0.0068	3/33	0.0291	0/33	0.0479	0/33	NA	NA
Fluoride	mg/l	0.8000	0/40	0.3586	22/40	NA	NA	NA	NA	2.6300	0/40
Iron, dissolved	mg/l	0.0371	10/36	0.0857	1/36	NA	NA	NA	NA	NA	NA
Iron, total	mg/l	0.4350	11/36	1.4903	3/36	1.0000	10/36	NA	NA	NA	NA
Lead, dissolved	mg/l	0.0010	3/36	0.0011	3/36	0.0030	1/36	0.1565	0/36	NA	NA
Lead, total	mg/l	0.0020	2/36	0.0024	2/36	0.0122	1/36	0.3130	0/36	NA	NA
Lithium, dissolved	mg/l	0.01	37/37	0.0695	2/37	NA	NA	NA	NA	NA	NA
Lithium, total	mg/l	0.0612	0/31	0.0665	0/31	NA	NA	NA	NA	NA	NA
Magnesium	mg/l	33.84	11/40	40.6100	1/40	NA	NA	NA	NA	NA	NA

Key at end of table.

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Table A-16

EASTERN MICHAUD FLATS SITE
DOWNSTREAM SURFACE WATER COMPARISON TO SCREENING CRITERIA

Chemical	Units	Groundwater Background[a]	Frequency of Exceedance of Groundwater Background	Surface Water Background[b]	Frequency of Exceedance of Surface Water Background	EPA Freshwater Chronic Criteria[c]	Frequency of Exceedance of EPA Chronic Criteria	EPA Freshwater Acute Criteria[c]	Frequency of Exceedance of EPA Acute Criteria	Derived Freshwater Chronic Criteria[d]	Frequency of Exceedance of Derived Criteria
Magnesium, dissolved	mg/l	19.67	31/31	39.8000	0/31	NA	NA	NA	NA	NA	NA
Manganese, dissolved	mg/l	0.0044	8/35	0.0137	1/35	NA	NA	NA	NA	NA	NA
Manganese, total	mg/l	0.0068	23/40	0.0540	3/40	NA	NA	NA	NA	75.0000	0/40
Mercury, dissolved	mg/l	ND	ND	0.0002	2/28	NA	NA	0.0008	0/28	NA	NA
Mercury, total	mg/l	0.0005	0/32	0.0002	1/32	0.000012	13/32	0.0024	0/32	NA	NA
Molybdenum, dissolved	mg/l	ND	ND	ND	2/39	NA	NA	NA	NA	NA	NA
Molybdenum, total	mg/l	0.07	0/40	0.0152	0/40	NA	NA	NA	NA	0.0430	0/40
Nickel, dissolved	mg/l	ND	ND	ND	3/38	0.3273	0/38	2.9446	0/38	NA	NA
Nickel, total	mg/l	0.034	0/40	0.0136	2/40	0.3851	0/40	3.4642	0/40	NA	NA
Nitrate (NO3 as N)	mg/l	4.54	0/40	1.1520	24/40	NA	NA	NA	NA	NA	NA
Orthophosphate (PO4 as P)	mg/l	0.081	26/40	0.0378	29/40	NA	NA	NA	NA	NA	NA
Phosphorus, total	mg/l	0.0598	31/37	0.1891	25/37	NA	NA	NA	NA	NA	NA
Potassium	mg/l	12.07	0/40	11.1000	0/40	NA	NA	NA	NA	NA	NA
Potassium, dissolved	mg/l	9.12	13/31	10.8700	5/31	NA	NA	NA	NA	NA	NA
Selenium, dissolved	mg/l	0.0025	2/30	ND	7/30	NA	NA	NA	NA	0.0020	2/30
Selenium, total	mg/l	0.0052	1/27	0.0021	6/27	0.0050	1/27	0.0200	0/27	NA	NA

Key at end of table.

Table A-16

EASTERN MICHAUD FLATS SITE
DOWNSTREAM SURFACE WATER COMPARISON TO SCREENING CRITERIA

Chemical	Units	Groundwater Background[a]	Frequency of Exceedance of Groundwater Background	Surface Water Background[b]	Frequency of Exceedance of Surface Water Background	EPA Freshwater Chronic Criteria[c]	Frequency of Exceedance of EPA Chronic Criteria	EPA Freshwater Acute Criteria[c]	Frequency of Exceedance of EPA Acute Criteria	Derived Freshwater Chronic Criteria[d]	Frequency of Exceedance of Derived Criteria
Silver, dissolved	mg/l	0.008	0/32	ND	1/32	NA	NA	0.0212	0/32	NA	NA
Silver, total	mg/l	0.007	0/35	ND	4/35	0.0001	4/35	0.0249	0/35	NA	NA
Sodium	mg/l	63.0772	2/40	50.7200	9/40	NA	NA	NA	NA	78.0000	1/40
Sodium, dissolved	mg/l	14.012	31/31	48.5350	13/31	NA	NA	NA	NA	NA	NA
Specific conductance, at 25 C	umhos/cm	1,045	6/39	1,173.0000	5/39	NA	NA	NA	NA	NA	NA
Sulfate	mg/l	69.05	5/40	52.9120	18/40	NA	NA	NA	NA	NA	NA
Thallium, dissolved	mg/l	0.001	0/18	ND	0/18	NA	NA	NA	NA	NA	NA
Thallium, total	mg/l	0.0011	0/40	ND	0/40	0.0400	0/40	1.4000	0/40	NA	NA
Total dissolved solids	mg/l	801.5	0/33	470.0000	8/33	NA	NA	NA	NA	NA	NA
Total Hardness	mg/l	NA	NA	324.6000	0/7	NA	NA	NA	NA	NA	NA
Total suspended solids	mg/l	71	0/18	38.8000	0/18	NA	NA	NA	NA	NA	NA
Vanadium, dissolved	mg/l	0.00839	8/40	ND	15/40	NA	NA	NA	NA	NA	NA
Vanadium, total	mg/l	0.0075	6/40	0.0252	6/40	NA	NA	NA	NA	0.0330	6/40
Zinc, dissolved	mg/l	1.17	0/26	0.0578	0/26	0.2204	0/26	0.2433	0/26	NA	NA
Zinc, total	mg/l	0.0973	0/28	0.0582	2/28	0.2593	0/28	0.2862	0/28	NA	NA
Gross alpha	pCi/L	5.612	1/40	5.0920	1/40	NA	NA	NA	NA	NA	NA

Key at end of table.

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Table A-16

EASTERN MICHAUD FLATS SITE
DOWNSTREAM SURFACE WATER COMPARISON TO SCREENING CRITERIA

Chemical	Units	Groundwater Background[a]	Frequency of Exceedance of Groundwater Background	Surface Water Background[b]	Frequency of Exceedance of Surface Water Background	EPA Freshwater Chronic Criteria[c]	Frequency of Exceedance of EPA Chronic Criteria	EPA Freshwater Acute Criteria[c]	Frequency of Exceedance of EPA Acute Criteria	Derived Freshwater Chronic Criteria[d]	Frequency of Exceedance of Derived Criteria
Gross beta	pCi/L	1.750	0/40	10.2000	3/40	NA	NA	NA	NA	NA	NA
Radium-226	pCi/L	1.642	1/39	1.4700	1/39	NA	NA	NA	NA	6.2	0/39
Radium-228	pCi/L	113.6	0/38	3.7200	1/38	NA	NA	NA	NA	NA	NA
Uranium-233/234	pCi/L	NA	NA	1.3990	0/4	NA	NA	NA	NA	NA	NA
Uranium-235	pCi/L	NA	NA	0.0877	0/3	NA	NA	NA	NA	100	0/3
Uranium-238	pCi/L	NA	NA	0.7861	1/4	NA	NA	NA	NA	192	0/4

[a] Upper 95th percentile of groundwater background samples.
[b] Upper 95th percentile of upstream surface water samples.
[c] From EPA 1986, 1994. Hardness-dependent water quality criteria calculated based on a water hardness of 287.
[d] See Section 2.3.

Key:

NA = Not available.
ND = Not detected.

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Table A-17

EASTERN MICHAUD FLATS SITE
SPRINGS SURFACE WATER SUMMARY

Chemical	Units	Frequency of Detection	Minimum Detected Concentration	Maximum Detected Concentration	Average Concentration
Alkalinity, bicarbonate	mg/L	42/42	174	657	236.9048
Alkalinity, carbonate	mg/L	0/20	ND	ND	0.5
Aluminum, dissolved	mg/L	12/39	0.0184	0.24	0.04089
Aluminum, total	mg/L	10/32	0.03	1.07177	0.088193
Ammonia (NH3 as N)	mg/L	6/42	0.2	0.5	0.179762
Antimony, dissolved	mg/L	3/42	0.08	0.37	0.041286
Antimony, total	mg/L	3/42	0.0522	0.75	0.049751
Arsenic, dissolved	mg/L	24/30	0.00107	0.05669	0.005369
Arsenic, total	mg/L	30/34	0.00111	0.03256	0.004782
Barium, dissolved	mg/L	41/42	0.04	0.1438	0.080333
Barium, total	mg/L	41/42	0.04	2.81	0.158351
Beryllium, dissolved	mg/L	4/40	0.001	0.019	0.00165
Beryllium, total	mg/L	4/42	0.006	0.025	0.002274
Boron, dissolved	mg/L	25/25	0.0599	0.39	0.169399
Boron, total	mg/L	25/25	0.055	0.43	0.158656
Cadmium, dissolved	mg/L	0/42	ND	ND	0.000414
Cadmium, total	mg/L	7/42	0.0002	0.0015	0.000495
Calcium	mg/L	42/42	39.5	109	62.4553
Calcium, dissolved	mg/L	32/32	57	109.3264	67.06439
Chloride	mg/L	42/42	14.6	56	25.6719
Chromium, dissolved	mg/L	33/40	0.00101	0.00625	0.001401
Chromium, total	mg/L	31/42	0.0001	0.00418	0.001253
Cobalt, dissolved	mg/L	1/32	0.0035	0.0035	0.001906
Cobalt, total	mg/L	2/32	0.0031	0.004	0.001972
Copper, dissolved	mg/L	8/40	0.003	0.00899	0.002497
Copper, total	mg/L	3/38	0.003	0.0047	0.001953
Dissolved oxygen	mg/L	42/42	3.6	14.9	8.086905

Key at end of table.

Table A-17

EASTERN MICHAUD FLATS SITE
SPRINGS SURFACE WATER SUMMARY

Chemical	Units	Frequency of Detection	Minimum Detected Concentration	Maximum Detected Concentration	Average Concentration
Fluoride	mg/L	42/42	0.3	0.8	0.535381
Gross alpha	pCi/L	31/42	1.39	8.84	2.063333
Gross beta	pCi/L	42/42	2.7	20.4	6.064048
Iron, dissolved	mg/L	14/33	0.0106	0.089	0.029417
Iron, total	mg/L	24/39	0.0133	1.21858	0.071053
Lead, dissolved	mg/L	5/38	0.001	0.0035	0.000808
Lead, total	mg/L	3/37	0.0014	0.0163	0.001116
Lithium, dissolved	mg/L	38/38	0.01969	0.0735	0.036952
Lithium, total	mg/L	30/30	0.023	0.06481	0.037154
Magnesium	mg/L	42/42	14	41.29772	23.06708
Magnesium, dissolved	mg/L	31/32	17.5	41.68011	23.83071
Manganese, dissolved	mg/L	13/37	0.001	0.0345	0.003982
Manganese, total	mg/L	16/42	0.0015	0.04604	0.004582
Mercury, dissolved	mg/L	12/24	0.0001	0.0002	0.000097
Mercury, total	mg/L	15/27	0.0001	0.0004	0.000117
Molybdenum, dissolved	mg/L	0/40	ND	ND	0.008888
Molybdenum, total	mg/L	1/33	0.0134	0.0134	0.006815
Nickel, dissolved	mg/L	3/40	0.01205	0.02227	0.00865
Nickel, total	mg/L	1/39	0.0132	0.0132	0.007236
Nitrate (NO3 as N)	mg/L	42/42	0.38	11	2.492619
Orthophosphate (PO4 as P)	mg/L	30/42	0.02	7.37	0.393167
pH	Std. Units	39/39	6.8	8.41	7.73359
Phosphorus, total	mg/L	30/36	0.02	8.75	0.49225
Potassium	mg/L	42/42	3.27866	14.96745	5.535701
Potassium, dissolved	mg/L	32/32	3.39254	15.45016	5.5522
Radium-226	pCi/L	33/42	0.07	5.2	0.720238
Radium-228	pCi/L	19/40	0.6	5.3	0.99

Key at end of table.

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Table A-17

EASTERN MICHAUD FLATS SITE
SPRINGS SURFACE WATER SUMMARY

Chemical	Units	Frequency of Detection	Minimum Detected Concentration	Maximum Detected Concentration	Average Concentration
Selenium, dissolved	mg/L	11/36	0.0015	0.0172	0.002392
Selenium, total	mg/L	13/31	0.0011	0.01007	0.001564
Silver, dissolved	mg/L	1/33	0.0077	0.0077	0.001733
Silver, total	mg/L	6/37	0.0028	0.004	0.001819
Sodium	mg/L	42/42	18.91083	82.80848	35.54707
Sodium, dissolved	mg/L	32/32	19.5	85.70874	35.25722
Specific conductance, at 25° C	umhos/cm	39/39	402	1245	667.9744
Sulfate	mg/L	42/42	27	241.7	55.64452
Temperature	degrees C	42/42	4.44444	21.8889	13.32937
Thallium, dissolved	mg/L	1/20	0.00059	0.00059	0.000417
Thallium, total	mg/L	0/42	ND	ND	0.001036
Total dissolved solids	mg/L	36/36	240	800	364.4444
Total Hardness	mg/L	4/4	220	254	240
Total suspended solids	mg/L	6/18	4	32	5.744444
Uranium-233/234	pCi/L	3/3	1.08	1.67	1.313333
Uranium-235	pCi/L	1/3	0.0714	0.0714	0.04174
Uranium-238	pCi/L	3/3	0.481	0.798	0.592333
Vanadium, dissolved	mg/L	16/42	0.0022	0.13	0.01494
Vanadium, total	mg/L	25/42	0.003	0.09	0.01449
Zinc, dissolved	mg/L	15/28	0.0064	0.06	0.019309
Zinc, total	mg/L	16/29	0.00433	0.101	0.019641

Key:

ND = Not detected.

Table A-18

EASTERN MICHAUD FLATS SITE
SPRINGS SURFACE WATER COMPARISON TO SCREENING CRITERIA

Chemical	Units	Groundwater Background[a]	Frequency of Exceedance of Groundwater Background	EPA Freshwater Chronic Criteria[b]	Frequency of Exceedance of EPA Chronic Criteria	EPA Freshwater Acute Criteria[b]	Frequency of Exceedance of EPA Acute Criteria	Derived Freshwater Chronic Criteria[c]	Frequency of Exceedance of Derived Criteria
Alkalinity, bicarbonate	mg/L	NA	NA	NA	NA	NA	NA	NA	NA
Alkalinity, carbonate	mg/L	NA	NA	NA	NA	NA	NA	NA	NA
Aluminum, dissolved	mg/L	ND	ND	NA	NA	NA	NA	NA	NA
Aluminum, total	mg/L	0.4190	2/32	0.08700	6/32	0.7500	1/32	NA	NA
Ammonia (NH3 as N)	mg/L	0.8	0/42	NA	NA	NA	NA	NA	NA
Antimony, dissolved	mg/L	ND	ND	NA	NA	NA	NA	NA	NA
Antimony, total	mg/L	0.17	1/42	0.03000	3/42	0.0880	2/42	NA	NA
Arsenic, dissolved	mg/L	0.0174	1/30	0.18000	0/30	0.3400	0/30	NA	NA
Arsenic, total	mg/L	0.0170	1/34	0.19000	0/34	0.3600	0/34	NA	NA
Barium, dissolved	mg/L	0.173	0/42	NA	NA	NA	NA	NA	NA
Barium, total	mg/L	0.2245	1/42	NA	NA	NA	NA	1.6200	1/42
Beryllium, dissolved	mg/L	ND	ND	NA	NA	NA	NA	NA	NA
Beryllium, total	mg/L	0.003	4/42	0.00530	4/42	0.1300	0/42	NA	NA
Boron, dissolved	mg/L	0.0784	21/25	NA	NA	NA	NA	NA	NA
Boron, total	mg/L	0.2400	5/25	NA	NA	NA	NA	1.0000	0/25

Key at end of table.

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Table A-18

EASTERN MICHAUD FLATS SITE
SPRINGS SURFACE WATER COMPARISON TO SCREENING CRITERIA

Chemical	Units	Groundwater Background[a]	Frequency of Exceedance of Groundwater Background	EPA Freshwater Chronic Criteria[b]	Frequency of Exceedance of EPA Chronic Criteria	EPA Freshwater Acute Criteria[b]	Frequency of Exceedance of EPA Acute Criteria	Derived Freshwater Chronic Criteria[c]	Frequency of Exceedance of Derived Criteria
Cadmium, dissolved	mg/L	0.0040	0/42	0.00217	0/42	0.0090	0/42	NA	NA
Cadmium, total	mg/L	0.0003	5/42	0.00256	0/42	0.0153	0/42	NA	NA
Calcium	mg/L	96.57	3/42	NA	NA	NA	NA	NA	NA
Calcium, dissolved	mg/L	54.61	32/32	NA	NA	NA	NA	NA	NA
Chloride	mg/L	177.8	0/42	230	0.42	860	0/42	NA	NA
Chromium, dissolved	mg/L	0.0130	0/40	0.01050	0/40	0.0100	0/40	NA	NA
Chromium, total	mg/L	0.0088	0/42	0.01100	0/42	0.0160	0/42	NA	NA
Cobalt, dissolved	mg/L	ND	ND	NA	NA	NA	NA	NA	NA
Cobalt, total	mg/L	0.017	0/32	NA	NA	NA	NA	0.0500	0/32
Copper, dissolved	mg/L	0.0040	4/40	0.03438	0/40	0.0270	0/40	NA	NA
Copper, total	mg/L	0.0090	0/38	0.04044	0/38	0.0318	0/38	NA	NA
Dissolved oxygen	mg/L	NA	NA	NA	NA	NA	NA	NA	NA
Fluoride	mg/L	0.8000	0/42	NA	NA	NA	NA	2.63	0/42
Iron, dissolved	mg/L	0.0371	9/33	NA	NA	NA	NA	NA	NA
Iron, total	mg/L	0.4350	1/39	1.00000	1/39	NA	NA	NA	NA

Key at end of table.

Table A-18

EASTERN MICHAUD FLATS SITE
SPRINGS SURFACE WATER COMPARISON TO SCREENING CRITERIA

Chemical	Units	Groundwater Background[a]	Frequency of Exceedance of Groundwater Background	EPA Freshwater Chronic Criteria[b]	Frequency of Exceedance of EPA Chronic Criteria	EPA Freshwater Acute Criteria[b]	Frequency of Exceedance of EPA Acute Criteria	Derived Freshwater Chronic Criteria[c]	Frequency of Exceedance of Derived Criteria
Lead, dissolved	mg/L	0.0010	4/38	0.00242	1/38	0.1244	0/38	NA	NA
Lead, total	mg/L	0.0020	2/37	0.00970	1/37	0.2489	0/37	NA	NA
Lithium, dissolved	mg/L	0.01	38/38	NA	NA	NA	NA	NA	NA
Lithium, total	mg/L	0.0612	1/30	NA	NA	NA	NA	NA	NA
Magnesium	mg/L	33.84	3/42	NA	NA	NA	NA	NA	NA
Magnesium, dissolved	mg/L	19.67	25/32	NA	NA	NA	NA	NA	NA
Manganese, dissolved	mg/L	0.0044	4/37	NA	NA	NA	NA	NA	NA
Manganese, total	mg/L	0.0068	3/42	NA	NA	NA	NA	75	0/42
Mercury, dissolved	mg/L	ND	ND	NA	NA	0.0008	0/24	NA	NA
Mercury, total	mg/L	0.0005	0/27	0.00001	15/27	0.0024	0/27	NA	NA
Molybdenum, dissolved	mg/L	ND	ND	NA	NA	NA	NA	NA	NA
Molybdenum, total	mg/L	0.07	0/33	NA	NA	NA	NA	0.0430	0/33
Nickel, dissolved	mg/L	ND	ND	0.28107	0/40	2.5283	0/40	NA	NA
Nickel, total	mg/L	0.034	0/39	0.33067	0/39	2.9745	0/39	NA	NA
Nitrate (NO3 as N)	mg/L	4.54	1/42	NA	NA	NA	NA	NA	NA

Key at end of table.

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Table A-18

EASTERN MICHAUD FLATS SITE
SPRINGS SURFACE WATER COMPARISON TO SCREENING CRITERIA

Chemical	Units	Groundwater Background[a]	Frequency of Exceedance of Groundwater Background	EPA Freshwater Chronic Criteria[b]	Frequency of Exceedance of EPA Chronic Criteria	EPA Freshwater Acute Criteria[b]	Frequency of Exceedance of EPA Acute Criteria	Derived Freshwater Chronic Criteria[c]	Frequency of Exceedance of Derived Criteria
Orthophosphate (PO4 as P)	mg/L	0.0809	12/42	NA	NA	NA	NA	NA	NA
pH	Std. units	7.76	16/39	NA	NA	NA	NA	NA	NA
Phosphorus, total	mg/L	0.060	18/36	NA	NA	NA	NA	NA	NA
Potassium	mg/L	12.07	1/42	NA	NA	NA	NA	NA	NA
Potassium, dissolved	mg/L	9.12	1/32	NA	NA	NA	NA	NA	NA
Selenium, dissolved	mg/L	0.0025	9/36	NA	NA	NA	NA	0.0020	10/36
Selenium, total	mg/L	0.0052	2/31	0.00500	2/31	0.0200	0/31	NA	NA
Silver, dissolved	mg/L	0.008	0/33	NA	NA	0.01555	0/33	NA	NA
Silver, total	mg/L	0.007	0/37	0.00012	6/37	0.0183	0/37	NA	NA
Sodium	mg/L	63.0772	1/42	NA	NA	NA	NA	78	1/42
Sodium, dissolved	mg/L	14.012	32/32	NA	NA	NA	NA	NA	NA
Specific conductance, at 25 C	µmhos/cm	1,045	5/39	NA	NA	NA	NA	NA	NA
Sulfate	mg/L	69.05	7/42	NA	NA	NA	NA	NA	NA
Temperature	degreesC	NA	NA	NA	NA	NA	NA	NA	NA
Thallium, dissolved	mg/L	0.001	0/20	NA	NA	NA	NA	NA	NA

Key at end of table.

Table A-18

EASTERN MICHAUD FLATS SITE
SPRINGS SURFACE WATER COMPARISON TO SCREENING CRITERIA

Chemical	Units	Groundwater Background[a]	Frequency of Exceedance of Groundwater Background	EPA Freshwater Chronic Criteria[b]	Frequency of Exceedance of EPA Chronic Criteria	EPA Freshwater Acute Criteria[b]	Frequency of Exceedance of EPA Acute Criteria	Derived Freshwater Chronic Criteria[c]	Frequency of Exceedance of Derived Criteria
Thallium, total	mg/L	0.0011	0/42	0.04000	0/42	1.4000	0/42	NA	NA
Total dissolved solids	mg/L	801.5	0/36	NA	NA	NA	NA	NA	NA
Total Hardness	mg/L	NA	NA	NA	NA	NA	NA	NA	NA
Total suspended solids	mg/L	71	0/18	NA	NA	NA	NA	NA	NA
Vanadium, dissolved	mg/L	0.00839	5/42	NA	NA	NA	NA	NA	NA
Vanadium, total	mg/L	0.0075	10/42	NA	NA	NA	NA	0.0330	7/42
Zinc, dissolved	mg/L	1.17	0/28	0.18917	0/28	0.2089	0/28	NA	NA
Zinc, total	mg/L	0.0973	1/29	0.22255	0/29	0.2457	0/29	NA	NA
Gross alpha	pCi/L	5.612	2/42	NA	NA	NA	NA	NA	NA
Gross beta	pCi/L	1,750	0/42	NA	NA	NA	NA	NA	NA
Radium-226	pCi/L	1.642	6/42	NA	NA	NA	NA	6.2	0.42
Radium-228	pCi/L	113.6	0/40	NA	NA	NA	NA	NA	NA
Uranium-233/234	pCi/L	NA	NA	NA	NA	NA	NA	NA	NA
Uranium-235	pCi/L	NA	NA	NA	NA	NA	NA	100	0/3
Uranium-238	pCi/L	NA	NA	NA	NA	NA	NA	192	0/3

Key at end of table.

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Table A-18 (Cont.)

[a] Upper 95th percentile of background groundwater samples.
[b] From U.S. Environmental Protection Agency 1986, 1994. Hardness-dependent water quality criteria calculated based on a water hardness of 240.
[c] See Section 2.3.

Key:

NA = Not available.

B

B Summary of Ecological Assessment Sampling Results

This appendix summarizes the ecological assessment investigations at the Eastern Michaud Flats Superfund Site (EMF Site) and presents the sampling results. The appendix is divided into two main sections—Sample Locations, Analytical Parameters, and Numbers of Samples; and Summary of Ecological Assessment Sampling Results.

Section 1 was taken from the Field Sampling Plan (FSP) for the site and revised to include the modifications agreed to by the Principal Responsible Parties (PRPs) and the United States Environmental Protection Agency (EPA). It should be noted that a two-phased approach was adopted for the ecological investigation of the Portneuf River delta. Phase 2 of the delta study, which included sediment toxicity testing and measurement of contaminants in fish and benthic invertebrates, was to be conducted only if Phase 1 results suggested that contaminant levels in sediment from the delta were of ecological concern. Because contamination of Portneuf River delta sediment was minimal, Section B.2 does not include results of contaminant levels in fish and benthic invertebrates or toxicity testing results. In addition, it was agreed during the course of the terrestrial investigations that the need for mineralogical analyses of soil and source materials would be evaluated; therefore, no data of this type are presented in Section B.2.

B.1 Sample Locations, Analytical Parameters, and Numbers of Samples

The COPCs and sample media investigated in the ecological assessment are shown in Table B-1. COPCs were identified on the basis of their spatial distribution in media surrounding the facility, their potential toxicity to ecological receptors, their tendency to mobilize and/or biomagnify in the food chain, evidence of contamination from previous investigations, and the need to resolve data gaps. COPCs include cadmium, fluoride, and zinc in soil, vegetation, and small mammals; and cadmium, fluoride, zinc, arsenic, selenium, and mercury in sediment. Sample media and target species include surface soil; vegetation (Russian olive fruit, sagebrush foliage, six-awn wheatgrass stems and leaves); small mammals (whole organisms and femurs of deer mice); and surface sediment.

An overview of habitats where these sample media and target species were collected is provided in Table B-2. Sampling was conducted in terrestrial and aquatic habitats. The terrestrial habitats included sagebrush steppe and riparian habitats. Soil, sagebrush foliage, thickspike wheatgrass, and deer mice were sampled in the sagebrush steppe habitat. Soil and Russian olive fruit were sampled in the riparian habitat. The aquatic habitats include riverine

habitat and river delta/reservoir habitat. In the riverine habitat, sediment was sampled and sediment toxicity testing was conducted. In the river delta/reservoir habitat, sediment was sampled.

Potential sampling locations were identified based on evaluation of contaminant levels indicated from previous investigations. Reconnaissance surveys were conducted in July and September 1994 to verify the suitability of sampling areas and locate access points. In addition, the reconnaissance surveys served to familiarize project biologists with site characteristics, enabling them to determine appropriate biota target species to be collected. The surveys were conducted by representatives of the PRPs, Idaho Department of Environmental Quality, U.S. Fish and Wildlife Service, EPA, and an E & E field team. Locations were verified in the field by the PRPs' representatives using a global positioning system (GPS) calibrated to known benchmarks near the EMF site. The GPS provides three-dimensional locations with an error of less than 2.0 seconds latitude and longitude and less than 500 feet in elevation, provided enough GPS satellites are in position to be acquired. Benchmarks used for reference to known locations are shown on Figure B-1. The first benchmark is located near the County Fairgrounds (42°55'00.0" north; 112°26'07.7" west; 4,658 feet above mean sea level [AMSL]). The second benchmark is located near Pocatello Creek Road and Parks Road (42°53'12.9" north; 112°23'45.8" west; 4,880 feet AMSL). Actual sample locations were then selected from areas that were investigated during the reconnaissance surveys, with some revision of the selection during follow-up meetings and discussions between the PRPs, EPA, and their representatives.

The numbers of samples to be collected for each media or target species were determined by establishing data quality objectives that permit meaningful statistical comparisons to be made with reference areas. The approach for establishing data quality objectives was in accordance with EPA guidance (EPA 1989b, EPA 1992b) and was applied to the site using representative data from published literature to estimate the expected degree of variability in study populations. A description of the approach and the data used to determine sample size is presented in Appendix C.

In the discussion that follows, sample locations, media and target species, numbers of samples, and analytical parameters are identified. Terrestrial habitat investigations are described in Section B.1.1. Aquatic studies are described in Section B.1.2.

B.1.1 Terrestrial Investigations

B.1.1.1 Sample Locations, Media, and Target Species

Sagebrush Steppe Habitat

Three locations—two potentially impacted locations representive of areas in the vicinity of the site (see Figure B-2) and one reference location presumed to be unaffected by the EMF site (see Figure B-3)—were selected for sampling from the sagebrush steppe habitat (see Table B-3). The first potentially impacted location is in Michaud Flats, approximately 1 mile north-northeast of the facilities in the direction of the prevailing winds. During the reconnaissance survey, this area was determined to have suitable habitat, sufficient vegetation for sampling, and easy access. The second potentially impacted area is in the foothills of the Bannock Range southwest of the EMF facilities. This location was identified during a subsequent meeting between the consultants for the PRPs and EPA.

A reference sagebrush steppe location was used to provide background data for the study. This habitat location was located at Ferry Butte, approximately 15 miles north-northeast of the EMF site near Blackfoot, Idaho.

A 1-hectare sample plot was established for sample collection within each of the two potentially impacted areas and the reference area. Each sample plot was subdivided into 25 subplots, of which only 10 to 20 subplots were sampled. Composite samples of soil and composite samples of vegetation within each subplot were collected.

The sagebrush steppe habitat is dominated by shrubs and grasses. The most prevalent communities in the area are characterized by codominance of sagebrush (*Artemisia* spp.) and perennial bunch grasses (*Agropyron* spp and *Elymus* spp.). Therefore, the following were chosen as the target species and plant tissue types from which vegetation was to be sampled from several plants within each subplot and composited:

- Big sagebrush (*Artemisia tridentata*) leaves and petioles (washed and unwashed);
- Thickspike wheatgrass (*Elymus lanceolaths (Scribn. & Sm.) Gould, formerly Agropyron dasystachyum)* leaves and stems (unwashed). Other common names for *E. lanceolaths* include northern wheatgrass (Britton and Brown 1970).

Since contaminant accumulation in vegetation may be due to either deposition of airborne particulates or soil uptake, half of the sagebrush vegetation mass obtained during

sampling was washed to remove loosely adhering contaminant particles; the remaining half of the sagebrush sample and all of the grass foliage samples were analyzed unwashed.

To assess the potential for bioaccumulation through higher trophic levels, concentrations of COPCs in deer mice (*Peromyscus maniculatus*) were determined. Deer mice are widespread throughout the area and potentially may ingest COPCs through soil, seeds, and foliage, or through consumption of invertebrates, e.g., grasshoppers and beetles. Because these mice serve as prey for raptors and other species of potential interest, they are an important link in local food webs. Deer mice were trapped from each of the three 1-hectare sample plots representative of sagebrush steppe habitat, and deer mice carcasses were assayed individually. Femurs were removed from deer mice and analyzed for fluoride, since the skeleton is the primary site of fluoride accumulation.

Riparian Habitat

Two riparian habitat locations—one potentially impacted location (see Figure B-2) and one reference location (see Figure B-3)—were sampled for soil and vegetation (see Table B-3). The potentially impacted location is along the Portneuf River, approximately 1 mile north-northeast of the EMF facilities. The reference site is along the Snake River just below the mouth of the Blackfoot River, approximately 15 miles north-northeast of the EMF site.

At each habitat location, a sample plot was established encompassing one or both sides of the Portneuf River along a 500-meter reach. The sample plot was divided into 20 subplots from which composited soil samples and vegetation samples were obtained. Vegetation samples consisted of the current year's fruit of Russian olive (*Elaeagnus angustifolia*), a favored food item of songbirds. Small mammals were not collected in the riparian habitat.

B.1.1.2 Analytical Parameters and Numbers of Samples

Soil and Vegetation

Composited surface soil and composited vegetation samples were collected at each of the five locations (three sagebrush steppe and two riparian locations). Both sample types were analyzed for cadmium, fluoride, and zinc. Additional soil parameters consisted of the following: pH, cation exchange capacity (CEC), soluble cation concentrations, and total organic carbon (TOC). The rationale for these parameters, as well as for soil and vegetation

analytical methods and associated detection limits, were provided in the FSP (E & E 1994b) and Quality Assurance Project Plan (QAPjP) for the ecological assessment (E & E 1994c).

The number of soil samples collected are summarized in Table B-4. A total of 50 soil samples were collected: composited soil samples were collected from 10 subplots at each of the three sagebrush steppe study locations, for a total of 30 soil samples, and from 10 subplots at each of two riparian study locations, for a total of 20 soil samples.

The number of vegetation samples collected are also summarized in Table B-4. A total of 110 vegetation samples were collected. Composited samples of big sagebrush foliage were collected from 20 subplots at each of three sagebrush steppe study locations, for a total of 60 sagebrush foliage samples. Each sagebrush sample was divided into two fractions in the laboratory, to provide a total of 120 samples for analysis (60 unwashed and 60 washed). Composited samples of thickspike wheatgrass stems and leaves were collected from 10 subplots at each of the three sagebrush steppe study locations, for a total of 30 thickspike wheatgrass samples. Composited samples of Russian olive fruit were collected from 10 subplots at each of the two riparian study locations, for a total of 20 Russian olive fruit samples. With the exception of sagebrush, 10 vegetation samples from each study site was considered adequate to distinguish the site from reference areas. Twenty sagebrush samples from each study site were required for fluoride analysis, whereas only 10 sagebrush samples from each study site were required for the other analyses (see Appendix C). The total number of analyses performed on soil and vegetation samples are summarized in Table B-5.

Small Mammals

Deer mice were collected from the three sagebrush steppe locations and analyzed for cadmium, fluoride, and zinc. Whole carcasses of individual mice were analyzed for cadmium, fluoride, and zinc; mouse femurs were analyzed separately for fluoride. Compositing of mouse femurs was done only if necessary to provide sufficient tissue mass for analysis.

The numbers of deer mouse samples collected are summarized in Table B-4. Ten mice were collected from each of the three sagebrush steppe study locations, for a total of 30 deer mouse samples. Femurs were removed from the deer mice in the laboratory and analyzed separately for fluoride. Ten small mammal samples from each study site was considered an adequate number to statistically distinguish potentially impacted areas from the

reference area (see Appendix C). The total number of analyses performed on deer mice are summarized in Table B-5.

B.1.2 Aquatic Investigations

B.1.2.1 Sample Locations, Media, and Target Species

Two distinct aquatic investigations were conducted in the Portneuf River and its delta at the American Falls Reservoir. The first investigation involved sediment sampling for chemical analysis and toxicity testing and was conducted in riverine habitat in the vicinity of the IWW ditch outfall. The second investigation involved sediment sampling for chemical analysis and was conducted several miles downriver from the operational site facilities, in depositional areas of the Portneuf River delta.

IWW Ditch Outfall

The IWW ditch is a small drainage ditch that transports noncontact cooling waters to the Portneuf River. The ditch is located above ground, approximately 500 m from the FMC facility aeration device to an underground pipe. After water enters the pipe, it is eventually discharged into the Portneuf River. Maximum water flow in the IWW ditch is less than 10 cubic feet per second. Seasonally, the IWW ditch has lush annual and perennial vegetation growing along its margins and a significant freshwater periphyton component.

In sediment sampling conducted for the Phase I RI/FS, a variety of sediment COPCs, including cadmium, fluoride, and zinc, were found at their highest concentrations in the Portneuf River at this outfall location. Levels of these COPCs were not found to be as elevated at other Portneuf River locations upstream of the outfall, or downstream of the outfall to River Mile 10 (E & E 1993). Therefore, these investigations were intended to determine the bioavailability and toxicity of sediment near this outfall.

