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Revision 5a

Screening Level Risk Assessment for the New Waste Calcining Facility

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DISCLAIMER

ABSTRACT

This screening level risk assessment evaluates potential adverse human health and ecological impacts resulting from continued operations of the calciner at the New Waste Calcining Facility (NWCF) at the Idaho Nuclear Technology and Engineering Center (INTEC), Idaho National Engineering and Environmental Laboratory (INEEL). The assessment was conducted in accordance with the Environmental Protection Agency (EPA) report, *Guidance for Performing Screening Level Risk Analyses at Combustion Facilities Burning Hazardous Waste.*[a] This screening guidance is intended to give a conservative estimate of the potential risks to determine whether a more refined assessment is warranted. The NWCF uses a fluidized-bed combustor to solidify (calcine) liquid radioactive mixed waste from the INTEC Tank Farm facility. Calciner off gas consists mostly of acid gases (primarily NO_x), low concentrations of volatilized metal species, trace organic compounds, and low-levels of radionuclides. Conservative stack emission rates were calculated based on maximum waste solution feed samples, conservative assumptions for off gas partitioning of metals and organics, stack gas sampling for mercury, and conservative measurements of contaminant removal (decontamination factors) in the off gas treatment system. Stack emissions were modeled using the ISC3 air dispersion model[b] to predict maximum particulate and vapor air concentrations and ground deposition rates. The exposure assessment evaluated potential impacts to a hypothetical subsistence farmer, subsistence farmer child, adult resident, and child resident located at the maximum offsite impact location, an INEEL worker located at the maximally-exposed adjacent onsite facility (CFA), and a hypothetical herdsman located at the maximally-exposed onsite location where grazing is allowed (south of U.S. Highway 20). Direct exposures through inhalation and indirect exposures from consumption of contaminated vegetables, meat, dairy products, and incidental ingestion of soil were evaluated. Direct short-term inhalation exposure was evaluated on U.S. Highway 20 by comparing the maximum concentrations to allowable toxic air pollutant increments published by the State of Idaho. Risk to ecological receptors was quantitatively evaluated using EPA guidance and methods developed at the INEEL for EPA CERCLA clean-up activities.

Results demonstrate that NWCF emissions calculated from best-available process knowledge would result in maximum onsite and offsite health and ecological impacts that are less than EPA-established criteria for operation of a combustion facility. Additional analyses may be performed in the future if: (1) results from emissions testing scheduled for early 1999 indicate that the emissions evaluated in this SLRA are not conservative, and (2) DOE decides to continue operation of the NWCF in the Idaho High Level Waste Environmental Impact Statement (HLWEIS). A final decision on this will be made by June 1, 2000 in accordance with the Notice of Noncompliance Consent Order.

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a. EPA, 1994, *Guidance for Performing Screening Level Risk Analyses at Combustion Facilities Burning Hazardous Waste*, Attachment C, Draft, Office of Emergency and Remedial Response, Office of Solid Waste, December 14, 1994.

b. EPA, 1995, *User's Guide for the Industrial Source Complex (ISC3) Dispersion Models (Revised)*, EPA-450/B-95-003a, b.

EXECUTIVE SUMMARY

This screening level risk assessment (SLRA) evaluates potential adverse human health and environmental effects resulting from continued operations of the New Waste Calcining Facility (NWCF) at the Idaho Nuclear Technology and Engineering Center (INTEC), which is part of the Idaho National Engineering and Environmental Laboratory (INEEL). The NWCF uses a fluidized-bed combustor to solidify (calcine) liquid radioactive mixed waste from the INTEC Tank Farm facility. Calcining operations were restarted in June 1997 and are currently scheduled to continue until June 1, 2000. DOE will be evaluating the future disposition of the NWCF in the Idaho High Level Waste Environmental Impact Statement (HLWEIS) which should be published by late 1999. A decision will be made by June 1, 2000 in accordance with the Notice of Noncompliance Consent Order.

Completion of this SLRA was specified in the Second Modification (dated July 31, 1998) of the Consent Order to the Notice of Noncompliance signed January 29, 1990 between the U.S. Department of Energy and the Idaho Division of Environmental Quality (DEQ). Revision 3 of the SLRA was submitted to the DEQ in May 1998 along with DOE's response to Notice of Deficiency comments on Revision 2. The DEQ responded in a letter received by DOE on November 22, 1998 that DOE did not adequately address the NOD comments and another revision to the SLRA with a quantitative ecological risk assessment must be submitted no later than December 31, 1998. Revision 4a, which was submitted to DEQ on December 28, 1998, contained revised responses to the NOD comments and evaluation of additional exposure scenarios but no quantitative ecological risk assessment due to time constraints. This current revision (5a) of the SLRA: (1) provides a quantitative ecological risk assessment, (2) revised inhalation toxicity values (reference concentrations and inhalation slope factors) to be consistent with those from the ATG Risk Assessment Work Plan[a] or EPA Region 9 Preliminary Remediation Goals (PRGs), (3) assessed emissions from auxiliary sources (in addition to revised estimates from the calciner), (4) provided a quantitative basis for development of contingencies for unsampled waste tanks, and (5) provided a more detailed basis and justification for the mercury emissions factor used. Toxicity values from ATG were used where appropriate because these values have been approved by EPA Region 10 and the Idaho HWPB.

This revision of the SLRA was completed in accordance with concise guidelines specified in: (1) *Guidance for Performing Screening Level Risk Analyses at Combustion Facilities Burning Hazardous Waste*, EPA Draft Attachment C, December 14, 1998 and, (2) *Exposure Assessment Guidance for RCRA Hazardous Waste Combustion Facilities*, EPA530-R-94-021, April 1994. Since submittal of Revision 3 of the SLRA in May 1998, EPA published new draft risk assessment guidelines in *Human Health Protocol for Hazardous Waste Combustion Facilities* (EPA530-D-98-001A, July 1998) (HHRAP). Significant

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[a] Allied Technology Group, Inc. (ATG) Risk Assessment Work Plan for the ATG Richland Mixed Waste Facility, October 9, 1998.

efforts were made in this revision of the SLRA to incorporate some of these new risk assessment methods (e.g. assessment of coplaner PCBs and a subsistence farmer child scenario).

Calciner off gas consists mostly of acid gases (primarily NO_x), low concentrations of volatilized metal species, trace organic compounds, and low-levels of radionuclides. For this SLRA and all previous versions, Contaminants of Potential Concern (COPCs) were determined and emission rates were calculated using best available process knowledge rather than trial burn measurements, which have proven very difficult in the past due to the high acid environment of the NWCF off gas. This process knowledge consisted of: (1) conservative feed rate concentrations, (2) the assumption that 100% of most organic compounds are released (with no destruction and removal), (3) conservative estimates of off gas partitioning and HEPA filtration for metals, and (4) conservative estimates of Products of Incomplete Combustion (PIC) formation using worst-case combinations of known PIC precursors in the feed. The emission rate for mercury was determined by an emissions factor (3.7%) which was calculated from three long-term (2–4 month) activated carbon stack gas samples taken during 1997–1998 calcining operations. Because of uncertainties in the exact inventory partioning of mercury downstream of the calciner, an upper-bound mercury emissions factor of 13% was also evaluated.

Consistent with EPA guidance, stack emissions were modeled using the ISC3 air dispersion model[b] to predict maximum particulate and vapor air concentrations and ground deposition rates. Maximum annual concentrations/depositions were determined at both offsite (off-INEEL) and onsite locations. Maximum short-term (time-averaged) concentrations were calculated along U.S. Highway 20 (6 km south of the INTEC), an area in which the commuting public could be exposed for short durations.

The exposure assessment evaluated potential impacts to a hypothetical subsistence farmer, subsistence farmer child, adult resident, and child resident located at the maximum offsite impact location, an INEEL worker located at the maximally-exposed adjacent INEEL facility (CFA), and a hypothetical herdsman located at the maximally-exposed onsite location where grazing is allowed (south of U.S. highway 20). Direct exposures through inhalation and indirect exposures from consumption of contaminated vegetables, meat, dairy products, and incidental ingestion of soil were evaluated. Direct short-term inhalation exposure was evaluated on U.S. Highway 20 by comparing the maximum concentrations to allowable toxic air pollutant (TAP) increments published by the State of Idaho or EPA Region 9 Preliminary Remediation Goals (PRGs).

The total (sum of direct and indirect) chemical excess cancer risks from long-term operation of the NWCF were calculated to be 2×10^{-7} for all exposure scenarios (see Table ES-1) which was dominated by the inhalation pathway. The direct (inhalation only) chemical cancer risk for the maximally-exposed onsite worker was estimated be 2×10^{-8}. The total (direct and indirect) chemical

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b. EPA, 1995, User's Guide for the Industrial Source Complex (ICS3) Dispersion Models (Revised), EPA-450/B-95-003a,b.

cancer risk for the hypothetical onsite herdsman was estimated to be 9×10^{-8}. Cancer risk from radionuclides was evaluated using conservative dose assessment methods and the latest EPA cancer incidence risk factors. The highest excess cancer risk from radionuclide emissions was calculated to be 1×10^{-6} for the subsistence farmer. All of these potential excess cancer risks are less than the EPA acceptable criterion of 1×10^{-5}.

Potential noncarcinogenic health effects were evaluated as a hazard quotient (HQ), which is the ratio of the chemical-specific exposure dose and a reference dose derived by the EPA to be adequately protective of human health. HQ values for chemicals affecting the same target organ were summed to determine a hepatoxicity (liver) and neurotoxicity (nervous system) hazard index (HI). Calculated HI values for all of the scenarios assessed were less than the EPA criterion of 0.25 (see Table ES-2).

Potential exposure to lead from calciner emissions was evaluated by comparing the maximum modeled offsite concentrations of lead in the air to the National Ambient Air Quality Standard (NAAQS) of 1.5 $\mu g/m^3$ and to the EPA soil benchmark level of 400 mg/kg. Results indicate exposures to lead from calciner emissions are well below these criteria.

Maximum short-term air concentrations estimated along U.S. Highway 20 were all well below the State of Idaho acceptable ambient air concentrations for noncarcinogens (AACs) and carcinogens (AACCs) or EPA Region 9 Preliminary Remediation Goals (PRGs)

Results from the Screening Level Ecological Risk Assessment (SLERA) indicate that soil concentrations for all contaminants except 1,3-dinitrobenzene were less than Ecologically Based Screening Levels (EBSLs) at the maximum impact location (immediately adjacent to the INTEC fenceline). However, average soil concentration for this contaminant in the INEEL area of major depositional impact were less than the EBSL. Actual impacts for this contaminant (and all the PICs evaluated in this SLRA) will be significantly less because their emission rates were conservatively calculated based on 100% of unburned fuel precursors (e.g. benzene) forming this single PIC.

New emissions testing is planned for the NWCF in an Off gas Demonstration Project (ODP) during the period of January through April, 1999. The results of the ODP, which are estimated to be available by the end of June 1999, will be used to determine whether the COPC emission rates evaluated in this SLRA conservatively bound the impacts from NWCF operations. If the ODP results show that actual emissions are higher than those evaluated in the SLRA, or if significant additional COPCs are detected, then DOE may decide to further revise this SLRA. This decision will also be based on the results of the Idaho High Level Waste Environmental Impact Statement (HLWEIS) which will determine whether or not the NWCF will be operated in the future. If a decision is made to restart the NWCF, then the SLRA may be further revised using the COPC emission rates determined in the ODP and new risk assessment guidance published in the HHRAP. The HLWEIS decision on the future of the NWCF is scheduled to be made by June 1, 2000.

Table ES-1. Summary of cancer risk estimates for SLRA.

	Total Excess Cancer Risk EPA screening criterion is **1E-05**		
	Direct	Indirect[a]	Total[b]
All chemicals	2E-07	3E-08	2E-07
Worst metal	2E-12 (beryllium)	3E-14 (beryllium)	
Worst non-metal	2E-07[c] (pentachloronitrobenzene-PIC)	2E-08 (benzo(a)pyrene)	
2,3,7,8-TCDD	2E-16	3E-08	
Radionuclides	7E-09	1E-06	1E-06

a. Highest value from the following six exposure scenarios: subsistence farmer, subsistence farmer child, adult resident, child resident, onsite worker, and onsite herdsman.

b. Because of the differences in environmental modeling methodologies and the basis for risk factors, cancer risk from radionuclides and non-radioactive contaminants are reported separately.

c. Estimate is very conservative because it assumes that 100% of the nitroaromatic PICs from the burning of the fuel forms this one compound.

Table ES-2. Summary of noncarcinogenic hazard index estimates for SLRA.

	Hazard Index EPA screening criterion is **0.25**		
	Direct	Indirect[a]	Total
All chemicals	0.09	0.01	0.10
Worst metal	0.0003 (mercury)	0.0003 (mercury)	
Worst non-metal	0.09[b] (1,3-dinitrobenzene-PIC)	0.01[b] (1,3-dinitrobenzene-PIC)	
Liver	0.0002[b] pentachloronitrobenzene-PIC	0.00000005[b] (pentachloronitrobenzene-PIC)	
Neurotoxin	0.009[b] (2,4-dinitrotoluene-PIC)	0.005[b] (2,6-dinitrotoluene-PIC)	

a. . Highest value from the following six exposure scenarios: subsistence farmer, subsistence farmer child, adult resident, child resident, onsite worker, and onsite herdsman.

b. Estimate is very conservative because it assumes that 100% of the nitroaromatic PICs from the burning of the fuel forms this one compound.

CONTENTS

FIGURES

TABLES

ACRONYMS

AAC	acceptable ambient concentrations for noncarcinogens
AACC	acceptable ambient concentrations for carcinogens
APCD	air pollution control device
APS	atmospheric protection system
CDD	chlorinated dibenzo-p-dioxin
CDF	chlorinated dibenzofuran
CSF	carcinogenic slope factor
DF	decontamination factors
DOE	U.S. Department of Energy
EBSL	ecologically based screening level
EPA	U.S. Environmental Protection Agency
ESRP	Eastern Snake River Plain
HEAST	Health Effects Assessment Summary Tables
HEPA	high-efficiency particulate air (filter)
HHRAP	Human Health Risk Assessment Protocol
HI	hazard index
HLWEIS	High Level Waste Environmental Impact Statement
HQ	hazard quotient
ICPP	Idaho Chemical Processing Plant
INTEC	Idaho Nuclear Technology and Engineering Center (formerly ICPP)
IDHW	Idaho Department of Health and Welfare
INEEL	Idaho National Engineering and Environmental Laboratory
IRIS	Integrated Risk Information System
MWC	municipal waste combustor

NAAQS	National Ambient Air Quality Standard
NESHAP	National Emission Standard for Hazardous Air Pollutants
NOAA	National Oceanic and Atmospheric Administration
NWCF	New Waste Calcining Facility
ODP	Off gas Demonstration Project
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
PIC	product of incomplete combustion
PRG	Preliminary Remediation Goal (EPA Region 9)
RfC	reference concentration
RfD	reference dose
SLRA	screening level risk assessment
SLERA	screening level ecological risk assessment
TEQ	toxicity equivalent
TRV	toxicity reference value
UCL	upper confidence limit
URF	unit risk factor

Screening Level Risk Assessment for the New Waste Calcining Facility

1. INTRODUCTION

This screening level risk assessment (SLRA) evaluates potential adverse human health and environmental effects resulting from continued operations of the New Waste Calcining Facility (NWCF) at the Idaho Nuclear Technology and Engineering Center (INTEC), Idaho National Engineering and Environmental Laboratory (INEEL). Operations were restarted in June 1997 and are currently scheduled to continue through June 1, 2000. A decision on the future status of the NWCF will be made by June 1, 2000 in accordance with the Notice of Noncompliance Consent Order. This decision will be based on the Idaho High Level Waste Environmental Impact Statement (HLWEIS) which will be published in late 1999. For the purposes of this risk assessment, emissions are assumed to occur for 16 years (1997–2012). Completion of this SLRA was specified in the Second Modification (dated July 31, 1998) to the Notice of Noncompliance Consent Order signed January 29, 1990 between the Department of Energy (DOE) and the Idaho Department of Health and Welfare (IDHW).

This SLRA followed the screening procedure outlined in the U.S. Environmental Protection Agency (EPA) guidance document *Guidance for Performing Screening Level Risk Analyses at Combustion Facilities Burning Hazardous Waste* (EPA 1994a). Since submittal of Revision 3 of the SLRA in May 1998, the EPA published new draft risk assessment guidelines in *Human Health Protocol for Hazardous Waste Combustion Facilities* (EPA530-D-98-001A, July 1998) (HHRAP). Efforts were made in this revision to incorporate some of these new risk assessment methods. In addition, a quantitative screening level ecological risk assessment (SLERA) was performed (Section 8).

1.1 Site Background

The INEEL is located on the Eastern Snake River Plain (ESRP), a low-lying volcanic region of basalt lava beds within the rugged basin and range mountains of southern Idaho. The INEEL encompasses more than 2,305 km^2, and aside from the INEEL buildings, the land is unincorporated and undeveloped desert terrain. The elevation of the ESRP is approximately 1,524 m above mean sea level (m.s.l.), with the surrounding mountains rising to about 3,657 m above mean sea level. General surface terrain on the INEEL is rolling to broken.

Average annual rainfall on the INEEL is light, 21.6 cm, and the region is classified as arid to semiarid. The relatively dry air and infrequent low clouds permit intense solar heating of the surface during the day and rapid radiational cooling at night. These factors contribute to give a large diurnal range of temperature near the ground. The local northeast to southwest orientation of the ESRP and bordering mountain ranges tend to channel the prevailing westerly winds so that a wind coming from the southwest predominates over the INEEL. The second most frequent wind direction is from the northeast, which occurs mostly at night from mountain valley drainage.

The Big Lost River is the major surface water feature on the INEEL. Stream flows are often depleted by irrigation and infiltration losses before reaching the INEEL. Stream flow in the stretch of river near the INTEC is intermittent. During the period from 1965 to 1994, 60% of the time no flow occurred. There are no recreational or consumptive uses of the water in this stretch.

The INTEC, which occupies a total of 59 hectares, is located in the south-central region of the INEEL, about 68 km west of Idaho Falls (Figure 1). The INTEC is 6 km from the nearest public highway, U.S. Highway 20, and 13.6 km from the nearest INEEL boundary. The calciner is located in NWCF Building 659 within the INTEC fenced area (Figure 2).

1.2 Process Description

The main function of the calciner is to convert a liquid mixed radioactive-hazardous waste of variable composition—usually solutions of nitric acid, sodium nitrate and aluminum nitrate that are contaminated radionuclides and low concentrations of chloride, fluoride, hazardous metals—to a noncorrosive, relatively stable, dry solid material to render the waste easier to handle and store.

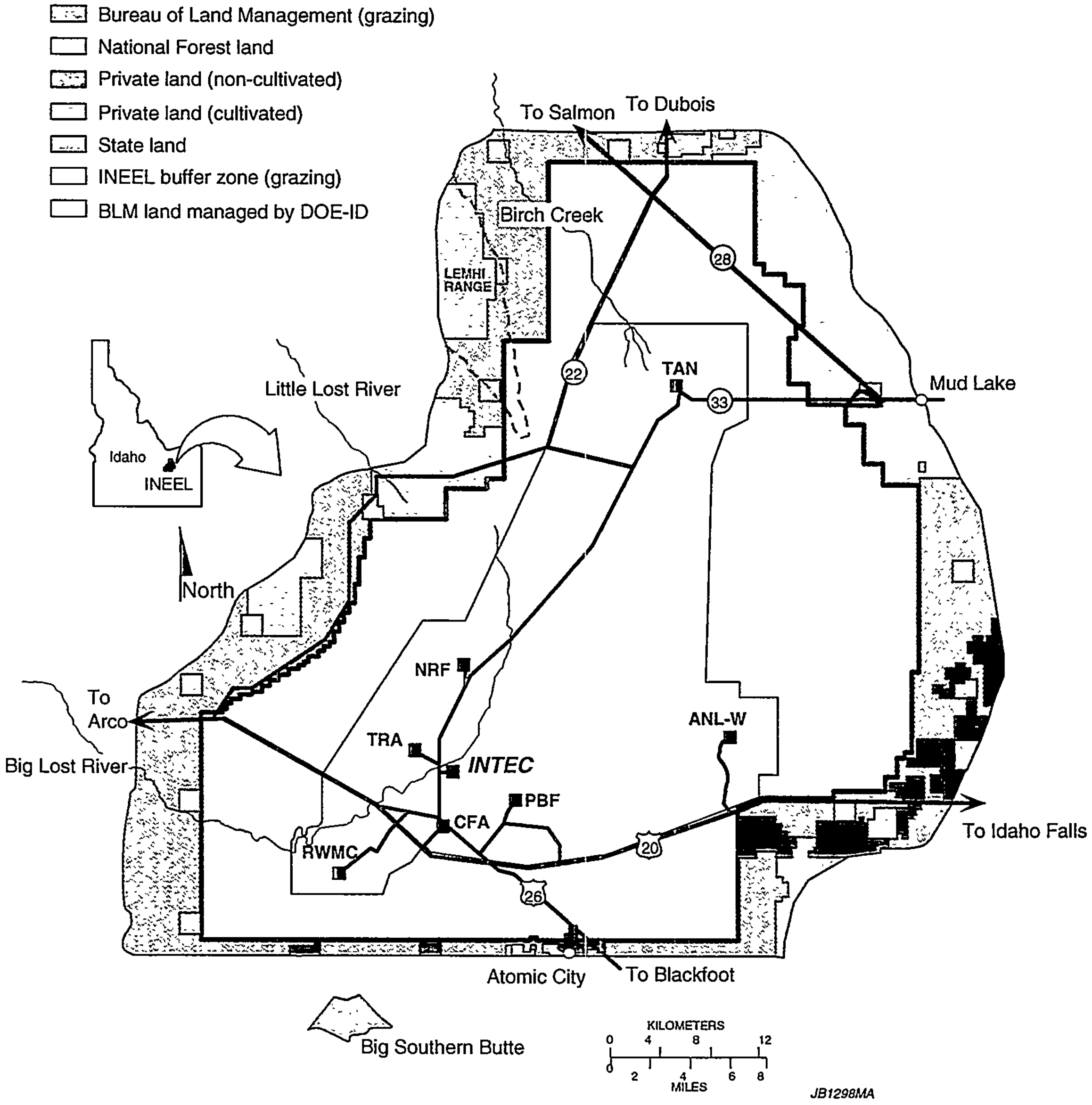

Figure 1. Map of the INEEL showing the location of the Idaho Nuclear Technology and Engineering Center (INTEC, formerly ICPP).

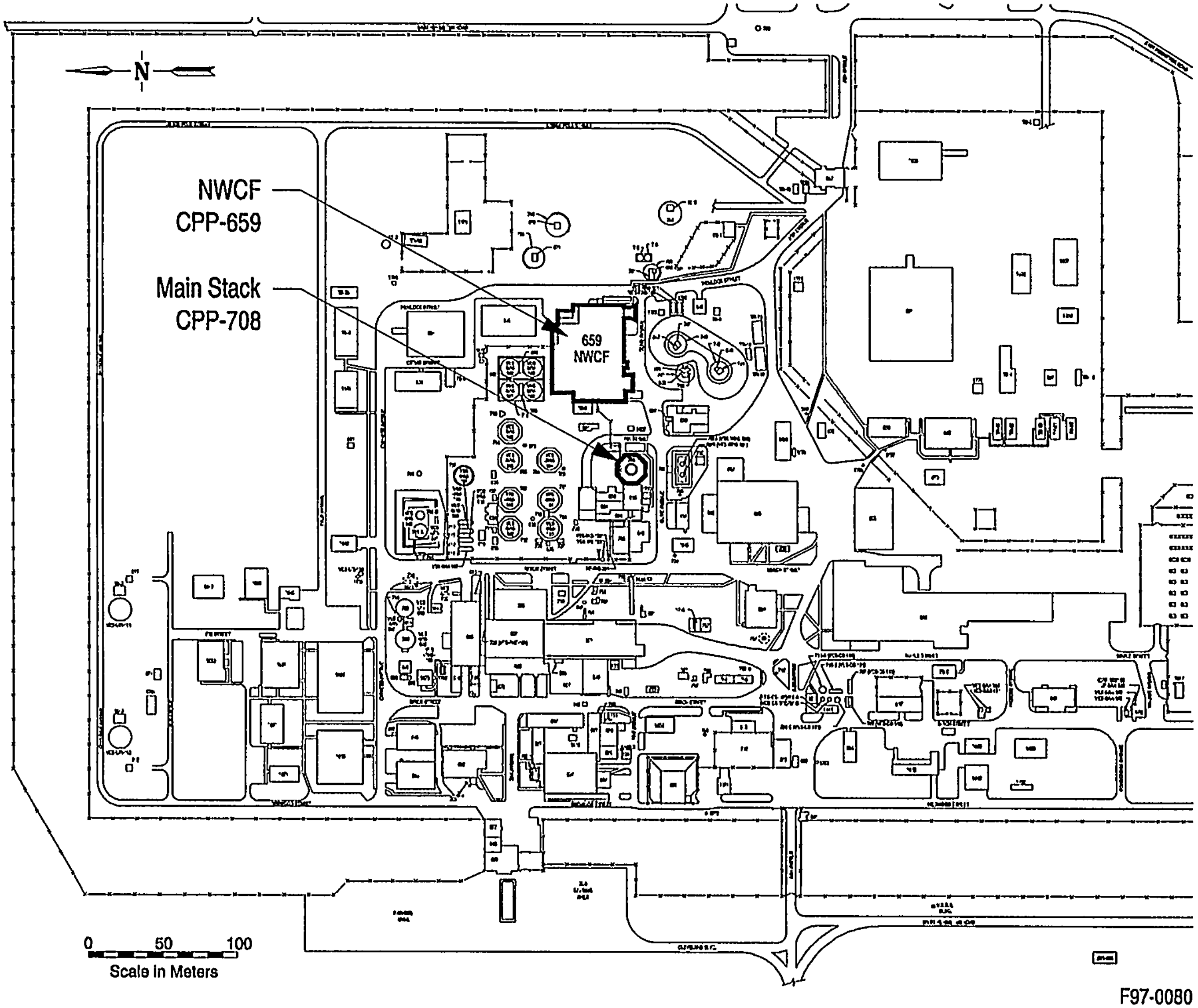

Figure 2. Partial plot plan of the Idaho Nuclear Technology and Engineering Center showing the New Waste Calcining Facility (CPP-659) and the Main Stack (CPP-708).

The calcination process involves spraying liquid radioactive mixed waste onto a heated fluidized bed of particles. Dissolved metals and fission products are converted to their salts and oxides through evaporation and solidification. The process removes water and decomposes acids. A detailed description of waste feed composition is given in Section 2 and Appendix A.

Waste solution feed is transferred from the Tank Farm facility to the calciner blend and hold tanks (Figure 3). Feed is then atomized by air and sprayed into a bed of heated spherical particles maintained at a temperature of approximately 500 to 600°C. During calcination, the particle size is maintained large enough to prevent excessive carry over, yet small enough to provide good heat transfer within the bed and to minimize the quantity of air required for fluidization. The size range helps minimize the solids carryover in the off-gas yet provides sufficient fines material to furnish seed particles for maintaining a stable bed-particle growth cycle. The calciner product removed from the bed and the fines removed from the off-gas in the cyclone are pneumatically transferred to the Calcined Solids Storage Facilities (CSSFs). Process heat is provided by inbed combustion. Kerosene is atomized with oxygen and sprayed into the fluidized bed of particles. When the fuel contacts the bed, it autoignites.

A combination of dry and wet off-gas cleanup equipment is used to remove particulate as well as to cool the calciner off-gas (Figure 3). Most of the solids are removed by the high efficiency cyclone. Additional particulate removal occurs in a quench tower and in the venturi scrubber. Liquid droplets of scrub solution and dissolved solids are removed in a de-entrainment separator and a mist eliminator. Before passing through the final high efficiency particulate air (HEPA) filters, the off-gas passes through a mist collector and heater to prevent condensation of water vapor in the HEPA filter housings. The final filtration system for the process off-gas consists of one stage of HEPA prefilters and two stages of HEPA finish filters installed in series. After passing through the HEPA filters, the off-gas passes through the INTEC atmospheric protection system (APS) for an additional single-stage HEPA filtration, and then it is discharged to the atmosphere through the INTEC 250-ft-high Main Stack. The Main Stack off-gas is monitored for radionuclide particulates and NO_x.

1.3 Land Use

No resident human populations are located within the INEEL Site boundary. The nearest permanent residents reside in Atomic City (population 35) and Arco (population 1,094), located approximately 12 km southeast and 33 km west of INTEC, respectively. Other population centers in the vicinity of the INEEL include Idaho Falls (population 48,200), located 67 km east of the INEEL, and Blackfoot (population 9,931), located 66 km southeast of the INEEL. Nonresident human populations at the INEEL consist of workers and visitors at the various DOE facilities, stock herdsmen, and hunters.

Three major highways traverse the INEEL. U.S. Highway 20 crosses the southern portion of the INEEL and is the primary transportation route between Idaho Falls and Arco. U.S. Highway 26 connects Blackfoot with U.S. Highway 20. U.S. Highway 22/33 bisects the northern portion of the INEEL, connecting the towns of Mud Lake and Howe. The nearest highway to the INTEC is U.S. Highway 20, approximately 6 km to the south.

Livestock grazing is permitted in areas along the perimeter of the INEEL. Livestock herders are likely to be present on the east and south grazing areas during the winter and to the west during the warmer months of the year. Grazing is not permitted north of U.S. Highway 20. Livestock populations are controlled, and dairy cattle are not allowed within the INEEL boundary.

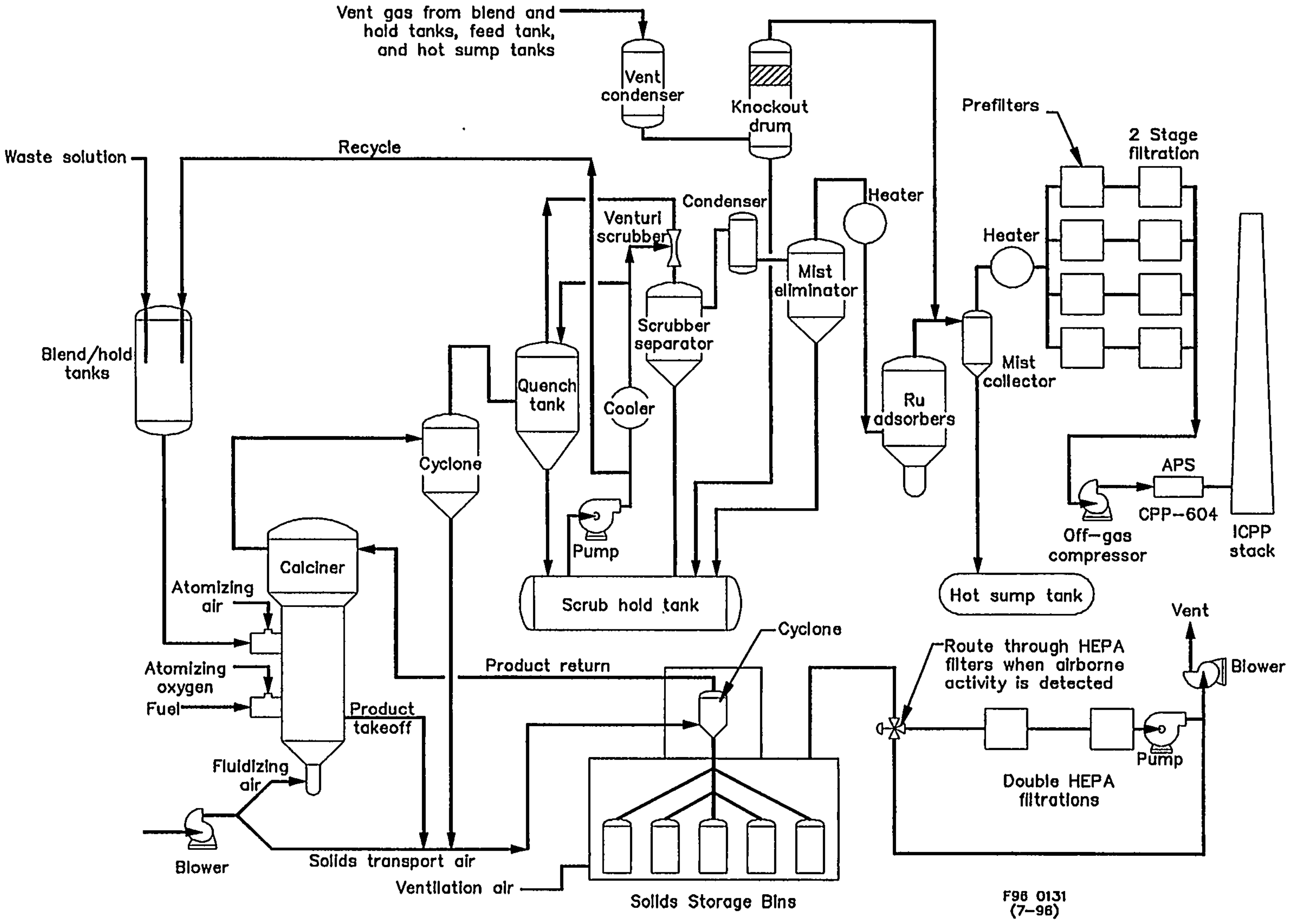

Figure 3. Schematic diagram of the New Waste Calcining Facility process and off-gas treatment system.

In 1989, the DOE established an agreement with the Idaho Department of Fish and Game that allows controlled harvesting hunts of pronghorn antelope and elk in selected areas. The temporary hunting zone extends 0.8 km (½ mile) inside the INEEL boundary. Most of the hunting occurs along portions of the northeast and northwest boundary lines (Figure 1). The game herds in both of these areas spend most of their time in areas that are not expected to be impacted by the NWCF plume. The area to the northeast is approximately 50 km from the NWCF, adjacent to farms west of Mud Lake. Hunting on the northwest boundary of the site occurs only in the southern terminus of the Lemhi Range, approximately 27 km north of the NWCF.

Other uses of the land are severely limited because of the climate, presence of lava flows, and general desert soil conditions on the INEEL. Because the INEEL is remotely located from most developed areas, INEEL lands and adjacent areas are not likely to experience residential and commercial development. No new development is planned near the INEEL Site (DOE-ID 1993). However, recreational and agricultural uses are expected to increase in the surrounding area in response to greater demand for recreational areas and the conversion of range land to crop land.

2. SOURCE CHARACTERIZATION

Source characterization involves estimating emissions from the NWCF and identifying the chemicals to be evaluated in the SLRA. The following sections discuss the selection process for the contaminants of potential concern (COPCs) evaluated in the SLRA, and the process knowledge and analytical methods used to determine COPC emission rates.

2.1 U.S. Environmental Protection Agency Guidance

The EPA (1994b) has provided a table of 163 chemicals recommended for identification in the SLRA (Table 1). These chemicals and any acid gases produced in the combustion process should be evaluated for direct exposure (inhalation) impacts.

For indirect exposures, the screening guidance focuses on a subset of these constituents, 12 metals and the "critical organics" listed in Table 1, which have been judged to be of the greatest concern by routes of exposure other than direct inhalation alone (EPA 1994a). The critical organic chemicals include the following:

- Chlorinated dibenzo-p-dioxins (CDDs) and chlorinated dibenzofurans (CDFs)
- Polycyclic aromatic hydrocarbons (PAHs)
- Polychlorinated biphenyls (total PCBs)
- Nitroaromatics (five listed)
- Phthalates (two listed)
- Other chlorinated organics—hexachlorobenzene and pentachlorophenol.

The sources of these organic emissions include: (1) incinerator and combustor feed materials, (2) kerosene which is used as the fuel for the calciner, and (3) products of incomplete combustion (PICs). PICs are organic compounds not present in the feed or fuel, which are formed by thermal breakdown and recombination in the combustion chamber, or are formed downstream in air pollution control devices (APCDs).

2.2 New Waste Calcining Facility Emissions Data

The calciner is a significantly different operation than traditional incinerators that burn solid hazardous waste. The feed consists of a concentrated solution that is relatively high in acid (HNO_3, HCl, and HF), contains dissolved metals and inorganic salts, and is relatively low in organic chemicals. The liquid feed is atomized and sprayed into a fluidized bed that is heated to a relatively low temperature of 500 to 600°C by combustion of kerosene fuel (at 25–30 gal/hour) and oxygen. When the liquid waste is sprayed into the calciner, the following occurs:

- Water is vaporized.
- Nitric acid and nitrates are decomposed to NO_x (Schindler 1995).

Table 1. Chemicals recommended for identification by EPA guidance (EPA 1994b).

Chemical Abstract Service No.	Chemical
	Metals
7440-36-0	Antimony
7440-38-2	Arsenic
7440-39-3	Barium
7440-41-7	Beryllium
7440-43-9	Cadmium
7440-47-3	Chromium
7439-2-1	Lead
7440-97-6	Mercury
7440-02-0	Nickel
7782-49-2	Selenium
7440-22-4	Silver
7440-28-0	Thallium
	Critical EPA organics (indirect pathway)
	Dioxins and furans
	TCDD, 2,3,7,8-
	PeCDD, 1,2,3,7,8-
	HxCDD, 1,2,3,7,8-
	HxCDD, 1,2,3,4,7,8-
	HxCDD, 1,2,3,6,7,8-
	HxCDD, 1,2,3,7,8,9-
	HpCDD, 1,2,3,4,6,7,8-
	OCDD
	TCDF, 2,3,7,8-
	PeCDF, 1,2,3,7,8-
	PeCDF, 2,3,4,7,8-
	HxCDF, 1,2,3,4,7,8-
	HxCDF, 1,2,3,6,7,8-
	HxCDF, 2,3,4,6,7,8-
	HxCDF, 1,2,3,7,8,9-
	HpCDF, 1,2,3,4,6,7,8-

Table 1. (continued).

Chemical Abstract Service No.	Chemical
	HpCDF, 1,2,3,4,7,8,9-
	OCDF
	2,3,7,8 TCDD TEQ
	Polycyclic aromatic hydrocarbons (PAHs)
56-55-3	Benzo (a) anthracene (BAA)
205-99-2	Benzo (b) fluoranthene (BBF)
	Benzo (k) fluoranthene (BKF)
50-32-8	Benzo (a) pyrene (BAP)
218-01-9	Chrysene (CHY)
53-70-3	Dibenz (a,h) anthracene (DBA)
193-39-5	Indeno (1,2,3-cd)pyrene (IDP)
	benzo(a)pyrene TEQ
	Other critical organics
99-65-0	Dinitrobenzene, 1,3-
121-14-2	Dinitrotoluene, 2,4-
606-20-2	Dinitrotoluene, 2,6-
117-81-7	Bis(2-ethylhexyl)phthalate
117-84-0	Di(n)octyl phthlate
118-74-1	Hexachlorobenzene
98-95-3	Nitrobenzene
1336-36-3	PCBs (209 congeners)
82-68-8	Pentachloronitrobenzene
87-86-5	Pentachlorophenol
	Acid gases
7647-01-0	Hydrogen chloride (HCl)
10102-44-0	Nitrogen dioxide (NO_2)
7664-39-3	Hydrogen fluoride (HF)
7446-09-5	Sulfur dioxide (SO_2)
	Others on EPA primary list
75-07-0	Acetaldehyde
98-86-2	Acetophenone

Table 1. (continued).

Chemical Abstract Service No.	Chemical
107-02-8	Acrolein
107-13-1	Acrylonitrile
120-12-7	Anthracene
100-52-7	Benzaldehyde
71-43-2	Benzene
	Benzo (j) fluoranthene
	Benzo (g,h) perylene
	Benzo (e) pyrene
96-07-7	Benzotrichloride
100-44-7	Benzyl chloride
92-52-4	Biphenyl
111-91-1	Bis(2-chloroethoxy)methane
74-97-5	Bromochloromethane
75-27-4	Bromodichloromethane
590-60-2	Bromoethene
75-25-2	Bromoform
74-83-9	Bromomethane
106-99-0	Butadiene, 1,3-
85-68-7	Butylbenzyl phthalate
56-23-5	Carbon tetrachloride
57-74-9	Chlordane
532-27-4	Chloroacetophenone, 2-
106-47-8	Chloroaniline, p-
106-90-7	Chlorobenzene
510-15-6	Chlorobenzilate
67-66-3	Chloroform
74-87-3	Chloromethane
91-58-7	Chloronaphthalene, B-
95-57-8	Chlorophenol, 2-
75-29-6	Chloropropane, 2-
1319-77-3	Cresol, m-
1319-77-3	Cresol, o-, (Methylphenol, 2-)

Table 1. (continued).

Chemical Abstract Service No.	Chemical
1319-77-4	Cresol, p-
4170-30-3	Crotonaldehyde
94-75-7	2,4-D
3547-04-4	DDE
96-12-8	Dibromo-3-chloropropane, 1,2-
84-74-2	Dibutyl phthalate
95-50-1	Dichlorobenzene, 1,2-
95-50-1	Dichlorobenzene, 1,3-
106-46-7	Dichlorobenzene, 1,4-
764-41-0	Dichloro-2-butene, (cis) 1,4-
764-41-0	Dichloro-2-butene, (trans) 1,4-
75-71-8	Dichlorodifluoromethane
107-06-2	Dichloroethane, 1,2-
75-35-4	Dichloroethylene, 1,1-
156-80-5	Dichloroethylene, (trans) 1,2-
120-83-2	Dichlorophenol, 2,4-
542-75-6	Dichloropropene, (cis) 1,3-
542-75-6	Dichloropropene, (trans) 1,3-
84-66-2	Diethyl phthalate
105-67-9	Dimethylphenol, 2,4-
131-11-3	Dimethyl phthalate
119-90-4	Dimethoxybenzidine, 3,3-
528-29-0	Dinitrobenzene, o-
100-25-4	Dinitrobenzene, p-
123-39-1	Dioxane, 1,4-
100-41-4	Ethylbenzene
106-93-4	Ethylene dibromide
75-21-8	Ethylene oxide
96-45-7	Ethylene thiourea
75-34-3	Ethylidene dichloride (1,1-dichloroethane)
206-44-0	Fluoranthene
50-00-0	Formaldehyde

Table 1. (continued).

Chemical Abstract Service No.	Chemical
76-44-8	Heptachlor
87-68-3	Hexachlorobutadine
319-84-6	Hexachlorocyclohexane, alpha (α-Lindane)
319-85-7	Hexachlorocyclohexane, beta (β-Lindane)
58-89-9	Hexachlorocyclohexane, gamma-
77-47-4	Hexachlorocyclopentadiene
67-72-1	Hexachloroethane
70-30-4	Hexachlorophene
110-54-3	Hexane, n-
123-33-1	Maleic hydrazide
72-43-5	Methoxychlor
71-55-6	Methyl chloroform
106-87-2	Methylcyclohexane
78-93-3	Methyl ethyl ketone
74-95-3	Methylene bromide
75-09-2	Methylene chloride
91-20-3	Naphthalene
88-74-4	Nitroaniline, o-
100-02-7	Nitrophenol, 4-
924-16-3	Nitroso di-n-butylamine, N-
608-93-5	Pentachlorobenzene
108-95-2	Phenol
75-44-5	Phosgene
123-36-6	Propionaldehyde
78-87-5	Propylene dichloride
91-22-5	Quinoline
106-51-4	Quinone
94-59-7	Safrole (5-(2-Propenyl)-1,3-benzodioxole)
100-42-5	Styrene
95-94-3	Tetrachlorobenzene, 1,2,4,5-
630-20-6	Tetrachloroethane, 1,1,1,2-
79-34-5	Tetrachloroethane, 1,1,2,2-

Table 1. (continued).

Chemical Abstract Service No.	Chemical
127-18-4	Tetrachloroethylene
58-90-21	Tetrachlorophenol, 2,3,4,6-
106-88-3	Toluene
95-53-4	Toluidine, o-
106-49-0	Toluidine, p-
120-82-1	Trichlorobenzene, 1,2,4-
79-00-5	Trichloroethane, 1,1,2-
79-01-6	Trichloroethylene
75-69-4	Trichlorofluoromethane
95-95-4	Trichlorophenol, 2,4,5-
88-06-2	Trichlorophenol, 2,4,6-
96-18-4	Trichloropropane, 1,2,3-
76-13-1	Trichloro-1,2,2-trifluoroethane, 1,1,2-
108-05-4	Vinyl acetate
75-01-4	Vinyl chloride
75-35-4	Vinylidine chloride
1330-20-7	xylene, m-dimethyl benzene
1330-20-8	xylene, o-dimethyl benzene
1330-20-9	xylene, p-dimethyl benzene

- Dissolved metals are converted to oxides, halides, and other stable solids that coat the existing solids.

- Some of the HCl and HF vaporize.

Upper-bound emissions estimates for current and future NWCF operations were developed based on a detailed examination of worst-case calciner waste feed (Tank Farm) compositions, maximum permitted annual and hourly feed volumes, and conservative APCD removal efficiencies. Appendix A contains detailed calculations for these emission rates. Four classes of chemicals are evaluated: metals, acid gases, trace organics in the feed solution, and PICs.

2.2.1 Metals

Metal emissions have been shown to be the primary risk drivers from operation of hazardous waste incinerators and incineration on a national basis. Using data from eight full-scale incinerator tests, the EPA found that the risks from metal emissions ranged from two to six orders of magnitude higher than values for organic chemical emissions (Dempsey and Oppelt 1993). This would be especially true for the NWCF because of the low concentrations of organics in its feed compared to traditional incinerators that burn solid hazardous wastes that are relatively high in organics.

The major contaminants of concern for NWCF emissions are the 12 metals listed in the EPA guidance (Table 1) and uranium, which was added based on its relatively high concentration (121 mg/L) in Tank Farm feed. Emission rates were calculated based on (1) worst-case tank feed concentrations, (2) contingencies for unanalyzed tanks and concentration increases from return of semivolatile species in the scrub solution, and (3) conservative APCD decontamination factors (DFs) (ratio of the influent concentration to the effluent concentration in a particular APCD, calculated as the reciprocal of the contaminant penetration fraction).

2.2.1.1 ***Non-volatile Metals.*** Appendix A provides a detailed description of the methods and assumptions used to calculate metal emissions rates. For calciner emissions, the methods are summarized as follows:

1. For those metals analyzed in all tanks with retrievable waste (Cd, Cr, Hg, Pb, Ni, and U), the maximum measured concentrations were selected (Appendix A).

2. For those metals that have been analyzed and detected in only one or two tanks (Ag, As, Ba, and Se), the concentration in the empty WM-188 tank was also considered. The maximum value was selected and one standard deviation of the mean concentration was added to account for the tanks that were not sampled.

3. For metals which have not been detected in any of the waste tanks (Be, Sb, and Tl), one-half of the minimum detection limit was assumed.

4. Upper-bound tank farm inventories (total grams) were calculated by multiplying the selected maximum upper-limit feed concentration by the total net (with scrub solution) feed volume of 1,180,000 gallons (which includes an additional 25% to account for future waste generation).

5. Total inventories were multiplied by APCD-specific DFs which were determined by measurements of a radioactive particulate (Sr-90) in the feed and offgas during operations in 1991, 1993, and 1997.

6. The annual emission rate was calculated by dividing the upper-bound tank farm inventory by either 7 years (1999–2005, the fastest calcining schedule) or 14 years (1999–2012, the more probable schedule). A 7-year averaging time was used for the noncarcinogenic metals (Ag, Ba, Hg, Pb, Se, Sb, Tl, U) because it results in the highest possible annual emission rate which is appropriate for assessing potential short-term noncarcinogenic health effects. The 14-year averaging time was used for carcinogens because it results in the most likely long-term averaged emission rate and because the soil concentration equations used in the

exposure assessment (Appendix B) assumed 16 years of deposition (assumed for earlier SLRA versions and not changed here).

Emissions of non-volatile metals are very small because of removal by four banks of HEPA filters. The HEPA filter DFs used to calculate emission rates for this version of the SLRA (900 for the NWCF filters and 300 for the APS filter) are "degraded" filter DFs which include the effects of NWCF upset conditions. These assumed DFs are significantly lower than those which are demonstrated after initial filter installation (1E+07 for the three NWCF HEPA filters and 3E+03 for the APS HEPA filter).

In addition to the HEPA filters, other APCDs in the initial section of the calciner consist of the calciner vessel, cyclone, quench tower, venturi scrubber, mist eliminator, and silica-gel absorbers (Figure 3). The combined DF for non-volatile metals through these systems was assumed to be 2,000 based on measured data from the predecessor of the NWCF, the Waste Calcining Facility, which had an off gas system similar to that of the NWCF. This value is conservative because some of the measurements indicated a much higher DF (5,000–10,000). The total DF for the filters and the initial calciner APCDs is calculated by multiplying the individual APCD DFs, as follows (Appendix A):

APCD	DF (nonvolatile metals)
cyclone, scrub system	2000
Absorbers	1
NWCF HEPAs (3)	900
APS HEPA (1)	300
Overall	**5.4E+8**

The APCD removal efficiency corresponding to the DFs can be calculated using the following equation:

$$DF = \frac{1}{(1 - EF)^n}$$

where:

EF = removal efficiency fraction for a particular device (e.g. HEPA)

n = number of devices in series.

Solving for EF gives

$$EF = 1 - \sqrt[n]{1/DF}.$$

For example, the DF value of 900 assumed for the three NWCF HEPA filters corresponds to an average removal efficiency of less than 90% per filter, which is a very conservative value. These HEPA filters are tested when initially installed to greater than 99.99999% removal efficiency for the entire bank.

HEPA filters have a minimum removal efficiency at a particle diameter, which depends on particle size and shape, between 0.1 and 0.3 microns. HEPA filters are normally rated for a test aerosol approximating the most-penetrating particle size (e.g., 0.3 micron DOP particles). Both larger and smaller particle sizes are removed at a higher efficiency than the rated efficiency (Lieberman and Scott 1970).

The size of the particles in the NWCF effluent containing the metals cannot be measured because concentrations are too small to measure. The particle size distribution expected to be discharging from a series of HEPA filters centers on the particle size for which the filters are least efficient. For air modeling purposes, particle sizes were calculated from published emissions data from medical waste incinerators and penetration through three HEPA filters (see Section 3).

Limited stack sampling was done in 1993 for some of the metals (see Table 3 and Appendix A, Table A-1). These data were not used for this SLRA because most of the analytical results were less than detection limits. The exception was mercury which showed a 0.5% feed-to-offgas emissions factor during the 1993 sampling. More recent and longer term sampling results from activated carbon filters during 1997–1998 calcining campaign indicated higher (3%) mercury emissions which were used to develop the emission rates in the SLRA (see Mercury section below).

Other low-toxicity non-volatile metals (e.g., zinc and copper) are present in some the waste. The aluminum species in the NWCF feed all become inert solids (Al_2O_3 or $NaAlO_2$) which are emitted only in small quantities. Copper and zinc are present in the waste only in trace concentrations (from their use in chemical analyses) and are likewise emitted only as solids. The trace emissions of all these non-volatile metals are then subject to removal by the four banks of HEPA filters.

2.2.1.2 ***Mercury.*** Mercury emissions from the NWCF are a major concern because of the large inventory of mercury in the waste tanks (5700 lbs), it relatively high volatility, and because of concerns about its effects on human health and the environment. Based on sample measurements made during the 1997–1998 calcining operation, approximately 87% of the Hg fed to the calciner was captured in the scrub solution. Offgas samples indicated that approximately 3% of the Hg was released out the stack (see discussion below). The remaining 10% was either retained in the calcined solids, collected by the silica-gel absorbers, or could be due to concentration and volume measurement errors.

The calcined solids consist of the bed solids, which are larger solids that remain in the fluidized bed, and fine solids ("fines"), which are blown out of the bed and collected by the cyclone. Both the accumulated bed solids and the fines collected in the cyclone are transferred to the calcined solids storage bins. The bed solids are sampled but there is not a sampling system for the fines. Analyses of the bed solids samples indicate that the bed solids contain about 0.3 % of the Hg from the feed. However, pilot-plant data indicate that the fines contain 10 to 20 times as much Hg as the bed solids (because of their shorter residence times in the high-temperature zone). Similar Hg distributions in the NWCF would indicate 3 to 6 % of the Hg from the feed being in the fines transferred to the bin sets. The silica-gel absorbers contain about 25 m^3 of Si-gel which is a porous solid whose high surface area gives it a high capacity for adsorbable vapors (the absorbers are not designed for sampling). However, for conservatism, maximum ecological impacts (soil concentrations) were screened using 13% (factor increase of 13/3 = 4.3) as an upper-bound estimate of the Hg emissions factor (see section 8).

The emission factor for Hg used in this evaluation is based on offgas samples taken with an activated carbon cartridge during the 1997–1998 NWCF operation. The activated carbon cartridges used to monitor the radioiodine emissions from the stack were also analyzed for their Hg content which was used to calculate emission as a fraction of the Hg in the net feed. Although used to measure radioiodine, these activated carbon filters are generally very efficient (90%) for mercury or other higher molecular weight vapors (Dunham et al. 1998). The fractional Hg emissions, from 3 sample cartridges with sample durations of 2 to 4 months, averaged 2.55% of the Hg in the net feed with a standard deviation of 0.865%. An upper-limit emission factor of 3.7% (or a feed-based DF of 27) is obtained by assuming an activated carbon collection efficiency of 90% and adding one standard deviation to cover process variations.

Some concern has been expressed that the Hg emissions determined using the activated carbon cartridges could be low because of Hg breakthrough in the activated carbon. The following evidence provides a reasonable basis for concluding that there was no breakthrough of Hg during the sampling period:

1. The average Hg concentrations on the activated carbon samples were 11 to 22 ppm which is much less than the typical absorption capacity of these absorbents (4000 ppm) (Dunham et al. 1998). Breakthrough does not occur until the activated carbon approaches saturation.

2. The most likely form of Hg is $HgCl_2$ which is readily sorbed by activated carbon at ambient temperature because of its low ambient vapor pressure (0.022 Pa) (compounds with low vapor pressures prefer the solid or liquid phase and are therefore more readily sorbed).

3. The analysts report that the Hg on the activated carbon was very non-uniform in distribution (requiring extensive mixing for aliquote replication) which indicates loading of the Hg on the front of the activated carbon. A saturated activated carbon sample would have a uniform concentration at the saturation level.

4. The stack samples taken during 1993 NWCF operation using an EPA sample train (40CFR266, App. IX) showed Hg emissions averaging 0.5% of the Hg in the feed, which is a factor of five lower than obtained in 1997–1998 with the activated carbon sampler.

5. The sample interval for the three samples taken with the activated carbon varied. One sample spanned 2 months and the other two samples spanned 4 months. If breakthrough were occurring, the sample with the shorter span would show a higher measured offgas Hg concentration. Instead, the sample of shorter duration showed an offgas Hg concentration in between those of the longer samples.