The potential localized impact of the IWW ditch outfall and other facility outfalls that historically discharged at this location were assessed by sampling sediment within 20 m downstream from where water from the pipe enters the river (identified as Sampling Station No. 17 [BEI 1992]). Two other sites on the Portneuf River in the vicinity of the outfall were sampled for sediment, one upstream of the IWW ditch outfall to serve as a reference location (identified as Sampling Station No. 21 [BEI 1992]) and one downstream of the outfall (identified as Sampling Station No. 16 [BEI 1992]). Sampling locations are described in Table B-6 and shown on Figure B-4. Assays of COPCs in composited sediment samples at

each location were performed, as were laboratory bioassays to determine potential sediment toxicity to benthic organisms.

Portneuf River Delta

There were three reasons for conducting studies in the delta region of the Portneuf River. First, no samples of water, sediment, or avian food items (benthic invertebrates and fish) were collected from the Portneuf River delta in the remedial investigation; thus, levels of site contaminants in environmental media and biota in this area are available only from previous investigations (e.g., Low and Mullins 1990). Second, the Portneuf River delta is an important breeding and feeding area for game waterfowl, piscivorous birds, and shorebirds, and is considered to have high ecological value. Third, sediment in the Portneuf River delta may have higher contaminant levels than sediment from upstream locations, because suspended particles that adsorb contaminants are deposited in the delta area.

The Snake River delta was selected as a reference ecosystem for the Portneuf River delta because the two rivers are similarly impacted by human activities. For example, both rivers receive irrigation drainage, flow through urban areas, and empty into American Falls Reservoir (Low and Mullins 1990). In addition, the deltas of both rivers provide similar aquatic habitat and are used by the same species of benthic invertebrates, fish, and waterfowl.

One purpose of sampling in the Portneuf River delta area was to estimate wildlife exposure to site contaminants. Therefore, sediment samples were collected from areas where birds concentrate and/or feed. Two main types of aquatic habitats in both delta areas were sampled: open water habitats within the river channel, which are likely to support fish-eating birds and dabbling ducks; and shallow water or exposed mudflat habitats adjacent to the river channel, which would support wading birds. Mudflat locations (even if dry) were selected from level areas, not from river banks. During the reconnaissance survey, waterfowl and shorebirds were observed to be concentrated in these habitats.

Sample collection sites in the delta areas are described in Table B-6 and illustrated in Figures B-5 and B-6. The sediment sampling program was designed so that five sampling stations in each river system were located above, and five stations were located below, the intersection the river and American Falls Reservoir (i.e., the average high water line).

In the Portneuf River delta, the two most upstream sampling sites were located approximately 0.5 km and approximately 1 km upstream of the furthest downstream site previously sampled in the RI/FS (identified as Sampling Station C [BEI 1994]) (see Figure

B-5). Eight subsequent sites were located at approximately 1-km intervals along the channel. Thus, there were 10 sampling sites in the Portneuf River delta. At each site, sediment was collected from the river channel and from the exposed mudflats or shallow water habitat adjacent to the channel.

For comparison with samples from the Portneuf River delta, samples were collected from 10 sample sites in the Snake River delta (see Figure B-6). The most upstream site was located on the Snake River near McTucker Island; subsequent sites were located at 1-km intervals along the channel. Thus, there were 10 sampling sites in the Snake River delta. At each site, sediment was collected from the river channel and from the exposed mudflats or shallow water habitat adjacent to the channel.

B.1.3 Analytical Parameters and Numbers of Samples

B.1.3.1 IWW Ditch Outfall

For the investigation of sediment toxicity at the IWW ditch outfall, one composited sediment sample was collected from each of three locations in the Portneuf River: at the IWW ditch outfall (Station 17), upstream of the IWW ditch outfall at Station 21, and downstream of the IWW ditch outfall at Station 16. Each of the three composited sediment samples was analyzed for fluoride, ammonia, TAL inorganic analytes, pH, TOC, acid-volatile sulfide/simultaneously extracted metals (AVS/SEM), particle-size distribution, and percent solids. The rationale for these parameters, as well as for analytical methods and associated detection limits, are provided in the FSP (E & E 1994b) and QAPjP (E & E 1994c). In addition, a subsample of the three sediment samples was used in toxicity tests with the amphipod (*Hyallela azteca*) and the midge (*Chironomus tentans*) (ASTM 1993). The numbers of samples are included in Table B-7, and the sediment analyses are summarized in Table B-8.

B.1.3.2 Portneuf River Delta

For the Portneuf River delta study, sediment samples from river channel and mudflat sites in the Portneuf and Snake River deltas were measured for fluoride, cadmium, zinc, arsenic, mercury, selenium, aluminum, iron, and additional parameters that play a role in metal speciation and bioavailability in sediment. The total number of samples collected from the Portneuf River and Snake River deltas are summarized in Table B-7, and the sediment analyses are summarized in Table B-8. For the Portneuf River delta, 20 sediment samples

(10 channel locations and 10 adjacent mudflats) were judged to be the minimum needed to characterize sediment in the approximately 10 km of river channel in the delta area. For comparison, the same number of water and sediment samples were collected from a 10-km length of the Snake River delta.

B.2 ECOLOGICAL ASSESSMENT SAMPLING RESULTS

The tables in Section B-2 (Tables B-9 through B-23) list two concentration values for each analyte in each sample type. The first value is the concentration reported by the laboratory along with any associated qualifiers; this value is referred to as the "detected concentration" in the tables. The second value is the "concentration for risk assessment". For data points with no qualifiers, the "detected concentration" and "concentration for risk assessment" are the same. Data values with qualifiers were handled as described in Section 3.2 (Data Evaluation). The reviewer qualifiers and qualification codes used in data validation for EPA Superfund projects are listed below. Qualification codes are placed after certain review qualifiers to define the analytical problem encountered during analysis. For example, J8 means that the reported value is an estimate because recovery of the matrix spike was outside acceptable limits for the analysis.

Reviewer Qualifiers:

- U = The material was analyzed for, but was not detected. The associated numerical value is the sample quantification limit.
- J = The associated numerical value is an estimated quantity.
- R = The data are unusable (compound may or may not be present). Resampling and reanalysis are necessary for verification.
- N = Presumptive evidence of presence of material.
- NJ = Presumptive evidence of the presence of material at an estimated quantity.
- UJ = The material was analyzed for, but was not detected. The sample quantitation limit is an estimated quantity.
- K = Data quality unknown due to missing or untraceable QC information or analytical practices inconsistent with specified analytical protocol. Data use commensurate with EPA data quality objective analytical level II.
- V = Unvalidated. Result could not be validated because raw data was not available. Data was reviewed and qualified to the extent possible. Data use is commensurate with EPA data quality objective analytical level III.

Qualification Codes:

1. Holding Times
2. Sample Preservation

3. Sample Custody
4. Missing Deliverables
5A. Calibration (initial)
5B. Calibration (continuing)
6. Field Blanks
7. Lab Blanks
8. Matrix Spike
9. Duplicate or Matrix Spike Duplicate
10. LCS (Laboratory Control Sample)
11. Detection Limit
12. Standards
13. Surrogates
14. Other
15. Furnace
16. CIP Serial Dilution
17. Chemical Recoveries
18. Trip Blanks
19. Internal Standards
20. Linear Range Exceeded
21. Potential False Positives
22. Sample lost in analysis

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Table B-1

OVERVIEW OF COPCs AND SAMPLE MATRICES

Potentially Affected Media	Sample Matrices	COPCs
Soil	Surface soil	Fluoride, cadmium, and zinc
Vegetation	Big sagebrush - foliage (washed and unwashed)	Fluoride, cadmium, and zinc
	Thickspike wheatgrass - stems and leaves	
	Russian Olive - fruit	
Small mammals	Deer mouse - whole organism	Fluoride, cadmium, and zinc
	Deer mouse - femur	Fluoride
Sediment	Surface sediment	Fluoride, cadmium, zinc, selenium, mercury, and arsenic

Table B-2

OVERVIEW OF HABITATS AND SAMPLE MATRICES

Habitats	Sample Matrices
Terrestrial - sagebrush steppe	Surface soil
	Big sagebrush - foliage (washed and unwashed)
	Thickspike wheatgrass - stems and leaves
	Deer mouse - whole organism and femur
Terrestrial - riparian	Surface soil
	Russian olive - fruit
Aquatic - river delta	Surface sediment
Aquatic - riverine	Surface sediment

Table B-3

LOCATIONS OF TERRESTRIAL STUDY SITES

Habitats	Study Sites	Location
Sagebrush steppe	Michaud Flats	Approximately 1 mile NNE of the FMC/Simplot facility on Michaud Flats, near the Portneuf River. 42° 55' 23.9" North; 112° 31' 37.2" West; 4,096 feet AMSL.
	Bannock Hills SW	Approximately 1-2 miles SW of the FMC/Simplot facility near electrical substation.
	Ferry Butte[a]	Approximately 15 miles NNE of the FMC/Simplot facility near the Blackfoot River. 43° 07' 29.4" North; 112° 29' 0.06" West; 4,358 feet AMSL.
Riparian	Portneuf River	Approximately 1 mile NNE of the FMC/Simplot facility on the Portneuf River. 42° 55' 16.0" North; 112° 31' 34.8" West; 4,208 feet AMSL.
	Snake River[a]	Approximately 15 miles NNE of the FMC/Simplot facility near the confluence of the Blackfoot and Snake rivers. 43° 07' 35.3" North; 112° 30' 44.8" West; 4,493 feet AMSL.

[a] Reference areas.

Key:

AMSL = Above mean sea level.

Table B-4

TOTAL NUMBER OF INVESTIGATIVE SAMPLES FOR SOIL, VEGETATION, AND SMALL MAMMALS

Sample Matrices	Sagebrush Steppe Locations			Riparian Locations		Total Number of Samples
	Michaud Flats	Bannock Hills SW	Ferry Butte	Portneuf River	Snake River	
Surface soil	10	10	10	10	10	50
Big sagebrush-foliage[a]	20	20	20	—	—	60
Thickspike wheatgrass - foliage	10	10	10	—	—	30
Russian olive - fruit	—	—	—	10	10	20
Deer mouse - whole organism[b]	10	10	10	—	—	30
Total number of samples	50	50	50	20	20	190

a Sagebrush foliage samples were divided into washed and unwashed fractions in the laboratory to provide a total of 120 samples.

b Deer mouse femurs were removed in the laboratory and analyzed separately for fluoride.

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Table B-5

TOTAL NUMBER OF INVESTIGATIVE ANALYSES FOR SOIL, VEGETATION, AND SMALL MAMMALS

Parameter	Sagebrush Steppe Locations						Riparian Locations		Total Number of Analyses
	Surface Soil	Sagebrush Foliage - Washed	Sagebrush Foliage - Unwashed	Thickspike Wheatgrass - Foliage	Deer Mouse - Whole	Deer Mouse - Femurs	Surface Soil	Russian Olive - Fruit	
Cadmium and zinc	30	30	30	30	30	—	20	20	190
Fluoride	30	60	60	30	30	30	20	20	280
pH, total organic carbon (TOC), CEC, redox potential, and soluble cations	30	—	—	—	—	—	20	—	50

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Table B-6

LOCATIONS OF AQUATIC STUDY SITES

Habitats	Study Sites	Location
IWW Ditch Outfall	Portneuf River upstream of the IWW ditch outfall[a]	Previously identified as Sampling Station No. 21.
	Portneuf River at the IWW ditch outfall	Within 20 meters downstream of the confluence of the IWW ditch outfall and the Portneuf River. Previously identified as Sampling Station No. 17.
	Portneuf River downstream of the IWW ditch outfall	Previously identified as Sampling Station No. 16.
Portneuf River Delta at American Falls Reservoir	Portneuf River Delta at American Falls Reservoir	Ten locations at approximately 1-km intervals starting approximately 1 km upstream from Station C and proceeding downstream (see Figure B-5).
	Snake River Delta[a] at American Falls Reservoir	Ten locations at approximately 1-km intervals starting near McTucker Island and proceeding downstream (see Figure B-6).

[a] Reference areas.

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Table B-7

TOTAL NUMBER OF INVESTIGATIVE SAMPLES FOR SEDIMENT

Sample Matrices	IWW Ditch Outfall	Portneuf River Delta		Snake River Delta		Other Portneuf River Locations	Total Number of Samples
		River Channel	Mudflats	River Channel	Mudflats		
Sediment - chemical analysis	1	10	10	10	10	2	43
Sediment - toxicity testing	1	—	—	—	—	2	3
Total Number of Samples	2	10	10	10	10	4	46

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Table B-8

TOTAL NUMBER OF INVESTIGATIVE ANALYSES FOR SEDIMENT

Parameter	IWW Ditch Outfall	Portneuf River Delta	Snake River Delta	Other Portneuf River Locations	Total Number of Analyses
Aluminum, arsenic, cadmium, fluoride, iron, mercury, selenium, zinc	1	20	20	2	43
Acid-volatile sulfide and simultaneously extracted metals	1	20	20	2	43
Total organic carbon	1	20	20	2	43
Particle-size distribution	1	20	20	2	43
Toxicity to *Hyallela azteca* and *Chironomus tentans*	1	—	—	2	3

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Table B-9

**TERRESTRIAL INVESTIGATIONS
SAGEBRUSH STEPPE AND RIPARIAN HABITATS
CADMIUM, FLUORIDE, AND ZINC IN SOIL
(mg/kg)**

Sample	Cadmium		Fluoride		Zinc	
	Detected Concentration	Concentration for Risk Assessment	Detected Concentration	Concentration for Risk Assessment	Detected Concentration	Concentration for Risk Assessment
Bannock Hills SW (Sagebrush Steppe)						
DOCU0101	31.6	31.6	1,520	1,520	282	282
DOCU0102	28.1	28.1	1,540	1,540	252	252
DOCU0103	28.7	28.7	1,370	1,370	281	281
DOCU0104	21	21	1,330	1,330	202	202
DOCU0105	29.9	29.9	1,630	1,630	262	262
DOCU0106	22.7	22.7	1,100	1,100	220	220
DOCU0107	34.1	34.1	1,680	1,680	342	342
DOCU0108	18.6	18.6	1,260	1,260	183	183
DOCU0109	27	27	1,270	1,270	244	244
DOCU0110	30.5	30.5	1,840	1,840	290	290
Michaud Flats (Sagebrush Steppe)						
DOCU0201	14.4	14.4	1,380	1,380	110	110
DOCU0202	31.1	31.1	3,200	3,200	219	219
DOCU0203	25.5	25.5	2,120	2,120	176	176
DOCU0204	29.1	29.1	1,830	1,830	193	193
DOCU0205	13.7	13.7	1,320	1,320	97.6	97.6

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Table B-9

**TERRESTRIAL INVESTIGATIONS
SAGEBRUSH STEPPE AND RIPARIAN HABITATS
CADMIUM, FLUORIDE, AND ZINC IN SOIL
(mg/kg)**

Sample	Cadmium		Fluoride		Zinc	
	Detected Concentration	Concentration for Risk Assessment	Detected Concentration	Concentration for Risk Assessment	Detected Concentration	Concentration for Risk Assessment
DOCU0206	27.3	27.3	2,580	2,580	201	201
DOCU0207	9.4	9.4	850	850	88.4	88.4
DOCU0208	16.3	16.3	1,045	1,045	137	137
DOCU0209	26.9	26.9	1,960	1,960	201	201
DOCU0210	16.7	16.7	1,640	1,640	136	136
Ferry Butte (Sagebrush Steppe)						
DOCU0301	0.62	0.62	342	342	61.1	61.1
DOCU0302	0.57	0.57	421	421	56.4	56.4
DOCU0303	1.2	1.2	375	375	49.4	49.4
DOCU0304	0.51	0.51	344	344	59.5	59.5
DOCU0305	0.7	0.7	365	365	53.7	53.7
DOCU0306	0.57	0.57	330	330	57.1	57.1
DOCU0307	0.84	0.84	349	349	64.1	64.1
DOCU0308	0.47	0.47	372	372	54.9	54.9
DOCU0309	0.47	0.47	330	330	58.3	58.3
DOCU0310	0.81	0.81	406	406	50.2	50.2

Table B-9

**TERRESTRIAL INVESTIGATIONS
SAGEBRUSH STEPPE AND RIPARIAN HABITATS
CADMIUM, FLUORIDE, AND ZINC IN SOIL
(mg/kg)**

Sample	Cadmium		Fluoride		Zinc	
	Detected Concentration	Concentration for Risk Assessment	Detected Concentration	Concentration for Risk Assessment	Detected Concentration	Concentration for Risk Assessment
Portneuf River (Riparian)						
DOCU0401	4.9	4.9	600	600	81.6	81.6
DOCU0402	7.6	7.6	950	950	101	101
DOCU0403	12.8	12.8	1,300	1,300	142	142
DOCU0404	0.64	0.64	321	321	47.4	47.4
DOCU0405	4.3	4.3	670	670	75.5	75.5
DOCU0406	4.4	4.4	720	720	72.3	72.3
DOCU0407	5.6	5.6	435	435	80.9	80.9
DOCU0408	27.6	27.6	2,930	2,930	197	197
DOCU0409	18.9	18.9	1,260	1,260	173	173
DOCU0410	16.6	16.6	1,540	1,540	167	167
Snake River (Riparian)						
DOCU0501	0.26 J8	0.26	298	298	26.1	26.1
DOCU0502	0.17 J8	0.17	226	226	26.7	26.7
DOCU0503	0.4 J8,15	0.4	275	275	31.5	31.5
DOCU0504	0.3 J8,15	0.3	253	253	21.2	21.2
DOCU0505	0.31 J8	0.31	252	252	28.5	28.5

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Table B-9

**TERRESTRIAL INVESTIGATIONS
SAGEBRUSH STEPPE AND RIPARIAN HABITATS
CADMIUM, FLUORIDE, AND ZINC IN SOIL
(mg/kg)**

Sample	Cadmium		Fluoride		Zinc	
	Detected Concentration	Concentration for Risk Assessment	Detected Concentration	Concentration for Risk Assessment	Detected Concentration	Concentration for Risk Assessment
DOCU0506	0.2 J8	0.2	175	175	15.5	15.5
DOCU0507	0.25 J8	0.25	213	213	21.2	21.2
DOCU0508	0.23 J8	0.23	250	250	23.2	23.2
DOCU0509	0.3 J8,15	0.3	238	238	24.3	24.3
DOCU0510	0.2 J8,15	0.2	265	265	22.9	22.9

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Table B-10

TERRESTRIAL INVESTIGATIONS
SAGEBRUSH STEPPE AND RIPARIAN HABITATS
SOLUBLE CATIONS IN SOIL
(mg/kg)

Sample	Calcium		Iron		Magnesium		Potassium		Sodium	
	Detected Concentration	Concentration for Risk Assessment	Detected Concentration	Concentration for Risk Assessment	Detected Concentration	Concentration for Risk Assessment	Detected Concentration	Concentration for Risk Assessment	Detected Concentration	Concentration for Risk Assessment
Bannock Hills SW (Sagebrush Steppe)										
DOCU0101	76.3	76.3	0.55	0.55	6.6	6.6	12.2	12.2	11.8 J8,16	11.8
DOCU0102	89.1	89.1	4.7	4.7	7.2	7.2	14.6	14.6	6.6 J8,16	6.6
DOCU0103	17.1	17.1	2.5	2.5	2.1	2.1	5	5	8.1 J8,16	8.1
DOCU0104	22.6	22.6	1.2	1.2	1.7	1.7	4.9	4.9	5.4 J8,16	5.4
DOCU0105	24.3	24.3	1.9	1.9	2.1	2.1	3.8	3.8	6 J8,16	6
DOCU0106	21	21	1.8	1.8	1.9	1.9	4.4	4.4	4.5 J8,16	4.5
DOCU0107	14.7	14.7	1.4	1.4	1.4	1.4	2.9	2.9	2.3 J8,16	2.3
DOCU0108	24	24	2.7	2.7	2.5	2.5	5	5	4.2 J8,16	4.2
DOCU0109	25.1	25.1	9.8	9.8	5.7	5.7	9.4	9.4	4.7 J8,16	4.7
DOCU0110	40.9	40.9	11.9	11.9	7.5	7.5	13.2	13.2	5.9 J8,16	5.9
Michaud Flats (Sagebrush Steppe)										
DOCU0201	16.7	16.7	10.4	10.4	5.2	5.2	8	8	5.3 J16	5.3
DOCU0202	25.1	25.1	9.6	9.6	5.3	5.3	7.9	7.9	5.1 J16	5.1
DOCU0203	17.8	17.8	13.8	13.8	6.6	6.6	9.1	9.1	5.1 J16	5.1
DOCU0204	33.3	33.3	14.4	14.4	8.5	8.5	10.9	10.9	6.2 J16	6.2
DOCU0205	22.6	22.6	10.8	10.8	6	6	7	7	7 J16	7
DOCU0206	23.4	23.4	10.8	10.8	5.9	5.9	6.2	6.2	5.8 J16	5.8

Table B-10

TERRESTRIAL INVESTIGATIONS
SAGEBRUSH STEPPE AND RIPARIAN HABITATS
SOLUBLE CATIONS IN SOIL
(mg/kg)

Sample	Calcium		Iron		Magnesium		Potassium		Sodium	
	Detected Concentration	Concentration for Risk Assessment	Detected Concentration	Concentration for Risk Assessment	Detected Concentration	Concentration for Risk Assessment	Detected Concentration	Concentration for Risk Assessment	Detected Concentration	Concentration for Risk Assessment
DOCU0207	39.4	39.4	33.1	33.1	19.2	19.2	21.8	21.8	9.9 J16	9.9
DOCU0208	25	25	10.8	10.8	7	7	7.7	7.7	5.9 J16	5.9
DOCU0209	25.6	25.6	12	12	6.6	6.6	9	9	5.8 J16	5.8
DOCU0210	26.6	26.6	29.1	29.1	14.2	14.2	12.3	12.3	7.6 J16	7.6
Ferry Butte (Sagebrush Steppe)										
DOCU0301	17.5	17.5	58.8	58.8	16.9	16.9	20.9 J8	20.9	5.3 U7	Rejected
DOCU0302	16.2	16.2	8.4	8.4	7.2	7.2	7	7	5.1 U7	Rejected
DOCU0303	16.6	16.6	19.1	19.1	10.8	10.8	14.6 J8	14.6	7.5	7.5
DOCU0304	27.8	27.8	88.6	88.6	34.2	34.2	32.5 J8	32.5	8.1	8.1
DOCU0305	20.4	20.4	42.2	42.2	18.5	18.5	23.8 J8	23.8	5.9 U7	Rejected
DOCU0306	20.8	20.8	22.1	22.1	12.6	12.6	11.5 J8	11.5	4.4 U7	Rejected
DOCU0307	14.9	14.9	2.1	2.1	4.5	4.5	9 J8	9	8.3	8.3
DOCU0308	40.9	40.9	20.3	20.3	15.3	15.3	25.1 J8	25.1	7.4 U7	Rejected
DOCU0309	26.1	26.1	76.1	76.1	32.7	32.7	29.6 J8	29.6	6.1 U7	Rejected
DOCU0310	39.1	39.1	24.8	24.8	19.9	19.9	21.4 J8	21.4	7.2 U7	Rejected
Portneuf River (Riparian)										
DOCU0401	36.1	36.1	5.8	5.8	19.1	19.1	21.5 J8	21.5	80.6	80.6
DOCU0402	249	249	0.69	0.69	113	113	80.5 J8	80.5	124	124

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Table B-10

TERRESTRIAL INVESTIGATIONS
SAGEBRUSH STEPPE AND RIPARIAN HABITATS
SOLUBLE CATIONS IN SOIL
(mg/kg)

Sample	Calcium		Iron		Magnesium		Potassium		Sodium	
	Detected Concentration	Concentration for Risk Assessment	Detected Concentration	Concentration for Risk Assessment	Detected Concentration	Concentration for Risk Assessment	Detected Concentration	Concentration for Risk Assessment	Detected Concentration	Concentration for Risk Assessment
DOCU0403	147	147	2.3	2.3	52.4	52.4	70.4 J8	70.4	63.8	63.8
DOCU0404	32.5	32.5	17	17	14	14	14.3 J8	14.3	71.1	71.1
DOCU0405	48.7	48.7	1.9	1.9	22.7	22.7	36.4 J8	36.4	140	140
DOCU0406	40.4	40.4	2.1	2.1	17.2	17.2	20.8 J8	20.8	184	184
DOCU0407	32.5	32.5	2.3	2.3	14.9	14.9	10.4 J8	10.4	30.2	30.2
DOCU0408	37.1	37.1	.93	0.93	9.2	9.2	42.5 J8	42.5	27.2	27.2
DOCU0409	50.4	50.4	1.9	1.9	26.1	26.1	12.7 J8	12.7	54.7	54.7
DOCU0410	45	45	5.6	5.6	17.7	17.7	8.2 J8	8.2	70.3	70.3
Snake River (Riparian)										
DOCU0501	22.6	22.6	2.6 J8	2.6	4.6 J8	4.6	4.4 J8	4.4	11.6	11.6
DOCU0502	27.8	27.8	4.5 J8	4.5	6.6 J8	6.6	11.7 J8	11.7	11.3	11.3
DOCU0503	33	33	4.3 J8	4.3	7 J8	7	14.8 J8	14.8	12.6	12.6
DOCU0504	26.9	26.9	7.4 J8	7.4	8.3 J8	8.3	24.4 J8	24.4	8.2	8.2
DOCU0505	35.4	35.4	.81 J8	0.81	8.3 J8	8.3	20.5 J8	20.5	7.9	7.9
DOCU0506	15.2	15.2	1.2 J8	1.2	3.5 J8	3.5	14 J8	14	6.9	6.9
DOCU0507	26.7	26.7	3.5 J8	3.5	5 J8	5	16 J8	16	7.3	7.3

Table B-10

TERRESTRIAL INVESTIGATIONS
SAGEBRUSH STEPPE AND RIPARIAN HABITATS
SOLUBLE CATIONS IN SOIL
(mg/kg)

Sample	Calcium		Iron		Magnesium		Potassium		Sodium	
	Detected Concentration	Concentration for Risk Assessment	Detected Concentration	Concentration for Risk Assessment	Detected Concentration	Concentration for Risk Assessment	Detected Concentration	Concentration for Risk Assessment	Detected Concentration	Concentration for Risk Assessment
DOCU0508	20.3	20.3	1.5 J8	1.5	4.7 J8	4.7	19.8 J8	19.8	6.8	6.8
DOCU0509	30.9	30.9	4.1 J8	4.1	6.3 J8	6.3	13.1 J8	13.1	9.2	9.2
DOCU0510	25.8	25.8	1.3 J8	1.3	4 J8	4	9.7 J8	9.7	7.2	7.2

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Table B-11

TERRESTRIAL INVESTIGATIONS
SAGEBRUSH STEPPE AND RIPARIAN HABITATS
CEC, pH, AND TOC IN SOIL

Sample	CEC (meq/100g)		pH		TOC (mg/kg)	
	Detected Concentration	Concentration for Risk Assessment	Detected Concentration	Concentration for Risk Assessment	Detected Concentration	Concentration for Risk Assessment
Bannock Hills SW (Sagebrush Steppe)						
DOCU0101	28.3	28.3	7.68 J1	7.7	12500	12500
DOCU0102	26	26	7.82 J1	7.8	11300	11300
DOCU0103	21.9	21.9	7.83 J1	7.8	9500	9500
DOCU0104	22	22	8 J1	8	7210	7210
DOCU0105	26.2	26.2	7.93 J1	7.9	10700	10700
DOCU0106	22	22	7.94 J1	7.9	8560	8560
DOCU0107	27.4	27.4	7.81 J1	7.8	12200	12200
DOCU0108	24.4	24.4	7.76 J1	7.8	11500	11500
DOCU0109	25.1	25.1	7.85 J1	7.9	9740	9740
DOCU0110	23.6	23.6	7.68 J1	7.7	9870	9870
Michaud Flats (Sagebrush Steppe)						
DOCU0201	25.7	25.7	7.06 J1	7.1	13100 J8	13100
DOCU0202	34	34	6.51 J1	6.5	21500 J8	21500
DOCU0203	27.1	27.1	6.92 J1	6.9	16200 J8	16200
DOCU0204	29.3	29.3	6.91 J1	6.9	19200 J8	19200
DOCU0205	22.3	22.3	7.11 J1	7.1	13300 J8	13300
DOCU0206	26.9	26.9	7.06 J1	7.1	22900 J8	22900

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Table B-11

TERRESTRIAL INVESTIGATIONS
SAGEBRUSH STEPPE AND RIPARIAN HABITATS
CEC, pH, AND TOC IN SOIL

Sample	CEC (meq/100g)		pH		TOC (mg/kg)	
	Detected Concentration	Concentration for Risk Assessment	Detected Concentration	Concentration for Risk Assessment	Detected Concentration	Concentration for Risk Assessment
DOCU0207	26.8	26.8	7.38 J1	7.4	9780 J8	9780
DOCU0208	23.6	23.6	7.11 J1	7.1	11600 J8	11600
DOCU0209	28.2	28.2	6.85 J1	6.9	14000 J8	14000
DOCU0210	21.6	21.6	7.05 J1	7.1	18800 J8	18800
Ferry Butte (Sagebrush Steppe)						
DOCU0301	25.1	25.1	6.62	6.6	7040	7040
DOCU0302	22.2	22.2	6.87	6.9	8200	8200
DOCU0303	20.7	20.7	7.55	7.6	5420	5420
DOCU0304	21.7	21.7	6.88	6.9	4610	4610
DOCU0305	21.3	21.3	7.21	7.2	8920	8920
DOCU0306	22.6	22.6	7.23	7.2	10210	10210
DOCU0307	22.8	22.8	7	7	8100	8100
DOCU0308	20.5	20.5	7.75	7.8	33040	33040
DOCU0309	21.1	21.1	6.86	6.9	6220	6220
DOCU0310	26.8	26.8	6.96	7	9570	9570
Portneuf River (Riparian)						
DOCU0401	34.4	34.4	8.55 J1	8.6	18200	18200
DOCU0402	40.3	40.3	7.23 J1	7.2	20700	20700

Table B-11

TERRESTRIAL INVESTIGATIONS
SAGEBRUSH STEPPE AND RIPARIAN HABITATS
CEC, pH, AND TOC IN SOIL

Sample	CEC (meq/100g)		pH		TOC (mg/kg)	
	Detected Concentration	Concentration for Risk Assessment	Detected Concentration	Concentration for Risk Assessment	Detected Concentration	Concentration for Risk Assessment
DOCU0403	55.3	55.3	7.56 J1	7.6	36000	36000
DOCU0404	30	30	8.17 J1	8.2	16000	16000
DOCU0405	30.3	30.3	8.51 J1	8.5	25200	25200
DOCU0406	31.4	31.4	8.63 J1	8.6	21200	21200
DOCU0407	42.6	42.6	7.86 J1	7.9	13300	13300
DOCU0408	40.7	40.7	8.01 J1	8	23400	23400
DOCU0409	68.2	68.2	8.26 J1	8.3	26700	26700
DOCU0410	60.9	60.9	8.27 J1	8.3	23000	23000
Snake River (Riparian)						
DOCU0501	19.7	19.7	7.9 J1	7.9	5500	5500
DOCU0502	14.7	14.7	7.85 J1	7.9	10100	10100
DOCU0503	20.9	20.9	7.67 J1	7.7	14500	14500
DOCU0504	24.8	24.8	8.02 J1	8	14300	14300
DOCU0505	21.7	21.7	7.67 J1	7.7	26200	26200
DOCU0506	11.9	11.9	7.76 J1	7.8	12800	12800
DOCU0507	16.4	16.4	7.86 J1	7.9	18900	18900

Table B-11

**TERRESTRIAL INVESTIGATIONS
SAGEBRUSH STEPPE AND RIPARIAN HABITATS
CEC, pH, AND TOC IN SOIL**

Sample	CEC (meq/100g)		pH		TOC (mg/kg)	
	Detected Concentration	Concentration for Risk Assessment	Detected Concentration	Concentration for Risk Assessment	Detected Concentration	Concentration for Risk Assessment
DOCU0508	15.2	15.2	7.9 J1	7.9	7980	7980
DOCU0509	13	13	7.94 J1	7.9	9820	9820
DOCU0510	11	11	7.66 J1	7.7	10160	10160

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Table B-12

TERRESTRIAL INVESTIGATIONS
SAGEBRUSH STEPPE HABITAT
CADMIUM, FLUORIDE, AND ZINC IN SAGEBRUSH FOLIAGE (unwashed)
(mg/kg)

Sample	Cadmium		Fluoride		Zinc	
	Detected Concentration	Concentration for Risk Assessment	Detected Concentration	Concentration for Risk Assessment	Detected Concentration	Concentration for Risk Assessment
Bannock Hills SW (Sagebrush Steppe)						
VSUU0101	0.86	0.86	70.4 J14	70.4	28.6	28.6
VSUU0102	1	1	82.4 J14	82.4	26.1	26.1
VSUU0103	0.88	0.88	47.3 J14	47.3	31.4	31.4
VSUU0104	1.1	1.1	74.4 J14	74.4	27.1	27.1
VSUU0105	1.1	1.1	90.7 J14	90.7	30.9	30.9
VSUU0106	1.2	1.2	<24.2 UJ14	12.1	39.8	39.8
VSUU0107	1	1	86.3 J14	86.3	28	28
VSUU0108	0.97	0.97	80.4 J14	80.4	34.5	34.5
VSUU0109	1	1	115 J14	115	32.3	32.3
VSUU0110	0.81	0.81	115 J14	115	33.5	33.5
VSUU0111	NA	NA	122 J14	122	NA	NA
VSUU0112	NA	NA	98.2 J14	98.2	NA	NA
VSUU0113	NA	NA	58.5 J14	58.5	NA	NA
VSUU0114	NA	NA	76.5 J14	76.5	NA	NA
VSUU0115	NA	NA	77.6 J14	77.6	NA	NA

Key at end of table.

Table B-12

TERRESTRIAL INVESTIGATIONS
SAGEBRUSH STEPPE HABITAT
CADMIUM, FLUORIDE, AND ZINC IN SAGEBRUSH FOLIAGE (unwashed)
(mg/kg)

Sample	Cadmium		Fluoride		Zinc	
	Detected Concentration	Concentration for Risk Assessment	Detected Concentration	Concentration for Risk Assessment	Detected Concentration	Concentration for Risk Assessment
VSUU0116	NA	NA	51.7 J14	51.7	NA	NA
VSUU0117	NA	NA	61.8 J14	61.8	NA	NA
VSUU0118	NA	NA	57.4 J14	57.4	NA	NA
VSUU0119	NA	NA	<24.7 UJ14	12.35	NA	NA
VSUU0120	NA	NA	93.6 J14	93.6	NA	NA
Michaud Flats (Sagebrush Steppe)						
VSUU0201	1.2	1.2	43.9 J14	43.9	30.6	30.6
VSUU0202	1	1	35 J14	35	33.5	33.5
VSUU0203	1.2	1.2	41.9 J14	41.9	35.2	35.2
VSUU0204	0.97	0.97	46.4 J14	46.4	36.8	36.8
VSUU0205	1.3	1.3	43.3 J14	43.3	36.5	36.5
VSUU0206	1.2	1.2	48 J14	48	37.3	37.3
VSUU0207	1	1	34.5 J14	34.5	38.2	38.2
VSUU0208	1.5	1.5	51.4 J14	51.4	44.2	44.2
VSUU0209	1.7	1.7	86.2 J14	86.2	49.1	49.1
VSUU0210	1.6	1.6	114 J14	114	41.2	41.2

Key at end of table.