2.2.1.3 ***Other Volatile/Semivolatile Metals.*** In addition to $HgCl_2$, the following volatile and semivolatile metal species could be formed in the calciner: $PbCl_2$, Sb_4O_6, $SbCl_3$, TlCl, SeO_2, and $BeCl_2$. Conservative emission rates for these species were calculated based on thermochemical calculations and conservative assumptions for scrubber removal (Appendix A). The conclusions of these calculations are:

1. Less than 10% of Pb, Be, and Tl are present in the offgas as volatile or semi-volatile chloride species. The remaining (>90%) exist as non-volatile oxide species that are removed by the filters.

2. Most of the Sb and all of the Se are present as volatile or semi-volatile species (Sb_4O_6, $SbCl_3$, SeO_2).

3. $PbCl_2$ and Sb_4O_6 are semi-volatile and may be partially captured by the filters. Since the filter DF for these semi-volatiles is unknown, their emission rates (1E-4 g/hr and 2.2E-4 g/hr, respectively) were conservatively calculated from the maximum possible mole flow rate of these vapors in the total NWCF offgas flow rate of 300 lb mol/hr (2000 scfm).

4. Other volatile metal species were assumed to have no removal in the filters (DF=1), but have the same tendency to accumulate in the scrub solution as Hg. Therefore, a scrub system DF of 27 (the same DF as used for Hg) was assumed based on their scrub solution solubility similar to $HgCl_2$. Some of these species are likely to be more soluble than $HgCl_2$ because of aqueous reactions. For the metals that partition between volatile and non-volatile species (Pb, Be, and Tl), a weighted DF (270) is calculated based on the percent that is nonvolatile and filterable (90% DF = 2.7E+5) and the percent that is volatile (10% DF = 27). Table 2 summarizes the decontamination factors used to develop the hazardous metal emission rates.

2.2.1.4 *Emissions from Fugitive and Auxiliary Sources.*

Fugitive Emissions Sources are prevented by operating the INTEC processes, including the tank farm, under vacuum so that leakage is inward. The process equipment is located in cells whose exiting ventilation air is monitored for any increase in radioactivity to verify the absence of leakage from the process equipment.

Auxiliary Emission Sources. The calciner vessel offgas (flow rate = 1,300 scfm) contributes the vast majority of radionuclide, gas, chlorine, metals, and organic emissions to the main stack. Other gaseous waste streams which are intermittently vented to either the main stack or the APS include the (Figure 4):

1. Process Equipment Waste (PEW) evaporator
2. Liquid Effluent Treatment and Disposal facility (LET&D)
3. NWCF Process Vessels (Appendix A, Figure 1)
4. WM-189 airlift pump (Appendix A, Figure 1)
5. High Level Liquid Waste Evaporator (HLLWE).

Of these only the NWCF process vessels are an integral part of the NWCF. The overall NWCF DF of 5.4E+08 for non-volatile metal emissions includes the emissions from the NWCF process vessels, the PEW evaporator, and LET&D because the DF was developed from stack measurements made when all of these systems were operating.

Table 2. Estimated decontamination factors (DFs) for volatile and semi-volatile metal species in the NWCF offgas.

Compound	Modeled Percent	Scrubber DF	HEPA filters DF	Overall DF or emission rate	Weighted overall DF or emission rate
$HgCl_2$ (volatile)	100	27	1	27	27
SeO_2 (volatile)	100	27	1	27	27
Sb_4O_6 (volatile)	99.9	27	1	1	2.2E-4 g/hr[a]
$SbCl_3$ (volatile)	<0.01	27	1	27	
Na_3AsO_4	100	2000	2.7E+5	5.4E+8	5.4E+8
PbO	90	2000	2.7E+5	5.4E+8	1E-4 g/hr[a]
$PbCl_2$ (volatile)	10	27	NA	NA	
CdO	100	2000	2.7E+5	5.4E+8	5.4E+8
Ag_2O	100	2000	2.7E+5	5.4E+8	5.4E+8
BaO	100	2000	2.7E+5	5.4E+8	5.4E+8
BeO	90	2000	2.7E+5	5.4E+8	270
$BeCl_2$ (volatile)	10	27	1	27	
Na_2CrO_4	100	2000	2.7E+5	5.4E+8	5.4E+8
NiO	100	2000	2.7E+5	5.4E+8	5.4E+8
Th_2O	90	2000	2.7E+5	5.4E+8	270
ThCl (volatile)	10	27	1	27	

a. Emission rates for these compounds were conservatively calculated based on maximum possible mole flowrates rather than DFs.

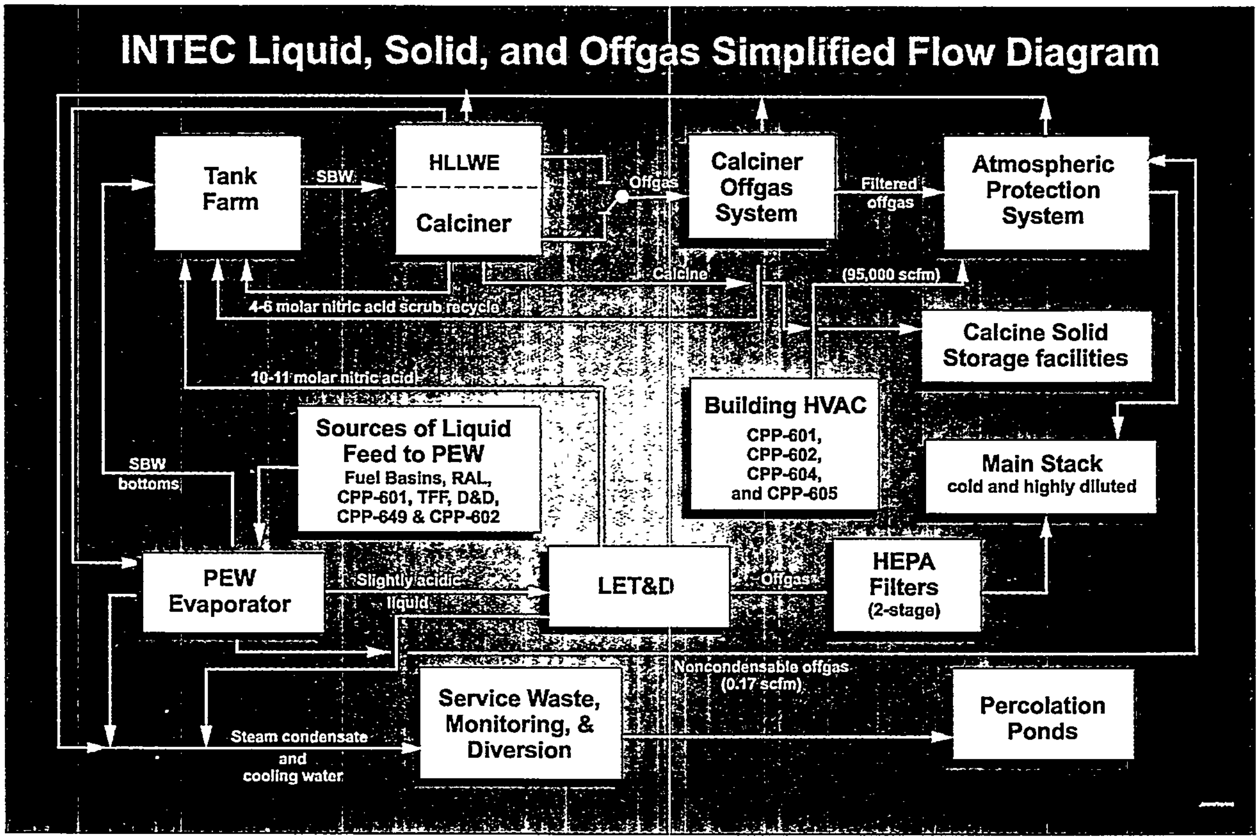

Figure 4. Simplified flow diagram of the liquid, solid, and offgas systems at INTEC. The yellow lines show waste streams that vent to the APS or main stack.

2.2.1.4.1 PEW Evaporator and LET&D—The PEW evaporator and LET&D are independent of the NWCF, but they often operate at the same time as the NWCF and always operate in sequence. The PEW evaporator condensate is vaporized by the LET&D, filtered (2 stages of HEPA filters) and then discharged to the main stack. The emission route for the two systems is the LET&D vapor.

Non-volatile metal emissions from the LET&D vapor are very low (at least a factor of a 1000 lower than from the NWCF) because the PEW is evaporated in series by the PEW evaporator and LET&D (each of which have a DF for non-volatile solutes of 1000 to 10,000; Appendix A), and the vapor is then filtered through two HEPA filters in series. In addition, the concentrations of solutes in the PEW are about a factor of 100 lower than in the NWCF feed (Appendix A).

The only direct emission source from the PEW evaporator is a vent from the condenser to the APS (Figure 4). The vent discharges purge air from the instrument probes and air displaced by filling the Vessel Off Gas (VOG) system. Potential emissions from this vent are extremely small compared to those evaluated from the calciner because of the small flow rate (maximum of 0.17 scfm or 0.009% of the calciner offgas), the low temperature, and because vapors are washed at the condenser outlet vent location. Therefore, no quantitative assessment of additional emissions from this vent were made.

2.2.1.4.2 NWCF Process Vessels—The NWCF facility contains sparged feed-storage vessels, sump vessels, and air-lifts whose offgas bypasses the calciner and scrub system, and joins the calciner off gas before the filters. The emissions from these process vessels are included in the overall NWCF DF because the DF was developed from stack measurements made when all of these systems were operating. These systems are a minor fraction of the overall NWCF emissions because their gas flow rates and velocities are lower than in the NWCF scrub system.

The primary mechanism of particulate emission from the NWCF process vessels and airlifts is entrainment of liquid droplets by the sparge and airlift air. An entrainment study on evaporators (Appendix A) indicates that an entrainment factor of 1E-4 kg liquid/kg gas is conservative for gas flows well in excess of the NWCF sparge rates of about 1 $ft^3/s\text{-}ft^2$. The total air input to the NWCF sparges and airlifts is < 100 scfm which is < 214 kg air/hr. The maximum entrainment from the vessels and airlifts for this air input is 0.0214 kg/hr (which is reduced greatly by the NWCF and APS filters before reaching the stack). The NWCF (maximum) feed rate of 778 L/hr (with a density of 1.27 kg/L) is 988 kg/hr. The entrainment relative to the feed is 2.15E-05 which corresponds to a DF of 46,000 (before filtration).

2.2.1.4.3 WM-189 Air-lift—One active waste storage tank (WM-189) uses a 3-stage air-lift pump for liquid transfers. The air input, which is not metered, is estimated at a maximum of 300 scf/min which has a potential for substantial entrainment of particulate metals. Most of the air-lift motive air discharges to the VOG system which filters it through the (single-stage) VOG filter and the APS filter before discharging to the stack. A minor potion of the air goes with the liquid waste to the calcium vessel, where it is subject to treatment by the NWCF offgas system. The WM-189 airlift has an atmospheric emission only when being used to transfer liquid out of WM-189. The other (active) waste storage tanks use steam jets which have no effluent gases. The airlift pump was not operating during the time of the stack measurements which were the basis for the overall NWCF non-volatile metal DF (5.4E+8). Therefore, additional calculations were made to account for the potential increase in emissions from this source as follows:

The maximum relative entrainment from the airlift comes with the maximum air input of 300 scfm (640 kg/hr) and the minimum liquid flow of about 30 gpm (130 kg/min). An entrainment factor of 5E-5 kg liquid/kg air is used because of the long settling time and low air velocity in the tank. With this entrainment factor, the entrainment from the tank is 0.032 kg/hr from the tank, and the relative entrainment is one part in 240,000 of the liquid transferred. The filter DF's for this analysis are 30 for the VOG filter (the same as for a single NWCF filter) and 300 for the APS filter. The overall particulate DF for the airlift filtered effluent is 2.2E+09 as compared to 5.4E+08 for the overall NWCF. For annual average emissions calculations, the airlift DF was adjusted to account for 33% maximum lifetime usage because WM-189 is the only active tank with an airlift. This airlift results in an annual average airlift pump DF of 6.7E+9:

$$\frac{1}{\frac{1}{2.2E+9}(0.33)} = 6.7E+9$$

2.2.1.4.4 High Level Liquid Waste Evaporator—The High Level Liquid Waste Evaporator (HLLWE) uses the same feed and sump vessels as the NWCF, but is not a part of the NWCF. It does not operate at the same time as the NWCF because of conflicting needs for the same feed and sump vessels. Therefore, it does not contribute emissions to the main stack while the calciner is operating. The HLLWE emits entrained liquid drops from the sparged NWCF vessels it uses for the feed and product. As during NWCF operation, the vessel off gas discharges through the NWCF and APS filters. The emissions are about the same as estimated above for sparging the same vessels with NWCF operation—about 4 % of the particulate emissions estimated for NWCF operation.

The HLLWE condensate is transferred to the PEW evaporator for reevaporation, and then vaporization and discharge from the LET&D. The emissions via this route are very small because liquid discharged by this route goes through three stages of evaporation (each with particulate DF's of 1000 to 10,000) and two sets of HEPA filters (with a combined DF of about 1000) before discharge.

Another minor HLLWE emission route is the vent on the condenser which vents the HLLWE purge air and the air displaced by filling (Figure 4). The emissions from this vent are negligible compared to that calculated for the calciner and airlift pump because of the small purge air input (less than 10 scf/hr or 0.17 scfm), the lower temperature, and because the discharge route is via the NWCF and APS filters. Therefore, no quantitative assessment of additional emissions from this vent were made.

2.2.1.4.5 Combined Non-Volatile Metal Emissions for the NWCF and Auxiliary Systems—The overall NWCF DF of 5.4E+08 for non-volatile metals includes the emissions from the NWCF process vessels, the PEW evaporator, and the LET&D because the DF was developed from stack measurements made when all of these systems were operating. The non-volatile metal emissions from the HLLWE and the PEW evaporator condenser vent were determined to be negligible. To account for potential increases in emissions from the WM-189 airlift pump (DF = 6.7E+9), the overall NWCF DF of 5.4E+8 was reduced to 5E+8 as follows:

$$\frac{1}{\frac{1}{5.4E+8}+\frac{1}{6.7E+9}}=5E+8$$

2.2.1.4.6 Mercury Emissions from Auxiliary Systems—The NWCF Hg DF of 27 includes Hg emissions from the PEW evaporator, the LET&D, and the NWCF process vessels because all of these systems were operating when the activated carbon filter samples were taken. Additional Hg emissions from the other auxiliary systems, WM-189 airlift pump, and the HLLWE) were calculated to be less than 0.1% that of the calciner (Appendix A). Therefore, no reduction in the overall Hg DF (27) was made.

2.2.1.5 *Estimation of Total Metal Emission Rates.* A summary of metal emissions from the calciner and auxiliary systems associated with the NWCF is given in Table 3. These calculated emission rates are compared to those determined during NWCF stack sampling in 1993 (Appendix A, Table A-1).

2.2.2 Acid/Combustion Gases and Vapors

Most of the materials emitted from calciner operations are acid and combustion gases—primarily NO_x and CO with smaller amounts of HNO_3, SO_2, HCl, and HF (Table 4). These gases are evaluated in this SLRA for their direct (inhalation) impacts. A major constraint on the annual NWCF feed volume (and, therefore, other contaminant emission rates) is the Permit to Construct (PTC) annual NO_x emission limit of 1,700 tons/year and short-term emission limit of 472 lb/hour (INEL 1995). The NOx emissions from the main stack are monitored during NWCF operations, and the waste feed rate to the NWCF is controlled at a rate such that the measured NOx emission remains below the PTC permit limit. Most of this NO_x is in the form of NO_2 in the offgas. To be conservative, 100% of the NO_x is assumed to be NO_2. The basis for the emission rates in Table 4 is discussed in Appendix A. In this revision, HCl emissions were reduced based on: (1) upper-limit estimates of the maximum one-year chlorine feed, and (2)

ASPEN model calculations which showed a maximum of 30% of the chlorine in the feed is discharged to the off gas (Appendix A). Emissions of acid or combustion gases from the auxiliary system, if any, would be negligible compared to those calculated for operation of the calciner.

Table 3. Metal emission rates developed for the NWCF (calciner and auxiliary sources) (see Appendix A for detailed assumptions and calculations).

Metal	Upper-Limit[a] Inventory (g)	Combined DF for all APCDs	Worst-case calculated stack emission rate (g/yr)	Worst-case calculated stack emission rate (g/s)[b]	Stack Emission Rate from Stack Sampling[c] (g/s)
Mercury (Hg)	2.60E+06	27	4.9E+04	1.6E-03	5.27E-04
Thallium (Tl)	1.50E+04	270	8	2.5E-07	<1.97E-03
Selenium (Se)	4.48E+03	27	24	7.6E-07	<1.97E-03
Antimony (Sb)	5.50E+03	2.2E-04[d]	0.94	3.0E-08	<1.97E-03
Lead (Pb)	1.30E+03	1.0E-04[d]	0.43	1.4E-08	<1.69E-03
Berylium (Be)	1.80E+03	270	0.5	1.6E-08	<3.62E-06
Cadmium (Cd)	5.56E+03	5E+08	7.9E-04	2.5E-11	<1.23E-04
Chromium (Cr)	1.95E+06	5E+08	2.8E-04	8.9E-12	<1.69E-04
Nickel (Ni)	1.88E+06	5E+08	2.7E-04	8.5E-12	<3.62E-04
Uranium (U)	8.69E+05	5E+08	2.5E-04	7.9E-12	Not sampled
Arsenic (As)	2.60E+05	5E+08	3.7E-05	1.2E-12	<3.16E-03
Barium (Ba)	7.62E+04	5E+08	2.2E-05	7.0E-13	<1.06E-04
Silver (Ag)	6.27E+04	5E+08	1.8E-05	5.7E-13	<9.28E-05

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a. Maximum concentration in any of the tanks times the total net waste volume (1,180,000 gal) without accounting for dilution by aluminum nitrate (required for proper calcining chemistry). Be, Sb, and Tl have not been detected; concentrations were assumed to be ½ of the minimum detection limit. The Hg inventory is the total currently in the tank farm.

b. Upper-limit inventory divided by a minimum 7-year calcining schedule for non-carcinogens (Ag, Ba, Hg, Pb, Se, Sb, Tl, U) or a 14-year schedule (more probable) for carcinogens (As, Be, Cd, Ni, Cr). The annual rate (g/yr) is then converted to g/s assuming continuous (3.15E+7 s/yr) operation to be consistent with the annual average air modeling results.

c. These rates are provided for comparison only and where not used in the exposure assessment. See Appendix A, Table A-1.

d. Values given are the Sb and Pb emission rates in grams/hour. Sb and Pb emission rates are calculated based on their maximum vapor pressures and mole fractions in the offgas (Appendix A). Annual emissions assume a 50% on-line factor.

Table 4. NWCF emissions of acid gases and organic constituents.[a]

Constituent	Maximum Feed Concentration (μg/L)	NWCF Input[b] (g/year)	DF	Assumed Stack Emission Rate[c] (g/second)
Gases				
NO_x as NO_2	NA	NA	NA	4.88E+01
CO	NA	NA	NA	3.06E+01
HNO_3	NA	NA	NA	1.39E+01
SO_2	NA	NA	NA	2.29E-01
HCl	NA	NA	NA	9.03E-02
HF	NA	NA	NA	5.14E-02
Organics in feed				
Pyridine	1.45E+04	7.67E+04	1	2.43E-03
Thiourea	2.11E+03	1.12E+04	100[d]	3.54E-06
Aniline	8.08E+02	4.27E+03	1	1.36E-04
Carbon disulfide	3.97E+02	2.10E+03	1	6.66E-05
1,4 dioxane	3.75E+02	1.98E+04	1	6.29E-04
Formic acid	2.42E+02	1.28E+03	1	4.06E-05
Hydrazine	1.70E+02	8.99E+02	1	2.85E-05
Methyl ethyl ketone	1.70E+02	8.99E+02	1	2.85E-05
Phenol	1.70E+02	8.99E+02	1	2.85E-05
Diethylphthalate	1.28E+02	6.77E+02	100[d]	2.15E-07
2,4-Dinitrotoluene	9.50E+01	5.03E+02	1	1.59E-05
2,4-Dinitrophenol	8.10E+01	4.28E+02	1	1.36E-05
Acetonitrile	4.80E+01	2.54E+02	1	8.05E-06
Benzo(a)pyrene	10	53	1	1.68E-06
Butylbenzylphthalate	10	53	100[d]	1.68E-08
Di-n-butylphthalate	10	53	100[d]	1.68E-08
Di-n-octylphthalate	10	53	100[d]	1.68E-08
Naphthalene	10	53	1	1.68E-06
Pentachlorophenol	10	53	1	1.68E-06
1,2,4-trichlorobenzene	10	53	1	1.68E-06
Formaldehyde	4.3	23	1	7.29E-07
Benzene	<10	26	1	8.39E-07

Table 4. (continued).

Constituent	Maximum Feed Concentration (μg/L)	NWCF Input[b] (g/year)	DF	Assumed Stack Emission Rate[c] (g/second)
Bromoform	<10	26	1	8.39E-07
Carbon tetrachloride	<10	26	1	8.39E-07
Chlorobenzene	<10	26	1	8.39E-07
Chloroform	<10	26	1	8.39E-07
1,2-Dichloroethane	<10	26	1	8.39E-07
Methylene chloride	<10	26	1	8.39E-07
Tetrachloroethylene	<10	26	1	8.39E-07
Toluene	<10	26	1	8.39E-07
1,1,1-Trichloroethane	<10	26	1	8.39E-07
1,1,2-Trichloroethane	<10	26	1	8.39E-07
Trichloroethylene	<10	26	1	8.39E-07
Products of Incomplete Combustion (PICs)				
2,3,7,8-TCDD TEQ	NA	NA	1	1.1E-10
Coplaner PCB TEQ	NA	NA	1	1.6E-11
1,3-Dinitrobenzene[e]	NA	NA	1	4.8E-01
Nitrobenzene[e]	NA	NA	1	3.5E-01
2,4-Dinitrotoluene[e]	NA	NA	1	5.2E-01
2,6-Dinitrotoluene[e]	NA	NA	1	5.2E-01
Pentachloronitrobenzene[e]	NA	NA	1	4.0E-02

Unquantified organics in feed[f]

Acetone
Methyl isobutyl ketone
Cresols
Methyl tert-butyl ether
Cumene
Nitrobenzene
Cyanogen
p-Nitrophenol
Dimethyl sulfate
2-Nitropropane
Hexachorobenzene
PCBs
Hexachoroethane
Phthalic anhydride
Furfural
o-Toluidine
Iodomethane
Xylene

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a. See Appendix A for detailed assumptions and calculations.

b. Maximum feed concentration times maximum gross NWCF waste feed of 5.3E+6 L/y (1.4E+6 gal/year).

c. Calculated from (NWCF Input, g/year)(1 year/3.154E+7 second)(1/DF). CO, HNO_3, SO_2, HCl, and HF use maximum hourly emission rates from Appendix A because they are evaluated against short-term (averaging time) air concentration toxicity criteria.

d. Thermal destruction is > 99% at temperatures less than 500°C (Appendix A). Emissions are increased by 45% to account for startup, shutdown, and process upset conditions.

e. These are maximum upper-bound values that assume 100% of the limiting fuel precursor (benzene, toluene, and chlorine) is converted to each constituent (see section 2.2.4).

f. These organics are possible contaminants in the feed that cannot be quantified.

2.2.3 Emissions from Organic Compounds in the Feed

The primary organic emissions from the calciner are from the burning of the kerosene fuel and consist of CO, CO_2, and some unburned fuel consisting mostly of nontoxic light hydrocarbons (methane and ethane) (Schindler 1995). Trace emissions of other organic compounds (Table 5) that are potentially in the calciner or PEW feeds were calculated based on: (1) purchase records of all chemicals thought to have possibly entered the INTEC aqueous waste systems, including PEW and tank farm, and (2) sampling data from 3 tanks which showed concentrations were less than a minimum quantification level of 10 ng/mL (Appendix A). For these undetected chemicals, concentrations were assumed to be 1/2 of the minimum quantification level (10 ng/L × 0.5 = 5 ng/L). Concentrations were then converted to total inventory using an upper-bound estimate of total (gross) feed volume of 1,400,000 gal and assumed to be released in one year. To be conservative, most of the organics were assumed to have no destruction or removal in the calciner or offgas treatment system (assumed DF = 1). For five chemicals, data were obtained that indicated the calciner conditions would result in > 99% thermal decomposition (Appendix A). For these chemicals, a DF of 100 was used (Table 4).

Although organic feed emissions were calculated based on identification of organics that could have been historically discharged to all the INTEC liquid waste systems, future emissions of organics from the PEW/LET&D systems will likely be negligible because discharges of organic chemicals to these systems are currently prohibited.

2.2.4 Products of Incomplete Combustion

Products of incomplete combustion (PICs) may be formed in the calciner due to the incomplete combustion and recombination of organics in the kerosene fuel with other constituents in the feed (e.g. nitrogen and chlorine). Extensive laboratory studies performed by Radian Corporation have indicated that it is not possible to reliably measure NWCF organic emissions because of the high concentrations of NO_2 in the offgas[a]. The analytical results showed poor recoveries of dynamically spiked analytes, very poor reproducibility, deterioration of the sample sorbent, and extensive corrosion of the analytical system. Also, no published emission factors have been identified that are suitable for application at the NWCF because of the nature of the feed materials, acidic operating conditions, and relatively low operating temperature.

An offgas demonstration project (ODP) which is attempting to measure contaminant concentrations in the NWCF offgas will be initially completed in late April, 1999, but the results will not be available until after submittal of this SLRA. Therefore, upper-bound estimates of PIC emission rates were calculated based on known compositions of the kerosene fuel, process knowledge, and conservative assumptions. These upper-bound estimates should conservatively bound any contribution of PIC emissions from auxiliary systems (PEW, LET&D, HLLWE) because the calciner contributes most of the chlorine emissions and all of the unburned fuel precursors (benzene and toluene).

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[a] Michael Fuchs, Radian Corporation, letter to C. A. Richert, Lockheed Martin Idaho Technologies Company, April 28, 1995.

The PICs of concern listed in EPA (1994a) include: (1) dioxins and dioxin-like compounds, (2) polycyclic aromatic hydrocarbons (PAHs), (3) PCBs, (4) nitroaromatics, (5) phthalates, and (6) other chlorinated organics (hexachlorobenzene and pentachlorophenol). In addition to the trace organics detected in the waste feed (section 2.2.3), the only PICs that could be created in any significant quantity from unburned fuel include dioxins/furans and nitroaromatics.

2.2.4.1 ***Dioxin and Furan Emissions.*** Polychlorinated dibenzo-p-dioxins (CDDs) and polychlorinated dibenzofurans (CDFs) emissions are identified by EPA guidance to be critical PIC contaminants for assessment of indirect pathway risks. However, no CDD/CDF sampling data are available for the calciner offgas, and no emission factor data have been identified that are appropriate for the conditions in the calciner (concentrated aqueous waste feed material, kerosene fuel, relatively low combustion temperature). An EPA dioxin report (EPA 1994c) lists three principal theories on sources of CDD/CDF in combustion sources: (1) feed material containing CDDs or CDFs that survive combustion, (2) feed material containing CDD/CDF precursors—chlorinated aromatic compounds such as PCBs, chlorinated phenols, and chlorinated benzenes—that thermally break down, molecularly rearrange in the offgas at a temperature range of 250 to 450°C, and condense onto the surface of fly-ash particles, and (3) de novo formation by nonprecursors in feed material such as petroleum products, chlorinated plastics, nonchlorinated plastics, cellulose, lignin, coke, coal, particulate carbon, and hydrogen chloride gas (which requires a chlorine donor). Based on these theories and the following conditions at the INTEC, anticipated calciner emissions of CDDs and CDFs are judged to be very small:

- No CDD/CDF have been detected in waste feed material (Schindler 1995; Appendix A).

- The calciner waste feed has very low or nonexistent concentrations of CDD and CDF precursors. The organic feed rates are composed almost entirely of the kerosene fuel, which is fed at 283 lb/hour (Schindler 1995). Maximum feed rates of nonfuel organic compound are very small, consisting mostly of pyridine (67 kg/year), isobutyl alcohol (25.8 kg/year), and 1,4 dioxane (17 kg/year) (Appendix A).

- Calciner effluent gases are rapidly quenched from 500 to 600°C (930 to 1100°F) in the combustion chamber to 65 to 75°C (150 to 160°F) and then heated to 90 to 120°C (190 to 250°F) before passage through the HEPA filters (to keep them dry). Rapid quenching to temperatures below 180 to 250°C in APCDs has been shown to inhibit the processes involved in CDD/CDF formation (EPA 1994c; 1994d).

Although it is likely that emissions of CDDs/CDFs from the calciner are low, a conservative upper-bound estimate of emissions is made in this SLRA because of the importance of these contaminants in combustion facility risk assessments. An upper-bound emission rate for the calciner can be derived from data in EPA guidance document *Combustion Emissions Technical Resource Document* (CETRED) (EPA 1994d). This same methodology was used to estimate CDD/CDF emissions for the INEEL Pit 9 Arc Melter operational risk assessment.[a] The CETRED contains CDD/CDF emissions data for various types of hazardous waste incinerators that, because of their relatively high chlorinated organic waste feed and high APCD temperature (compared to the calciner), would likely provide an upper-bound estimate of CDD /CDF emissions from the calciner. Data from 12 municipal waste combustors (MWC) with spray dryers and fabric filters (Table 4.7-4 in CETRED) are the most appropriate for developing a conservative emission rate for the calciner. The average emission factor for these MWC units is 0.20 ng/dscm (nanograms/dry standard cubic meter in offgas) at 7% O_2 (2,3,7,8-TCDD TEQ).

The MWC emission value is slightly greater than the values proposed in CETRED (0.12–0.17 ng TEQ/dscm) as being achievable by the "best controlled sources." It also is slightly greater than the Pit 9 Arc Melter 95% upper confidence limit (UCL) value calculated from the same data less "outliers" (0.17 ng_TEQ/dscm).

The EPA dioxin report (EPA 1994c) lists an MWC emission factor range of 0.05 to 3 ng TEQ/kg waste combusted. For comparison, the upper range value (3 ng TEQ/kg) can be converted to ng/dscm in the calciner offgas based on kerosene fuel input (283 lb/hour) and calculated dry standard offgas flow rate by the following:

NWCF cyclone offgas (CYCL-OG) dry flow rate (Schnidler 1995) =

302.33 lbmol/hour (total) - 101.3 lbmol/hour (H_2O) = <u>201 lbmol/hour</u>

$$\text{dscm/second} = \left(\frac{201\,\text{lbmol}}{\text{hour}}\right)\left(\frac{359\,\text{ft}^3\,[0°\text{C}, 1\,\text{atm}]}{\text{lbmol}}\right)\left(\frac{0.0283\,\text{m}^3}{\text{ft}^3}\right)\left(\frac{1\,\text{hour}}{3{,}600\,\text{second}}\right)$$

$$= \underline{0.57\ \text{m}^3/\text{second}}$$

$$\text{emission factor} = \left(\frac{3\,\text{ng}}{\text{kg}}\right)\left(\frac{1\,\text{kg}}{2.2\,\text{lb}}\right)\left(\frac{283\,\text{lb}}{\text{hour}}\right)\left(\frac{1\,\text{hour}}{3{,}600\,\text{second}}\right)\left(\frac{\text{second}}{0.57\,\text{dscm}}\right)$$

$$= \underline{0.19\ \text{ng/dscm}}$$

This value is nearly identical to the CETRED value (0.20 ng TEQ/dscm). No conversion was made to adjust the calciner offgas to the 7% O_2 emission factor basis because: (1) this method (7% O_2 adjustment) applies to traditional air-oxidized incinerators, (2) the calciner is fed excess O_2 to facilitate combustion of the kerosene and has excess O_2 (15 mole %) in the offgas, and (3) it is conservative not to adjust the calciner flow rate down to 7% O_2 because the adjustment results in a higher flow rate and, therefore, a mass emission rate using the emission factor.

Using the 0.20-ng TEQ/dscm emission factor and dry standard calciner offgas flow rate, the calciner TCDD emission rate is calculated as

$$\text{2,3,7,8-TCDD TEQ emission rate} = \left(\frac{0.2\text{E-9 g}}{\text{m}^3}\right)\left(\frac{0.57\,\text{m}^3}{\text{second}}\right) = \underline{1.1\text{E-10 g/s}}$$

2.2.4.2 ***Polynuclear Aromatic Hydrocarbons and Phthalates.*** Polynuclear aromatic hydrocarbons (PAHs) and phthalates are two other PICs of concern that may be formed in combustion units. Phthalates are very unlikely to be emitted from combustion units unless the units burn plastics or materials with phthalate plasticizers (EPA 1998). As such, U.S. EPA OSW does not recommend automatic inclusion of phthalates in risk assessments. However, these compounds were evaluated in the SLRA as previously described in section 2.2.3 -- any of these chemicals identified in INTEC purchase records that could have possibly entered either the tank farm or the PEW were conservatively assumed to be released on an annual basis (the entire potential feed inventory was assumed to be released each year over the assumed 16 year operating time). Four constituents were evaluated in the SLRA in this manner:

benzo(a)pyrene (PAH with the highest relative potency factor [RPF])

butylbenzylphthalate

di-n-butylphthalate

di-n-octylphthalate

2.2.4.3 ***Polychlorinated Biphenyls.*** Polychlorinated biphenyls (PCBs) have not been identified as present or being input into the tank farm or PEW evaporator. However, some limited data suggest that they might be formed as PICs in boilers or incinerators (EPA 1998) that burn at higher temperatures (700 – 1000 °C) than the calciner (500 – 600 °C). Other studies suggest that PCBs might only be formed to a very limited amount (0.3% of the chlorine input) and only in incinerators burning hazardous waste with a high chlorine content (60% or greater) (EPA 1998). Since the maximum chlorine content of the tank farm waste is less than 0.1% (0.03 M) and the calciner operates at a relatively low temperature, it is unlikely that any PCBs are formed as PICs in the calciner.

For conservatism, however, potential health impacts from dioxin-like coplaner PCBs were evaluated in this SLRA using a coplaner emissions factor of 0.55 ng/dscm, which is a low temperature boiler emissions factor provided by EPA (1998). Using the stack gas flow rate calculated in the previous section (0.57 dscm/s), the coplaner PCB emission rate was calculated to be 3.14E-10 g/s. Multiplying by the most conservative toxicity equivalency factor (TEF) for any coplaner PCB (0.1) (EPA 1998), the PCB coplaner toxicity equivalent quotient (TEQ) emission rate is 3.14E-11. Since an annual average emission rate is required to calculate appropriate carcinogenic impacts, this short-term rate is further multiplied by an annual operating time fraction ("on-stream factor") of 0.5, giving an annual average coplaner TEQ emission rate of 1.6E-11 g/s. This emission rate was then modeled using the fate and transport parameters of Arochlor 1254 (EPA 1998), and both direct and indirect risks were calculated using dioxin slope factors (section 5) as specified in EPA (1998).

2.2.4.4 **Nitroaromatics.** Five nitroaromatic compounds are listed in EPA (1994a) for analyzing indirect exposures: (1) 1,3-Dinitrobenzene, (2) Nitrobenzene, (3) 2,4-Dinitrotoluene, (4) 2,6-Dinitrotoluene, and (5) Pentachloronitrobenzene (PCNB). These compounds may be formed in the calciner by reaction of the unburned aromatics in the kerosene fuel (benzene and toluene rings) with the high concentration of nitrogen (nitric acid) in the feed. PCNB is less likely to be formed because of the limited availability of chlorine in the feed and the difficulty of synthesizing a penta-chlorinated organic molecule (the benzene and toluene in the unburned fuel is more likely to form nitrobenzene and nitrotoluene).

Since it is not known which specific chlorinated organic PICs might be formed in the offgas, it was conservatively assumed that all of the chlorine in the offgas reacted to form the highly toxic PCNB. Assessment of the maximum potential formation of PCNB provides a reasonably conservative bound for impacts from any combination of potential chlorinated PICs that are of concern in the NWCF offgas because of its relatively high toxicity. For example, PCNB has an EPA Region 9 Preliminary Remediation Goal (PRG) in air of 0.026 ug/m^3 compared to 1.1 ug/m^3 for trichloroethylene and 4.1 ug/m^3 for methylene chloride. The lower PRG for PCNB indicates that this compound is from 42–160 times as toxic and therefore provides a conservative bound to the health impact assessment. If the available chlorine were apportioned to the actual (unknown) PICs being formed in the off gas, it is highly likely that the calculated health impacts would be significantly less than those calculated by assuming all of the available chlorine forms PCNB.

Upper-bound estimates of nitroaromatic emission rates were calculated as follows:

Assumptions:

1. Average kerosene feed rate = 30 gal/hour.
2. Kerosene aromatic volume fraction (max) = 0.18 (average from two NWCF kerosene supplier test reports).
3. Conservative estimate of unburned fuel fraction (max) = 0.05
4. Density of kerosene = 0.78 g/cm^3
5. Unlimited nitrogen availability.

Methods:

1. Maximum rate of unburned aromatic PIC precursors (benzene and toluene rings) (Q_a):

$$Q_a = \left(\frac{30\text{ gal}}{\text{hr}}\right)\left(\frac{3785\text{ cm}^3}{\text{gal}}\right)\left(\frac{\text{hr}}{3600\text{ s}}\right)\left(\frac{0.78\ g}{cm^3}\right)(0.18)(0.05) = \underline{0.22\text{ g/s}}$$

The fraction of the Q_a that is either benzene or toluene is unknown. Therefore, it is conservatively assumed that 100% of Q_a is available for formation of both the benzene precursor PICs (e.g. 1,3-Dinitrobenzene) and the toluene precursor PICs (e.g. 2,4-Dinitrotoluene).

2. Upper-bound emission rate of any single nitroaromatic PIC, assuming unlimited N and Cl availability (Q_{ap}):

$$Q_{ap} = Q_a\left(\frac{MW_{ap}}{MW_a}\right)$$

where

MW_{ap} = molecular weight of the nitroaromatic PIC (g)

MW_a = molecular weight of the aromatic precursor (benzene or toluene) (g)

PIC	MW_{ap}/MW_a	Q_{ap} (g/s)	
1,3-Dinitrobenzene	2.15	0.48	
Nitrobenzene	1.58	0.35	
2,4-Dinitrotoluene	2.33	0.52	
2,6-Dinitrotoluene	2.33	0.52	
Pentachloronitrobenzene	3.78	0.84	(see step 3)

3. Chlorine was determined to be the limiting precursor for PCNB. Therefore, a Cl-limiting emission rate was calculated and used for this PIC instead of the benzene-limiting rate calculated above (0.84 g/s):

   Maximum Cl in the offgas = 680 kg/y as HCl (0.022 g/s or 6.2E-04 mol/s) (from Appendix A).

   One mole of PCNB ($C_6Cl_5NO_2$) requires 5 moles of HCl.

   The Cl-limiting emission rate for PCNB is therefore:

$$Q_a\,(\text{PCNB}) = \left(\frac{6.2\text{E-}04\ \text{mol Cl}}{\text{s}}\right)\left(\frac{1\,\text{mol PCNB}}{5\,\text{mol Cl}}\right)\left(\frac{295\,\text{g}}{\text{mol PCNB}}\right)$$

$$Q_a\,(\text{PCNB}) = \underline{0.04\ \text{g/s}}\ \ \text{(less than that calculated in step 2)}$$

4. The emission rates calculated in steps 3 and 4 assume that 100% of the aromatic precursors are converted to a single PIC. Because the actual distribution of the mass between the nitroaromatics is unknown, all of the PICs are evaluated with their respective Q_{ap} in the exposure and risk assessment sections of this document. However, when impacts are summed across all contaminants (hazard index and total cancer risk), only the nitroaromatic with the highest hazard quotient (HQ) or cancer risk is included. This will conservatively bound the impacts from any combination of nitroaromatic PICs.

It should be noted that the calculation of maximum nitroaromatic PIC production using the above methods conservatively accounts for any potential contribution of these PICs from auxiliary systems because they are based on unburned fuel which can only be present in the calciner offgas.

2.2.4.5 Other Potential PICs. Fluorinated (and chloro-fluoro) compounds were not evaluated in the SLRA for the following reasons: (1) reasonably conservative estimates of fluorine in the offgas are low (0.043 g/s) and (2) the only fluorinated (and chloro-fluoro) compounds listed on the EPA PIC list are freon species that have very low toxicity values compared to the PICs.

2.2.5 Process Upset Conditions

The most significant air pollution control by-pass event is filter deterioration that is a partial by-pass. Filter deterioration is considered in Appendix A and factored into the average filter efficiency used for the calculations (see discussion on upset factors below). The silica-gel adsorbers can be by-passed. The emission rate calculations took no credit for the adsorbers (DF=1) to conservatively account for this. The scrub system cannot be bypassed. Its loss of scrub solution leads to rapid calciner shutdown.

Most operating upsets result in reduced feed rates or shutdown, thus reducing emissions. Maximum emissions of the most significant species (e.g., Hg) occur with smooth operation at the maximum feed rate. Temperature excursions have not been observed. The controller is programmed to shut off feed if a temperature excursion occurs. Inadequate fluidization leads to reduced feed rates and often to shutdown. Plugging of the solids discharge from the product removal cyclone leads to increased solids flow into the scrub system. The incremental solids from the cyclone are relatively large and readily removed by the scrubber. The increased solids to the scrubber usually leads to increased scrub solution purging which reduces the Hg emission. Excessive fines generation from improper feed composition results in increased fines to the scrub system and possibly to increased solids emissions. Improper feed formulations usually lead to reduced feed rates and they are normally corrected when the problem is recognized.

The EPA (1994a) recommends that organic emissions be increased by an "upset factor" to account for startup, shutdown, and process upset conditions. If no site-specific data are available, the EPA recommends a factor of 1.45. This factor was applied to the five organics with an assumed DF of 100. For those organics with an assumed DF of 1, no increase is needed because 100% of the feed was assumed to be emitted to the atmosphere. No upset factors were used or needed for PICs because PIC emissions assumed 100% of the necessary precursors (all available unburned fuel and chlorine) were converted to a worst-case PIC release rate.

An upset factor was indirectly incorporated for non-volatile metal emissions by using "degraded" HEPA filter DFs (see section 2.2.1.1) which were determined by examining 3 years of on-line filter performance measurements. The DFs assumed for this SLRA (900 for the 3 NWCF filters and 300 for the APS filter; total DF of 2.7E+5) include the effects of process upset conditions over the 3 years of operations over which the measurements were made. The NWCF filters always meet minimum HEPA filter test criteria of DF >1E+7 (penetration < 9E-8) at installation. The APS filter always meets the test criteria of DF > 3000 (penetration < 3E-04, 99.97% efficiency). The use of the degraded DF (2.7E+5 total for all filters) in the risk assessment is equivalent to a "filtration upset factor" greater than 100,000 [(1E+7)(3000)/2.7E+5], which conservatively bounds the EPA default upset factor of 1.45.

3. AIR DISPERSION AND DEPOSITION MODELING

Air modeling was performed to evaluate the atmospheric dispersion, transport, and ground deposition of contaminants from the NWCF release point to downwind locations at which members of the public could potentially be located. In accordance with EPA guidance (EPA 1994b), the modeling was conducted using a 1 g/second release of a generic particulate contaminant and a generic vapor contaminant. Model output for maximum air concentrations ($\mu g/m^3$ per g/second released) and maximum ground depositions (g/m^2-year per g/second) were then multiplied by contaminant-specific release rates (g/second) and vapor and particulate partitioning factors to obtain contaminant-specific results (Section 4).

The ISCST3 model (EPA 1995a, code version 96113, *BEE-LINE Software,* Version 3.3) was used for the analysis. This model has been approved by the EPA and the State of Idaho and is specified for use in EPA SLRA guidance (EPA 1994a). The following sections detail model input parameter values, many of which are specified in the guidance.

3.1 Control Options Input

The following control pathway modeling options (CO) were selected:

- Regulatory default job control and dispersion options (EPA 1995a):
    - Final plume rise, stack-tip downwash.
    - Buoyancy-induced dispersion.
    - Calms processing routine.
    - No use of missing data processing routine.
    - Default wind profile exponents.
    - Default vertical potential temperature gradients.
    - Upper bound values for supersquat buildings.
    - No exponential decay for RURAL mode.
- RURAL dispersion coefficients (sigmas).
- Concentration; dry, wet, and total deposition and depletion for particulate runs.
- Concentration; wet deposition and depletion for vapor runs.
- Annual averaging time for offsite receptor runs.
- Annual, 24-hour, and 1-hour averaging times for U.S. Highway 20 receptor runs.

- Terrain heights evaluated [taken from the INEEL Graphical Information System (GIS) database]. These elevations were developed from U.S. Geological Survey 1:24,000 scale maps and have a vertical accuracy to within 7 m for 90% of the data.

3.2 Source Input

The following parameter values were used for the source (SO) pathway for the INTEC Main Stack (INEL 1995):

- Release rate (QS) = 1 g/second
- Location = (UTM) 343923 E., 4825948 N.
- Elevation = 1498.3 m
- Height (HS) = 76.2 m
- Exit diameter (DS) = 1.98 m
- Effluent temperature (TS) = 29.44°C
- Effluent exit velocity (VS) = 18.83 m/s, calculated from diameter and flow rate (V_A)
- Effluent flow rate (V_A) = 123,000 acfm, calculated by

$$V_A = V_S \left(\frac{P_S}{P_A}\right)\left(\frac{T_A}{T_S}\right)$$

where

V_S = standard conditions flow rate as measured by stack flow meter (100,000 to 110,000 scfm nominal). (The 100,000 scfm value is used to be conservative because it results in a lower plume height.)

P_S = standard pressure (29.92 in. Hg)

P_A = ambient pressure at the INEEL (25.06 in. Hg) (Clawson, et al. 1989)

T_S = standard temperature [294 K, as specified by the flow meter manufacturer (Kurtz)]

T_A = stack gas temperature (302.5 K).

Other parameters include the following:

- Particulate diameter (PARTDIAM): 0.25, 0.75, 1.25, 1.75, 2.5, 3.5, and 4.5 μm (from California Air Resources Board test report C-87-122, January 31, 1990 on medical waste incinerators).

- Mass fraction (MASSFRAX): 0.033, 0.152, 0.316 0.259, 0.187, 0.047, and 0.005 (calculated penetration of the given particle sizes through 3 banks of HEPA filters). This method produces a size distribution that is smaller than the generic default values given in the EPA (1994a) guidance. Smaller particulate sizes have been shown to be more conservative for INEEL assessments because the particulate are transported the longer distances required to reach the relatively distant INEEL receptor locations (less particulate falls out near the facility).

- Particulate density (PARTDENS): 1 g/cm^3

- Particle scavaging coefficients (PARTSLIQ, PARTSICE): 1.0, 0.4, 0.6, 0.69, 1.8, 2.6, and 3.7 (× 10^{-4} second-mm/hour-1), from data in ISC3 manual (EPA 1995a) (liquid and ice are assumed to be the same)

- Vapor scavaging coefficients (GAS-SCAV) are assumed to be 1.7×10^{-4} (both liquid and ice) based on scavaging coefficient data given in the ISC3 manual for the smallest available particulate size and the EPA guidance (EPA 1994a).

Building downwash was not evaluated because the Main Stack height is greater than 2.5 × adjacent building heights (EPA 1995b).

3.3 Receptor Information

Three different receptor (RE) grids were evaluated for each particulate and vapor modeling run:

1. **POL50**: A large 50-km radius polar grid (Figure 5) was evaluated for the initial annual average modeling runs to determine regional dispersion and deposition trends for contour plotting and for locating refined discrete grids in areas of maximum impact. Receptors were placed at 10-degree radials at the following distances (in meters): 100, 150, 200, 300, 400, 500, 700, 1,000, 1,500 to 5,000 (at 500-m intervals), 6,000 to 10,000 (at 1,000-m intervals), 12,000 to 20,000 (at 2,000-m intervals), and 25,000 to 50,000 (at 5,000-m intervals). This placement required 1,152 receptors (36 radials × 32 distances).

   This coarse grid was also used to assess maximum air concentrations and depositon rates at additional onsite scenarios evaluated in this revision (worker and herdsman). By examining isopleths in Figures 8 and 9, conservative estimates of maximum impacts at the Central Facilities Area (CFA) and grazing locations south of U.S. 20 were made. The assessment of maximum short-term impacts did not require a coarse receptor grid because, for the NWCF, maximum short-term impacts occur along U.S. Highway 20, which is adequately evaluated using a discrete line of receptors (see **US20**, below).

2. **RG3**: Two refined (100-m interval) receptor grids were placed in two major offsite impact areas identified from the POL50 coarse grid modeling (Figure 6). The first major impact area was located along the southern INEEL boundary and used seven rows of receptors over a distance of 3,500 m (252 receptors). The second major impact area was located on Big Southern Butte and used 224 receptors. Big Southern Butte is a major impact area because the higher terrain elevations intersect the elevated plume centerline height.

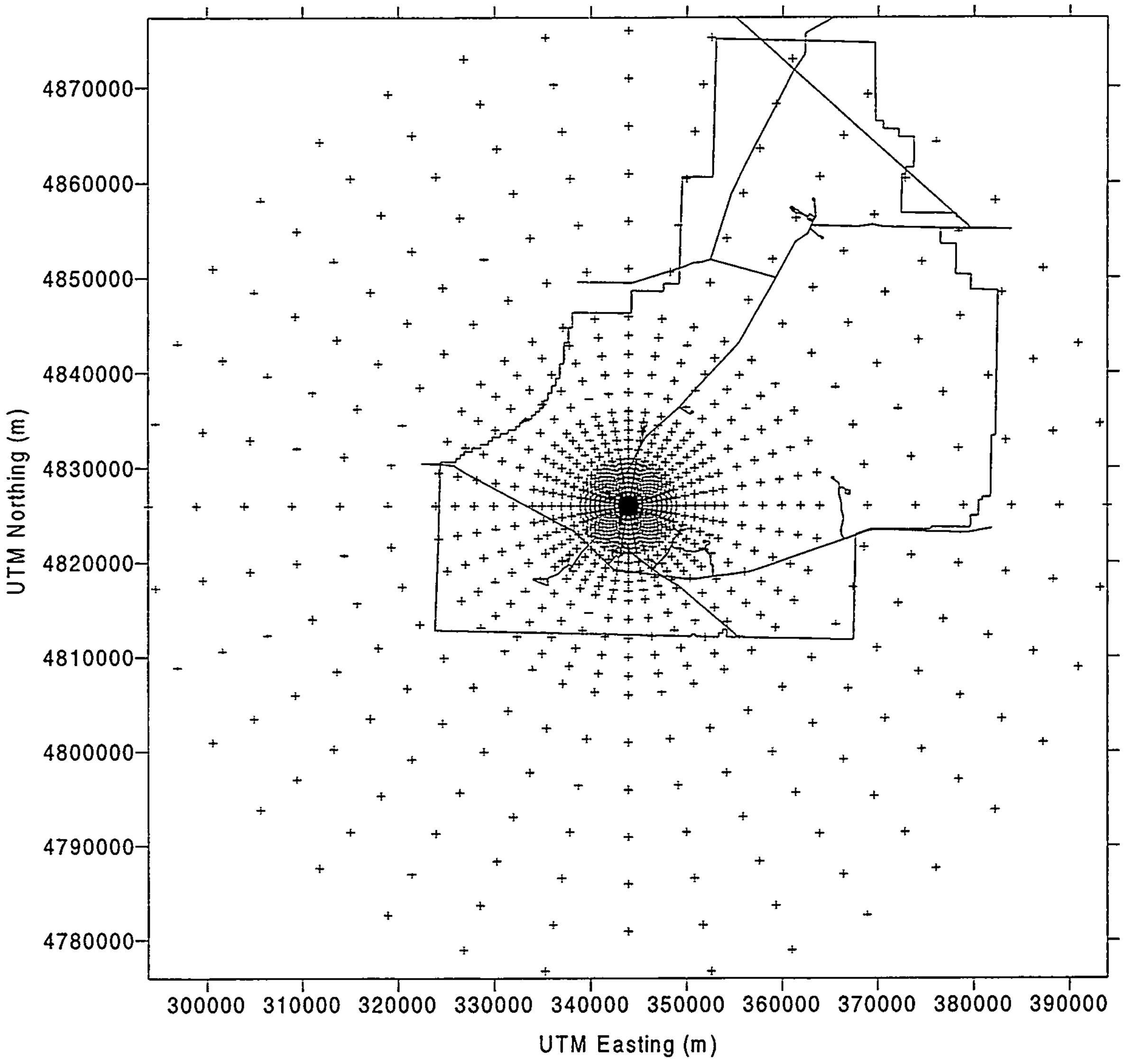

Figure 5. The 50-km polar receptor grid (1,152 receptors) initially evaluated in the modeling. Modeling results from this grid were used to determine regional dispersion and deposition trends and to develop refined receptor grids in areas of maximum impact.

3. <u>US20</u>: Discrete receptors were placed at 100-m intervals along major impact areas of U.S. Highway 20/26 (160 total receptors), which lies on the INEEL (Figure 7). These receptors were only evaluated for direct inhalation impacts because the only potential receptors are transient motorists. Chronic exposure scenarios or indirect exposures are not possible because no residences, farming, grazing, or off-road public access is allowed in the area.