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Table B-12

TERRESTRIAL INVESTIGATIONS
SAGEBRUSH STEPPE HABITAT
CADMIUM, FLUORIDE, AND ZINC IN SAGEBRUSH FOLIAGE (unwashed)
(mg/kg)

Sample	Cadmium		Fluoride		Zinc	
	Detected Concentration	Concentration for Risk Assessment	Detected Concentration	Concentration for Risk Assessment	Detected Concentration	Concentration for Risk Assessment
VSUU0211	NA	NA	31.5 J14	31.5	NA	NA
VSUU0212	NA	NA	52.4 J14	52.4	NA	NA
VSUU0213	NA	NA	25.5 J14	25.5	NA	NA
VSUU0214	NA	NA	56.1 J14	56.1	NA	NA
VSUU0215	NA	NA	66.9 J14	66.9	NA	NA
VSUU0216	NA	NA	<22.3 J14	11.15	NA	NA
VSUU0217	NA	NA	56.4 J14	56.4	NA	NA
VSUU0218	NA	NA	67.4 J14	67.4	NA	NA
VSUU0219	NA	NA	87.8 J14	87.8	NA	NA
VSUU0220	NA	NA	31.3 J14	31.3	NA	NA
Ferry Butte (Sagebrush Steppe)						
VSUU0301	0.35	0.35	<24 UJ14	12	29.1	29.1
VSUU0302	<0.19 U	0.095	<24.5 UJ14	12.25	29.4	29.4
VSUU0303	<0.19 U	0.095	<24.9 UJ14	12.45	28.1	28.1
VSUU0304	<0.19 U	0.095	<24.4 UJ14	12.2	30.1	30.1
VSUU0305	<0.19 U	0.095	<23.4 UJ14	11.7	25.6	25.6

Key at end of table.

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Table B-12

TERRESTRIAL INVESTIGATIONS
SAGEBRUSH STEPPE HABITAT
CADMIUM, FLUORIDE, AND ZINC IN SAGEBRUSH FOLIAGE (unwashed)
(mg/kg)

Sample	Cadmium		Fluoride		Zinc	
	Detected Concentration	Concentration for Risk Assessment	Detected Concentration	Concentration for Risk Assessment	Detected Concentration	Concentration for Risk Assessment
VSUU0306	0.2	0.2	<24.5 UJ14	12.25	27.8	27.8
VSUU0307	0.21	0.21	<24.8 UJ14	12.4	36.4	36.4
VSUU0308	0.29	0.29	<24 UJ14	12	44.1	44.1
VSUU0309	0.21	0.21	<23.6 UJ14	11.8	28.7	28.7
VSUU0310	<0.2 U	0.1	<24.7 UJ14	12.35	22.7	22.7
VSUU0311	NA	NA	<24 UJ14	12	NA	NA
VSUU0312	NA	NA	<24.4 UJ14	12.2	NA	NA
VSUU0313	NA	NA	<24.3 UJ14	12.15	NA	NA
VSUU0314	NA	NA	<23.2 UJ14	11.6	NA	NA
VSUU0315	NA	NA	<24.3 UJ14	12.15	NA	NA
VSUU0316	NA	NA	<24.8 UJ14	12.4	NA	NA
VSUU0317	NA	NA	<23.7 UJ14	11.85	NA	NA
VSUU0318	NA	NA	<24.4 UJ14	12.2	NA	NA
VSUU0319	NA	NA	<24.4 UJ14	12.2	NA	NA
VSUU0320	NA	NA	<22.7 UJ14	11.35	NA	NA

Key:

NA = Not analyzed.

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Table B-13

**TERRESTRIAL INVESTIGATIONS
SAGEBRUSH STEPPE HABITAT
CADMIUM, FLUORIDE, AND ZINC IN SAGEBRUSH FOLIAGE (washed)
(mg/kg)**

Sample	Cadmium		Fluoride		Zinc	
	Detected Concentration	Concentration for Risk Assessment	Detected Concentration	Concentration for Risk Assessment	Detected Concentration	Concentration for Risk Assessment
Bannock Hills SW (Sagebrush Steppe)						
VSUU0101	0.6	0.6	<39 UJ	19.5	22.7	22.7
VSUU0102	0.81	0.81	<57.9 UJ	28.95	22.5	22.5
VSUU0103	0.68	0.68	<52.3 UJ	26.15	26.1	26.1
VSUU0104	0.68	0.68	<62.4 UJ	31.2	23.5	23.5
VSUU0105	0.76	0.76	<52.3 UJ	26.15	31.5	31.5
VSUU0106	0.87	0.87	<68.7 UJ	34.35	30.2	30.2
VSUU0107	0.77	0.77	<51.6 UJ	25.8	25.1	25.1
VSUU0108	0.76	0.76	<63.8 UJ	31.9	27.1	27.1
VSUU0109	01.2	1.2	<47.6 UJ	23.8	22.4	22.4
VSUU0110	0.59	0.59	<60.2 UJ	30.1	28.7	28.7
VSUU0111	NA	NA	<46.4 UJ	23.2	NA	NA
VSUU0112	NA	NA	<54.5 UJ	27.25	NA	NA
VSUU0113	NA	NA	<51.4 UJ	25.7	NA	NA
VSUU0114	NA	NA	<53.8 UJ	26.9	NA	NA
VSUU0115	NA	NA	<51.7 UJ	25.85	NA	NA
VSUU0116	NA	NA	<35.6 UJ	17.8	NA	NA

Key at end of table.

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Table B-13

TERRESTRIAL INVESTIGATIONS
SAGEBRUSH STEPPE HABITAT
CADMIUM, FLUORIDE, AND ZINC IN SAGEBRUSH FOLIAGE (washed)
(mg/kg)

Sample	Cadmium		Fluoride		Zinc	
	Detected Concentration	Concentration for Risk Assessment	Detected Concentration	Concentration for Risk Assessment	Detected Concentration	Concentration for Risk Assessment
VSUU0117	NA	NA	<56.4 UJ	28.2	NA	NA
VSUU0118	NA	NA	<58.2 UJ	29.1	NA	NA
VSUU0119	NA	NA	<52.8 UJ	26.4	NA	NA
VSUU0120	NA	NA	<30.1 UJ	15.05	NA	NA
Michaud Flats (Sagebrush Steppe)						
VSUU0201	1.1	1.1	<55.6 UJ	27.8	31.7	31.7
VSUU0202	0.92	0.92	<76.5 UJ	38.25	24	24
VSUU0203	1.2	1.2	<76.6 UJ	38.3	38.6	38.6
VSUU0204	1.3	1.3	<45.8 UJ	22.9	36.7	36.7
VSUU0205	1.2	1.2	<52.1 UJ	26.05	35	35
VSUU0206	1.5	1.5	<58.9 UJ	29.45	41.5	41.5
VSUU0207	1.1	1.1	<49.6 UJ	24.8	35.3	35.3
VSUU0208	1.1	1.1	<59.1 UJ	29.55	43.9	43.9
VSUU0209	0.61	0.61	<59.5 UJ	29.75	15	15
VSUU0210	0.96	0.96	<174 UJ	87	24.9	24.9
VSUU0211	NA	NA	<64 UJ	32	NA	NA
VSUU0212	NA	NA	<43.1 UJ	21.55	NA	NA

Key at end of table.

Table B-13

TERRESTRIAL INVESTIGATIONS
SAGEBRUSH STEPPE HABITAT
CADMIUM, FLUORIDE, AND ZINC IN SAGEBRUSH FOLIAGE (washed)
(mg/kg)

Sample	Cadmium		Fluoride		Zinc	
	Detected Concentration	Concentration for Risk Assessment	Detected Concentration	Concentration for Risk Assessment	Detected Concentration	Concentration for Risk Assessment
VSUU0213	NA	NA	<43.6 UJ	21.8	NA	NA
VSUU0214	NA	NA	<74.7 UJ	37.35	NA	NA
VSUU0215	NA	NA	<89.3 UJ	44.65	NA	NA
VSUU0216	NA	NA	<78.3 UJ	39.15	NA	NA
VSUU0217	NA	NA	<109 UJ	54.5	NA	NA
VSUU0218	NA	NA	<55.2 UJ	27.6	NA	NA
VSUU0219	NA	NA	<93.8 UJ	46.9	NA	NA
VSUU0220	NA	NA	<99.4 UJ	49.7	NA	NA
Ferry Butte (Sagebrush Steppe)						
VSUU0301	0.34	0.34	<24.6 UJ14	12.3	27.4	27.4
VSUU0302	0.2 U	0.1	<24.8 UJ14	12.4	25.6	25.6
VSUU0303	0.2 U	0.1	<24.8 UJ14	12.4	25.8	25.8
VSUU0304	0.2 U	0.1	<24.8 UJ14	12.4	27	27
VSUU0305	0.2 U	0.1	<25.2 UJ14	12.6	24.3	24.3
VSUU0306	.2 U	0.1	<24.1 UJ14	12.05	25.8	25.8
VSUU0307	0.21	0.21	<24.6 UJ14	12.3	26.9	26.9
VSUU0308	0.28	0.28	<27.8 UJ	13.9	40.7	40.7

Key at end of table.

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Table B-13

TERRESTRIAL INVESTIGATIONS
SAGEBRUSH STEPPE HABITAT
CADMIUM, FLUORIDE, AND ZINC IN SAGEBRUSH FOLIAGE (washed)
(mg/kg)

Sample	Cadmium		Fluoride		Zinc	
	Detected Concentration	Concentration for Risk Assessment	Detected Concentration	Concentration for Risk Assessment	Detected Concentration	Concentration for Risk Assessment
VSUU0309	0.23	0.23	<56 UJ	28	29.2	29.2
VSUU0310	.2 U	0.1	<24.4 UJ14	12.2	23.5	23.5
VSUU0311	NA	NA	<39.5 UJ	19.75	NA	NA
VSUU0312	NA	NA	<24.3 UJ14	12.15	NA	NA
VSUU0313	NA	NA	<24.3 UJ14	12.15	NA	NA
VSUU0314	NA	NA	<24.3 UJ14	12.15	NA	NA
VSUU0315	NA	NA	<36.3 UJ14	18.15	NA	NA
VSUU0316	NA	NA	<24.4 UJ14	12.2	NA	NA
VSUU0317	NA	NA	<24.4 UJ14	12.2	NA	NA
VSUU0318	NA	NA	<36.6 UJ	18.3	NA	NA
VSUU0319	NA	NA	<24.2 UJ14	12.1	NA	NA
VSUU0320	NA	NA	<36.1 UJ	18.05	NA	NA

Key:

NA = Not analyzed.

Table B-14

TERRESTRIAL INVESTIGATIONS
SAGEBRUSH STEPPE HABITAT
CADMIUM, FLUORIDE, AND ZINC IN THICKSPIKE WHEATGRASS LEAVES AND STEMS (unwashed)
(mg/kg)

Sample	Cadmium		Fluoride		Zinc	
	Detected Concentration	Concentration for Risk Assessment	Detected Concentration	Concentration for Risk Assessment	Detected Concentration	Concentration for Risk Assessment
Bannock Hills SW (Sagebrush Steppe)						
VGU0101	0.33	0.33	40.2 J14	40.2	8	8
VGU0102	0.35	0.35	39.6 J14	39.6	8.2	8.2
VGU0103	0.5	0.5	46.6 J14	46.6	10	10
VGU0104	0.45	0.45	39.6 J14	39.6	6.5	6.5
VGU0105	0.77	0.77	96.7 J14	96.7	15	15
VGU0106	0.88	0.88	111 J14	111	13.5	13.5
VGU0107	0.53	0.53	58.5 J14	58.5	16.5	16.5
VGU0108	0.69	0.69	52 J14	52	13.4	13.4
VGU0109	0.49	0.49	96.3 J14	96.3	11.1	11.1
VGU0110	0.4	0.4	40.7 J14	40.7	12.7	12.7
Michaud Flats (Sagebrush Steppe)						
VGU0201	0.52	0.52	35.4 J14	35.4	10.2	10.2
VGU0202	0.42	0.42	<25 UJ14	12.5	8	8
VGU0203	0.36	0.36	<24.4 UJ14	12.2	8.4	8.4
VGU0204	0.49	0.49	<22.7 UJ14	11.35	7.9	7.9
VGU0205	0.45	0.45	<23.8 UJ14	11.9	13	13

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Table B-14

TERRESTRIAL INVESTIGATIONS
SAGEBRUSH STEPPE HABITAT
CADMIUM, FLUORIDE, AND ZINC IN THICKSPIKE WHEATGRASS LEAVES AND STEMS (unwashed)
(mg/kg)

Sample	Cadmium		Fluoride		Zinc	
	Detected Concentration	Concentration for Risk Assessment	Detected Concentration	Concentration for Risk Assessment	Detected Concentration	Concentration for Risk Assessment
VGU0206	0.33	0.33	<24.2 UJ14	12.1	10.8	10.8
VGU0207	0.49	0.49	<24.1 UJ14	12.05	11.1	11.1
VGU0208	0.59	0.59	51.1 J14	51.1	15.1	15.1
VGU0209	0.44	0.44	40.9 J14	40.9	9.1	9.1
VGU0210	.52	0.52	25 J14	25	14.1	14.1
Ferry Butte (Sagebrush Steppe)						
VGU0301	<0.19 U	0.095	<24 UJ14	12	7.6	7.6
VGU0302	<0.2 U	0.1	<24.1 UJ14	12.05	5.2	5.2
VGU0303	<0.19 U	0.095	<23.5 UJ14	11.75	7.8	7.8
VGU0304	0.39	0.39	<24.1 UJ14	12.05	8.3	8.3
VGU0305	<0.17 U	0.085	<25 UJ14	12.5	9.4	9.4
VGU0306	<0.2 U	0.1	<24.8 UJ14	12.4	9.1	9.1
VGU0307	<0.13 U	0.065	<24.8 UJ14	12.4	10.5	10.5
VGU0308	<0.19 U	0.095	<24.4 UJ14	12.2	7.4	7.4
VGU0309	0.14	0.14	<24.5 UJ14	12.25	8.1	8.1
VGU0310	<0.15 U	0.075	<24.4 UJ14	12.2	8.9	8.9

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Table B-15

TERRSTRIAL INVESTIGATIONS
RIPARIAN HABITAT
CADMIUM, FLUORIDE, AND ZINC IN RUSSIAN OLIVE FRUIT (unwashed)
(mg/kg)

Sample	Cadmium		Flouride		Zinc	
	Detected Concentration	Concentration for Risk Assessment	Detected Concentration	Concentration for Risk Assessment	Detected Concentration	Concentration for Risk Assessment
Portneuf River (Riparian)						
VROU0401	<0.2 U	0.1	<24.8 UJ14	12.4	9.3	9.3
VROU0402	0.2	0.2	<24.7 UJ14	12.35	10.2	10.2
VROU0403	<0.2 U	0.1	<24.9 UJ14	12.45	8.9	8.9
VROU0404	<0.2 U	0.1	<24.7 UJ14	12.35	8.5	8.5
VROU0405	0.25	0.25	<23.4 UJ14	11.7	11.3	11.3
VROU0406	0.24	0.24	<24.6 UJ14	12.3	13.3	13.3
VROU0407	<0.2 U	0.1	<23.1 UJ14	11.55	7.3	7.3
VROU0408	0.24	0.24	<22.5 UJ14	11.25	11.9	11.9
VROU0409	<0.19 U	0.095	<24.4 UJ14	12.2	11.2	11.2
VROU0410	0.33	0.33	<22.8 UJ14	11.4	10.5	10.5
Snake River (Riparian)						
VROU0501	0.66	0.66	<23.8 UJ14	11.9	6.9	6.9
VROU0502	<0.2 U	0.1	<22.9 UJ14	11.45	9.4	9.4
VROU0503	<0.19 U	0.095	<23.7 UJ14	11.85	7.3	7.3
VROU0504	<0.2 U	0.1	<23.4 UJ14	11.7	5.8	5.8
VROU0505	<0.2 U	0.1	<23.7 UJ14	11.85	8.7	8.7

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Table B-15

TERRSTRIAL INVESTIGATIONS
RIPARIAN HABITAT
CADMIUM, FLUORIDE, AND ZINC IN RUSSIAN OLIVE FRUIT (unwashed)
(mg/kg)

Sample	Cadmium		Flouride		Zinc	
	Detected Concentration	Concentration for Risk Assessment	Detected Concentration	Concentration for Risk Assessment	Detected Concentration	Concentration for Risk Assessment
VROU0506	<0.2 U	0.1	<24.9 UJ14	12.45	7.5	7.5
VROU0507	<0.2 U	0.1	<23.8 UJ14	11.9	7.3	7.3
VROU0508	<0.19 U	0.095	<24.8 UJ14	12.4	5.4	5.4
VROU0509	<0.2 U	0.1	<22.7 UJ14	11.35	5.5	5.5
VROU0510	<0.2 U	0.1	<24.5 UJ14	12.25	8.1	8.1

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Table B-16

TERRESTRIAL INVESTIGATIONS
SAGEBRUSH STEPPE HABITAT
CADMIUM, FLUORIDE, AND ZINC IN DEER MOUSE TISSUE
(mg/kg)

Sample	Cadmium (whole body)		Fluoride (whole body)		Fluoride (femur)		Zinc (whole body)	
	Detected Concentration	Concentration for Risk Assessment	Detected Concentration	Concentration for Risk Assessment	Detected Concentration	Concentration for Risk Assessment	Detected Concentration	Concentration for Risk Assessment
Bannock Hills SW (Sagebrush Steppe)								
MWBU0101	1.2 J10	1.2	149 J8	149	226 J14	226	48.1	48.1
MWBU0102	0.68 J10	0.68	173 J8	173	451 J14	451	31.7	31.7
MWBU0103	0.64 J10	0.64	135 J8	135	280 J14	280	37.2	37.2
MWBU0104	0.37 J10	0.37	105 J8	105	285 J14	285	36.9	36.9
MWBU0105	0.59 J10	0.59	112 J8	112	<188 UJ14	94	36.9	36.9
MWBU0106	0.53 J10	0.53	109 J8	109	<375 UJ14	187.5	37.3	37.3
MWBU0107	0.24 J10	0.24	156 J8	156	<188 UJ14	94	41.5	41.5
MWBU0108	0.39 J10	0.39	93.8 J8	93.8	196 J14	196	34	34
MWBU0109	0.71 J10	0.71	109 J8	109	399 J14	399	40.4	40.4
MWBU0110	0.79 J10	0.79	143 J8	143	760 J14,10	760	40.8	40.8
Michaud Flats (Sagebrush Steppe)								
MWBU0201	0.4 J10	0.4	50.4 J8	50.4	423 J14,10	423	34.7	34.7
MWBU0202	0.12 J10	0.12	56.6 J8	56.6	519 J14,10	519	34.4	34.4
MWBU0203	0.09 J10	0.09	135 J8	135	853 J14,10	853	43.5	43.5
MWBU0204	0.14 J10	0.14	114 J8	114	561 J14,10	561	37	37
MWBU0205	0.23 J10	0.23	83.8 J8	83.8	609 J14,10	609	41.6	41.6

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Table B-16

TERRESTRIAL INVESTIGATIONS
SAGEBRUSH STEPPE HABITAT
CADMIUM, FLUORIDE, AND ZINC IN DEER MOUSE TISSUE
(mg/kg)

Sample	Cadmium (whole body)		Fluoride (whole body)		Fluoride (femur)		Zinc (whole body)	
	Detected Concentration	Concentration for Risk Assessment	Detected Concentration	Concentration for Risk Assessment	Detected Concentration	Concentration for Risk Assessment	Detected Concentration	Concentration for Risk Assessment
MWBU0206	0.19 J10	0.19	91.1 J8	91.1	677 J14,10	677	42.9	42.9
MWBU0207	0.36 J10	0.36	102 J8	102	1,030 J14,10	1,030	33	33
MWBU0208	0.14 J10	0.14	84 J8	84	537 J14,10	537	34.3	34.3
MWBU0209	0.08 J10	0.08	59.4 J8	59.4	291 J14,10	291	36	36
MWBU0210	0.42 J10	0.42	133 J8	133	833 J14,10	833	38.5	38.5
Ferry Butte (Sagebrush Steppe)								
MWBU0301	0.12 J5B	0.12	< 12.5 UJ8	6.25	301 J14,10	301	46.4	46.4
MWBU0302	0.04 J5B	0.04	< 13.6 UJ8	6.8	264 J14,10	264	34.1	34.1
MWBU0303	0.02 J5B	0.02	< 13.4 UJ8	6.7	< 160 UJ14,10	80	40.5	40.5
MWBU0304	0.14	0.14	< 15 UJ8	7.5	< 115 UJ14,10	57.5	48.3	48.3
MWBU0305	0.03 J5B	0.03	< 13.2 UJ8	6.6	< 234 UJ14,10	117	28.2	28.2
MWBU0306	0.02 J5B	0.02	< 14.7 UJ8	7.35	< 160 UJ14,10	80	32.6	32.6
MWBU0307	0.06	0.06	< 12.1 UJ8	6.05	< 139 UJ14,10	69.5	37	37
MWBU0308	0.03	0.03	< 13.6 UJ8	6.8	< 119 UJ14,10	59.5	33.6	33.6
MWBU0309	0.15	0.15	< 13.9 UJ8	6.95	195 J14,10	195	43.6	43.6
MWBU0310	0.05	0.05	< 14.2 UJ8	7.1	< 160 UJ14,10	80	41.4	41.4

Table B-17

AQUATIC INVESTIGATIONS
PORTNEUF RIVER AND SNAKE RIVER DELTAS
ALUMINUM, ARSENIC, AND CADMIUM IN SEDIMENT
(mg/kg)

Sample	Aluminum		Arsenic		Cadmium	
	Detected Concentration	Concentration for Risk Assessment	Detected Concentration	Concentration for Risk Assessment	Detected Concentration	Concentration for Risk Assessment
Portneuf River Bank						
SDCPDB01	4,610	4,610	2.4	2.4	0.51	0.51
SDCPDB02	10,700	10,700	3.5	3.5	1.4	1.4
SDCPDB03	12,500	12,500	3.9	3.9	1.3	1.3
SDCPDB04	12,900	12,900	3.3	3.3	1.6	1.6
SDCPDB05	15,100	15,100	4.4	4.4	1.2	1.2
SDCPDB06	14,200	14,200	4.6	4.6	0.96	0.96
SDCPDB07	8,210	8,210	2.7	2.7	0.71	0.71
SDCPDB08	5,930	5,930	2.5	2.5	0.6	0.6
SDCPDB09	5,300	5,300	2.5	2.5	0.81	0.81
SDCPDB10	7,510	7,510	2.9 U7	Rejected	0.77	0.77
Portneuf River Channel						
SDCPDC01	8,160	8,160	3.3	3.3	0.83	0.83
SDCPDC02	8,910	8,910	3.4	3.4	1.2	1.2
SDCPDC03	8,390	8,390	2.8	2.8	0.87	0.87
SDCPDC04	5,400	5,400	2.1	2.1	0.61	0.61

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Table B-17

AQUATIC INVESTIGATIONS
PORTNEUF RIVER AND SNAKE RIVER DELTAS
ALUMINUM, ARSENIC, AND CADMIUM IN SEDIMENT
(mg/kg)

Sample	Aluminum		Arsenic		Cadmium	
	Detected Concentration	Concentration for Risk Assessment	Detected Concentration	Concentration for Risk Assessment	Detected Concentration	Concentration for Risk Assessment
SDCPDC05	4,990	4,990	2	2	0.68	0.68
SDCPDC06	5,260	5,260	1.9	1.9	0.75	0.75
SDCPDC07	5,130	5,130	2.6	2.6	1.1	1.1
SDCPDC08	6,470	6,470	2.1	2.1	1.1	1.1
SDCPDC09	6,080	6,080	2.6	2.6	0.9	0.9
SDCPDC10	6,180	6,180	2.3	2.3	0.77	0.77
Snake River Bank						
SDCSDB01	4,170	4,170	1.7	1.7	0.36	0.36
SDCSDB02	4,030	4,030	1.9	1.9	0.3	0.3
SDCSDB03	4,010	4,010	2.1	2.1	0.25	0.25
SDCSDB04	5,340	5,340	2.4	2.4	0.39	0.39
SDCSDB05	7,990	7,990	3.5	3.5	0.63	0.63
SDCSDB06	7,790	7,790	3.2	3.2	0.61	0.61
SDCSDB07	6,490	6,490	2.9	2.9	0.62	0.62
SDCSDB08	2,420	2,420	2.8	2.8	0.19	0.19

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Table B-17

AQUATIC INVESTIGATIONS
PORTNEUF RIVER AND SNAKE RIVER DELTAS
ALUMINUM, ARSENIC, AND CADMIUM IN SEDIMENT
(mg/kg)

Sample	Aluminum		Arsenic		Cadmium	
	Detected Concentration	Concentration for Risk Assessment	Detected Concentration	Concentration for Risk Assessment	Detected Concentration	Concentration for Risk Assessment
SDCSDB09	5,980	5,980	5.4	5.4	0.51	0.51
SDCSDB10	5,560	5,560	3	3	0.42	0.42
Snake River Channel						
SDCSDC01	8,740	8,740	4.5	4.5	0.7	0.7
SDCSDC02	11,500	11,500	11.3	11.3	0.79	0.79
SDCSDC03	2,020	2,020	1.9	1.9	<0.27 U	0.135
SDCSDC04	4,420	4,420	2.5	2.5	<0.32 U	0.16
SDCSDC05	5,130	5,130	2.8	2.8	0.4	0.4
SDCSDC06	4,070	4,070	2.1	2.1	0.32	0.32
SDCSDC07	3,430	3,430	2.1	2.1	<0.23 U	0.115
SDCSDC08	3,180	3,180	2.2	2.2	0.22	0.22
SDCSDC09	2,720	2,720	2	2	<0.28 U	0.14
SDCSDC10	1,950	1,950	1.8	1.8	<0.24 U	0.12

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Table B-18

AQUATIC INVESTIGATIONS
PORTNEUF RIVER AND SNAKE RIVER DELTAS
FLUORIDE, IRON, AND MERCURY IN SEDIMENT
(mg/kg)

Sample	Fluoride		Iron		Mercury	
	Detected Concentration	Concentration for Risk Assessment	Detected Concentration	Concentration for Risk Assessment	Detected Concentration	Concentration for Risk Assessment
Portneuf River Bank						
SDCPDB01	324	324	7,080	7,080	<0.07 U7	Rejected
SDCPDB02	350	350	11,600	11,600	<0.18 U7	Rejected
SDCPDB03	309	309	14,300	14,300	0.19 J7	0.19
SDCPDB04	529	529	14,700	14,700	0.46	0.46
SDCPDB05	304 J8	304	16,700	16,700	<0.16 U7	Rejected
SDCPDB06	269 J8	269	18,000	18,000	<0.09 U7	Rejected
SDCPDB07	250 J8	250	9,240	9,240	<0.07 U7	Rejected
SDCPDB08	343 J8	343	8,020	8,020	<0.06 U7	Rejected
SDCPDB09	328 J8	328	7,430	7,430	<0.06 U	0.03
SDCPDB10	330 J8	330	10,100	10,100	<0.09 U7	Rejected
Portneuf River Channel						
SDCPDC01	429	429	10,000	10,000	<0.2 U7	Rejected
SDCPDC02	352	352	10,600	10,600	<0.14 U7	Rejected
SDCPDC03	318	318	10,200	10,200	<0.14 U7	Rejected
SDCPDC04	413	413	6,860	6,860	<0.1 U7	Rejected

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Table B-18

AQUATIC INVESTIGATIONS
PORTNEUF RIVER AND SNAKE RIVER DELTAS
FLUORIDE, IRON, AND MERCURY IN SEDIMENT
(mg/kg)

Sample	Fluoride		Iron		Mercury	
	Detected Concentration	Concentration for Risk Assessment	Detected Concentration	Concentration for Risk Assessment	Detected Concentration	Concentration for Risk Assessment
SDCPDC05	406	406	5,940	5,940	<0.1 U7	Rejected
SDCPDC06	367 J8	367	7,020	7,020	<0.08 U7	Rejected
SDCPDC07	277 J8	277	6,320	6,320	<0.06 U7	Rejected
SDCPDC08	298 J8	298	8,850	8,850	<0.08 U7	Rejected
SDCPDC09	402 J8	402	8,780	8,780	<0.07 U	0.035
SDCPDC10	306 J8	306	8,370	8,370	<0.08 U	0.04
Snake River Bank						
SDCSDB01	381	381	7,030	7,030	<0.05 U	0.025
SDCSDB02	184	184	6,720	6,720	<0.05 U	0.025
SDCSDB03	187	187	6,650	6,650	<0.07 U7	Rejected
SDCSDB04	282	282	8,290	8,290	<0.06 U	0.03
SDCSDB05	268	268	10,900	10,900	<0.08 U	0.04
SDCSDB06	327	327	12,100	12,100	<0.07 U	0.035
SDCSDB07	329 J8	329	10,900	10,900	<0.06 U	0.03
SDCSDB08	185 J8	185	5,660	5,660	<0.05 U	0.025

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Table B-18

AQUATIC INVESTIGATIONS
PORTNEUF RIVER AND SNAKE RIVER DELTAS
FLUORIDE, IRON, AND MERCURY IN SEDIMENT
(mg/kg)

Sample	Fluoride		Iron		Mercury	
	Detected Concentration	Concentration for Risk Assessment	Detected Concentration	Concentration for Risk Assessment	Detected Concentration	Concentration for Risk Assessment
SDCSDB09	389 J8	389	12,100	12,100	<0.16 U7	Rejected
SDCSDB10	210 J8	210	9,280	9,280	<0.05 U	0.025
Snake River Channel						
SDCSDC01	301	301	12,100	12,100	<0.07 U	0.035
SDCSDC02	238	238	19,000	19,000	<0.07 U7	Rejected
SDCSDC03	114	114	4,900	4,900	<0.05 U	0.025
SDCSDC04	270	270	7,100	7,100	<0.07 U	0.035
SDCSDC05	253	253	9,470	9,470	<0.08 U	0.04
SDCSDC06	259 J8	259	7,440	7,440	<0.06 U7	Rejected
SDCSDC07	242 J8	242	6,630	6,630	<0.06 U	0.03
SDCSDC08	183 J8	183	6,460	6,460	<0.05 U7	Rejected
SDCSDC09	188 J8	188	5,550	5,550	<0.06 U	0.03
SDCSDC10	140	140	4,630	4,630	<0.06 U	0.03

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Table B-19

AQUATIC INVSTIGATIONS
PORTNEUF RIVER AND SNAKE RIVER DELTAS
SELENIUM, ZINC, AND TOC IN SEDIMENT
(mg/kg)

Sample	Selenium		Zinc		Total Organic Carbon	
	Detected Concentration	Concentration for Risk Assessment	Detected Concentration	Concentration for Risk Assessment	Detected Concentration	Concentration for Risk Assessment
Portneuf River Bank						
SDCPDB01	0.61	0.61	27.7	27.7	37,100 J8	37,100
SDCPDB02	0.73	0.73	58.1	58.1	24,500 J8	24,500
SDCPDB03	1.7	1.7	66.9	66.9	37,100 J8	37,100
SDCPDB04	1.5	1.5	67.4	67.4	38,600 J8	38,600
SDCPDB05	1.6	1.6	68.8	68.8	42,300 J8	42,300
SDCPDB06	1.3	1.3	65.8	65.8	48,800 J8	48,800
SDCPDB07	0.95	0.95	41	41	48,100 J8	48,100
SDCPDB08	<0.38 U	0.19	29.6	29.6	61,600 J8	61,600
SDCPDB09	0.59	0.59	29.2	29.2	52,300	52,300
SDCPDB10	0.5	0.5	41.1	41.1	40,100	40,100
Portneuf River Channel						
SDCPDC01	1	1	44.7	44.7	61,800 J8	61,800
SDCPDC02	0.72	0.72	49.1	49.1	45,000 J8	45,000
SDCPDC03	1.1	1.1	45.3	45.3	45,900 J8	45,900
SDCPDC04	0.65	0.65	28	28	40,200 J8	40,200

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Table B-19

AQUATIC INVSTIGATIONS
PORTNEUF RIVER AND SNAKE RIVER DELTAS
SELENIUM, ZINC, AND TOC IN SEDIMENT
(mg/kg)

Sample	Selenium		Zinc		Total Organic Carbon	
	Detected Concentration	Concentration for Risk Assessment	Detected Concentration	Concentration for Risk Assessment	Detected Concentration	Concentration for Risk Assessment
SDCPDC05	<0.42 U	0.21	28.9	28.9	56,400 J8	56,400
SDCPDC06	0.37	0.37	29.4	29.4	67,600 J8	67,600
SDCPDC07	0.77	0.77	28.8	28.8	28,200 J8	28,200
SDCPDC08	0.54	0.54	36	36	28,100 J8	28,100
SDCPDC09	0.52	0.52	37	37	38,000	38,000
SDCPDC10	0.69	0.69	34.2	34.2	55,700	55,700
Snake River Bank						
SDCSDB01	0.58	0.58	34.2	34.2	24,300	24,300
SDCSDB02	0.48	0.48	27.2	27.2	14,300	14,300
SDCSDB03	0.56	0.56	26.9	26.9	14,000	14,000
SDCSDB04	0.51	0.51	34.1	34.1	16,600	16,600
SDCSDB05	1.1	1.1	50.6	50.6	47,300	47,300
SDCSDB06	0.98	0.98	50.5	50.5	41,700	41,700
SDCSDB07	0.65	0.65	42.4	42.4	45,600	45,600
SDCSDB08	0.3	0.3	20.5	20.5	12,400	12,400

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Table B-19

AQUATIC INVSTIGATIONS
PORTNEUF RIVER AND SNAKE RIVER DELTAS
SELENIUM, ZINC, AND TOC IN SEDIMENT
(mg/kg)

Sample	Selenium		Zinc		Total Organic Carbon	
	Detected Concentration	Concentration for Risk Assessment	Detected Concentration	Concentration for Risk Assessment	Detected Concentration	Concentration for Risk Assessment
SDCSDB09	0.83	0.83	46	46	53,400	53,400
SDCSDB10	0.61	0.61	37.2	37.2	28,000	28,000
Snake River Channel						
SDCSDC01	0.82	0.82	51.1	51.1	44,000	44,000
SDCSDC02	0.85	0.85	70.9	70.9	22,000	22,000
SDCSDC03	<0.4 U	0.2	19.9	19.9	9,880	9,880
SDCSDC04	0.74	0.74	32	32	30,600	30,600
SDCSDC05	0.7	0.7	37	37	37,500	37,500
SDCSDC06	0.57	0.57	27.3	27.3	20,100	20,100
SDCSDC07	0.46	0.46	26.1	26.1	46,300	46,300
SDCSDC08	0.43	0.43	25.5	25.5	25,900	25,900
SDCSDC09	0.64	0.64	25.7	25.7	12,000	12,000
SDCSDC10	0.43	0.43	18.9	18.9	20,600	20,600

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Table B-20

AQUATIC INVESTIGATIONS
PORTNEUF RIVER AND SNAKE RIVER DELTAS
ACID VOLATILE SULFIDE IN SEDIMENT

Sample	Acid Volatile Sulfide (AVS)		
	Detected Concentration (mg/kg)	Concentration for Risk Assessment (mg/kg)	Concentration for Risk Assessment (μmole/g)
Portneuf River Bank			
SDCPDB01	<6.5 J1,8	3.25	0.101
SDCPDB02	<6.8 J1,8	3.4	0.106
SDCPDB03	<7.4 J1	3.7	0.114
SDCPDB04	<7.5 J1	3.75	0.117
SDCPDB05	<7.3 J1	3.65	0.114
SDCPDB06	<6.8 J1	3.4	0.106
SDCPDB07	<6.9 J8	3.45	0.108
SDCPDB08	6.4 J8	6.4	0.100
SDCPDB09	<6.8 J8	3.4	0.106
SDCPDB10	<6.3 J8	3.15	0.097
Portneuf River Channel			
SDCPDC01	114 J1,8	114	3.541
SDCPDC02	44.6 J1,8	44.6	1.390
SDCPDC03	289 J1	289	9.034
SDCPDC04	220 J1	220	6.863
SDCPDC05	17.1 J1	17.1	0.532
SDCPDC06	23.5 J1,8	23.5	0.733
SDCPDC07	<8.1 J8	4.05	0.125
SDCPDC08	<7.9 J8	3.95	0.123
SDCPDC09	54.4 J8	54.9	1.71
SDCPDC10	<8.7 J8	4.35	0.135
Snake River Bank			
SDCSDB01	<6.7 J8	3.35	0.104

Table B-20

AQUATIC INVESTIGATIONS
PORTNEUF RIVER AND SNAKE RIVER DELTAS
ACID VOLATILE SULFIDE IN SEDIMENT

Sample	Acid Volatile Sulfide (AVS)		
	Detected Concentration (mg/kg)	Concentration for Risk Assessment (mg/kg)	Concentration for Risk Assessment (μmole/g)
SDCSDB02	<6.4 J1,8	3.25	0.099
SDCSDB03	<6.3 J1,8	3.15	0.098
SDCSDB04	<6.7 J8	3.35	0.104
SDCSDB05	<8.4 J8	4.2	0.131
SDCSDB06	<7.1 J8	3.55	0.110
SDCSDB07	<6.7 J8	3.35	0.103
SDCSDB08	<6.2 J8	3.1	0.097
SDCSDB09	9.6 J8	9.6	0.150
SDCSDB10	<5.5 J8	2.75	0.104
Snake River Channel			
SDCSDC01	<8.3 J8	4.15	0.129
SDCSDC02	<7.5 J1,8	3.75	0.117
SDCSDC03	<6.7 J1,8	3.35	0.104
SDCSDC04	<7.7 J8	3.85	0.119
SDCSDC05	258 J8	258	8.046
SDCSDC06	156 J8	156	4.872
SDCSDC07	18.1 J8	18.1	0.564
SDCSDC08	<7 J8	3.5	0.108
SDCSDC09	<7.1 J8	3.55	0.110
SDCSDC10	<7.1 J8	3.55	0.110

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Table B-21

AQUATIC INVESTIGATIONS
PORTNEUF RIVER AND SNAKE RIVER DELTAS
SIMULTANEOUSLY EXTRACTABLE METALS (CADMIUM, COPPER, AND LEAD) IN SEDIMENT

Sample	SEM Cadmium (µmole/g)		SEM Copper (µmole/g)		SEM Lead (µmole/g)	
	Detected Concentration	Concentration for Risk Assessment	Detected Concentration	Concentration for Risk Assessment	Detected Concentration	Concentration for Risk Assessment
Portneuf River Bank						
SDCPDB01	<0.0006378 UJ7,14,10	Rejected	0.0135345 J14,10	0.0135345	0.0064273 J14,10	0.0064273
SDCPDB02	0.0031224 J14,10	0.00315885	0.0457255 J14,10	0.0461303	0.0224834 J14,10	0.0222252
SDCPDB03	0.0014905 J14,10	0.0014905	0.0339814 J14,10	0.0339814	0.0123068 J14,10	0.0123068
SDCPDB04	0.0046033 J14,10	0.0046033	0.0759933 J14,10	0.0759933	0.0718693 J14,10	0.0718693
SDCPDB05	0.0018576 J14,10	0.0018576	0.0421506 J14,10	0.0421506	0.015034 J14,10	0.015034
SDCPDB06	0.0019474 J14,10	0.0019634	0.0597633 J14,10	0.0617854	0.0222101 J14,16,10	0.022759
SDCPDB07	0.0015032 J14,10	0.0015032	0.0463537 J14,10	0.0463537	0.0149835 J14,16,10	0.0149835
SDCPDB08	0.0008508 J14,10	0.0008508	0.0235061 J14,10	0.0235061	0.0112842 J14,16,10	0.0112842
SDCPDB09	0.0010582 J14,10	0.0010582	0.0214764 J14,10	0.0214764	0.0110897 J14,16,10	0.0110897
SDCPDB10	0.0017371 J14,10	0.0017371	0.0334118 J14,10	0.0334118	0.0175987 J14,16,10	0.0175987
Portneuf River Channel						
SDCPDC01	<0.0023452 UJ14,10	0.0011726	0.0402772 J7,14,10	0.0402772	0.0165004 J14,10	0.0165004
SDCPDC02	0.0033709 J14,10	0.0033709	0.0343778 J14,10	0.0343778	0.0174605 J14,10	0.0174605
SDCPDC03	0.0027218 J14,10	0.0027218	0.0420517 J14,10	0.0420517	0.0172547 J14,10	0.0172547
SDCPDC04	0.001751 J14,10	0.001751	0.0214623 J14,10	0.0214623	0.0132808 J14,10	0.0132808
SDCPDC05	0.001178 J14,10	0.001178	0.0144101 J14,10	0.0144101	0.0096111 J14,10	0.0096111
SDCPDC06	0.0011979 J14,10	0.0011979	0.0125442 J14,10	0.0125442	0.0079999 J14,10	0.0079999

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Table B-21

AQUATIC INVESTIGATIONS
PORTNEUF RIVER AND SNAKE RIVER DELTAS
SIMULTANEOUSLY EXTRACTABLE METALS (CADMIUM, COPPER, AND LEAD) IN SEDIMENT

Sample	SEM Cadmium (μmole/g)		SEM Copper (μmole/g)		SEM Lead (μmole/g)	
	Detected Concentration	Concentration for Risk Assessment	Detected Concentration	Concentration for Risk Assessment	Detected Concentration	Concentration for Risk Assessment
SDCPDC07	0.0011651 J14,10	0.0011651	0.0248619 J14,10	0.0248619	0.0096182 J14,16,10	0.0096182
SDCPDC08	0.0011131 J14,10	0.0011131	0.0183238 J14,10	0.0183238	0.0085337 J14,16,10	0.0085337
SDCPDC09	0.0020504 J14,10	0.0020504	0.0504411 J14,10	0.0504411	0.0161353 J14,16,10	0.0161353
SDCPDC10	0.0017898 J14,10	0.0017898	0.0470529 J14,10	0.0470529	0.0158152 J14,16,10	0.0158152
Snake River Bank						
SDCSDB01	0.0007729 J14,10	0.0010752	0.023323 J14,10	0.02393315	.0100214 J14,16,10	0.0105378
SDCSDB02	<0.0009065 UJ7,14,10	Rejected	0.0201401 J14,10	0.0201401	0.0096801 J14,10	0.0096801
SDCSDB03	<0.0003616 UJ7,14,10	Rejected	0.0178363 J14,10	0.0178363	0.0084837 J14,10	0.0084837
SDCSDB04	<0.0014231 UJ7,14,10	Rejected	0.023057 J14,10	0.023057	0.0117339 J14,10	0.0117339
SDCSDB05	<0.0018697 UJ7,14,10	Rejected	0.0432181 J14,10	0.0432181	0.0173003 J14,10	0.0173003
SDCSDB06	0.0024606 J14,10	0.0024606	0.0422817 J14,10	0.0422817	0.0193459 J14,10	0.0193459
SDCSDB07	0.0019004 J14,10	0.0019004	0.034995 J14,10	0.034995	0.0146798 J14,10	0.0146798
SDCSDB08	<0.0001387 UJ7,14,10	Rejected	0.011265 J14,10	0.011265	0.30079749 J14,10	0.3007975
SDCSDB09	<0.0018462 UJ7,14,10	Rejected	0.0505205 J14,10	0.0505205	0.0220037 J14,10	0.0220037
SDCSDB10	<0.0017 UJ7,14,10	Rejected	0.0299642 J14,10	0.0299642	0.0165446 J14,10	0.0165446
Snake River Channel						
SDCSDC01	.0020736 J14,10	0.0020736	0.0576261 J14,10	0.0576261	0.0220988 J14,10	0.0220988
SDCSDC02	.0021566 J14,10	0.0021566	0.0492489 J14,10	0.0492489	0.0234114 J14,10	0.0234114

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Table B-21

AQUATIC INVESTIGATIONS
PORTNEUF RIVER AND SNAKE RIVER DELTAS
SIMULTANEOUSLY EXTRACTABLE METALS (CADMIUM, COPPER, AND LEAD) IN SEDIMENT

Sample	SEM Cadmium (μmole/g)		SEM Copper (μmole/g)		SEM Lead (μmole/g)	
	Detected Concentration	Concentration for Risk Assessment	Detected Concentration	Concentration for Risk Assessment	Detected Concentration	Concentration for Risk Assessment
SDCSDC03	< .0001484 UJ7,14,10	Rejected	0.0061777 J14,10	0.0061777	0.0052572 J14,10	0.0052572
SDCSDC04	< .00144 UJ7,14,10	Rejected	0.0395382 J14,10	0.0395382	0.0102173 J14,10	0.0102173
SDCSDC05	< .0016054 UJ7,14,10	Rejected	0.0254707 J14,10	0.0254707	0.0135894 J14,10	0.0135894
SDCSDC06	< .0010861 UJ7,14,10	Rejected	0.0164265 J14,10	0.0164265	0.0102606 J14,10	0.0102606
SDCSDC07	< .0004208 UJ7,14,10	Rejected	0.0122673 J14,10	0.0122673	0.0085733 J14,10	0.0085733
SDCSDC08	< .0005265 UJ7,14,10	Rejected	0.0098046 J14,10	0.0098046	0.0070719 J14,10	0.0070719
SDCSDC09	< .0001582 UJ7,14,10	Rejected	0.0125084 J14,10	0.0125084	0.0084165 J14,10	0.0084165
SDCSDC10	< .0001633 UJ7,14,10	Rejected	0.0081105 J14,10	0.0081105	0.006987 J14,10	0.006987

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Table B-22

AQUATIC INVESTIGATIONS
PORTNEUF RIVER AND SNAKE RIVER DELTAS
SIMULTANEOUSLY EXTRACTABLE METALS (MERCURY, NICKEL, AND ZINC) IN SEDIMENT

Sample	SEM Mercury (µmole/g)		SEM Nickel (µmole/g)		SEM Zinc (µmole/g)	
	Detected Concentration	Concentration for Risk Assessment	Detected Concentration	Concentration for Risk Assessment	Detected Concentration	Concentration for Risk Assessment
Portneuf River Bank						
SDCPDB01	0.00000325 J8,14	0.00000325	0.0100603 J14,10	0.0100603	0.0508739 J14,10	0.0508739
SDCPDB02	0.00003125 J8,14	0.000029905	0.0290119 J14,10	0.0257567	0.1470813 J14,10	0.1429809
SDCPDB03	0.00000368 J14	0.00000368	0.0200212 J14,10	0.0200212	0.0852645 J14,10	0.0852645
SDCPDB04	0.00006226 J14	0.00006226	0.0288958 J14,10	0.0288958	0.2036894 J14,10	0.2036894
SDCPDB05	<0.00001026 UJ7,14	Rejected	0.0243468 J14,10	0.0243468	0.1041097 J14,10	0.1041097
SDCPDB06	<0.00001483 UJ8,14	0.000013738	0.048657 J14,16,10	0.0482201	0.1675708 J14,16,10	0.1665999
SDCPDB07	<0.0000128 UJ7,14	Rejected	0.0327164 J14,16,10	0.0327164	0.108588 J14,16,10	0.108588
SDCPDB08	<0.00001188 UJ7,14,10	Rejected	0.0173827 J14,16,10	0.0173827	0.072242 J14,16,10	0.072242
SDCPDB09	<0.00001597 UJ7,14	Rejected	0.0174969 J14,16,10	0.0174969	0.0746282 J14,16,10	0.0746282
SDCPDB10	<0.00002275 UJ7,14	Rejected	0.026567 J14,16,10	0.026567	0.098816 J14,16,10	0.098816
Portneuf River Channel						
SDCPDC01	.00000581 J8,14	0.00000581	0.0325468 J14,10	0.0325468	0.1459176 J14,10	0.1459176
SDCPDC02	.00000421 J8,14	0.00000421	0.0220636 J14,10	0.0220636	0.150795 J14,10	0.150795
SDCPDC03	.00000509 J14	0.00000509	0.0334212 J14,10	0.0334212	0.1572409 J14,10	0.1572409
SDCPDC04	.00000408 J14	0.00000408	0.0189423 J14,10	0.0189423	0.1075974 J14,10	0.1075974
SDCPDC05	<.00000893 UJ7,14	Rejected	0.0107879 J14,10	0.0107879	0.0836376 J14,10	0.0836376

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Table B-22

AQUATIC INVESTIGATIONS
PORTNEUF RIVER AND SNAKE RIVER DELTAS
SIMULTANEOUSLY EXTRACTABLE METALS (MERCURY, NICKEL, AND ZINC) IN SEDIMENT

Sample	SEM Mercury (µmole/g)		SEM Nickel (µmole/g)		SEM Zinc (µmole/g)	
	Detected Concentration	Concentration for Risk Assessment	Detected Concentration	Concentration for Risk Assessment	Detected Concentration	Concentration for Risk Assessment
SDCPDC06	.00000386 J8,14	0.00000386	0.0098914 J14,10	0.0098914	0.0813303 J14,10	0.0813303
SDCPDC07	.00000402 J14	0.00000402	0.0168838 J14,16,10	0.0168838	0.0797301 J14,16,10	0.0797301
SDCPDC08	.00000394 J14	0.00000394	0.0137363 J14,16,10	0.0137363	0.0794638 J14,16,10	0.0794638
SDCPDC09	.00000395 J14	0.00000395	0.0294937 J14,16,10	0.0294937	0.1301912 J14,16,10	0.1301912
SDCPDC10	.00000434 J14	0.00000434	0.0298642 J14,16,10	0.0298642	0.1243011 J14,16,10	0.1243011
Snake River Bank						
SDCSDB01	0.00000333 J14	0.00000333	0.0208868 J14,16,10	0.020497	0.0939355 J14,16,10	0.0954038
SDCSDB02	0.00000317 J8,14	0.00000317	0.0189992 J14,10	0.0189992	0.0788862 J14,10	0.0788862
SDCSDB03	0.00000662 J8,14	0.00000662	0.0168219 J14,10	0.0168219	0.0712601 J14,10	0.0712601
SDCSDB04	0.00000335 J8,14	0.00000335	0.0266982 J14,16,10	0.0266982	0.1129315 J14,16,10	0.1129315
SDCSDB05	0.00000419 J8,14	0.00000419	0.043869 J14,16,10	0.043869	0.1895837 J14,16,10	0.1895837
SDCSDB06	0.00001022 J8,14	0.00001022	0.0445233 J14,16,10	0.0445233	0.1821801 J14,16,10	0.1821801
SDCSDB07	0.00000332 J8,14	0.00000332	0.0360435 J14,10	0.0360435	0.1504694 J14,10	0.1504694
SDCSDB08	0.00000311 J8,14	0.00000311	0.0337455 J14,16,10	0.0337455	0.0720847 J14,16,10	0.0720847
SDCSDB09	0.00000481 J8,14	0.00000481	0.0554972 J14,16,10	0.0554972	0.2240691 J14,16,10	0.2240691
SDCSDB10	0.00000836 J8,14	0.00000836	0.0351394 J14,16,10	0.0351394	0.1180206 J14,16,10	0.1180206

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Table B-22

AQUATIC INVESTIGATIONS
PORTNEUF RIVER AND SNAKE RIVER DELTAS
SIMULTANEOUSLY EXTRACTABLE METALS (MERCURY, NICKEL, AND ZINC) IN SEDIMENT

Sample	SEM Mercury (µmole/g)		SEM Nickel (µmole/g)		SEM Zinc (µmole/g)	
	Detected Concentration	Concentration for Risk Assessment	Detected Concentration	Concentration for Risk Assessment	Detected Concentration	Concentration for Risk Assessment
Snake River Channel						
SDCSDC01	0.00000413 J8,14	0.00000413	0.0382054 J14,10	0.0382054	0.1661087 J14,10	0.1661087
SDCSDC02	0.00001426 J8,14	0.00001426	0.0438645 J14,10	0.0438645	0.1801438 J14,10	0.1801438
SDCSDC03	0.00000333 J8,14	0.00000333	0.0085044 J14,10	0.0085044	0.0392589 J14,10	0.0392589
SDCSDC04	0.00000383 J8,14	0.00000383	0.0252309 J14,16,10	0.0252309	0.1072583 J14,16,10	0.1072583
SDCSDC05	0.00000413 J8,14	0.00000413	0.0343075 J14,16,10	0.0343075	0.1450432 J14,16,10	0.1450432
SDCSDC06	0.00000359 J8,14	0.00000359	0.0235532 J14,16,10	0.0235532	0.1003419 J14,16,10	0.1003419
SDCSDC07	0.00000354 J8,14	0.00000354	0.0231712 J14,16,10	0.0231712	0.087936 J14,16,10	0.087936
SDCSDC08	0.00000348 J8,14	0.00000348	0.0159868 J14,16,10	0.0159868	0.0732285 J14,16,10	0.0732285
SDCSDC09	0.00000355 J8,14	0.00000355	0.0187758 J14,16,10	0.0187758	0.0809952 J14,16,10	0.0809952
SDCSDC10	0.00000352 J8,14	0.00000352	0.0150855 J14,16,10	0.0150855	0.0613752 J14,16,10	0.0613752

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Table B-23

AQUATIC INVESTIGATIONS
PORTNEUF RIVER AND SNAKE RIVER DELTAS
ACID VOLATILE SULFIDE AND SIMULTANEOUS EXTRACTABLE METALS IN SEDIMENT

Sample	SEM Total Metals (µmole/g)		SEM/AVS Ratio	
	Detected Concentration	Concentration for Risk Assessment	Detected Concentration	Concentration for Risk Assessment
Portneuf River Bank				
SDCPDB01	0.081537	0.081537	0.80191	0.80191
SDCPDB02	0.2474557	0.2402818	2.32899	2.26038
SDCPDB03	0.1530681	0.1530681	1.33143	1.33143
SDCPDB04	0.3851134	0.3851134	3.28257	3.28257
SDCPDB05	0.1875091	0.1875091	1.63605	1.63605
SDCPDB06	0.3001635	0.30134515	2.84706	2.822055
SDCPDB07	0.2041576	0.2041576	1.88681	1.88681
SDCPDB08	0.1252778	0.1252778	1.24731	1.24731
SDCPDB09	0.1257654	0.1257654	1.18322	1.18322
SDCPDB10	0.1781533	0.1781533	1.82752	1.82752
Portneuf River Channel				
SDCPDC01	0.2375931	0.2375931	0.06709	0.06709
SDCPDC02	0.228072	0.228072	0.16403	0.16403
SDCPDC03	0.2526953	0.2526953	0.02797	0.02797
SDCPDC04	0.1630379	0.1630379	0.02376	0.02376
SDCPDC05	0.1196337	0.1196337	0.22455	0.22455

Table B-23

AQUATIC INVESTIGATIONS
PORTNEUF RIVER AND SNAKE RIVER DELTAS
ACID VOLATILE SULFIDE AND SIMULTANEOUS EXTRACTABLE METALS IN SEDIMENT

Sample	SEM Total Metals (µmole/g)		SEM/AVS Ratio	
	Detected Concentration	Concentration for Risk Assessment	Detected Concentration	Concentration for Risk Assessment
SDCPDC06	0.1129677	0.1129677	0.15394	0.15394
SDCPDC07	0.132263	0.132263	1.05256	1.05256
SDCPDC08	0.1211746	0.1211746	0.98377	0.98377
SDCPDC09	0.2283156	0.2283156	0.13331	0.13331
SDCPDC10	0.2188276	0.2188276	1.61196	1.61196
Snake River Bank				
SDCSDB01	0.1489429	0.15145015	1.43148	1.455575
SDCSDB02	0.1286154	0.1286154	1.2965	1.2965
SDCSDB03	0.1147702	0.1147702	1.16454	1.16454
SDCSDB04	0.175847	0.175847	1.67814	1.67814
SDCSDB05	0.295845	0.295845	2.25708	2.25708
SDCSDB06	0.2908018	0.2908018	2.63918	2.63918
SDCSDB07	0.2380914	0.2380914	2.29253	2.29253
SDCSDB08	0.125212	0.125212	1.28726	1.28726
SDCSDB09	0.3539415	0.3539415	2.35477	2.35477
SDCSDB10	0.2013771	0.2013771	1.92461	1.92461

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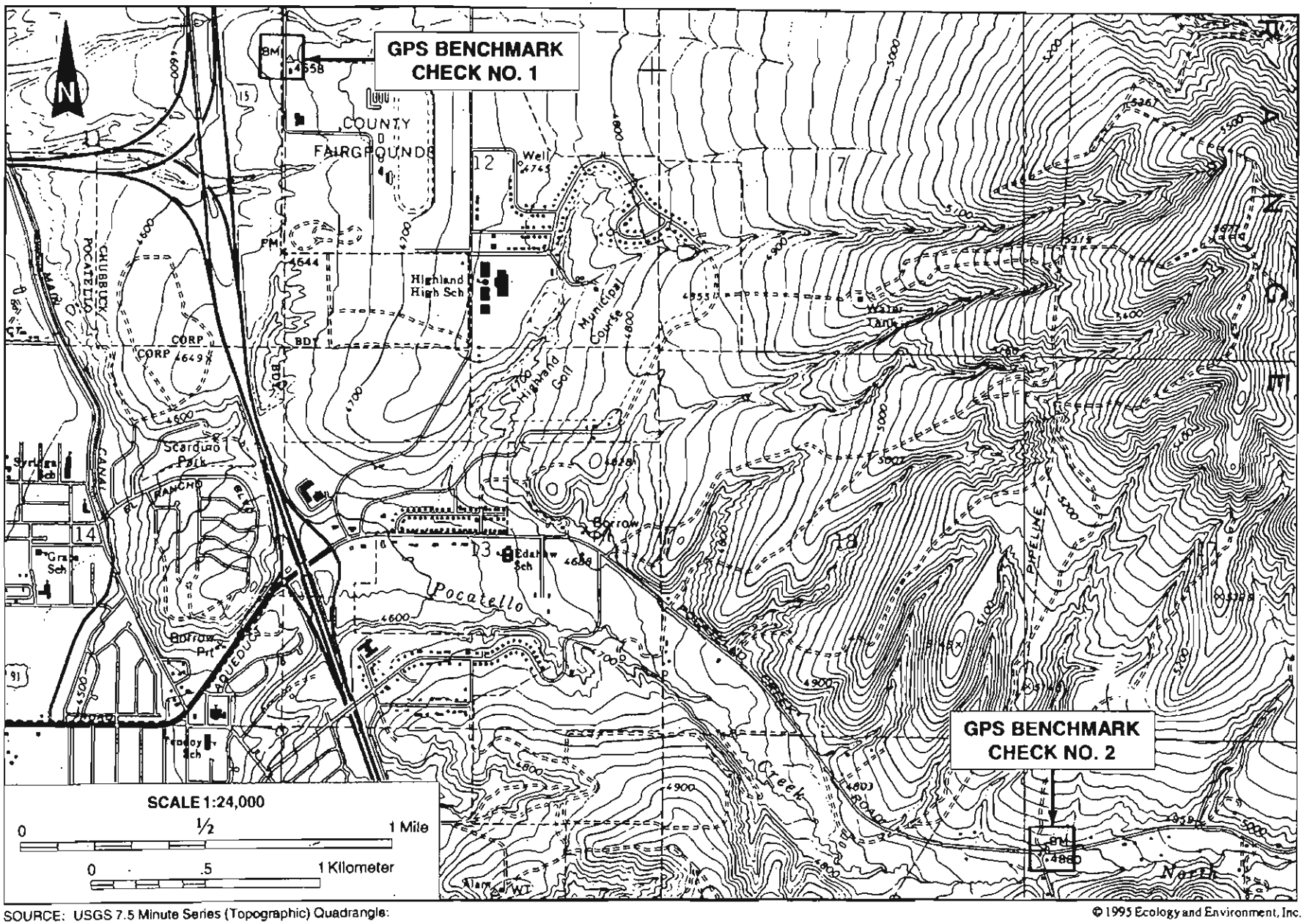
Table B-23

AQUATIC INVESTIGATIONS
PORTNEUF RIVER AND SNAKE RIVER DELTAS
ACID VOLATILE SULFIDE AND SIMULTANEOUS EXTRACTABLE METALS IN SEDIMENT

Sample	SEM Total Metals (µmole/g)		SEM/AVS Ratio	
	Detected Concentration	Concentration for Risk Assessment	Detected Concentration	Concentration for Risk Assessment
Snake River Channel				
SDCSDC01	0.2861168	0.2861168	2.21356	2.21356
SDCSDC02	0.2988395	0.2988395	2.54505	2.54505
SDCSDC03	0.0593499	0.0593499	.57046	0.57046
SDCSDC04	0.1836885	0.1836885	1.53185	1.53185
SDCSDC05	0.2200204	0.2200204	0.02734	0.02734
SDCSDC06	0.151672	0.151672	0.03113	0.03113
SDCSDC07	0.1323721	0.1323721	0.2347	0.2347
SDCSDC08	0.1066217	0.1066217	0.97838	0.97838
SDCSDC09	0.1208576	0.1208576	1.08983	1.08983
SDCSDC10	0.0917251	0.0917251	.83212	0.83212



SOURCE: USGS 7.5 Minute Series (Topographic) Quadrangle: Pocatello North, ID 1971.

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Figure B-1 GPS BENCHMARK CHECK POINTS

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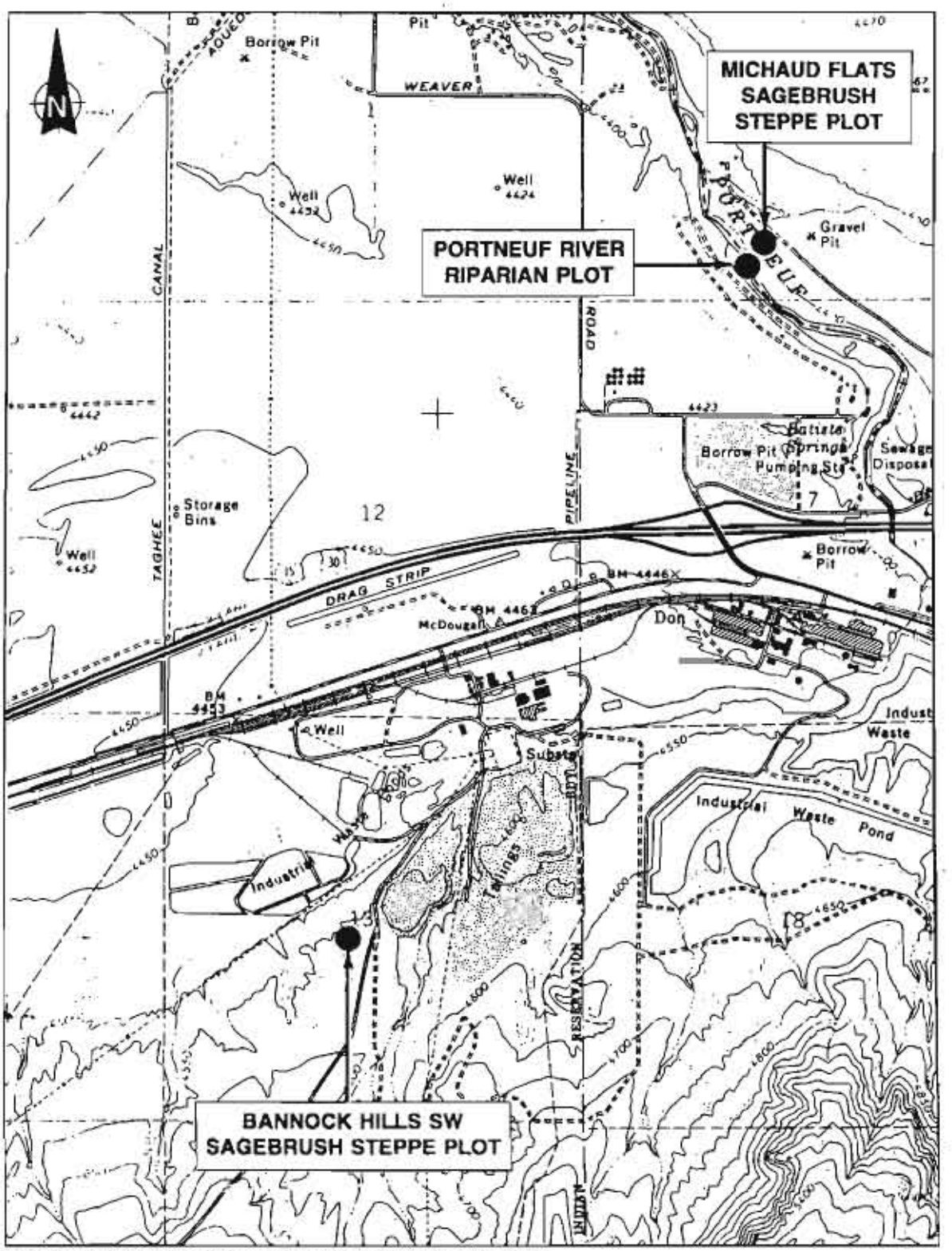

SOURCE: USGS 7.5 Minute Series (Topographic) Quadrangle: Michaud, ID 1971, Photoinspected 1974.

SCALE 1:24,000

0 ½ 1 Mile

0 .5 1 Kilometer

Figure B-2 POTENTIALLY IMPACTED TERRESTRIAL SAMPLING POINTS

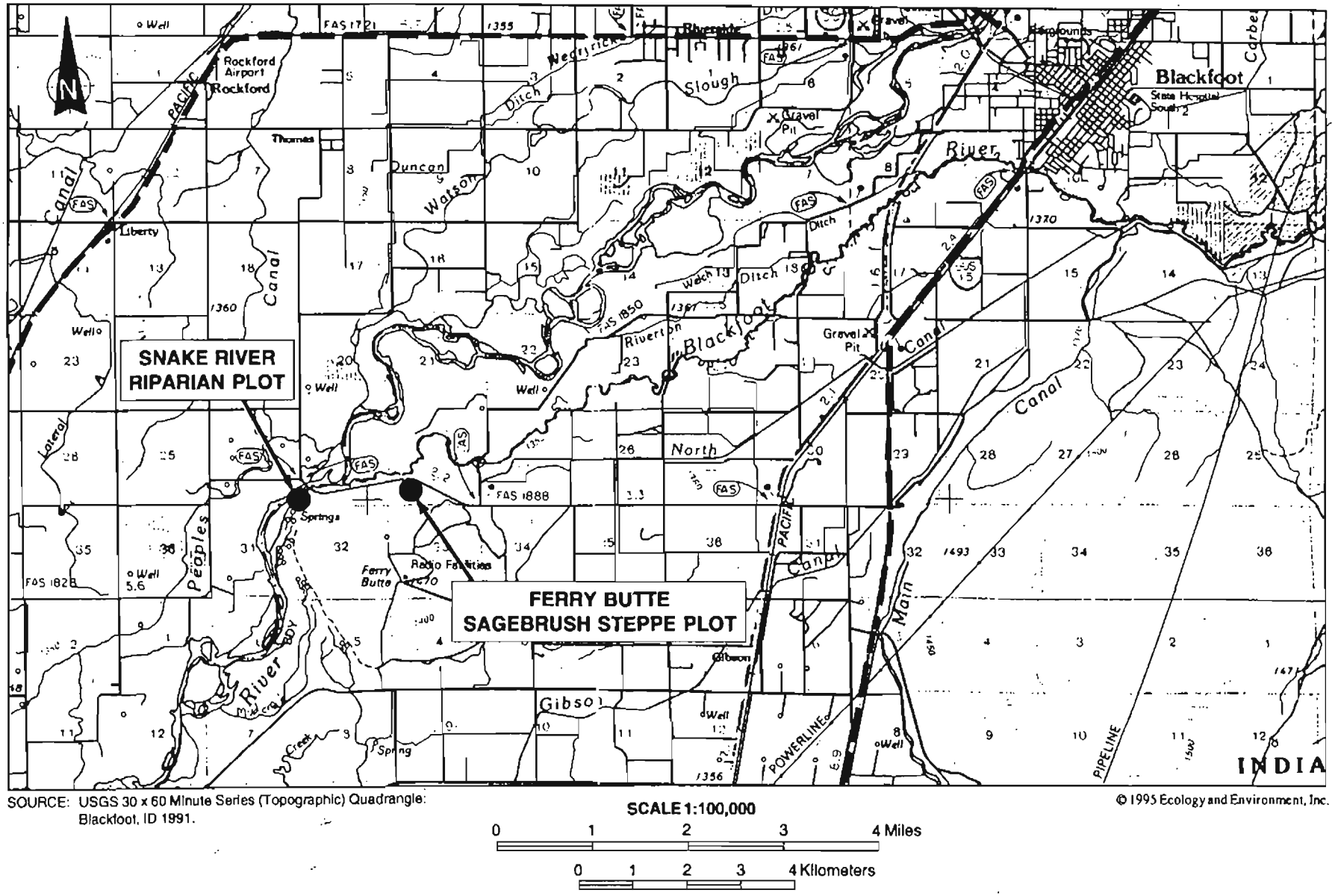

Figure B-3 TERRESTRIAL SAMPLING REFERENCE PLOTS

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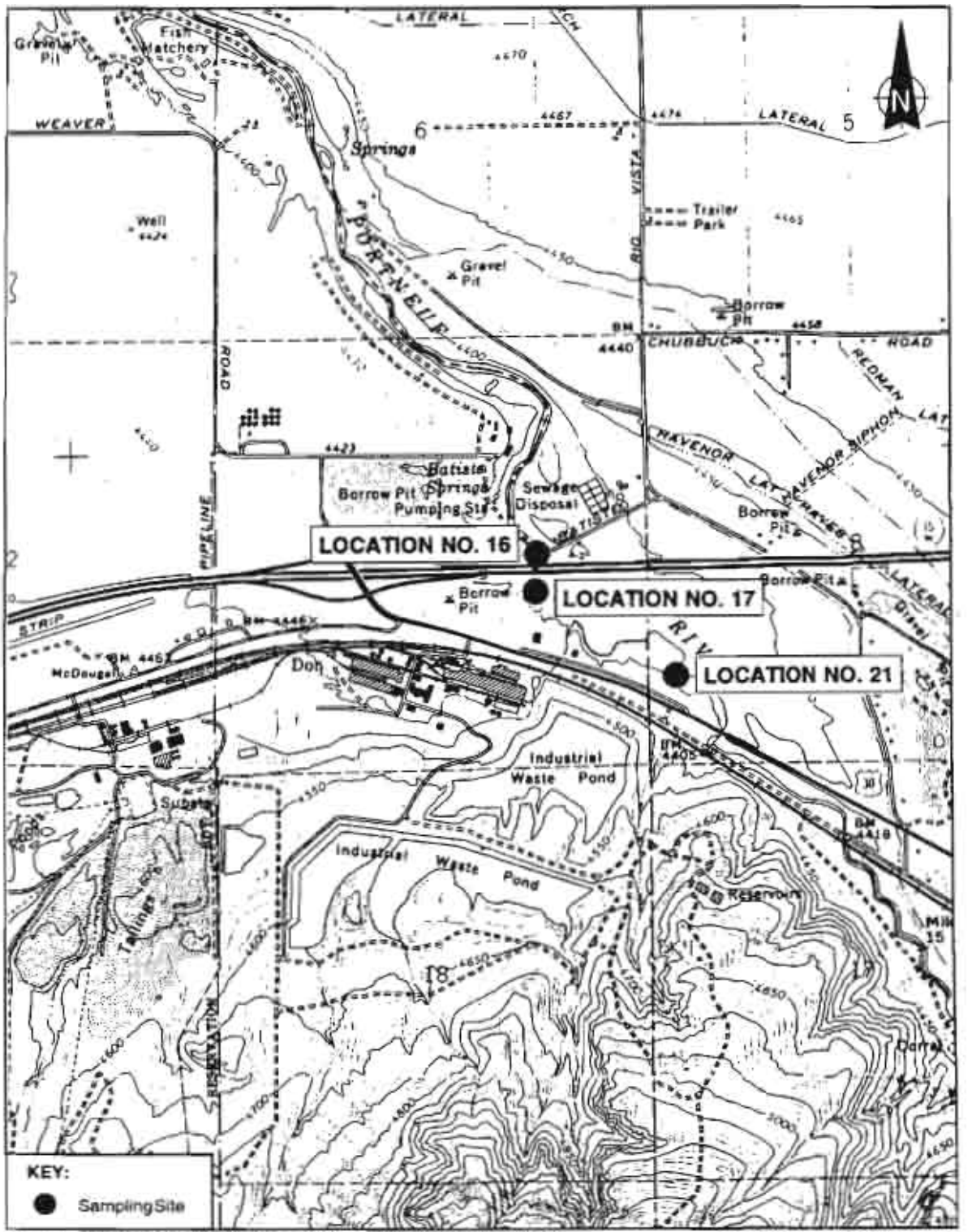

Figure B-4 PORTNEUF RIVER SAMPLING SITES

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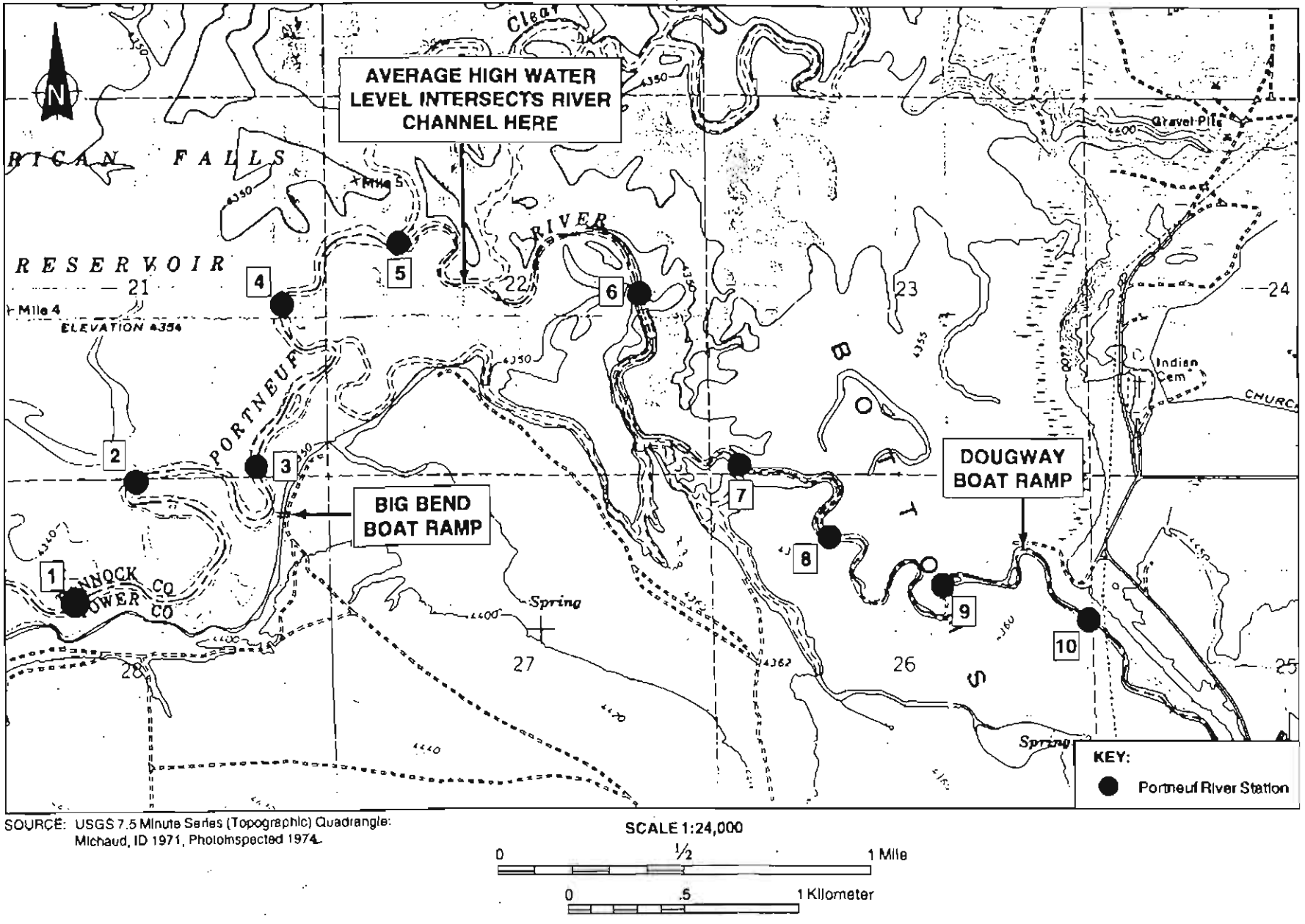

SOURCE: USGS 7.5 Minute Series (Topographic) Quadrangle: Michaud, ID 1971, Photoinspected 1974.