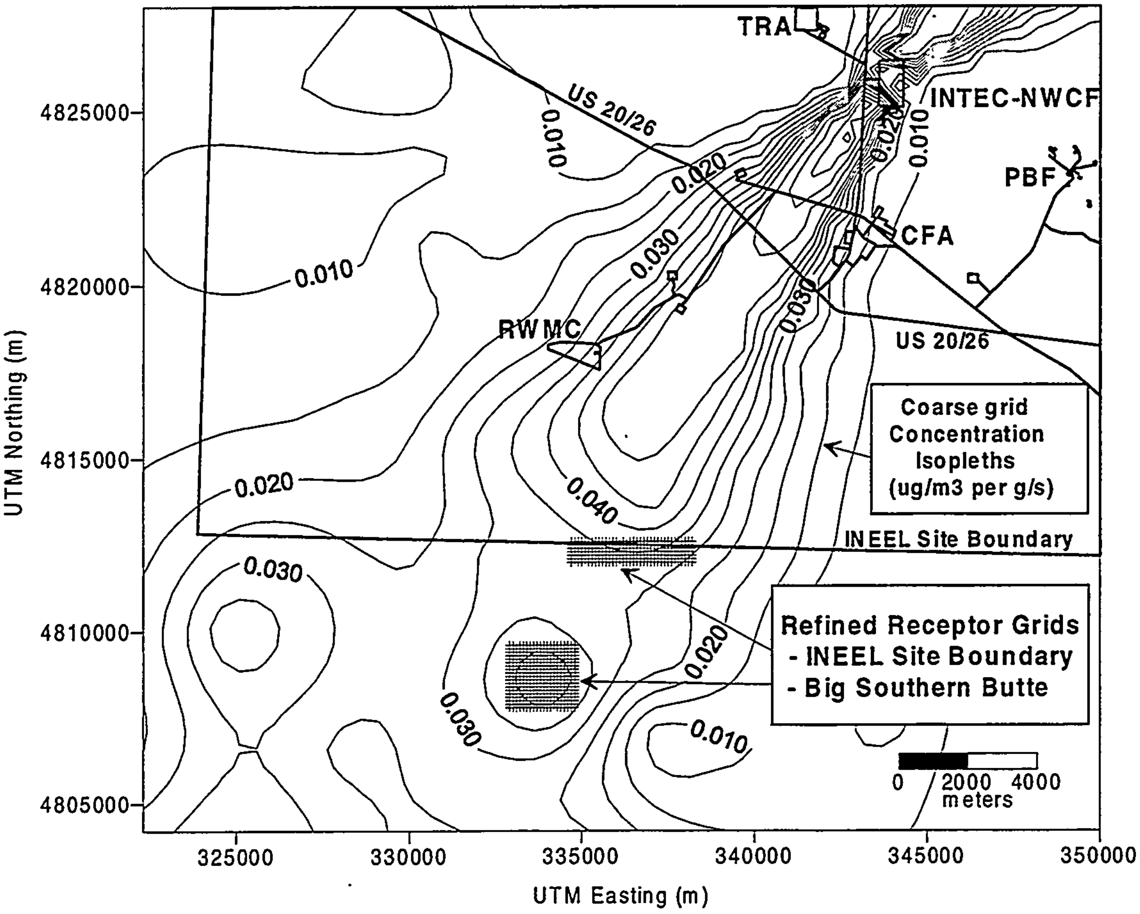

Figure 6. The two refined (100-m interval) receptor grids evaluated in offsite areas of maximum impact (South INEEL boundary and Big Southern Butte).

3.4 Meteorological Information

Three years (1993 to 1995) of onsite meteorological (ME) data were available from the Grid 3 (GRD3) 250-ft (61-m) tower, which is located approximately 1.5 km north of the INTEC. The GRD3 data were processed into sequential hourly ISC3 data input format by the National Oceanic and Atmospheric Administration (NOAA) Air Resources Laboratory in Idaho Falls, Idaho. One to three years of site-specific meteorological data have typically been used at the INEEL and approved by the State of Idaho DEQ for air permitting, toxics assessments, PSD, and NEPA analyses. The EPA's *Guideline on Air Quality Models*, which is the basis for the EPA guidance on this subject, specifies that "5 years of NWS data or at least 1 year's site-specific data is required" (EPA 1995b). The five-year data recommendation applies to National Weather Service (NWS) data from airports, which are generally a significant distance away from the site being assessed and may have significant data gaps. The INEEL NOAA data has few data gaps, is considered to be of high quality, and provides very representative data for the source-to-receptor transport distances evaluated in this assessment. In addition, previous modeling analyses have shown that the maximum annual concentration observed over 5 years at the INEEL is not significantly different than that observed over a 2 to 3-year period.

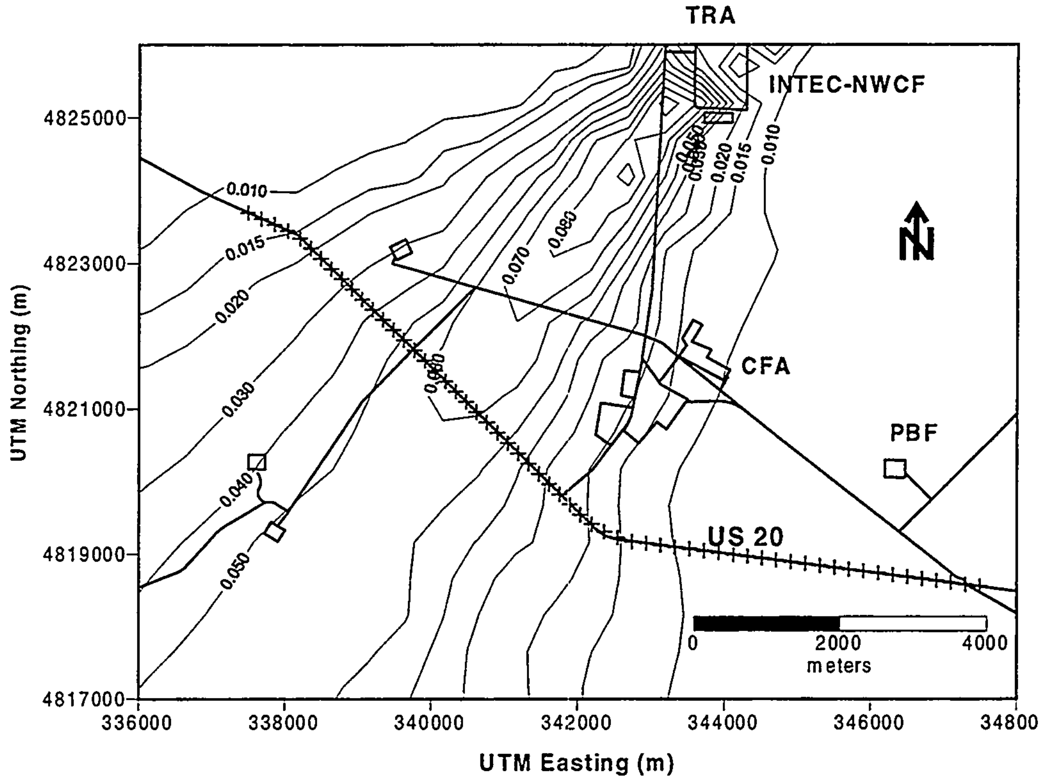

Figure 7. Discrete (100-m interval) receptors placed along major impact areas on U.S. Highway 20 (every other receptor is shown).

The NOAA determined stability classes using the lateral turbulence (σ_A) and wind speed method as outlined in the EPA report *Onsite Meteorological Program Guidance for Regulatory Modeling Applications* (EPA 1987). The percent of recoverable data was 99.5% for 1993, 99.1% for 1994, and 99.98% for 1995. The small amount of missing data in the NOAA files was filled using hourly data (for the same month, day, and hour) from other INEEL towers (e.g., the CFA) or, for single hour gaps, linear interpolation. Wind speeds less than the anemometer starting threshold (0.26 m/second) were set to 0.0 for calms processing in ISC3. Wind speeds between the anemometer starting threshold and 1.0 m/second were set to 1.0 m/second to ensure that unrealistic concentration estimates are not calculated by the model (EPA 1995a; EPA 1996). Mixing heights from Salt Lake City (the location of the closest available upper air station) were used because no site-specific database currently exists for the INEEL.

Additional processing to determine ISC3-required deposition parameters was accomplished as follows:

1. Surface roughness length (z_0) was taken from the ISC3 manual (EPA 1995a) for desert shrub land terrain (0.26 m).

2. The Monin-Obukhov length (L) was calculated using a published relationship between surface roughness length and stability class (Golder 1972). The calculation of this parameter by the Meteorological Preprocessor for Regulatory Models (MPRM) (EPA 1996) was not possible because the model requires cloud cover input, which is not recorded at the INEEL.

3. Friction velocity (u*) was calculated using an equation for atmospheric boundary layer similarity theory described by Ramsdell et al. (1994).

4. Required hourly precipitation codes (MPRM, Table F-9) are not reported at the INEEL. Test modeling runs were made with several precipitation codes. This parameter was found not to affect wet deposition results (probably because the ISC3 input values for liquid and frozen scavaging coefficients were set to the same value in accordance with EPA guidance). Therefore, all code input was set to "19" (light snow).

3.5 Modeling Results

Maximum modeled concentrations and ground deposition rates are summarized in Table 5. The offsite results are as follows:

Cyv— maximum offsite vapor air concentration (μg-second/g-m^3)

Cyp— maximum offsite particulate air concentration (μg-second/g-m^3)

Dywv— maximum offsite vapor wet deposition rate (second/m^2-year)

Dydp— maximum offsite particulate dry deposition rate (second/m^2-year)

Dywp— maximum offsite particulate wet deposition rate (second/m^2-year).

In addition to these maximum offsite values, maximum onsite values were determined for: (1) the maximum annual and short-term (time-averaged) concentrations on U.S. Highway 20 for evaluation of an acute direct inhalation scenario, (2) the maximum onsite vapor concentration at an adjacent INEEL facility (CFA) for evaluation of a worker scenario, and (3) the maximum onsite vapor concentration and particulate deposition rate south of U.S. 20 for evaluation of a herdsman scenario. All of the maximum offsite values occurred in the same area of the north end of Big Southern Butte, which is where the elevated plume centerline began to impact the rising terrain (Figures 8 and 9). The maximums in that area were approximately 50% higher than those obtained at the south INEEL Site boundary. Although it is extremely unlikely that any individual would reside in this maximum impact area, these values are used in the exposure assessment (Section 4) to be conservative.

Table 5. Refined grid ISC3 modeling results.

Output Parameter	Receptor Location	Averaging Time	Maximum Value[a]	UTM Location (m)
Cyv (μg-second/g-m^3)	Offsite	Annual	0.06213	334200 E 4809700 N
Cyp (μg-second/g-m^3)	Offsite	Annual	0.06156	334200 E 4809700 N
Dywv (second/m^2-year)	Offsite	Annual	3.7E-04	334200 E 4809800 N
Dydp (second/m^2-year)	Offsite	Annual	4.5E-04	334200 E 4809700 N
Dywp (second/m^2-year)	Offsite	Annual	2.4E-04	334200 E 4809800 N
Particulate total deposition	Offsite	Annual	6.9E-04	334200 E 4809800 N
Particulate concentration[b]	U.S. 20	Annual	0.06387	340264 E 4821311 N
Particulate concentration[b]	U.S. 20	24-hour	0.46083	340122 E 4821452 N
Particulate concentration[b]	U.S. 20	1-hour	2.92910	341609 E 4819969 N
Vapor concentration[b]	U.S. 20	Annual	0.06390	Same as annual particulate
Vapor concentration[b]	U.S. 20	24-hour	0.46153	Same as 24-hour particulate
Vapor concentration[b]	U.S. 20	1-hour	2.94854	Same as 1-hour particulate
Vapor concentration[b]	CFA[c]	Annual	0.025	342630 E 4821520 N
Vapor concentration	Onsite, S of US 20[d]	Annual	0.065	340320 E 4821200 N
Particulate deposition	Onsite, S of US 20[d]	Annual	1.3E-03	340240 E 4821330 N

a. The ISC3 model output is provided to five decimal places to minimize rounding error in the exposure assessment calculations.

b. Direct inhalation is the only potential exposure pathway for receptors at this location (transient motorists only).
Adjacent onsite facility with the highest air concentration.

Used for the onsite herdsman scenario. Grazing is not allowed north of U.S. 20.

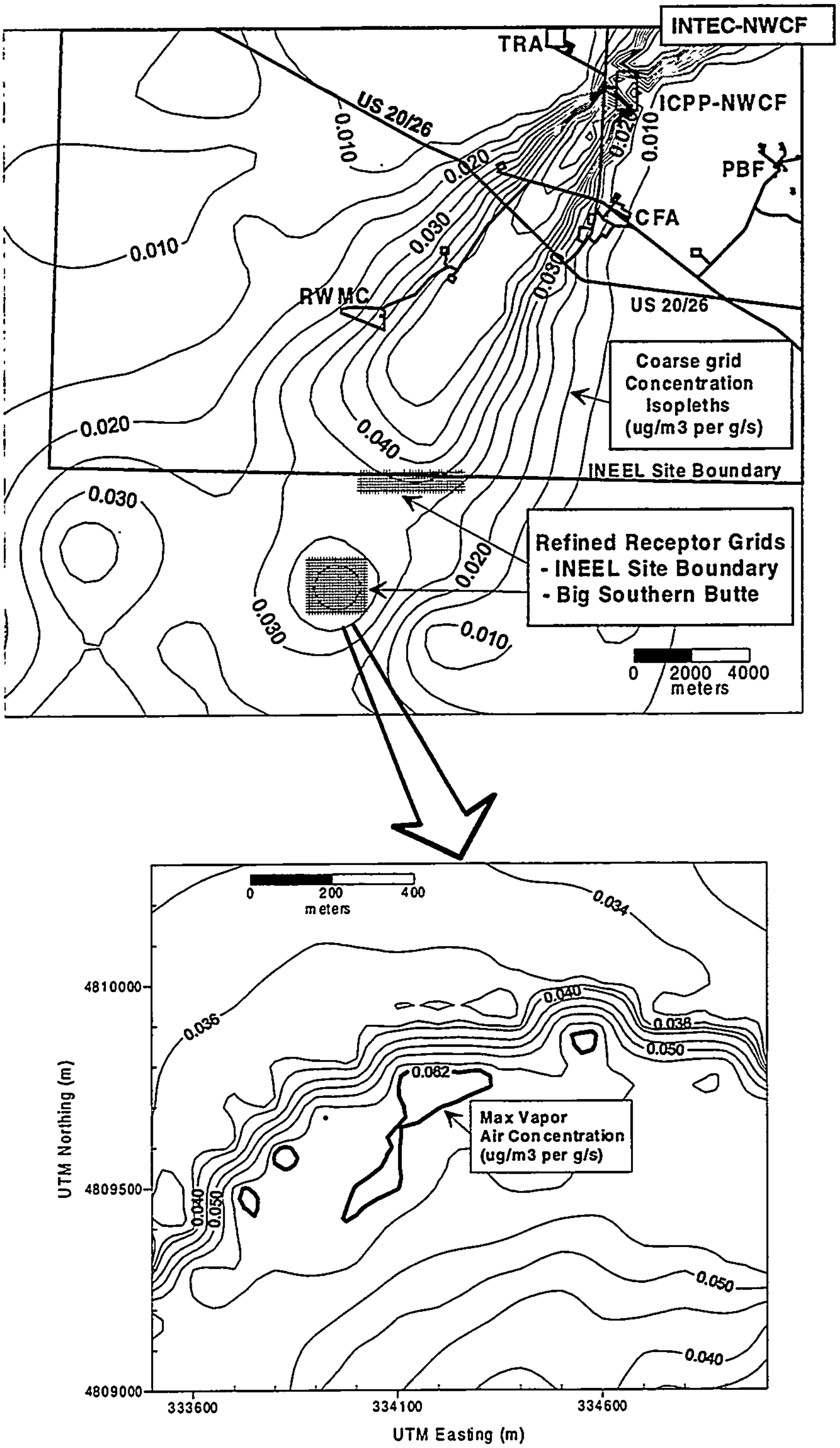

Figure 8. The maximum vapor air concentration (0.062 µg/m^3) occurred on the north end of the Big Southern Butte refined modeling grid. The maximum vapor wet deposition (3.7E-04 g/m^2-year per g/second) occurred in the same area.

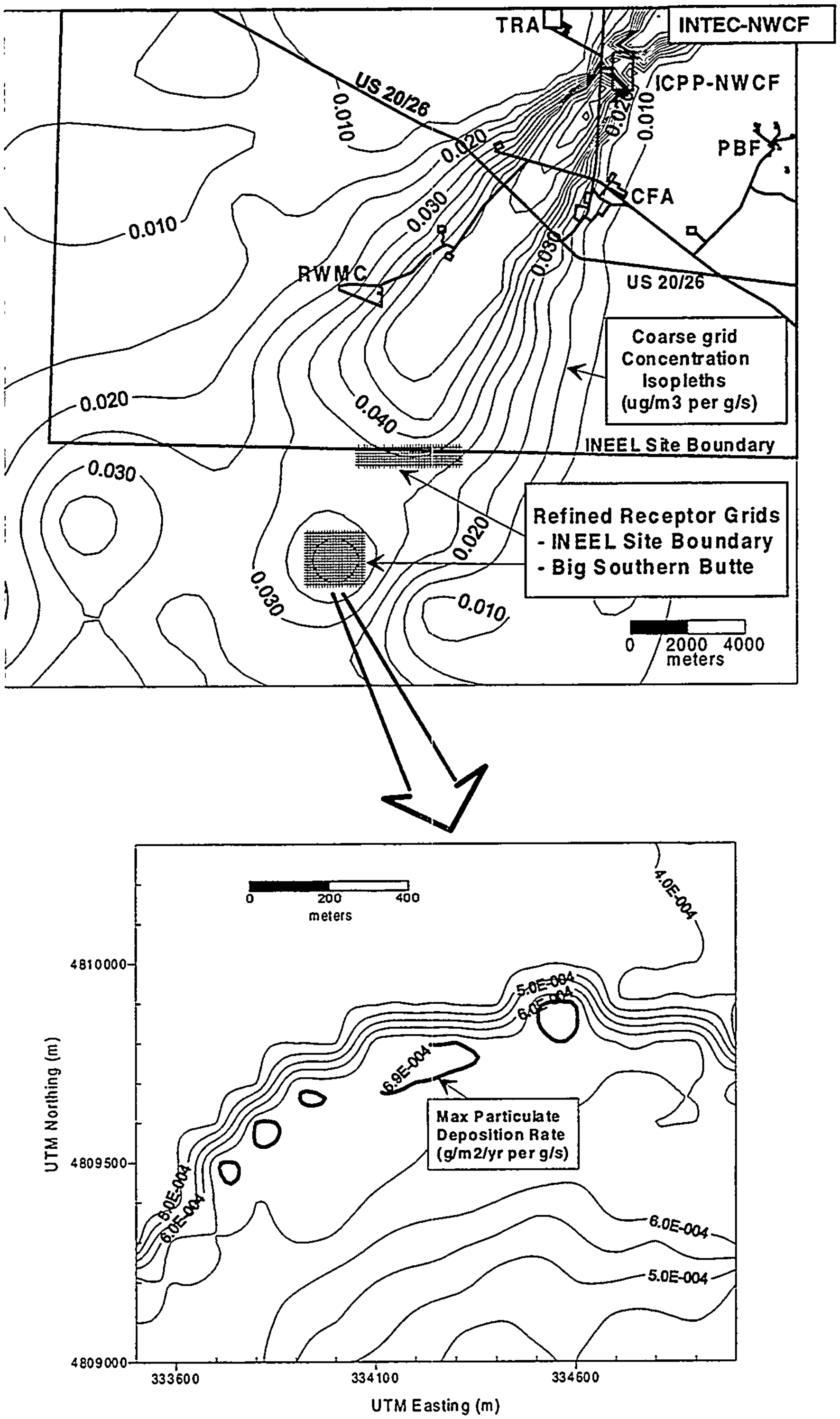

Figure 9. The maximum particulate total deposition rate (6.9E-04g/m^2-year) occurred on the north end of the Big Southern Butte refined modeling grid. The maximum particulate air concentration (0.062 µg/m^3) occurred in the same area.

4. EXPOSURE ASSESSMENT

The objective of the exposure assessment is to estimate the type and magnitude of exposures to constituents released in stack emissions from the NWCF. The exposure assessment guidance (EPA 1994a) specifies four exposure scenarios that should be considered: (1) subsistence farming, (2) subsistence fishing, (3) adult residential, and (4) child residential. Additional exposure scenarios evaluated at the request of EPA Region 10 and the Idaho DEQ include a subsistence farmer child, an onsite worker, and an onsite herdsman.

Onsite hunting was investigated and determined to not be a significant exposure scenario for impacts from the NWCF because:

1. Controlled hunting access is allowed only within one-half mile of the INEEL boundary on infrequent occasions. Most of the hunting occurs on the northeast site boundary, adjacent to the farms west of Mud Lake (approximately 50 km northeast of NWCF), and on the northwest site boundary on the southern terminus of the Lemhi Range (Figure 1).

2. The Environmental Science and Research Foundation (Warren and Mitchell, in press) recently completed a major big game dose study on the INEEL that examined measured radionuclide concentrations in deer and pronghorn antelope on the INEEL over the period 1972 through 1996. In the vast majority of animals examined, tissue concentrations were similar to background levels and were attributed to global fallout from nuclear weapons testing. Although this study did not examine organic or metal contaminant concentrations, it indicates that this exposure pathway is not likely to be significant at the INEEL.

3. Calculated impacts for a hypothetical hunter are bounded by the subsistence farmer scenario because of the relative ingestion rates of contaminated meat assumed in the exposure equations (the hunter eats limited amounts of potentially contaminated game while the farmer continuously consumes contaminated beef, milk, and vegetables). Since the calculated subsistence farmer risk and hazard index were significantly less than the SLRA criteria (1E-05 risk and 0.25 hazard index), the calculated hypothetical hunter impacts would also be less than these criteria.

Ingestion of fish was investigated and determined to not be a significant exposure pathway for impacts from the NWCF because:

1. There are no watershed areas that support subsistence or significant recreational fishing within 50 km of the NWCF.

2. All streams near the INEEL are intermittent streams that terminate inside the INEEL. Therefore, there is no potential for contaminant transport in surface waters to offsite locations.

Both direct and indirect exposures were evaluated for the subsistence farmer, subsistence farmer child, adult, child, and onsite herdsman scenarios. The direct exposure consists of inhalation of the maximum air concentration at the receptor location. Only direct inhalation exposure is assessed for the onsite worker because there are no food products grown or produced at the site. The maximum air concentration is assumed to be collocated with the point of maximum combined wet and dry deposition. U.S. Highway 20 bisects the southern portion of the INEEL; therefore, a short-term direct inhalation exposure also is evaluated by estimating the maximum short-term air concentration at this location and comparing it to the State of Idaho acceptable ambient air concentrations for noncarcinogens and carcinogens (AAC/AACC). The indirect exposures include the ingestion of aboveground produce, beef and milk, and soil. The ingestion of contaminated drinking water was not evaluated in this SLRA because: (1) surface water is not a source of drinking water in the area, and (2) the groundwater, which is a source of drinking water, is at a depth of approximately 140 m below land surface and, moreover, the low annual precipitation of 21.6 cm, combined with the degradative and sorptive properties of chemicals in the soil, eliminates groundwater as a potential exposure pathway to offsite individuals.

4.1 Human Exposure Scenarios

Table 6 presents the rates of consumption of contaminated food, ingestion of contaminated soil, and inhalation rates for each of the three major exposure scenarios specified in the EPA (1994a) guidance. Additional scenarios evaluated in this revison at the request of EPA Region 10 and the Idaho DEQ were a subsistence farmer child and an onsite herdsman. The onsite herdsman scenario assumed the same values as the subsistence farmer. The inhalation impacts evaluated for all scenarios, including the onsite worker, were calculated using a Unit Risk Factor (URF) and Reference Concentration (RfC), both of which assume an inhalation rate of 20 m^3/day (EPA 1997).

A discussion of indirect and direct exposures for each of the three major exposure scenarios evaluated is described below.

Table 6. Exposure scenario consumption rates and fraction contaminated for the three major exposure scenarios specified in the EPA (1994a) guidance (EPA 1994a).

	Exposure Scenario					
	Subsistence Farmer[a]		Adult Resident		Child Resident	
Contaminated Food or Medium	Rate	Fraction	Rate	Fraction	Rate	Fraction
Beef (g/day)	57	1	NA[b]	NA	NA	NA
Milk (g/day)	181	1	NA	NA	NA	NA
Aboveground produce (g dry weight/day)	28	1	28	0.25	5	0.25
Soil (mg/day)	100	1	100	1	200	1
Air (m^3/day)[c]	20	1	20	1	4.3	1

a. Same values were assumed for the onsite herdsman.

NA = not applicable

Inhalation impacts were calculated using a URF or RfC, which assumes a 20 m^3/day inhalation rate.
Units are for consumption rates. All fractions of contaminated food or a medium are dimensionless.

4.1.1 Subsistence Farmer and Onsite Herdsman

In the subsistence-farmer scenario, an adult farmer is exposed via consumption of home-grown beef and milk, consumption of home-grown produce (aboveground), incidental soil ingestion, and direct inhalation of vapors and particles. The subsistence farmer is assumed to raise cattle for both beef and milk consumption and grow crops for home consumption. The subsistence farmer is assumed to continuously reside at the location of maximum air concentration and wet and dry deposition.

The onsite herdsman added for this revision is assumed to reside 1/3 of a year at the location of maximum air concentration and deposition rate south of U.S. Highway 20 (no grazing is allowed north of the highway). The herdsman scenario assumes the same intake rates as the subsistence farmer; therefore impacts were calculated by scaling the subsistence farmer risk/hazard index based on the ratio of air concentrations (for direct impacts) and deposition rates (for indirect impacts) at the two assumed locations. Carcinogenic risk, which is based on total intake, was further scaled by the ratio of annual residence times assumed for the two scenarios (the onsite herdsman resides for 1/3 of a year; therefore, the subsistence farmer risk was further multiplied by 1/3).

4.1.2 Adult Resident

In the adult-resident scenario, an adult is exposed via consumption of home-grown produce (aboveground), incidental soil ingestion, and direct inhalation of vapors and particles. The adult resident is assumed to reside at the location of maximum air concentration and wet and dry deposition.

4.1.3 Child Resident

In the child-resident scenario, a child is exposed via consumption of home-grown produce (aboveground), incidental soil ingestion, and direct inhalation of vapors and particles. Typically the incidental soil ingestion rate is higher for children than for adults. The child resident is assumed to reside at the location of maximum air concentration and wet and dry deposition.

4.1.4 U.S. Highway 20 Receptor

U.S. Highway 20 bisects the southern portion of the INEEL; therefore, a short-term direct inhalation exposure was evaluated by estimating the maximum short-term air concentration at this location and comparing it to the State of Idaho acceptable ambient concentrations for noncarcinogens and carcinogens (AAC/AACC).

4.1.5 Onsite Worker

Maximum inhalation impacts for an INEEL worker at any adjacent onsite INEEL facility (excluding INTEC) were added for this revision. Indirect (ingestion) impacts to workers were not assessed because there is no food grown or produced at the INEEL. Since inhalation impacts were evaluated for all scenarios using a URF or RfC, worker impacts were calculated by scaling the susbsistence farmer inhalation impacts based on the ratio of the air concentrations determined for the two locations. Carcinogenic risk, which is based on total inhalation intake, was further scaled by the ratio of annual residence times assumed for the two scenarios (the worker spends 2000 hours per year onsite; therefore, the subsistence farmer risk was multiplied by 2000/8760).

4.1.6 Subsistence Farmer Child

For this revision, impacts were also calculated for a "subsistence farmer child," as requested by EPA Region 10. This scenario is basically the same as the child resident scenario except that it also assumes consumption of contaminated beef and milk, and the fractions of contaminated soil and food products are assumed to be 1.0. Only those chemicals that accounted for greater than 99% of the total risk (benzo[a]pyrene and 2,3,6,7 TCDD) and total hazard quotient (1,3-dinitrobenzene, 2,4-dinitrotoluene, and 2,6-dinitrotoluene) from the previous scenario results (see section 6) were assessed since these chemicals would also account for the vast majority of impacts in this scenario. Also, reassessment of these chemicals for this scenario was done using the most current the fate and transport parameters from EPA (1998).

4.2 Exposure Pathways

The indirect and direct exposure pathways selected for screening analyses are described in the following paragraphs.

4.2.1 Aboveground Produce Exposure Route

Aboveground produce is ingested by humans and cattle. For human ingestion of aboveground produce, the following two pathways of contaminant transport are included: (1) deposition of particle phase contaminants directly onto the plant surfaces, and (2) direct transfer of vapor phase contaminants into plant material. Cattle ingestion of aboveground plants is discussed below in the section for beef and dairy.

4.2.2 Beef and Dairy Exposure Route

For concentration of a contaminant in beef, three pathways are included. The first pathway is deposition directly onto forage plant surfaces and direct transfer of vapor-phase contaminants into forage plant material, followed by cattle consuming contaminated forage which results in bioaccumulation in muscle tissue. The second pathway is grain and silage root uptake of contaminants in soil, followed by cattle consuming contaminated grain and silage which results in bioaccumulation in muscle tissue. The third pathway is incidental ingestion of soil by cattle resulting in bioaccumulation in muscle tissue. For concentration of contaminants in cow's milk, the same three pathways also are included, except that the bioaccumulation of contaminants is in the cow's milk not muscle tissue.

4.2.3 Soil Exposure Route

For incidental ingestion of soil by adults and children, the soil is assumed to be contaminated by deposition of emissions onto soils. The concentration of chemicals in soil was developed from the maximum modeled deposition (combined wet and dry) at the hypothetical receptor location.

4.2.4 Air Exposure Route

Direct inhalation exposure for the subsistence farmer, adult, and child scenarios were evaluated at the offsite location of maximum air concentration. Maximum short-term concentrations were calculated along U.S. Highway 20, along which the commuting public could be exposed for short durations. The onsite herdsman was evaluated at the location of maximum air concentration south of U.S. Highway 20 where grazing is allowed. Maximum onsite worker impacts were determined to occur at the Central Facilities Area (CFA), approximately 4 km south of NWCF.

Equations that are used in the screening analysis to calculate concentrations of contaminants in media and food for the indirect exposure pathway are presented in table format in Appendix B. The tables show the equations, identify the exposure scenario and list all input parameters (air modeling results, calculated values, and site-specific or chemical-specific values). Chemical-specific parameter values are presented in Table B-1 of Appendix B. Default values were used in the exposure algorithms when site-specific values were not available or when guidance specified their use for conservatism. The default values are typically conservative and tend to overestimate the actual risk associated with exposure to emissions (EPA 1994a). Equations that are used in the screening analysis to calculate both indirect and direct exposures to the subsistence farmer, adult resident, and child resident are presented in table format in appendices C, D, and E, respectively.

5. TOXICITY ASSESSMENT

A toxicity assessment was conducted to identify toxicity values or health benchmarks for the contaminants of concern. A toxicity value is the numerical expression of a substance dose-response relationship that is used in the risk evaluation. The toxicity values or health benchmarks used in this toxicity assessment include the reference dose (RfD), reference concentration (RfC), cancer slope factor (CSF), and unit risk factor (URF), as well as the State of Idaho acceptable ambient concentrations for noncarcinogens (AACs) and carcinogens (AACCs) for the short-term exposure scenario on U.S. Highway 20/26. The RfD and RfC are used to evaluate noncarcinogenic effects. They are an estimate of the daily exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects. The CSF and URF are used to evaluate carcinogenic effects and represent a plausible upper-bound estimate of the probability of a response per unit intake of a chemical over an individual's lifetime.

Toxicity values and health benchmarks were obtained from the following references, in order of hierarchy: (1) the EPA Integrated Risk Information System (IRIS) database (on-line), (2) the EPA Health Effects Assessment Summary Tables (HEAST) (EPA 1997), (3) the Allied Technical Group (ATG) Risk Assessment Work Plan (RAWP)[a], (4) EPA Region 9 (on-line), and (5) State of Idaho AACs/AACCs, as published in the Rules for the Control of Air Pollution in Idaho (IDAPA 16.01.01, Sections 585 and 586) (on-line). The ATG toxicity data were used because they have been approved by EPA Region 10 and the State of Idaho DEQ. In addition, for some criteria pollutants (carbon monoxide, sulfur dioxide, and lead), National Ambient Air Quality Standards (NAAQS) were used when toxicity values were not available in the other sources. Tables 7 and 8 summarize the toxicity values for the oral and inhalation routes of exposure, respectively.

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[a] Allied Technical Group, Inc. (ATG) Risk Assessment Work Plan for the ATG Richland Mixed Waste Facility, October 9, 1998.

Table 7. Toxicity values for the oral route of exposure for the indirect pathway.

	CSF^{oral} $(mg/kg/day)^{-1}$		RfD^{oral} (mg/kg/day)	
Chemical	Value	Reference	Value	Reference
Antimony	ND		4.00E-04	IRIS
Arsenic	1.51E+00	IRIS	3.00E-04	IRIS
Barium	ND		7.00E-02	IRIS
Benzo(a)pyrene	7.30E+00	IRIS	ND	
Beryllium	4.30E+00	IRIS	5.00E-03	IRIS
Cadmium	ND		1.00E-03	IRIS
Chromium VI	ND		5.00E-03	IRIS
1,3-Dinitrobenzene	ND		1.00E-04	IRIS
2,4-Dinitrotoluene	ND		2.00E-03	IRIS
2,6-Dinitrotoluene	ND		1.00E-03	HEAST
Di(n)octylphthalate	ND		2.00E-02	HEAST
2,3,7,8-TCDD (TEQ)	1.50E+05	HEAST	ND	
Lead	ND		ND	
Mercury	ND		3.00E-04	IRIS
Nickel	ND		2.00E-02	IRIS
Nitrobenzene	ND		5.00E-04	IRIS
Pentachloronitrobenzene	2.60E-01	HEAST	3.00E-03	IRIS
Penatachlorophenol	1.20E-01	IRIS	3.00E-02	IRIS
Selenium	ND		5.00E-03	IRIS
Silver	ND		5.00E-03	IRIS
Thallium	ND		8.00E-04	IRIS

ND = no toxicity data are available.

NA = Not applicable. The oral route of exposure was not evaluated for this chemical.

Table 8. Toxicity values and or health benchmarks for the inhalation route of exposure for the direct pathway.

	URF $(\mu g/m^3)^{-1}$		RfC (mg/m^3)	
Chemical	Value	Reference	Value	Reference
Acetonitrile	ND		5.00E-02	HEAST
Aniline	ND		1.00E-03	IRIS
Antimony	ND		2.50E-02	IDHW
Arsenic	4.30E-03	IRIS	ND	
Barium	ND		5.00E-04	HEAST
Benzene	7.80E-06	IRIS	9.00E-03	NCEA
Benzo(a)pyrene	8.86E-04	ATG	ND	
Beryllium	2.40E-03	IRIS	2.00E-05	IRIS
Bromoform	1.10E-06	IRIS	7.00E-02	ATG
Butylbenzylphthalate	ND		7.00E-01	ATG
Cadmium	1.80E-03	IRIS	2.00E-04	EPA9
Carbon disulfide	ND		7.30E-01	IRIS
Carbon monoxide	ND		1.00E+01	NAAQS
Carbon tetrachloride	2.00E-03	ATG	2.00E-03	ATG
Chlorobenzene	ND		2.00E-02	HEAST
Chloroform	2.30E-05	IRIS	3.01E-03	ATG
Chromium VI	1.20E-02	IRIS	ND	
Dibutylphthalate	ND		3.50E-01	ATG
1,2-Dichloroethane	2.60E-05	IRIS	1.00E-02	EPA9
Diethylphthalate	ND		2.80E+00	ATG
1,3-Dinitrobenzene	ND		3.50E-04	ATG
2,4-Dinitrophenol	ND		7.00E-03	ATG
2,4-Dinitrotoluene	ND		7.00E-03	ATG
2,6-Dinitrotoluene	ND		3.50E-03	ATG
Di(n)octylphthalate	ND		7.00E-02	ATG
1,4-Dioxane	3.14E-06	ATG	ND	
Ethylene glycol	ND		7.00E+00	ATG
Formaldehyde	1.30E-05	IRIS	ND	
Formic acid	ND		7.00E+00	EPA9

Table 8. (continued).

Chemical	URF ($\mu g/m^3$)$^{-1}$ Value	URF Reference	RfC (mg/m^3) Value	RfC Reference
2,3,7,8-TCDD (TEQ)	3.43E+01	ATG	ND	
Hydrazine	4.90E-03	IRIS	ND	
Hydrogen chloride	ND		2.00E-02	IRIS
Hydrogen fluoride	ND		2.60E-02	Calculated
(Iso)thiourea	5.56E-04	IDHW	ND	
Lead	ND		1.50E-03	NAAQS
Mercury	ND		3.00E-04	IRIS
Methyl ethyl ketone	ND		1.00E+00	IRIS
Methylene chloride	4.70E-07	IRIS	3.00E+00	HEAST
Napthalene	ND		3.00E-03	EPA9
Nickel	2.40E-04	EPA9	ND	
Nitric acid	ND		2.50E-01	IDHW
Nitrobenzene	ND		2.00E-03	HEAST
Nitrogen dioxide	ND		3.50E+00	EPA9
Pentachloronitrobenzene	7.43E-05	ATG	1.05E-02	ATG
Pentachlorophenol	3.40E-05	ATG	1.05E-01	ATG
Phenol	ND		2.10E+00	ATG
Pyridine	ND		3.50E-03	ATG
Selenium	ND		1.00E-02	IDHW
Silver	ND		5.00E-03	IDHW
Sulfur dioxide	ND		8.00E-02	NAAQS
Tetrachloroethylene	3.14E-05	EPA9	2.70E-01	ATG
Thallium	ND		2.80E-04	ATG
Uranium	ND		1.00E-02	IDHW
Toluene	ND		4.00E-01	IRIS
1,2,4-Trichlorobenzene	ND		2.00E-01	ATG
1,1,1-Trichloroethane	ND		1.00E-01	ATG
1,1,2-Trichloroethane	1.60E-05	IRIS	1.40E-02	ATG
Trichloroethylene	ND		2.10E-02	ATG

Table 8. (continued).

	URF $(\mu g/m^3)^{-1}$		RfC (mg/m^3)	
Chemical	Value	Reference[a]	Value	Reference[a]
Hydrogen chloride	ND		2.00E-02	IRIS
Hydrogen fluoride	ND		2.60E-02	Calculated
(Iso)thiourea	5.56E-04	IDHW	ND	
Lead	ND		1.50E-03	NAAQS
Mercury	ND		3.00E-04	IRIS
Methyl ethyl ketone	ND		1.00E+00	IRIS
Methylene chloride	4.70E-07	IRIS	3.00E+00	HEAST
Napthalene	ND		3.00E-03	EPA9
Nickel	2.40E-04	EPA9	ND	
Nitric acid	ND		2.50E-01	IDHW
Nitrobenzene	ND		2.00E-03	HEAST
Nitrogen dioxide	ND		3.50E+00	EPA9
Pentachloronitrobenzene	7.43E-05	ATG	1.05E-02	ATG
Pentachlorophenol	3.40E-05	ATG	1.05E-01	ATG
Phenol	ND		2.10E+00	ATG
Pyridine	ND		3.50E-03	ATG
Selenium	ND		1.00E-02	IDHW
Silver	ND		5.00E-03	IDHW
Sulfur dioxide	ND		8.00E-02	NAAQS
Tetrachloroethylene	3.14E-05	EPA9	2.70E-01	ATG
Thallium	ND		2.80E-04	ATG
Uranium	ND		1.00E-02	IDHW
Toluene	ND		4.00E-01	IRIS
1,2,4-Trichlorobenzene	ND		2.00E-01	ATG
1,1,1-Trichloroethane	ND		1.00E-01	ATG
1,1,2-Trichloroethane	1.60E-05	IRIS	1.40E-02	ATG
Trichloroethylene	ND		2.10E-02	ATG

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[a] Sources:

ND = no toxicity data are available.
IDHW = Idaho Division of Health and Welfare, Toxic Air Pollutant AAC/AACC
NCEA = National Center for Environmental Assessment (EPA)
ATG = Allied Technical Group Risk Assessment Work Plan
EPA9 = Derived from EPA Region 9 on-line toxicity values
NAAQS = National Ambient Air Quality Standard
Calculated = 1% of ACGIH-TLV.

6. RISK CHARACTERIZATION

The objective of the risk characterization, the final step in the overall risk assessment process, is to integrate the results of the exposure assessment and the toxicity assessment to estimate risk to humans from the exposure of onsite contaminants. The toxicity and exposure assessments are summarized and integrated into quantitative expressions of risk. These quantitative expressions of risk include: (1) the increased probability of cancer in an individual over a lifetime, referred to as the excess lifetime individual cancer risk arising from both oral and inhalation routes of exposure; (2) for oral exposures, a measure of an individual's exposure to chemicals with noncancer health effects relative to the RfD, referred to as the hazard quotient; (3) for inhalation exposures, a hazard quotient relative to the RfC in air; and (4) where appropriate, a hazard index, which represents the combined hazard quotients for chemicals with the same noncarcinogenic health effects.

The carcinogenic effects or probability that an individual will develop cancer over a lifetime of exposure are estimated from projected intakes and chemical-specific dose-response relationships or URFs. The calculation of health risks from the potential exposure to carcinogenic contaminants involves multiplying the CSF for each carcinogen by the estimated average daily intake value. When a CSF is not established for a contaminant but a URF has been established for the contaminant, then the health risk is calculated by multiplying the URF for the carcinogen to the estimated air concentration. The risk is expressed probabilistically and is compared to EPA's acceptable risk critieria of 1×10^{-5} for combustion units (EPA 1998a). The risks are summed across all chemicals and pathways to determine the total excess cancer risk from NWCF emissions (including auxiliary systems).

Noncarcinogenic effects are characterized by comparing projected intakes of substances to toxicity values or health benchmarks. The chronic RfD for ingestion and the RfC for inhalation are used to compare toxic effects of noncarcinogenic contaminants. The hazard potential from toxic effects is computed as the ratio of estimated average daily intake to the RfD, or the ratio of the estimated air concentration to the RfC, and is referred to as the hazard quotient. The sum of the hazard quotients is equal to the hazard index. Hazard quotients for noncarcinogens may be added if health effects caused by exposure to the contaminant are similar, affecting the same target organs (i.e., liver or neurotoxic effects) to calculate an overall hazard index for, liver or neurotoxic effects. The hazard quotient (HQ) or hazard index (HI) should be interpreted as an index of relative health and does not provide a probabilistic expression of risk. A value less than one indicates that it is unlikely for even sensitive subpopulations to experience adverse health effects. However, for this SLRA EPA recommends that stack emissions may only contribute 25% of the total noncarcinogenic health standard (EPA 1998a). Therefore, if the estimated HI and HQ values are less than 0.25, no further risk analysis is necessary and emissions are considered protective of the public health. Exposures to noncarcinogens from the direct exposure pathway should not be added to those from the indirect pathways (EPA 1994a).

6.1 Direct Inhalation Exposures

The excess lifetime individual cancer risk from direct inhalation of a chemical carcinogen is calculated from the URF for each exposure scenario as follows:

$$Cancer\ Risk_{(inh)ij} = C_{(air)ij} * URF_{(inh)i}$$

where

$Cancer\ Risk_{(inh)ij}$ = Excess lifetime cancer risk via inhalation (unitless), for chemical i and exposure receptor j

$C_{(air)ij}$ = Concentration in air (μg/m^3), for chemical i, exposure j

$URF_{(inh)i}$ = Inhalation unit risk factor (per μg/m^3), for chemical i.

The total cancer risk to the individual via inhalation is estimated by summing the lifetime individual cancer risk for all carcinogenic chemicals via the inhalation route of exposure. Results for the offsite scenarios are presented in Table 9 and indicate inhalation exposures are well below the EPA acceptable criterion of 1×10^{-5} (EPA 1998a).

The hazard quotient for inhalation exposures to noncarcinogenic chemicals is calculated for each exposure scenario as follows:

$$HQ_{(inh)ij} = (C_{(air)ij}/RfC_i) * 10^{-3}$$

where

$HQ_{(inh)ij}$ = hazard quotient via inhalation (unitless), chemical i, exposure j

$C_{(air)ij}$ = concentration in air (μg/m^3), chemical i, exposure scenario j

RfC_i = reference concentration (mg/m^3), chemical i

10^{-3} = unit conversion factor (mg/μg).

Table 10 presents the hazard quotients for inhalation exposure to noncarcinogenic chemicals for the offsite scenarios. The results indicate that all hazard quotients are well below the EPA acceptable level of 0.25. Table 11 lists chemicals with neurotoxin and liver effects. Chemicals with neurotoxin effects include 2,4-dinitrotoluene, 2,6-dinitrotoluene, and mercury. The HI for neurotoxin effects is 0.009. The PIC 2,6-dinitrotoluene is the biggest contributor to this HI. Chemicals with liver effects include di-n-octylphthalate, pentatchloronitrobenzene, and pentachlorophenol. The HI for liver effects is 0.0002. The total hazard index (irrespective of specific toxic effects) for inhalation of noncarcinogenic chemicals is 0.09.

For the acute inhalation exposure to transient travelers on U.S. Highway 20, estimated ambient air concentrations for chemical emissions are compared to the State of Idaho acceptable ambient concentrations for noncarcinogens and carcinogens (AAC/AACC) or EPA Region 9 Preliminary Remediation Goals (PRGs) for ambient air. The AACs are 24-hour averages and the AACCs are annual averages. These criteria are chronic exposure criteria that will conservatively bound any short-term acute exposure criteria. It should be noted that the State of Idaho does not require evaluation of carcinogenic impacts at public highways because the short-term receptor exposure time (perhaps 10 minutes per day) is not appropriate for evaluating the long-term, chronic intake required for carcinogenic exposure assessment. However, to demonstrate the low potential hazards from these chemicals, carcinogenic risks at U.S. Highway 20 are presented in this SLRA, indicating the potential risks that a receptor might be exposed to if the receptor were to remain on the highway location of maximum air concentration for a lifetime. Table 12 presents the results and indicates all chemical emissions are well below the State of Idaho AAC/AACC or the EPA Region 9 PRG.

Table 9. Cancer risk estimates for inhalation route of exposure at the INEEL boundary.

Chemical	Air Concentration[a] (ug/m^3)	URF[b] (ug/m^3)	Cancer risk
Aniline	8.45E-06	1.63E-06	1E-11
Arsenic	7.33E-14	4.30E-03	3E-16
Benzene	5.21E-08	7.80E-06	4E-13
Benzo(a)pyrene	1.04E-07	8.86E-04	9E-11
Beryllium	9.94E-10	2.40E-03	2E-12
Bromoform	5.21E-08	1.10E-06	6E-14
Cadmium	1.55E-12	1.80E-03	3E-15
Carbon tetrachloride	5.21E-08	1.50E-05	8E-13
Chloroform	5.21E-08	2.30E-05	1E-12
Chromium	5.53E-13	1.20E-02	7E-15
Coplaner PCBs	9.94E-13	3.43E+1	3E-11
1,2-Dichloroethane	5.21E-08	2.60E-05	1E-12
1,4-Dioxane	3.91E-05	3.14E-06	1E-10
Formaldehyde	4.53E-08	1.30E-05	6E-13
2,3,7,8-TCDD	6.83E-12	3.43E+01	2E-10
Hydrazine	1.77E-06	4.90E-03	9E-09
(Iso)thiourea	2.20E-07	5.56E-04	1E-10
Methylene chloride	5.21E-08	4.70E-07	2E-14
Nickel	5.30E-13	2.40E-04	2E-16
Pentachloronitrobenzene(PIC)	2.49E-03	7.43E-05	2E-07
Pentachlorophenol	1.04E-07	3.43E-05	4E-12
Tetrachloroethylene	5.21E-08	3.14E-05	2E-12
1,1,2-Trichloroethane	5.21E-08	1.60E-05	8E-13
Total Cancer Risk			**2E-07**

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a. The air concentration value is the product of the emission rate (see Section 2) and Cyv value of 6.21E-02. Because vapor and particulate concentrations are similar, the higher of the two is assumed for all chemicals.

b. See Section 5 for source of URF values.

Table 10. Noncarcinogenic hazard quotient estimates for inhalation exposure at INEEL boundary.

Chemical	Air Concentration[a] (ug/m^3)	RfC[b] (mg/m^3)	HQ
Acetonitrile	5.00E-07	5.00E-02	1E-08
Aniline	8.45E-06	1.00E-03	8E-06
Antimony	1.86E-09	2.50E-02	7E-11
Barium	4.35E-14	5.00E-04	9E-14
Benzene	5.21E-08	9.00E-03	6E-09
Beryllium	9.94E-10	2.00E-05	5E-08
Bromoform	5.21E-08	7.00E-02	7E-10
Butylbenzylphthalate	1.04E-09	7.00E-01	1E-12
Cadmium	1.55E-12	2.00E-04	8E-12
Carbon disulfide	4.14E-06	7.30E-01	6E-09
Carbon monoxide	1.90E+00	1.00E+01	2E-04
Carbon tetrachloride	5.21E-08	2.00E-03	3E-08
Chlorobenzene	5.21E-08	2.00E-02	3E-09
Chloroform	5.21E-08	3.01E-03	2E-08
Chromium	5.53E-13	1.02E-04	5E-12
Dibutylphthalate	1.04E-09	3.50E-01	3E-12
1,2-Dichloroethane	5.21E-08	1.02E-02	5E-09
Diethylphthalate	1.34E-08	2.80E+00	5E-12
1,3-Dinitrobenzene(PIC)	2.98E-02	3.50E-04	9E-02
2,4-Dinitrophenol	8.45E-07	7.00E-03	1E-07
2,4-Dinitrotoluene	9.88E-07	7.00E-03	1E-07
2,4-Dinitrotoluene(PIC)	3.23E-02	7.00E-03	5E-03
2,6-Dinitrotoluene(PIC)	3.23E-02	3.50E-03	9E-03
Di(n)octyl phthalate	1.04E-09	7.00E-02	1E-11
Ethylene glycol	6.52E-06	7.00E+00	9E-10
Formic acid	2.52E-06	7.00E+00	4E-10
Hydrogen chloride	5.61E-03	1.99E-02	3E-04
Hydrogen fluoride	3.19E-03	2.60E-02	1E-04
Lead	8.70E-10	1.50E-03	6E-10
Mercury	9.94E-05	3.00E-04	3E-04
Methyl ethyl ketone	1.77E-06	1.00E+00	2E-09
Methylene chloride	5.21E-08	3.00E+00	2E-11

Table 10. (continued).

Chemical	Air Concentration[a] (ug/m^3)	RfC[b] (mg/m^3)	HQ
Naphthalene	1.04E-07	3.01E-03	3E-08
Nitric acid	8.64E-01	2.50E-01	3E-03
Nitrobenzene(PIC)	2.17E-02	2.00E-03	1E-02
Nitrogen dioxide	3.03E+00	3.50E+00	9E-04
Pentachloronitrobenzene(PIC)	2.49E-03	1.05E-02	2E-04
Pentachlorophenol	1.04E-07	1.05E-01	1E-09
Phenol	1.77E-06	2.10E+00	8E-10
Pyridine	1.51E-04	3.50E-03	4E-05
Selenium	4.72E-08	1.00E-02	5E-09
Silver	3.54E-14	5.00E-03	7E-15
Sulfur dioxide	1.42E-02	8.00E-02	2E-04
Tetrachloroethylene	5.21E-08	2.70E-01	2E-10
Thallium	1.55E-08	2.80E-04	6E-08
Toluene	5.21E-08	4.00E-01	1E-10
1,2,4-Trichlorobenzene	1.04E-07	2.00E-01	5E-10
1,1,1-Trichloroethane	5.21E-08	1.02E-01	5E-10
1,1,2-Trichloroethane	5.21E-08	1.40E-02	4E-09
Trichloroethylene	5.21E-08	2.10E-02	2E-09
Uranium	4.91E-13	1.00E-02	5E-14
Total Hazard Index[c]			**0.09**

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a. The air concentration value is the product of the emission rate (see Section 2) and Cyv value of 6.21E-02. Because vapor and particulate concentrations are similar, the higher of the two is assumed for all chemicals.

b. See Section 5 for the source of the RfC values.

c. The total hazard index irrespective of specific toxic effects (i.e., liver or neurotoxin). Also, the total hazard index only includes the nitroaromatic PIC with the highest hazard quotient (1,3-dinitrobenzene).

Table 11. Direct exposure (inhalation) hazard quotient and hazard index for chemicals with liver or neurotoxin effects.

	Subsistence-Farmer HQ		Adult-Resident HQ		Child-Resident HQ	
Chemical	Liver	Neurotoxim	Liver	Neurotoxin	Liver	Neurotoxin
2,4-Dinitrotoluene (PIC)		5E-03		5E-03		5E-03
2,6-Dinitrotoluene (PIC)		9E-03		9E-03		9E-03
Di(n)octylphthalate	1E-11		1E-11		1E-11	
Mercury		3E-04		3E-04		3E-04
Pentachloronitro-benzene(PIC)	2E-04		2E-04		2E-04	
Pentachlorophenol	1E-09		1E-9		1E-09	
Total Hazard Index[a]	**2E-04**	**9E-03**	**2E-04**	**9E-03**	**2E-04**	**9E-03**

a. The total hazard index includes only the nitroaromatic PIC with the highest hazard quotient (see PIC calculations in Section 2).

Table 12. Acute inhalation exposure to transient travelers on U.S. Highway 20.

Chemical	Air Concentration[a] (ug/m^3)	Screening Concentration Criteria[b] (ug/m^3)	Source[b]	Ratio of Air Concentration to Screening Concentration
Acetonitrile	3.72E-06	3.35E+03	AAC	1.11E-09
Aniline	8.69E-06	1.40E-01	AACC	6.21E-05
Antimony	1.38E-08	2.50E+01	AAC	5.54E-10
Arsenic	7.54E-14	2.30E-04	AACC	3.28E-10
Barium	3.23E-13	2.50E+01	AAC	1.29E-14
Benzene	5.36E-08	1.20E-01	AACC	4.47E-07
Benzo(a)pyrene	1.07E-07	3.00E-04	AACC	3.58E-04
Beryllium	1.02E-09	4.20E-03	AACC	2.43E-07
Bromoform	3.87E-07	2.50E+02	AAC	1.55E-09
Butylbenzylphthalate	7.75E-09	7.30E+02	PRG	1.06E-11
Cadmium	1.60E-12	5.60E-04	AACC	2.85E-09
Carbon disulfide	3.07E-05	1.50E+03	AAC	2.05E-08
Carbon monoxide	1.41E+01	1.00E+04	NAAQS	1.41E-03
Carbon tetrachloride	5.36E-08	6.70E-02	AACC	8.00E-07
Chlorobenzene	3.87E-07	1.75E+04	AAC	2.21E-11
Chloroform	5.36E-08	4.30E-02	AACC	1.25E-06
Chromium	5.69E-13	8.30E-05	AACC	6.85E-09
Dibutylphthalate	7.75E-09	2.50E+02	AAC	3.10E-11
1,2-Dichloroethane	5.36E-08	2.00E+03	AACC	2.68E-11
Diethylphthalate	9.92E-08	2.50E+02	AAC	3.97E-10
1,3-Dinitrobenzene(PIC)	2.22E-01	5.00E+01	AAC	4.43E-03
2,4-Dinitrophenol	6.28E-06	7.30E+00	PRG	8.60E-07
2,4-Dinitrotoluene	7.34E-06	7.30E+00	PRG	1.01E-06
2,4-Dinitrotoluene(PIC)	2.40E-01	7.30E+00	PRG	3.29E-02
2,6-Dinitrotoluene(PIC)	3.32E-02	3.70E+00	PRG	8.98E-03
Di(n)octyl phthalate	7.75E-09	7.30E+01	PRG	1.06E-10
1,4-Dioxane	4.02E-05	7.10E-01	AACC	5.66E-05
Ethylene glycol	4.85E-05	6.35E+03	AAC	7.63E-09
Formaldehyde	4.66E-08	7.70E-02	AACC	6.05E-07
Formic acid	1.87E-05	4.70E+02	AAC	3.99E-08
2,3,7,8-TCDD	7.03E-12	2.20E-08	AACC	3.20E-04
Hydrazine	1.82E-06	3.40E-04	AACC	5.36E-03

Table 12. (continued).