Figure B-5 PORTNEUF RIVER DELTA SAMPLING SITES

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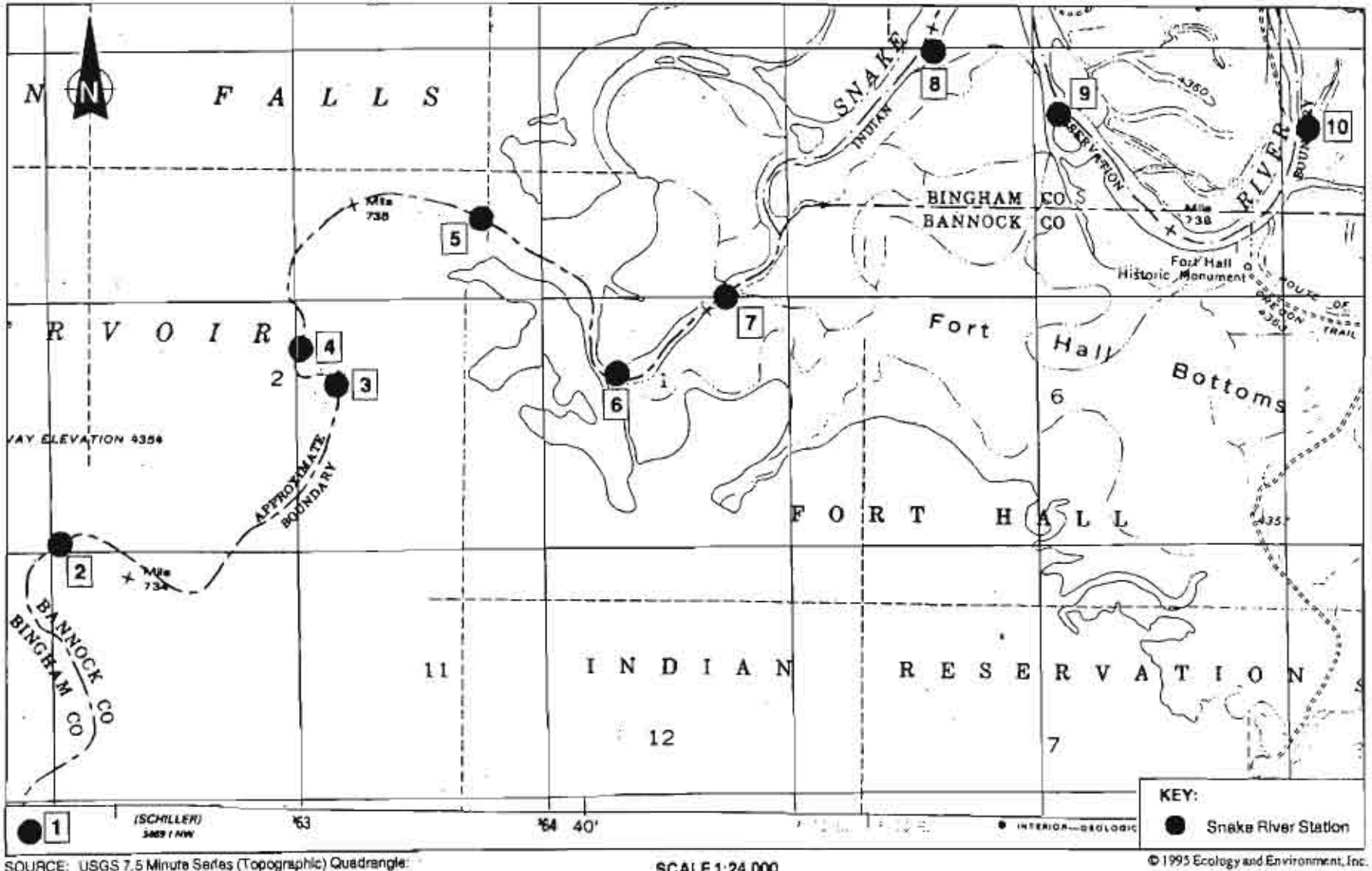

SOURCE: USGS 7.5 Minute Series (Topographic) Quadrangle: Springfield, ID 1955, Photoinspected 1974.

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Figure B-6 SNAKE RIVER DELTA SAMPLING SITES

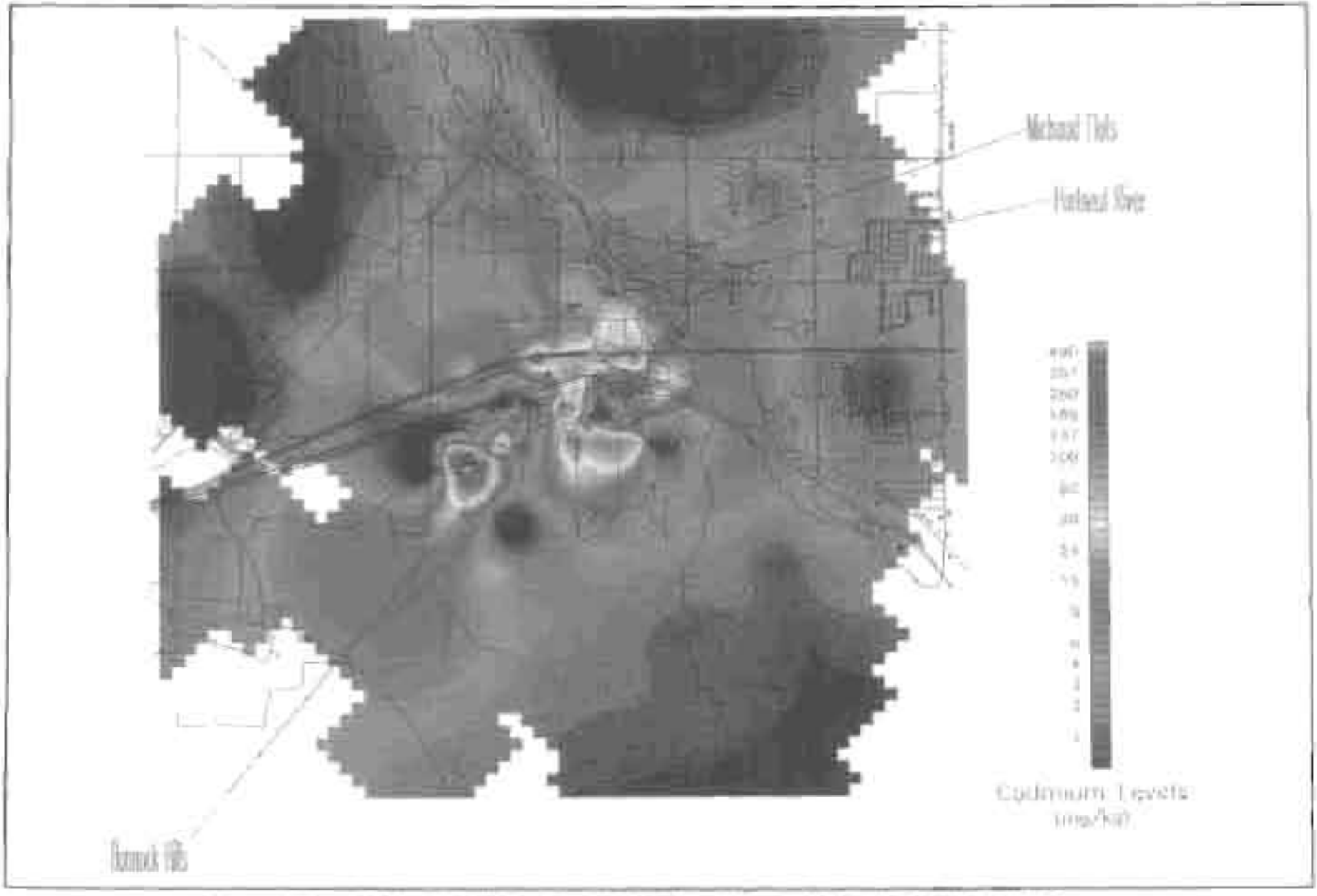

Figure B-7 CADMIUM LEVELS IN SURFACE SOIL, IN RELATION TO THE BANNOCK HILLS, MICHAUD FLATS, AND PORTNEUF RIVER SAMPLE LOCATIONS

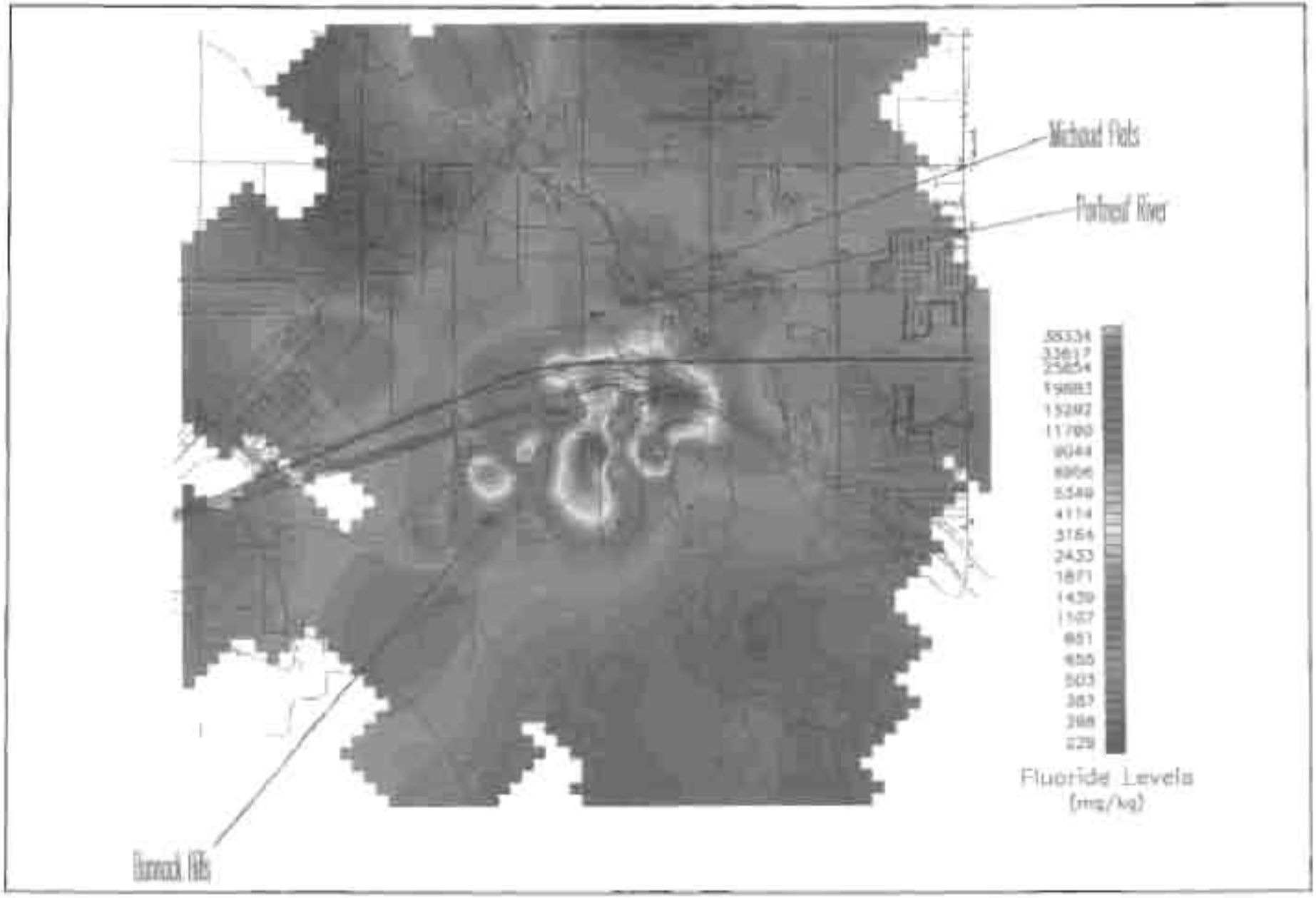

Figure 8-6 FLUROIDE LEVELS IN SURFACE SOIL, IN RELATION TO THE BANNOCK HILLS, MICHAUD FLATS, AND PORTNEUF RIVER SAMPLE LOCATIONS

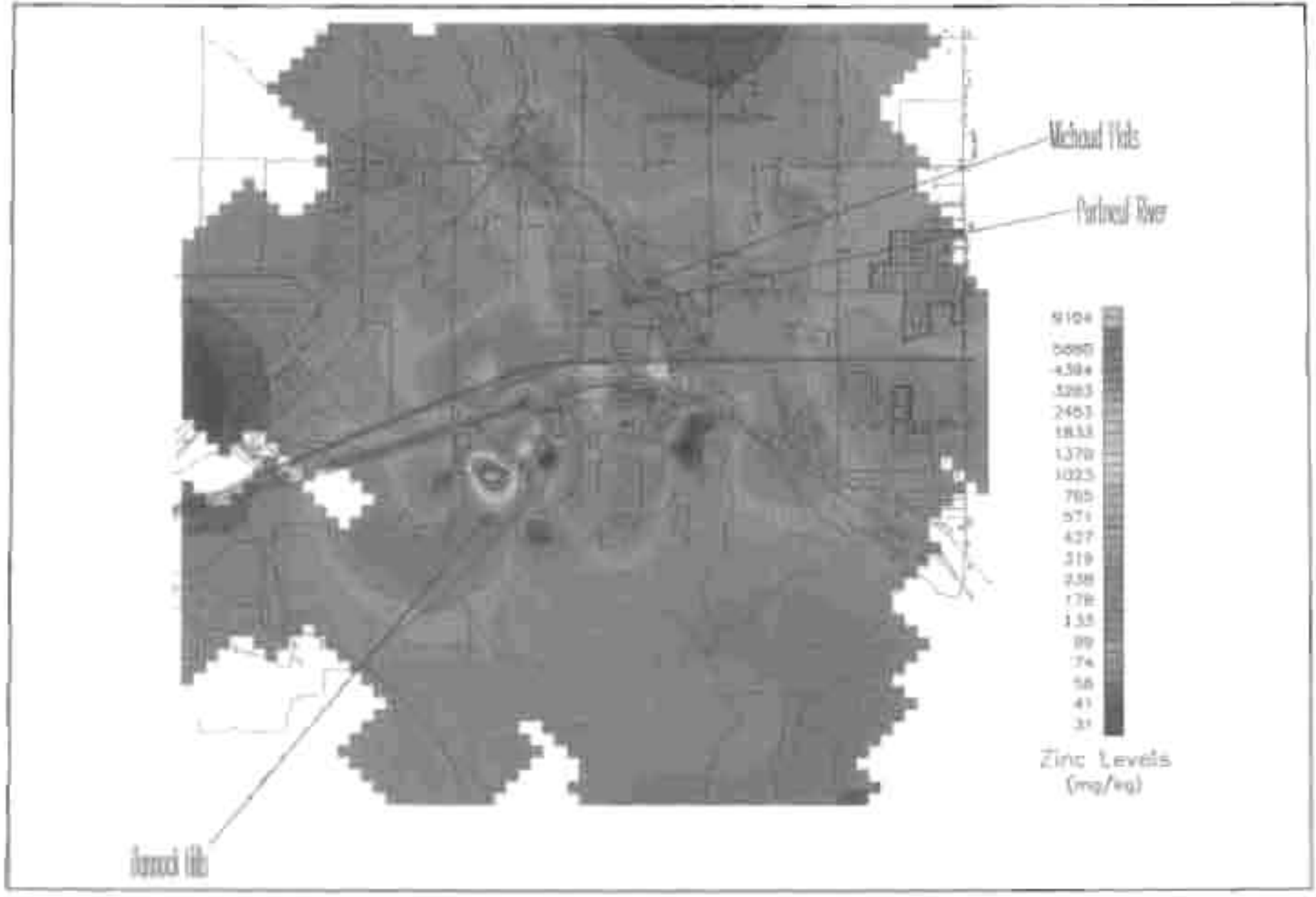

Figure 8-9 ZINC LEVELS IN SURFACE SOIL, IN RELATION TO THE BANNOCK HILLS, MICHAUD FLATS, AND PORTNEUF RIVER SAMPLE LOCATIONS

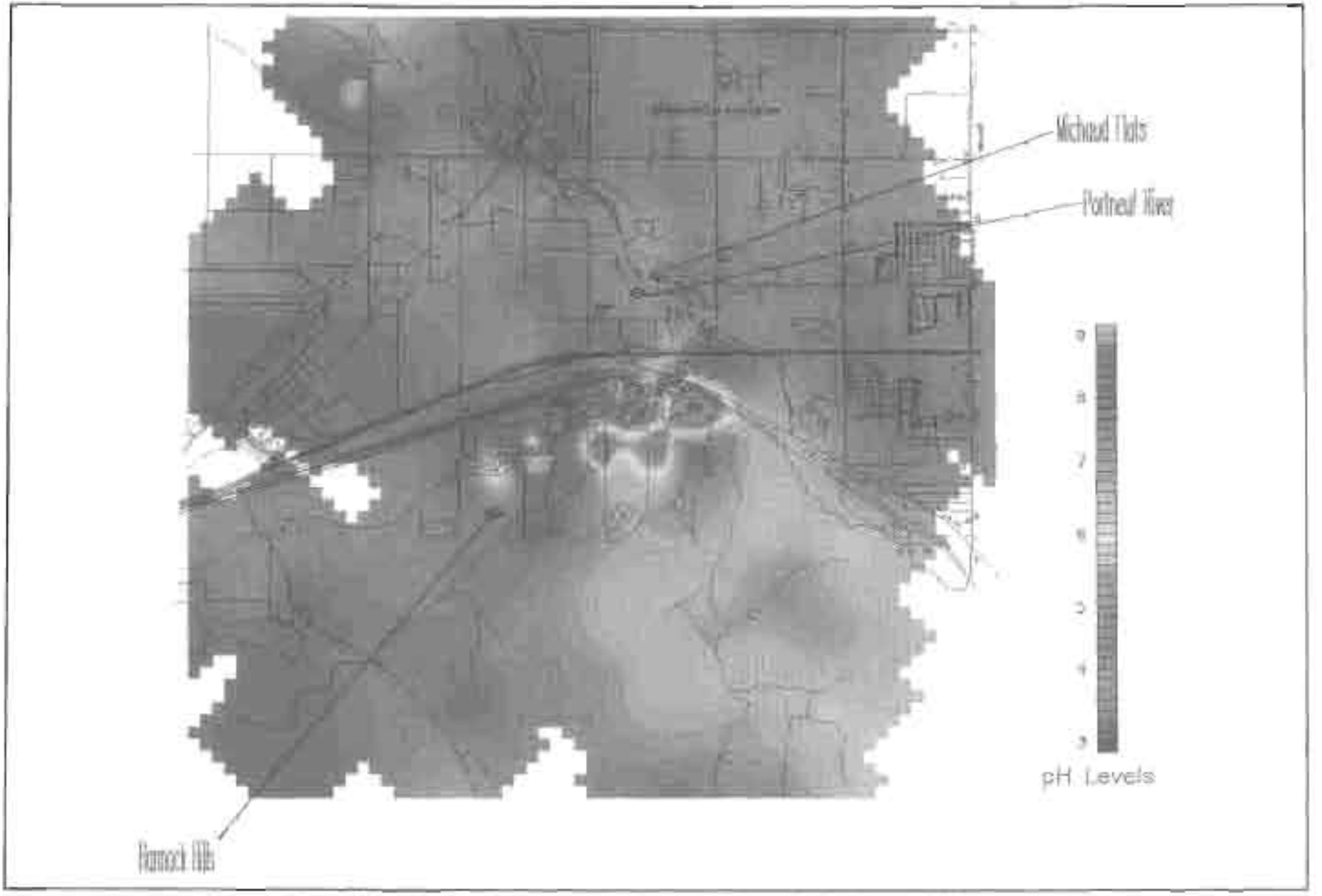

Figure B-10 pH LEVELS IN SURFACE SOIL, IN RELATION TO THE BANNOCK HILLS, MICHAUD FLATS, AND PORTNEUF RIVER SAMPLE LOCATIONS

C

C Statistical Approach

This appendix provides supporting information for the statistical evaluation of the data collected in the ecological investigation of the EMF site (see Section 3 and Appendix B). The "box/whisker" plots used to graphically display and evaluate the data in Section 3 are generally described in Section C.1. The rationale used to identify the appropriate sample size for the field investigations is provided in Section C.2. The statistical analyses used to compare data collected from site-impacted locations to background (or reference) locations are described in Section C.3.

C.1 Box/Whisker Plots

Box/whisker plots display both the central tendency and variability of data. Figure C-1 shows an idealized box/whisker plot (like those used to present the ecological assessment data in Section 3) and defines the important attributes. The central tendency of the data is indicated by the median. The variability of the data is indicated by the height of the box and length of the "whiskers".

Box and Whiskers

The lower box value (first quartile), median (second quartile), and upper box value (third quartile) divide the values in a data set (excluding outliers and extreme values) into four equal parts by frequency. Thus, 25% of the values in a data set lie between the tip of the lower whisker and the lower box value (LBV), 25% lie between the LBV and the median, 25% lie between the median and upper box value (UBV), and 25% lie between the UBV and the tip of the upper whisker. Values that lie far from the middle of the distribution are referred to as outliers and extreme values if they meet the conditions shown in Figure C-1 and specified below.

Outliers

A data point is deemed to be an outlier if the following conditions hold:

$$value > UBV + 1.5(UBV - LBV)$$

or

$$value < LBV - 1.5(UBV - LBV)$$

were UBV is the upper box value of the box in the box plot (i.e., the 75th percentile) and LBV is the lower box value (i.e., the 25th percentile).

Extreme Values

A data point is deemed to be an extreme value if the following conditions hold:

$$value > UBV + 3(UBV - LBV)$$

or

$$value < LBV - 3(UBV - LBV)$$

where UBV is the upper box value of the box in the box plot (i.e., the 75th percentile) and LBV is the lower box value (i.e., the 25th percentile).

C.2 Determination of Sample Size

Numbers of samples to be collected for each media or target species were determined by establishing data quality objectives that permit meaningful statistical comparisons to be made of differences between the site and reference areas. The approach for establishing sample size was in accordance with EPA guidance (EPA 1989, 1992a), and was applied to the EMF site using representative data from published literature to estimate the expected degree of variability in study populations.

As noted in EPA 1989, "there is no simple and strictly correct answer" to the question of how many samples to collect. In general, larger sample sizes provide more precise estimates of sample statistics, such as the average concentration of COPCs in tissues of a given target species. However, considerations of time, money, and availability of the target species can place practical constraints on the numbers of samples collected for site investigations. Therefore, guidelines presented in EPA guidance for the confidence level and power of the statistical tests, and the minimal detectable difference between the site and reference areas, were used to determine sample size.

One of the objectives of the ecological assessment was to collect a sufficient sample size to statistically distinguish potentially impacted areas from reference areas. In statistical terms, the "null hypothesis" states that the mean COPC concentrations in media at the site are the same as the mean COPC concentrations at the reference area. Two types of statistical errors may be made in testing the null hypothesis. Rejecting a null hypothesis when it is true is referred to as a Type I error. That is, a Type I error is committed if samples taken from the EMF Site are mistakenly considered to be significantly different from samples taken from a reference area. The probability of avoiding a Type I error is referred to as the "confidence" of the hypothesis test. Conversely, accepting a false null hypothesis is referred to as a Type II error. That is, a Type II error is committed if the site is mistakenly considered to be not significantly different from the reference area. The probability of avoiding a Type II error is referred to as the "power" of the hypothesis test.

In preliminary investigations of hazardous waste sites, the power of the test is considered to be possibly more important that the confidence level. According to EPA (1992a), 90% is the minimum power to be used in hypothesis tests for risk assessment purposes. The minimum level of confidence is considered to be 70%.

Determination of sample size requires specification of the power, confidence, and the magnitude of the difference to be detected (minimal detectable difference [MDD]). For sampling of media such as soils, the minimum difference between the mean concentrations of the site and background is considered to be 30% for risk assessment purposes (EPA 1992a).

Finally, an estimate of the expected variability of sample populations is needed. For the EMF Site, the standard deviation of COPC levels for various samples matrices was obtained from published studies (see Table C-1). These studies were considered to be representative because they examined the same or similar species as the target species for the ecological assessment, and because (with one exception) they were conducted in Idaho or adjacent states.

For the EMF Site, the sample size needed to detect a difference of 50% between the mean COPC concentrations at the site and a reference area, with a power of 90% and a confidence of 80%, was determined. An MDD of 50% was evaluated because of the high variability evident in the biological data presented in Table C-1. In general, an MDD of 50% encompasses 1 standard deviation for most of the data, which is likely to be adequate for risk assessment purposes at the EMF Site. A confidence of 80% rather than 70% was evaluated, since 70% was judged to provide too much uncertainty in distinguishing the site from

background (that is, the probability of rejecting a true null hypothesis was set at 20% rather than at 30%). The sample size (n) was determined following EPA (1989), and adjusted to provide the required samples size (n') to account for the use of estimated rather than known standard deviations.

Given these data quality objectives, a sample size of 10 was found to be adequate for nearly all target matrices and analytes (Table C-1). A larger sample size was indicated for fluoride in sagebrush. For fluoride in sagebrush, a sample size of 19 was suggested from calculations based on Arthur and Gates (1988). Therefore, as a conservative approach, a sample size of 20 was selected for analysis of fluoride in sagebrush foliage at the EMF Site.

C.3 Statistical Analysis

The objective of the statistical analyses of the chemical concentration data in the various environmental media was to identify any significant differences between the average concentrations at different locations. Concentrations at locations suspected of being contaminated were compared to concentrations at background locations. In addition, comparisons were made among different locations suspected of contamination. A confidence level of 80%, i.e., a false positive rate of 20% or a *p*-value equal to or less than 0.20, was used for the comparisons between locations of suspected contamination and background locations. A 95% confidence level (*p*-value equal to or less than 0.05) was used in all other statistical tests. These critical levels were selected based on EPA risk assessment guidance (EPA 1989, 1992a) and general statistical practice (e.g., Gilbert 1987, EPA 1992b), as discussed in the previous section.

Several statistical tools were used in the data analyses, including both parametric and nonparametric techniques. A parametric technique is one in which certain assumptions have been made about the way the data are distributed. The majority of parametric tests assume that the data are normally distributed, i.e., the values in the data set are symmetrically distributed about its mean or average value, and the overall distribution of values has a bell-shaped appearance. In general, parametric tests are more powerful (i.e., they are more likely to detect a true difference between locations), but are only valid and should only be used if the data are normally distributed. If the data set is not normal then either it must be mathematically transformed into a normal distribution before the parametric test can be used, or the corresponding nonparametric test must be used.

Initially, descriptive statistics (e.g., mean, variance) and the "frequency of detects" were used to provide basic descriptions of each parameter in the data set and to determine those parameters for which statistical comparisons would be appropriate. Parameters with a high frequency of detects were candidates for comparisons using parametric tests (e.g., t-test, ANOVA), but required additional testing before that decision was made. These parameters were examined for normality and homogeneity of variances among the comparison groups. The statistical tools used for this task include both statistical tests (Shapiro-Wilk, Levene) and/or graphical representations of the data (normality plots, box/whisker plots). The results of the normality and homogeneity of variances testing were used to identify which type of statistical comparisons—parametric or nonparametric—were most appropriate.

The tests used for parametric comparison of groups of data were the t-test when only two groups were being compared and single factor analysis of variance (ANOVA) where three or more groups were being compared. Similarly, the Mann-Whitney test was used for nonparametric comparison of two groups and the Kruskal-Wallis test was used for nonparametric comparison of three or more groups. The results of the statistical analyses are tabulated in Tables C-2 through C-9, and discussed in Section 3.

Because COPC levels were expected to be elevated at sample locations near the facilities, one-tailed significance tests were conducted when comparing impacted sites with reference sites using the t-test or Mann-Whitney test. When two impacted sites such as Bannock Hills SW and Michaud Flats were compared, two-tailed significance tests were conducted because there was no *a priori* reason to expect one site to have higher COPC levels than the other. The *p*-values listed in Tables C-2 to C-9 reflect this approach.

C.4 Evaluation of Data Quality Objectives

Tables C-10 to C-19 list the average concentration, sample standard deviation, coefficient of variation (CV), and percent difference between impacted and reference sites for each COPC in each sample type (soil, sagebrush, wheatgrass, etc.). For some sample types, the CV was greater than anticipated from previous studies in the area (see Section C.2). This had little effect on statistical comparisons, however, because the percent difference between impacted and reference sites was large, much greater than the 50% difference that was assumed when selecting target sample sizes. Therefore, data quality objectives were met with

regard to the sample size needed to distinguish concentrations of COPCs at the site from background concentrations.

C.5 References

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Table C-1

DETERMINATION OF SAMPLE SIZE

Matrix	Chemical	Reference	Study Matrix	Sample Type	Location	Average Concentration (mg/kg)	Standard Deviation (mg/kg)	Coefficient of Variation (%)	Number of Samples[a]	
									n	n'
Surface soil	Fluoride	Arthur & Gates 1988	Surface soil	0 to 5 cm	Idaho (INEL)	519	132	25.4%	2	4
	Zinc	Arthur & Gates 1988	Surface soil	0 to 5 cm	Idaho (INEL)	81.4	12.3	15.1%	1	2
Deer mouse	Cadmium	Beyer *et al.* 1985	White-footed mouse	Whole body	Pennsylvania	1.2	0.3	25.0%	1	2
	fluoride	Kay *et al.* 1975	Deer mouse	Femur	Montana	143.8	65.8	45.8%	8	9
	Zinc	Beyer *et al.* 1985	White-footed mouse	Whole body	Pennsylvania	145	42	29.0%	3	5
Sagebrush	Fluoride	Arthur & Gates 1988	Sagebrush	Washed foliage	Idaho (INEL)	16.9	11.6	68.6%	17	19
	Zinc	Arthur & Gates 1988	Sagebrush	Washed foliage	Idaho (INEL)	29.2	8.8	30.1%	3	5
Crested wheatgrass	Fluoride	Arthur & Gates 1988	Grass	Washed composites	Idaho (INEL)	30.3	9.6	31.7%	4	5
	Fluoride	Kay *et al.* 1975	Grass and Forbs	Composites	Western Montana	5.1	1.8	35.3%	4	6
	Zinc	Arthur & Gates 1988	Grass	Washed composites	Idaho (INEL)	41.4	18.3	44.2%	7	9

[a] Power = 90%, Significance Level = 80%, Minimum Detectable Difference = 50%

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Table C-2

SUMMARY OF STATISTICAL ANALYSES ON COPCs IN SURFACE SOIL

Chemical	Data Distribution					Tests for Homogeneity of Variances		Test Used for Analysis of Variance	ANOVA Kruskal-Wallis Significantly Different at 80%?[a]	Test Used for Paired Comparisons	Paired Comparisons p-values			
	BH	FL	FB	PR	SR	Levene's p-value	Homogeneity Assumption Valid at 95%?				BH > FB	FL > FB	PR > SR	BH = FL
Cadmium	Normal	Normal	Normal	Normal	Normal	< 0.00001	No	Kruskal-Wallis	Yes	Mann-Whitney	0.000078	0.000078	0.00078	0.0247
Fluoride	Normal	Normal	Normal	Lognormal	Normal	0.00007	No	Kruskal-Wallis	Yes	Mann-Whitney	0.000078	0.000078	0.000078	0.129
Zinc	Normal	Normal	Normal	Normal	Normal	< 0.00001	No	Kruskal-Wallis	Yes	Mann-Whitney	0.000078	0.000078	0.000078	0.000034

[a] For the three sagebrush steppe sites, "Yes" indicates a significant difference ($p < 0.2$) between at least one pair of the three examined groups: Bannock Hills SW (BH), Michaud Flats (FL), and Ferry Butte (FB).

Key:

BH = Bannock Hills SW.
COPC = Contaminant of potential concern.
FL = Michaud Flats.
FB = Ferry Butte.
PR = Portneuf River riparian site.
SR = Snake River riparian site.

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Table C-3

SUMMARY OF STATISTICAL ANALYSES ON COPCs IN UNWASHED SAGEBRUSH FOLIAGE

Chemical	Data Distribution			Tests for Homogeneity of Variances		Test Used for Analysis of Variance	ANOVA Kruskal-Wallis Significantly Different at 80%?[a]	Test Used for Paired Comparisons	Paired comparisons p-value		
	BH	FL	FB	Levene's p-value	Homogeneity Assumption Valid at 95%?				BH > FB	FL > FB	BH ≠ FL
Cadmium	Normal	Normal	Not normal Not lognormal	0.0087	No	Kruskal-Wallis	Yes	Mann-Whitney	0.000072	0.000072	0.0058
Fluoride	Normal	Normal	Normal	0.000021	No	Kruskal-Wallis	Yes	Mann-Whitney	<0.00001	<0.00001	0.00205
Zinc	Normal	Normal	Lognormal	0.797	Yes	ANOVA	Yes	Tukey's t-test	0.406	0.0018	0.0075

[a] "Yes" indicates a significant difference ($p < 0.2$) between at least one pair of the three examined groups: Bannock Hills SW (BH), Michaud Flats (FL), and Ferry Butte (FB).

Key:

BH = Bannock Hills SW.
COPC = Contaminant of potential concern.
FL = Michaud Flats.
FB = Ferry Butte.

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Table C-4

SUMMARY OF STATISTICAL ANALYSES ON COPCs IN WASHED SAGEBRUSH FOLIAGE

Chemical	Data Distribution			Test for Homogeneity of Variances		Test Used for Analysis of Variance	ANOVA or Kruskal-Wallis Significantly Different at 80%?[a]	Test Used for Paired Comparisons	Paired Comparisons p-value		
	BH	FL	FB	Levene's p-value	Homogeneity Assumption Valid at 95%				BH > FB	FL > FB	BH ≠ FL
Cadmium	Lognormal	Normal	Not Normal Not Lognormal	0.341	Yes	Kruskal-Wallis	Yes	Mann-Whitney	0.00008	0.00008	0.0033
Fluoride[b]	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Zinc	Normal	Lognormal	Not Normal Not Lognormal	0.0266	No	Kruskal-Wallis	Yes	Mann-Whitney	0.237	0.087	0.0172

a "Yes" indicates a significant difference ($p < 0.2$) between at least one pair of the three examined groups: Bannock Hills SW (BH), Michaud Flats (FL), and Ferry Butte (FB).
b All reported values were less than method detection limit; meaningful statistical comparisons not possible.

Key:

BH = Bannock Hills SW.
COPC = Contaminant of potential concern.
FB = Ferry Butte.
FL = Michaud Flats.
NA = Not analyzed.

Table C-5

SUMMARY OF STATISTICAL ANALYSES ON COPCs IN THICKSPIKE WHEATGRASS

Chemical	Data Distribution			Test for Homogeneity of Variances		Test Used for Analysis of Variance	ANOVA Kruskal-Wallis Significantly Different at 80%?[a]	Test Used for Paired Comparisons	Paired Comparisons p-value		
	BH	FL	FB	Levene's p-value	Homogeneity Assumption Valid at 95%				BH > FB	FL > FB	BH ≠ FL
Cadmium	Normal	Normal	Not Normal Not Lognormal	0.0277	No	Kruskal-Wallis	Yes	Mann-Whitney	0.000143	0.000143	0.225
Fluoride	Not Normal Not Lognormal	Not Normal Not Lognormal	Normal	<0.00001	No	Kruskal-Wallis	Yes	Mann-Whitney	0.00008	0.171	0.001
Zinc	Normal	Not Normal Not Lognormal	Normal	0.155	Yes	Kruskal-Wallis	Yes	Mann-Whitney	0.0142	0.0105	0.325

[a] "Yes" indicates a significant difference ($p < 0.2$) between at least one pair of the three examined groups: Bannock Hills SW (BH), Michaud Flats (FL), and Ferry Butte (FB).

Key:

BH = Bannock Hills SW.
COPC = Contaminant of potential concern.
FL = Michaud Flats.
FB = Ferry Butte.

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Table C-6

SUMMARY OF STATISTICAL ANALYSES ON COPCs IN RUSSIAN OLIVE

Chemical	Data Distribution		Tests for Homogeneity of Variances		Test Used for Paired Comparisons	Paired Comparison *p*-value
	PR	SR	Levene's *p*-value	Homogeneity Assumption Valid at 95%		PR > SR
Cadmium	Not Normal Not Lognormal	Not Normal Not Lognormal	0.601	Yes	Mann-Whitney	0.068
Fluoride[a]	NA	NA	NA	NA	NA	NA
Zinc	Normal	Normal	0.859	Yes	t-test	0.000205

[a] All reported values were less than method detection limit; meaningful statistical comparisons not possible.

Key:

COPC = Contaminant of potential concern.
NA = Not analyzed.
PR = Portneuf River riparian site.
SR = Snake River riparian site.

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Table C-7

SUMMARY OF STATISTICAL ANALYSES ON COPCs IN DEER MICE

Chemical	Data Distribution			Tests for Homogeneity of Variances		Test Used for Analysis of Variance	ANOVA Kruskal-Wallis Significantly Different at 80%?[a]	Test Used for Paired Comparisons	Paired comparisons p-value		
	BH	FL	FB	Levene's p-Value	Homogeneity Assumption Valid at 95%				BH > FB	FL > FB	BH ≠ FL
Cadmium	Normal	Normal	Lognormal	0.153	Yes	ANOVA	Yes	Tukey's t-test	0.00007	0.00017	0.00065
Fluoride (Whole Body)	Normal	Normal	Normal	0.00008	No	Kruskal-Wallis	Yes	Mann-Whitney	0.00008	0.00008	0.0055
Fluoride (Femur)	Lognormal	Normal	Lognormal	0.17	Yes	ANOVA	Yes	Tukey's t-test	0.00415	0.00007	0.0021
Zinc	Normal	Normal	Normal	0.12	Yes	ANOVA	No	Tukey's t-test	0.499	0.452	0.46

[a] "Yes" indicates a significant difference ($p < 0.2$) between at least one pair of the three examined groups: Bannock Hills SW (BH), Michaud Flats (FL), and Ferry Butte (FB).

Key:

BH = Bannock Hills SW.
COPC = Contaminant of potential concern.
FL = Michaud Flats.
FB = Ferry Butte.

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Table C-8

SUMMARY OF STATISTICAL ANALYSES ON SUSPECTED CONTAMINANTS AND ALUMINUM IN DELTA SEDIMENT

Chemical	Data Distribution				Tests for Homogeneity of Variances		Test Used for Analysis of Variance	ANOVA Kruskal-Wallis Significantly Different at 80%?[a]	Test Used for Paired Comparison	Paired Comparisons *p*-value		
	PB	PC	SB	SC	Levene's *p*-value	Homogeneity Assumption Valid at 95%				PB > SB	PC > SC	PR > SR[b]
Aluminum	Lognormal	Lognormal	Lognormal	Lognormal	0.0796	Yes	ANOVA	Yes	t-test	0.0078	0.0128	0.00074
Arsenic	Lognormal	Normal	Normal	Not Normal Not Lognormal	0.0495	No	Kruskal-Wallis	No	Mann-Whitney	0.126	0.338	0.188 (SR > PR)[c]
Cadmium	Lognormal	Lognormal	Lognormal	Lognormal	0.017	No	Kruskal-Wallis	Yes	Mann-Whitney	0.0005	0.00044	<0.00001
Fluoride	Normal	Normal	Normal	Normal	0.562	Yes	ANOVA	Yes	t-test	0.053	0.00002	0.00004
Selenium	Lognormal	Lognormal	Lognormal	Lognormal	0.279	Yes	ANOVA	No	t-test	0.319	0.487	0.13
Zinc	Lognormal	Lognormal	Lognormal	Lognormal	0.142	Yes	ANOVA	Yes	t-test	0.0482	0.173	0.0335

[a] "Yes" indicates a significant difference ($p < 0.2$) between at least one pair of the four examined groups: Portneuf River Channel (PC), Snake River Channel (SC), Portneuf River Bank (PB), and Snake River Bank (SB).

[b] Portneuf River (PR), channel and bank, and Snake River (SR), channel and bank, for the combined dataset from each river location.

[c] *p*-value shown for Snake River > Portneuf River.

Key:

PB = Portneuf River Bank.
PC = Portneuf River Channel.
SB = Snake River Bank.
SC = Snake River Channel.

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Table C-9

SUMMARY OF STATISTICAL ANALYSES ON ELEMENT TO ALUMINUM RATIOS FOR SUSPECTED CONTAMINANTS IN DELTA SEDIMENT

Element to Aluminum (Al) Ratio	Data Distribution				Tests for Homogeneity of variances		Test Used for Analysis of Variance	ANOVA Kruskal-Wallis Significantly Different at 80%?[a]	Test Used for Paired Comparisons	Paired Comparisons p-value		
	PB	PC	SB	SC	Levene's p-value	Homogeneity Assumption Valid at 95%?				PB > SB	PC > SC	PR > SR[b]
Arsenic/Al	Normal	Normal	Not Normal	Normal	0.0061	No	Kruskal-Wallis	Yes	Mann-Whitney	0.0057 (SB > PB)[c]	0.00008 (SC > PC)[c]	<0.00001 (SR > PR)[c]
Cadmium/Al	Normal	Normal	Normal	Normal	0.063	No	Kruskal-Wallis	Yes	Mann-Whitney	0.00258	0.00008	<0.00001
Fluoride/Al	Normal	Normal	Normal	Normal	0.93	Yes	ANOVA	Yes	t-test	0.138 (SB > PB)[c]	0.498	0.143 (SR > PR)[c]
Selenium/Al	Normal	Normal	Normal	Normal	0.0767	No	Kruskal-Wallis	Yes	Mann-Whitney	0.0207 (SB > PB)[c]	0.0172 (SC > PC)[c]	0.0019 (SR > PR)[c]
Zinc/Al	Normal	Normal	Not Normal	Normal	0.00006	No	Kruskal-Wallis	Yes	Mann-Whitney	<0.00001 (SB > PB)[c]	0.00001 (SC > PC)[c]	<0.00001 (SR > PR)[c]

[a] "Yes" indicates a significant difference ($p < 0.2$) between at least one pair of the four examined groups: Portneuf River Channel (PC), Snake River Channel (SC), Portneuf River Bank (PB), and Snake River Bank (SB).

[b] Portneuf River (PR), channel and bank, and Snake River (SR), channel and bank, for the combined dataset from each river location.

[c] p-value shown for Snake River > Portneuf River.

Key:

PB = Portneuf River Bank.
PC = Portneuf River Channel.
SB = Snake River Bank.
SC = Snake River Channel.

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Table C-10

DESCRIPTIVE STATISTICS FOR COPCs IN SURFACE SOIL AT SAGEBRUSH STEPPE LOCATIONS

Chemical	Bannock Hills SW					Michaud Flats					Ferry Butte			
	Number of Samples	Average Concentration (mg/kg)	Standard Deviation (mg/kg)	Coefficient of Variation (%)	Relative Percent Difference from Ferry Butte	Number of Samples	Average Concentration (mg/kg)	Standard Deviation (mg/kg)	Coefficient of Variation (%)	Relative Percent Difference from Ferry Butte	Number of Samples	Average Concentration (mg/kg)	Standard Deviation (mg/kg)	Coefficient of Variation (%)
Cadmium	10	27.22	4.954	18	3,927	10	21.04	7.705	37	3,012	10	0.676	0.226	33
Fluoride	10	1,454	227	16	300	10	1,792.5	715	40	393	10	363.4	30.9	9
Zinc	10	255.8	46.7	18	353	10	155.9	47.9	31	176	10	56.47	4.6	8

Key:

COPC = Contaminant of potential concern.

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Table C-11

DESCRIPTIVE STATISTICS FOR COPCs
IN SURFACE SOIL AT RIPARIAN HABITATS

Chemical	Portneuf Riparian					Snake Riparian			
	Number of Samples	Average Concentration (mg/kg)	Standard Deviation (mg/kg)	Coefficient of Variation (%)	Relative Percent Difference from Snake Riparian	Number of Samples	Average Concentration (mg/kg)	Standard Deviation (mg/kg)	Coefficient of Variation (%)
Cadmium	10	10.334	8.45	82	3,844	10	0.262	0.068	26
Fluoride	10	1,072	764	71	339	10	244.5	34.3	14
Zinc	10	113.77	51.6	45	370	10	24.22	4.45	18

Key:

COPC = Contaminant of potential concern.

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Table C-12

DESCRIPTIVE STATISTICS FOR COPCs IN WASHED SAGEBRUSH FOLIAGE

Chemical	Bannock Hills SW					Michaud Flats					Ferry Butte			
	Number of Samples	Average Concentration (mg/kg)	Standard Deviation (mg/kg)	Coefficient of Variation (%)	Relative Percent Difference from Ferry Butte	Number of Samples	Average Concentration (mg/kg)	Standard Deviation (mg/kg)	Coefficient of Variation (%)	Relative Percent Difference from Ferry Butte	Number of Samples	Average Concentrations (mg/kg)	Standard Deviation (mg/kg)	Coefficient of Variation (%)
Cadmium	10	0.772	0.1745	23	365	10	1.099	0.2385	22	562	10	0.166	0.0916	55
Fluoride[a]	20	–	–	–	–	20	–	–	–	–	20	–	–	–
Zinc	10	25.98	3.3259	13	-6	10	32.66	8.9228	27	18	10	27.62	4.8675	18

[a] All values less than method detection limit.

Key:

COPC = Contaminant of potential concern.

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Table C-13

DESCRIPTIVE STATISTICS FOR COPCs IN UNWASHED SAGEBRUSH FOLIAGE

Chemical	Bannock Rifle SW					Michaud Flats					Ferry Butte			
	Number of Samples	Average Concentration (mg/kg)	Standard Deviation (mg/kg)	Coefficient of Variation (%)	Relative Percent Difference from Ferry Butte	Number of Samples	Average Concentration (mg/kg)	Standard Deviation (mg/kg)	Coefficient of Variation (%)	Relative Percent Difference from Ferry Butte	Number of Samples	Average Concentration (mg/kg)	Standard Deviation (mg/kg)	Coefficient of Variation (%)
Cadmium	10	0.992	0.1204	12	470	10	1.267	0.2578	20	628	10	0.174	0.0932	54
Fluoride	20	74.1825	29.6615	40	514	20	51.5525	23.9438	46	327	20	12.075	0.2900	2
Zinc	10	31.22	4.1001	13	3	10	38.26	5.3571	14	27	10	30.2	5.9939	20

Key:
COPC = Contaminant of potential concern.

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Table C-14

DESCRIPTIVE STATISTICS FOR COPCs IN THICKSPIKE WHEATGRASS

Chemical	Bannock Hills SW					Michaud Flats					Ferry Butte			
	Number of Samples	Average Concentration (mg/kg)	Standard Deviation (mg/kg)	Coefficient of Variation (%)	Relative Percent Difference from Ferry Butte	Number of Samples	Average Concentration (mg/kg)	Standard Deviation (mg/kg)	Coefficient of Variation (%)	Relative Percent Difference from Ferry Butte	Number of Samples	Average Concentrations (mg/kg)	Standard Deviation (mg/kg)	Coefficient of Variation (%)
Cadmium	10	0.539	0.1835	34	335	10	0.461	0.0781	17	272	10	0.124	0.0955	77
Fluoride	10	62.12	28.0145	45	410	10	22.45	14.8672	66	84	10	12.18	0.2251	2
Zinc	10	11.49	3.2804	29	40	10	10.77	2.5725	24	31	10	8.23	1.4221	17

Key:

COPC = Contaminant of potential concern.

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Table C-15

DESCRIPTIVE STATISTICS FOR COPCs IN RUSSIAN OLIVE FRUIT

Chemical	Portneuf Riparian					Snake Riparian			
	Number of Samples	Average Concentration (mg/kg)	Standard Deviation (mg/kg)	Coefficient of Variation (%)	Relative Percent Difference from Snake Riparian	Number of Samples	Average Concentration (mg/kg)	Standard Deviation (mg/kg)	Coefficient of Variation (%)
Cadmium	10	0.1755	0.086681	49.4	75.5	10	0.10	0.002	2
Fluoride[a]	10	—	—	—	—	10	—	—	—
Zinc	10	10.24	1.782134	17.4	42.4	10	7.19	1.341185	18.7

[a] All values are less than method detection limit.

Key:

COPC = Contaminant of potential concern.

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Table C-16

DESCRIPTIVE STATISTICS FOR COPCs IN DEER MICE

Chemical	Bannock Hills SW					Michaud Flats					Ferry Butte			
	Number of Samples	Average Concentration (mg/kg)	Standard Deviation (mg/kg)	Coefficient of Variation (%)	Relative Percent Difference from Ferry Butte	Number of Samples	Average Concentration (mg/kg)	Standard Deviation (mg/kg)	Coefficient of Variation (%)	Relative Percent Difference from Ferry Butte	Number of Samples	Average Concentration (mg/kg)	Standard Deviation (mg/kg)	Coefficient of Variation (%)
Cadmium	10	0.614	0.26788	43.6	830	10	0.217	0.13005	59.9	228	10	0.066	0.05082	77.0
Fluoride (whole body)	10	128.48	26.2432	20.4	1,786	10	90.93	30.3335	33.3	1,235	10	6.81	0.44957	6.6
Fluoride (femur)	10	297.25	199.603	67.2	128	10	633.3	220.348	34.8	386	10	130.35	90.0472	69.1
Zinc	10	38.48	4.53132	11.8	-0.23	10	37.59	3.84894	10.2	-2.5	10	38.57	6.52637	16.9

Key:

COPC = Contaminant of potential concern.

Table C-17

DESCRIPTIVE STATISTICS FOR ALUMINUM AND SUSPECTED CONTAMINANTS IN BANK SEDIMENT

Chemical	Portneuf Bank					Snake Bank			
	Number of Samples	Average Concentration (mg/kg)	Standard Deviation (mg/kg)	Coefficient of Variation (%)	Relative Percent Difference from Snake Bank	Number of Samples	Average Concentration (mg/kg)	Standard Deviation (mg/kg)	Coefficient of Variation (%)
Aluminum	10	9696	3872.80	40%	80%	10	5378	1769.22	33%
Arsenic	9	3.311	0.85	26%	15%	10	2.89	1.06	37%
Cadmium	10	0.986	0.37	37%	130%	10	0.428	0.16	37%
Fluoride	10	333.6	75.51	23%	22%	10	274.2	80.48	29%
Selenium	10	0.967	0.53	54%	47%	10	0.66	0.24	37%
Zinc	10	49.56	17.52	35%	34%	10	36.96	10.35	28%

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Table C-18

DESCRIPTIVE STATISTICS FOR ALUMINUM AND SUSPECTED CONTAMINANTS IN CHANNEL SEDIMENT

Chemical	Portneuf Channel					Snake Channel			
	Number of Samples	Average Concentration (mg/kg)	Standard Deviation (mg/kg)	Coefficient of Variation (%)	Relative Percent Difference from Snake Channel	Number of Samples	Average Concentration (mg/kg)	Standard Deviation (mg/kg)	Coefficient of Variation (%)
Aluminum	10	6497	1465.15	23%	38%	10	4716	3087.75	65%
Arsenic	10	2.51	0.53	21%	-24%	10	3.32	2.91	88%
Cadmium	10	0.881	0.20	22%	184%	10	0.31	0.25	80%
Fluoride	10	356.8	54.64	15%	63%	10	218.8	60.09	27%
Selenium	10	0.657	0.27	41%	13%	10	0.584	0.20	35%
Zinc	10	36.14	7.80	22%	8%	10	33.44	16.12	48%

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Table C-19

DESCRIPTIVE STATISTICS FOR ALUMINUM AND SUSPECTED CONTAMINANTS IN BANK AND CHANNEL SEDIMENT

Chemical	Portneuf Bank and Channel (Combined)					Snake Bank and Channel (Combined)			
	Number of Samples	Average Concentration (mg/kg)	Standard Deviation (mg/kg)	Coefficient of Variation (%)	Relative Percent Difference	Number of Samples	Average Concentration (mg/kg)	Standard Deviation (mg/kg)	Coefficient of Variation (%)
Aluminum	20	8096.5	3288.54	41%	60%	20	5047	2472.70	49%
Arsenic	19	2.89	0.79	27%	-7%	20	3.11	2.14	69%
Cadmium	20	0.934	0.29	31%	153%	20	0.369	0.21	57%
Fluoride	20	345.2	65.25	19%	40%	20	246.5	74.74	30%
Selenium	20	0.812	0.44	54%	31%	20	0.622	0.22	35%
Zinc	20	42.85	14.88	35%	22%	20	35.2	13.31	38%

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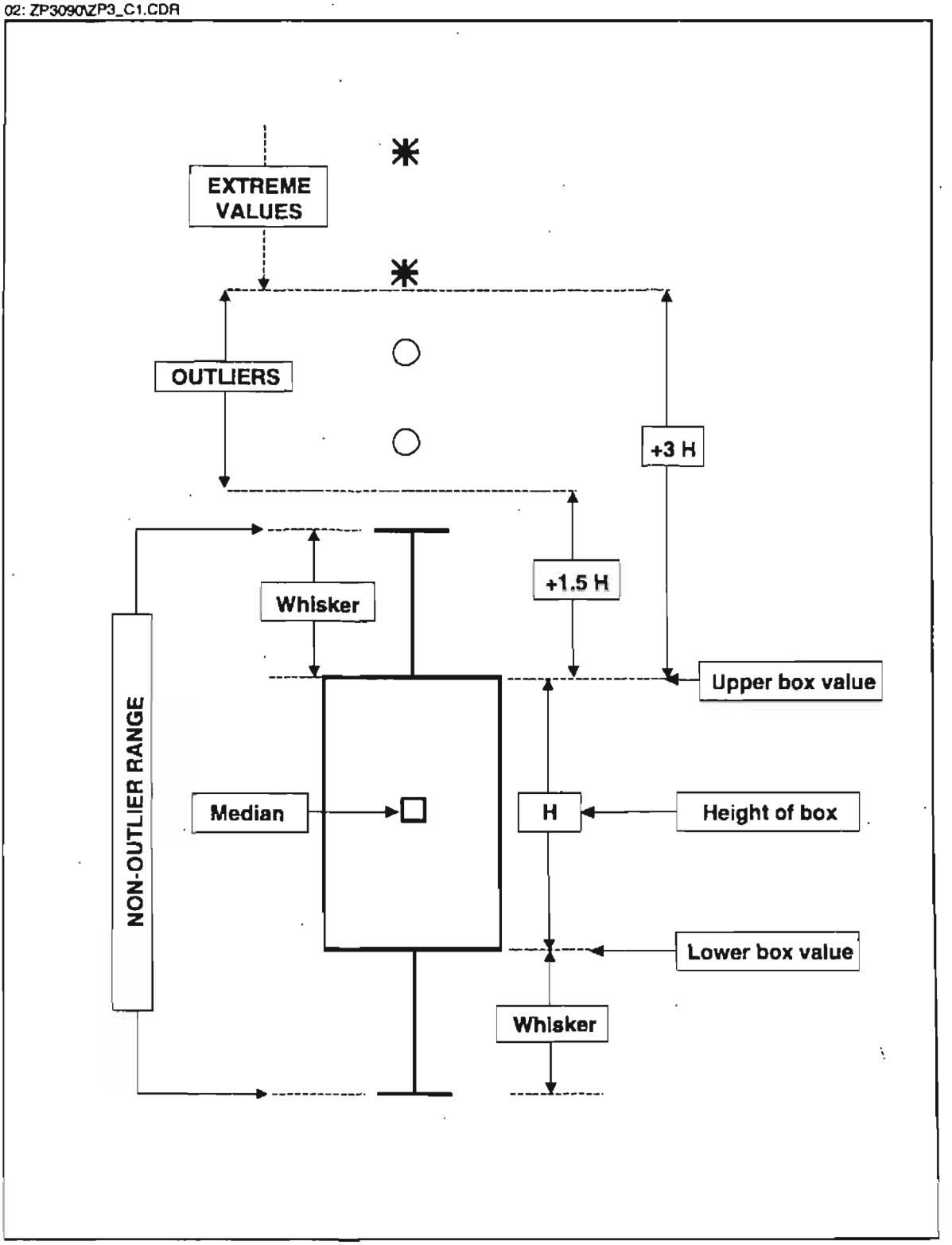

SOURCE: Ecology and Environment, Inc., 1995

Figure C-1 AN IDEALIZED BOX/WHISKER PLOT

D

D State and Federal Agency Correspondence Regarding Threatened, Endangered, or Other Species of Concern

ecology and environment, inc.
BUFFALO CORPORATE CENTER
368 PLEASANTVIEW DRIVE, LANCASTER, NEW YORK 14086, TEL. 716/684-8060
International Specialists in the Environment

October 12, 1993

Mr. Jim Pfeifer
Idaho State Fish and Game
600 S. Walnut Street
P.O. Box 25
Boise, Idaho 83707

Dear Mr. Pfeifer:

Enclosed is a copy of the Pocatello 30 x 60 minute quadrangle map highlighting the Eastern Michaud Flats Superfund site which includes both the Simplot and FMC facilities. The EPA is currently conducting a Remedial Investigation/Feasibility Study (RI/FS) on this site.

Our firm Ecology and Environment, Inc. (E & E), has been contracted to prepare an Ecological Risk Assessment for this RI/FS. An integral part of this assessment involves the the identification of threatened, endangered, or other species of concern, wildlife refuges, significant habitat and other natural landscape features such as wetlands which may be directly or indirectly impacted by the site. For this reason, I would appreciate any information you have concerning the above-mentioned items within 10 miles of the site.

We greatly appreciate your assistance in this matter. If you have any questions concerning this data request, please do not hesitate to call me at 716-684-8060.

Sincerely,

Steven Peterson

Steven Peterson, Ph.D.
Ecologist

jav/zp3080

enclosure

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Well
Gravel Pit
Tyhee
Well No 3
Well No 4
Well No 5
Chubbuck
Gravel Pit
Don
Michaud
Pocatello
Pocatello
Creek
Radio Tower
Radio Facility
Radio Tower
Idaho State Univ.
Red Hill
Well
POWERLINE
UNION
PACIFIC

IDAHO CONSERVATION DATA CENTER

Idaho Department of Fish and Game • 600 South Walnut • P.O. Box 25 Boise, Idaho 83707 • (208) 334-3402 • FAX 334-2114

26 November 1993

Steven Peterson, Ecologist
Ecology and Environment, Inc.
Buffalo Corporate Center
368 Pleasantview Drive
Lancaster, New York 14086

Dear Mr. Peterson:

Your lettter of 12 October 1993, addressed to Jim Pfeifer, Idaho Department of Fish and Game, reached my desk last week. The Conservation Data Center has already responded to this request (with a species list) via the Boise Field Office, U. S. Fish and Wildlife Service. The following list is more lengthy because it contains not only listed and candidate species, but species with other categories of status (e.g., state species of special concern) that fall within the 10-mile buffer.

The 10-mile buffer includes parts of American Falls Reservoir, some areas north of the reservoir, and part of Fort Hall Bottoms. The inclusion of these areas greatly increases the number of species involved.

Animal Species	Comments
pygmy rabbit	This species might be found in any areas with big sagebrush cover.
wolverine	This is a single, recent sighting in Fort Hall Bottoms.
Townsend's big-eared bat	This is a specimen collection only and does not denote a roost or hibernaculum. Several specimens have been collected from various areas around the Pocatello area.

Animal Species	Comments
bald eagle	wintering area
trumpeter swan	wintering area (Swans were transplanted two years ago to the Snake River at/near the Fort Hall Bottoms area.)
long billed curlew	nesting area
black tern	colonial nesting area
common tern	colonial nesting area
Caspian tern	colonial nesting area
California gull	colonial nesting area
ring-billed gull	colonial nesting area
eared grebe	nesting area
western grebe	colonial nesting area
Clark's grebe	colonial nesting area
yellow-billed cuckoo	probable nesting area
double-crested cormorant	colonial nesting area
pinyon jay	nesting area
Idaho Dunes tiger beetle	Found on the north side of American Falls Reservoir.

Plant Species	Comments
Lepidium papilliferum	This is represented by an old (1949) collection.
Muhlenbergia racemosa	This, too, is a single, older collection (1962).

Enclosed is a booklet entitled "Rare, threatened and endangered plants and animals of Idaho," which provides the categories of status for each of the species and defines each status.

If you have questions, please contact me.

Sincerely,

George Stephens

George Stephens
Information Manager

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Please note: The quantity and quality of data collected by the Idaho Conservation Data Center (CDC) are dependent on the research and observations of many individuals and organizations. In most cases, these data are not the result of comprehensive or site-specific field surveys; many natural areas in Idaho have never been thoroughly surveyed. For these reasons, the CDC cannot provide a definitive statement on the presence, absence, or condition of biological elements in any part of Idaho. CDC reports summarize the existing information known to the CDC at the time of the request regarding the biological elements or locations in question. They should never be regarded as final statements on the elements or areas being considered, nor should they be substituted for on-site surveys required for environmental assessments.

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BUFFALO CORPORATE CENTER
368 PLEASANTVIEW DRIVE, LANCASTER, NEW YORK 14086, TEL. 716/684-8060
International Specialists in the Environment

October 12, 1993

Ms. Peggy N. Guillory
U.S. Fish and Wildlife Service
4696 Overland Road, Rm. 576
Boise, Idaho 83705

Dear Ms. Guillory:

Enclosed is a copy of the Pocatello 30 x 60 minute quadrangle map highlighting the Eastern Michaud Flats Superfund site which includes both the Simplot and FMC facilities. The EPA is currently conducting a Remedial Investigation/Feasibility Study (RI/FS) on this site. William Mullins, from your agency, is a member of the Technical Advisory Group affiliated with this site.

Our firm Ecology and Environment, Inc. (E & E), has been contracted to prepare an Ecological Risk Assessment for this RI/FS. An integral part of this assessment involves the identification of threatened, endangered, or other species of concern, wildlife refuges, significant habitat and other natural landscape features such as wetlands which may be directly or indirectly impacted by the site. For this reason, I would appreciate any information you have concerning the above-mentioned items within 10 miles of the site.

We greatly appreciate your assistance in this matter. If you have any questions concerning this data request, please do not hesitate to call me at 716-684-8060.

Sincerely,

Steven Peterson

Steven Peterson, Ph.D.
Ecologist

jav/zp3080

enclosure

cc: William Mullins

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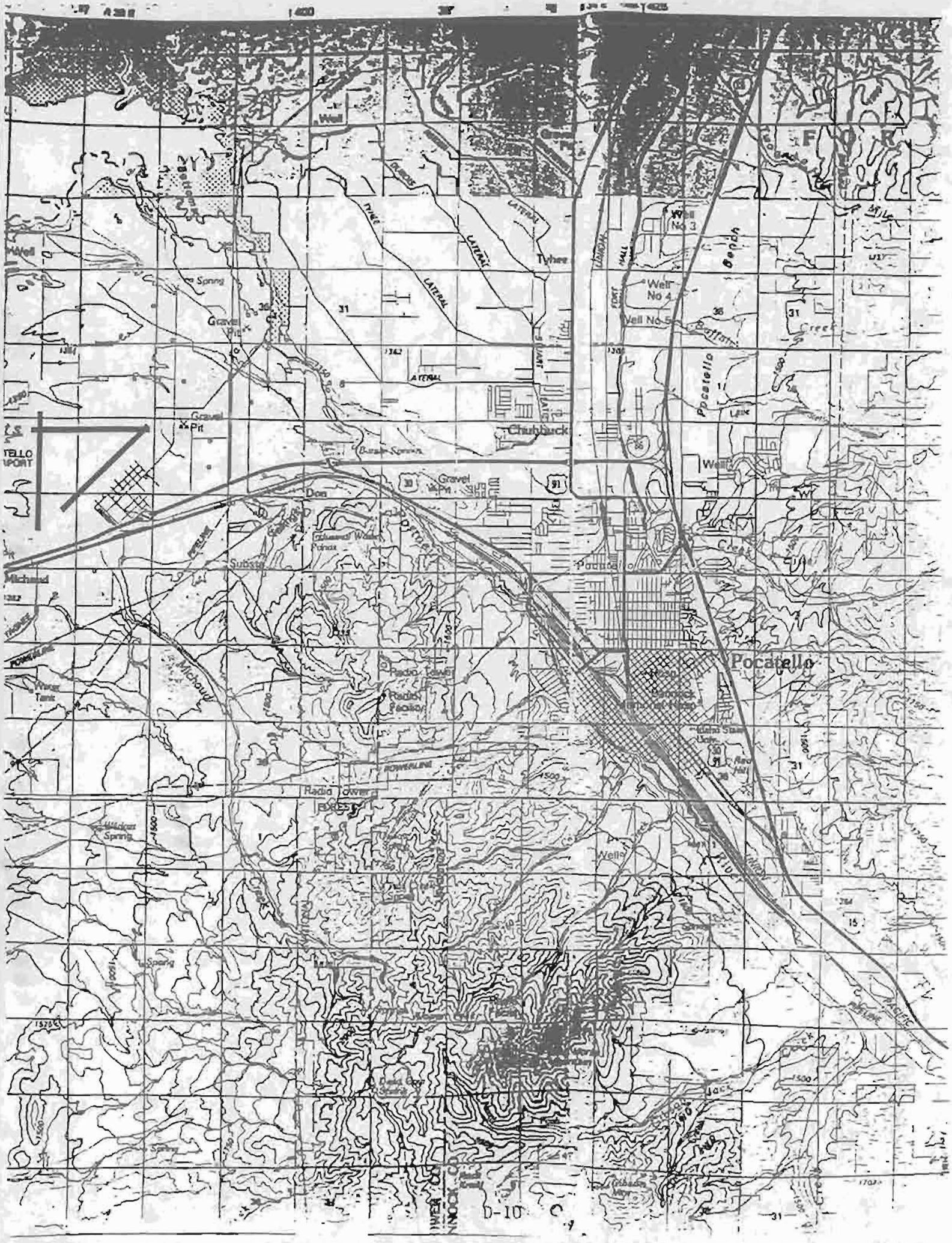
Well
Tyhee
Well No 3
Well No 4
Well No 5
Gravel Pit
Chubbuck
Pocatello
Radio Tower
Radio Facility
Michaud
Substa
Don
Spring
Water Tank
Radio Tower
Well
Creek
Pocatello Creek
Bannock Creek
Jack
Spring
Idaho State Univ
Red Hill
POWERLINE
PIPELINE
PACIFIC
LATERAL
TYHEE
UNION
FORT HALL
Bench
Buffalo
Creek
Lake
Pocatello
River
BANNOCK CO
CHUBBUCK CO

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Boise Field Station
4696 Overland Road, Room 576
Boise, Idaho 83705

November 16, 1993

Dr. Steven Peterson
Ecology and Environment, Inc.
368 Pleasantview Drive
Lancaster, New York 14086

Subject: Eastern Michaud Flats Superfund Site
(SP# 1-4-94-SP-14/ File # 1019.1032)

Dear Dr. Peterson:

As requested by your letter dated October 12, 1993, and received by this office on October 18, 1993, we have enclosed a list (Enclosure A) of endangered and threatened, proposed, and/or candidate species that may be present in the proposed project area. The list fulfills the requirements of the U.S. Fish and Wildlife Service (Service) under Section 7(c) of the Endangered Species Act of 1973 (Act), as amended. The requirements for Federal agency compliance under the Act are outlined in Enclosure B. Please reference the species list number on Enclosure A in all subsequent correspondence, reports, environmental assessments, environmental impact statements, biological assessments (evaluations), Coordination Act reports, etc.

If a listed species appears on Enclosure A, a biological assessment (evaluation) would be prudent. If a biological assessment is not commenced within 180 days of this response a subsequent species list request is required by regulations. Should your biological assessment determine that a listed species is likely to be affected adversely by the Eastern Michaud Flats Superfund Site project, Ecology and Environment, Inc. or the Environmental Protection Agency should request formal Section 7 consultation through this office. If a proposed species is likely to be jeopardized by a Federal action, regulations require a conference between the Federal agency and the Service.

Candidate species that appear on Enclosure A have no protection under the Act, but are included for early planning consideration. Proposed species could be formally listed and candidate species could be formally proposed and listed during project planning, thereby falling within the scope of Section 7 of the Endangered Species Act. Therefore, if they appear on Enclousre A, we recommend that additional surveys be made for proposed and/or candidate

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species that are likely to be in your project area. If the project is likely to adversely impact a candidate species, informal consultation with this office is recommended.

The National Wetlands Inventory (NWI) maps show wetlands in the vicinity of the project area. The Service recommends that you contact the U.S. Army Corps of Engineers to conduct a site specific inventory of the area. National Wetland Inventory maps provide general information on wetlands but do not preclude the need for a site specific wetland inventory.

In future species list requests you should specify the legal description of the project area for the Service to provide you with a response.

If you have any questions regarding Federal consultation responsibilities under the Act or for wetland policy, please contact Bill Mullins or Marilyn Hemker of this office at (208) 334-1931.

Thank you for your continued interest in the Endangered Species Program.