Chemical	Air Concentration[a] (ug/m^3)	Screening Concentration Criteria[b] (ug/m^3)	Source[b]	Ratio of Air Concentration to Screening Concentration
Hydrogen chloride	4.17E-02	3.75E+02	AAC	1.11E-04
Hydrogen fluoride	2.37E-02	2.60E+01	AAC	9.12E-04
(Iso)thiourea	1.63E-06	1.80E-03	AACC	9.08E-04
Lead	6.46E-09	1.50E+00	NAAQS	4.31E-09
Mercury	7.38E-04	2.50E+00	AAC	2.95E-04
Methyl ethyl ketone	1.32E-05	2.95E+04	AAC	4.46E-10
Methylene chloride	5.36E-08	2.40E-01	AACC	2.23E-07
Naphthalene	7.75E-07	2.50E+04	AAC	3.10E-11
Nickel	5.50E-13	4.20E-03	AACC	1.30E-10
Nitric acid	6.42E+00	2.50E+02	AAC	2.57E-02
Nitrobenzene(PIC)	1.62E-01	2.50E+02	AAC	6.46E-04
Nitrogen dioxide	2.25E+01	1.00E+02	NAAQS	2.25E-01
Pentachloronitrobenzene(PIC)	1.85E-02	1.40E-02	PRG	7.10E-01
Pentachlorophenol	7.75E-07	2.50E+01	AAC	3.10E-08
Phenol	1.32E-05	9.50E+02	AAC	1.38E-08
Pyridine	1.12E-03	7.50E+02	AAC	1.50E-06
Selenium	3.51E-07	1.00E+01	AAC	3.51E-08
Silver	2.63E-13	5.00E+00	AAC	5.26E-14
Sulfur dioxide	1.06E-01	8.00E+01	NAAQS	1.32E-03
Tetrachloroethylene	5.36E-08	2.10E+00	AACC	2.55E-08
Thallium	1.15E-07	5.00E+00	AAC	2.31E-08
Toluene	3.87E-07	1.88E+04	AAC	2.07E-11
1,2,4-Trichlorobenzene	7.75E-07	1.85E+03	AAC	4.19E-10
1,1,1-Trichloroethane	3.87E-07	9.55E+04	AAC	4.05E-12
1,1,2-Trichloroethane	5.36E-08	6.20E-02	AACC	8.65E-07
Trichloroethylene	3.87E-07	1.35E+04	AACC	2.88E-11
Uranium	3.65E-12	1.00E+01	AAC	3.65E-13

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a. The air concentration value is the product of the emission rate (see Section 2) and Cyv value of 6.21E-02. Because vapor and particulate concentrations are similar, the higher of the two is assumed for all chemicals.

b. State of Idaho Acceptable Ambient Air Concentration (AAC) for noncarcinogens or carcinogens (AACC), EPA Region 9 Preliminary Remediation Goal (PRG) value for ambient air, or National Ambient Air Quality Standard.

Onsite Scenarios. For the two added onsite scenarios (herdsman and worker) evaluated in this revision, inhalation impacts were calculated by scaling the maximum offsite risk and hazard index based on the ratio of air concentrations at the two onsite scenario locations relative to the air concentration at the maximum offsite location. This can be done because intake, and therefore risk, are directly proportional to air concentration. Carcinogenic risk, which is based on total intake, was further scaled by the ratio of annual residence times assumed for the two scenarios relative to the continuously-exposed offsite scenarios. Hazard index was not scaled based on residence time because subchronic or acute affects can occur over short exposure durations.

Using Figure 8, the maximum air concentration at any location south of U.S. Highway 20 (maximum herdsman impact location) is 0.065 ug/m^3 per g/s which is almost the same as the maximum offsite location (0.062 ug/m^3 per g/s) (the offsite value is relatively high because the elevated terrain is closer to the elevated plume centerline). The risk at the herdsman location was therefore calculated by multiplying the maximum offsite risk (2E-07) by the ratio of the air concentrations (0.065/0.062) and the ratio of the assumed annual residence times at the two locations (1/3), giving a maximum inhalation risk of 7E-08. The maximum total hazard index would be approximately the same as that at the maximum offsite location in Table 10, 0.09.

Using Figure 8, the maximum air concentration at any onsite facility is 0.025 ug/m^3 per g/s at the northwest corner of the Central Facilities Area (CFA) (UTM location 342630 East and 4821520 North), which is 40% of the maximum offsite concentration (0.062 ug/m^3 per g/s). The concentration at CFA is lower because of the relative heights between the elevated plume centerline and the receptor location. The risk at the CFA location was therefore calculated by multiplying the maximum offsite risk (2E-07) by the ratio of the air concentrations (0.025/0.062) and assumed annual residence times (2000/8760) at the two locations, giving a maximum inhalation risk of 2E-8. The maximum total hazard index was calculated by multiplying the maximum offsite hazard index by the ratio of the air concentrations (0.09 × 0.025/0.062) at the two locations, giving a maximum inhalation hazard index of 0.04.

6.2 Indirect Exposures

The excess lifetime individual cancer risk from indirect exposure of a chemical carcinogen via ingestion is calculated as follows:

$$Cancer\ risk = \frac{I * ED * EF * CSF}{BW * AT * 365}$$

where

I = total daily intake of contaminant (mg/day)

ED = exposure duration (year)

EF = exposure frequency (day/year)

CSF = oral cancer slope factor (mg/kg/day)$^{-1}$

BW = body weight (kg)

AT = averaging time (year)

365 = units conversion factor (days/year).

The total cancer risk via ingestion is estimated by summing the lifetime individual cancer risk for all carcinogenic chemicals via the ingestion route of exposure. Table 13 presents the results for the offsite scenarios. Summed across all chemicals, the total risk estimates for the subsistence farmer, adult resident, child resident, and subsistence farmer child are 3E-08, 1E-10, 5E-10, and 3E-8, respectively, which are well below the EPA acceptable criterion of 1×10^{-5} (EPA 1998a).

The hazard quotient for indirect exposures to noncarcinogenic chemicals via ingestion is calculated for each exposure scenario as follows:

$$HQ = I/(BW * RfD)$$

where

I = total daily intake of contaminant (mg/day)

BW = body weight (kg)

RfD = reference dose (mg/kg/day).

Hazard quotients for indirect exposures to chemicals that affect the same target organ are added together to obtain a hazard index for the target organ. Tables 14 and 15 present the hazard quotient and hazard index results for the three offsite scenarios. In all cases, the values are less than the EPA acceptable criterion of 0.25 (EPA 1998a). In addition, the noncancer effects of dioxin (2,3,7,8-TCDD) were evaluated by comparing the general background level of exposure of adults to dioxins (1-3 pg/kg/d) to the estimated daily intake of dioxin for subsistence farmer and adult (maximum of 0.0003 pg/kg/d) from the calciner emissions. The noncancer effects from this incremental exposure are negligible.

Tables used for estimating individual cancer risk and hazard quotients for the various chemicals and exposure scenarios are presented in Appendix F. The tables provide the equations used, identify the parameters in the equation, and provide the parameter values (or if calculated, the tables from which the values are obtained).

Table 13. Indirect exposure excess cancer risks for the offsite scenarios.

Chemical	Subsistence Farmer	Adult Resident	Child Resident	Subsistence Farmer Child[a]
Arsenic	1E-17	8E-20	7E-20	a
Benzo(a)pyrene[b]	1E-08	3E-11	7E-11	1E-08
Coplaner PCBs[b]	9E-12	3E-13	1E-12	a
Beryllium	3E-14	3E-15	5E-15	a
2,3,7,8-TCDD[b]	2E-08	8E-11	4E-10	2E-08
Pentachloronitrobenzene	1E-11	3E-12	3E-12	a
Pentachlorophenol	3E-12	2E-13	4E-13	a
Total Risk	**3E-08**	**1E-10**	**5E-10**	**3E-08**

a. Only those chemicals which accounted for greater than 99% of the total risk were evaluated for this scenario. Because the relative contribution of individual chemical risk to total risk is approximately the same for all scenarios; evaluation of the remaining chemicals would not change the total risk.

b. For this revision, these chemicals were re-evaluated using the fate and transport parameter values given in EPA (1998).

Onsite Herdsman Scenario. Indirect impacts for the onsite herdsman scenario were calculated by multiplying the indirect risk and hazard index for the subsistence farmer (from Tables 13 and 14) by the ratio of the ground deposition rate at the maximum herdsman location relative to the ground deposition rate at the subsistence farmer (maximum offsite) location. This can be done because media concentrations, intake, and risk are directly proportional to ground deposition rate. Carcinogenic risk, which is based on total intake, was further scaled by the ratio of annual residence time assumed for the herdsman relative to the continuously-exposed subsistence farmer scenario (1/3). Hazard index was not scaled based on residence time because subchronic or acute effects can occur over short exposure durations. This method (scaling subsistence farmer indirect impacts to determine the herdsman impacts) will overestimate any potential herdsman impacts because the herdsman scenario does not include consumption of contaminated milk or produce (as assumed for the farmer).

Using Figure 9, the maximum ground deposition rate at any location south of U.S. Highway 20 (maximum herdsman impact location) is 1.3E-03 g/m^2-year per g/s. The maximum ground deposition rate at the maximum offsite impact location is 6.9E-04 g/m^2-year per g/s. The indirect risk at the herdsman location was therefore calculated by multiplying the subsistence farmer indirect risk (3E-08, Table 13) by the ratio of the ground deposition rates (1.3E-03/6.9E-04) and the ratio of the assumed annual residence times for the two scenarios (1/3), giving a maximum indirect risk of 1.9E-08. The maximum total hazard index was calculated by multiplying the subsistence farmer hazard index (0.002, Table 14) by the ratio of the ground deposition rates, giving a maximum indirect hazard index of 0.0038. This is less than the maximum offsite hazard index (0.01 for the subsistence farmer child scenario).

Table 14. Indirect exposure hazard quotients for the offsite scenarios.

Chemical	Subsistence Farmer	Adult Resident	Child Resident	Subsistence Farmer Child[a]
Antimony	6E-11	6E-12	9E-12	a
Arsenic	4E-14	4E-16	2E-15	a
Barium	8E-17	2E-17	8E-17	a
Beryllium	2E-12	3E-13	3E-12	a
Cadmium	2E-12	2E-14	1E-13	a
Chromium VI	1E-14	1E-15	3E-15	a
1,3-Dinitrobenzene(PIC)[b]	2E-03	7E-04	3E-03	1E-02
2,4-Dinitrotoluene(PIC)[b]	1E-04	4E-05	2E-04	8E-04
2,6-Dinitrotoluene(PIC)[b]	2E-04	7E-05	3E-04	2E-03
Di(n)octyl phthalate	1E-09	4E-10	8E-10	a
Mercury	3E-04	3E-07	4E-06	a
Nickel	2E-15	5E-17	5E-16	a
Nitrobenzene(PIC)	9E-05	3E-05	9E-05	a
Pentachloronitrobenzene(PIC)	3E-08	8E-09	5E-08	a
Pentachlorophenol	1E-09	2E-10	1E-09	a
Selenium	2E-09	1E-11	2E-11	a
Silver	5E-15	9E-18	1E-17	a
Thallium	8E-08	1E-09	7E-09	a
Total Hazard Index[c]	**0.002**	**0.0007**	**0.003**	**0.01**

a. Only those chemicals which accounted for greater than 99% of the total hazard quotient were evaluated for this scenario. Because the relative contribution of individual chemical risk to total risk is approximately the same for all scenarios; evaluation of the remaining chemicals would not change the total risk.

b. For this revision, these chemicals were re-evaluated using the fate and transport parameter values given in EPA (1998).

c. The total hazard index is irrespective of specific toxic effects (i.e. liver and neurotoxin). Also, the total hazard index includes only the nitroaromatic PIC with the highest hazard quotient (see PIC calculations in Section 2).

6.3 Lead

No health-effects benchmark for inhalation (or ambient air) is available for lead. Therefore, a hazard quotient was calculated by comparing the maximum estimated air concentration of 9E-10 $\mu g/m^3$ (Table 10) to the National Ambient Air Quality Standard for lead, 1.5 $\mu g/m^3$. In addition the maximum offsite soil lead concentration of 1E-08 mg/kg (Appendix B) was compared to the EPA soil health-based level of 400 mg/kg (EPA Region 9). Both the estimated soil and air lead levels are well below these screening criteria.

Table 15. Indirect exposure hazard quotient and hazard index for chemicals with liver or neurotoxin effects.

	Subsistence Farmer		Adult Resident		Child Resident		Subsistence Farmer Child	
Chemical	Liver	Neuro	Liver	Neuro	Liver	Neuro	Liver	Neuro
2,4-Dinitrotoluene		1E-04		4E-05		2E-04		8E-04
2,6-Dinitrotoluene		2E-04		7E-05		3E-04		2E-03
Mercury		3E-04		3E-07		4E-06		a
Di(n)octyl phthalate	1E-09		4E-10		8E-10		a	
Pentachloronitrobenzene	3E-08		8E-09		5E-08		a	
Pentachlorophenol	1E-09		2E-10		1E-09		a	
Total Hazard[b] Index	**3E-08**	**5E-04**	**9E-09**	**7E-05**	**5E-08**	**3E-04**	a	**2E-03**

a. Only those chemicals which accounted for greater than 99% of the total hazard quotient were evaluated for this scenario (see Table 14).

b. The total hazard index includes only the nitroaromatic PIC with the highest hazard quotient (see Section 2).

6.4 Radionuclides

Radionuclide emissions were evaluated for lifetime excess cancer risk using: (1) the maximum annual dose from ICPP main stack emissions calculated in the 1997 INEEL National Emission Standards for Hazardous Air Pollutants (NESHAPS) dose assessment, (2) current EPA risk factors for morbidity (cancer incidence) (EPA 1994e), and (3) conservative exposure durations of 40 years for the subsistence farmer, 30 years for the adult resident, and 6 years for the child resident and subsistence farmer child scenarios.

The INEEL annual NESHAPS dose assessment evaluates the maximum annual effective dose equivalent (EDE) to any potential offsite residence, office, or school from all INEEL radionuclide emissions. Effective dose equivalent is a risk-weighted sum of the organ doses in the body (EPA 1989).

In 1997, the combined emissions from the ICPP main stack (including those from NWCF) resulted in a maximum calculated annual EDE of 0.0316 mrem to any potential offsite receptor.[a] For 1997 and

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[a] LMITCO letter from S.K. Zohner to J.P. Law, *^{129}I CORRECTION TO THE 1996 RADIOACTIVE NESHAP REPORT FOR THE INEEL – SKZ-05-98*, July 28, 1998.

which is near the maximum impact location determined in the SLRA air modeling (see Section 3.3 Receptor Information).

The NESHAPS dose assessment provides a conservative assessment of the maximum potential EDE that could occur through direct inhalation, ingestion of contaminated food products, external exposure from ground surface deposits, and air immersion (submersion). These pathways have been demonstrated to account for the vast majority of doses to individuals who may be exposed to airborne releases of radionuclides (EPA 1989). The exposure pathway models used in the NESHAPS dose assessment have been compared to those in the combustion guidance and were determined to produce more conservative (higher predictions of) media concentrations and human intakes (Abbott 1997).

The emissions used in the annual NESHAPS dose assessment are obtained from a combination of EPA-approved stack monitoring as reported in the INEEL Radioactive Waste Management System (RWMIS) database and conservative calculations for volatile radionuclides that are likely to be released but are at less than instrument detection limits. In 1997, emissions of ^{129}I (0.106 Ci) accounted for 99% of the calculated effective dose equivalent (EDE) (0.0316 mrem) from the ICPP main stack, which is a cancer risk-weighted sum of the organ doses. The vast majority of this EDE (98.6%) was through the ingestion pathway. Tritium (^{3}H) emissions (144 Ci) accounted for most of the remaining EDE (3.2E-04 mrem). A summary of the 1997 NESHAPS results for the INEEL is given below:

Nuclide	Emission Rate (Ci/yr)	Annual Dose (mrem/yr)	Percent of Total Dose and Risk
I-129	1.06E-01[a]	3.16E-02	98.8%
H-3	1.32E+02	3.21E-04	1.0%
Ba-137m	2.44E-03	3.14E-05	0.1%
Cs-137	2.44E-03	1.73E-05	0.1%
C-14	2.94E-02	7.72E-06	0.0%
Pu-238	4.98E-06	7.56E-06	0.0%
Sr-90	3.13E-04	7.01E-06	0.0%
Pu-239	5.65E-07	9.28E-07	0.0%
Y-90	3.13E-04	2.24E-07	0.0%
Ru-106	6.34E-05	2.21E-07	0.0%
Cs-134	6.18E-06	1.08E-07	0.0%
Rh-106	6.34E-05	3.59E-08	0.0%
Sb-125	1.03E-05	3.39E-08	0.0%
Co-60	1.10E-06	3.23E-08	0.0%
Eu-154	9.52E-07	1.89E-08	0.0%
Te-125m	2.58E-06	1.29E-09	0.0%
Total	1.32E+02	3.20E-02	100.0%

The vast majority (99.4%) of the organ dose (dose equivalent) from ^{129}I occurs in the thyroid organ. Lifetime excess cancer incidence risk for the total body can therefore be calculated by:

1. Dividing the thyroid organ dose equivalent (1.0 mrem) by a quality factor of 1 (for beta, gamma radiation) and a conversion factor (1 mrad/1000 rad) to obtain absorbed dose (1.0E-03 rad),

2. Multiplying the absorbed dose by the EPA (1994e) cancer incidence risk factor for the thyroid (3.21E-05 risk/rad) to obtain annual risk (3.24E-08),

3. Multiplying the annual risk by the exposure durations for the subsistence farmer, adult, and child scenarios (40, 30, and 6 years respectively) to obtain lifetime risks (1.3×10^{-6} for the subsistence farmer, 9.7×10^{-7} for the adult and 2.0×10^{-7} for the child).

6.4 Human Health Impacts—Conclusions

Tables 16 and 17 summarize the SLRA cancer risk estimates and noncarcinogenic hazard index estimates. The total cancer risk estimate for the inhalation route of exposure for any offsite scenario is 2 × 10^{-7} (see Table 9). The total inhalation cancer risk estimates for both onsite scenarios (7 × 10^{-8} for the herdsman; 2 × 10^{-8} for the worker) are less than this value because these receptors have shorter residency times times at their work locations and because of the effects of the elevated plume height at receptor locations that are closer to the stack. The total cancer risk estimate for the indirect exposure is 3 × 10^{-8}, 1 × 10^{-10}, 5 × $10^{-10'}$, and 3 x 10^{-8} for the subsistence farmer, adult resident, child resident, and subsistence farmer child respectively (see Table 13). The total indirect cancer risk for the onsite herdsman scenario (1.9 × 10^{-8}) is less than the subsistence farmer and subsistence farmer child risks for the same reasons cited above. The highest total (direct plus indirect) excess cancer risk estimate for any scenario is 2 × 10^{-7}. The maximum lifetime excess cancer risk estimate for releases of radionuclides is 1 x 10^{-6}, which almost enitirely due to ingestion of I^{129}. The risk estimates for all scenarios are less than the EPA screening criterion of 1 x 10^{-5}.

The noncarcinogenic hazard index (irrespective of specific toxic effects) for the inhalation route of exposure for all offsite scenarios is 0.09 (see Table 10). The inhalation hazard index for the onsite herdsman scenario (0.09) is the same as the offsite scenarios. The inhalation hazard index for the onsite worker is less (0.04) because of the effects of the elevated plume height at receptor locations that are closer to the stack. The indirect exposure hazard indices for the offsite scenarios (irrespective of specific toxic effects) are 0.002, 0.0007, 0.003, and 0.01 for the subsistence farmer, adult resident, child resident, and subsistence farmer child, respectively (see Table 14). The indirect hazard index for the onsite herdsman scenario (0.0038) is less than the maximum indirect hazard index for the offsite scenarios. The biggest contributor to both the direct and indirect hazard indices is 1,3-dinitrobenzene (PIC). However, the hazard index estimates for all of the nitroaromatic PICs are very conservative because the emission rate calculations assumed 100% of the unburned fuel PIC precursors formed each single compound (see Section 2). All noncarcinogenic hazard indices are well below the EPA screening criterion of 0.25.

The results of this SLRA demonstrate that NWCF emissions calculated from best-available process knowledge (including stack gas measurements of mercury) and conservative assumptions would result in maximum onsite and offsite health impacts that are less than EPA-established criteria for operation of a combustion facility. Additional analyses may be performed in the future if: (1) results from emissions testing scheduled for early 1999 indicate that the emissions evaluated in this SLRA are not conservative, and (2) DOE decides to continue operation of the NWCF in the Idaho High Level Waste Environmental Impact Statement, scheduled to be decided by June 1, 2000.

Table 16. Summary of cancer risk estimates for SLRA.

	Total Excess Cancer Risk EPA screening criterion is **1E-05**		
	Direct	Indirect[a]	Total[b]
All chemicals	2E-07	3E-08	2E-07
Worst metal	2E-12 (beryllium)	3E-14 (beryllium)	
Worst non-metal	2E-07[c] (pentachloronitrobenzene-PIC)	2E-08 (2,3,7,8-TCDD)	
Radionuclides	7E-09	1E-06	1E-06

a. Highest value from the following scenarios: subsistence farmer, subsistence farmer child, adult resident, child resident, onsite worker, and onsite herdsman.

b. Because of the differences in environmental modeling methodologies and the basis for risk factors, cancer risk from radionuclides and non-radioactive contaminants were reported separately and not summed together.

c. Estimate is very conservative because it assumes 100% of the nitroaromatic PICs from the burning of the fuel forms this one compound.

Table 17. Summary of noncarcinogenic hazard index estimates for SLRA.

	Hazard Index EPA screening criterion is **0.25**		
	Direct	Indirect[a]	Total
All chemicals	0.09	0.01	0.10
Worst metal	0.0003 (mercury)	0.0003 (mercury)	
Worst non-metal	0.09[b] (1,3-dinitrobenzene-PIC)	0.01[b] (1,3-dinitrobenzene-PIC)	
Liver	0.0002 (pentachloronitrobenzene-PIC)	0.00000005 (pentachloronitrobenzene-PIC)	
Neurotoxin	0.009[b] (2,6-dinitrotoluene-PIC)	0.002[b] (2,6-dinitrotoluene-PIC)	

a. Highest value from the following scenarios: subsistence farmer, subsistence farmer child, adult resident, child resident, onsite worker, and onsite herdsman..

b. Estimate is very conservative because it assumes 100% of the nitroaromatic PICs from the burning of the fuel forms this one compound.

7. UNCERTAINTY

In this risk assessment, methodologies are employed to evaluate the risks to human health and the environment from NWCF emissions. It should be recognized that such risk assessment methodologies represent an inexact science, and uncertainties are associated with their application. Uncertainties arise because of the need to make assumptions and inferences to compensate for the unknowns or lack of data. In this SLRA, conservative assumptions and methods were employed to adequately bound any potential health impacts that might actually occur as a result of these uncertainties. Uncertainties associated with evaluating the impacts on ecological receptors are addressed in Section 8. The following text summarizes the major uncertainties in the human health portion of this SLRA.

7.1 Source Term Uncertainty

Two major sources of uncertainty in the source term development are selection of the chemical species emitted to the stack and the development of accurate emission rates. Because calculation of the risks and hazards quotients are directly proportional to the emission rates used in the exposure assessment, best or conservative estimates of actual emission rates must be used.

The emission rate estimates for metals used in this SLRA are considered to be conservative (higher than what would be likely observed) because they are based on the following assumptions:

1. For each metal, the maximum concentration measured in any of the seven tanks with retrievable waste was used. To account for tanks that do not have sample analyses for all thirteen metal constituents (see Table 2, Appendix A), the higher of the concentrations in the analyzed tank(s) or the empty WM-188 tank (generally highest in concentration from all the sampled tanks) plus one standard deviation was assumed.

2. No credit was taken for dilution of the feed concentrations with aluminum nitrate (added for proper calcining chemistry), which would reduce the metal feed rates by at least a factor of two.

3. Conservative assumptions were made for off gas partitioning of semivolatiles (e.g., $PbO/PbCl_2$)

4. For non-carcinogenic metals, the total inventory was assumed to be fed over an accelerated 7-year calcining schedule (1999–2005) which is not considered likely at this time. This results in a factor of two higher maximum annual emission rate than that which would occur if the existing inventories of waste are calcined over the more likely 14-year schedule (to 2012).

5. Mercury emission rate estimates are based on long-term activated carbon filter analysis from previous calcining campaigns and are likely to be the most accurate metal emission rate used in this assessment. However, based on requests from EPA Region 10, an upper-bound emission rate was also evaluated in the ecological risk assessment (Section 8) which assumed that 10% of the feed mercury unaccounted for in either the scrub solution or the stack offgas also went up the stack. This likely overestimates the actual stack emission rate of mercury by a factor of four.

There is a significant amount of uncertainty associated with the PICs that may be formed in the NWCF off gas. PICs are formed by incomplete combustion of organic compounds in the feed or fuel and reactions with other compounds or compound fragments that are present (Dempsey and Oppelt 1993). Actual PIC emission rates in the NWCF have not been quantified in this SLRA because previous attempts to accurately measure their low levels in the highly acidic NWCF off gas have not been successful and because they are difficult or impossible to actually predict (Dempsey and Oppelt 1993). Of particular concern in the NWCF are the benzene and toluene PIC precursors in the kerosene fuel and the chlorine in the off gas (680 kg/year, 0.02 g/s as HCl) which can result in toxic chlorinated organic species. Although there is significant uncertainty regarding which PIC species are actually emitted, the dioxins/furan, nitroaromatic, and PCB emissions calculated in Section 2 provide a reasonably conservative estimate of the maximum potential *impact* (risk or hazard index) from any combination of PICs that could possibly be formed.

The emission rates estimated for organic chemicals are believed to be conservative for several reasons. First, most of the trace organic constituents detected in the feed are assumed to be released to the atmosphere with no destruction and removal efficiency. For 2,3,7,8-TCDD, a conservative emission rate was calculated using emission factors developed from municipal waste combustors with much higher dioxin precursor feed rates. Also, coplaner PCBs that might be formed in the offgas were calculated using a published EPA emissions factor from a combustion unit with much higher PIC precursor (chlorine and organic material) feed rates. Nitroaromatic PIC production was calculated assuming 100% reaction of all the aromatic precursors in a conservative estimate (5%) of the unburned kerosene fuel with all of the chlorine in the off gas. Finally, no credit was taken for removal of these PICs in the off-gas treatment system, which operates below the boiling point of the semi-volatiles of concern. These factors are judged to result in significant overestimates of all organic emission rates.

7.2 Air Modeling Uncertainty

In general, models are imperfect mathematical tools that attempt to simulate highly complex environmental phenomena. Therefore, significant uncertainty usually exists in modeling output for both air concentration and ground deposition rate. These uncertainties result from imperfect model structures and inaccuracies or natural variability in the model input parameter values. Although ISC3 is the preferred EPA air dispersion model for this SLRA and for other regulatory compliance issues, ISC3 is subject to the same uncertainties.

A major source of model structural uncertainty results when the "straight-line" Gaussian plume model algorithm is applied in ISC3 for large offsite receptor distances at the INEEL. The Gaussian plume model assumes that atmospheric dispersion conditions (wind direction, wind speed, and turbulence) do not change between the release point and any receptor location over the time interval of the meteorological data (1-hour). Offsite distances from the ICPP are large (e.g., 15 to 20 km), and dispersion conditions will likely change over the time required to transport the contaminants to receptors (2-hour average). However, published validation studies have indicated that the Gaussian plume model is reasonably reliable for estimating the longer time-averaged (e.g., annual) concentrations and relatively flat terrain conditions evaluated in this SLRA. Errors in the highest estimated concentrations of +10 to 40% are found to be typical (EPA 1995b). The longer plume transport times required at the INEEL increase this uncertainty somewhat.

A related major source of uncertainty exists in the prediction of model output at specific receptor locations. Because of shifting winds, contaminants may follow trajectories that are not straight, which may cause model predictions at specific downwind locations, especially over the large INEEL distances, to be highly uncertain. Adding to this spatial prediction problem, is the uncertainty that exists in the meteorological data file wind vectors. Measurement or processing (time-averaging) errors of 5 to 10 degrees can result in concentration errors of 20 to 70% (EPA 1995b). Such uncertainties indicate that the precise time and location are in doubt, not necessarily that an estimated concentration does not occur.

Potential underprediction of impacts due to this spatial prediction uncertainty is avoided in this SLRA by selecting the maximum offsite air concentrations and ground deposition rate at any offsite location for use in the exposure assessment. This assumption ensures that the exposure assessment conservatively bounds any potential offsite receptor regardless of the uncertainty in wind direction. This maximum impact location occurred on the lower north slopes of Big Southern Butte (Figure 5) in uninhabited, desert shrub land about a half mile east-southeast of "Frenchman's Cabin." The particulate air concentration at Frenchman's Cabin (transient residents) and Atomic City (nearest continually inhabited location) was calculated to be less than half of the maximum impact location value. Therefore, the air modeling results used in the exposure assessment are likely to significantly over predict the actual impacts that might occur to any real resident.

7.3 Exposure Assessment Uncertainty

Exposure scenario assumptions also may contribute to the uncertainties of the study. All of these assumptions would likely produce upper-bound estimates of the potential risks to actual receptors that might be exposed in the area. Some of these conservatisms include continuous 30 to 40-year exposure for the adult scenarios, the assumption that food products are produced at the point of maximum air concentration and ground deposition rate, and, for the subsistence farmer and child, the assumption that 100% of their food products are grown at the point of maximum ground deposition rate.

The onsite herdsman scenario, which was added to this revision, assumes the same continuous contaminated food (meat, milk, and produce) ingestion rates as the high-end scenario, the subsistence farmer. This produces estimates of impact from indirect pathways that are likely to be biased significantly high since the herdsman would not have food processing facilities onsite and would not consume food products that have been grown on the grazing location (especially milk and produce).

In the radionuclide exposure assessment (Section 6.4), the annual risk determined from the 1997 NESHAPS dose was multiplied by exposure durations of 40 years for the subsistence farmer and 30 years for the adult resident to obtain lifetime dose and risk. Unless the NWCF actually operates for this length of time, the lifetime risk calculated in this manner will significantly overpredict actual potential lifetime risk. This is because the vast majority of the maximum annual NESHAPS dose was due to surficial contamination of crops which can only occur while the facility is operating. Annual doses from residual activity in the soil and from root uptake after operations have ceased will be significantly less. Therefore, the assumed exposure duration assumptions (40 and 30 years) will likely overpredict lifetime risk by a factor of at least two (30 years assumed exposure/16 years maximum operations).

7.4 Toxicity Assessment Uncertainty

Many uncertainties and unknowns are associated with the toxic effects of the contaminants of concern for this study. The EPA has outlined some of these sources of uncertainty in its *Guidelines for Carcinogenic Risk Assessment* (EPA 1986). They include extrapolation from high to low doses and from animals to humans; species differences in uptake, metabolism, and organ distribution; species differences in target site susceptibility; and human population variability in diet, environment, activity patterns, and for cultural factors. Safety factors are built into the toxicity and exposure values to compensate for these sources of uncertainty, and result in a bias toward overestimating risk.

Although the risk assessment methodology contains considerable sources of uncertainty, the consistent adoption of conservative assumptions and parameter values, and adherence to EPA guideline recommendations, are considered to provide reasonably conservative estimates of the risk posed by NWCF operations.

8. NWCF SCREENING LEVEL ECOLOGICAL RISK ASSESSMENT (SLERA)

The objective of this assessment is to determine the potential for adverse effects on ecological receptor populations, including protected wildlife species, as a result of exposure to NWCF emissions.

8.1 Methods

The assessment was performed using the same basic methodology developed in the *Guidance Manual for Conducting Screening Level Ecological Risk Assessments at the INEL* (VanHorn et al., 1995), subsequently referred to as the Guidance Manual. The methodology has been applied in INEEL ERAs for various Waste Area Groups (WAGs) including the WAG 3 Comprehensive RI/BRA and RI/FS (DOE-ID, 1997, DOE-ID, 1998). The methodology was specifically designed to follow the direction provided by the *Framework for Ecological Risk Assessment* (EPA, 1992a) Ecological Risk Assessment Guidance for Superfund, Process for Designing and Conducting Ecological Risk Assessments (EPA 1997b), EPA Region 10 Supplemental Risk Assessment Guidance for Superfund (1997), and other EPA guidelines (1998b, 1991, 1992b, 1993a, 1994f). This framework divides the ERA process into three steps: problem formulation, analysis, and risk characterization.

The interactions between the stressor characteristics, the ecosystem potentially at risk, and the ecological effects are defined in the problem formulation step of the ERA (EPA, 1992a). The problem formulation phase includes in characterization of stressors (i.e., identification of the contaminants, extent and concentrations), definition of assessment and measurement endpoints, and construction of the conceptual site model (CSM) (Section 8.2).

In the analysis step (Section 8.3), the likelihood and significance of an adverse reaction from exposure to the stressor(s) were evaluated. The behavior and fate of the contaminants of potential concern (COPCs) in the terrestrial environment was presented in a general manner since no formal fate and transport modeling (other than deposition) was conducted for this assessment. The ecological effects assessment includes a hazard evaluation and dose-response assessment, including a comprehensive review of toxicity data for contaminants to identify the nature and severity of toxic properties. Dose receptors from surface deposition of NWCF emissions were developed and used to assess potential risk to receptors. Because no dose-based toxicological criteria exist for ecological receptors, it was necessary to apply appropriate toxicity reference values (TRVs) for the contaminants and functional groups at INEEL.

The risk characterization step includes two primary elements (EPA, 1992a). The first element is the development of an indication of the likelihood of adverse effects to ecological receptors. The second element is the presentation of the assessment results in a form that serves as input to the risk management process. To determine whether there is any indication of risk due to the contaminant concentrations a screening against INEEL specific ecologically-based screening levels (EBSLs) was performed. Exceedence of the EBSL concentration was used as an indicator of potential effects. The risk characterization section of this assessment is presented in Section 8.4.

A comparison of the screening level ecological risk assessment (SLERA) approach used in the Risk Assessment Work Plan for the Mixed Waste Facility RCRA/TSCA permit application (ATG, 1998) to the INEEL methods and parameters was performed. The exposure calculations are similar with the exception to the use of the functional groups at the INEEL.

8.2 Problem Formulation

Primary elements of the problem formulation step for the NWCF ERA are described in the following sections. The problem formulation includes the definition of contaminant extent and concentrations (Section 8.2.1), ecosystem characterization (Section 8.2.2), identification of pathways and routes of exposure (Section 8.2.3), presentation of the conceptual site model (CSM) (Section 8.2.4), and definition of assessment endpoints (Section 8.2.5).

8.2.1 Contamination Extent and Concentration

Contaminant-specific soil concentrations (mg/kg) for the SLERA were calculated using ISC3-modeled deposition rates (wet + dry) and the soil concentration (Sc_{tc}) equation given in EPA 1994a (Appendix B, Table B-3). This equation calculates the maximum 1-year average soil concentration over the entire deposition period (assumed to be 16 years for NWCF) and provides a conservative measure to assess both maximum short-term and long-term (chronic) impacts. The use of the maximum 1-year soil concentration will likely overestimate ecosystem impacts that require longer chronic exposure. For the SLERA, all of the NWCF contaminants with calculated emission rates (Section 2) and soil transport parameters published in EPA (1998a) were assessed.

Soil concentrations vary spatially, ranging from a maximum close in to the stack (depending on stack parameters and particle settling properties) to increasingly lower levels at greater distances from the stack. For initial screening purposes, the maximum contaminant-specific soil concentration was used in the SLERA which was determined by ISC3 modeling to be immediately adjacent to the INTEC facility fenceline (southwest and northeast). This maximum soil concentration will overestimate impacts to biota over the vast majority of the plume impact area, especially if population-level impacts are considered. Therefore, an "impact-area-averaged" soil concentration was also assessed which provides a more appropriate estimate of soil concentrations at locations beyond the INTEC fence. This area of impact was determined by integrating the ISC3-modeled deposition rate (wet and dry) within the 5%-of-maximum deposition rate isopleth and then dividing by the area encompassed by that isopleth (Figure 10). This gives an average soil concentration in the area where most of contaminants have been deposited. The average integrated concentration within the 5%-of-maximum isopleth was calculated using Surfer® for Windows 3D surface mapping software.[a] For vapor deposition (mercury and organics), the average deposition rate was calculated to be 7% of the maximum point value near the INTEC fence line and 3.4 times the maximum off-site deposition rate. For particulate deposition, the average deposition rate was calculated to be 10% of the maximum point value near the INTEC fence line and 1.6 times the maximum off-site soil concentration. Contaminant-specific soil concentrations are listed in Table 18.

Soil concentrations for mercury were calculated by assuming 48.2% of the total mercury emissions (1.5E-03 g/s, from Section 2) are deposited locally, in accordance with EPA (1998a) guidance. Soil concentrations for radionuclides were not assessed for ecological receptors because it is assumed that, for low levels of radioactivity, the human population (residential scenario) is for the most sensitive receptor (ATG 1998).

8.2.2 Ecosystem Characterization

The INEEL is located in a cool desert ecosystem characterized by shrub-steppe vegetative communities typical of the northern Great Basin and Columbia Plateau region. The surface of the INEEL is relatively flat with several prominent volcanic buttes and numerous basalt flows that provide important habitat for small and large mammals, reptiles, and some raptors. The shrub-steppe communities are dominated by sagebrush (*Artemisia* spp.) and provide habitat for sagebrush community species such as

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[a] Golden Software, Inc., 809 14th Street, Golden, CO 80401-1866 (303-279-1021).

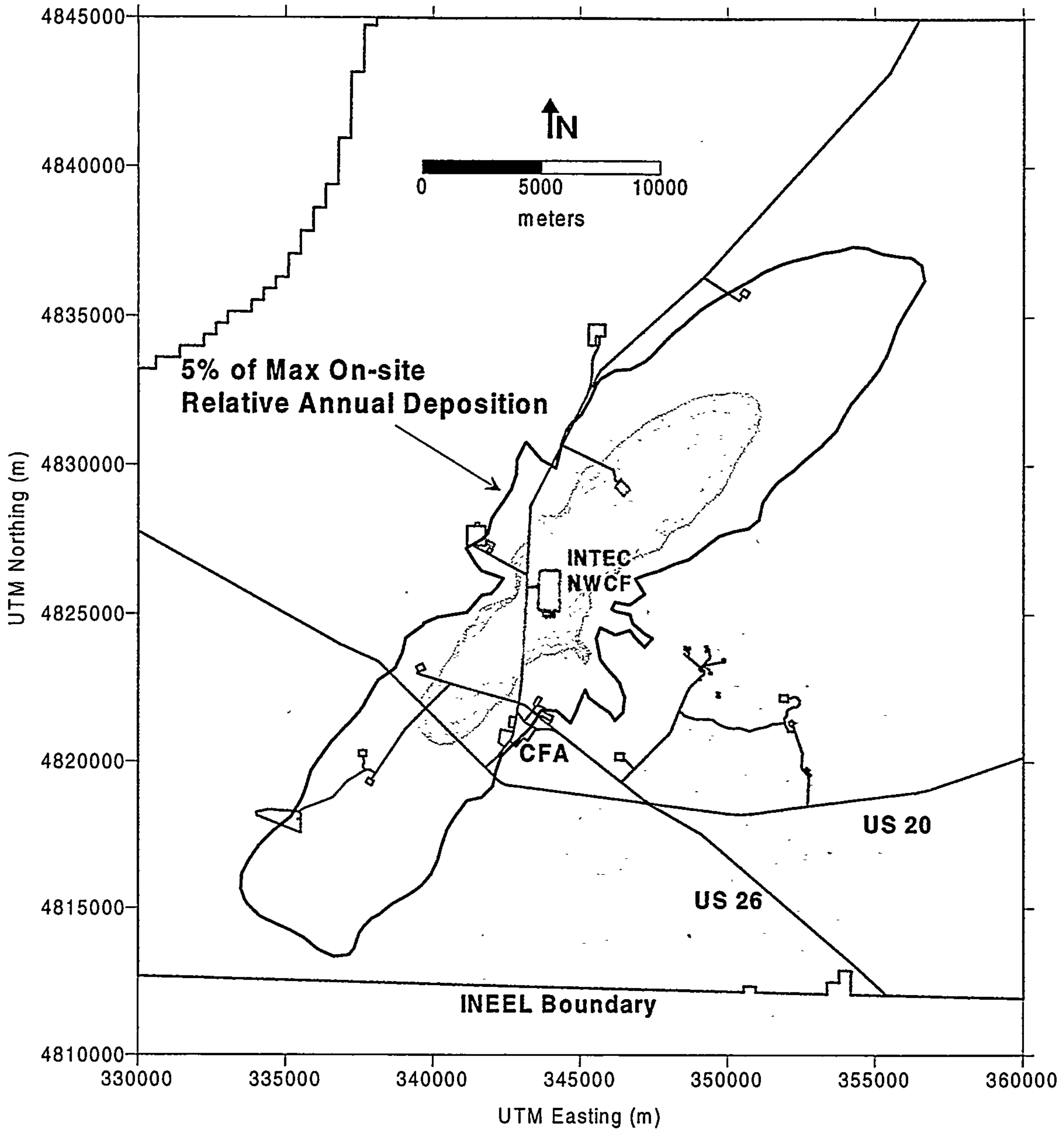

Figure 10. In addition to initial screening using the maximum soil concentration (located adjacent to the INTEC fence line), ecological impacts were also evaluated using an "impact area-averaged" soil concentration which was determined by integrating the areal deposition rate ($g/m^2/y$) within the 5% of maximum deposition rate isopleth and then dividing by the area encompassed by that isopleth.

Table 18. Surface soil concentrations (mg/kg) from NWCF contaminant emissions. Concentrations are calculated from ISC3 modeled wet and dry deposition rates over an assumed 16 year NWCF operating period and a 1-cm mixing depth, in accordance with combustion guidance soil equations.

	Maximum Soil Concentration (mg/kg)		
Metals	Max Off-site[a]	Max On-site[b]	Average[c]
Antimony (Sb)	3.41E-11	5.45E-10	5.45E-11
Arsenic (As)	1.86E-14	2.98E-13	2.98E-14
Barium (Ba)	1.83E-13	2.93E-12	2.93E-13
Beryllium (Be)	5.60E-10	8.96E-09	8.96E-10
Cadmium (Cd)	2.13E-12	3.41E-11	3.41E-12
Chromium (Cr)	8.59E-14	1.37E-12	1.37E-13
Lead (Pb)	1.02E-08	1.64E-07	1.64E-08
Mercury (Hg^{+2})[d]	5.78E-05	2.83E-03	1.96E-04
Mercury (methyl)[e]	1.16E-06	5.66E-05	3.92E-06
Nickel (Ni)	3.72E-13	5.95E-10	5.95E-11
Selenium (Se)	1.79E-09	2.87E-08	2.87E-09
Silver (Ag)	1.62E-16	2.59E-15	2.59E-16
Thallium (Tl)	9.87E-09	1.58E-07	1.58E-08
Aluminum (Al)[f]	1.12E-05	1.79E-04	1.79E-05
Manganese (Mn)[f]	5.62E-06	8.99E-05	8.99E-06
Zinc (Zn)[f]	3.31E-06	5.30E-05	5.30E-06
Organics (feed)			
1,1,1-Trichloroethane	2.18E-15	1.07E-13	7.43E-15
1,1,2-Trichloroethane	7.54E-12	3.70E-10	2.56E-11
1,2,4-trichlorobenzene	1.68E-10	8.25E-09	5.72E-10
1,2-Dichloroethane	1.14E-12	5.57E-11	3.86E-12
1,4 dioxane	8.36E-09	4.10E-07	2.84E-08
2,4-Dinitrophenol	4.48E-09	2.19E-07	1.52E-08
Acetonitrile	5.34E-18	2.61E-16	1.81E-17
Aniline	8.14E-09	3.99E-07	2.77E-08
Benzene	6.00E-13	2.94E-11	2.04E-12
Benzo(a)pyrene	3.44E-05	1.69E-03	1.17E-04
Bromoform	4.48E-11	2.20E-09	1.52E-10
Butylbenzylphthalate	1.63E-09	8.01E-08	5.56E-09
Carbon disulfide	1.85E-11	9.05E-10	6.28E-11

Table 18. (continued).

Metals	Maximum Soil Concentration (mg/kg) Max Off-site[a]	Max On-site[b]	Average[c]
Carbon tetrachloride	6.24E-13	3.06E-11	2.12E-12
Chlorobenzene	4.09E-12	2.00E-10	1.39E-11
Chloroform	1.21E-12	5.92E-11	4.10E-12
Diethylphthalate	3.45E-09	1.69E-07	1.17E-08
Di-n-butylphthalate	1.43E-09	6.99E-08	4.85E-09
Di-n-octylphthalate	8.39E-07	4.11E-05	2.85E-06
Formaldehyde	1.64E-13	8.05E-12	5.59E-13
Formic acid	3.58E-09	1.76E-07	1.22E-08
Methyl ethyl ketone	1.06E-10	5.20E-09	3.61E-10
Methylene chloride	2.72E-13	1.33E-11	9.26E-13
Naphthalene	4.48E-10	2.20E-08	1.52E-09
Pentachlorophenol	1.35E-06	6.60E-05	4.58E-06
Phenol	7.00E-08	3.43E-06	2.38E-07
Pyridine	1.10E-10	5.41E-09	3.75E-10
Tetrachloroethylene	1.13E-12	5.52E-11	3.83E-12
Toluene	1.37E-12	6.73E-11	4.67E-12
Trichloroethylene	8.74E-13	4.28E-11	2.97E-12
<u>Organics (PICs)</u>			
2,3,7,8-TCDD TEQ	1.62E-09	7.95E-08	5.52E-09
1,3-Dinitrobenzene	2.75E-03	1.35E-01	9.35E-03
Nitrobenzene	8.39E-05	4.11E-03	2.85E-04
2,4-Dinitrotoluene	8.55E-03	4.19E-01	2.91E-02
2,6-Dinitrotoluene	1.02E-02	4.99E-01	3.46E-02
Pentachloronitrobenzene	4.28E-06	2.10E-04	1.46E-05

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a. South of the INEEL near Big Southern Butte. This is the location where maximum human health impacts were evaluated (section 3).

b. Immediately adjacent to the SW and NE INTEC fence line.

c. An integrated average within the 5% of maximum deposition rate isopleth.

d. Based on a conservative best-estimate of the Hg emission rate (3.7 % of feed). Upper-bound soil concentrations are a factor of 4.3 higher based on the ratio of the upper-bound emissions factor (13%) to the best-estimate emissions factor (3%).

e. Assumed to be 2% of the total Hg (EPA 1998). Upper-bound soil concentrations are a factor of 4.3 higher.

f. Metal emissions that may be present based on preliminary (4/99) offgas sampling data. Soil concentrations were calculated using emission rates from the highest of 3 sample results and fate and transport parameters for zinc (EPA 1998).

sage grouse *(Centrocercus urophasianus),* pronghorn antelope *(Antilocapra americana),* and sage sparrows *(Amphispiza belli).* Other communities include rabbitbrush *(Chrysothamnus* spp.), grasses and forbs, salt desert shrubs *(Atriplex* spp.), and exotic or weed species. Juniper woodlands are located near the buttes and in the northwest portion of the INEEL. The juniper woodlands provide important habitat for raptors and large mammals. Limited riparian communities exist on the INEEL along intermittently flowing waters of the Big Lost River and Birch Creek drainages. Stream flow that reaches the INEEL flows to the Big Lost River playa or the Birch Creek playa, in which water is lost to evaporation and infiltration.

8.2.2.1 Abiotic Components. The INTEC facility is located on the alluvial plain of the Big Lost River. The main channel of the Big Lost River passes within 100m of the northwest corner of INTEC facility fences along its route to the Sinks (approximately 18 km [11 mi] to the north).

The topography surrounding the facility is relatively flat. The soils surrounding the facilities are comprised primarily of Typic-Camborthids-Typic Calciorthids (TCC), Typic Torrifluvents (TTF) and Malm-Bondfarm-Matheson complex soils (Figure 11).

Both TCC and TTF soils are alluvium, which are deposited by the Big Lost River. TTF soils are somewhat newer than TCC soils and are found in closer proximity to the river. The TCC soils are loams or silty loams over gravelly or sandy loams, and the surface is frequently hardened due to alkaline conditions. The TTF soils are also loams or sandy loams over gravelly subsoils. However, the gravels associated with TTF soils are finer and more frequently found on the surface than those of TCC soils. Both soil types are often dry and generally alkaline and saline, impermeable, erodible and have little organic accumulation in the upper layer (Olson et al. 1995). Spring thaws and intense rainstorms may lead to significant soil erosion in these soil types.

The Malm-Bondfarm-Matheson complex consists of moderately deep, well drained, sandy-loam soils on basalt plains. A calcic horizon is present at approximately 30 cm (12 in.). Permeability of these soils is moderately rapid, and the erosion hazards for these soils are slight to moderate (Olson et al. 1995).

8.2.2.2 Biotic Components. Sagebrush-steppe habitat on the INEEL supports a number of species including sage grouse, pronghorn elk (*Cervus elaphus*), and waterfowl (all important game species). Grasslands provide habitat for species such as the western meadowlark (*Sturnella neglecta*) and mule deer (also a game species). Rock outcroppings support species such as bats, woodrats (*Neotoma cinerea*), and cottontail (*Sylvilagus nuttalli*). No areas of critical habitat as defined in 40 CFR 300 are known to exist within the assessment area.

The flora and fauna that exist in the assessment are representative of those found across the INEEL and are described in the following subsections. Flora was determined using a vegetation map constructed for the INEEL using Landsat imagery and field measurements from vegetation plots (EG&G Idaho, 1993). Fauna was characterized using a 1986 vertebrate survey performed on the INEEL (Reynolds et al., 1986) and data collected subsequent to that survey. The flora and fauna present in the assessment area have not been verified with a comprehensive field survey. However, information presented here is supported by previous field surveys and observations described in the WAG 3 ERA conducted as part of the OU 3-13 Comprehensive RI/FS (DOE 1997).

8.2.2.2.1 Flora—The 15 INEEL vegetation cover classes defined using Landsat imagery data (Kramber et al., 1992) have been combined into eight cover classes applied for INEEL ERAs (VanHorn et al., 1995). The vegetation mapped in the NWCF assessment area is shown in Figure 12. Six of the eight vegetation cover classes are represented, including sagebrush-steppe on lava, sagebrush/rabbitbrush, grassland, salt desert shrub, playa-bareground/disturbed, and juniper. The species composition for each

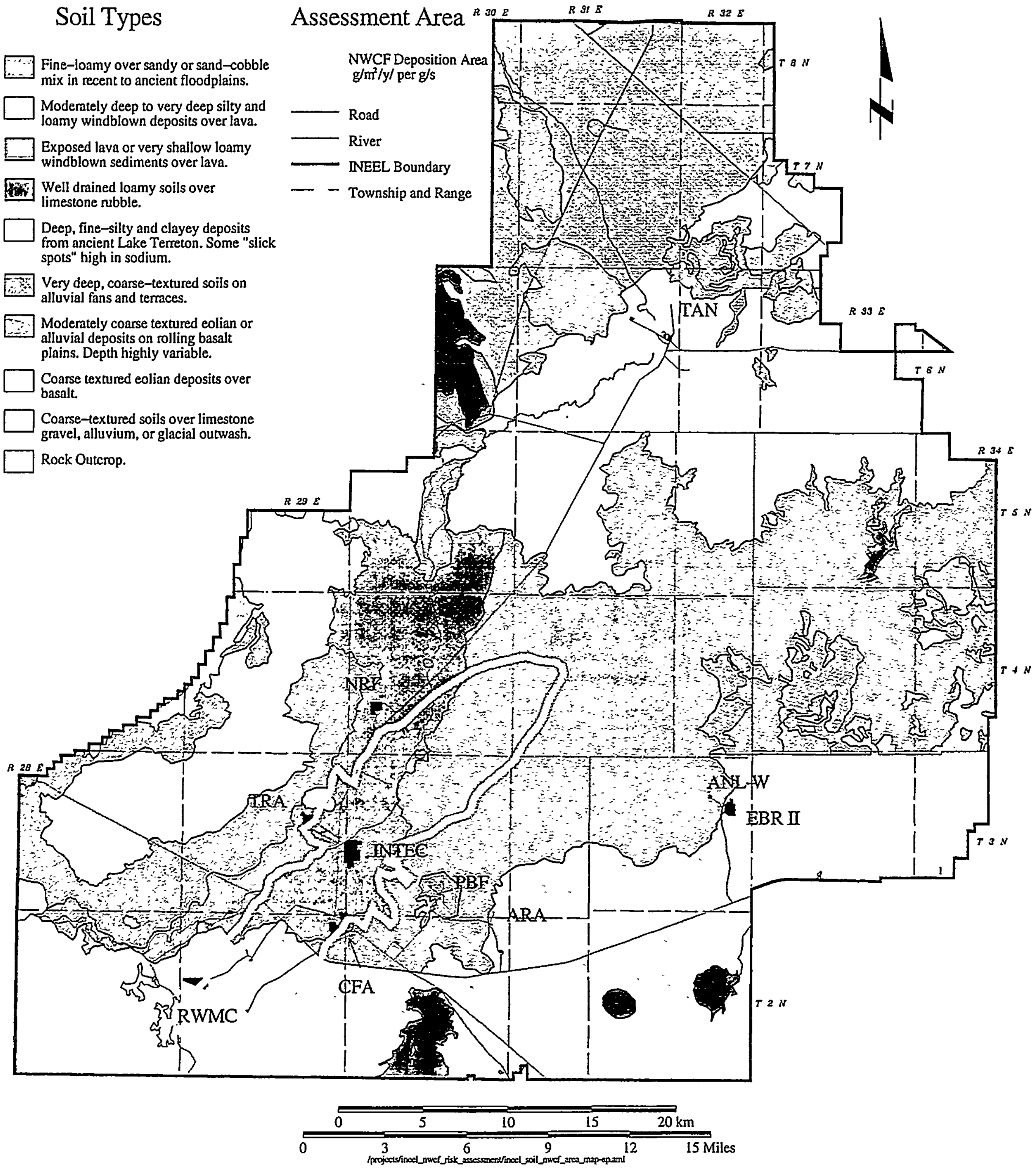

Figure 11. Soil types in the NWCF assessment area.