Sincerely,

Susan B. Martin

for Charles H. Lobdell
State Supervisor

Enclosures

cc: FWS-ES, Portland
IDFG-HQ., Boise
IDFG, Region 5, Pocatello

ENCLOSURE A

LISTED AND PROPOSED ENDANGERED AND THREATENED
SPECIES, AND CANDIDATE SPECIES, THAT MAY OCCUR
WITHIN THE AREA OF THE EASTERN MICHAUD FLATS SUPERFUND SITE PROJECT
FWS-1-4-94-SP-14

LISTED SPECIES	COMMENTS
Bald Eagle - T5S, R32E (Haliaeetus leucocephalus)	Wintering area
Bald Eagle - T5S, R33E (Haliaeetus leucocephalus)	Wintering area
Bald Eagle - T5S, R34E (Haliaeetus leucocephalus)	Wintering area
Bald Eagle - T6S, R32E (Haliaeetus leucocephalus)	Wintering area

PROPOSED SPECIES

None

CANDIDATE SPECIES

Trumpeter Swan (C2) - T5S, R32E
(Cygnus buccinator)

Trumpeter Swan (C2) - T5S, R33E
(Cygnus buccinator)

Black Tern (C2) - T5S, R32E
(Chlidonias niger)

Wolverine (C2) - T5S, R33E
(Gulo gulo luscus)

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Idaho Dunes Tiger Beetle (C2) - T5S, R34E
(Cicindela arenicola)

Townsend's Western Big-eared bat (C2) - T7S, R34E
(Plecotus townsendii townsendii)

Pygmy Rabbit (C2) - T6S, R34E
(Brachylagus idahoensis)

Slick spot peppergrass (C2) - T7S, R34E
(Lepidium papilliferum)

GENERAL COMMENTS

C2 = Category 2 Taxa for which information now in possession of the U.S. Fish and Wildlife Service 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. Further biological research and field study may be needed to ascertain the status of taxa in this category.

ENCLOSURE B

FEDERAL AGENCIES' RESPONSIBILITY UNDER SECTIONS 7(a) AND (c)
OF THE ENDANGERED SPECIES ACT

SECTION 7(a) - Consultation/Conference

Requires: 1) Federal agencies to utilize their authorities to carry out programs to conserve endangered and threatened species;

2) Consultation with FWS when a Federal action may affect a listed endangered or threatened species to insure that any action authorized, funded or carried out by a Federal agency is not likely to jeopardize the continued existence of listed species; or result in destruction or adverse modification of critical habitat. The process is initiated by the Federal agency after determining the action may affect a listed species; and

3) Conference with FWS when a Federal action is likely to jeopardize the continued existence of a proposed species or result in destruction or adverse modification of proposed critical habitat.

SECTION 7(c) - Biological Assessment for Major Construction Activities [1/]

Requires Federal agencies or their designees to prepare Biological Assessment (BA) for major construction activities. The BA analyzes the effects of the action[2/] on listed and proposed species. The process begins with a Federal agency in requesting from FWS a list of proposed and listed threatened and endangered species (list attached). If the BA is not initiated within 90 days of receipt of the species list, the accuracy of the species list should be formally verified with our Service. The BA should be completed within 180 days after its initiation (or within such a time period as is mutually agreeable). No irreversible commitment of resources is to be made during the BA process which would foreclose reasonable and prudent alternatives to protect endangered species. Planning, design, and administrative actions may be taken; however, no construction may begin.

We recommend the following for inclusion in the BA; an onsite inspection of the area to be affected by the proposal which may include a detailed survey of the area to determine if the species are present; a review of literature and scientific data to determine species' distribution, habitat needs, and other biological requirements; interviews with experts, including those within FWS, State conservation departments, universities and others who may have data not yet published in scientific literature; an analysis of the effects of the proposal on the species in terms of individuals and populations, including consideration of cumulative effects of the proposal on the species and its habitat; an analysis of alternative actions considered. The BA should document the results, including a discussion of study methods used, any problems encountered, and other relevant information. The BA should conclude whether or not a listed or proposed species will be affected. Upon completion, the BA should be forwarded to our office.

1/ A major construction activity is a construction project (or other undertaking having similar physical impacts) which is a major action significantly affecting the quality of human environment as referred to in the NEPA (42 U.S.C. 4332 (2)(c).

2/ "Effects of the action" refers to the direct and indirect effects on an action on the species or critical habitat, together with the effects of other activities that are interrelated or interdependent with that action.

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E

E Ecosystems and Species of Concern

This appendix provides a summary of the ecosystems and species of concern at the Eastern Michaud Flats Superfund Site (EMF Site) in Pocatello, Idaho. The appendix provides information on regional ecology, principal ecosystem types in the vicinity of the site, species of regulatory concern, and designated wetlands. The potential for exposure of these species to site contaminants also is discussed.

E.1 Regional Ecology

The EMF Site is located in the intermountain sagebrush ecoregion (USDA 1980) at the boundary of two physiographic provinces, the Basin and Range province and the Columbia Plateau province. The region is bounded by mountains on both the east and west. The area between the mountains is a semidesert because of the orographic rain shadow created by the mountains to the west, which intercept the moisture brought by the prevailing westerly winds. Total average annual precipitation ranges from 5 to 20 inches. Almost no rain falls in the summer; the precipitation comes in winter and spring when evaporation and transpiration are minimal. Therefore, more than half the precipitation enters the soil profile (West 1989; USDA 1980). The region's weather is characterized by hot summers and moderately cold winters. The average annual temperature ranges from 40° to 55°F.

The soils in the region are typically aridisols and have a heavy accumulation of alkaline and saline salts. These soils are often dry, not permeable, highly erodible, and have little organic accumulation in the upper layer (USDA 1975, 1980). Winter snows, which melt rapidly in spring, and intense summer rainstorms result in flooding and soil erosion.

The combination of the climate and the soils have influenced the vegetative types in this ecoregion. The major vegetation type is sagebrush steppe characterized by grasses and shrubs such as perennial bunchgrasses (*Agropyron spp.*) and sagebrush (*Artemisia spp.*). Other important plants include Mormon tea (*Ephedra spp.*), rabbit brush (*Chrysothamnus spp.*), horsebrush (*Tetradymia spp.*), cheatgrass (*Bromus tectorum*), and Idaho fescue (*Festuca idahoensis*). Other vegetation types regionally present include saltbush-greasewood shrublands in saline environments, blackbrush shrubland in areas where soil depth is restricted, and juniper-pinyon Woodlands at higher elevations (West 1989).

Wildlife typical of dry shrublands is expected to occur in this ecoregion. The most common terrestrial fauna are small mammals, including deer mice, jackrabbits, kangaroo mice, and wood rats; reptiles and amphibians, including snakes, lizards, and toads; various

raptors, including eagles and hawks; ground-nesting and shrub-nesting birds; pronghorn; mule deer; and mammalian predators, including American badger, gray fox, bobcat, and coyote (USDA 1980). Cattle typically graze in sagebrush-steppe habitats, and many areas are adversely affected by overgrazing.

Riverine/riparian ecosystems are a functionally significant part of the ecology of this arid region. Rivers support aquatic life and provide drinking water, habitat, and food sources for terrestrial and semiaquatic wildlife. Rivers in this region are typically alkaline, and bottom substrates are sandy or gravelly at lower elevations. Riparian ecosystems vary in plant community structure, but typically species of willow or cottonwood form a narrow zone of shrubs and trees along river banks. Many riverine/riparian ecosystems of the western U.S. have been degraded by overgrazing, agriculture, and other development.

E.2 Ecosystem Types at the EMF Site

The following is a description of the local ecosystem types at the EMF Site based on Bechtel Environmental, Inc. ([BEI] 1994) and other information. The site and the surrounding area can be divided into several basic ecosystem types, including upland ecosystems (sagebrush steppe, juniper woodland, agricultural areas, and cliffs/caves/canyons) and aquatic and wetland ecosystems (riverine/riparian, springs, and reservoir ecosystems).

E.2.1 Sagebrush Steppe

The sagebrush steppe vegetation type occupies 34% of the EMF study area, which has been defined as the area within a 3-mile radius of the site facilities (BEI 1994). The most prevalent area of sagebrush steppe is located adjacent to the southern boundary of the EMF Site in the Bannock Range foothills (BEI 1994). In addition, most of the study area encompassing the Fort Hall Indian Reservation is in this vegetation type. Codominance of sagebrush and bunchgrass characterizes this vegetation type. Common species include big sagebrush (*Artemisia tridentata*), rabbit brush (*Chrysothamnous nauseosus*), antelope bitterbrush (*Purshia tridentata*), blue bunchgrass (*Agropyron spicatum*), western wheat grass (*Agropyron smithii*), Idaho fescue (*Festuca idahoensis*), squirrel tail (*Sitanion hysterix*), and Indian rice grass (*Oryzopsis hymenoides*).

The diversity of plant life in sagebrush steppe ecosystems is generally moderate (13 to 24 higher plant species in ungrazed stands). Shrubs reach 0.5 to 1.0 m in height and have a

cover of 10% to 80%, depending on site conditions. The herbaceous layer consists mainly of grasses reaching 30 to 40 cm during the growing season. Disturbance, particularly fire and grazing, favors the growth of annual grasses, weeds, and shrubs other than sagebrush (West 1989). This vegetation type is used as rangeland for cattle grazing in the vicinity of the site.

Wildlife usage in this cover type is similar to that described for the region (see Section 2.2.1), with small mammals, deer, reptiles, songbirds, and raptors among the common inhabitants.

E.2.2 Juniper Woodland

At elevations greater than 6,600 feet in the Bannock Range, a juniper woodland intergrades with the sagebrush steppe along the sides of draws (BEI 1994). This vegetation type is dominated by Utah juniper (*Juniperus osteosperma*) and Rocky Mountain juniper (*J. scopulorum*). These species reach 10 to 15 m in height at maturity.

This vegetation type provides important wildlife habitat. The most common large mammal is the mule deer. Other wildlife that may utilize this vegetative type include mammalian predators such as mountain lions, coyotes, and bobcats; small mammals such as wood rats, pocket gophers, weasels, porcupines, and chipmunks; songbirds such as flickers, jays, nuthatches, and juncos; and raptors such as red-tailed hawks and goshawks (USDA 1980).

E.2.3 Agricultural Areas

Agricultural areas, including cropland, fallow, and disturbed areas, comprise 40% of the site and surrounding area (BEI 1994). The dominant crops are potatoes and wheat. The majority of the agricultural areas are located north of the EMF Site in the Michaud Flats (BEI 1994).

Wildlife usage is limited to species that are more tolerant of human disturbance. Typical wildlife species include small mammals such as mice and voles. The availability of crops can attract wildlife such as pheasants, geese, and deer.

E.2.4 Cliffs/Caves/Canyons

An area of cliffs, caves, and canyons is located adjacent to the southern edge of the site (BEI 1994). This habitat type is important because it is potential habitat for a Federal Category 2 species, the Townsend's big-eared bat. Nesting golden eagles have also been observed here.

E.2.5 Riverine/Riparian

Riparian wetland vegetation in the vicinity of the EMF Site occurs along Michaud Creek, the Portneuf River, and in association with springs and seeps in the Eastern Michaud Flats (BEI 1994). The riparian wetlands along Michaud Creek and the Portneuf River are scrub-shrub/forested wetlands dominated by peachleaf willow (*Salix lasidandra*), coyote willow (*Salix exigua*), red-osier dogwood (*Cornus sericea*), cottonwood (*Populus angustifolia*), Russian olive (*Eleagnus angustifolia*), and river birch (*Betula occidentalis*). In areas where the shrub layer is more open, herbaceous species such as grasses, sedges, and dandelion (*Taraxacum offinale*) occur. Further from the site, the Snake River supports extensive riparian communities.

The lower Portneuf River is considered one of the most well-developed riparian ecosystems in southeastern Idaho. The Portneuf River riparian wetlands are an important habitat for wildlife in the vicinity of the EMF Site (BEI 1994). This area provides food, cover, nesting habitat, and travel corridors for a variety of species, including waterfowl, white-tailed and mule deer, colonial nesting birds, and songbirds. This habitat is also utilized by nesting and wintering bald eagles. Based on observations made during E & E site visits, numerous semiaquatic wildlife and waterfowl are expected to occur in the riparian habitats of the Portneuf River downriver from the FMC/Simplot facilities.

The Portneuf River is also a significant aquatic habitat downstream from the EMF Site. Aquatic biota occurring in the Portneuf River are listed by BEI (1994). The Portneuf River between the EMF Site and the American Falls Reservoir supports game and nongame species of fish, the most important of which are described in Section 2.2.3. The river has been channelized with earthen and concrete channels through Pocatello and is unlikely to support a viable fishery immediately upstream of the site.

E.2.6 American Falls Reservoir

The American Falls Reservoir and surrounding wetland/riparian habitat provide food, cover, nesting habitat, and travel corridors for a large and diverse population of migratory waterfowl, including mallards, gadwalls, northern shovelers, and Canada geese; shorebirds such as sandpipers, snipes, and dowitchers; and colonial water birds such as cormorants, black-crowned night herons, egrets, and great blue herons. The exposed mudflats, caused by the draw-down of the reservoir in late summer, provide a feeding and resting area for large concentrations of migratory shorebirds and Canada geese.

The Fort Hall Bottoms are located on the upper end of the American Falls Reservoir. These bottomlands provide excellent feeding habitat for shorebirds and waterfowl species.

E.3 Species of Concern

Based on correspondence received from the U.S. Fish and Wildlife Service (USFWS) (Martin 1993) and the Idaho Conservation Data Center (Stephens 1993), information provided in Moseley and Groves (1992), and review of previous work completed during preparation of the RI report, 11 federal- and state-listed species of concern have been identified in the general vicinity of the EMF Site. Endangered, threatened, or rare species (or their habitat) are listed on Table E-1. Migratory raptors and waterfowl, upland game birds, commercial fish, and deer are also abundant in the site vicinity. A brief description of the specific habitat and food requirements of each of these groups and a discussion of whether they are considered potential receptors of contaminants from the site are provided below.

E.3.1 Raptors

Numerous species of migratory raptors are likely to occur in the upland and riparian habitats adjacent to the EMF Site. Noteworthy species include golden eagles (*Aquila chryaestos*) and prairie falcons (*Falco mexicanus*), which are recorded as nesting in the bluffs directly to the south of the EMF facilities (BEI 1994). One federal- and state-listed species, the bald eagle (*Haliaeetus leucocephalus*), is reported in the area. The bald eagle is listed by the State of Idaho and by the USFWS as endangered in Idaho. Bald eagles are regularly observed at the American Falls Reservoir, the Snake River below the reservoir, and further downstream at Minidoka National Wildlife Refuge during the winter. Individual eagles have been sighted between the mouth of the Portneuf River and the Rainbow Beach area of the

American Falls Reservoir, which is along the northern boundary of the EMF Site. In 1990, 61 bald eagles were observed on the upper end of the American Falls Reservoir, 22 were seen in the Fort Hall Bottoms, and 39 were counted between the mouth of the Portneuf River and Rainbow Beach (USDOI 1990).

In February 1993, a sighting of an immature bald eagle was recorded in the Fort Hall Bottoms near the mouth of the Portneuf River during ecological reconnaissance surveys conducted for the RI (BEI 1994). Eagles are thought to take wounded waterfowl, which move up the Portneuf River for cover in the winter. Other prey items could include fish and carrion of deer and livestock. A nesting and overwintering population of bald eagles occurs along the Snake River, approximately 30 km northwest of the EMF facilities (BEI 1994). Additional details concerning the local bald eagle populations may be found in BEI (1994).

Based on the food and habitat requirements of the bald eagle and its reported presence near the site, there may be a moderate potential exposure pathway for site contaminants to enter the food chain of the bald eagle through the consumption of contaminated prey from the Portneuf River and the American Falls Reservoir.

The peregrine falcon (*Falco peregrinus*) has been sighted occasionally in the area, particularly during their fall migration (USDOI 1990). The State of Idaho and the USFWS classify the peregrine falcon as endangered in Idaho. These birds may occasionally use habitats within the study area for hunting during migration (BEI 1994). The staple of the peregrine falcons' diet consists of passerine birds taken on the wing (Brown and Amadon 1989). Domestic poultry and mammals up to the size of a young rabbit are also taken. Based on available information, it does not appear that peregrine falcons are likely to be exposed to site-related contaminants. Because of its transient use of the site area, neither the USFWS nor the State of Idaho describe the peregrine falcon as present in the area.

E.3.2 Waterfowl

Numerous waterfowl (ducks, geese, and swans) migrate through and over-winter in the American Falls Reservoir area. Several of the more common species include Canada goose (*Branta canadensis*), goldeneye (*Bucephala clangula*), mallards (*Anas platyrhynchos*) and green- and blue-winged teal (*Anas crecca* and *A. discors*). As the reservoir is drawn down in late summer, large numbers of migrating shorebirds and Canada geese use the exposed mudflats for feeding and resting areas. Primary areas of use extend on either side of the mouth of the Portneuf River. During fall migration, peak waterfowl counts frequently

exceed 44,000 Canada geese and 44,000 ducks. The winter population of Canada goose numbers more than 20,000 in the American Falls Reservoir (USDOI 1990). Waterfowl tend to move up the Portneuf River in winter, and waterfowl groups dominated by mallards in groups up to 200 birds were reported by BEI (1994).

The bulk of the duck, goose, and swan populations are plant feeders with diets consisting of marsh and aquatic plants, including pondweed, smartweed, and various grasses, supplemented by invertebrates. In addition, the agriculture fields adjacent to the river provide food for numerous species, including Canada geese, goldeneye, and ruddy ducks (*Oxyura jamaicensis*) (BEI 1994; Martin *et al.* 1951).

None of the waterfowl species are considered threatened or endangered by the State of Idaho or the USFWS. However, they are protected by the Migratory Bird Treaty Act, and one species, the trumpeter swan (*Cygnus buccinator*), is listed as a Federal Category 2 species, which indicates it is being considered for listing as a threatened or endangered species. Swans were transplanted in 1991 to the Snake River near the Fort Hall Bottoms area (Stephens 1993).

Many of the waterfowl species that occur in the vicinity of the EMF Site are important game species. Mallards are considered the most important waterfowl species for hunting on the Fort Hall Indian Reservation. Typically, several thousand ducks and geese are harvested annually from the Fort Hall Bottoms (BEI 1994).

Waterfowl in the Fort Hall Bottoms and Portneuf River could be exposed to site-related contaminants through the food chain or through incidental ingestion of contaminated sediments. In addition, in 1988 an estimated 50 migrating snow geese (*Chen caerulescens*) and Ross' geese (*Chen rossii*) were reported killed after landing on an FMC pond during a storm (USDOI 1990). No additional information is available at this time concerning bird mortality at on-site ponds.

E.3.3 Colonial Waterbirds

Numerous species of colonial waterbirds, including pelicans, herons, shorebirds, gulls, and terns, reside or migrate in the riparian habitats along the Portneuf River and the American Falls Reservoir. Great blue heron (*Aredea herodias*), black-crowned night heron (*Nycticorax nycticorax*), and white pelicans (*Pilecanus erthrorhynchos*) have been seen in the vicinity of the EMF facilities (BEI 1994), and a heron rookery was located at the mouth of the Portneuf River. White pelicans were reported as fishing and hunting on the Fort Hall

Indian Reservation (BEI 1994). Nesting areas for terns, including black tern (*Chlidonias nigar*), common tern (*Sterna hirundo*), and caspian tern (*Sterna caspia*); and gulls, including California gull (*Larus californicus*) and ring-billed gull (*Larus delawarenis*), are located in the Fort Hall Bottoms area (Stephens 1993). None of the colonial nesting birds are considered threatened or endangered by the State of Idaho or the USFWS, but the black tern is a Federal Category 2 species, which indicates it is being considered for listing as threatened or endangered. The long-billed curlew (*Numenius americanus*), a State Special Concern species, is also reported in the area. In addition, many of these birds are also protected by the Migratory Bird Treat Act.

These colonial nesting birds are at the top of the aquatic food chain, feeding on aquatic and terrestrial insects, fishes, amphibians, reptiles, crustaceans, and mollusks. Colonial nesting birds could be exposed to site-related contaminants through the food chain or through incidental ingestion of contaminated sediments.

E.3.4 Upland Game Birds and Songbirds

Two species of birds, pheasant (*Phasianus colchicus*) and sage grouse (*Centrocercus urophasianus*), are important game species in the vicinity of the EMF Site. No data are available regarding the harvest numbers or populations of upland game birds taken (BEI 1994). Pheasant harvest data for the Fort Hall Indian Reservation show annual harvests of 675 to 1,090 birds over a three-year period (1988-1990) (BEI 1994).

The pheasant prefers agricultural land with dense shrubby hedgerows, which provide protective cover and travel corridors (DeGraaf and Rudis 1986). The staples of their diet include cultivated grains and weed seeds such as ragweed, dandelion, and Russian thistle (Martin *et al.* 1951). The sage grouse prefers sagebrush habitats, and its range is limited by the distribution of sagebrush: nearly 75% of the bird's food consists of the leaves and flower clusters of various sagebrush species. Other plant items consumed by sage grouse include dandelion, alfalfa, and clover (Martin *et al.* 1951)

Since an abundance of food items and a variety of different cover types exist in the vicinity of the EMF Site, nesting pairs of sage grouse may be in the area. In addition, based on the food and habitat requirements of these birds, there may be potential exposure from uptake through the food chain or from direct contact with, or incidental ingestion of, contaminated soils.

Numerous songbirds, including the horned lark (*Eremophila alpestric*), black-billed magpie (*Pica pica*), robin (*Turdus migratorius*), and sage thrasher (*Oreoscoptes montanus*), commonly occur in sagebrush steppe habitat. Birds such as the robin and many other species are also attracted to riparian habitat for food, water, and nesting sites. One species of songbird, the yellow-billed cuckoo (*Coccyzus americanus*), is a State Special Concern species with a probable nesting occurrence in the area (Stephens 1993). The yellow-billed cuckoo is predominantly insectivorous and is likely to frequent pastures and thickets along stream banks. The potential exposure of songbirds to site-related contaminants through incidental ingestion of soil and consumption of contaminated insects, fruits, or seeds is likely to be high.

E.3.5 Small Mammals and Bats

Sagebrush steppe provides excellent habitat for a diverse and abundant community of small mammals such as the deer mouse (*Peromyscus maniculatus*). These species are important prey items for raptors and carnivores. Hence, any adverse impacts of site-related contaminants to populations of small mammals would be expected to indirectly affect the diversity and abundance of predator species. In addition, small mammals can act as a source of contaminant exposure for predatory wildlife.

In addition, one species of small mammal, the pygmy rabbit (*Brachylagus idahoensis*), is listed as a Federal Category 2 species and a State Species of Concern. This rabbit prefers areas with tall sagebrush growing in clumps and feeds primarily on sagebrush (Burt and Grossenheider 1976). Potential habitat for this species exists on site and immediately adjacent to the site. According to the Idaho Conservation Data Center (Stephens 1993), this species might be found in any area with big sagebrush cover. Therefore, this species may be exposed to contaminants from soil and through the food chain.

Bats are also common in southeastern Idaho. One species, Townsend's big-eared bad (*Piccotus townsendi*), is a colonial bat preferring caves, bluffs, and mine tunnels. This insectivore's diet consists of various types of flies, moths, caddisflies, mosquitoes, and ground beetles (Martin *et al.* 1951; Burt and Grossenheider 1976). Townsend's big-eared bat is listed as a Federal Category 2 species, which indicates it is being considered for listing as a threatened or endangered species. Potential habitat for this species exists in the bluffs immediately south of the EMF Site. Townsend's big-eared bat has been observed in similar habitat within 10 km of the site (BEI 1994), and several specimens have been collected in the Pocatello area, although there are no known roosts in the site area (Stephens 1993). If it

occurs in the bluffs, this species may be exposed to contaminants from intake through the terrestrial or aquatic food chains.

E.3.6 Large Herbivores

Mule deer (*Odocoileus hemionus*) and white-tailed deer (*Odocoileus virginianus*) are known to occur in the vicinity of the EMF Site (Bechtel 1994). The white-tailed deer prefers forest edges, swamp borders, and areas interspersed with fields and woodland openings. The mule deer prefers grassland areas interspersed with shrubs (Burt and Grossenheider 1976). In the west, white-tailed deer feed mainly on Oregon-grape, pine, spruce, and willow (Martin *et al.* 1951). In the mountain desert region, mule deer feed on serviceberry, sagebrush, oak, and various grasses, including fescue, bluegrass, and bromegrass (Martin *et al.* 1951).

Both species are important hunting resources on the Fort Hall Indian Reservation (BEI 1994). Based on the food and habitat requirements of these species, the potential exists for exposure to contaminants from consumption of forage and by direct contact with, or incidental ingestion of, contaminated soils. These deer may also serve as a source of contamination to carnivores and scavengers higher in the food chain.

E.3.7 Carnivores

Important mammalian carnivores expected to occur in the EMF Site area include coyote (*Canis latrans*) and long-tailed weasel (*Mustela frenata*). The wolverine (*Gulo gulo luscus*), a Federal Candidate species and State Special Concern species, is known from a single recent sighting in the Fort Hall Bottoms (Stephens 1993). The wolverine is more typically found in high, forested mountain and tundra habitats. Based on its limited occurrence in the site area, exposure of the wolverine to site-related contaminants is considered unlikely. However, other more common carnivores could be exposed to site-related contaminants through consumption of contaminated prey and contact with, and incidental ingestion of, contaminated soil.

E.3.8 Plants and Invertebrates

Plants form the base of the food chain and provide cover and nesting sites for wildlife. The dominant plant species of sagebrush steppe, riparian, and other ecosystem types at the EMF Site were described in Section 2.2.2. Impacts of site contaminants on the growth,

reproduction, and survival of these plants could have adverse effects on the diversity and abundance of wildlife in the area. Moreover, impacts of the site to native plant communities could result in invasion of weeds, increased erosion, or other consequences.

Only two plant species are listed as State Special Concern species, and one of these—the slick-spot peppergrass (*Lipidium papilliferum*)—is a Federal Candidate species. Slick spot peppergrass is a small white flower in the mustard family. It requires native sagebrush steppe habitat that has not been disturbed by fire or invasion of weeds. This species is known from an old (1949) collection (Stephens 1993). The other state-listed species, green muhly (*Muhlenbergia racemosa*), is also known from an old (1962) collection (Stephens 1993). Based on their limited occurrence in the site area, exposure of these listed plant species to site-related contaminants is considered unlikely.

Terrestrial invertebrates, including soil-dwelling and herbivorous species, are also important components of the site's ecosystems. These species could be exposed to site-related contaminants in soil and in their food items. One species, the Idaho dunes tiger beetle (*Cadindela arenicola*), is a Federal Candidate species and a State Special Concern species. A population is known to occur on the north side of American Falls Reservoir (Stephens 1993). Since this known occurrence is likely to be outside of the area affected by the site, the Idaho dunes tiger beetle is not considered likely to be exposed to site-related contaminants.

E.3.9 Game and Commercial Fish

Several fish species, especially the Utah sucker (*Catostomus ardens*), largescale sucker (*Carostomus macrocheilus*), carp (*Cyprinus carpio*), and Utah chub (*Gila atraria*), are important commercial species in the American Falls Reservoir. Game fish species of the lower Portneuf River include rainbow trout (*Oncorhynchus mykiss*), brown trout (*Salmo trutta*), and several other common species, but game fish are not particularly abundant in this part of the river. The two species of suckers are probably the most common fish in the lower Portneuf River, both in terms of numbers and biomass (BEI 1994). A brief description of each species is provided below.

The Utah sucker is an adaptable species living in lakes, reservoirs, rivers, and creeks with slow to rapid current and a variety of temperatures. This fish is a bottom feeder, consuming both plants and benthic organisms (Lee *et al.* 1980). The largescale sucker prefers slower-moving portions of large rivers and streams, but it also may be found in lakes. It is an omnivorous species that consumes plant material and a variety of small invertebrates (Lee

et al. 1980). Over 300,000 pounds of Utah sucker and largescale sucker were commercially harvested from the American Falls Reservoir in 1992 (BEI 1994). These fish are also food items for most piscivores, including larger fish, mergansers, osprey, and eagles.

Based on the food and habitat requirements of these fish, a potential exposure pathway may exist for site-related contaminants in the surface water and sediments of the Portneuf River to impact these fish through direct contact with, or ingestion of, sediments and through the food chain. These fish also may act as a source of contamination to piscivores.

E.4 Designated Wetlands

BEI (1994) provides a summary of wetlands in the EMF study area. In addition to field reconnaissance, USFW National Wetland Inventory (NWI) maps were reviewed to identify designated wetlands located in the study area. These wetlands are described briefly below.

E.4.1 Michaud Creek

Five wetland areas were identified along Michaud Creek, including three riverine, open-water perennial wetlands; a palustrine emergent, seasonally persistent, excavated wetland; and a palustrine wetland associated with an impounded area on the creek.

E.4.2 Portneuf River

Based on the review of NWI maps, the Portneuf River channel and its associated riparian corridor are designated wetlands along their entire length. The river channel is classified as a lower perennial riverine wetland. This type of wetland occurs in areas with a low grade and slow water velocity, with some water flow throughout the year.

The riparian corridor adjacent to either side of the Portneuf River is comprised of several wetland covertypes, including: two palustrine forested, broad-leaf deciduous, temporarily flooded wetlands; two palustrine, semipermanently flooded aquatic beds of floating vascular vegetation; 14 palustrine scrub-shrub, broad-leaved deciduous, temporarily or seasonally flooded wetlands; eight palustrine open-water wetlands associated with springs and the fish hatchery; and 11 palustrine emergent, persistent, temporarily or seasonally flooded wetlands.

The Fort Hall Bottoms is also a designated wetland comprised of several covertypes. The dominant covertype is palustrine emergent wetland characterized by erect rooted herbaceous hydrophytes. Several scrub-shrub and open-water wetlands also are found in the Fort Hall Bottoms.

E.4.3 Other Wetlands

The NWI maps identified four wetlands classified as palustrine that are associated with excavated areas such as gravel and borrow pits and irrigation canals. In addition, the NWI maps identified five palustrine emergent wetlands in agriculture fields. These wetlands had been altered and farmed or were not evident due to the time of year (BEI 1994). Five palustrine emergent wetlands identified on the NWI maps along irrigation canals were associated with seepage areas. Five emergent palustrine wetlands on the Fort Hall Indian Reservation were also identified on the NWI maps. The industrial waste ponds located on the EMF Site are designed as palustrine open-water wetlands that are artificially flooded.

E.5 References

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Table E-1

FEDERAL AND STATE LISTED SPECIES OF CONCERN KNOWN TO OCCUR WITHIN THE EMF STUDY AREA[a]

Common Name	Scientific Name	Status[b]		Habitat[c]
		Federal Status	State Status	
Plants				
Slick spot peppergrass	*Lepidium papilliferum*	C2	SC	O
Green muhly	*Muhlenbergia racemosa*	—	SC	W
Invertebrates				
Idaho dunes tiger beetle	*Cicindela arenicola*	C2	SC	O
Birds				
Bald eagle	*Haliaeetus leucocephalus*	E	E	P
Trumpeter swan	*Cygnus buccinator*	C2	SC	P
Long billed curlew	*Numenius americanus*	3c	SC	O
Black tern	*Chlidonias niger*	C2	SC	P
Yellow-billed cuckoo	*Coccyzus americanus*	3b	SC	O
Mammals				
Pygmy rabbit	*Brachylagus idahoensis*	C2	SC	O
Wolverine	*Gulo gulo luscus*	C2	SC	F
Townsend's big-eared bat	*Plecotus townsendii*	C2	SC	B

[a] Species listed herein include only those species considered to be endangered, threatened, federal candidates species, or state species of special concern.

[b] Federal and state status are coded as follows:

- E = Endangered - taxa in danger of extinction throughout all or a significant portion of their range.
- T = Threatened - taxa likely to be classified as endangered within the foreseeable future throughout all or a significant portion of its range.
- C2 = Taxa for which information indicates that proposing to list as endangered or threatened is possibly appropiate, but for which conclusive data are not available.
- 3b = Taxonomic status is in question.
- 3c = Taxon is more widespread or abundant than previously believed.
- SC = Special Concern - a species suffering a decline that could threaten the species if allowed to continue unchecked or occurs in such small numbers or with such a restricted distribution or specialized habitat requirement that it could easily become threatened.

[c] Habitat types are as follows:

- F = forest.
- B = Bluff.
- P = Pond, lake, open water.
- W = Wetland (i.e. marsh, riverbank).
- O = Open grassy or shrubby area.

Source: Bechtel 1994; Martin 1993; Stephens 1993. See Appendix C for correspondence with federal and state agencies.

F

F Previous Studies of Site Contamination

Several investigations of contamination of soils, vegetation, fish, and wildlife have been conducted in the vicinity of the EMF Site. Principal among these are a study of water quality in the Portneuf River (Minshall and Andrews 1973); an investigation of trace element contamination of vegetation and soils by the United States Geological Survey (USGS) (Severson and Gough 1979); an investigation of contaminants in surface water, sediment, and biota in the American Falls Reservoir by the USGS and United States Fish and Wildlife Service (USFWS) (Low and Mullins 1990); and a report of fluoride in piscivorous birds (Henny and Burke 1990). Each of these studies is briefly summarized below. In addition, a number of other previous studies are briefly summarized, based primarily on the literature reviews of BEI (1994) and Science International, Inc. (SII 1994).

F.1 Minshall and Andrews 1973

Water quality conditions were assessed between 1967 and 1971 over a 72-kilometer (km) stretch of the Portneuf River, from upstream of urban and agricultural sources to downstream of the EMF Site. Important potential sources of pollutants identified in this study included suspended solids from cropland, organic wastes from cattle and municipal sewage, nitrogen and phosphorus from fertilized fields and sewage, and wastes from the phosphate ore processing plants.

Significant changes in water quality associated with the EMF Site were documented. At the time of the study, two outfalls were active on either side of the river. Phosphate and fluoride levels increased dramatically at a sampling location 100 to 350 meters below the facility outfalls. A marked reduction in diversity of benthic invertebrates was also noted at this location. The observed impacts on the benthic fauna were attributed to toxic effluents, although no measurements of contaminant concentrations other than fluoride were obtained. The plant effluents were also presumed to be responsible for fish kills in the Portneuf River reported by the State of Idaho. Recovery of the ecosystem was observed 2 km downstream of the site and was attributed to the addition of large volumes of clean spring water diluting the industrial wastes.

F.2 Severson and Gough 1979

Concentrations of 23 trace elements were determined in vegetation and soil at points along a transect from 64 km downwind (northeasterly) to 64 km upwind (southwesterly) of

the facilities. Plant species sampled included sagebrush and cheatgrass. Nine trace elements—cadmium, chromium, fluoride, nickel, phosphorus, selenium, uranium, vanadium, and zinc—in sagebrush showed a significant decline in concentration with downwind distance from the site. Selenium was the only element found in cheatgrass to show a relationship to the site operations, and concentrations of most trace elements were higher in sagebrush than in cheatgrass. Estimated element concentrations in sagebrush within 4 km downwind from the site were considered to be substantially higher than concentrations observed in sagebrush from nonimpacted areas of the western United States. However, concentrations of trace elements in vegetation samples taken further than 4 to 8 km from the facilities were not considered to be particularly elevated. Chromium, fluoride, and zinc were considered by the authors to have concentration ranges potentially toxic to plants growing within 8 km of the facilities. Concentrations of cadmium, chromium, fluoride, vanadium, and zinc in vegetation were sufficiently high to pose potential risks to livestock.

Several trace elements in surface soils showed a significant relationship with distance from the site, including beryllium, fluoride, iron, lead, lithium, potassium, rubidium, thorium, and zinc. Of these, the soils close to the processing plants had unusually high levels of fluoride, vanadium, and zinc.

F.3 Low and Mullins 1990

This investigation focused on the potential impacts of irrigation drainwater to the American Falls Reservoir. The authors also reviewed previous studies of contamination-related problems in fish and wildlife populations of the American Falls Reservoir. Studies conducted over the past 20 years document elevated levels of mercury and selenium in reservoir sediments, fish, and birds. The contamination is widespread and affects birds collected from the Snake River below the reservoir as well as fish and birds in various locations within the reservoir. Some of the studies also found elevated levels of cadmium and organochlorine compounds in the reservoir. One study attributed the possible sources of contaminants to sewage effluent, irrigation drainage, or emissions from the phosphate facilities and other industrial facilities in Pocatello.

Low and Mullins (1990) obtained samples from various species of fish, benthic invertebrates, aquatic plants, and birds collected from near the mouth of the Portneuf River and other locations in the American Falls Reservoir. Sediment and water samples were also

analyzed. Concentrations of inorganic contaminants in surface water were generally lower than levels reported in previous studies and were below the water quality criteria selected for comparison by the authors. Concentrations of dissolved trace elements taken at the Portneuf River sampling site were not elevated compared to other reservoir sampling sites.

Sediment concentrations of selenium and mercury were higher than the upper 95th percentile of local soils in a majority of samples taken from the reservoir. The highest sediment mercury concentration was found at the Portneuf River.