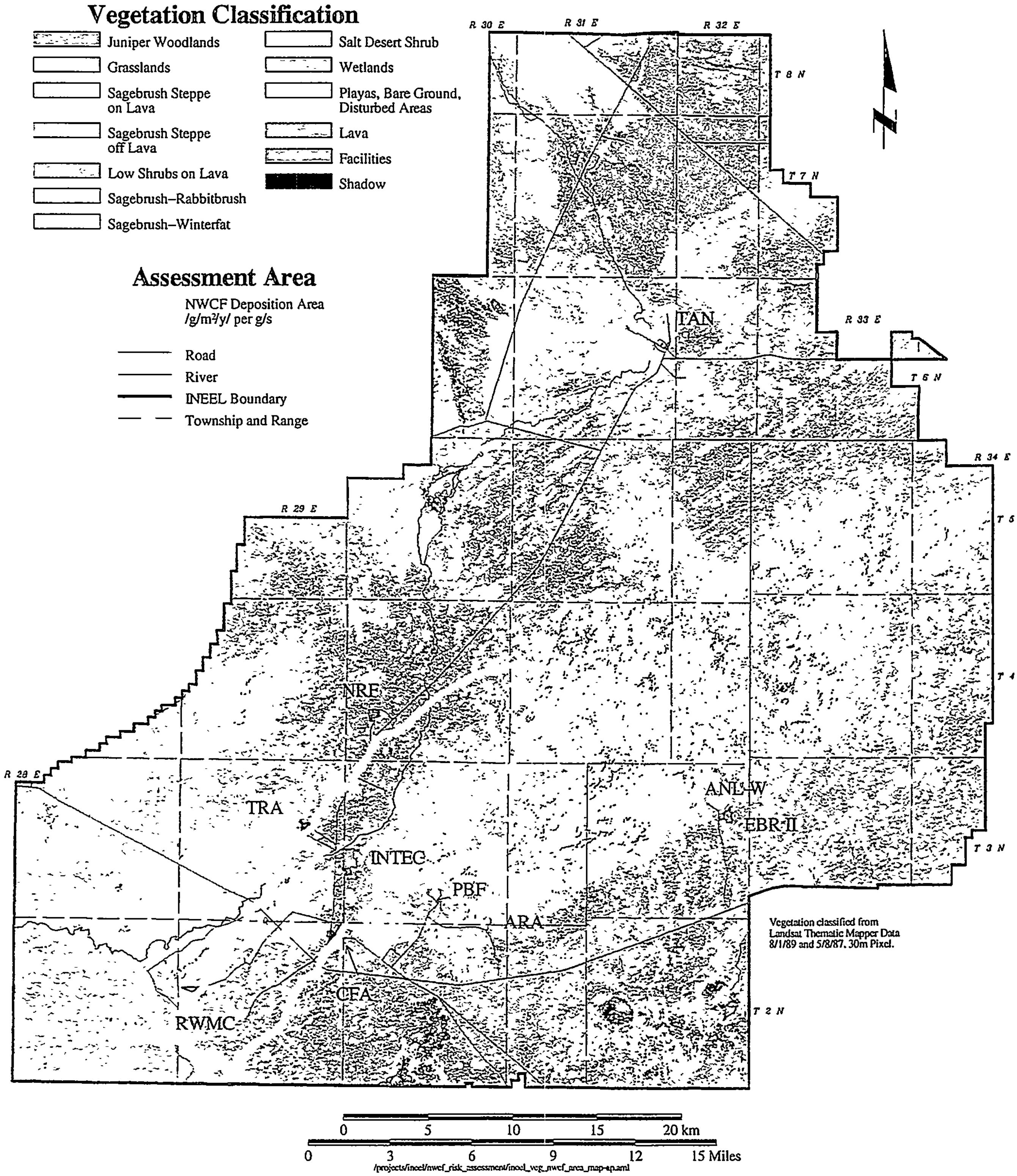

Figure 12. Vegetation cover types in the NWCF assessment area

of these classes is summarized on Table 19. Sagebrush-steppe on lava and sagebrush/rabbitbrush are the two predominant vegetation types found in the assessment area. The dominant vegetation species within these two communities is Wyoming big sagebrush (*Artemisia tridentata* spp. *wyomingensis*). Grasslands present in the area are comprised primarily of wheat grasses (*Agropyron* spp., *Elymus* spp). Table 20 summarizes the vegetative composition within the assessment area.

8.2.2.2.2 Fauna—A comprehensive list of fauna potentially present within the assessment area is presented in Appendix G. The list incorporates the concept of functional grouping as described in the Guidance Manual (VanHorn et al., 1995). The functional grouping approach is designed to group similar species to aid in analyzing the effects of stressors on INEEL ecosystem components. The primary purpose for functional grouping is to apply existing data from one or more species within the group to assess the risk to the group as a whole. Functional groups are used to perform a limited evaluation of exposures for all potential receptors and provide a mechanism for focusing subsequent analyses on receptors that best characterize potential contaminant effects. Species characteristics including trophic level, breeding, and feeding locations were used to construct functional groups for INEEL species. Individual groups were assigned a unique identifier consisting of a one- or two-letter code to indicate taxon (A = amphibians, AV = birds, M = mammals, R = reptiles, I = insects), and a three-digit code derived from the combination of trophic category and feeding habitats. For example, AV122 represents

Table 19. Species composition for NWCF assessment area vegetation classes.

Vegetation Cover Class	INEEL Vegetation Cover Class	Dominant Species
Grasslands	Steppe Basin Wildrye Grassland	*Leymus cinereus* *Descurainia sophia* *Sisymbrium altissimum* *Elymus lanceolatus* *Artemisia tridentata* ssp. *wyomingensis* *Elymus elymoides* *Chrysothamnus viscidiflorus*
Sagebrush/Rabbitbrush	Sagebrush-steppe off lava Sagebrush-winterfat Sagebrush-rabbitbrush	*Artemisia tridentata* ssp. *wyomingensis* *Chrysothamnus viscidiflorus* *Bromus tectorum* *Sisymbrium altissimum* *Achnatherum hymenoides*
Salt desert shrubs	Salt desert shrub	*Atriplex nuttallii* *Atriplex canescens* *Atriplex confertifolia* *Krascheninnikovia lanata*
Sagebrush-steppe on lava	Sagebrush-steppe on lava	*Artemisia tridentata* ssp. *wyomingensis* *Achnatherum hymenoides* *Chrysothamnus viscidiflorus*
Playa-bare ground/disturbed areas	Playa-bare ground/gravel borrow pits old fields, disturbed areas, seedings	*Kochia scoparia* *Salsola kali* *Artemisia tridentata* ssp. *wyomingensis* *Chrysothamnus viscidiflorus*

Table 20. Summary of vegetation in the NCWF assessment area

Vegetation cover class	Area (hectares)	Area (acres)	Percent cover (%)
Juniper	<1	3	<1
Grassland	805	1,990	9.4
Sagebrush/Rabbitbrush	6,400	15,900	37.1
Salt Desert Shrub	43	106	<1
Sagebrush-Steppe on lava	8,400	20,800	48.2
Playa-bareground/ disturbed areas	100	250	1.5
Facilities	300	730	3.8
Totals	16,050	39,800	100.00

the group of seed-eating (herbivorous) bird species whose feeding habitat is the terrestrial surface and/or understory. The trophic categories (first digit in three-digit code) are as follows: 1 = herbivore, 2 = insectivore, 3 = carnivore, 4 = omnivore, and 5 = detrivore. The feeding habitat codes (second and third digits in three-digit code) are derived as follows:

1.0 Air

- 2.0 Terrestrial
  - 2.1 Vegetation canopy
  - 2.2 Surface/understory
  - 2.3 Subsurface
  - 2.4 Vertical habitat (man-made structures, cliffs, etc.)
- 3.0 Terrestrial/Aquatic Interface
  - 3.1 Vegetation canopy
  - 3.2 Surface/understory
  - 3.3 Subsurface
  - 3.4 Vertical habitat
- 4.0 Aquatic
  - 4.1 Surface water
  - 4.2 Water column
  - 4.3 Bottom

The functional grouping methodology is described in detail in the Guidance Manual (VanHorn et al., 1995).

The list of species potentially present in the assessment area was developed by updating 1986 data on the relative abundance, habitat use, and seasonal presence of fish, amphibians, reptiles, birds, and mammals recorded on the INEEL (Reynolds et al., 1986) and communicating with INEEL researchers and personnel conducting ecological studies since 1986. Fauna that are not supported by the existing habitat or that are rare or uncommon or otherwise unlikely to be found in the assessment area were not included in the literature search for species-specific exposure and/or toxicity data. Those species are represented by the functional group with which they are associated. A complete list of species within individual functional groups, as well as those not included in the literature search can be found in Appendix G.

Species potentially present in the NWCF assessment area represent all 23 INEEL avian functional groups and 9 of 10 mammalian functional groups. Both reptilian functional groups are represented by species inhabiting the assessment area. No surface hydrology exists to support fish.

Although some population studies have been conducted for cyclic rabbit and rodent populations, several game species (e.g., pronghorn, sagegrouse), and raptors, no recent comprehensive studies have been conducted to assess either WAG-specific or INEEL-wide wildlife population status and/or trends with respect to contaminant effects.

Wildlife species present in the assessment area include birds, mammals, and reptiles that are associated with facilities, sagebrush-steppe, rock outcroppings, shrubs, and grasslands. The varying behaviors of these species include but are not limited to grazing and browsing on vegetation, burrowing and flying, and preying on insects and small mammals. If prey, such as a small mammal, becomes contaminated by ingesting contaminated soil or vegetation, and is then captured by a predator, such as a ferruginous hawk, the contamination can be taken offsite when the hawk returns to its nest to feed nestlings. Scenarios for potential exposure of fauna to NWCF contaminants are discussed in Section 8.2.3.

The flora and fauna present within the assessment area are combined into a simplified food web model. Variability in environmental conditions, such as population sizes or seasons, is not considered in this model, and a constant environment is assumed. Because aquatic (i.e., percolation and sewage treatment ponds) and terrestrial habitats are present in the area, the model includes only terrestrial species. Present at the site are decomposers, producers (vegetation), primary consumers or herbivores (e.g., rodents), secondary consumers or carnivores (e.g., snakes), and tertiary or top carnivores (e.g., raptors). These relationships were incorporated to identify direct and indirect exposure to contaminants for the CSM as discussed in Section 8.2.3. This model depicts the possible transport of NWCF contaminants through the food web.

8.2.2.2.3 Threatened, Endangered and Sensitive Species—A list of threatened and endangered (T/E) and sensitive species was compiled from the U.S. Fish and Wildlife Service (Martin 1997); the Idaho Department of Fish and Game Conservation Data Center threatened, endangered, and sensitive species for the State of Idaho (CDC 1994); and Radiological and Environmental Sciences Laboratory (RESL) documentation for the INEEL (Reynolds et al. 1986). Threatened, endangered (T/E) or sensitive species that could exist in the NWCF assessment area are listed in Table 21.

Avian species include six terrestrial species: the ferruginous hawk (*Buteo regalis*), the peregrine falcon (*Falco peregrinus*), the northern goshawk (*Accipiter gentilis*), the loggerhead shrike (*Lanius ludovicianus*), the burrowing owl (*Athene cunicularia*), and the bald eagle (*Haliaeetus leucocephalus*).

Table 21. Threatened and endangered species, species of concern, and sensitive species that may be found in the NCWF assessment area.

Common Names	Scientific Name	Federal Status[b,c]	State Status[c]	BLM Status[c]	USFS[d] Status[c]
Plants					
Lemhi milkvetch	*Astragalus aquilonius*	—	S	S	S
Plains milkvetch	*Astragalus gilviflorus*	NL	1	S	S
Winged-seed evening primrose	*Camissonia pterosperma*	NL	S	S	—
Spreading gilia	*Ipomopsis (=Gilia) polycladon*	NL	2	S	—
King's bladderpod	*Lesquerella kingii var. cobrensis*	—	M	—	—
Puzzling Halimolobos	*Halimolobos perplexa var. perplexa*	—	M	—	S
Birds					
Peregrine falcon	*Falco peregrinus*	LE	E	—	—
Bald eagle	*Haliaeetus leucocephalus*	LT	T	—	—
Ferruginous hawk	*Buteo regalis*	C2	SSC	S	—
White-faced Ibis	*Plegadis chihi*	C2	—	—	—
Loggerhead shrike	*Lanius ludovicianus*	C2	NL	S	—
Northern goshawk	*Accipiter gentilis*	C2	S	—	S
Mammals					
Gray wolf	*Canis lupus*	LE/XN	E	—	—
Pygmy rabbit	*Brachylagus (=Sylvilagus) idahoensis*	C2	SSC	S	—
Townsend's western big-eared bat	*Corynonhinus (=Plecotus) townsendii*	C2	SSC	S	S
Merriam's shrew	*Sorex merriami*	—	S	—	—
Long-eared myotis	*Myotis evotis*	C2	—	—	—
Small-footed myotis	*Myotis ciliolabrum (=subulatus)*	C2	—	—	—
Reptiles and Amphibians					
Northern sagebrush lizard	*Sceloporus graciosus*	C2	—	—	—

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a. This list was compiled from the U.S. Fish and Wildlife Service (USFWS) (letter dated Marcy 11, 1998) the Idaho Department of Fish and Game Conservation Data Center threatened, endangered, and sensitive species for the State of Idaho (CDC 1994), and RESL documentation for the INEEL (Reynolds et al. 1986).

b. The USFWS no longer maintains a candidate (C2) species listing but addresses former listed species as "species of concern" (USFWS April 30, 1996). The C2 designation is retained here to maintain consistency between the SLERA and WAG ERA assessments.

c. Status Codes: INPS = Idaho Native Plant Society; S = sensitive; 2 = State Priority 2; 3c = no longer considered for listing; M = State monitor species; NL = not listed: 1 = State Priority 1 (INPS); LE = listed endangered; E = endangered; T = threatened; XN = experimental population, nonessential; SSC = species of special concern; and C2 = Category 2 (defined in CDC 1994). BLM = Bureau of Land Management; INPS = Idaho Native Plant Society; R = removed from sensitive list (non-agency code added here for clarification).

d. United States Forest Service (USFS) Region 4.

Three aquatic species: the white-faced ibis (*Plegadis chihi*), the black tern (*Childonias niger*), and the trumpeter swan (*Cygnus buccinator*) are not likely to occur in the assessment area because of the absence of permanent surface water. Therefore, these species are not evaluated as potential receptors in this assessment. The bald eagle and peregrine falcon are federally listed species. The remaining avian species are species of concern (formerly C2).

Five mammalian species species of concern potentially occur in the assessment including: the pygmy rabbit (*Brachylagus idahoensis*), Townsend's western big-eared bat [*Corynorhinus(=Plecotus) townsendii*], long-eared myotis (*Myotis evotis*), small-footed myotis [*Myotis ciliolabrum (=subulatus)*] and gray wolf (*Canis lupus*). The occurrence of the gray wolf on the INEEL is unverified. However, because of anecdotal evidence (Morris 1998) and the fact that the wolf is federally listed, the species is evaluated in the assessment.

The sagebrush lizard (*Sceloporous graciosus*) is the only reptile species of concern with a potential presence in the assessment area.

8.2.3 Pathways of Contaminant Migration and Exposure

Contaminated surface soil represents the major source of possible contaminant exposure for ecological components within the NCWF assessment area. Subsurface soil and surface water pathways were not analyzed as part of this assessment. Surface soil, as defined in the combustion guidance (see Section 8.2.1) includes the uppermost 1 cm.

The ecological pathways/exposure model for NWCF contaminated surface soil is shown in Figure 13. This model depicts surface soil contamination transport through plant uptake and direct exposure to vegetation and primary consumers. Ecological receptors in upper trophic levels may then be exposed indirectly by ingesting prey that have bioaccumulated contaminants in their tissue. Receptors having potential for direct exposure to surface soils are presented in Table 22.

8.2.4 Conceptual Site Model

The pathways/exposure model for surface soil and food web analysis were integrated to produce the NWCF CSM shown in Figure 14. This model reflects both direct and indirect (i.e., predation) receptor exposure pathways for NWCF COPCs.

8.2.5 Assessment Endpoints

Assessment endpoints are "formal expressions of the actual environmental values that are to be protected" (Suter, 1989). Assessment endpoints developed for this ERA are presented on Table 23. The endpoints were developed around the protection of INEEL biota represented by functional groups and individual T/E and sensitive species known to exist in the assessment and identified as having potential for exposure to COPCs. Each T/E and sensitive species with the potential for exposure is addressed individually in the risk analysis, whereas potential effects to other receptors of concern are dealt with at the functional group level. Assessment endpoints defined for the ERA reflect INEEL-wide hazard/policy goals discussed in the Guidance Manual (VanHorn et al., 1995) and incorporate the suggested criteria for developing assessment endpoints, including ecological relevance and policy goals (EPA, 1992a; Suter, 1993).

These assessment endpoints are the focus for ERA risk characterization and link the measurement endpoints to the ERA goals. The primary objective of this ERA is to identify COPCs and levels of those contaminants that represent potential risk to ecological components in the assessment area.

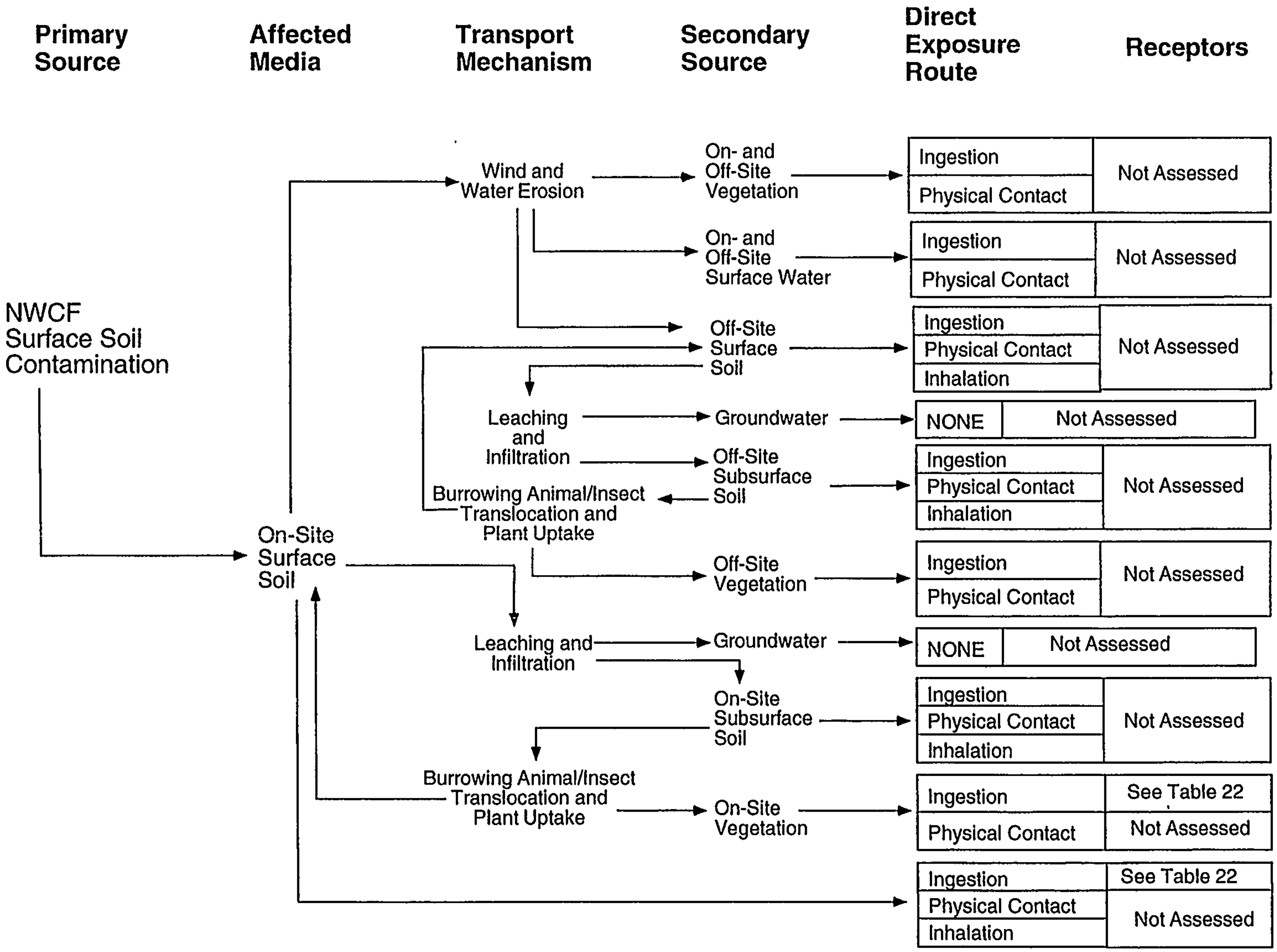

Figure 13. Ecological pathways/exposure model for NWCF surface soil contamination.

Table 22. Summary of exposure media and ingestion routes for NWCF receptors.

Receptor	Surface Soils	Vegetation	Prey Ingestion[a] Invertebrates	Mammals	Birds
Avian herbivores (AV122)	X	X			
Avian insectivores (AV210A)	X		X		
Avian insectivores (AV222)	X		X		
Avian insectivores (AV232)	X		X		
Avian carnivores (AV310)	X			X	X
Northern goshawk	X			X	X
Peregrine falcon	X			X	
Avian carnivores (AV322)	X			X	
Bald eagle	X			X	
Ferruginous hawk	X			X	
Loggerhead shrike	X			X	X
Avian carnivores (AV322A) Burrowing owl	X		X	X	
Avian omnivores (AV422)	X	X	X	X	X
Mammalian herbivores (M122)	X	X			
Mammalian herbivores (M122A)	X	X			
Pygmy rabbit	X	X			
Mammalian insectivores (M210A)	X		X		
Townsend's western big-eared bat	X		X		
Small-footed myotis	X		X		
Long-eared myotis	X		X		
Mammalian insectivores (M222) Merriam's shrew	X		X		
Mammalian carnivore (M322)	X			X	
Mammalian omnivores (M422)	X	X	X		
Reptilian carnivores (R322)	X			X	
Plants	X				

a. Indirect exposure.

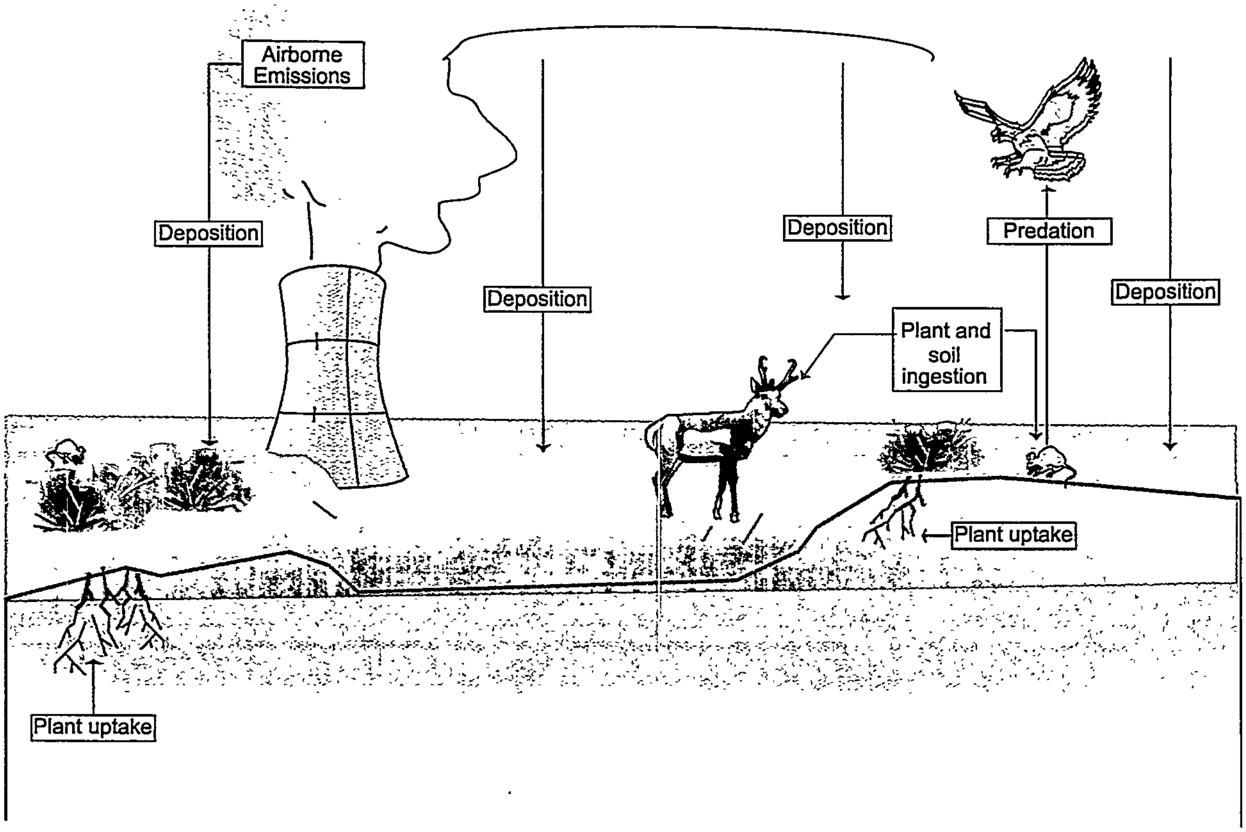

Figure 14. NWCF ecological conceptual site model.

Table 23. Summary of assessment endpoints for NWCF.

Management Goal	NWCF ERA Assessment Endpoint	Indicator of Risk
Maintain INEEL T/E individuals and populations by limiting exposure to organic and inorganic contamination.	Survival of T/E individuals and reproductive success of T/E populations: bald eagle, peregrine falcon, northern goshawk, burrowing owl, ferruginous hawk, pygmy rabbit, Townsend's western big-eared bat, long-eared myotis, small-footed myotis, gray wolf, and sagebrush lizard.	Avg. soil concentration > EBSL
Maintain abundance and diversity of INEEL native biota by limiting exposure to organic and inorganic contamination.	Survival and growth of native vegetation	Avg. soil concentration > EBSL
	Survival and reproduction of wildlife populations (identified in the site conceptual model: small mammals, large mammals, song birds, raptors, top predators; represented by functional groups).	Avg. soil concentration > EBSL

Source: Suter 1993.

Consequently, toxic effects to ecological components as a result of exposure to COPCs were considered a primary concern for biota. Although adverse effects due to physical and/or behavioral stressors are also of concern in evaluating potential risks to INEEL ecological components, these effects are not addressed by this ERA.

8.2.6 Measurement Endpoint Selection

This section describes the selection of measurement endpoints for the WAG ERA. Measurement endpoints are measurable responses of ecological receptors to contaminants that can be related to ERA assessment endpoints. For this ERA, ecological components (flora and fauna) inside the assessment area were not measured or surveyed directly. Rather, published references were used as the primary sources of ecological and toxicological data from which measurement endpoints were derived. Values extracted from these references were used to calculate dose for all ecological receptors and to develop TRVs for contaminants.

Table 24 summarizes the measurement endpoints developed to address NWCF ERA assessment endpoints. Quantified critical exposure levels (QCELs) and adjustment factors (AFs) were constructed from the literature to develop appropriate TRVs for receptors associated with NWCF contaminant pathways. Criteria for development of these TRVs are discussed in Appendix G. In general, the criteria incorporate the requirements for appropriate measurement endpoints, including relevance to an assessment endpoint, applicability to the route of exposure, use of existing data, and consideration of scale (VanHorn et al., 1995).

Values for species dietary habits, home ranges, site use, exposure duration, soil ingestion, food digestion, and body weights for the representative species are documented in Appendix D3 of the OU 10-04 Comprehensive RI/FS (DOE, 1999). The exposure-point concentrations of contaminants in surface soil were used to calculate dose for each affected receptor.

8.3 Analysis

The risk analysis step involves assessing exposure to contaminants (characterization of exposure) and potential effects of exposure (characterization of effects). These activities are conducted interactively to ensure that the methods used to assess exposure and effects are compatible. Assessing exposure and effects is based on the ecological endpoints and conceptual models derived during the problem formulation presentation.

8.3.1 Exposure Calculations

Potential exposures for functional groups, including T/E, and sensitive species were determined based on site-specific life history and feeding habits when possible. Quantification of group and individual exposures incorporated species-specific numerical exposure factors including body weight, ingestion rate, and fraction of diet composed of vegetation or prey, and soil consumed from the affected area. Parameters used to model contaminant intakes by the functional groups and species (assessment endpoints) are presented in Table 25. These values were derived from a combination of parameters that produced the most conservative overall exposure for the group. The functional group parameters in Table 25 represent the most conservative combination of percent prey, percent vegetation, percent soil, ED, ingestion rate, body weight, and home ranges from species within the functional group. The input parameters and exposure equations are documented in detail in the OU 10-04 RI/FS Workplan (DOE, 1999).

Table 24. Summary of NWCF ERA endpoints.

NWCF Assessment Endpoint	Ecological Component	Functional Group (Other Groups Represented)	Measurement Species (Toxicity Reference Value Test Species)
No indication of possible effects on T/E and C2 individuals and populations as a result of contaminant exposure.	Pygmy rabbit	M122A (M123)	Rat, mouse/meadow vole (M122A), and deer mouse (M422)
	Gray wolf	M322	Dog, mouse (M422)
	Peregrine falcon, and northern goshawk	AV310	Chicken, goshawk, and American kestrel/red-tailed hawk (AV322)
	Ferruginous hawk, loggerhead shrike, bald eagle, and burrowing owl	AV322, AV322A	Chicken, goshawk, and American kestrel/red-tailed hawk (AV322)
	Sagebrush lizard	R222	None located
	Bats	M210, M210A	Rat, mouse/meadow vole (M122A), and deer mouse (M422)
No indication of possible effects on native vegetation communities as a result of contaminant exposure.	Vegetation	Sagebrush and bunchgrass	Bush beans and crop plants
No indication of possible effects on wildlife populations as a result of contaminant exposure (represented by functional groups identified in the site conceptual model: small mammals, large mammals, song birds, raptors, and top predators, invertebrates).	Small mammals	M422, M122A (M222, M123)	Rat, mouse/meadow vole (M122A), and deer mouse (M422)
	Mammalian carnivores and omnivores	M422A, M322	Rat, mouse, dog, cat, and mink/fox
	Mammalian herbivores	M121, M122, M122A	Rat, mouse, and mule deer/pronghorn
	Avian carnivores	AV322, AV322A, M122A	Goshawk (AV310) and American kestrel/red-tailed hawk (AV322)
	Avian herbivores	AV121, AV122	Chicken, pheasant, quail, and passerines/sharp-tailed and ruffed grouse
	Avian insectivore	AV210, AV222 (AV210A, AV221, AV22A)	Chicken, pheasant, quail, passerines/American robin (AV222), and cliff swallow (AV210A)
	Avian omnivores	AV422	Chicken, pheasant, turkey, black, mallard
	Mammalian insectivore	M210A (M210)	Rat, mouse/meadow vole (M122A), and deer mouse (M422)
	Reptiles	R222, R322	Western racer (none located)
	Invertebrates	Phytophagous, saprophagous, and entomophagous	Unidentified

8.3.1.1 Exposure Modeling. Exposure models are used to calculate dose to functional groups and T/E species. For exposure to surface soil contamination, dose (intake) in mg/kg body weight-day can be estimated using the following equation, as adapted from EPA's Wildlife Exposure Factors Handbook (EPA, 1993b):

$$EE_{soil} = \frac{[(PP \; x \; CP) + (PV \; x \; CV) + (PS \; x \; CS)] \; x \; IR \; x \; ED \; x \; SUF}{BW} \qquad (8\text{-}1)$$

where

EE_{soil} = estimated exposure from all soil exposure pathways (mg/kg body weight-day)

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

CP = concentration of contaminant in prey item ingested (mg/kg)

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

CV = concentration of contaminant in vegetation ingested (mg/kg)

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

CS = concentration of contaminant in soil ingested (mg/kg)

IR = ingestion rate (kg/day), food intake rate (g/day) divided by 1,000 g/kg

ED = exposure duration (fraction of year spent in the affected area) (unitless)

BW = receptor-specific body weight (kg)

SUF = site usage factor (site area divided by home range; cannot exceed 1) (unitless).

The concentration of contaminant in prey can be estimated using the equation (VanHorn et al, 1995):

$$CP = CS \times CF \qquad (8\text{-}2)$$

where

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

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

CF = contaminant-specific bioaccumulation factor (unitless).

Table 25. NWCF EBSL parameter input values.

Functional Groups	PP	PV	PS	SUF	ED	IR (kg/day)	BW (kg)
Amphibians (A232)	9.41E-01	0.00E+00	5.90E-02	1.00E-00	1.00E-00	6.49E-05	8.00E-03
Avian herbivores (AV121)	0.00E+00	9.90E-01	1.00E-02	1.00E-00	1.00E-00	3.50E-03	1.29E-02
Avian herbivores (AV122)	0.00E+00	9.07E-01	9.30E-02	1.00E-00	1.00E-00	1.46E-03	3.50E-03
Avian herbivores (AV132)	0.00E+00	8.20E-01	1.80E-01	1.00E-00	1.00E-00	1.07E-02	7.46E-02
Avian herbivores (AV142)	0.00E+00	9.18E-01	8.20E-02	1.00E-00	1.00E-00	2.75E-02	3.16E-01
Trumpeter swan	0.00E+00	9.18E-01	8.20E-02	1.00E-00	1.00E-00	2.75E-01	1.09E+01
Avian herbivores (AV143)	0.00E+00	9.18E-01	8.20E-02	1.00E-00	1.00E-00	2.92E-02	3.47E-01
Avian insectivores (AV210)	9.80E-01	0.00E+00	2.00E-02	1.00E-00	1.00E-00	2.90E-03	1.00E-02
Black tern	9.80E-01	0.00E+00	2.00E-02	1.00E-00	1.00E-00	9.84E-03	6.53E-02
Avian insectivores (AV210A)	9.70E-01	0.00E+00	3.00E-02	1.00E-00	1.00E-00	3.89E-03	1.46E-02
Avian insectivores (AV221)	9.70E-01	0.00E+00	3.00E-02	1.00E-00	1.00E-00	1.99E-03	6.65E-03
Avian insectivores (AV222)	9.07E-01	0.00E+00	9.30E-02	1.00E-00	1.00E-00	3.07E-03	1.09E-02
Avian insectivores (AV222A)	9.07E-01	0.00E+00	9.30E-02	1.00E-00	1.00E-00	2.82E-03	1.00E-02
Avian insectivores (AV232)	8.20E-01	0.00E+00	1.80E-01	1.00E-00	1.00E-00	1.12E-03	2.32E-02
Avian insectivores (AV233)	8.20E-01	0.00E+00	1.80E-01	1.00E-00	1.00E-00	4.78E-03	2.15E-02
White-faced ibis	8.90E-01	0.00E+00	1.10E-01	1.00E-00	1.00E-00	4.27E-02	6.22E-01
Avian insectivores (AV241)	8.20E-01	0.00E+00	1.80E-01	1.00E-00	1.00E-00	6.41E-03	3.38E-02
Avian insectivores (AV242)	8.20E-01	0.00E+00	1.80E-01	1.00E-00	1.00E-00	1.13E-02	8.10E-02
Avian carnivores (AV310)	9.80E-01	0.00E+00	2.00E-02	1.00E-00	1.00E-00	1.61E-02	1.39E-01
Northern goshawk	9.80E-01	0.00E+00	2.00E-02	1.00E-00	1.00E-00	6.00E-02	1.05E-00
Peregrine falcon	9.80E-01	0.00E+00	2.00E-02	1.00E-00	1.00E-00	4.96E-02	7.82E-01
Avian carnivores (AV322)	9.80E-01	0.00E+00	2.00E-02	1.00E-00	1.00E-00	7.44E-03	4.25E-02
Bald eagle	9.80E-01	0.00E+00	2.00E-02	1.00E-00	1.00E-00	1.60E-01	4.74E-00
Ferruginous hawk	9.80E-01	0.00E+00	2.00E-02	1.00E-00	1.00E-00	6.19E-02	1.10E-00
Loggerhead shrike	9.80E-01	0.00E+00	2.00E-02	1.00E-00	1.00E-00	7.44E-03	4.25E-02
Avian carnivores (AV322A)	9.70E-01	0.00E+00	3.00E-02	1.00E-00	1.00E-00	1.73E-02	1.55E-01
Burrowing owl	9.70E-01	0.00E+00	3.00E-02	1.00E-00	1.00E-00	1.73E-02	1.55E-01
Avian carnivores (AV333)	8.20E-01	0.00E+00	1.80E-01	1.00E-00	1.00E-00	1.84E-02	1.71E-01
Avian carnivores (AV342)	9.80E-01	0.00E+00	2.00E-02	1.00E-00	1.00E-00	4.64E-02	7.06E-01
Avian omnivores (AV422)	6.27E-01	2.80E-01	9.30E-02	1.00E-00	1.00E-00	1.13E-02	8.02E-02
Avian omnivores (AV432)	5.70E-01	2.50E-01	1.80E-01	1.00E-00	1.00E-00	2.75E-02	3.16E-01
Avian omnivores (AV433)	5.70E-01	2.50E-01	1.80E-01	1.00E-00	1.00E-00	5.33E-02	8.74E-01

Table 25. (continued).

Functional Groups	PP	PV	PS	SUF	ED	IR (kg/day)	BW (kg)
Avian omnivores (AV442)	6.20E-01	2.70E-01	1.10E-01	1.00E-00	1.00E-00	4.41E-02	6.54E-01
Mammalian herbivores (M121)	0.00E+00	9.80E-01	2.00E-02	1.00E-00	1.00E-00	3.14E-01	5.80E-00
Mammalian herbivores (M122)	0.00E+00	9.37E-01	6.30E-02	1.00E-00	1.00E-00	3.30E-03	1.10E-02
Mammalian herbivores (M122A)	0.00E+00	9.23E-01	7.70E-02	1.00E-00	1.00E-00	4.27E-03	1.57E-02
Pygmy rabbit	0.00E+00	9.80E-01	2.00E-02	1.00E-00	1.00E-00	4.53E-02	4.04E-01
Mammalian herbivores (M123)	0.00E+00	9.23E-01	7.70E-02	1.00E-00	1.00E-00	1.51E-02	8.89E-02
Mammalian insectivores (M210)	9.80E-01	0.00E+00	2.00E-02	1.00E-00	1.00E-00	1.43E-03	9.03E-03
Mammalian insectivores (M210A)	9.80E-01	0.00E+00	2.00E-02	1.00E-00	1.00E-00	1.43E-03	4.65E-03
Townsend's western big-eared bat	9.90E-01	0.00E+00	1.00E-02	1.00E-00	1.00E-00	2.37E-03	1.10E-02
Small-footed myotis	9.90E-01	0.00E+00	1.00E-02	1.00E-00	1.00E-00	1.44E-03	4.69E-03
Long-eared myotis	9.90E-01	0.00E+00	1.00E-02	1.00E-00	1.00E-00	1.77E-03	6.65E-03
Mammalian insectivores (M222)	9.76E-01	0.00E+00	2.40E-02	1.00E-00	1.00E-00	1.66E-03	6.00E-03
Mammalian carnivores (M322)	9.23E-01	0.00E+00	7.70E-02	1.00E-00	1.00E-00	1.66E-02	1.78E-01
Mammalian omnivores (M422)	8.06E-01	1.00E-01	9.40E-02	1.00E-00	1.00E-00	3.06E-03	1.70E-02
Mammalian omnivores (M422A)	8.06E-01	1.00E-01	9.40E-02	1.00E-00	1.00E-00	2.60E-01	5.05E-00
Reptilian insectivores (R222)	9.76E-01	0.00E+00	2.40E-02	1.00E-00	1.00E-00	5.60E-05	6.61E-03
Sagebrush lizard	9.76E-01	0.00E+00	2.40E-02	1.00E-00	1.00E-00	5.60E-05	6.61E-03
Reptilian carnivores (R322)	9.52E-01	0.00E+00	4.80E-02	1.00E-00	1.00E-00	6.80E-03	1.50E-02
Plants	0.00E+00	0.00E+00	1.00E-00	1.00E-00	1.00E-00		

The concentration of contaminant in vegetation (CV) can be estimated using the equation (VanHorn et al. 1995):

$$CV = CS \times PUF \tag{8-3}$$

where

CV = concentration of contaminant in vegetation (mg/kg)

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

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

Contaminant-specific PUFs (from Baes et al. 1984 and other literature sources) and concentration factors (CFs) for calculating EBSLs for metals are presented in Table 26. Concentration factors for metals were developed as discussed in the OU 10-04 Workplan (DOE, 1999). The log of PUF and CFs for organics is estimated using 1.588-0.578 log K_{ow}, and -7.735 + 1.033 log K_{ow}, respectively (Travis and Arms 1988). Log partitioning coefficients (K_{ow}) were taken from the *Groundwater Chemicals Desk Reference* (Montgomery and Welkom 1990).

8.3.1.2 EBSL Calculations. As discussed in detail in Appendix D of the OU 10-04 Workplan (DOE 1999), the EBSLs for contaminates of concern are useful for quickly screening sites for ecological receptors at the INEEL. The similarity in receptors across the facility makes it possible to develop these INEEL-wide screening levels. EBSLs are defined as concentrations of COPCs in soil (or other media) that are not expected to produce an adverse effect to selected ecological receptors under chronic exposure conditions. EBSLs are calculated by inverting the exposure equation presented previously. The exposure model estimates the potential intake. In the risk assessment process these intake values are compared to toxicity reference values (TRVs) to evaluate potential effects to receptors. These equations can be manipulated to allows the calculation of a contaminant concentration in a medium that would not be potentially harmful to the receptors with chronic exposure.

To calculate EBSLs for screening against nonradiological soil contamination concentrations, the target hazard quotient (TQ) will be determine. This is defined as a quantitative method for evaluating potential adverse impacts to exposed populations, and is calculated using the equation.

$$THQ = \frac{EE_{soil}}{TRV} \tag{8-4}$$

where

THQ = target hazard quotient (unitless), established at 1.0 for nonradionuclide contaminate exposure

EE_{soil} = estimated exposure from soil (mg/kg body weight-day)

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

Thus, solving for the concentration of the nonradionuclide contaminant in the soil (CS) and assuming that when THQ equals 1 that EE_{soil} = TRV. The EBSL for contaminant in the soil is calculated using the equation:

Table 26. PUFs and CFs for NWCF contaminants (unitless) used in EBSL calculations.

	PUF[a]	PUFs for EBSLs[b]	CF for EBSLs[c]
Metals[d]			
Antimony	2.0E-02	1.0E+00	1.0E+00
Arsenic	4.0E-02	1.0E+00	1.0E+00
Barium	1.5E-02	1.0E+00	1.0E+00
Beryllium	1.0E-02	1.0E+00	1.0E+00
Cadmium	5.5E-01	1.0E+00	1.0E+00
Chromium III	1.9E-01	1.0E+00	1.0E+00
Chromium VI	7.5E-03	1.0E+00	1.0E+00
Lead	2.0E-02	1.0E+00	1.0E+00
Mercury	9.0E-01	1.0E+00	1.0E+00
Nickel	6.0E-02	1.0E+00	1.0E+00
Selenium	2.5E-02	1.0E+00	1.0E+00
Silver	4.0E-01	1.0E+00	1.0E+00
Thallium	4.0E-03	1.0E+00	1.0E+00
Organics (feed)[e]			
1,1,1-Trichloroethane	1.4E+00	1.4E+00	1.0E+00
1,1,2-Trichloroethane	NA	NA	NA
1,2,4-trichlorobenzene	1.3E-01	1.0E+00	1.0E+00
1,2-Dichloroethane	5.4E+00	5.4E+00	1.0E+00
1,4 dioxane	3.8E+01	3.8E+01	1.0E+00
2,4-Dinitrophenol	NA	NA	NA
Acetonitrile	6.1E+01	6.1E+01	1.0E+00
Aniline	NA	NA	NA
Benzene	2.3E+00	2.3E+00	1.0E+00
Benzo(a)pyrene	1.2E-02	1.0E+00	1.0E+00
Bromoform	NA	NA	NA
Butylbenzylphthalate	6.5E-02	1.0E+00	1.0E+00
Carbon disulfide	2.7E+00	2.7E+00	1.0E+00
Carbon tetrachloride	1.2E+00	1.2E+00	1.0E+00
Chlorobenzene	NA	NA	NA
Chloroform	2.8E+00	2.8E+00	1.0E+00
Diethylphthalate	1.4E+00	1.4E+00	1.0E+00

Table 26. (continued).

	PUF[a]	PUFs for EBSLs[b]	CF for EBSLs[c]
Di-n-butylphthalate	2.3E-02	1.0E+00	1.0E+00
Di-n-octylphthalate	1.9E-04	1.0E+00	1.0E+00
Formaldehyde	3.9E+01	3.9E+01	1.0E+00
Formic acid	NA	NA	NA
Methyl ethyl ketone	2.7E+01	2.7E+01	1.0E+00
Methylene chloride	6.9E+00	6.9E+00	1.0E+00
Naphthalene	4.0E-01	1.0E+00	1.0E+00
Pentachlorophenol	1.0E+00	1.0E+00	1.0E+00
Phenol	5.6E+00	5.6E+00	1.0E+00
Pyridine	NA	NA	NA
Tetrachloroethylene	1.2E+00	1.2E+00	1.0E+00
Toluene	1.0E+00	1.0E+00	1.0E+00
Trichloroethylene	1.6E+00	1.6E+00	1.0E+00
Organics (PICs)			
2,3,7,8-TCDD TEQ	5.1E-03	1.0E+00	1.0E+00
1,3-Dinitrobenzene	4.5E+00	4.5E+00	1.0E+00
Nitrobenzene	3.3E+00	3.3E+00	1.0E+00
2,4-Dinitrotoluene	2.7E+00	2.7E+00	1.0E+00
2,6-Dinitrotoluene	2.7E+00	2.7E+00	1.0E+00
Pentachloronitrobenzene	2.7E-02	1.0E+00	1.0E+00

a. PUF = plant uptake factor.
b. Plant uptake factor used in EBSL calculations.
c. Bioconcentration factor used in EBSL calculations.
d. Values for metals come from Baes et al. (1984) or literature values as discussed in the OU 10-04 Workplan (DOE 1999).
e. Values for organics come from allometric equations presented in Travis and Arms (1988).

$$EBSL_{soil} = \frac{TRV \times BW}{[(PP \times CF) + (PV \times PUF) + (PS)] \times IR \times ED \times SUF} \quad (8\text{-}5)$$

where

$EBSL_{soil}$ = INEEL-specific ecological based screening level for non-radionuclide contaminants in soil (mg/kg).

Exposure parameters including dietary composition (percent soil [PS], percent prey [PP], and percent vegetation [PV]), home range, temporal and spatial habitat use data (site use factor [SUF] and exposure duration [ED]), soil ingestion rate, food ingestion rate (IR), body weight (BW), and uptake factors (bioaccumulation factors [CF or BAFs] and plant uptake factors [PUFs]) are input to calculate the EBSL. The input values for calculating EBSLs for each functional group/contaminant combination, assume that members of the functional groups are exposed to stressors to the maximum extent, perhaps beyond what is actually expected. For example, it is assumed that a raptor captures 100% of its prey from a contaminated site, and that all the prey are exposed to maximum contaminant concentrations at the site. This is similar to the human risk assessment concept of the "maximally exposed individual," a hypothetical individual who is assumed to live and grow his own food at a location of maximum exposure to a stressor. Each parameter is discussed in Appendix D in more detail of the OU 10-04 Workplan (DOE 1999). The defaults used in the calculation of EBSLs are presented in Table 27.

8.3.1.3 Uncertainty Associated with Functional Groups. The selection of receptor parameters used is designed to ensure that each of the members of the functional groups is conservatively represented. Since all members of a functional group are considered similar, it is reasonable to assume that all members of a group will be equally exposed to site-related contaminants. Quantification of dose for each functional group is expected to provide sufficient data to assess the general condition of the ecosystem and to be adequately protective of the majority of species potentially inhabiting the assessment area. In addition, sensitive species are included on the list of receptors for which dose is calculated. Hence, uncertainty associated with the selection of receptor parameters is expected to minimally influence dose estimates.

8.3.1.4 Uncertainty Associated with the Ingestion Rate. Estimation for terrestrial receptors intake (ingestion) estimates used for the terrestrial receptors are based upon data in the scientific literature, when available. Food ingestion rates are calculated by use of allometric equations reported in Nagy (1987). Uncertainties associated with the use of allometric equations could result in either an over- or underestimation of the true dose rate, since actual ingestion rates are known for few species.

8.3.1.5 Uncertainty Associated with the Receptor Site Usage. The calculation of dose incorporated the probability that the receptors may use or inhabit each site. The SUF is defined as the affected area (ha) divided by the home range (ha) of the receptor. If a given receptor's home range is larger than the affected area, then it is reasonable to assume that the receptor may not spend 100% of its life within the site area. Incorporation of the SUF adjusts the dose to account for the estimated time the receptor spends on the site. The less time spent on the site, the lower the dose. However, most home ranges are estimated from available literature values and allometric equations. Home range and usage of areas also vary from season to season as well as year to year (depending on the species of interest), and are difficult to measure. This uncertainty could result in either an over- or underestimation of the true dose rates. For EBSL calculations this SUF is defaulted to 1 or 100%.

Table 27. Parameter defaults and assumptions for EBSL calculations.

Parameter	EBSL Soil/Sediment Calculations
PV	Herbivores—100 minus PS Insectivores—0 Carnivores—0 Omnivores—PV from literature minus PS/2.
PP	Herbivores—0 Insectivores—100 minus PS Carnivores—100 minus PS Omnivores—PP from literature minus PS/2.
PS	The highest value (i.e., greatest exposure) was selected from species within a functional group. Individual species evaluated using values as presented.
BAFs	A BAFs for all metals was taken from Baes et al. (1984) and other available literature. The log of the BAF for organics will be estimated using the Travis and Arms (1988) equation -7.735+1.033 log K_{ow}. Log partitioning coefficients (K_{ow}s) are available from Montgomery and Welkom (1990). BAFs for EBSL calculation are assumed to be 1.0 if not greater.
PUFs	PUFs for all metals examined from Baes et al. (1984) and other available literature. The log of PUF for organics will be estimated using the Travis and Arms (1988) equation of 1.588-0.578 log K_{ow}. Log partitioning coefficients (K_{ow}s) are available from Montgomery and Welkom (1990). Assumed to be 1.0 if not larger by calculation using allometric equations. PUFs for EBSL calculation are assumed to be 1.0 if not greater.
ED	Defaulted to 1.
SUF	Defaulted to 1.
BW	The smallest BW/IR ratio was selected from species within each functional group.
IR	Calculated using allometric equations from Nagy (1987). The largest IR/BW ratio was used from the species within each functional group.

8.3.1.6 Uncertainty Associated with the PUFs and CFs. Using PUFs to estimate plant concentrations has the advantages that it is easy to use and requires minimum data inputs (i.e., the measured or estimated concentration of metal in soil and a PUF taken from the literature). A PUF of 0.01 indicates that the plant concentration should be 1/100th of the total concentration in soil. PUFs for metals are taken from Baes et al. (1984) and other studies. Although preference is given to studies that reported the steady-state concentration of metals in plants at edible maturity, various soil properties are not considered and data for numerous plant species (both animal feeds and those consumed by humans) are combined. However, since root uptake of metals is a complex process that depends on various soil properties (e.g., pH, CEC, and organic matter content) as well as the metal and type of plant involved, the use of generic or crop-specific PUFs taken from the literature may not accurately estimate the concentration of metals in plants for all environmental conditions and species that may occur. The PUF for organics is estimated using the geometric mean regression equation developed by Travis and Arms (1988) and using log K_{ow} values. The reliability of estimated PUFs is directly related to the reliability of the K_{ow} values used for the organics. Since K_{ow} values can vary greatly, use of the Travis and Arms (1988) equation to estimate a PUF for organics may over- or underestimate the true dose for organics. There is a great deal of uncertainty associated with the bioaccumulation factors (BAFs) or concentration factors (CFs) used to calculate dose. Very few CFs are available in the scientific literature, since they must be both contaminant- and receptor-specific. In the absence of specific CFs, a value of 1 was assumed. This assumption could over- or underestimate the true dose from the contaminant, and the magnitude of error cannot be quantified. Travis and Arms (1988) and Baes et al. (1984) report CFs for contaminants to beef and milk; all of these are less than 1 for the contaminants in the assessment area. If the terrestrial receptors of concern accumulate metals and PCBs in a similar way and to a comparable degree as beef and dairy cattle, the use of a CF of 1 for all contaminants and receptors would overestimate the dose. On the other hand, if the terrestrial receptors of concern accumulate metals and PCBs to a much larger degree than beef and dairy cattle, the assumption of CFs equal to 1 could underestimate the true dose.

8.3.1.7 Uncertainty Associated with Soil Ingestion. The exposure assessment incorporates percentage of soil ingested by each representative of the functional groups. Although food ingestion rates have the greatest effect on intake estimates, soil ingestion rates could also influence intake rates and, therefore, dose estimates. The EPA Wildlife Exposure Factors Handbook (EPA 1993b) and Beyer et al. (1994) was used to assign soil ingestion parameters to four of the 12 functional groups, and Arthur and Gates (1988) was used to assign percent soil ingested by two common species. Estimating the percent soil ingested may over- or underestimate the dose since the effect of the estimated values on the overall dose outcome is dependent on the concentration of contaminant in the media of concern.

8.3.2 Ecological Effects Assessment

Ecological effects assessment consists of three elements:

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

Appendix G contains a general description of the procedures of ecological effects assessment and discussions of the each of the three elements as they apply to the development of TRVs for individual COPCs evaluated in this assessment.

Information on the toxicological effects on mammalian receptors of the following contaminants was not located. Therefore, these contaminations could not be evaluated for potential risk.

1,1,2-Trichloroethane
2,4-Dinitrophenol
Bromoform
Chlorobenzene
Formic Acid
Pyridine
Pentachloronitrobenzene

Information on the toxicological effects on avian receptors of the following contaminants was not located. Therefore these contaminations could not be evaluated for potential risk.

Antimony
Barium
Beryllium
Chromium VI
1,1,1-Trichloroethane
1,1,2-Trichloroethane
1,2,4-trichlorobenzene
1,4 dioxane
2,4-Dinitrophenol
Acetonitrile
Aniline
Benzene
Benzo(a)pyrene
Bromoform
Butylbenzylphthalate
Carbon disulfide
Carbon tetrachloride
Chlorobenzene
Chloroform
Diethylphthalate
Di-n-butylphthalate
Di-n-octylphthalate
Formaldehyde
Formic acid
Hydrazine
Methyl ethyl ketone
Methylene chloride
Naphthalene
Pentachlorophenol
Phenol
Pyridine
Tetrachloroethylene
Toluene
Trichloroethylene
1,3-Dinitrobenzene
Nitrobenzene
2,4-Dinitrotoluene
2,6-Dinitrotoluene

8.4 Risk Evaluation

Risk evaluation is the final step of the process. The risk evaluation determines whether there is any indication of risk due to the contaminant concentrations to INEEL functional groups, and subsequently T/E, and sensitive species and discusses the uncertainty inherent in the assessment.

8.4.1 EBSL Screening

Table 28 compares modeled concentrations to the EBSLs for the COPCs identified at the NWCF. Concentrations were developed as discussed in Section 8.2.1. An additional screen of EBSL/4 is provided to be consistent with the ATG approach of evaluating .25 of the HQ for their screening level risk assessment (ATG, 1998). Plant, earthworm, and soil microbes benchmark values taken from Oak Ridge (Efroymson et al, 1997a, 1977b) were screened against modeled contaminant concentrations. Based on this screening, only 1,3 dinitrobenzene exceeds an EBSL. As shown in Table 28, the highlighted concentration for 1,3 dinitrobenzene indicates that this contaminant may pose a potential risk to ecological receptors from maximum modeled concentrations. However, the average on-site concentration is below the EBSL or any benchmark values.

8.4.2 Comparison of INEEL Approach and Methods to ATG

A comparison of the SLERA approach used in the Risk Assessment Work Plan for the Mixed Waste Facility RCRA/TSCA permit application (ATG, 1998) to the INEEL methods and parameters was performed. The exposure calculations are similar with the exception to the use of the functional groups at the INEEL. The use of functional groups may provide an additional level of conservatism compared to the evaluation of individual species.

Table 28. Screening of modeled concentrations to EBSLs for mammalian and avian receptors and other benchmarks (exceedence of benchmark is highlighted). All values are in mg/kg.

	Max Off-site	Max On-site	Average	Mammalian EBSL	Mammalian EBSL/4	Avian EBSL	Avian EBSL/4	Plant [a] Benchmarks	Earthworm[b] Screening Values	Soil Microbes[b] Screening Values
Metals										
Antimony (Sb)	3.41E-11	5.45E-10	5.45E-11	1.35E+00	3.38E-01	NA	NA	5.00E+00	NA	NA
Arsenic (As)	1.86E-14	2.98E-13	2.98E-14	8.44E-01	2.11E-01	1.28E+00	3.20E-01	1.00E+01	6.00E+01	1.00E+02
Barium (Ba)	1.83E-13	2.93E-12	2.93E-13	1.10E+01	2.75E+00	NA	NA	5.00E+02	N	3.00E+03
Beryllium (Be)	5.60E-10	8.96E-09	8.96E-10	7.14E-01	1.79E-01	NA	NA	1.00E+01	N	n
Cadmium (Cd)	2.13E-12	3.41E-11	3.41E-12	3.83E-02	9.58E-03	2.36E-03	5.90E-04	4.00E+00	2.00E+01	2.00E+01
Chromium (Cr) as Cr III	8.59E-14	1.37E-12	1.37E-13	8.11E+02	2.03E+02	2.82E+00	7.05E-01	1.00E+00	4.00E-01	1.00E+01
Chromium (Cr) as Cr VI	8.59E-14	1.37E-12	1.37E-13	1.62E-01	4.05E-02	NA	NA	NA	NA	NA
Lead (Pb)	1.02E-08	1.64E-07	1.64E-08	8.76E+00	2.19E+00	9.94E-01	2.49E-01	5.00E+01	5.00E+02	9.00E+02
Mercury (Hg^{+2}) as inorganic[c]	5.78E-05	2.83E-03	1.96E-04	3.57E-01	8.93E-02	4.18E+00	1.05E+00	3.00E-01	1.00E-01	3.00E+01
Mercury (Hg) as organic[d]	1.16E-06	5.66E-05	3.92E-06	6.21E-03	1.55E-03	6.49E-02	1.62E-02	NA	1.00E-01	3.00E+01
Nickel (Ni)	3.72E-13	5.95E-10	5.95E-11	6.17E+01	1.54E+01	6.83E+01	1.71E+01	3.00E+01	2.00E+02	9.00E+01
Selenium (Se)	1.79E-09	2.87E-08	2.87E-09	4.22E-01	1.06E-01	1.72E-01	4.30E-02	1.00E+00	7.00E+01	1.00E+02
Silver (Ag)	1.62E-16	2.59E-15	2.59E-16	3.67E+01	9.18E+00	3.02E+01	7.55E+00	2.00E+00	NA	5.00E+01
Thallium (Tl)	9.87E-09	1.58E-07	1.58E-08	1.30E-01	3.25E-02	1.01E-01	2.53E-02	1.00E+00	NA	NA
Aluminum (Al)[e]	1.12E-05	1.79E-04	1.79E-05	8.50E+00	2.13E+00	NA	NA	NA	NA	NA
Managanese (Mn)[e]	5.62E-06	8.99E-05	8.99E-06	1.05E+01	2.63E+00	NA	NA	NA	NA	NA
Zinc (Zn)[e]	3.31E-06	5.30E-05	5.30E-06	NA	NA	3.29e+00	8.23e-01	NA	NA	NA
Organics (feed)										
1,1,1-Trichloroethane	2.18E-15	1.07E-13	7.43E-15	8.13E+01	2.03E+01	NA	NA	NA	NA	NA
1,1,2-Trichloroethane	7.54E-12	3.70E-10	2.56E-11	NA	NA	NA	NA	NA	NA	NA
1,2,4-trichlorobenzene	1.68E-10	8.25E-09	5.72E-10	1.82E+00	4.55E-01	NA	NA	NA	2.00E+01	NA
1,2-Dichloroethane	1.14E-12	5.57E-11	3.86E-12	1.11E+01	2.77E+00	1.39E+00	3.47E-01	NA	NA	NA
1,4 dioxane	8.36E-09	4.10E-07	2.84E-08	1.58E-02	3.95E-03	NA	NA	NA	NA	NA
2,4-Dinitrophenol	4.48E-09	2.19E-07	1.52E-08	NA	NA	NA	NA	NA	NA	NA

Table 28. (continued).

	Max Off-site	Max On-site	Average	Mammalian EBSL	Mammalian EBSL/4	Avian EBSL	Avian EBSL/4	Plant[a] Benchmarks	Earthworm[b] Screening Values	Soil Microbes[b] Screening Values
Acetonitrile	5.34E-18	2.61E-16	1.81E-17	3.08E-01	7.70E-02	NA	NA	NA	NA	NA
Aniline	8.14E-09	3.99E-07	2.77E-08	NA	NA	NA	NA	NA	NA	NA
Benzene	6.00E-13	2.94E-11	2.04E-12	5.50E+00	1.38E+00	NA	NA	NA	NA	NA
Benzo(a)pyrene	3.44E-05	1.69E-03	1.17E-04	2.69E+00	6.73E-01	NA	NA	NA	NA	NA
Bromoform (tribromomethane)	4.48E-11	2.20E-09	1.52E-10	NA	NA	NA	NA	NA	NA	NA
Butylbenzylphthalate	1.63E-09	8.01E-08	5.56E-09	1.43E+01	3.58E+00	NA	NA	NA	NA	NA
Carbon disulfide	1.85E-11	9.05E-10	6.28E-11	5.91E-01	1.48E-01	NA	NA	NA	NA	NA
Carbon tetrachloride	6.24E-13	3.06E-11	2.12E-12	9.71E+01	2.43E+00	NA	NA	NA	NA	NA
Chlorobenzene	4.09E-12	2.00E-10	1.39E-11	NA	NA	NA	NA	NA	4.00E+01	NA
Chloroform	1.21E-12	5.92E-11	4.10E-12	1.54E+01	3.85E+00	NA	NA	NA	NA	NA
Diethylphthalate	3.45E-09	1.69E-07	1.17E-08	1.53E+02	3.83E+01	NA	NA	NA	NA	NA
Di-n-butylphthalate	1.43E-09	6.99E-08	4.85E-09	1.50E+01	3.75E+00	NA	NA	2.00E+02	NA	NA
Di-n-octylphthalate	8.39E-07	4.11E-05	2.85E-06	4.71E+01	1.18E+01	NA	NA	NA	NA	NA
Formaldehyde	1.64E-13	8.05E-12	5.59E-13	4.59E-01	1.15E-01	NA	NA	NA	NA	NA
Formic acid	3.58E-09	1.76E-07	1.22E-08	NA	NA	NA	NA	NA	NA	NA
Hydrazine	none	none	none	1.43E-03	3.58E-04	NA	NA	NA	NA	NA
Methyl ethyl ketone (2-butanone)	1.06E-10	5.20E-09	3.61E-10	3.83E+01	9.58E+00	NA	NA	NA	NA	NA
Methylene chloride	2.72E-13	1.33E-11	9.26E-13	1.00E+00	2.50E-01	NA	NA	NA	NA	NA
Naphthalene	4.48E-10	2.20E-08	1.52E-09	1.43E+00	3.58E-01	NA	NA	NA	NA	NA
Pentachlorophenol	1.35E-06	6.60E-05	4.58E-06	1.30E-01	3.25E-02	NA	NA	3.00E+00	6.00E+00	4.00E+02
Phenol	7.00E-08	3.43E-06	2.38E-07	8.23E+00	2.06E+00	NA	NA	NA	3.00E+01	1.00E+02
Pyridine	1.10E-10	5.41E-09	3.75E-10	NA	NA	NA	NA	NA	NA	NA
Tetrachloroethylene	1.13E-12	5.52E-11	3.83E-12	3.33E+00	8.33E-01	NA	NA	NA	NA	NA
Toluene	1.37E-12	6.73E-11	4.67E-12	6.04E+01	1.51E+01	NA	NA	2.00E+02	NA	NA
Trichloroethylene	8.74E-13	4.28E-11	2.97E-12	1.74E+01	4.35E+00	NA	NA	NA	NA	NA

Table 28. (continued).

	Max Off-site	Max On-site	Average	Mammalian EBSL	Mammalian EBSL/4	Avian EBSL	Avian EBSL/4	Plant [a] Benchmarks	Earthworm[b] Screening Values	Soil Microbes[b] Screening Values
Organics (PICs)										
2,3,7,8-TCDD TEQ	1.62E-09	7.95E-08	5.52E-09	1.07E-06	2.68E-07	4.76E-06	1.19E-06	NA	NA	NA
1,3-Dinitrobenzene	2.75E-03	1.35E-01	9.35E-03	7.82E-02	1.96E-02	NA	NA	NA	NA	NA
Nitrobenzene	8.39E-05	4.11E-03	2.85E-04	1.96E+00	4.90E-01	NA	NA	NA	NA	NA
2,4-Dinitrotoluene	8.55E-03	4.19E-01	2.91E-02	1.54E+00	3.85E-01	NA	NA	NA	NA	NA
2,6-Dinitrotoluene	1.02E-02	4.99E-01	3.46E-02	2.18E+00	5.46E-01	NA	NA	NA	NA	NA
Pentachloronitrobenzene	4.28E-06	2.10E-04	1.46E-05	NA	NA	2.44E+00	6.10E-01	NA	NA	NA

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a. Values from Efroymson, R. A., M. E. Will, G. W. Suter II, and A. C. Wooten, 1997, *Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Terrestrial Plans*, 1997 Revision, Oak Ridge National Laboratory, Oak Ridge, TN, 128 pp., ES/ER/TM-85/R3.

b. Values from Efroymson, R. A., M. E. Will, and G. W. Suter II, 1997, *Toxicological Benchmarks for Contaminants of Potential Concern for Effects on Soil and Litter Invertebrates and Heterotropic Processes*, 1997 Revision, Oak Ridge National Laboratory, Oak Ridge, TN, 128 pp., ES/ER/TM-126/R2.

c. Based on a conservative best-estimate of the Hg emission rate (3.7 % of feed). Upper-bound soil concentrations are a factor of 4.3 higher based on the ratio of the upper-bound emissions factor (13%) to the best-estimate emissions factor (3%).

d. Assumed to be methyl Hg which is calculated as 2% of the total Hg (EPA 1998). Upper-bound soil concentrations are a factor of 4.3 higher.

e. Metal emissions that may be present based on preliminary offgas sampling data. Soil concentrations calculated using emission rates from the highest of 3 sample results and fate and transport parameters for zinc (EPA 1998).

The PUF and CF input parameters were compared and both use the Travis and Arms (1988) allometric equations to calculate PUFs and CFs for organics. Baes et al. (1984) were used solely by ATG while the INEEL did an extensive search to identify additional PUFs for metals. However, in all cases the metal values are similar. The default of 1.0 or higher (whichever was greater) was used in the calculation of the EBSL (as shown in Table 27). This should add an additional level of conservatism.

A major uncertainty in any assessment is the selection of benchmarks for screening. For plants, earthworms, and soil microbes this assessment used those values developed by the Oak Ridge National Laboratory (Efroymson et al. 1997a, Efroymson et al. 1997b, and others). The values used by ATG (ATG, 1998) are summarized in Table 29 and are compared to the values used in this assessment. Although there are significant differences in some of the organic values, investigation of the modeled contaminant concentrations indicates that none of them are exceeded.

As shown in Table 30, the toxicity reference development for avian and mammalian receptors was also evaluated. The studies selected for development of toxicity values and the adjustment factors used to extrapolate to other species may vary considerably. The ATG document (ATG, 1998) did not reference or discuss the studies adequately to make a complete comparison, however, INEEL values appear to be both less than or greater than ATG values depending on the contaminant. Investigation of the modeled contaminant concentrations for both the metals and the organic feed indicates that neither the ATG or INEEL values would be exceeded. However, this is not the cases for the organic pics. As noted several of the studies used by ATG could not be located. In these cases either different studies were selected or the contaminant was not assessed. Specifically, this includes 1,3 dinitrobenzene, the ATG (ATG 1998) avian study cited evaluating this contaminant could not be located. The mammalian study used is 10^4 higher than the avian study. If the avian study was located and found to be applicable then this contaminant would potentially be at unacceptable levels given the concentration modeled. Pentachloronitrobenzene was also assessed in this SLERA using a different study than selected by ATG (ATG, 1998). However, the lower toxicity values would not be exceeded by the modeled contaminant concentrations.

8.4.3 Discussion of Uncertainty

The NWCF SLERA, by definition, is a conservative approach to assess potential risk to ecological receptors from emission contaminants. The assessment incorporates levels of uncertainty that could either overestimate or underestimate the actual risk to these receptors. To compensate for potential uncertainties, the assessment incorporates various factors that are designed to be conservative rather than result in a conclusion of no indication of risk when actual risk may exist. Regardless, uncertainties exist that could affect the estimation of true risk associated with the assessment area. These are summarized in Table 31.

Principal sources of uncertainty lie within the development of an exposure assessment and toxicity assessment. Uncertainties inherent in the exposure assessment are associated with estimation of receptor ingestion rates, estimation of site usage, and estimation of PUFs and CFs. Additional uncertainties are associated with the depiction of site characteristics, the determination of the nature and extent of contamination, and the derivation of TRVs. All of these uncertainties are likely to influence risk estimates.

Table 29. Comparison of plant, earthworm and soil microbe benchmarks to ATG values (mg/kg).

	Oak Ridge Plant Benchmarks	ATG Plant	Oak Ridge[a] Earthworm Benchmarks	Oak Ridge Soil[b] Microbes Benchmarks	ATG Soil Invertebrate And Soil Microorganisms
Metals					
Antimony (Sb)	5.00E+00	5.00E-01	NA	NA	NA
Arsenic (As)	1.00E+01	1.00E+00	6.00E+01	1.00E+02	6.80E-01
Barium (Ba)	5.00E+02	5.00E+00	NA	3.00E+03	3.00E+03
Beryllium (Be)	1.00E+01	1.00E-01	NA	NA	NA
Cadmium (Cd)	4.00E+00	2.00E-01	2.00E+01	2.00E+01	1.00E+01
Chromium (Cr) as Cr III	1.00E+00	NA	4.00E-01	1.00E+01	NA
Chromium (Cr) as Cr VI	NA	1.80E-02			2.00E-01
Lead (Pb)	5.00E+01	4.60E+00	5.00E+02	9.00E+02	1.00E+02
Mercury (Hg) as inorganic	3.00E-01	3.00E-03	1.00E-01	3.00E+01	5.00E-02
Mercury (Hg) as organic	NA	3.00E-03	1.00E-01	3.00E+01	2.50E-01
Nickel (Ni)	3.00E+01	2.50E+01	2.00E+02	9.00E+01	1.00E+02
Selenium (Se)	1.00E+00	5.00E-02	7.00E+01	1.00E+02	7.70E+00
Silver (Ag)	2.00E+00	2.00E-02	NA	5.00E+01	5.00E+01
Thallium (Tl)	1.00E+00	1.00E-02	NA	NA	NA
Organics (feed)					
1,1,1-Trichloroethane	NA	NA	NA	NA	NA
1,1,2-Trichloroethane	NA	NA	NA	NA	NA
1,2,4-trichlorobenzene	NA	NA	2.00E+01	NA	NA
1,2-Dichloroethane	NA	NA	NA	NA	NA
1,4 dioxane	NA	NA	NA	NA	NA
2,4-Dinitrophenol	NA	NA	NA	NA	NA
Acetonitrile	NA	NA	NA	NA	NA
Aniline	NA	NA	NA	NA	NA
Benzene	NA	NA	NA	NA	NA
Benzo(a)pyrene	NA	1.20E+00	NA	NA	2.50E+01
Bromoform (tribromomethane)	NA	NA	NA	NA	NA
Butylbenzylphthalate	NA	NA	NA	NA	NA
Carbon disulfide	NA	NA	NA	NA	NA
Carbon tetrachloride	NA	NA	NA	NA	1.00E+03
Chlorobenzene	NA	NA	4.00E+01	NA	4.00E+01

Table 29. (continued).

	Oak Ridge Plant Benchmarks	ATG Plant	Oak Ridge[a] Earthworm Benchmarks	Oak Ridge Soil[b] Microbes Benchmarks	ATG Soil Invertebrate And Soil Microorganisms
Chloroform	NA	NA	NA	NA	NA
Diethylphthalate	NA	NA	NA	NA	NA
Di-n-butylphthalate	2.00E+02	NA	NA	NA	NA
Di-n-octylphthalate	NA	NA	NA	NA	NA
Formaldehyde	NA	NA	NA	NA	NA
Formic acid	NA	NA	NA	NA	NA
Methyl ethyl ketone (2-butanone)	NA	NA	NA	NA	NA
Methylene chloride	NA	NA	NA	NA	NA
Naphthalene	NA	NA	NA	NA	NA
Pentachlorophenol	3.00E+00	NA	6.00E+00	4.00E+02	NA
Phenol	NA	NA	3.00E+01	1.00E+02	NA
Pyridine	NA	NA	NA	NA	NA
Tetrachloroethylene	NA	NA	NA	NA	NA
Toluene	2.00E+02	2.00E+02	NA	NA	NA
Trichloroethylene	NA	NA	NA	NA	NA
Organics (PICs)					
2,3,7,8-TCDD TEQ	NA	NA	NA	NA	NA
1,3-Dinitrobenzene	NA	NA	NA	NA	2.26E+00
Nitrobenzene	NA	NA	NA	NA	2.26E+00
2,4-Dinitrotoluene	NA	NA	NA	NA	NA
2,6-Dinitrotoluene	NA	NA	NA	NA	NA
Pentachloronitrobenzene	NA	NA	NA	NA	NA

a. Values from Efroymson, R. A., M. E. Will, G. W. Suter II, and A. C. Wooten, 1997, *Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Terrestrial Plans,* 1997 Revision, Oak Ridge National Laboratory, Oak Ridge, TN, 128 pp., ES/ER/TM-85/R3.

b. Values from Efroymson, R. A., M. E. Will, and G. W. Suter II, 1997, *Toxicological Benchmarks for Contaminants of Potential Concern for Effects on Soil and Litter Invertebrates and Heterotropic Processes*, 1997 Revision, Oak Ridge National Laboratory, Oak Ridge, TN, 128 pp., ES/ER/TM-126/R2.

Table 30. Comparison of mammalian and avian toxicity values used at the INEEL to ATG values (all values in mg/kg-day).

	Mammalian Toxicity Values			Avian Toxicity Values		
	INEEL TRV (R1)	INEEL QCE	ATG TRVs	INEEL TRV (R1)	INEEL QCE	ATG TRVs
<u>Metals</u>						
Antimony (Sb)	1.25E+00	1.25E+00	6.60E-02	NA	NA	NA
Arsenic (As)	7.80E-01	3.10E+00	1.25E+00	1.29E+00	5.14E+00	2.46E+00
Barium (Ba)	1.02E+01	5.10E+00	5.10E-01	NA	NA	2.08E+01
Beryllium (Be)	6.60E-01	6.60E-01	6.60E-01	NA	NA	NA
Cadmium (Cd)	3.00E-03	5.50E-03	1.90E-01	7.00E-02	1.40E-01	1.13E+01
Chromium (Cr) as Cr III	7.50E+02	1.50E+03	2.74E+03	4.10E+00	4.90E+01	1.00E+00
Chromium (Cr) as Cr VI	1.50E-01	3.00E-01	2.40E+00	NA	NA	1.00E+00
Lead (Pb)	8.00E+00	8.00E+00	4.80E-01	1.40E+00	2.60E+01	2.50E-01
Mercury (Hg) as inorganic	3.40E-01	6.80E-01	1.01E+00	6.05E+00	1.21E+01	3.25E+00
Mercury (Hg) as organic	7.00E-02	1.40E-01	3.20E-02	8.00E-03	6.40E-02	3.25E+00
Nickel (Ni)	5.70E+01	1.14E+02	8.00E+00	3.87E+01	7.74E+01	6.50E+01
Selenium (Se)	4.00E-01	2.00E-01	5.80E-02	2.50E-01	5.00E-01	5.00E-01
Silver (Ag)	3.40E+01	6.80E+01	3.75E-01	4.37E+01	8.73E+01	1.78E+02
Thallium (Tl)	1.10E-01	1.80E+00	2.70E-03	1.50E-01	1.20E+01	3.50E-01
<u>Organics (feed)</u>						
1,1,1-Trichloroethane	1.00E+03	1.00E+03	1.00E+03	NA	NA	NA
1,1,2-Trichloroethane	NA	NA	NA	NA	NA	NA
1,2,4-trichlorobenzene	1.70E+00	2.00E+01	NA	NA	NA	NA
1,2-Dichloroethane	5.00E+01	5.00E+01	5.00E+01	8.60E+00	1.72E+01	1.72E+01
1,4 dioxane	5.00E-01	5.00E-01	1.07E-01	NA	NA	NA
2,4-Dinitrophenol	NA	NA	NA	NA	NA	NA
Acetonitrile	1.60E+01	1.90E+02	NA	NA	NA	NA
Aniline	NA	NA	NA	NA	NA	NA
Benzene	1.10E+01	2.64E+02	2.64E+01	NA	NA	NA
Benzo(a)pyrene	2.78E+01	5.00E+02	1.00E-01	NA	NA	3.00E-03
Bromoform (tribromomethane)	NA	NA	NA	NA	NA	NA
Butylbenzylphthalate	1.33E+01	1.59E+02	NA	NA	NA	NA
Carbon disulfide	9.20E-01	1.10E+01	NA	NA	NA	NA
Carbon tetrachloride	1.00E+01	1.00E+01	1.60E+01	NA	NA	NA
Chlorobenzene	NA	NA	NA	NA	NA	NA
Chloroform	3.75E+01	1.50E+02	5.14E+01	NA	NA	NA
Diethylphthalate	1.88E+02	7.50E+02	NA	NA	NA	NA
Di-n-butylphthalate	1.39E+01	1.25E+02	NA	NA	NA	NA

Table 30. (continued).

	Mammalian Toxicity Values			Avian Toxicity Values		
	INEEL TRV (R1)	INEEL QCE	ATG TRVs	INEEL TRV (R1)	INEEL QCE	ATG TRVs
Di-n-octylphthalate	4.35E+01	1.74E+02	NA	NA	NA	NA
Formaldehyde	1.50E+01	1.50E+01	2.30E+00	NA	NA	NA
Formic acid	NA	NA	NA	NA	NA	NA
Methyl ethyl ketone (2-butanone)	8.86E+02	1.77E+03	NA	NA	NA	NA
Methylene chloride	5.85E+00	5.85E+00	5.85E+00	NA	NA	NA
Naphthalene	1.30E+00	5.30E+00	NA	NA	NA	NA
Pentachlorophenol	1.20E-01	2.40E-01	3.00E-01	NA	NA	NA
Phenol	4.00E+01	6.00E+01	NA	NA	NA	NA
Pyridine	NA	NA	NA	NA	NA	NA
Tetrachloroethylene	3.50E+00	1.40E+01	1.40E+00	NA	NA	NA
Toluene	5.58E+01	2.23E+02	2.60E+01	NA	NA	NA
Trichloroethylene	2.50E+01	1.00E+02	7.00E-01	NA	NA	NA
<u>**Organics (PICs)**</u>						
2,3,7,8-TCDD TEQ	1.00E-06	1.00E-06	NA	7.00E-05	1.40E-05	NA
1,3-Dinitrobenzene	4.00E-01	4.00E-01	1.25E+00	NA	NA	3.76E-04
Nitrobenzene	5.56E+00	3.00E+02	NA	NA	NA	NA
2,4-Dinitrotoluene	3.50E+00	1.40E+01	NA	NA	NA	NA
2,6-Dinitrotoluene	5.00E+00	2.00E+01	4.00E-01	NA	NA	NA
Pentachloronitrobenzene	NA	NA	4.75E-04	3.54E+00	7.07E+00	7.07E+00

Table 31. Sources and effects of uncertainties in the ecological risk assessment.

Uncertainty Factor	Effect of Uncertainty (Level of Magnitude)	Comment
Estimation of ingestion rates (soil and food)	May overestimate or underestimate risk (moderate)	Few intake ingestion estimates used for terrestrial receptors are based on data in the scientific literature (preferably site-specific) when available. Food ingestion rates are calculated by using allometric equations available in the literature (Nagy 1987). Soil ingestion values are generally taken from Beyer et al. (1987).
Estimation of bioaccumulation and plant uptake factors and use of default values in calculating PUFs	May overestimate risk and the magnitude of error cannot be quantified (high).	Few bioaccumulation factors (CFs) or plant uptake factors (PUFs) are available in the literature that are both contaminant- and receptor-specific. In the absence of more specific information, PUFs and CFs for metals were obtained from Baes et al. (1984) and other literature sources and for organics from Travis and Arms (1988).
Use of modeled screening concentrations.	May overestimate (high) risk.	The calculated screening impacts from organic PICs are based on very conservative emissions estimates which assume all of the unburned fuel is converted to this single PIC (see Section 2). Actual emissions and the resulting soil concentrations, although unknown, would likely be significantly less than the values evaluated.
Estimation of toxicity reference values	May overestimate (high) or underestimate (moderate) risk	To compensate for potential uncertainties in the exposure assessment, various adjustment factors are incorporated to extrapolate toxicity from the test organism to other species.
Use of functional grouping	May overestimate (high)	Functional groups were designed as an assessment tool that would ensure that all species potentially present at the facility would be addressed. A hypothetical species is developed using input values to the exposure assessment that represents the greatest exposure of the combined functional group members.

Ecotoxicological data is recognized as one of the major uncertainties in ERA. As with the human health risk assessments, the TRVs are updated as new information is available. This is an ongoing effort that will continue throughout the ERA process at the INEEL.

In relation to extrapolations between individuals and populations, it is difficult to accurately predict ecological effects of toxic substances because of the complexity of the ecosystem. Most toxicity information comes from laboratory studies of single contaminant impacts on single species. Hence, there is a great deal of uncertainty in extrapolating controlled laboratory results to complex field situations and from one species to another. Single contaminant studies cannot predict the interactions of multiple contaminants with each other and with the ecosystem. Additionally, interactions of organisms with the ecosystem are complex and not easily predicted.

Few data are available for the invertebrate populations at the INEEL. Invertebrates are important links in dietary exposure for wildlife. There is sufficient ecological and toxicological data to adequately characterize the contaminant effects in the invertebrate component of the ecosystem. Such uncertainty will propagate into some of the other endpoint compartments, in particular those representing mammalian, avian, and reptilian insectivores.

There are a number of T/E or sensitive species that could occur in the NWCF assessment area. In some cases, they are known to exist in close proximity to INTEC facilities. The lack of information concerning the presence or absence of T/E and/or sensitive species in the vicinity of INEEL facilities and at the INEEL in general has been previously identified as an acceptable data gap.

8.4.4 NWCF SLERA Summary and Results

A screening of modeled concentrations of contaminant deposited to soil from activities planned at the NWCF to 0.25 of the EBSLs was performed. The maximum modeled concentration of 1,3-dinitrobenzene was the only contaminant to exceed any EBSL. However, the average concentration was below EBSL values. The calculated screening impacts from 1,3-dinitrobenzene are based on very conservative emissions estimates which assume all of the unburned fuel is converted to this single PIC (see section 2). Actual emissions and the resulting soil concentrations, although unknown, would likely be significantly less than the values evaluated.

Based on these results adverse effects to ecological receptors from the continued use of the NWCF appear to be unlikely. However, limited or no toxicity data is available for many of these contaminants and this limitation (as well as other uncertainties) needs to be recognized.

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Appendix A

Chemical Emission Rates

UPPER-ENVELOPE NWCF EMISSIONS FOR SCREENING-LEVEL RISK ANALYSIS

Estimates of maximum atmospheric emissions of hazardous chemicals from NWCF operations are needed for a screening-level risk analysis of the NWCF emissions. The following section develops an upper-envelope NWCF feed composition and calculates maximum annual, maximum hourly, and long-term emissions of the hazardous metals, acid vapors, and organic compounds from the feed for current and future NWCF operation at temperatures of 500 to 600°C. The estimated emissions are upper-envelope values based on an upper-envelope feed composition except for Hg whose lifetime emission is based on the total inventory Hg of the tank farm. The calculated emissions are for most species much higher than actual emissions.

1. NWCF Feed Term

Most of the upper-envelope emissions estimates are based on upper-envelope feed compositions which are estimates of the maximum concentrations that might be expected in any current or future NWCF feed based on current analyses of the tank farm. Separate upper-envelope (worst single year) annual and hourly feed rates are developed based on the NWCF NO_x emissions limits.

1.1. Feed composition

The derivation of the upper-envelope NWCF feed composition begins with Table 1 which gives the tank farm composition data available at the end of 1998. Two of the tanks are empty (to their operating heels of 5000 to 15,000 gal), two contain small quantities of dilute wastes, and seven contain significant volumes of waste. Some of the wastes from WM-189 and -185 are being calcined during 1999 NWCF operation. Current plans are to evaporate blends of wastes from WM-181, -184, and -186 in the High Level Liquid Waste (HLLWE), and store the concentrated bottoms in two tanks. Table 2 shows the expected compositions and volumes in the tank farm after the evaporation in the HLLWE (ignoring waste calcination in 1999 and future waste generation). Table 3 identifies the highest concentration in Table 2 for each of the RCRA metals. The upper-envelope concentrations are selected depending on the number of tanks for which analyses are available:

1. The highest concentration from Table 2 is used when analyses are available for every tank.

2. For those species for which not all the tanks are analyzed, one standard deviation of the concentrations was added to the highest concentration. For those species for which only one or two tanks have been analyzed, the concentrations in empty WM-188 were also considered

3. For species which were not detected in the analyses (Be, Sb, Tl), one half of the minimum detection limit was used.

4. The upper-limit concentration for Hg in Table 3 is derived in Section 3 based on the total tank farm Hg inventory from Table 1 accumulating in a postulated last tank.

Table 1. Chemical compositions of wastes in tank farm, December, 1998.

Waste tank	WM-180	WM-181	WM-182	WM-183	WM-184	WM-185	WM-186	WM-187	WM-188	WM-189	WM-19
Vol. gal	278600	275900	10300	23300	262600	74800	281500	29100	13500	146100	500
Sp. G.	1.262	1.156	1.2	1.216	1.219	1.25	1.158	1.134	1.306	1.307	
Acid, N	1.14	1.8	1.07	1.69	1.67	1.58	1.36	1.78	2.65	2.57	0.023
NO3, M	4.56	3.68	3.77	4.34	3.99	4.93	2.945	3.04	5.85	6.23	0.018
F, M	0.042	0.089	0.042	0.046	0.0232	0.16	0.040	0.119	0.302	0.222	0.007
Cl, M	0.031	0.012	0.019	0.0109	0.0275	0.028	0.0180	0.0035	0.0148	0.024	3.4E-
SO4, M	0.032	0.024	0.025	0.025	0.0274	0.036	0.029	0.010	0.0348	0.0067	
P, M		0.0061	3E-5	1E-4	0.0105	0.0026	0.0005		3.5E-4	2.9E-4	
Al, M	0.63	0.22	0.604	0.59	0.507	0.74	0.264	0.323	0.828	0.915	
Na, M	2.0	0.9	1.113	0.695	1.284	1.313	0.841	0.118	0.738	0.901	
K, M	0.18	0.14	0.108	0.093	0.085	0.184	0.139	0.0137	0.142	0.114	
Ca, M	0.034	0.044	0.025	0.0366	0.016	0.070	0.050	0.046	0.148	0.084	
B, M	0.01	0.015	0.009	0.013	<0.014	0.0195	<0.014	0.014	0.037	0.025	
Fe, M	0.018	0.012	0.024	0.052	0.0146	0.0248	0.0156	0.0126	0.0535	0.025	
Zr, M	<0.001	0.0046	0.006	<0.016	<0.012	0.011	<0.012	0.015	0.0255	0.0357	
Ag, mg/l	0.48	3.66				<0.8 to 10			5.1		
As, mg/l	3.5	< 3				0.11 to 23			46		
Ba, mg/l	7.1	5.1				9			13.5		
Be, mg/l						<0.79[u]			<0.79[U]		
Cd, mg/l	90	584	105	135	< 530	172	< 530	< 530	1210	540	
Cr, mg/l	198	151	260	675	< 210	255	215	< 210	750	225	
Hg, mg/l	195	90	200	580	138	782	181	540	1500	1024/ 2800[a]	
Pb, mg/l	290	207			59	190	87		200	216	
Ni, mg/l	94	70			< 243	88	< 243		270	< 117	
Se, mg/l	0.82	< 1				< 1					
Sb, mg/l						<2.45[u]			<2.45[U]		
Tl, mg/l						<6.8[u]			<6.8[U]		
U, mg/l	78	76	63	89	43	76	91	11	120	54	

u, not detected; given value is the minimum detection limit.

a, There is a discrepancy between the measured concentration of 1024 and the concentration of 2800 calculated from known inputs.

Table 2. Expected calcineable wastes in tank farm after evaporation in the HLLWE.

Waste tank	WM-180	WM-181/184	WM-181/186	WM-185	WM-187	WM-189
Vol. gal	278,600	233,000	185,000	74,800[b]	29,100	146,100[b]
Acid, N	1.14	2.9	3.35	1.58	1.78	2.57
NO3, M	4.56	7.7	7.8	4.93	3.04	6.23
F, M	0.042	0.079	0.127	0.16	0.119	0.222
Cl, M	0.031	0.038	0.036	0.028	0.0035	0.024
SO4, M	0.032	0.045	0.062	0.036	0.010	0.0067
Al, M	0.63	0.70	0.565	0.74	0.323	0.915
Na, M	2.0	2.00	1.95	1.313	0.118	0.901
K, M	0.18	0.18	0.32	0.184	0.0137	0.114
Ca, M	0.034	0.044	0.11	0.070	0.046	0.084
B, M	0.01	< 0.025	< 0.033	0.0195	0.014	0.025
Fe, M	0.018	0.024	0.033	0.0248	0.0126	0.025
Zr, M	<0.001	< 0.016	< 0.022	0.011	0.015	0.0357
Ag, mg/l	0.48			<0.8 to 10		
As, mg/l	3.5			0.11 to 23		
Ba, mg/l	7.1			9		
Be, mg/l				<0.79[u]		
Cd, mg/l	90	< 945	< 1240	172	< 530	540
Cr, mg/l	198	< 325	440	255	< 210	225
Hg, mg/l	195	210	343	782	540	1024/ 2800[a]
Pb, mg/l	290	190	285	190		216
Ni, mg/l	94	< 315	< 420	88		< 117
Se, mg/l	0.82			< 1		
Sb, mg/l				<2.45[u]		
Tl, mg/l				<6.8[u]		
U, mg/l	78	93	194	76	11	54

u, not detected; given value is the minimum detection limit.

a, There is a discrepancy between the measured concentration of 1024 and the concentration of 2800 calculated from known inputs.

b, Much of this volume will be solidified by 1999 NWCF operation.

Aluminum nitrate must be added to the wastes in the tank farm to achieve Al concentrations significantly greater than the combined concentrations of Na and K before the waste can be calcined in the NWCF. The upper-envelope flowsheet ignores the need for addition of aluminum nitrate and other chemicals and assumes that the NWCF can calcine straight tank farm waste. This assumption provides a margin of conservatism of at least a factor of two for every actual flowsheet.

Table 3. Composition of upper-limit NWCF feed.

	Highest concentration in Table 2	Concentration in WM-188	Number of non-empty tanks with analyses	Upper-limit concentration
Acid, N	3.35		7	3.35
Cl, M	0.038		7	0.043
Ag, mg/l	10	5	2	14
As, mg/l	23	46	2	58
Ba, mg/l	9	13.5	2	17
Be, mg/l	<0.79[u]	<0.79[u]	1	0.4
Cd, mg/l	< 1240		7	1240
Cr, mg/l	440		7	440
Hg, mg/l	2800		7	3000
Pb, mg/l	290		7	290
Ni, mg/l	< 420		7	420
Se, mg/l	< 1		1	1
Sb, mg/l	<2.45[u]	<2.45[u]	1	1.225
Tl, mg/l	<6.8[u]	<6.8[u]	1	3.4
U, mg/l	194		7	194

u, not detected; given value is the minimum detection limit.

1.2. NWCF feed volumes and maximum rate

The total volume of the wastes in Table 2 is 947,000 gal. An additional allowance of 25 % for future wastes (returned scrub solutions, decontamination solutions, PEW evaporator bottoms) brings the volume to be calcined to 1,180,000 gal (4,480,000 l).

Major constraints on the NWCF feed rate are an hourly NO_x emission limit of 472 lb/hr and an annual NO_x emission limit of 1700 tons/yr. The feed that allows the largest feed volume with a fixed NO_x limit is the one with the lowest nitrate concentration, which is a WM-185 blend (not the upper-envelope feed of Table 3) containing about 6 M nitrate. This feed allows a gross hourly feed rate of 205 gph (778 l/hr). (This calculation ignores the nitrate content of the calcined solids and assumes that every mole of nitrate in the feed results in an atmospheric emission of one mole of NO_x.) The NWCF feed contains 7.5 to 25 % recycled scrub solution. With the maximum 92.5 % waste (and the scrub solution having the same nitrate concentration as the waste), the upper-envelope net feed rate becomes 190 gph (718 l/hr).

2. Removal of Non-Volatile Calcine Species

The non-volatile calcine species can be emitted both directly in the calciner off-gas and indirectly from auxiliary systems as shown in Figure 3 of the SLRA. The auxiliary systems are: 1) NWCF sparged feed and sump vessels which are an integral part of the NWCF, 2) PEW evaporator and LET&D which are independent systems that operate at the same time as the

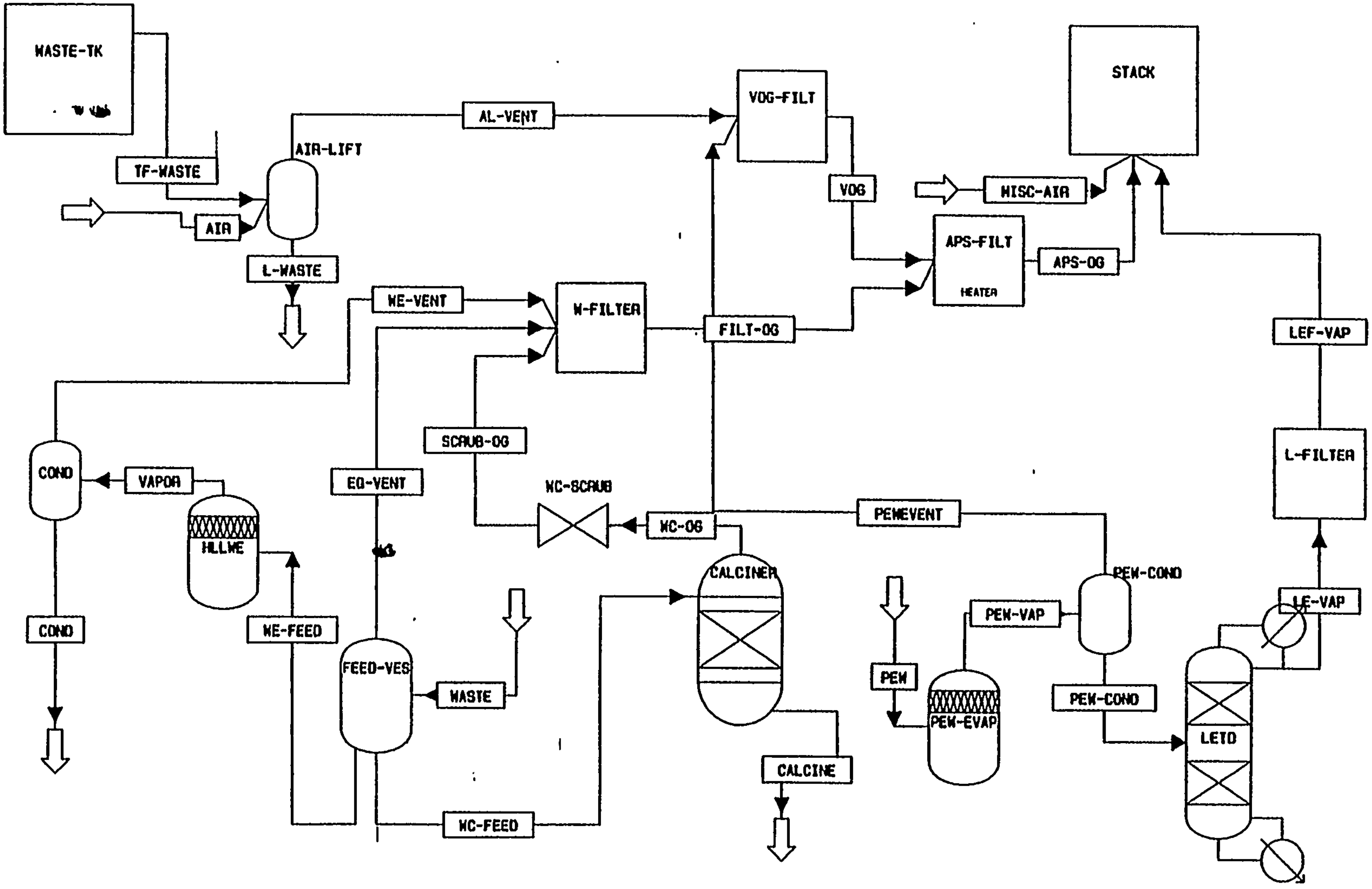

Figure 1. Schematic diagram of INTEC off-gas systems for NWCF and auxiliary systems.

NWCF, 3) the air-lift pump in waste tank WM-189 which is used transfer waste from WM-189 (and no other tank) to the NWCF, and 4) the HLLWE which is an independent system that does not operate at the same time as the NWCF.

2.1 NWCF calciner emissons

When calcined, most of the metals of Tables 1, 2, and 3 form non-volatile oxides which are readily scrubbed and filtered from the off gas in the off-gas system, shown in Figure 1 and in Figure 3 of the the SLRA, which contains a scrub system, a set of Si-gel absorbers, and a set of HEPA filters. It is followed by the APS filters which are an independent system. The decontamination efficiency (DF) of the off-gas system (input/effluent) is assumed to be be the same for all of the non-volatile metal oxides.

The solids retention in the initial section of the calciner, consisting of the calciner vessel, cyclone, quench tower, Venturi scrubber, and mist eliminator, is lumped together for estimating the emissions of non-volatile solids, because the most extensive measured data[1] on this section of a calciner are overall DF's for this section from the WCF (the predecessor of the NWCF) which had an off-gas system similar to that of the NWCF. The measured[1] DF's, in this section of the WCF, for non-volatile solids represented by ^{90}Sr, exceeded 2000 for the runs using in-bed combustion. Some measurements[2,3] during NWCF cold operation indicate that the overall DF (feed-to-effluent) through the scrub system for the NWCF is 5000 to 10,000.

The silica-gel absorbers that follow the scrub system can also remove solids. For conservatism, no credit is taken for the absorbers in this model because they are occasionally left off line. (When operating, they achieve a DF for solids of about 10.)

The NWCF filter system consists of four parallel banks of filters which each filter the off gas through three HEPA filters in series. The filters are tested individually, when purchased, for the HEPA filter standard of 99.97 % removal of a 0.3 micron test aerosol. Although each filter bank contains three stages of filters, these banks are leak tested after installation to verify an overall efficiency for the set of three filters equivalent to two HEPA filters in series (i. e., two stages of filters with a test aerosol removal efficiency of 99.97 % each). Thus, the filter banks always meet the test criteria (penetration of < 9E-8) when put on line. Filter deterioration in service is detected by changes in pressure drops or by radiation buildup on the APS filters that follow. Filters are taken out of service and replaced whenever signs of filter degradation are observed.

The NWCF off-gas next goes to the APS system which provides another stage of filtration with HEPA filters. The APS filters are well heated and essentially always meet their test criteria of 99.97 % efficiency as determined by the guidelines of ASME N 510, Section 10.

The overall (long-term average) NWCF DF for non-volatile species was determined by comparison[4] of the stack emissions[5,6,7] of ^{90}Sr with the ^{90}Sr in the NWCF feeds during months of NWCF operation in 1991, 1993, and 1997. The ratio of the total ^{90}Sr in the NWCF feed during these years to the total stack ^{90}Sr emission for the months of NWCF operation is 5.4E+08 which is used as an overall DF for all non-volatile species in the NWCF. This overall DF based on stack emissions includes emissions from all auxiliary operations and coincident INTEC operations (e. g., the PEW evaporator and LET&D). This DF based on long-term emissions data includes the effects of operating upsets. The DF of 5.4E+08 is lower than for "normal" operation because it is effected strongly by periods of upset operation.

The decontamination factors (reciprocal of penetration) of non-volatile species for the NWCF and APS filters in Table 4 were selected to obtain an overall DF of 5.4E+08. The APS filter, which is less vulnerable to wetting and has a good retest record, is assigned a DF of 300, and the NWCF filter set is assigned a DF of 900 (about 97 % efficiency for each of two filters in series). The "normal' filter efficiencies are much higher, but short periods of degraded operation weigh heavily on the long-term average efficiency.

Table 4. Decontamination factors of the NWCF and APS off-gas systems used in emissions calculations for non-volatile solids.

Section	**Decontamination Factor**
Calciner, cyclone, and scrub system	2000
Absorbers	1
NWCF filters	900
APS filter	300
Overall	5.4E+8

2.2 Auxiliary emissions sources

Auxiliary systems with emissions are 1) the NWCF process vessels, 2) the PEW evaporator and Liquid Effluent Treatment and Disposal (LET&D) systems, 3) the WM-189 airlift, and 4) the High Level Liquid Waste Evaporator (HLLWE). Only the NWCF process vessels are an integral part of the NWCF. The overall NWCF DF of 5.4E+08 includes emissions from the NWCF process vessels, and coincident operation of the PEW evaporator, and LET&D (starting in 1993).

1. NWCF process vessels

The NWCF facility contains sparged feed-storage vessels, sump vessels, and air-lifts whose off-gas bypasses the calciner and scrub system and joins the calciner off gas before the NWCF filters. The emissions from these vessels and air-lifts are a minor fraction of the NWCF emissions because their gas flows and velocities are lower than in the NWCF scrub system. The emissions from the process vessels are included in the overall NWCF DF of 5.4E+08 because these emissions were included in the stack effluent samples on which the overall NWCF DF is based.

The primary mechanism of particulate emission from the NWCF process vessels and airlifts is entrainment of liquid droplets by the sparge and airlift air. An entrainment study[10] on evaporators indicates that an entrainment factor of 1E-4 kg liquid/kg gas is conservative for gas flows well in excess of the NWCF sparge rates of about 1 $ft^3/s\text{-}ft^2$. The total air input to the NWCF sparges and airlifts is < 100 scfm which is < 214 kg air/hr. The maximum particulate entrainment from the vessels and airlifts for this air input is 0.0214 kg/hr (which is reduced greatly by the NWCF and APS filters before reaching the stack). The NWCF (maximum) feed rate of 778 l/hr (with a density of 1.27 kg/l) is 988 kg/hr. The entrainment relative to the feed is 2.15E-05 which corresponds to a DF of 46,000 (before filtration). This entrainment is 4.3 % of the particulate emission from the calciner and scrub system, obtained using the DF of Table 4, for the point before the NWCF filters where the vessel off-gas flow joins the calciner off gas.

2. PEW evaporator and LET&D

The PEW evaporator and LET&D are independent of the NWCF, but they often operate at the same time as the NWCF. The PEW evaporator and LET&D operate in sequence and usually operate together. The PEW evaporator condensate is vaporized by the LET&D, filtered (double HEPA filters) and discharged to the stack as a vapor. The emission route for the two systems is the LET&D vapor. Emissions for coincident operation of the PEW evaporator and LET&D are included in the overall DF for the NWCF because emissions for PEW evaporator and LET&D operation at normal rates were included in the stack effluent samples on which the overall NWCF DF is based.

The non-volatile particulate emissions in the LET&D vapor are very low (at least a factor of a 1000 lower than from the NWCF) because the PEW is evaporated in series by the PEW evaporator and LET&D systems (each of which have a DF for non-volatile solutes[8,9] of 1000 to 10,000), and the vapor is then filtered through two HEPA filters in series. In addition, the solute concentrations of solutes in the PEW are about a factor of 100 lower than in the NWCF feed.

The only other emission source from the PEW evaporator is a vent from the condenser. The vent discharges the purge air from the instrument probes and air displaced by vessel filling to the Vessel Off Gas (VOG) system which filters effluents with a VOG filter and the APS filter (Figure 1). The emission from the vent is very small because of the small gas flow (5 to 10 scf/hr), and the vent location at the condenser outlet cools the off gas and washes the off gas with condensing vapor before it vents.

3. WM-189 air-lift

One active waste storage tank (WM-189, and also spare tank WM-190) uses a 3-stage air-lift pump for liquid transfers. Emissions from use of the WM-189 air-lift pump are not included in the NWCF overall DF because this air-lift pump was not operated during the NWCF operating period on which the overall DF is based. The motive air input, which is not metered, is estimated at a maximum of 300 scf/min which has a potential for substantial entrainment. (Normally the motive air input is much less than the maximum capacity.) Most of the air-lift motive air discharges into the tank, which serves as a huge (50-ft diameter) settling chamber, and then goes to the VOG system which filters it through the (single-stage) VOG filter and the APS filter before discharging to the stack. (A small portion of the air goes with the liquid to the NWCF and discharges through the NWCF off-gas system which has one more filter than the VOG system.) The WM-189 airlift has an atmospheric emission only when being used to transfer liquid out of WM-189. The other (active) waste storage tanks use steam jets which have no effluent gases.

The maximum relative entrainment from the airlift comes with the maximum air input of 300 scfm (640 kg/hr) and the minimum liquid flow of about 30 gpm (130 kg/min). An entrainment factor of 5E-5 kg liquid/kg air is used because of the long settling time and low air velocity (< 1 % of the air velocities in the sparged tanks) in the tank. (The entrainment factor of 5E-5 kg liquid/kg air is conservative compared to the data[10] for low gas velocities.) With this entrainment factor, the particulate entrainment from the tank is 0.032 kg/hr from the tank; and the relative entrainment is one part in 240,000 of the liquid transferred. The filter DF's assumed for this analysis are 30 for the VOG filter (the same as for a single NWCF filter in Table 4) and 300 for the APS filter (from Table 4). The overall particulate DF for the filtered effluent is 2.2E+09 as compared to 5.4E+08 for the NWCF (i. e., addition of the calculated airlift emission to the NWCF emission would increase the calculated overall emission by about 50 %).

4. High level liquid waste evaporator

The high level liquid waste evaporator (HLLWE) uses the same feed and sump vessels as the NWCF, but is not a part of the NWCF. It does not operate at the same time as the NWCF because of conflicting needs for the same feed and sump vessels.

HLLWE operation emits entrained liquid drops from the sparged NWCF vessels it uses for the feed and product. As during NWCF operation, the vessel off gases discharge through the NWCF and APS filters. The emissions are about the same as estimated above for sparging the same vessels with NWCF operation -- about 4 % of the particulate emissions estimated for NWCF operation.

The HLLWE condensate is evaporated by the PEW evaporator, whose condensate is vaporized and discharged from the LET&D. The emissions via this route are very small the liquid goes through three stages of evaporation (each with particulate DF's of 1000 to 10,000) and two sets of HEPA filters (with a combined DF of about 900) before discharge.

Another minor HLLWE emission route is the vent on the condenser which vents the HLLWE purge air and the air displaced by filling. The emission is very small because of the small purge air input (about 10 scf/hr). The discharge route is via the NWCF and APS filters.

2.3. Combined particulate emissions

The WM-189 air-lift pump is only one of the above sources that is not included in the overall NWCF DF of 5.4E+08. The overall particulate emission DF (reciprocal of emission fraction), obtained by adding the WM-189 air-lift pump emission to the emission for the NWCF and coincident operations is 4E+08. This DF would apply to the maximum annual and hourly emissions. The DF for the lifetime emissions can consider that an airlift is found only in one (WM-189) of the five tanks of Table 2. Weighting of the airlift usage for long-term emissions at 33 % of the wastes (which is a conservative weighting allowing for some reuse of WM-189) gives a combined DF of 5E+08.