Mercury levels were slightly elevated in reservoir fish, and selenium was elevated in juvenile mallard ducks and invertebrates that serve as their food source. The risks of these exposures to wildlife were not quantitatively addressed by Low and Mullins, but the selenium concentrations in mallards were considered within the range of concentrations known to cause reproductive problems in birds. The highest level of selenium in benthic invertebrates was found in a sample of mayfly nymphs taken from the Portneuf River.

F.4 Henny and Burke 1990

Black-crowned night heron carcasses were collected from the Fish Hatchery Springs located downgradient of the site. Bone fluoride levels were three times the femur fluoride concentrations associated with reduced fertility in birds fed fluoride-containing diets in the laboratory and were considered by the authors to be among the highest levels reported in the literature for wild birds. Adverse effects of fluoride on bone strength were not demonstrated in this study, nor were dietary or other routes of fluoride exposure investigated.

F.5 Other Studies

Literature reviews of previous investigations in the vicinity of the EMF Site are provided by BEI (1994) and SII (1994). The studies described above in Sections F.1 through F.4 were reviewed by BEI and SII, along with other relevant studies. Noteworthy studies not previously mentioned in this appendix include the spring and well studies of Perry (1990), Goldstein (1981), and Jacobson (1989); and fluoride monitoring studies of Miller (1986, 1987, 1990, 1991). The cited spring and well studies confirm the likelihood that Batiste Springs is impacted by the EMF Site. The fluoride monitoring studies confirm that sagebrush and forage grasses show elevated fluoride concentrations in the vicinity of the site.

Finally, low-grade deposits of placer gold in sands and gravels of the Snake River plain were investigated recently by the USGS (Desborough *et al.* 1988a, 1988b; Desborough and Foord 1992). Of particular interest is the finding by USGS of mineral forms of gold and silver associated with mercury, and the identification of free mercury recovered from gravels to depths of 12 meters in areas on the Fort Hall Indian Reservation. The gold, silver, and mercury are attributed to natural lode sources occurring in the Snake River or transported long distances from sources in Wyoming.

F.6 Summary

The studies reviewed in this section demonstrate historical contamination of soil, upland vegetation, sediment, fish, macroinvertebrates, and waterfowl in the vicinity of the EMF Site. The principal contaminants of ecological concern noted by previous authors include cadmium, chromium, fluoride, mercury, selenium, vanadium, and zinc. Potential sources other than the phosphate facilities include municipal sewage, agricultural activities, and other industry on the Portneuf River, as well as natural geological sources.

F.7 References

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G

G Contaminant Release, Migration, and Fate

This appendix provides an evaluation of factors affecting the release, migration, and fate of contaminants at the EMF Site. Since a detailed overview of the fate and transport of COPCs at the site is presented in the Human Health Risk Assessment (HHRA) report, this section focuses on issues and data most relevant to the ecological risk assessment. In particular, this section emphasizes factors affecting mobility, bioavailability, and food chain dynamics of cadmium, fluoride, and zinc in the terrestrial environment.

G.1 Sources and Receiving Media

This section provides a brief overview of the physical and chemical processes used at the FMC and Simplot facilities to separate phosphorus from ore, a general description of how contaminants are (or were) released as a result of these processes, and a description of environmental media affected by this contamination. Detailed descriptions of the processes and exposure pathways are provided in the HHRA report.

Nearly all of the site-related contaminants that have been identified in the RI originate as constituents of the phosphate ore processed by the facilities. Compared to local background soils, the ore is enriched in many metals, transition elements, and radionuclides. As the ore is processed in these facilities, its constituents undergo chemical and physical changes and partition into various products, by-products, and waste streams, depending on each constituent's physical and chemical properties. As a result, constituents of the ore are released to the air, water, and soil in several ways and in various chemical forms.

The ore processed by FMC and Simplot is a shale mined nearby that consists primarily of calcium fluorophosphate ($CaFPO_4$). The ore also contains small amounts of numerous related substances in which other metals and transition elements, including arsenic, cadmium, chromium, magnesium, nickel, uranium, vanadium, and zinc, replace the calcium, fluoride, and phosphorus in the chemical structure. The compounds that comprise the ore are generally stable and relatively insoluble in water, which is why these materials were originally deposited as sediments and converted to shale in the geological past. Tests have shown that constituents of the ore do not leach out of the ore to an appreciable extent under conditions encountered in the natural environment.

G.1.1 FMC Facility

The processes used by the FMC facility break down the stable ore structure to liberate and recover the phosphorus. This is accomplished mainly through complex chemical reactions that occur in the electric furnaces. These reactions also change the chemical form of many constituents of the ore, some of which emerge from the furnaces in chemical forms that are much more soluble, mobile, and bioavailable than they were in the original ore. The principal products of the complex chemical reactions that occur in the furnaces are gaseous elemental phosphorus, carbon monoxide, calcium silicate slag, and ferrophos.

Contaminants that originate as constituents of the ore have been or may be released from the process and from the site in several ways, including primarily:

- Fugitive dust emissions from the ore-handling operations and from the ore pile itself;
- Direct air emissions from the process that can eventually settle out on area soils;
- Fugitive dust emissions of scrubber solids, slag, and ferrophos that result from storing, handling, and using these materials on site; and
- Migration of constituents of scrubber solids and phossy water (any water used in the process that has come in contact with produced elemental phosphorus) from unlined ponds, which were formerly used to manage these materials, to the groundwater.

Consequently, when contamination levels are measured in environmental media on or near the site, the concentrations may reflect contributions of material form numerous site sources with different chemical, mobility, bioavailability, and toxicological properties.

G.1.2 Simplot Facility

Like the FMC process, the objective of the Simplot process is to liberate phosphorus from the ore. However, the Simplot process, which digests the ore with sulfuric acid, produces phosphoric acid rather than elemental phosphorus. The sulfuric acid displaces phosphate from the calcium fluorophosphate ore, converting the phosphate to phosphoric acid and forming calcium sulfate, commonly known as gypsum.

As in the FMC process, the fates of the minor constituents of the ore depend on the chemical reactions they undergo in the process and the chemical forms they assume. The

conditions that exist during the digestion are not as extreme as those that occur in FMC's electric furnaces; however, the strongly acidic digestion conditions used in the Simplot process can solubilize many metals, thereby increasing their mobility. During Simplot's ore processing, the principal intermediates are ammonia, sulfuric acid, and phosphoric acid. Final products include these materials and various fertilizer products. Most of the environmental contamination related to the facility is apparently associated with the production of phosphoric acid.

Contaminants that originate as constituents of the ore, other raw materials, or intermediate or final products manufactured at the site have been or may be released from the process and from the site in several ways, including primarily:

- Fugitive dust and process emissions from the ore-handling and calcining operations carried out prior to activation of the slurry pipeline ore delivery system in September 1991;
- Fugitive dust emissions from raising the berms on the gypstacks, from facility roadways and other areas, and from other materials handling operations;
- Process air emissions, including sulfur dioxide and ammonia;
- Migration of contaminants via the groundwater from the gypstacks, the former Overflow Pond, and other unlined ponds and ditches;
- Migration of contaminants via the groundwater to off-site areas followed by eventual release to the Portneuf River.

G.2 Fate and Migration of Contaminants in Soil

In this section, the fate and migration of COPCs in the terrestrial (sagebrush steppe and riparian) habitats of the EMF Site are discussed by describing measured soil geochemical parameters that control the migration and bioavailability (potential uptake by plants and animals) of COPCs at the site. Emphasis is placed on the fate and migration of fluorides, since it has been determined that this element may pose risks to ecological receptors at the site.

As described above, the migration pathways of contaminants at the EMF Site are numerous. The fate and migration of chemicals in the terrestrial ecosystem depend in part on physical and chemical processes occurring in soils that may influence the bioavailability of constituents in the soil pore water. Geochemical soil properties such as soil pH, redox

potential, cation exchange capacity (CEC), mineralogical composition, soluble cations, base saturation, organic matter content, and other environmental factors such as rainfall and infiltration into the soil determine the rates by which chemical reactions (i.e., mineral solubilization, precipitation, ion exchange, and chemical adsorption) occur in the soil/pore water interphase. In turn, these reactions can regulate the levels of dissolved chemicals in the soil pore water that may be bioavailable. Ion exchange reactions and other specific adsorption reactions occur on clay minerals, oxide minerals, and soil organic matter. In general, the efficiency of clay minerals in adsorbing chemicals is related to (1) the surface area of the clay, (2) the chemical characteristics of the soil and pore water such as redox potential, soil pH, moisture content, and (3) the concentration of competing chemicals in the soil solution (Cataldo and Wildung 1978). Chemicals can also react with organic matter by ion exchange and chelation reactions.

G.2.1 Sagebrush Steppe Habitat

Laboratory measurements of soil geochemical characteristics were determined from soil samples collected during the ecological investigations. These measurements included soil pH, CEC, total organic carbon (TOC), and soluble cations (calcium, magnesium, potassium, sodium, and iron). Table G-1 summarizes and compares the results of these measurements between the two potentially impacted sagebrush steppe sites (Bannock Hills SW and Michaud Flats) and the reference site (Ferry Butte). The concentration of calcium and soil pH were elevated at the Bannock Hills SW site compared with the Michaud Flats and Ferry Butte sites. Conversely, the concentrations of magnesium, potassium, and iron in the Bannock Hills SW site soils were lower compared with the Michaud Flats and Ferry Butte sites. Other soil parameters, including CEC, TOC, and iron concentrations, were approximately the same among the three sites.

The neutral to alkaline pH values in soils at the EMF Site are typical of western U.S. soils because of the presence of calcite ($CaCO_3$), which buffers the pH at alkaline values. High soil alkalinity conditions (pH >8) and the presence of high concentrations of calcium (calcareous soils) tend to render metals such as cadmium and zinc less bioavailable compared with acidic soils. At high alkalinity conditions, metals precipitate out of solution by forming insoluble complexes.

The results of these geochemical analyses suggest that metal contaminants such as cadmium and zinc are less bioavailable at the Bannock Hills SW site compared to the

Michaud Flats and Ferry Butte sites. However, cationic metals are generally mobile only in acidic systems having pH values of 4.5 or less (Bodek 1988). The high alkalinity of these soils is likely a mechanism that restricts the mobility of cationic metals. The high pH values are expected to have a major influence on the immobility of these cations because of the decreasing solubilities of most oxides, hydroxides, and carbonates complexes expected to form under high pH conditions.

As described above, industrial operations at the EMF Site have also introduced fluoride to site soils. Several soil properties also influence the bioavailability of fluoride, including clay content, soil pH, and levels of soluble cations. Unlike cadmium and zinc, fluoride is strongly bound with soil minerals under acidic conditions; however, under alkaline conditions fluoride ions tend to be relatively more mobile and bioavailable (Bodek *et al.* 1988). The soil chemistry of fluoride ions in alkaline, high soluble calcium conditions such as those expected to occur in the soil/pore water interphase of the EMF Site soils is controlled by the solubility of fluorite (CaF_2). Chemical reactions involving fluorite can limit the availability of dissolved fluoride.

Other routes by which fluoride can be absorbed by plants at the EMF Site include gaseous diffusion and direct ion-exchange or partitioning of deposited particulate-containing fluoride.

Comparison of uptake factors (UF, the ratio of plant tissue to soil chemical concentrations) for sagebrush (unwashed and washed) and thickspike wheatgrass indicates that the UFs for cadmium and zinc are lower for the Bannock Hills SW site than for Michaud Flats (Table G-3), indicating that cadmium and zinc are less bioavailable at the Bannock Hills SW site than at Michaud Flats. For fluoride, the UFs for sagebrush (unwashed) and thickspike wheatgrass are higher for the Bannock Hills SW site than for Michaud Flats. The relative magnitudes of the UFs confirm that cadmium and zinc are likely to be mobilized and taken up by plants more readily at areas of low pH in the site vicinity, whereas fluoride shows the opposite behavior.

Concentration factors (CF, the ratio of animal tissue to soil chemical concentrations) are provided in Table G-4. The CFs do not show a consistent pattern of difference between the Bannock Hills SW and Michaud Flats sampling locations. The cadmium CF in deer mouse whole-body samples is greater in samples collected from the Bannock Hills SW site than in samples collected at Michaud Flats, whereas zinc shows the opposite (and expected) pattern. The fluoride CF in mouse whole-body samples is greater in samples collected at the

Bannock Hills SW site than at Michaud Flats, whereas fluoride CFs in mouse femurs show the opposite pattern. In general, the mouse data do not confirm that variation in contaminant mobility and uptake by plants at the EMF Site is a good predictor of animal concentrations. The mouse data may be confounded by adherence of soil contaminants to the animal's fur (i.e., the whole-body analysis may reflect incidental contamination as well as tissue concentration).

More consistent patterns, evident in both the vegetation and mouse data for all three COPCs, are the greater UFs and CFs at the background location (Ferry Butte) relative to the potentially impacted locations (Bannock Hills SW and Michaud Flats). This difference is probably not due to underlying differences in geochemical characteristics; rather, it reflects the relative tendency for uptake to decrease at higher contaminant concentrations. At the EMF Site, this may be a result, in part, of the fact that contamination is largely confined to the upper surface horizon of the soil.

G.2.2 Riparian Habitat

Soil geochemical properties were also measured from soil samples collected from potentially impacted Portneuf River and Snake River (reference area) riparian sites. Table G-2 summarizes and compares the results of these measurements. The concentrations of soluble cations, soil pH, CEC, and TOC in samples collected from the Portneuf River site were elevated compared to the reference site. As described above, the high alkalinity conditions and high concentrations of soluble cations encountered at the Portneuf River site, including high CEC and TOC levels, potentially would tend to render metals such as cadmium and zinc unavailable for uptake. Comparison of UFs for Russian olive fruit indicates that cadmium and zinc UFs are lower for the Portneuf River site compared to Snake River site (see Table G-3). This could be a result of geochemical differences, in part, between the two locations. However, since the Portneuf River site has elevated soil concentrations of cadmium and zinc compared with the reference site, the difference in UFs is more likely a result of a concentration effect, as described above for the sagebrush steppe habitat.

G.3 References

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Table G-1

SAGEBRUSH STEPPE HABITAT
SOLUBLE CATIONS AND OTHER SOIL PARAMETERS

Parameter	Units[a]	Minimum Detected Concentration	Maximum Detected Concentration	Average Concentration
Bannock Hills, SW				
Calcium	meq/100g	0.0734	0.4446	0.1772
Magnesium	meq/100g	0.0115	0.0617	0.0319
Potassium	meq/100g	0.0074	0.0374	0.0193
Sodium	meq/100g	0.0100	0.0513	0.0259
Iron	meq/100g	0.0030	0.0639	0.0207
pH	Standard units	7.68	8.0	7.83
CEC	meq/100g	21.9	28.3	24.69
TOC	mg/kg	7,210	12,500	10,308
Michaud Flats				
Calcium	meq/100g	0.0833	0.1966	0.1275
Magnesium	meq/100g	0.0428	0.1580	0.0695
Potassium	meq/100g	0.0159	0.0559	0.0256
Sodium	meq/100g	0.0222	0.0430	0.0277
Iron	meq/100g	0.0516	0.1778	0.0832
pH	Standard units	6.51	7.38	7.00
CEC	meq/100g	21.6	34.0	26.55
TOC	mg/kg	9,780	22,900	16,038
Ferry Butte				
Calcium	meq/100g	0.0744	0.2041	0.1199
Magnesium	meq/100g	0.0370	0.2815	0.1421
Potassium	meq/100g	0.0179	0.0833	0.0501
Sodium	meq/100g	0.0326	0.0361	0.0342
Iron	meq/100g	0.0113	0.4759	0.1942
pH	Standard units	6.62	7.75	7.09
CEC	meq/100g	20.5	26.8	22.48

Key at end of table.

Table G-1

SAGEBRUSH STEPPE HABITAT
SOLUBLE CATIONS AND OTHER SOIL PARAMETERS

Parameter	Units[a]	Minimum Detected Concentration	Maximum Detected Concentration	Average Concentration
TOC	mg/kg	4,610	33,040	10,133

[a] To convert mg/kg to meq/100g, the concentration expressed as mg/kg was divided by equivalent weight of the element (for iron the equivalent weight used was 18.62 grams) multiplied times 10.

Key:

CEC = Cation exchange capacity.
TOC = Total organic carbon.

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Table G-2

RIPARIAN HABITAT
SOLUBLE CATIONS AND OTHER SOIL PARAMETERS

Parameter	Units[a]	Minimum Detected Concentration	Maximum Detected Concentration	Average Concentration
Portneuf River				
Calcium	meq/100g	0.1622	1.2425	0.3586
Magnesium	meq/100g	0.0757	0.9300	0.2521
Potassium	meq/100g	0.0210	0.2064	0.0815
Sodium	meq/100g	0.1183	0.800	0.3678
Iron	meq/100g	0.0032	0.0913	0.0218
pH	Standard units	7.23	8.63	8.11
CEC	meq/100g	30.0	68.2	43.41
TOC	mg/kg	13,300	36,000	22,370
Snake River				
Calcium	meq/100g	0.0758	0.1766	0.1320
Magnesium	meq/100g	0.0288	0.0683	0.0480
Potassium	meq/100g	0.0113	0.0626	0.0381
Sodium	meq/100g	0.0296	0.0548	0.0387
Iron	Standard units	0.0044	0.0397	0.0168
pH	meq/100g	7.66	8.02	7.82
CEC	meq/100g	11.0	24.8	16.93
TOC	mg/kg	5,500	26,200	13,026

[a] To convert mg/kg to meq/100g, the concentration expressed as mg/kg was divided by equivalent weight of the element (for iron the equivalent weight used was 18.62 grams) multiplied times 10.

Key:

CEC = Cation exchange capacity.
TOC = Total organic carbon.

Table G-3

SUMMARY OF UPTAKE FACTORS
FOR VEGETATION

Habitat	Chemical	Vegetation	Location	UF	Percentage of Background
Sagebrush steppe	Cadmium	Sagebrush (unwashed)	Bannock Hills	0.0364	14
			Michaud Flats	0.0602	23
			Ferry Butte[a]	0.2609	—
		Sagebrush (washed)	Bannock Hills	0.0284	12
			Michaud Flats	0.0522	21
			Ferry Butte[a]	0.2441	—
		Thickspike wheatgrass	Bannock Hills	0.0198	11
			Michaud Flats	0.0219	12
			Ferry Butte[a]	0.1824	—
	Flouride	Sagebrush (unwashed)	Bannock Hills	0.0510	NC
			Michaud Flats	0.0288	NC
			Ferry Butte[a]	—	—
		Thickspike wheatgrass	Bannock Hills	0.0427	NC
			Michaud Flats	0.0125	NC
			Ferry Butte[a]	—	—
	Zinc	Sagebrush (unwashed)	Bannock Hills	0.1220	23
			Michaud Flats	0.2454	46
			Ferry Butte[a]	0.5348	—
		Sagebrush (washed)	Bannock Hills	0.1016	21
			Michaud Flats	0.2095	43
			Ferry Butte[a]	0.4891	—
		Thickspike wheatgrass	Bannock Hills	0.0449	31
			Michaud Flats	0.0691	47
			Ferry Butte[a]	0.1457	—

Key at end of table.

Table G-3

SUMMARY OF UPTAKE FACTORS FOR VEGETATION

Habitat	Chemical	Vegetation	Location	UF	Percentage of Background
Riparian	Cadmium	Russian olive	Portneuf River	0.0170	3
			Snake River[a]	0.5916	—
	Zinc	Russian olive	Portneuf River	0.0900	30
			Snake River[a]	0.2982	—

[a] Background location.

Key:

UF = Uptake factor.
NC = Not calculated.

Table G-4

SUMMARY OF CONCENTRATION FACTORS FOR DEER MICE

Chemical	Tissue	Location	CF	Percentage of Background
Cadmium	Whole body	Bannock Hills	0.0226	23
		Michaud Flats	0.0103	11
		Ferry Butte[a]	0.0971	—
Fluoride	Whole body	Bannock Hills	0.0884	NC
		Michaud Flats	0.0507	NC
		Ferry Butte[a]	—	—
	Femur	Bannock Hills	0.2044	57
		Michaud Flats	0.3533	99
		Ferry Butte[a]	0.3587	—
Zinc	Whole body	Bannock Hills	0.1504	22
		Michaud Flats	0.2411	35
		Ferry Butte[a]	0.6830	—

[a] Background location.

Key:

CF = Concentration factor.
NC = Not calculated.

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H Toxicity Testing at the IWW Ditch Outfall

Water and sediment samples collected from the industrial waste water (IWW) ditch and its outfall in the Portneuf River contained elevated levels of contaminants such as cadmium (see Appendix A). Because metals may adsorb to particles and be deposited in bottom sediment, toxicity tests were conducted on sediment collected from the Portneuf River near the IWW ditch outfall. The tests were done to determine if sediment in this area of the river is contaminated to a level hazardous to benthic organisms.

H.1 Methods

The field work was conducted on September 22, 1994. Sediment was collected from three locations in the Portneuf River: at the IWW ditch outfall (Sampling Station 17); upstream of the IWW ditch outfall (Sampling Station 21); and downstream of the IWW ditch outfall (Sampling Station 16). At each station, bottom sediment was collected from at least three points on a transect across the river channel. Sediment was collected using a stainless-steel spoon and/or scoop, screened through a No. 4 stainless-steel sieve to remove rocks and large gravel, and composited in a 2-gallon plastic pail. Subsamples for chemical analysis were taken from the large composite sample at each station, and the remainder was used in 10-day toxicity tests with the amphipod *Hyalella azteca* and larvae of the midge *Chironomus tentans* following ASTM (1993) methods. The toxicity tests were conducted between October 4 and 14, 1994 by EA Engineering and Sciences, Inc. The sediment samples were stored in the dark at 4°C between the time of receipt at the laboratory (September 24, 1994) and initiation of the tests (October 4, 1994). Thus, sample storage time was within the 2-week holding time recommended by ASTM (1993).

H.2 Results

Survival and growth of *H. azteca* and *C. tentans* in the three field sediment samples and laboratory control sample (silica sand) are shown in Table H-1. Upstream sediment collected at Station 21 served as a field control since it was collected from a portion of the river believed to be largely unimpacted by the facilities. No toxicity to *H. azteca* or *C. tentans* was observed in the tests. Survival and growth of the two test organisms were not significantly different in sediment from the two potentially impacted stations (16 and 17) compared with survival and growth in the control sediment and silica sand. Statistical comparisons between potentially impacted stations and controls were made using the same

statistical approach applied to data from the other ecological investigations at the site (see Appendix C), including the use of an 80% confidence level to minimize the probability of Type II error (EPA 1992). The results suggest that Portneuf River sediment at the IWW ditch outfall and downstream to Station 16 has not been contaminated to a toxic level by discharges from the IWW ditch.

Contaminant levels in sediment from stations 16, 17, and 21 are listed in Table H-2. Several metals known to be elevated in soil from the facilities (cadmium, chromium, vanadium, and zinc) were present at a higher concentration in sediment from stations 16 and 17, than at upstream Station 21. Cadmium in sediment from Station 17 was approximately 3 times greater than in any sediment sample collected from the Portneuf River delta during the October 1994 delta study. However, the SEM/AVS ratio for sediment from stations 16 and 17 was less than 1.0, suggesting that divalent metals such as cadmium and zinc are bound by sulfide and therefore are not bioavailable (DiToro *et al.* 1992).

H.3 Conclusions

Site contaminants appear to be present in sediment from the Portneuf River near the IWW ditch outfall, but at levels not toxic to benthic organisms, most likely because the contaminants are not bioavailable. Metal contamination at the site is largely a result of phosphate ore particles and slag. These relatively immobile mineral forms also may be the predominant forms of metals in Portneuf River sediment near the facilities. Since benthic test organisms were not affected at the elevated concentrations of metals found at the IWW ditch outfall, impacts of these site contaminants to aquatic life are expected to be minimal.

H.4 References

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Table H-1

RESULTS OF SEDIMENT TOXICITY TESTS WITH *HYALELLA AZTECA* AND *CHIRONOMUS TENTANS*

Test Organism	Sediment Sample	10-day Survival (percent)	Mean (± standard deviation) Dry Weight of Surviving Organisms (mg)
H. azteca	Lab control[a]	95[b]	0.34 (±0.03)
	Station 16	90 ns[d]	0.32 (±0.03) ns[d]
	Station 17	88 ns[d]	0.33 (±0.03) ns[d]
	Station 21[c]	98	0.33 (±0.05)
C. tentans	Lab control[a]	79[b]	1.54 (±0.46)
	Station 16	96 ns[d]	1.97 (±0.15) ns[d]
	Station 17	92 ns[d]	1.48 (±0.19) ns[d]
	Station 21[c]	83	1.86 (±0.23)

[a] Silica sand.

[b] The minimum acceptable average survival in the laboratory control is 80% for *H. azteca* and 70% of *C. tenans* (ASTM 1993).

[c] Field control sample.

[d] ns = Not significantly different from either laboratory or upstream control.

Table H-2

RESULTS OF CHEMICAL ANALYSES ON PORTNEUF RIVER SEDIMENT USED IN BIOASSAYS WITH *HYALELLA AZTECA* AND *CHIRONOMUS TENTANS*

Analyte	Units	Station 16		Station 17		Station 21	
		Reported Concentration	Review Qualifiers	Reported Concentration	Review Qualifiers	Reported Concentration	Review Qualifiers
Aluminum	mg/kg	3,480		1,710		1,930	
Antimony	mg/kg	0.80	J8	0.64	J8	0.67	J8
Arsenic	mg/kg	2.4		2.5		2.1	
Barium	mg/kg	75.8		102		49.1	
Beryllium	mg/kg	0.21		0.15		0.11	
Boron	mg/kg	10.3	U7	6.6	U7	8.0	U7
Cadmium	mg/kg	0.70		3.2	J8	0.44	J8
Calcium	mg/kg	104,000		72,500		95,600	
Chromium	mg/kg	10.6	J8	7.0	J8	5.1	J8
Cobalt	mg/kg	1.7	U	2.7		2.4	
Copper	mg/kg	4.9		12.9		1.3	
Iron	mg/kg	6,990		4,850		7,290	
Lead	mg/kg	5.3	J8	3.9	J8	6.4	J8
Magnesium	mg/kg	3,120	J16	1,640	J16	2,430	J16
Manganese	mg/kg	214	J16	1,120	J16	190	J16

Key at end of table.

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Table H-2

RESULTS OF CHEMICAL ANALYSES ON PORTNEUF RIVER SEDIMENT USED IN BIOASSAYS WITH *HYALELLA AZTECA* AND *CHIRONOMUS TENTANS*

Analyte	Units	Station 16		Station 17		Station 21	
		Reported Concentration	Review Qualifiers	Reported Concentration	Review Qualifiers	Reported Concentration	Review Qualifiers
Mercury	mg/kg	0.05	U	0.05	U	0.06	U
Molybdenum	mg/kg	34.1		22.8		28.4	
Nickel	mg/kg	6.0		6.6		5.4	
Potassium	mg/kg	886		587		358	
Selenium	mg/kg	0.36	UJ8	0.29	UJ8	0.28	UJ8
Silver	mg/kg	2.3	J8	2.1	J8	2.1	J8
Sodium	mg/kg	135		224		80.0	
Thallium	mg/kg	0.37	U	0.30	U	0.26	U
Vanadium	mg/kg	10.2	J8	6.4	J8	4.2	J8
Zinc	mg/kg	27.7		49.0		18.3	
AVS	µmol/g	0.187		0.184		0.20	
SEM (sum)	µmol/g	0.142		0.130		0.133	
SEM/AVS	—	0.762		0.711		0.67	
SEM-Cadmium	µmol/g	0.00062	J14, 10	0.0019	J14, 10	0.00017	UJ14, 10
SEM-Copper	µmol/g	0.026	J14, 10	0.025	J14,10	0.014	UJ7, 14, 10

Key at end of table.

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Table H-2

RESULTS OF CHEMICAL ANALYSES ON PORTNEUF RIVER SEDIMENT USED IN BIOASSAYS WITH *HYALELLA AZTECA* AND *CHIRONOMUS TENTANS*

Analyte	Units	Station 16		Station 17		Station 21	
		Reported Concentration	Review Qualifiers	Reported Concentration	Review Qualifiers	Reported Concentration	Review Qualifiers
SEM-Nickel	µmol/g	0.041	J14, 10	0.018	UJ7, 14, 10	0.082	J14, 10
SEM-Lead	µmol/g	0.012	J14, 10, 16	0.0060	J14, 10, 16	0.008	J14, 10, 16
SEM-Zinc	µmol/g	0.063	UJ7, 14, 10	0.080	J14, 10	0.029	UJ7, 14, 10
Fluoride	mg/kg	245	J5B, 8, 10	312	J5B, 8, 10	183	J8, 10
TOC	mg/kg	14,600	J5B, 8	18,000	J5B, 8	20,300	J5B, 8

Key:

AVS = Acid volatile sulfide.
SEM = Simultaneously extracted metals.
TOC = Total organic carbon.

I Ecological Effects Profile for Fluoride

This appendix provides a literature survey of some documented ecological effects of fluoride. The following published information is reviewed:

- Background concentrations in environmental media;
- Concentrations at contaminated sites;
- Mammalian and avian toxicity; and
- Phytotoxicity.

The information provided is not intended to be an exhaustive review; rather, it focuses on issues pertinent to evaluating ecological risks at the EMF Site.

I.1 Background Concentrations

Elemental fluorine (F) rarely occurs in its free state. It generally forms fluorides, which occur naturally in soils, water, and the atmosphere (NRC 1974). Average soil fluoride concentrations of approximately 360 mg/kg dry weight (DW) were reported by Kabata-Pendias and Pendias (1992) for the United States, with lower values found in sandy soils and higher concentrations in loamy and clayey soils. The range for most normal soils is 150 to 400 mg/kg DW. The fluoride content of plants in uncontaminated areas generally does not exceed approximately 30 mg/kg DW (Kabata-Pendias and Pendias 1992).

Concentrations of fluoride in plants collected from areas in the western U.S. with no known industrial or natural sources are within the expected background range. For example, average fluoride levels from uncontaminated ecosystems in Montana were 4.5 mg/kg DW in 75 grass samples, and 3.5 mg/kg DW in six sagebrush samples (Kay *et al.* 1975a). In addition, the average concentration of fluoride in six vegetation samples from a "low-fluoride" study area in Utah was 8.0 mg/kg (Shupe *et al.* 1984).

Regional background levels of fluoride in animal bones have also been reported. Kay *et al.* (1975a) determined baseline concentrations of fluoride in bones of 41 species of wildlife in the western U.S. Average fluoride levels in femurs of various mammalian species ranged from 64 mg/kg DW (Richardson ground squirrel [*Spermophilus richardsonii*]) to 589 mg/kg DW (masked shrew [*Sorex cinereus*]). The mean femur fluoride level in 70 deer mouse (*Peromyscus maniculatus*) samples was 143 mg/kg DW, with a standard deviation of 66 mg/kg DW. Concentrations of fluoride in bones of herbivores were 20 to 50 times greater

than concentrations in vegetation, and fluoride generally was found at higher concentrations in predators than in prey (Kay *et al.* 1975a).

I.2 Concentrations at Contaminated Sites

Fluoride concentrations in soil, plants, and wildlife are found at levels higher than background in areas affected by certain types of industrial emissions, phosphate fertilizer application, and mining. Soil and plant concentrations of >3,000 mg/kg DW have been reported from contaminated areas (Kabata-Pendias and Pendias 1992).

Elevated levels of fluoride in wildlife have also been reported. For example, fluoride in the bones of 174 field voles (*Microtus agrestis*) collected at a "moderately polluted" site in England ranged from 300 to 4,800 mg/kg DW (mean of 2,074 mg/kg; standard deviation of 803 mg/kg). At a "heavily polluted" site, bone fluoride levels in 36 field voles ranged from 910 to 11,000 mg/kg (mean of 7,148 mg/kg; standard deviation of 2,413 mg/kg). Background levels of bone fluoride in 48 field voles ranged from 23 to 540 mg/kg DW (mean of 168 mg/kg; standard deviation of 127 mg/kg) (Walton 1987). In another study, average fluoride levels in tissues of mule deer (*Odocoileus hemionus*) and white-tailed (*Odocoileus virginianus*) deer were 5 to 50 times higher at contaminated sites in Montana compared to control sites (Kay *et al.* 1975b).

Naturally elevated fluoride in ecosystems is associated with geothermal waters in the western United States. Exposure of wildlife at thermal springs occurs primarily from drinking fluoride-enriched water and from consumption of vegetation growing in and near the springs (Kubota *et al.* 1982).

I.3 Mammalian and Avian Toxicity

Fluoride toxicity from subchronic and chronic exposures to fluoride in laboratory tests has been documented for rats, mice, mink, kestrels, owls, and other test species (e.g., Aulerich *et al.* 1987; Bird and Massari 1983; Hoffman *et al.* 1985; Pattee *et al.* 1988; Shupe *et al.* 1987). Fluoride is transported to and accumulates in the bones of most vertebrate species. Fluoride ingestion at proper levels enhances development and hardening of healthy bones and teeth. However, in long-term exposures to excessive amounts of fluoride, bones and teeth develop lesions and can become brittle and porous, resulting in breakage. Excessive fluoride may also alter the normal growth of bones and teeth. Adverse effects on

reproduction have also been documented, including reduced fertility and survival of young. From laboratory tests, mammalian and avian NOAELs for affects on bone strength, reproduction, and development following oral exposure range from 5.2 mg/kg/d to 21 mg/kg/d (NRC 1974, 1993; ATSDR 1993).

NRC (1993) concluded that bone strength in animals fed a nutritionally adequate diet is not adversely affected unless chronic exposure to fluoride is at least 50 mg/kg in diet or 50 mg/L in water. Consistent with this recommendation, Shupe *et al.* (1987) reported effects to mink bones at doses above 50 mg/kg fresh weight (FW), or 125 mg/kg DW fluoride in food (a NOAEL of approximately 12.8 mg/kg-bw/day of fluoride). For larger herbivores such as whitetail deer, 25 to 50 mg/kg DW in food items resulted in some degeneration of the teeth and long bones (Suttie *et al.* 1985). Threshold tolerance levels of fluoride in feed for domestic livestock range from 30 mg/kg DW to 60 mg/kg DW, levels that may be indicative of tolerance levels for wild grazing animals (Shupe et al. 1979).

The threshold for reproductive effects in mammals and birds is approximately 100 mg/kg in food, or 100 mg/L in water (NRC 1993). Consistent with this recommendation, Pattee *et al.* (1988) reported 232 mg/kg fluoride wet weight (200 mg/kg fluoride added to 32 mg/kg in normal diet) resulted in decreased hatching success in eastern screech owls (*Otus asio*). A dose of 56.5 mg/kg fluoride (approximately 7.8 mg/kg/day) had no adverse effects on reproduction (Opresko *et al.* 1994).

From the available information, the mink NOAEL for bone of 12.8 mg/kg/day (Shupe *et al.* 1987) appears to be an appropriate toxicity benchmark for mammalian toxicity, and the screech owl NOAEL of 7.8 mg/kg/day (Pattee *et al.* 1988) is judged to be sufficiently protective of bird life at the EMF Site.

Bone levels of fluoride are sometimes measured in association with toxicity tests and field studies. For example, in a 30-day exposure of wood mice (*Apodemus sylvaticus*) to 200 mg/L sodium fluoride (NaF) in drinking water, mouse femurs contained a mean concentration of 2,108 mg/kg DW of fluoride, which was approximately 3 times the control concentration (Cooke *et al.* 1990). In mink, average femur concentrations of 2,213 mg/kg DW in kits and 2,485 mg/kg DW in adults were associated with the dietary dose of 125 mg/kg DW (Shupe *et al.* 1987). According to Puls (1988), bone levels in cattle are normally below 1,800 mg/kg DW. Therefore, femur bone concentrations of greater than 2,000 mg/kg DW would appear to be abnormally high in mammals and indicative of potentially toxic exposure.

I.4 Phytotoxicity

According to Kabata-Pendias and Pendias (1992), plant uptake of fluoride is not closely related to the fluoride content of soil. Fluoride in soil typically has low bioavailability. Foliar uptake of fluoride from atmospheric sources can be much more significant than root uptake from soil, and fluoride absorbed as airborne hydrogen fluoride is highly toxic. Effects of fluoride on plants include foliar injury and deformation of fruits.

Concentrations of fluoride in plant tissues are a measure of potential phytotoxicity. Kabata-Pendias and Pendias (1992) present plant tissue concentrations of 50 to 100 mg/kg DW as excessive or toxic.

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