3. Volatile Mercury Compounds

Mercury volatilization during calcination is a major concern because the mercury in the NWCF feed is essentially all volatilized from the calciner, mostly as $HgCl_2$. (The Hg is $HgCl_2$ in the calciner off gas and scrub system because of the presence of HNO_3 and HCl in the off gas.) The mercury volatilized from the calciner is collected in the scrub solution in which the mercury accumulates throughout the campaign. Scrub solution is recycled back into every feed batch, but the recycled mercury is revolatilized and returns to the scrub solution.

3.1 Emission factor for mercury

Hg compounds are emitted from the NWCF scrub system because of: 1) the volatility of $HgCl_2$ (and other molecular Hg compounds) in the scrub solution, and 2) incomplete absorption of the Hg compounds in the scrub system. There is essentially no removal of molecular Hg compounds by the filters. Thus, the NWCF Hg emission depends on the concentration and chemical species distribution in the scrub solution as well as the Hg concentration in the feed.

The emission factor for Hg used in this evaluation is based on off-gas samples taken with a activated carbon cartridge during 1997-1998 NWCF operation. The charcoal cartridges used to monitor the radioiodine emissions from the stack were also analyzed for their Hg content which was used to calculate emission as a fraction of the Hg in the net feed. [Although used to measure radioiodine, activated carbon filters are generally very efficient (90%) for mercury[11] or other higher molecular weight vapors]. The fractional Hg emissions, from 3 sample cartridges with sample durations of 2 to 4 months, averaged 2.55 % of the Hg in the net feed with a standard deviation of 0.865 %. An upper-limit emission of 3.7 % (or a feed-based DF of 27) is obtained by assuming a charcoal collection efficiency of 90 % and adding one standard deviation to cover process variations. (The 3.7 % could also be considered to represent 70 % collection efficiency without an allowance for process variation.)

Some concern has been expressed that the Hg emissions determined using the charcoal cartridges could be low because of charcoal saturation and Hg breakthrough. We do have some evidences that there was no significant breakthrough of Hg during the sampling period:

1. The average Hg concentrations on the charcoal samples were 11 to 22 ppm which is much less than the typical absorption capacity of these absorbents (25,000 ppm[12]).

2. The most likely form of Hg is $HgCl_2$ which is readily sorbed by charcoal at ambient temperature because of its low ambient vapor pressure (0.022 Pa by the equation of Bernard[13]).

3. The analysts report that the Hg on the charcoal was very non-uniform in distribution (requiring extensive mixing for aliquot replication) which indicates loading of the Hg on the front of the charcoal. A saturated charcoal sample would have a uniform concentration at the saturation level.

4. The stack samples[14,15,16] taken during 1993 NWCF operation using an EPA sample train (40CFR266, App. IX) showed Hg emissions averaging 0.5 % of the Hg in the feed which is a factor of five lower than obtained in 1997-1998 with the charcoal sampler.

5. The sample interval for the three samples taken with the charcoal varied. One sample spanned 2 months and the other two samples spanned 4 months. If significant breakthrough were occurring, the sample with the shorter span would show a higher measured off-gas Hg concentration because it operated for the smaller fraction of the sample period after breakthrough. Instead, the sample of shorter duration showed an off-gas Hg concentration in between those of the longer samples.

3.2 Lifetime emission

The waste in the INTEC tank farm contains about 2.6 Mg (nearly 3 tons) of Hg which could be recycled to the tank farm and fed to the NWCF more than once during the calcination of the waste in the tank farm. Most of the Hg in NWCF feed is collected in the scrub solution and returned to the tank farm at the end of the operating campaign or when the scrub solution is purged because of operating upsets. In the 1997-1998 NWCF operation, about 87 % of the Hg fed to the NWCF was returned tank farm in the scrub solution and vessel flushes at the end of the campaign. (The 13 % of the Hg not returned to the tank farm includes the 2.5 to 3.7 % emitted from the stack, the Hg in the calcined solids, Hg absorbed in the Si-gel absorbers, and Hg plated out in process piping.) For a conservative analysis, this return fraction is increased to 90 %.

The lifetime Hg emission depends on the management of the high-Hg scrub solutions which, after the 1997-1998 NWCF operation, contained over half of the Hg in the tank farm. The usual practice is to evaporate the scrub solutions (and decontamination wastes) from the previous run in the HLLWE and blend them into the feed for the next run. (The Hg emissions from HLLWE operation are discussed in section 3.3.) This practice minimizes the number of tanks in use, but also produces the worst case lifetime emission because the Hg in the scrub solutions is refed to the NWCF several times. The worst-case lifetime Hg emission is calculated assuming calcination of all of the waste in the tank farm with the returned scrub solution:

1. The waste is calcined in 5 runs: 1) (the current run) the wastes from WM-185 and –189, 2) an evaporated blend (0.5:1) of wastes from WM-181 and -184, 3) an evaporated blend 0.5:1) of wastes from WM-181 and -186, 4) the waste from WM-180, and 5) the newly-generated and miscellaneous wastes.

2. 90 % of the Hg in the feed to each run is returned to the tank farm in the scrub solution and flushes and then blended into the feed for the next run (worst-case sequence).

3. The emission for each run is 3.7 % of the Hg in the feed.

The lifetime Hg emission for the above scenario is 340 kg.

3.3 Auxiliary sources

Most of the Hg emissions from the auxiliary systems (Figure 1) are included in the 3.7 % emission factor because the 3.7 % factor is based on stack measurements with the auxiliary systems running. The Hg emissions from the NWCF scrub system are much higher than the auxiliary system emissions because the NWCF scrub system has a higher liquid temperature (74°C), a higher gas flow (about 1300 scf/min), and a higher Hg concentration in the liquid (10 to 50 g/l).

1. PEW evaporator and LET&D

The PEW evaporator and LET&D operate in sequence and usually operate together. The PEW evaporator condensate is vaporized by the LET&D, filtered (double HEPA filters) and discharged to the stack. The emission route is the LET&D vapor. The PEW evaporator and LET&D were processing a normal volume of feed (about 30,000 gal/mo.) during 1997-1998 period of NWCF operation during which the NWCF Hg emission was measured. Hence the NWCF emission factor of 3.7 % includes concurrent operation of the PEW evaporator and LET&D.

Planning is beginning on the characterization of the PEW evaporator and LET&D. There is a set[8] of data on Hg behavior in the LET&D during a period in 1993 which included some NWCF operation. The Hg concentrations in the condensate fed to the LET&D ranged from 0.1 to 10 mg/l. The Hg behavior was evaluated by comparing the Hg concentrations in the feed and bottoms. The test results[8] indicate that essentially all of the Hg is retained in the LET&D bottoms; the material balances were 93.6 to 158 % retention in the bottoms. A worst-case LET&D Hg emission, based on 30,000 gal/mo. of PEW containing 10 mg Hg/l and on a LET&D Hg retention of 93.6 % , is 0.9 kg/yr which is minor compared to the Hg emissions attributed (above) to the NWCF. The more likely LET&D Hg emissions are a few g/yr.

The only direct emission source from the PEW evaporator is a vent from the condenser. The vent discharges the purge air from the instrument probes and air displaced by filling. The Hg emission from the vent is very small because of the small gas flow (5 to 10 scf/hr), the low temperature at the condenser (< 35°C), and the low Hg concentrations in the condensate (< 10 mg/l). The vent emissions are included in the stack effluent sampled by the charcoal filter sampler used to develop the 3.7 % Hg emissions fraction.

2. NWCF process vessels

The NWCF facility, shown in Figure 1, contains sparged feed-storage vessels, sump vessels, and air-lifts whose off-gas bypasses the calciner and scrub system and joins the calciner off gas before the filters. The Hg emissions from these vessels and air-lifts are a minor fraction (estimated by ratioing off-gas flows and $HgCl_2$ vapor pressures at about 0.1 %) of the NWCF Hg emissions because their temperatures (< 35°C) and gas flows (totaling < 100 scf/min) are much lower than in the NWCF scrub system. The Hg concentrations are also much lower than in the scrub system except for the one tank which receives some scrub solution. Emissions in the off gas from these vessels are also included in the stack effluent sampled by the charcoal filter sampler used to develop the 3.7 % Hg emissions fraction.

3. WM-189 air-lift

One active waste storage tank (WM-189 and also spare tank WM-190) uses an air-lift pump for liquid transfers. The air input, which is not metered, is estimated at maximum of 300 scf/min which is substantial but still less than the 1300 scf/min in the NWCF scrub system. (Normally the motive air input is much less than the maximum capacity.) The Hg emission, which was not included in the 1997 stack charcoal samples because the air-lift was not used at that time, is a small fraction (estimated by ratioing off-gas flows and $HgCl_2$ vapor pressures at less than 0.1 %) of the emission from the NWCF scrub system because of the lower liquid temperature (< 20°C), air throughput, and aqueous Hg concentration. The WM-189 airlift has an atmospheric emission only when being used to transfer liquid out of WM-189. The other (active) waste storage tanks use steam jets which do not have a non-condensable off gas.

4. High level liquid waste evaporator

The high level liquid waste evaporator (HLLWE) is not a part of the NWCF and does not operate at the same time because of conflicting needs for the same vessels. The primary HLLWE emission route is via the PEW evaporator and LET&D. The HLLWE condensate is transferred to the PEW evaporator whose condensate is vaporized and discharged from the LET&D. The Hg concentrations in the HLLWE condensate average between 20 and 30 mg/l which represent a DF of about 30 from the feed. The PEW evaporator, which has not been characterized, is expected to reduce the Hg in its condensate to less than 10 mg/l; and the LET&D to remove another 93.6 % of the Hg. For maximum HLLWE operation, which cannot occur in the same year as NWCF operation, the HLLWE would produce about 400,000 gal of condensate for which the Hg emission from LET&D would be less than 1 kg/yr.

HLLWE operation also emits some Hg from the sparged NWCF vessels it uses for the feed and product. The emissions are estimated based on the similarity of sparge gas flows, temperature, and liquid compositions as about the same as from the same vessels during NWCF operation -- about 0.1 % of the Hg emissions estimated (above) for NWCF operation.

The other HLLWE emission route is the vent on the condenser which vents the HLLWE purge air and the air displaced by filling. The emission is very small because of the small purge air input (about 10 scf/hr), low condenser temperature (near ambient), and the low Hg concentration in the condensate.

4. Other Volatile and Semi-Volatile Calcine Species

In order to check the possibility of other volatile compounds of the hazardous metals, the vapor pressures[17] of the oxides and chlorides of the hazardous metals having measurable vapor pressures at temperatures between 50 and 750°C are plotted in Figure 2. (Most of the metal oxides have measurable vapor pressures only at temperatures above 750°C.) At the calciner temperature of 500 to 600°C, Sb_2O_3, $CdCl_2$, $PbCl_2$, and all the compounds on Figure 2 with higher vapor pressures would probably vaporize from the calcine. The emissions of these species vaporized from the calciner depend on whether they remain vapors or condense as filterable solids when the off gas is cooled to 65 to 75°C in the scrub system, and then reheated to the (about 85 to 95°C) temperature of the filters. The more volatile compounds with vapor pressures greater than that of $HgCl_2$ will behave like $HgCl_2$ with vapor not absorbed in the scrub system being sufficiently volatile to pass through the filters.

The metal chlorides are much more volatile than the oxides. The question of which of the hazardous metals species are thermochemically favorable in the calciner was addressed by a series of Gibbs free energy minimization calculations using an ASPEN Gibbs reactor block (RGIBBS) for the calculation. The calculations were done at 500 and 600°C using the bulk calciner off-gas composition from the the ASPEN waste systems model[18]. (The program used the "solids" OPSET and the "solids" and "inorganic" data bases, which are the NBS[19] and Barin[20] data bases, respectively.) The calculations were run in three steps:

1. The first set of calculations introduced the hazardous metals (as oxides) with the off gas and HCl, but no Na, K, or Ca compounds, in order to determine whether HCl could react with the oxides. These calculations showed that the chlorides of Pb, Tl, Cr, and Be are thermochemically favored over the oxides in NWCF off-gas containing HCl.

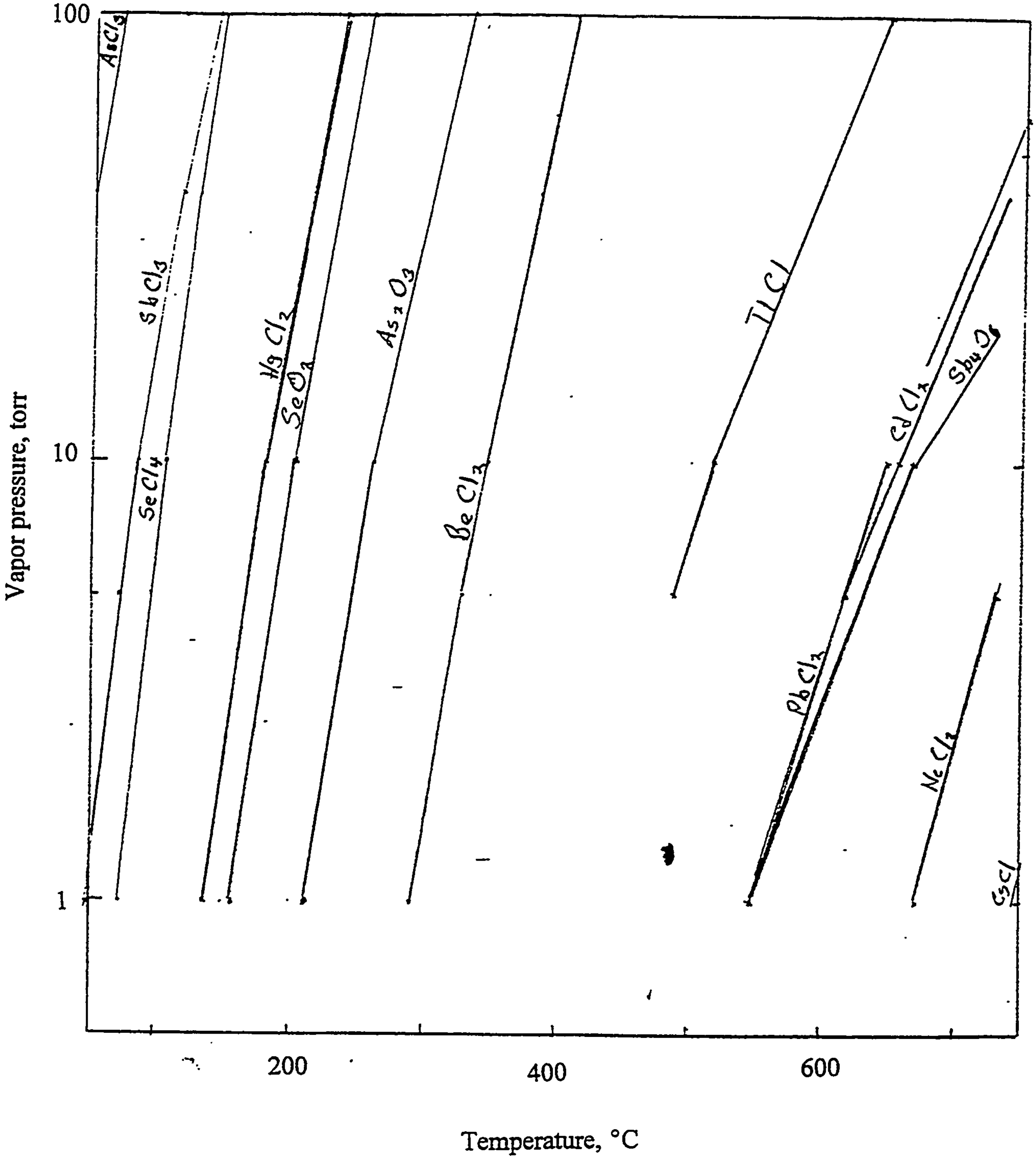

Figure 2. Vapor pressures[17] of hazardous metal compounds.

2. The second set of calculations added Na, K, and Ca (nitrates or oxides) to test their calculated ability to tie up Cl. These calculations indicate that Na, K, and Ca could each react quantitatively with the HCl and force the equilibria for Pb, Tl, Cr, and Be to the oxides. (There may be kinetic constraints on this conclusion.)

3. The third set of calculations repeated set 2 with the formation of NaCl, KCl, and $CaCl_2$ suppressed to test the favorability of Na_2CrO_4 and Na_3AsO_4 in the presence of HCl. These calculations indicate that Na_2CrO_4 and Na_3AsO_4 form quantitatively even in the presence of HCl.

The calculated speciation is compiled in Table 5. The first two columns show the calculated speciation without the reactions with Na, K, and Ca; the last two columns show the calculated speciation with the reactions with Na, K, and Ca. The presence of Na compounds shifts the calculated equilibria of Pb, Tl, Be, Cr, and As from volatile chlorides to non-volatile oxides, chromates, and arsenates. (Some support for the calculated speciation of Cr as non-volatile is provided by a material balance on Cr for a pilot plant test which accounted for all of the Cr in the solids streams.)

There is some uncertainty about the thermodynamic calculations because 1) lack of experimental verification, 2) questions on whether the solid species can mix sufficiently to react, 3) potential kinetic constraints, and 4) an uncertainty about the accuracy of the ASPEN data bases used to extrapolate free energies to calcination temperatures. To allow for these uncertainties and possible kinetic constraints, the upper-envelope emissions calculations assume that the Pb, Tl, and Be are 10 % as the chloride and 90 % as an oxide rather than the very low fractions of chlorides shown in columns 3 and 4 of Table 5. The Cr and As are considered to be the sodium chromates and arsenates, as predicted, because all NWCF feeds contain large concentrations of sodium.

The volatile and semi-volatile species identified in Table 5 as possibly being formed in the NWCF are $PbCl_2$, Sb_4O_6, TlCl, SeO_2, and $BeCl_2$. The question of their filterability after cooling to the NWCF filter temperature (85 to 95°C) was addressed as follows (and illustrated with the calculations for $PbCl_2$ and Sb_4O_6):

1. The vapor pressures of Figure 2 were replotted as log pressure vs 1/T and extrapolated to 100°C to estimate the vapor pressure at 100°C. (1E-11 torr for $PbCl_2$ and Sb_4O_6)

2. For conservatism, the extrapolated vapor pressure at 100°C was increased by a factor of 2 to 100 depending on the distance extrapolated. (to 1E-9 torr for $PbCl_2$ and Sb_4O_6)

3. The mole flow of each vapor carried by a total off-gas flow[18] of 300 lbmol/hr (2000 scfm) at a pressure of 300 torr[18] was calculated (1E-8 lbmol/hr for $PbCl_2$ and Sb_4O_6) and then converted to mass flow (1E-4 g/hr of $PbCl_2$ and 2.2E-4 g/hr of Sb_4O_6).

5. The feed rate of each vapor was calculated from the feed concentrations of Table 3, then reduced by a factor of 27 for removal in the scrub system (2 g/hr of $PbCl_2$ and 0.02 g/hr of Sb_4O_6) and compared with the mass flows from step 4.

Table 5. Fractions of hazardous metal species formed during calcination as calculated by Gibbs free energy minimization without and with sodium.

Species evaluated	No Na at 500°C	No Na at 600°C	With Na at 500°C	With Na at 600°C
$PbCl_2$ PbO	1.0 2E-7	1.0 3E-5	2E-18 1.0	3E-16 1.0
$SbCl_3$ Sb_4O_6	1E-4 1.0	2E-5 1.0		
$CdCl_2$ CdO	6E-22 1.0	7E-22 1.0		
$NiCl_2$ NiO	8E-8 1.0	3E-8 1.0		
$TlCl$ Tl_2O	1.0 9E-12	1.0 3E-10	2E-7 1.0	6E-6 1.0
$AsCl_3$ Na_3AsO_4 As_2O_3	0 1.0	0 1.0	0 1.0 0	0 1.0 0
$SeCl_4$ SeO_2	0 1.0	0 1.0		
CrO_2Cl_2 Na_2CrO_4 CrO_3	1.0 0 7E-7	1.0 0 1.4E-4	0 1.0 0	2E-16 1.0 0
$BeCl_2$ BeO	1.0 0	1.0 0	2E-9 1.0	2E-7 1.0

The conclusions of the above set of calculations are:

1. The low concentrations of $TlCl$, $BeCl_2$, and SeO_2 are completely volatile at filter temperatures because of their relatively high vapor pressures and hence will not be removed by the filters.

2. The vapor pressures of $PbCl_2$ and Sb_4O_6 are in a range where filter DF's for $PbCl_2$ and Sb_4O_6 will be limited by volatility. Their emissions can be characterized conservatively by the mass flows of 1E-4 g/hr for $PbCl_2$ and 2.2E-4 g/hr for Sb_4O_6.

3. The species with vapor pressures less than Sb_4O_6 are non-volatile at 100°C.

The scrub system DF of 27 (the same DF as for 3.7 % Hg emission) is used for the vaporized hazardous metal species assuming they have the same scrub inefficiencies and solubilities as $HgCl_2$. Some of them are probably more soluble than $HgCl_2$ because of aqueous reactions. These volatile species would have the same tendency to accumulate in the scrub solution as Hg.

5. Emissions Calculations for Hazardous Metals

The decontamination factors for the hazardous metals with volatile compounds are estimated in Table 6 from the percents of each compound from Table 5 by a weighted averaging of the DF's for the compounds using:

1) a DF for the calciner through scrub system of 2000 if non volatile or 27 (based on Hg) if volatile (and absorbed in the scrub system);

2) a DF for the filters of 2.7E+05 if filterable or 1 if volatile;

3) the previously calculated vapor flows of $PbCl_2$ and Sb_4O_6.

Conservative lifetime and annual average emissions are estimated in Table 7 based mostly on the upper-limit feed concentrations of Table 3. The calculated emissions are conservative because the upper-limit feed concentrations are much higher than the average concentrations. The calculations proceed from left to right:

1. The feed concentrations are from Table 3.

2. The upper-limit inventories (except for Hg) are obtained by multiplying the concentration by a total net feed volume of 1,180,000 gal (which allows 25 % for future waste generation). The Hg inventory is the total in the tank farm (from the concentrations and volumes in Table 1).

3. The emissions DF's are from Table 6 except that the overall DF's for the non-volatiles are decreased to 5E+08 (as described in section 2) to include some operation of the WM-189 air lift.

4. The lifetime emissions are obtained (except for Hg) by dividing inventory by DF. The Hg emission is derived in section 3 based on the potential operating scenario providing the highest Hg emissions. The Pb and Sb emissions are calculated using the g/hr emissions values derived in section 4 and the assumption of a long-term on-stream factor of 50 %.

5. NWCF operation will operate from 7 to 14 years (to 2005 or 2012) depending on operability and flowsheet efficiency (i. e., net:gross feed ratio). The annual average emissions average the life-time emissions over either a 7- or 14-year period chosen for conservatism. Carcinogens As, Be, Cd, and Cr are averaged over 14 years; the noncarginogens, which may produce short-term health effects, are averaged over 7 years, which gives the higher annual emission rate.

Table 6. Estimation of weighted overall decontamination factors or mass emissions for the hazardous metals.

Compound	Percent	DF for calc. ... scrubber	DF for filters	Overall DF or emission for specie	Weighted overall DF or emission[a]
$HgCl_2$	27	27	1	27	27
SeO_2	27	27	1	27	27
Sb_4O_6 $SbCl_3$	99.9 <0.01	27 27	n. a. 1	2.2E-4 g/hr 27	2.2E-4 g/hr
Na_3AsO_4	100	2000	2.7E+5	5.4E+8	5.4E+8
PbO $PbCl_2$	90 10	2000 27	2.7E+5 n. a.	5.4E+8 1E-4 g/hr	1E-4 g/hr
CdO	100	2000	2.7E+5	5.4E+8	5.4E+8
Ag_2O	100	2000	2.7E+5	5.4E+8	5.4E+8
BaO	100	2000	2.7E+5	5.4E+8	5.4E+8
BeO $BeCl_2$	90 10	2000 27	2.7E+5 1	5.4E+8 27	270
Na_2CrO_4	100	2000	2.7E+5	5.4E+8	5.4E+8
NiO	100	2000	2.7E+5	5.4E+8	5.4E+8
Tl_2O $TlCl$	90 10	2000 27	2.7E+5 1	5.4E+8 27	270
U_3O_8	100	2000	2.7E+5	5.4E+8	5.4E+8

a) DF for NWCF only; use of WM-189 air lift would reduce DF for non-volatile species.

Table 7. Estimation of conservative lifetime and annual-average emission.

Specie	Upper-limit concentration, mg/l	Upper-limit inventory, g	Emission DF	Lifetime emission, g	Annual Ave[c]. emission, g/yr	Annual Ave. emission, g/s
Ag	14	6.27E+04	5E+08	1.25E-04	1.8E-05	5.7E-13
As	58	2.60E+05	5E+08	5.20E-04	3.7E-05	1.15E-12
Ba	17	7.62E+04	5E+08	1.52E-04	2.2E-05	7.0E-13
Be[b]	0.4	1.8E+03	270	7	0.5	1.6E-08
Cd	1240	5.56E+06	5E+08	1.11E-02	7.9E-04	2.5E-11
Cr	440	1.95E+06	5E+08	3.90E-03	2.8E-04	8.9E-12
Hg[a]	3000	2.60E+06		3.43E+05	49000	1.6E-03
Pb[d]	290	1.30E+06	1.0E-04 g/hr	3	0.43	1.4E-08
Ni	420	1.88E+06	5E+08	3.76E-03	2.7E-04	8.5E-12
Se	1	4.48E+03	27	166	24	7.6E-07
Sb[b,d]	1.225	5.5E+03	2.2E-4 g/hr	6.6	0.94	3.0E-08
Tl[b]	3.4	1.5E+04	270	56	8	2.5E-07
U	194	8.69E+05	5E+08	1.74E-03	2.5E-04	7.9E-12

a) Hg emission is based on 343 kg lifetime emission.

b) Be, Sb, Tl have not been detected, concentrations are ½ of MDL values

c) based for As, Be, Cd, Cr & Ni on 14 yr of operation (1999-2012), and for others on 7 yr of operation (1999-2005).

d) Pb & Sb are based on g/hr emissions and 50 % on line factor.

The upper-limit hourly emissions of Table 8 are calculated in a similar way using the upper-limit feed concentrations and the maximum net feed rate of 718 l/hr from section 2. The calculations are conservative primarily because the net feed rate is conservative. The emissions DF's for non-volatile species are 4E+08 as derived in section 2 for including operation of the WM-189 air lift, the PEW evaporator and LET&D. The Pb and Sb emissions again are based on the g/hr values.

Table 8. Estimation of upper-limit hourly emissions.

Specie	Upper-limit concentration, mg/l	Upper-limit feed rate, g/hr	Emissions DF	Emissions, g/hr	Emissions, g/s
Ag	14	10	4E+08	2.5E-08	6.9E-12
As	58	42	4E+08	1.0E-07	2.8E-11
Ba	17	12	4E+08	3.1E-08	8.6E-12
Be[b]	0.4	0.28	27	0.011	3.1E-06
Cd	1240	890	4E+08	2.2E-06	6.1E-10
Cr	435	312	4E+08	7.8E-07	2.2E-10
Hg	3000	2154	27	80	2.2E-02
Pb	290	208	1.0E-04 g/hr	1.0E-04	2.8E-08
Ni	420	302	4E+08	7.5E-07	2.1E-10
Se	1	0.72	27	0.027	7.5E-06
Sb[b]	1.225	0.9	2.2E-04 g/hr	2.2E-04	6.1E-08
Tl[b]	3.4	2.4	270	9.0E-03	2.5E-06
U	194	139	4E+08	3.5E-07	9.7E-11

a) Pb and Sb emissions are based on g/hr rates.

b) Be, Sb, Tl have not been detected, concentrations are ½ of MDL values

6. Emissions of Hazardous Organic Chemicals from Feed

The upper-envelope emissions from calcination of hazardous organic chemicals possibly in the tank farm are developed below in Table 9. The chemicals listed in Table 9 are those determined[21,22] to have possibly entered the PEW and then gone to the tank farm (with or without a waste code[23]). The concentrations are upper-limit based on all INTEC chemical receipts, not otherwised accounted for, going (via PEW) to the tank farm. The feed volume is a maximum volume of 1,400,000 gal/yr (before evaporation from Table 1). The feed concentrations are 1) set at 1/2 of the minimum quantification level if waste tank analyses[24] show their concentrations as less than the minimum detection level, or 2) a "process knowledge" estimate[21]. The analyses of the wastes in the tank farm done to date indicate that the process knowledge estimates of Table 9 are very conservative. For the species for which both process knowledge estimates[21] and analyses[24] are available, the analyses are much lower. No information is available for many of the compounds.

The NWCF input is the feed concentration multiplied by the total waste volume (1,400,000 gal). The NWCF DF in Table 9 is based on an thermal stability-based incinerability index[25], derived at the University of Dayton, which gives the temperature for 99 % thermal decomposition in 2 seconds. A DF of 100 is used when the incinerability index is <500°C; and a DF of 1 is used when the incinerability index is >500°C. The NWCF provides a temperature of 500 to 600°C for 6 seconds, so it should provide decompositions much greater than 99 % (at least for species whose decomposition is first order) for species with incinerability indices is <500°C. The analysis assumes, except for the incinerable species, that the organic species in the tank farm are emitted totally to the atmosphere. Some may be emitted from the HLLWE or other indirect routes; however, the route does not effect the total emission. The compounds that are incinerable are low volatility species not readily volatilized by indirect routes.

Most of the estimate upper-envelope emissions are less than 1 kg/yr. The highest calculated emission from Table 9 is for pyridine (77 kg/yr).

The evaporation of current PEW in the PEW evaporator and LET&D adds minor quantities of organic chemicals to the quantities calculated in Table 9. Current chemical handling procedures follow RCRA requirements and limit organic chemicals to soluble chemicals (e. g., acetone) dissolved in waste solutions. Recent analyses of PEW for organic chemicals (VOA's) report nearly all as undetected. A few soluble solvents (e. g., acetone) are are sometimes reported at concentrations of < 1 ppm. The largest potential emission via the PEW evaporator and LET&D would be < 1 kg/yr of acetone.

Table 9. Upper-envelope emissions of hazardous organic chemicals in the NWCF feed.

Chemical	Max Conc. ng/ml	Feed conc. ng/ml	NWCF input g	NWCF DF	Emission g
Acetone	(c)				
Acetonitrile	48 (b)	48	250	1	250
Aniline	808 (b)	808	4200	1	4200
Benzene	<10 (a)	5	26	1	26
Benzo(a)pyrene	10 (b)	10	53	1	53
Bromoform	<10 (a)	5	26	1	26
Butylbenzylphthalate(d)	10 (b)	10	53	100	<1
Carbon disulphide	397 (b)	397	2100	1	2100
Carbon tetrachloride	<10 (a)	5	26	1	26
Chlorobenzene	<10 (a)	5	26	1	26
Chloroform	<10 (a)	5	26	1	26
Cresols		(c)			
Cumene	(c)				
Cyanogen	(c)				
1,2-dichloroethane	<10 (a)	5	26	1	26
Diethylphthalate (d)	128 (b)	128	660	100	7
Dimethyl sulfate	(c)				
Di-n-buthyphthalate(d)	10 (b)	10	53	100	<1
2,4-dinitrophenol	81 (b)	81	420	1	420
2,4-dinitrotoluene	95 (b)	95	500	1	500
Di-n-octhyphthalate	10 (b)	10	53	100	<1
1,4-dioxane	3750 (b)	3750	20,000	1	20,000
Ethylene glycol (e)			3300	1	3300
Hexachlorobenzene	(c)				
Hexachloroethane	(c)				
Formaldehyde	4.3 (b)	4.3	23	1	23
Formic acid	242 (b)	242	1300	1	1300
Furfural	(c)				
Hydrazine	170 (b)	170	880	1	880
Iodomethane	(c)				
Methylene chloride	<10 (a)	5	26	1	26

Methyl ethyl ketone	170 (b)	170	880	1	880
Methyl isobutyl ketone	(c)				
Methyl tert-butyl ether	(c)				
Naphthalene	10 (b)	10	53	1	53
Nitrobenzene	(c)				
p-nitrophenol	(c)				
2-nitropropane	(c)				
PCB's	(c)				
Pentachlorophenol	10 (b)	10	53	1	53
Phenol	170 (b)	170	900	1	900
Phthalic anhydride	(c)				
Pyridine	14,500 (b)	14,500	75,000	1	75,000
Tetrachloroethylene	<10 (a)	5	26	1	26
Thiourea (d)	2110 (b)	2110	11,000	100	110
1,2,4-trichlorobenzene	10 (b)	10	53	1	53
1,1,1-Trichloroethane	<10 (a)	5	26	1	26
1,1,2-Trichloroethane	<10 (a)	5	26	1	26
Trichloroethylene	<10 (a)	5	26	1	26
Toluene	<10 (a)	5	26	1	26
o-toluidine	(c)				
xylene	(c)				

(a) less than a minimum quantification level of 10 ng/ml and also less than a minimum detection level estimated at 1 ng/ml; analyzed[24] in 3 tanks

(b) Process knowledge estimate[21] based on the assumption that all of the chemical purchased went to the tank farm via the Process Equipment Waste system.

(c) Possible contamination that cannot be quantified.

(d) Thermally decomposes[26] >99% at temperatures less than 500°C.

(e) Process knowledge for one-time transfer to one tank.

7. Emissions of Acid Vapors and Gases

Calculated upper-envelope emissions of acid vapors and gaseous pollutants for NWCF operation are tabulated in Table 10. The bases of the emissions estimates are discussed below.

Table 10. Calculated upper-envelope emissions of acid vapors and gases for NWCF operation.

Specie	Maximum Hourly Emission, kg/hr	Maximum Hourly Emission, g/s	Maximum Annual Emission, Mg/yr[a]	Maximum Annual Emission, g/s
NO_x	214	59.4	1540	48.8
CO	110	30.6	790	25.0
SO_2	0.825	0.229	6.0	0.19
HNO_3	50	13.9	360	11.4
HCl	0.325	0.0903	0.68	0.022
HF	0.185	0.0514	1.35	0.043

a) A year is 300 days of operation.

The NO_x emissions in Table 10 are permit limits. The NO_x emissions from the ICPP stack are monitored during NWCF operation; and the the waste feed rate to the NWCF is controlled at a rate such that the measured NO_x emission remains below the permit limit.

The CO emission is based on 1) 40 percent of the carbon in the fuel becoming CO, and 2) the maximum NWCF fuel capacity of 45.6 gph (138 kg/hr) rather than the normal fuel rate of about 30 gph. The 40 percent of the carbon becoming CO is based on a measured[27] value of 30 percent in the original WCF with a contingency added for the potential for operation with damaged fuel nozzles. (Limited sampling[28] during NWCF cold operation indicates that the CO in the NWCF off gas is less than in the WCF.)

The SO_2 emission is based on the NWCF fuel capacity (138 kg/hr) and a low-grade fuel containing 0.3 percent S. (The NWCF currently uses kerosene specified for <0.04 percent S.)

The emissions of HNO_3, HCl, and HF depend on vapor-liquid equilibria in the NWCF scrub system. Nitric acid is added to the scrub solution to dissolve the calcine solids collected in the scrub solution. The nitric acid not consumed by the dissolution reaction can volatilize from the scrub solution into the off gas. The nitric acid also reacts with the chlorides and fluorides collected in the scrub solution to form HCl and HF which can also volatilize into the off gas. Thus, the volatilization of the three acids depends on the chemical equilibria in the solution and the vapor-liquid equilibria between the scrub solution and the off gas.

The scrub solution chemical and vapor-liquid equilibria calculations were done using two ASPEN models. The models are steady-state models which are assumed to envelope the unsteady-state operation of the scrub system. An earlier model[18] for ICPP was modified, by removing non-NWCF processes, and using the NWCF feed composition and flow, and scrub solution flow of this document. The resulting model is a steady-state model which includes scrub recycle to feed and a (steady state) scrub discharge to the tank farm. The second model replaced the property parameter set of the first model with a more-recent[29] property parameter set.

The models are set for upper-envelope emissions by: 1) using a relatively high ratio of nitric acid addition to scrub recycle (0.85 gal. of HNO_3 per gal. of scrub solution recycled), 2) using a relatively low scrub solution return to the tank farm (0.033 gal. per gal. of scrub solution recycled), and 3) using the upper-envelope feed concentration of Table 1. The models were run using both a low scrub recycle rate (16 gph) and a high scrub recycle rate (30 gph). The highest calculated emissions from any of the calculations is used in Table 11.

The HNO_3 emissions of Table 11 were verified with material balances for nitrate in the NWCF scrub system during NWCF Run H-4. The HNO_3 emission of Table 11 is a little higher than the median value from the material balances.

The models calculate that 30 % of the Cl in the net feed is discharged in the off-gas from the scrub system. The maximum hourly HCl emission is 30 % of the maximum Cl feed rate based on the Cl concentration in Table 3. The maximum annual HCl emission is based on Cl availability in the tank farm. It assumes that the two tanks with the highest Cl content (WM-180 and the postulated last tank) are calcined in one year with 30 % of their Cl emitted as HCl.

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Table A-1. Calculation of stack emission rates from stack sampling during NWCF "hot feed" in 1993[a].

Metal	Sampling Date	Conc. (ug/m3 @ STP)	Stack Flowrate @STP[b]		Emission Rate[c] (g/s)	Average Rate (g/s)
			scfm	M^3/s		
Sb	4/1/93	<81	118470	55.92	<4.53E-03	
	7/28/93	<14	100390	47.38	<6.63E-04	<1.97E-03
	8/11/93	<15	102120	48.20	<7.23E-04	
Hg	4/1/93	16	118470	55.92	8.95E-04	
	7/28/93	10	100390	47.38	4.74E-04	5.27E-04
	8/11/93	4.4	102120	48.20	2.12E-04	
Cr	4/1/93	<4.1	118470	55.92	<2.29E-04	
	7/28/93	<2.8	100390	47.38	<1.33E-04	<1.69E-04
	8/11/93	<3	102120	48.20	<1.45E-04	
As	4/1/93	<120	118470	55.92	<6.71E-03	
	7/28/93	<28	100390	47.38	<1.33E-03	<3.16E-03
	8/11/93	<30	102120	48.20	<1.45E-03	
Se	4/1/93	<81	118470	55.92	<4.53E-03	
	7/28/93	<14	100390	47.38	<6.63E-04	<1.97E-03
	8/11/93	<15	102120	48.20	<7.23E-04	
Pb	4/1/93	<41	118470	55.92	<2.29E-03	
	7/28/93	<28	100390	47.38	<1.33E-03	<1.69E-03
	8/11/93	<30	102120	48.20	<1.45E-03	
Cd	4/1/93	<4.1	118470	55.92	<2.29E-04	
	7/28/93	<1.4	100390	47.38	<6.63E-05	<1.23E-04
	8/11/93	<1.5	102120	48.20	<7.23E-05	
Ba	4/1/93	<3.2	118470	55.92	<1.79E-04	
	7/28/93	1.4	100390	47.38	6.63E-05	<1.06E-04
	8/11/93	<1.5	102120	48.20	<7.23E-05	
Be	4/1/93	<0.12	118470	55.92	<6.71E-06	
	7/28/93	<0.042	100390	47.38	<1.99E-06	<3.62E-06
	8/11/93	<0.045	102120	48.20	<2.17E-06	
Ni	4/1/93	<12	118470	55.92	<6.71E-04	
	7/28/93	<4.2	100390	47.38	<1.99E-04	<3.62E-04
	8/11/93	<4.5	102120	48.20	<2.17E-04	
Ag	4/1/93	<2.5	118470	55.92	<1.40E-04	
	7/28/93	<1.4	100390	47.38	<6.63E-05	<9.28E-05
	8/11/93	<1.5	102120	48.20	<7.23E-05	
Th	4/1/93	<81	118470	55.92	<4.53E-03	
	7/28/93	<14	100390	47.38	<6.63E-04	<1.97E-03
	8/11/93	<15	102120	48.20	<7.23E-04	

a. Sampling and analytical results documented in 1) FAH-5-93 and FAH-20-93 (4/1/93 values), 2) FAH-9-93 and FAH-8-95 (7/28/93 values), and 3) FAH-10-93 and FAH-9-95 (8/11/93 values). Sampling methods were in accordance with 40 CFR 266, Appendix IX.

b. Higher of the turbine and anometer flowrates at the time of sampling.

c. Calculated by (ug/m3)(m3/s)(10-6 g/ug).

Appendix B

Chemical Specific Inputs and Chemical Media Concentrations for Evaluation of all Receptors

Table B-1. Chemical-specific inputs for indirect and direct exposure assessment.

Chemical	Fv	ksg	K_{ds}	K_{dsw}	K_{dbs}	H	Da	Dw	Bv	Br	Ba_{beef}	Ba_{milk}	BCF	BAF	BSAF	Fw
Antimony	0.00E+00	NA	2.00E+00	2.00E+00	2.00E+00	NA	NA	8.00E-06	NA	2.00E-01	1.00E-03	1.00E-04	1.00E+00	NA	NA	2.00E-01
Arsenic	0.00E+00	NA	2.90E+01	2.90E+01	2.90E+01	NA	NA	8.00E-06	NA	3.60E-02	2.00E-03	6.00E-03	4.40E+01	NA	NA	2.00E-01
Barium	0.00E+00	NA	5.30E+02	5.30E+02	5.30E+02	NA	NA	8.00E-06	NA	1.50E-01	1.50E-04	3.50E-04	NA	4.00E+00	NA	6.00E-01
Benzo(a)pyrene	4.00E-01	NA	1.20E+04	9.00E+04	4.80E+04	8.40E-07	4.30E-02	9.00E-06	1.30E+06	1.10E-02	3.40E-02	1.10E-02	NA	1.00E+06	NA	6.00E-01
Beryllium	0.00E+00	NA	7.00E+01	7.00E+01	7.00E+01	NA	NA	8.00E-06	NA	1.00E-02	1.00E-03	9.00E-07	2.00E+01	NA	NA	6.00E-01
Cadmium	0.00E+00	NA	1.60E+02	1.60E+02	1.60E+02	NA	NA	8.00E-06	NA	1.80E-01	1.20E-01	7.60E-03	6.40E+01	NA	NA	6.00E-01
Chromium VI	0.00E+00	NA	1.80E+01	1.80E+01	1.80E+01	NA	NA	8.00E-06	NA	1.10E+00	5.50E-03	1.50E-03	1.60E+01	NA	NA	6.00E-01
1,3-dinitrobenzene	1.00E+00	NA	2.80E-01	2.00E+00	1.10E+00	1.20E-07	2.80E-01	7.60E-06	6.80E-03	5.30E+00	7.90E-07	2.50E-07	1.40E+00	NA	NA	6.00E-01
2,4-dinitrotoluene	1.00E+00	NA	8.70E-01	6.50E+00	3.50E+00	1.50E-07	2.00E-01	7.10E-06	1.50E+02	2.70E+00	2.50E-06	7.90E-07	3.20E+00	NA	NA	6.00E-01
2,6-dinitrotoluene	1.00E+00	NA	6.70E-01	5.00E+00	2.70E+00	1.30E-07	8.00E-02	8.00E-06	1.30E+02	3.20E+00	1.90E-06	6.10E-07	2.60E+00	NA	NA	6.00E-01
Di(n)octylphthalate	8.00E-01	NA	2.80E+05	2.10E+06	1.10E+06	7.70E-07	8.00E-02	8.00E-06	9.50E+06	1.80E-03	NA	NA	NA	6.60E+04	NA	6.00E-01
2,3,7,8-TCDD	2.70E-01	NA	1.40E+05	1.00E+06	5.70E+05	9.10E-06	4.70E-02	8.00E-06	4.55E+05	3.30E-03	4.00E-02	7.00E-03	NA	NA	6.70E-02	6.00E-01
Lead	0.00E+00	NA	8.80E+04	8.80E+04	8.80E+04	NA	NA	8.00E-06	NA	1.80E-02	3.00E-04	2.50E-04	NA	8.00E+00	NA	6.00E-01
Mercury	0.00E+00	NA	1.50E+02	1.50E+02	1.50E+02	9.00E-03	NA	8.00E-06	NA	2.00E-03	2.50E-01	4.50E-04	NA	1.30E+05	NA	6.00E-01
Nickel	0.00E+00	NA	8.20E+01	8.20E+01	8.20E+01	NA	NA	8.00E-06	NA	1.60E-02	6.00E-03	1.00E-03	4.70E+01	NA	NA	6.00E-01
Nitrobenzene	1.00E+00	NA	6.00E-01	4.50E+00	2.40E+00	2.10E-05	7.60E-02	8.60E-06	7.00E-01	3.40E+00	1.70E-06	5.40E-07	2.40E+00	NA	NA	6.00E-01
Pentachloro-nitrobenzene	1.00E+00	NA	3.80E+02	2.90E+03	1.50E+03	2.90E-02	8.00E-02	8.00E-06	7.90E-01	8.10E-02	1.10E-03	3.50E-04	1.40E+02	NA	NA	6.00E-01
Pentachlorophenol	1.00E+00	NA	1.10E+03	8.30E+03	4.40E+03	1.40E-05	5.60E-02	5.10E-06	5.10E+03	4.50E-02	3.00E-03	9.60E-04	NA	NA	NA	6.00E-01
Selenium	0.00E+00	NA	4.30E+00	4.30E+00	4.30E+00	NA	NA	8.00E-06	NA	1.60E-02	1.50E-02	4.00E-03	6.00E+00	NA	NA	2.00E-01
Silver	0.00E+00	NA	4.00E-01	4.00E-01	4.00E-01	NA	NA	8.00E-06	NA	4.00E-01	3.00E-03	2.00E-02	5.00E-01	NA	NA	6.00E-01
Thallium	0.00E+00	NA	7.40E+01	7.40E+01	7.40E+01	NA	NA	8.00E-06	NA	2.10E-01	4.00E-02	2.00E-03	1.20E+02	NA	NA	6.00E-01

Source: EPA, 1994, *Guidance for Performing Screening Level Risk Analyses at Combustion Facilities Burning Hazardous Wastes*, Draft, U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, Office of Solid Waste, December 14.

Table B-2. Toxicity values and or health benchmarks for the inhalation and oral routes of exposure.

Chemical	CSF_{oral} $(mg/kg/day)^{-1}$		RfD_{oral} $(mg/kg/day)^{-1}$		URF $(\mu g/m^3)^{-1}$		RfC (mg/m^3)	
	Value	Reference	Value	Reference	Value	Reference	Value	Reference
Acetonitrile	NA		NA		ND		5.00E-02	HEAST
Aniline	NA		NA		ND		1.00E-03	IRIS
Antimony	ND		4.00E-04	IRIS	ND		2.50E-02	IDHW
Arsenic	1.50E+01	IRIS	3.00E-04	IRIS	4.3E-03	IRIS	ND	
Barium	ND		7.00E-02	IRIS	ND		5.00E-04	HEAST
Benzene	NA		NA		7.8E-06	IRIS	9.00E-03	NCEA
Benzo(a)pyrene	7.30E+00	IRIS	ND		8.86E-04	ATG	ND	
Beryllium	4.30E+00	IRIS	5.00E-03	IRIS	2.40E-03	IRIS	2.00E-05	IRIS
Bromoform	NA		NA		1.10E-06	IRIS	7.00E-02	ATG
Butylbenzylphthalate	NA		NA		ND		7.00E-01	ATG
Cadmium	ND		1.00E-03	IRIS	1.80E-03	IRIS	2.00E-04	EPA9
Carbon disulfide	NA		NA		ND		7.30E-01	IRIS
Carbon monoxide	NA		NA		ND		1.00E+01	NAAQS
Carbon tetrachloride	NA		NA		2.00E-03	ATG	2.00E-03	EPA9
Chlorobenzene	NA		NA		ND		2.00E-02	HEAST
Chloroform	NA		NA		2.30E-05	IRIS	3.01E-03	ATG
Chromium VI	ND		5.00E-03	IRIS	1.20E-02	IRIS	ND	
Dibutylphthalate	NA		NA		ND		3.50E-01	ATG
1,2-dichloroethane	NA		NA		2.60E-05	IRIS	1.00E-02	EPA[b]
Diethylphthalate	NA		NA		ND		2.80E+00	ATG
1,3-dinitrobenzene	ND		1.00E-04	IRIS	ND		3.50E-04	ATG

Table B-2. (continued).

	CSF_{oral} $(mg/kg/day)^{-1}$		RfD_{oral} $(mg/kg/day)^{-1}$		URF $(\mu g/m^3)^{-1}$		RfC (mg/m^3)	
Chemical	Value	Reference	Value	Reference	Value	Reference	Value	Reference
2,4-dinitrophenol	NA		NA		ND		7.00E-03	ATG
2,4-dinitrotoluene	ND		2.00E-03	IRIS	ND		7.00E-03	ATG
2,6-dinitrotoluene	ND		1.00E-03	HEAST	ND		3.50E-03	ATG
Di(n)octylphthalate	ND		2.00E-02	HEAST	ND		7.00E-02	ATG
1,4-dioxane	NA		NA		3.14E-06	ATG	ND	
Ethylene glycol	NA		NA		ND		7.00E+00	ATG
Formaldehyde	NA		NA		1.30E-05	IRIS	ND	
Formic acid	NA		NA		ND		7.00E+00	EPA9
2,3,7,8-TCDD	1.50E+5	HEAST	ND		3.43E+01	ATG	ND	
Hydrazine	NA		NA		4.90E-03	IRIS	ND	
Hydrogen chloride	NA		NA		ND		2.00E-02	IRIS
Hydrogen fluoride	NA		NA		ND		2.60E-02	Calculated
(Iso)thiourea	NA		NA		5.56E-04	IDHW	ND	
Lead	ND		ND		ND		1.53E-03	NAAQS
Mercury	ND		3.00E-04	IRIS	ND		3.00E-04	IRIS
Methyl ethyl ketone	NA		NA		ND		1.00E+00	IRIS
Methylene chloride	NA		NA		4.70E-07	IRIS	3.00E+00	HEAST
Napthalene	NA		NA		ND		3.00E-03	EPA9
Nickel	ND		2.00E-02	IRIS	2.40E-04	EPA9	ND	
Nitrobenzene	ND		5.00E-04	IRIS	ND		2.00E-03	HEAST
Nitric acid	NA		NA		ND		2.50E-01	IDHW
Nitrogen dioxide	NA		NA		ND		3.50E+00	EPA9

Table B-2. (continued).

	CSF_{oral} $(mg/kg/day)^{-1}$		RfD_{oral} $(mg/kg/day)^{-1}$		URF $(\mu g/m^3)^{-1}$		RfC (mg/m^3)	
Chemical	Value	Reference	Value	Reference	Value	Reference	Value	Reference
Pentachloronitrobenzene	2.60E-01	HEAST	3.00E-03	IRIS	7.43E-05	ATG	1.05E-02	ATG
Pentachlorophenol	1.20E-01	IRIS	3.00E-02	IRIS	3.40E-05	ATG	1.05E-01	ATG
Phenol	NA		NA		ND		2.10E+00	ATG
Pyridine	NA		NA		ND		3.50E-03	ATG
Selenium	ND		5.00E-03	IRIS	ND		1.00E-02	IDHW
Silver	ND		5.00E-03	IRIS	ND		5.00E-03	IDHW
Sulfur dioxide	NA		NA		ND		8.00E-02	NAAQS
Tetrachloroethylene	NA		NA		3.14E-05	EPA9	2.70E-01	ATG
Thallium	ND		8.00E-04	IRIS	ND		2.80E-04	ATG
Uranium	NA		NA		ND		1.00E-02	IDHW
Toluene	NA		NA		ND		4.00E-01	IRIS
1,2,4-Trichorobenzene	NA		NA		ND		2.00E-01	ATG
1,1,1-Trichloroethane	NA		NA		ND		1.00E-01	ATG
1,1,2-Trichloroethane	NA		NA		1.60E-05	IRIS	1.40E-02	ATG
Trichloroethylene	NA		NA		ND		2.10E-02	ATG

ND = No toxicity data are available.
NA = Not applicable. The oral route of exposure was not evaluated for this chemical.
IDHW = Idaho Division of Health and Welfare, Toxic Air Pollutant AAC/AACC
NCEA = National Center for Environmental Assessment (EPA)
ATG = Allied Technical Group Risk Assessment Work Plan
EPA9 = Derived from EPA Region 9 on-line toxicity values
NAAQS = National Ambient Air Quality Standard.
Calculated = 1% of ACGIH-TLV.

Table B-3. Soil concentration from deposition.

Exposure Scenarios
All

Equation

$$Sc = \frac{\left(\frac{Ds * Tc - Sc_{Tc}}{ks}\right) + \left(\frac{Sc_{Tc}}{ks} * \left[1 - \exp(-ks * (T_2 - Tc)\right]\right)}{(T_2 - T_1)}$$

$$Sc_{Tc} = \frac{Ds * (1 - \exp(-ks * Tc))}{ks}$$

$$Ds = \frac{100 * Q}{z * BD} * [F_v (0.31536 * Vdv * Cyv + Dywv) + (Dydp + Dywp) * (1 - F_v)]$$

Parameter	Definition	Value
Sc	Average soil concentration over exposure duration (mg/kg)	
Ds	Deposition term (mg/kg-year)	Calculated (Tables B-11 and B-13)
Tc	Time period over which deposition occurs (years)	16
Sc_{Tc}	Soil concentration at time Tc (mg/kg)	Calculated (Tables B-11 and B-13)
ks	Soil loss constant ($year^{-1}$)	(Tables B-11 and B-13)
T_2	Exposure duration (year)	Scenario-specific (40, 30, and 9)
Z	Soil mixing depth (cm)	1 (20 used for soluble COPCs with root uptake as the critical exposure pathway)
BD	Soil bulk density (g/cm^3)	1.5
0.31536	Units conversion factor (m-g-s/cm-µg-year)	
Vdv	Dry deposition velocity (cm/second)	3
Cyv	Normalized vapor-phase air concentration (µg-second/g-m^3)	0.06213
Q	Stack emissions (g/second)	Site-specific (Table A-2)
F_v	Fraction of air concentration in vapor phase (dimensionless)	Chemical-specific (Table B-1)
Dywv	Normalized yearly wet deposition from vapor phase (second/m^2-year)	0.00037
Dydp	Normalized yearly dry deposition from particle phase (second/m^2-year)	0.00045
Dywp	Normalized yearly wet deposition from particle phase (second/m^2-year)	0.00024
100	Units conversion factor ([mg-m^2]/[kg-cm^2])	

Description

These equations calculate an average soil concentration over the exposure duration caused by wet and dry deposition onto soil, deposition of wet vapors to soil, and diffusion of dry vapors to soil. Contaminants are assumed to be incorporated only to a finite depth (the mixing depth, Z).

Source: EPA, 1994, *Guidance for Performing Screening Level Risk Analyses at Combustion Facilities Burning Hazardous Wastes*, Draft, U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, Office of Solid Waste, December 14.

Table B-4. Loss constant from leaching.

Exposure Scenarios
All
Equation
$ksl = \frac{P + I - R - EV}{\Theta_s * Z * [1.0 + (BD * Kd_s / \Theta_s)]}$

Parameter	Definition	Value
ksl	Loss constant from leaching (year^{-1})	
P	Average annual precipitation (cm/year)	22.1
I	Average annual irrigation (cm/year)	138
R	Average surface runoff (cm/year)	1.27
Ev	Average annual evapotranspiration (cm/year)	30.48
Θ_s	Soil volumetric water content (mL/cm^3)	0.2
Z	Soil depth from which leaching removal occurs (cm)	1
Kd_s	Soil-water partition coefficient (cm^3/g)	Chemical-specific (Table B-1)
BD	Soil bulk density (g/cm^3)	1.5

Description

This equation calculates the contaminant loss constant caused by leaching from soil.

Source: EPA, 1994, *Guidance for Performing Screening Level Risk Analyses at Combustion Facilities Burning Hazardous Wastes*, Draft, U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, Office of Solid Waste, December 14.

Table B-5. Loss constant from surface runoff.

Exposure Scenarios
All

Equation

$$ksr = \frac{R}{\Theta_s * Z} * \left(\frac{1}{1 + (Kd_s * BD / \Theta_s)} \right)$$

Parameter	Definition	Value
ksr	Loss constant from surface runoff (year^{-1})	
R	Average annual runoff (cm/year)	1.27
Θ_s	Soil volumetric water content (mL/cm^3)	0.2
Z	Soil mixing depth (cm)	1
Kd_s	Soil-water partition coefficient (cm^3/g)	Chemical-specific (Table B-1)
BD	Soil bulk density (g/cm^3)	1.5

Description

This equation calculates the contaminant loss constant caused by runoff from soil.

Source: EPA, 1994, *Guidance for Performing Screening Level Risk Analyses at Combustion Facilities Burning Hazardous Wastes*, Draft, U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, Office of Solid Waste, December 14.

Table B-6. Loss constant from all processes.

Exposure Scenarios
All
Equation
$ks = ksl + kse + ksr + ksg + ksv$

Parameter	Definition	Value
ks	Soil loss constant from all processes ($year^{-1}$)	
ksl	Loss constant from leaching ($year^{-1}$)	Calculated (Tables B-11 to B-13)
kse	Loss constant from soil erosion ($year^{-1}$)	0
ksr	Loss constant from surface runoff ($year^{-1}$)	Calculated (Tables B-11 to B-13)
ksg	Loss constant from degradation ($year^{-1}$)	Calculated (Tables B-11 to B-13)
ksv	Loss constant from volatilization ($year^{-1}$)	Calculated (Tables B-11 to B-13)

Description

This equation is used to calculate the soil loss constant, which accounts for the loss of contaminant from soil by several mechanisms.

Source: EPA, 1994, *Guidance for Performing Screening Level Risk Analyses at Combustion Facilities Burning Hazardous Wastes*, Draft, U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, Office of Solid Waste, December 14.

Table B-7. Loss constant from volatilization

Exposure Scenarios
All
Equation
$ksv = \left[\frac{3.1536x10^7 * H}{Z * Kd_s * R * T * BD}\right] * \left[0.482 * u^{0.78} * \left(\frac{\mu_a}{\rho_a * D_a}\right)^{-0.67} * \left(\sqrt{\frac{4 * A}{\pi}}\right)^{-0.11}\right]$

Parameter	Definition	Value
ksv	Loss constant from volatilization (year^{-1})	
3.1536 × 10^7	Conversion constant (second/year)	
H	Henry's Law constant (atm-m^3/mol)	Table B-1
Z	Soil mixing depth (cm)	1
Kd_s	Soil-water partition coefficient (cm^3/g)	Table B-1
R	Universal gas constant (atm-m3/mol-K)	8.205E-5
BD	Soil bulk density (g/cm^3)	1.5
T	Ambient air temperature (k)	278.8
u	Average annual wind speed (m/second)	3.35
μ	Viscosity of air (g/cm-second)	1.81E-4
ρ_a	Density of air (g/cm^3)	1.2E-3
D_a	Diffusivity of contaminant in air (cm^2/second)	Table B-1
A	Surface area of contaminated area (m^2)	2023.4

Description
This equation is used to calculate the contaminant loss constant caused by volatilization from soil.

Source: EPA, 1994, *Guidance for Performing Screening Level Risk Analyses at Combustion Facilities Burning Hazardous Wastes*, Draft, U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, Office of Solid Waste, December 14.

Table B-8. Aboveground plant concentration from direct deposition.

Exposure Scenarios
All

Equation

$$Pd = \frac{1000 * Q * (1 - Fv) * [Dydp + (Fw * Dywp)] * Rp * [1.0 - \exp(-kp * Tp)]}{Yp * kp}$$

Parameter	Definition	Value
Pd	Concentration in plant from direct deposition (mg/kg)	
1000	Units conversion factor (mg/g)	
Q	Stack emissions (g/second)	Site-specific (Section 2)
Fv	Fraction of air concentration present in vapor phase (dimensionless)	Chemical-specific (Table B-1)
Dydp	Yearly dry deposition rate (s/m^2-year)	0.00045
Fw	Fraction of wet deposition that adheres to plant surfaces (dimensionless)	Chemical-specific (Table B-1)
Dywp	Yearly particle phase wet deposition rate (g/m^2/year)	0.00024
Rp	Interception fraction of edible portion of plant tissue (dimensionless)	0.04
kp	Plant surface loss coefficient (year^{-1})	18
Tp	Length of plant exposure to deposition of edible portion of plant, per harvest (year)	0.16
Yp	Yield or standing crop biomass of the edible portion of the plant (kg DW/m^2)	1.7

Description

This equation calculates the contaminant concentration in aboveground vegetation caused by wet and dry deposition of contaminant on the plant surface.

Source: EPA, 1994, *Guidance for Performing Screening Level Risk Analyses at Combustion Facilities Burning Hazardous Wastes*, Draft, U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, Office of Solid Waste, December 14.

Table B-9. Aboveground vegetable concentration from air-to-plant transfer.

Exposure Scenarios

All

Equation

$$Pv = Q * F_v * \frac{Cyv * Bv * VG_{ag}}{\rho_a}$$

Parameter	Definition	Value
Pv	Concentration of pollutant in the plant from air-to-plant transfer (mg/kg)	
Q	Stack emissions (g/second)	Section 2
Tv	Fraction of air concentration in vapor phase (dimensionless)	Chemical-specific (Table B-1)
Cyv	Normalized vapor-phase air concentration (μg-second/g-m^3)	0.06213
Bv	Air-to-plant biotransfer factor ([mg pollutant/kg plant tissue DW]/[μg pollutant/g air])	Chemical-specific (Table B-1)
Vg_{ag}	Empirical correction factor for aboveground produce (dimensionless)	0.01
ρ_a	Density of air (g/m^3)	1.2×10^3

Description

This equation calculates the contaminant concentration in aboveground vegetation caused by direct uptake of vapor-phase contaminants into the plant leaves.

Source: EPA, 1994, *Guidance for Performing Screening Level Risk Analyses at Combustion Facilities Burning Hazardous Wastes*, Draft, U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, Office of Solid Waste, December 14.

Table B-10. Aboveground produce concentration from root uptake.

Exposure Scenarios

All

Equation

$$Pr = Sc * Br$$

Parameter	Definition	Value
Pr	Concentration of pollutant in the plant from direct uptake from soil (mg/kg)	
Sc	Average soil concentration of pollutant over exposure duration (mg/kg)	Calculated (Tables B-11 to B-13)
Br	Plant-soil bioconcentration factor for aboveground produce [μg/g DW]/[μg/g soil]	Chemical-specific (Table B-1)

Description

This equation calculates the contaminant concentration in aboveground vegetation caused by direct uptake of contaminants from soil.

Source: EPA, 1994, *Guidance for Performing Screening Level Risk Analyses at Combustion Facilities Burning Hazardous Wastes*, Draft, U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, Office of Solid Waste, December 14.

Table B-11. Subsistence farmer produce calculations.

Chemical	Sc (mg/kg)	ScTc (mg/kg)	Ds (mg/kg/y)	ks (Year^{-1})	ksl (Year^{-1})	kse (Year^{-1})	ksr (Year^{-1})	ksg (Year^{-1})	ksv (Year^{-1})	Pd (mg/kg)	Pv (mg/kg)	Pr (mg/kg)
Antimony	1.36E-11	3.41E-11	1.38E-09	4.05E+01	4.01E+01	0.00E+00	3.97E-01	0.00E+00	0.00E+00	1.84E-11	0.00E+00	2.73E-12
Arsenic	7.44E-15	1.86E-14	5.52E-14	2.97E+00	2.94E+00	0.00E+00	2.91E-02	0.00E+00	0.00E+00	7.37E-16	0.00E+00	2.68E-16
Barium	7.85E-14	1.83E-13	3.22E-14	1.63E-01	1.61E-01	0.00E+00	1.60E-03	0.00E+00	0.00E+00	5.13E-16	0.00E+00	1.18E-14
Benzo(a)pyrene	2.22E-05	3.44E-05	2.70E-06	2.95E-02	7.13E-03	0.00E+00	7.06E-05	0.00E+00	2.23E-02	7.39E-10	4.52E-07	2.44E-07
Beryllium	2.24E-10	5.60E-10	6.90E-10	1.23E+00	1.22E+00	0.00E+00	1.21E-02	0.00E+00	0.00E+00	1.10E-11	0.00E+00	2.24E-12
Cadmium	8.52E-13	2.13E-12	1.15E-12	5.40E-01	5.34E-01	0.00E+00	5.29E-03	0.00E+00	0.00E+00	1.83E-14	0.00E+00	1.53E-13
Chromium VI	3.44E-14	8.59E-14	4.09E-13	4.77E+00	4.72E+00	0.00E+00	4.67E-02	0.00E+00	0.00E+00	6.52E-15	0.00E+00	3.78E-14
1,3-dinitrobenzene(PIC)	1.10E-03	2.75E-03	1.89E+00	6.88E+02	2.07E+02	0.00E+00	2.05E+00	0.00E+00	4.79E+02	0.00E+00	0.00E+00	5.83E-03
2,4-dinitrotoluene	1.05E-07	2.61E-07	6.27E-05	2.40E+02	8.53E+01	0.00E+00	8.44E-01	0.00E+00	1.54E+02	0.00E+00	1.23E-09	2.82E-07
2,4-dinitrotoluene(PIC)	3.42E-03	8.55E-03	2.05E+00	2.40E+02	8.53E+01	0.00E+00	8.44E-01	0.00E+00	1.54E+02	0.00E+00	4.04E-05	9.23E-03
2,6-dinitrotoluene(PIC)	4.08E-03	1.02E-02	2.05E+00	2.01E+02	1.07E+02	0.00E+00	1.05E+00	0.00E+00	9.37E+01	0.00E+00	3.50E-05	1.30E-02
Di(n)octyl phthalate	6.62E-07	8.39E-07	5.32E-08	1.64E-03	3.06E-04	0.00E+00	3.02E-06	0.00E+00	1.33E-03	2.46E-12	6.61E-08	1.19E-09
2,3,78-TCDD	1.10E-09	1.62E-09	1.21E-10	2.26E-02	6.11E-04	0.00E+00	6.05E-06	0.00E+00	2.20E-02	5.89E-14	7.00E-12	3.61E-12
Lead	8.11E-09	1.02E-08	6.44E-10	9.82E-04	9.72E-04	0.00E+00	9.62E-06	0.00E+00	0.00E+00	1.03E-11	0.00E+00	1.46E-10
Mercury	2.31E-05	5.78E-05	3.33E-05	5.76E-01	5.70E-01	0.00E+00	5.64E-03	0.00E+00	0.00E+00	5.30E-07	0.00E+00	4.62E-08
Nickel	2.97E-13	7.43E-13	7.82E-13	1.05E+00	1.04E+00	0.00E+00	1.03E-02	0.00E+00	0.00E+00	1.25E-14	0.00E+00	4.76E-15
Nitrobenzene(PIC)	3.36E-05	8.39E-05	1.38E+00	1.64E+04	1.17E+02	0.00E+00	1.15E+00	0.00E+00	1.63E+04	0.00E+00	1.27E-07	1.14E-04
Pentachloronitrobenzene(PIC)	1.71E-06	4.28E-06	1.58E-01	3.68E+04	2.25E-01	0.00E+00	2.23E-03	0.00E+00	3.68E+04	0.00E+00	1.64E-08	1.39E-07
Pentachlorophenol	5.39E-07	1.35E-06	6.62E-06	4.92E+00	7.78E-02	0.00E+00	7.70E-04	0.00E+00	4.84E+00	0.00E+00	4.44E-09	2.42E-08
Selenium	7.17E-10	1.79E-09	3.50E-08	1.95E+01	1.93E+01	0.00E+00	1.91E-01	0.00E+00	0.00E+00	4.67E-10	0.00E+00	1.15E-11
Silver	6.47E-17	1.62E-16	2.62E-14	1.62E+02	1.60E+02	0.00E+00	1.59E+00	0.00E+00	0.00E+00	4.18E-16	0.00E+00	2.59E-17
Thallium	3.95E-09	9.87E-09	1.15E-08	1.17E+00	1.15E+00	0.00E+00	1.14E-02	0.00E+00	0.00E+00	1.83E-10	0.00E+00	8.29E-10

Table B-12. Adult resident produce calculations.

Chemical	Sc (mg/kg)	ScTc (mg/kg)	Ds (mg/kg/y)	ks (Year^{-1})	ksl (Year^{-1})	ksc (Year^{-1})	ksr (Year^{-1})	ksg (Year^{-1})	ksv (Year^{-1})	Pd (mg/kg)	Pv (mg/kg)	Pr (mg/kg)
Antimony	1.82E-11	3.41E-11	1.38E-09	4.05E+01	4.01E+01	0.00E+00	3.97E-01	0.00E+00	0.00E+00	1.84E-11	0.00E+00	3.63E-12
Arsenic	9.93E-15	1.86E-14	5.52E-14	2.97E+00	2.94E+00	0.00E+00	2.91E-02	0.00E+00	0.00E+00	7.37E-16	0.00E+00	3.57E-16
Barium	1.02E-13	1.83E-13	3.22E-14	1.63E-01	1.61E-01	0.00E+00	1.60E-03	0.00E+00	0.00E+00	5.13E-16	0.00E+00	1.52E-14
Benzo(a)pyrene	2.30E-05	3.44E-05	2.70E-06	2.95E-02	7.13E-03	0.00E+00	7.06E-05	0.00E+00	2.23E-02	7.39E-10	4.52E-07	2.53E-07
Beryllium	2.99E-10	5.60E-10	6.90E-10	1.23E+00	1.22E+00	0.00E+00	1.21E-02	0.00E+00	0.00E+00	1.10E-11	0.00E+00	2.99E-12
Cadmium	1.14E-12	2.13E-12	1.15E-12	5.40E-01	5.34E-01	0.00E+00	5.29E-03	0.00E+00	0.00E+00	1.83E-14	0.00E+00	2.05E-13
Chromium VI	4.58E-14	8.59E-14	4.09E-13	4.77E+00	4.72E+00	0.00E+00	4.67E-02	0.00E+00	0.00E+00	6.52E-15	0.00E+00	5.04E-14
1,3-dinitrobenzene(PIC)	1.47E-03	2.75E-03	1.89E+00	6.88E+02	2.07E+02	0.00E+00	2.05E+00	0.00E+00	4.79E+02	0.00E+00	0.00E+00	7.78E-03
2,4-dinitrotoluene	1.39E-07	2.61E-07	6.27E-05	2.40E+02	8.53E+01	0.00E+00	8.44E-01	0.00E+00	1.54E+02	0.00E+00	1.23E-09	3.76E-07
2,4-dinitrotoluene(PIC)	4.56E-03	8.55E-03	2.05E+00	2.40E+02	8.53E+01	0.00E+00	8.44E-01	0.00E+00	1.54E+02	0.00E+00	4.04E-05	1.23E-02
2,6-dinitrotoluene(PIC)	5.43E-03	1.02E-02	2.05E+00	2.01E+02	1.07E+02	0.00E+00	1.05E+00	0.00E+00	9.37E+01	0.00E+00	3.50E-05	1.74E-02
Di(n)octyl phthalate	6.12E-07	8.39E-07	5.32E-08	1.64E-03	3.06E-04	0.00E+00	3.02E-06	0.00E+00	1.33E-03	2.46E-12	6.61E-08	1.10E-09
2,3,78-TCDD	1.11E-09	1.62E-09	1.21E-10	2.26E-02	6.11E-04	0.00E+00	6.05E-06	0.00E+00	2.20E-02	5.89E-14	7.00E-12	3.65E-12
Lead	7.47E-09	1.02E-08	6.44E-10	9.82E-04	9.72E-04	0.00E+00	9.62E-06	0.00E+00	0.00E+00	1.03E-11	0.00E+00	1.34E-10
Mercury	3.08E-05	5.78E-05	3.33E-05	5.76E-01	5.70E-01	0.00E+00	5.64E-03	0.00E+00	0.00E+00	5.30E-07	0.00E+00	6.16E-08
Nickel	3.96E-13	7.43E-13	7.82E-13	1.05E+00	1.04E+00	0.00E+00	1.03E-02	0.00E+00	0.00E+00	1.25E-14	0.00E+00	6.34E-15
Nitrobenzene(PIC)	4.48E-05	8.39E-05	1.38E+00	1.64E+04	1.17E+02	0.00E+00	1.15E+00	0.00E+00	1.63E+04	0.00E+00	1.27E-07	1.52E-04
Pentachloronitrobenzene(PIC)	2.28E-06	4.28E-06	1.58E-01	3.68E+04	2.25E-01	0.00E+00	2.23E-03	0.00E+00	3.68E+04	0.00E+00	1.64E-08	1.85E-07
Pentachlorophenol	7.19E-07	1.35E-06	6.62E-06	4.92E+00	7.78E-02	0.00E+00	7.70E-04	0.00E+00	4.84E+00	0.00E+00	4.44E-09	3.23E-08
Selenium	9.57E-10	1.79E-09	3.50E-08	1.95E+01	1.93E+01	0.00E+00	1.91E-01	0.00E+00	0.00E+00	4.67E-10	0.00E+00	1.53E-11
Silver	8.63E-17	1.62E-16	2.62E-14	1.62E+02	1.60E+02	0.00E+00	1.59E+00	0.00E+00	0.00E+00	4.18E-16	0.00E+00	3.45E-17
Thallium	5.26E-09	9.87E-09	1.15E-08	1.17E+00	1.15E+00	0.00E+00	1.14E-02	0.00E+00	0.00E+00	1.83E-10	0.00E+00	1.10E-09

Table B-13. Child resident produce calculations.

Chemical	Sc (mg/kg)	ScTc (mg/kg)	Ds (mg/kg/y)	ks (Year^{-1})	ksl (Year^{-1})	ksc (Year^{-1})	ksr (Year^{-1})	ksg (Year^{-1})	ksv (Year^{-1})	Pd (mg/kg)	Pv (mg/kg)	Pr (mg/kg)
Antimony	6.05E-11	3.41E-11	1.38E-09	4.05E+01	4.01E+01	0.00E+00	3.97E-01	0.00E+00	0.00E+00	1.84E-11	0.00E+00	1.21E-11
Arsenic	3.24E-14	1.86E-14	5.52E-14	2.97E+00	2.94E+00	0.00E+00	2.91E-02	0.00E+00	0.00E+00	7.37E-16	0.00E+00	1.17E-15
Barium	2.26E-13	1.83E-13	3.22E-14	1.63E-01	1.61E-01	0.00E+00	1.60E-03	0.00E+00	0.00E+00	5.13E-16	0.00E+00	3.40E-14
Benzo(a)pyrene	3.30E-05	3.44E-05	2.70E-06	2.95E-02	7.13E-03	0.00E+00	7.06E-05	0.00E+00	2.23E-02	7.39E-10	4.52E-07	3.63E-07
Beryllium	9.45E-10	5.60E-10	6.90E-10	1.23E+00	1.22E+00	0.00E+00	1.21E-02	0.00E+00	0.00E+00	1.10E-11	0.00E+00	9.45E-12
Cadmium	3.35E-12	2.13E-12	1.15E-12	5.40E-01	5.34E-01	0.00E+00	5.29E-03	0.00E+00	0.00E+00	1.83E-14	0.00E+00	6.03E-13
Chromium VI	1.51E-13	8.59E-14	4.09E-13	4.77E+00	4.72E+00	0.00E+00	4.67E-02	0.00E+00	0.00E+00	6.52E-15	0.00E+00	1.66E-13
1,3-dinitrobenzene(PIC)	4.89E-03	2.75E-03	1.89E+00	6.88E+02	2.07E+02	0.00E+00	2.05E+00	0.00E+00	4.79E+02	0.00E+00	0.00E+00	2.59E-02
2,4-dinitrotoluene	4.64E-07	2.61E-07	6.27E-05	2.40E+02	8.53E+01	0.00E+00	8.44E-01	0.00E+00	1.54E+02	0.00E+00	1.23E-09	1.25E-06
2,4-dinitrotoluene(PIC)	1.52E-02	8.55E-03	2.05E+00	2.40E+02	8.53E+01	0.00E+00	8.44E-01	0.00E+00	1.54E+02	0.00E+00	4.04E-05	4.10E-02
2,6-dinitrotoluene(PIC)	1.81E-02	1.02E-02	2.05E+00	2.01E+02	1.07E+02	0.00E+00	1.05E+00	0.00E+00	9.37E+01	0.00E+00	3.50E-05	5.79E-02
Di(n)octyl phthalate	7.49E-07	8.39E-07	5.32E-08	1.64E-03	3.06E-04	0.00E+00	3.02E-06	0.00E+00	1.33E-03	2.46E-12	6.61E-08	1.35E-09
2,3,78-TCDD	1.53E-09	1.62E-09	1.21E-10	2.26E-02	6.11E-04	0.00E+00	6.05E-06	0.00E+00	2.20E-02	5.89E-14	7.00E-12	5.04E-12
Lead	9.11E-09	1.02E-08	6.44E-10	9.82E-04	9.72E-04	0.00E+00	9.62E-06	0.00E+00	0.00E+00	1.03E-11	0.00E+00	1.64E-10
Mercury	9.16E-05	5.78E-05	3.33E-05	5.76E-01	5.70E-01	0.00E+00	5.64E-03	0.00E+00	0.00E+00	5.30E-07	0.00E+00	1.83E-07
Nickel	1.24E-12	7.43E-13	7.82E-13	1.05E+00	1.04E+00	0.00E+00	1.03E-02	0.00E+00	0.00E+00	1.25E-14	0.00E+00	1.99E-14
Nitrobenzene(PIC)	1.49E-04	8.39E-05	1.38E+00	1.64E+04	1.17E+02	0.00E+00	1.15E+00	0.00E+00	1.63E+04	0.00E+00	1.27E-07	5.07E-04
Pentachloronitrobenzene(PIC)	7.61E-06	4.28E-06	1.58E-01	3.68E+04	2.25E-01	0.00E+00	2.23E-03	0.00E+00	3.68E+04	0.00E+00	1.64E-08	6.16E-07
Pentachlorophenol	2.36E-06	1.35E-06	6.62E-06	4.92E+00	7.78E-02	0.00E+00	7.70E-04	0.00E+00	4.84E+00	0.00E+00	4.44E-09	1.06E-07
Selenium	3.18E-09	1.79E-09	3.50E-08	1.95E+01	1.93E+01	0.00E+00	1.91E-01	0.00E+00	0.00E+00	4.67E-10	0.00E+00	5.09E-11
Silver	2.88E-16	1.62E-16	2.62E-14	1.62E+02	1.60E+02	0.00E+00	1.59E+00	0.00E+00	0.00E+00	4.18E-16	0.00E+00	1.15E-16
Thallium	1.66E-08	9.87E-09	1.15E-08	1.17E+00	1.15E+00	0.00E+00	1.14E-02	0.00E+00	0.00E+00	1.83E-10	0.00E+00	3.49E-09

Table B-14. Air concentration.

Exposure Scenarios
All
Equation
$C_a = Q * [Fv * Cyv + (1.0 - Fv) * Cyp]$

Parameter	Definition	Value
C_a	Total air concentration (µg/m^3)	
Q	Stack emissions (g/second)	Site-specific (see Tables 9 and 10)
Fv	Fraction of air concentration in vapor phase (dimensionless)	Chemical-specific (Table B-1)
Cyv	Normalized vapor-phase air concentration (µg-second/g-m^3)	0.06213
Cyp	Normalized particle phase air concentration (µg-second/g-m^3)	0.06156

Description

This equation calculates the total air concentration of a constituent based on the fraction in the vapor phase and the fraction in the particle phase.

Source: EPA, 1994, *Guidance for Performing Screening Level Risk Analyses at Combustion Facilities Burning Hazardous Wastes*, Draft, U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, Office of Solid Waste, December 14.

Appendix C

Exposure Calculations for Subsistence Farmer

Table C-1. Forage (pasture grass or hay) concentration from direct deposition.

Equation

$$Pd = \frac{1{,}000 * Q * (1 - Fv)[Dydp + (Fw * Dywp)] * Rp * [1.0 - \exp(-kp * Tp)]}{Yp * kp}$$

Parameter	Definition	Value
Pd	Concentration in plant from direct deposition (mg/kg)	
1,000	Units conversion factor (mg/g)	
Q	Stack emissions (g/second)	Site-specific (Section 2)
Dydp	Yearly dry deposition rate of pollutant (s/m^2-year)	0.00045
Fw	Fraction of wet deposition that adheres to plant surfaces (dimensionless)	Chemical-specific (Table B-1)
Fv	Fraction of pollutant air concentration present in the vapor phase (dimensionless)	Chemical-specific (Table B-1)
Dywp	Yearly particle phase wet deposition rate (g/m^2/year)	0.00024
Rp	Interception fraction of edible portion of the plant tissue (dimensionless)	0.5
kp	Plant surface loss coefficient ($year^{-1}$)	18
Tp	Length of plant's exposure to deposition per harvest of edible portion of plant (year)	0.12
Yp	Yield or standing crop biomass of the edible portion of the plant (kg DW/m^2)	0.24

Description

This equation calculates the contaminant concentration in aboveground vegetation caused by wet and dry deposition of contaminant on the plant surface.

Source: EPA, 1994, *Guidance for Performing Screening Level Risk Analyses at Combustion Facilities Burning Hazardous Wastes*, Draft, U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, December 14.

Table C-2. Forage (pasture grass or hay) concentration from air-to-plant transfer.

Equation
$$Pv = \frac{(Cyv * Bv * VG_{ag})}{\rho_a}$$

Parameter	Definition	Value
Pv	Concentration of pollutant in the plant from air-to-plant transfer (mg/kg)	
Fv	Fraction of pollutant air concentration in the vapor phase (dimensionless)	Chemical-specific (Table B-1)
Cyv	Vapor-phase air concentration of pollutant in air caused by direct emissions (μg pollutant/m^3)	0.06213
Bv	Air-to-plant biotransfer factor [(mg pollutant/kg plant tissue DW)/(μg pollutant/g air)]	Chemical-specific (Table B-1)
Vg_{ag}	Empirical correction factor that reduces produce concentration because Bv was developed for azalea leaves	1.0
ρ_a	Density of air (g/m^3)	1.2×10^3

Description
This equation calculates the contaminant concentration in aboveground vegetation caused by direct uptake of vapor-phase contaminants into the plant leaves.

Source: EPA, 1994, *Guidance for Performing Screening Level Risk Analyses at Combustion Facilities Burning Hazardous Wastes*, Draft, U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, December 14.

Table C-3. Forage, silage, and grain concentration from root uptake.

Exposure Scenarios

All

Equation

$$Pr = \sum_{i} Sc * Br_i$$

Parameter	Definition	Value
Pr	Concentration of pollutant in the plant from direct uptake from soil (mg/kg)	
Sc	Average soil concentration of pollutant over exposure duration (mg/kg)	Calculated (Table B-11)
Br_i	Plant-soil bioconcentration factor plant species *i* (forage, silage, and grain) [µg/g DW]/[µg/g soil]	Chemical-specific (Table B-1)

Description

This equation calculates the contaminant concentration in aboveground vegetation caused by direct uptake of contaminants from soil.

Source: EPA, 1994, *Guidance for Performing Screening Level Risk Analyses at Combustion Facilities Burning Hazardous Wastes*, Draft, U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, December 14.

Table C-4. Beef concentration from plant and soil ingestion.

Exposure Scenarios
Subsistence Farmer
Equation
$A_{beef} = (F * Qp * P + Qs * Sc) * Ba_{beef}$

Parameter	**Definition**	**Value**
A_{beef}	Concentration of pollutant in beef (mg/kg)	
F	Fraction of plant grown on contaminated soil and eaten by bovine animal (dimensionless)	1
Qp	Quantity of plant eaten by bovine each day (kg plant tissue DW/day)	8.8
P	Total concentration of pollutant in the plant eaten by bovine animal (mg/kg) = Pd + Pv + Pr	Calculated (Table B-11)
Qs	Quantity of soil eaten by bovine animal (kg soil/day)	0.5
Sc	Soil concentration (mg/kg)	Calculated (Table B-11)
Ba_{beef}	Biotransfer factor for beef (day/kg)	Chemical-specific (Table B-1)

Description
This equation calculates the concentration of contaminant in beef caused by ingestion of forage and soil.

Source: EPA, 1994, *Guidance for Performing Screening Level Risk Analyses at Combustion Facilities Burning Hazardous Wastes*, Draft, U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, December 14.

Table C-5. Milk concentration from plant and soil ingestion.

Exposure Scenarios
Subsistence Farmer
Equation
$A_{milk} = (F * Qp * P + Qs * Sc) * Ba_{milk}$

Parameter	Definition	Value
A_{milk}	Concentration of pollutant in milk (mg/kg)	
F	Fraction of plant grown on contaminated soil and eaten by animal (dimensionless)	1
Qp	Quantity of plant eaten by animal each day (kg plant tissue DW/day)	13.2
P	Total concentration of pollutant in the plant eaten by animal (mg/kg) = Pd + Pv + Pr	Calculated (Table B-11)
Qs	Quantity of soil eaten by animal (kg soil/day)	0.4
Sc	Soil concentration (mg/kg)	Calculated (see Table B-11)
Ba_{milk}	Biotransfer factor for milk (day/kg)	Chemical-specific (Table B-1)

Description
This equation calculates the concentration of contaminant in milk caused by ingestion of forage and soil.

Source: EPA, 1994, *Guidance for Performing Screening Level Risk Analyses at Combustion Facilities Burning Hazardous Wastes*, Draft, U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, December 14.

Table C-6. Soil intake for subsistence-farmer scenario.

Equation

$$I_{soil} = Sc * CR_{soil} * F_{soil}$$

Parameter	Definition	Value
I_{soil}	Daily intake of contaminant from ingested soil (mg/day)	
Sc	Soil concentration (mg/kg)	Calculated (Table B-11)
CR_{soil}	Consumption rate of soil (kg/day)	0.0001
F_{soil}	Fraction of consumed soil contaminated (unitless)	1

Chemicals

- 2,3,7,8-TCDD-TEQ
- 1,3-dinitrobenzene
- 2,4-dinitrotoluene
- 2,6-dinitrotoluene
- Antimony
- Arsenic
- Barium
- Benzo(a)pyrene toxicity equivalents
- Beryllium
- Bis (2-ethylhexyl) phthalate
- Cadmium
- Chromium
- Di(n)octyl phthalate
- Hexachlorobenzene
- Mercury
- Nickel
- Nitrobenzene
- Pentachloronitrobenzene
- Pentachlorophenol
- Selenium
- Silver
- Thallium
- Total polychlorinated biphenyls (PCBs)

Source: EPA, 1994, *Guidance for Performing Screening Level Risk Analyses at Combustion Facilities Burning Hazardous Wastes*, Draft, U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, December 14.

Table C-7. Aboveground produce intake for subsistence-farmer scenario.

Equation

$$I_{ag} = (Pd + Pv + Pr) * CR_{ag} * F_{ag}$$

Parameter	Definition	Value
I_{ag}	Daily intake of contaminant from aboveground produce (mg/day)	
Pd	Concentration in aboveground produce from deposition (mg/kg)	Calculated (Table B-11)
Pv	Concentration in aboveground produce from air-to-plant transfer (mg/kg)	Calculated (Table B-11)
Pr	Concentration in aboveground produce from root uptake (mg/kg)	Calculated (Table B-11)
CR_{ag}	Consumption rate of aboveground produce (kg/day)	0.028
F_{ag}	Fraction of aboveground produce contaminated (unitless)	1

Chemicals

2,3,7,8-TCDD-TEQ
1,3-dinitrobenzene
2,4-dinitrotoluene
2,6-dinitrotoluene
Antimony
Arsenic
Barium
Benzo(a)pyrene toxicity equivalents
Beryllium
Bis (2-ethylhexyl) phthalate
Cadmium
Chromium
Di(n)octyl phthalate
Hexachlorobenzene
Mercury
Nickel
Nitrobenzene
Pentachloronitrobenzene
Pentachlorophenol
Selenium
Silver
Thallium
Total polychlorinated biphenyls (PCBs)

Description

This equation calculates the concentration in beef caused by ingestion of forage and soil.

Source: EPA, 1994, *Guidance for Performing Screening Level Risk Analyses at Combustion Facilities Burning Hazardous Wastes*, Draft, U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, December 14.

Table C-8. Beef and milk intake for subsistence-farmer scenario.

Equation

$$I_{beef} = A_{beef} * CR_{beef} * F_{beef}$$

$$I_{milk} = A_{milk} * CR_{milk} * F_{milk}$$

Parameter	Definition	Value
I_{beef}	Daily intake of contaminant from beef (mg/day)	
A_{beef}	Concentration in beef (mg/kg)	Calculated (Table C-11)
CR_{beef}	Consumption rate of beef (kg/day)	0.057
F_{beef}	Fraction of beef contaminated (unitless)	1
I_{milk}	Daily intake of contaminant from milk (mg/day)	Calculated (Table C-12)
A_{milk}	Concentration in milk (mg/kg)	Calculated (Table C-11)
CR_{milk}	Consumption rate of milk (kg/day)	0.18
F_{milk}	Fraction of milk contaminated (unitless)	1

Chemicals

2,3,7,8-TCDD-TEQ
1,3-dinitrobenzene
2,4-dinitrotoluene
2,6-dinitrotoluene
Antimony
Arsenic
Barium
Benzo(a)pyrene toxicity equivalents
Beryllium
Bis (2-ethylhexyl) phthalate
Cadmium
Chromium
Di(n)octyl phthalate
Hexachlorobenzene
Mercury
Nickel
Nitrobenzene
Pentachloronitrobenzene
Pentachlorophenol
Selenium
Silver
Thallium
Total polychlorinated biphenyls (PCBs)

Source: EPA, 1994, *Guidance for Performing Screening Level Risk Analyses at Combustion Facilities Burning Hazardous Wastes*, Draft, U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, December 14.

Table C-9. Total daily intake for subsistence-farmer scenario.

Equation

$$I = I_{soil} + I_{ag} + I_{beef} + I_{milk} + I_{dw}$$

Parameter	Definition	Value
I	Total daily intake of contaminant (mg/day)	
I_{soil}	Daily intake of contaminant from soil (mg/day)	Calculated (Table C-12)
I_{ag}	Daily intake of contaminant from aboveground produce (mg/day)	Calculated (Table C-12)
I_{beef}	Daily intake of contaminant from beef (mg/day)	Calculated (Table C-12)
I_{milk}	Daily intake of contaminant from milk (mg/day)	Calculated (Table C-12)
I_{dw}	Daily intake of contaminant from drinking water (mg/day)	Calculated (Table C-12)

Chemicals

2,3,7,8-TCDD-TEQ
1,3-dinitrobenzene
2,4-dinitrotoluene
2,6-dinitrotoluene
Antimony
Arsenic
Barium
Benzo(a)pyrene toxicity equivalents
Beryllium
Bis (2-ethylhexyl) phthalate
Cadmium
Chromium
Di(n)octyl phthalate
Hexachlorobenzene
Mercury
Nickel
Nitrobenzene
Pentachloronitrobenzene
Pentachlorophenol
Selenium
Silver
Thallium
Total polychlorinated biphenyls (PCBs)

Source: EPA, 1994, *Guidance for Performing Screening Level Risk Analyses at Combustion Facilities Burning Hazardous Wastes*, Draft, U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, December 14.

Table C-10. Average intake for subsistence farmer via inhalation.

Equation

$$ADI(inh)i,j = \frac{C(air)_{i,j} * IR_j * ET * EF * ED_j * 0.001}{BW_j * AT}$$

Parameter	Definition	Value
ADI $(inh)_{ij}$	Average daily intake via inhalation (mg/kg-day) for chemical i in exposure scenario j	
$C(air)_{ij}$	Ambient air concentration (µg/m^3) for chemical i in exposure scenario j	Tables 9 and 10
Ir_j	Inhalation rate (m^3/hour)	0.83
ET	Exposure time (hour/day)	24
EF	Exposure frequency (day/year)	350
ED_j	Exposure duration (year) for exposure scenario j	40
BW_j	Body weight (kg) for exposure scenario j	70
AT	Averaging time (days)	25,550
0.001	Unit conversion factor (mg/µg)	

Description

The lifetime individual cancer risk is calculated from the average daily intake via inhalation (ADI). The ADI is calculated for each exposure scenario.

Source: EPA, 1994, *Guidance for Performing Screening Level Risk Analyses at Combustion Facilities Burning Hazardous Wastes*, Draft, U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, December 14.

Table C-11. Beef and milk calculations (mg/kg) for subsistence farmer.

Chemical	Pd	Pv	Pr	A_{beef}	A_{milk}
Antimony	1.53E-09	0.00E+00	2.73E-12	1.35E-11	2.02E-12
Arsenic	6.12E-14	0.00E+00	2.68E-16	1.09E-15	4.89E-15
Barium	4.26E-14	0.00E+00	1.18E-14	7.76E-17	2.62E-16
Benzo(a)pyrene	6.13E-08	4.52E-05	2.44E-07	1.40E-05	6.71E-06
Beryllium	9.12E-10	0.00E+00	2.24E-12	8.16E-12	1.09E-14
Cadmium	1.52E-12	0.00E+00	1.53E-13	1.82E-12	1.71E-13
Chromium VI	0.00E+00	0.00E+00	3.78E-14	2.81E-14	1.15E-14
1,3-dinitrobenzene(PIC)	0.00E+00	1.69E-07	5.83E-03	4.10E-08	1.94E-08
2,4-dinitrotoluene	0.00E+00	1.23E-07	2.82E-07	9.06E-12	4.26E-12
2,4-dinitrotoluene(PIC)	0.00E+00	4.04E-03	9.23E-03	2.96E-07	1.39E-07
2,6-dinitrotoluene(PIC)	0.00E+00	3.50E-03	1.30E-02	2.80E-07	1.34E-07
Di(n)octyl phthalate	2.04E-10	6.61E-06	1.19E-09	0.00E+00	0.00E+00
2,3,78-TCDD	4.88E-12	7.00E-10	3.61E-12	2.71E-10	6.85E-11
Lead	8.51E-10	0.00E+00	1.46E-10	3.85E-12	4.10E-12
Mercury	4.40E-05	0.00E+00	4.62E-08	9.97E-05	2.66E-07
Nickel	1.03E-12	0.00E+00	4.76E-15	5.57E-14	1.38E-14
Nitrobenzene(PIC)	0.00E+00	1.27E-05	1.14E-04	1.93E-09	9.11E-10
Pentachloronitrobenzene(PIC)	0.00E+00	1.64E-06	1.39E-07	1.81E-08	8.44E-09
Pentachlorophenol	0.00E+00	4.44E-07	2.42E-08	1.32E-08	6.14E-09
Selenium	3.88E-08	0.00E+00	1.15E-11	5.12E-09	2.05E-09
Silver	3.47E-14	0.00E+00	2.59E-17	9.16E-16	9.16E-15
Thallium	1.52E-08	0.00E+00	8.29E-10	5.72E-09	4.26E-10

Table C-12. Intake calculations (mg/kg) for subsistence farmer.

Chemical	I_{soil}	I_{ag}	I_{dw}	I_{beef}	I_{milk}	I_{total}
Antimony	1.36E-15	5.92E-13	0.00E+00	7.69E-13	3.64E-13	1.73E-12
Arsenic	7.44E-19	2.81E-17	0.00E+00	6.21E-17	8.79E-16	9.70E-16
Barium	7.85E-18	3.44E-16	0.00E+00	4.42E-18	4.72E-17	4.03E-16
Benzo(a)pyrene	2.22E-09	1.95E-08	0.00E+00	7.98E-07	1.21E-06	2.03E-06
Beryllium	2.24E-14	3.71E-13	0.00E+00	4.65E-13	1.97E-15	8.60E-13
Cadmium	8.52E-17	4.81E-15	0.00E+00	1.04E-13	3.07E-14	1.39E-13
Chromium VI	3.44E-18	1.24E-15	0.00E+00	1.60E-15	2.07E-15	4.92E-15
1,3-dinitrobenzene(PIC)	1.10E-07	4.08E-05	0.00E+00	2.34E-09	3.48E-09	4.09E-05
2,4-dinitrotoluene	1.05E-11	7.94E-09	0.00E+00	5.16E-13	7.67E-13	7.95E-09
2,4-dinitrotoluene(PIC)	3.42E-07	2.60E-04	0.00E+00	1.69E-08	2.51E-08	2.60E-04
2,6-dinitrotoluene(PIC)	4.08E-07	3.66E-04	0.00E+00	1.60E-08	2.42E-08	3.67E-04
Di(n)octyl phthalate	6.62E-11	1.88E-09	0.00E+00	0.00E+00	0.00E+00	1.95E-09
2,3,78-TCDD	1.10E-13	2.99E-13	0.00E+00	1.55E-11	1.23E-11	2.82E-11
Lead	8.11E-13	4.38E-12	0.00E+00	2.19E-13	7.39E-13	6.15E-12
Mercury	2.31E-09	1.61E-08	0.00E+00	5.68E-06	4.78E-08	5.75E-06
Nickel	2.97E-17	4.82E-16	0.00E+00	3.18E-15	2.49E-15	6.18E-15
Nitrobenzene(PIC)	3.36E-09	3.20E-06	0.00E+00	1.10E-10	1.64E-10	3.20E-06
Pentachloronitrobenzene(PIC)	1.71E-10	4.34E-09	0.00E+00	1.03E-09	1.52E-09	7.06E-09
Pentachlorophenol	5.39E-11	8.03E-10	0.00E+00	7.50E-10	1.10E-09	2.71E-09
Selenium	7.17E-14	1.34E-11	0.00E+00	2.92E-10	3.69E-10	6.74E-10
Silver	6.47E-21	1.24E-17	0.00E+00	5.22E-17	1.65E-15	1.71E-15
Thallium	3.95E-13	2.83E-11	0.00E+00	3.26E-10	7.68E-11	4.32E-10

Appendix D

Exposure Calculations for Adult Resident

Table D-1. Soil intake for adult-resident scenario.

Equation
$I_{soil} = Sc * CR_{soil} * F_{soil}$

Parameter	Definition	Value
I_{soil}	Daily intake of contaminant from soil (mg/day)	
Sc	Soil concentration (mg/kg)	Calculated (Table B-12)
CR_{soil}	Consumption rate of soil (kg/day)	0.0001
F_{soil}	Fraction of consumed soil contaminated (unitless)	1

Chemicals	
2,3,7,8-TCDD-TEQ 1,3-dinitrobenzene 2,4-dinitrotoluene 2,6-dinitrotoluene Antimony Arsenic Barium Benzo(a)pyrene toxicity equivalents Beryllium Bis (2-ethylhexyl) phthalate Cadmium Chromium	Di(n)octyl phthalate Hexachlorobenzene Mercury Nickel Nitrobenzene Pentachloronitrobenzene Pentachlorophenol Selenium Silver Thallium Total polychlorinated biphenyls (PCBs)

Source: EPA, 1994, *Guidance for Performing Screening Level Risk Analyses at Combustion Facilities Burning Hazardous Wastes*, Draft, U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, December 14.

Table D-2. Aboveground vegetable intake for adult-resident scenario.

Equation

$$I_{ag} = (Pd + Pv + Pr) * CR_{ag} * F_{ag}$$

Parameter	Definition	Value
I_{ag}	Daily intake of contaminant from aboveground vegetables (mg/day)	
Pd	Concentration in aboveground vegetables from deposition (mg/kg)	Calculated (Table B-12)
Pv	Concentration in aboveground vegetables from air-to-plant transfer (mg/kg)	Calculated (Table B-12)
Pr	Concentration in aboveground produce from root uptake (mg/kg)	Calculated (Table B-12)
CR_{ag}	Consumption rate of aboveground vegetables (kg/day)	0.028
Fag	Fraction of aboveground vegetables contaminated (unitless)	0.25

Chemicals

2,3,7,8-TCDD-TEQ
1,3-dinitrobenzene
2,4-dinitrotoluene
2,6-dinitrotoluene
Antimony
Arsenic
Barium
Benzo(a)pyrene toxicity equivalents
Beryllium
Bis (2-ethylhexyl) phthalate
Cadmium
Chromium
Di(n)octyl phthalate
Hexachlorobenzene
Mercury
Nickel
Nitrobenzene
Pentachloronitrobenzene
Pentachlorophenol
Selenium
Silver
Thallium
Total polychlorinated biphenyls (PCBs)

Source: EPA, 1994, *Guidance for Performing Screening Level Risk Analyses at Combustion Facilities Burning Hazardous Wastes*, Draft, U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, December 14.

Table D-3. Total daily intake for adult-resident scenario.

Equation

$$I = I_{soil} + I_{ag} + I_{dw}$$

Parameter	Definition	Value
I	Total daily intake of contaminant (mg/day)	
I_{soil}	Daily intake of contaminant from soil (mg/day)	Calculated (Table D-5)
I_{ag}	Daily intake of contaminant from aboveground vegetables (mg/kg)	Calculated (Table D-5)
I_{dw}	Daily intake of contaminant from drinking water (mg/day)	Calculated (Table D-5)

Chemicals

2,3,7,8-TCDD-TEQ
1,3-dinitrobenzene
2,4-dinitrotoluene
2,6-dinitrotoluene
Antimony
Arsenic
Barium
Benzo(a)pyrene toxicity equivalents
Beryllium
Bis (2-ethylhexyl) phthalate
Cadmium
Chromium
Di(n)octyl phthalate
Hexachlorobenzene
Mercury
Nickel
Nitrobenzene
Pentachloronitrobenzene
Pentachlorophenol
Selenium
Silver
Thallium
Total polychlorinated biphenyls (PCBs)

Source: EPA, 1994, *Guidance for Performing Screening Level Risk Analyses at Combustion Facilities Burning Hazardous Wastes*, Draft, U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, December 14.

Table D-4. Average for adult resident intake via inhalation.

Equation		
$ADI(inh)i,j = \frac{C(air)_{i,j} * IR_j * ET * EF * ED_j * 0.001}{BW_j * AT}$		
Parameter	**Definition**	**Value**
ADI $(inh)_{i,j}$	Average daily intake via inhalation (mg/kg-day) for chemical i in exposure scenario j	
$C(air)_{i,j}$	Ambient air concentration ($\mu g/m^3$) for chemical i in exposure scenario j	Tables 9 and 10
Ir_j	Inhalation rate (m^3/hour)	0.83
ET	Exposure time (hour/day)	24
EF	Exposure frequency (day/year)	350
ED_j	Exposure duration (year) for exposure scenario j	30
BW_j	Body weight (kg) for exposure scenario j	70
AT	Averaging time (day)	25,550
0.001	Unit conversion factor (mg/µg)	
Description		
The lifetime individual cancer risk is calculated from the average daily intake via inhalation (ADI). The ADI is calculated for each exposure scenario.		

Source: EPA, 1994, *Guidance for Performing Screening Level Risk Analyses at Combustion Facilities Burning Hazardous Wastes*, Draft, U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, December 14.

Table D-5. Intake calculations (mg/day) for adult resident.

Chemical	I_{soil}	I_{ag}	I_{dw}	I_{total}
Antimony	1.82E-15	1.54E-13	0.00E+00	1.56E-13
Arsenic	9.93E-19	7.66E-18	0.00E+00	8.66E-18
Barium	1.02E-17	1.10E-16	0.00E+00	1.20E-16
Benzo(a)pyrene	2.30E-09	4.95E-09	0.00E+00	7.25E-09
Beryllium	2.99E-14	9.79E-14	0.00E+00	1.28E-13
Cadmium	1.14E-16	1.56E-15	0.00E+00	1.67E-15
Chromium VI	0.00E+00	3.98E-16	0.00E+00	3.98E-16
1,3-dinitrobenzene(PIC)	0.00E+00	5.44E-05	0.00E+00	5.44E-05
2,4-dinitrotoluene	1.39E-11	2.64E-09	0.00E+00	2.66E-09
2,4-dinitrotoluene(PIC)	4.56E-07	8.64E-05	0.00E+00	8.69E-05
2,6-dinitrotoluene(PIC)	5.43E-07	1.22E-04	0.00E+00	1.23E-04
Di(n)octyl phthalate	6.12E-11	4.70E-10	0.00E+00	5.32E-10
2,3,78-TCDD	1.11E-13	7.50E-14	0.00E+00	1.86E-13
Lead	7.47E-13	1.01E-12	0.00E+00	1.76E-12
Mercury	3.08E-09	4.14E-09	0.00E+00	7.22E-09
Nickel	3.96E-17	1.32E-16	0.00E+00	1.71E-16
Nitrobenzene(PIC)	4.48E-09	1.07E-06	0.00E+00	1.07E-06
Pentachloronitrobenzene(PIC)	2.28E-10	1.41E-09	0.00E+00	1.64E-09
Pentachlorophenol	7.19E-11	2.57E-10	0.00E+00	3.29E-10
Selenium	9.57E-14	3.38E-12	0.00E+00	3.47E-12
Silver	8.63E-21	3.17E-18	0.00E+00	3.17E-18
Thallium	5.26E-13	9.02E-12	0.00E+00	9.54E-12

Appendix E

Exposure Calculations for Child Resident

Table E-1. Soil intake for child-resident scenario.

Equation

$$I_{soil} = Sc * CR_{soil} * F_{soil}$$

Parameter	Definition	Value
I_{soil}	Daily intake of contaminant from soil (mg/kg)	
Sc	Soil concentration (mg/kg)	Calculated (Table B-13)
Cr_{soil}	Consumption rate of soil (kg/day)	0.0002
F_{soil}	Fraction of consumed soil contaminated (unitless)	1

Chemicals

2,3,7,8-TCDD-TEQ
1,3-dinitrobenzene
2,4-dinitrotoluene
2,6-dinitrotoluene
Antimony
Arsenic
Barium
Benzo(a)pyrene toxicity equivalents
Beryllium
Bis (2-ethylhexyl) phthalate
Cadmium
Chromium
Di(n)octyl phthalate
Hexachlorobenzene
Mercury
Nickel
Nitrobenzene
Pentachloronitrobenzene
Pentachlorophenol
Selenium
Silver
Thallium
Total polychlorinated biphenyls (PCBs)

Source: EPA, 1994, *Guidance for Performing Screening Level Risk Analyses at Combustion Facilities Burning Hazardous Wastes*, Draft, U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, December 14.

Table E-2. Aboveground vegetable intake for child-resident scenario.

Equation

$$I_{ag} = (Pd + Pv + Pr) * CR_{ag} * F_{ag}$$

Parameter	Definition	Value
I_{ag}	Daily intake of contaminant from aboveground vegetables (mg/day)	
Pd	Concentration in aboveground vegetables from deposition (mg/kg)	Calculated (Table B-13)
Pv	Concentration in aboveground vegetables from air-to-plant transfer (mg/kg)	Calculated (Table B-13)
Pr	Concentration in aboveground vegetables from root uptake (mg/kg)	Calculated (Table B-13)
CR_{ag}	Consumption rate of aboveground vegetables (kg/day)	0.005
F_{ag}	Fraction of aboveground vegetables contaminated (unitless)	0.25

Chemicals

2,3,7,8-TCDD-TEQ
1,3-dinitrobenzene
2,4-dinitrotoluene
2,6-dinitrotoluene
Antimony
Arsenic
Barium
Benzo(a)pyrene toxicity equivalents
Beryllium
Bis (2-ethylhexyl) phthalate
Cadmium
Chromium
Di(n)octyl phthalate
Hexachlorobenzene
Mercury
Nickel
Nitrobenzene
Pentachloronitrobenzene
Pentachlorophenol
Selenium
Silver
Thallium
Total polychlorinated biphenyls (PCBs)

Source: EPA, 1994, *Guidance for Performing Screening Level Risk Analyses at Combustion Facilities Burning Hazardous Wastes*, Draft, U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, December 14.

Table E-3. Total daily intake for child-resident scenario.

Equation

$$I = I_{soil} + I_{ag} + I_{dw}$$

Parameter	Definition	Value
I	Total daily intake of contaminant (mg/day)	
I_{soil}	Daily intake of contaminant from soil (mg/day)	Calculated (Table E-5)
I_{ag}	Daily intake of contaminant from aboveground vegetables (mg/day)	Calculated (Table E-5)
I_{dw}	Daily intake of contaminant from drinking water (mg/day)	Calculated (Table E-5)

Chemicals

2,3,7,8-TCDD-TEQ
1,3-dinitrobenzene
2,4-dinitrotoluene
2,6-dinitrotoluene
Antimony
Arsenic
Barium
Benzo(a)pyrene toxicity equivalents
Beryllium
Bis (2-ethylhexyl) phthalate
Cadmium
Chromium
Di(n)octyl phthalate
Hexachlorobenzene
Mercury
Nickel
Nitrobenzene
Pentachloronitrobenzene
Pentachlorophenol
Selenium
Silver
Thallium
Total polychlorinated biphenyls (PCBs)

Source: EPA, 1994, *Guidance for Performing Screening Level Risk Analyses at Combustion Facilities Burning Hazardous Wastes*, Draft, U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, December 14.

Table E-4. Average intake for child via inhalation.

Equation

$$ADI(inh)i,j = \frac{C(air)_{i,j} * IR_j * ET * EF * ED_j * 0.001}{BW_j * AT}$$

Parameter	Definition	Value
ADI $(inh)_{i,j}$	Average daily intake via inhalation (mg/kg-day) for chemical i in exposure scenario j	
$C(air)_{i,j}$	Ambient air concentration (µg/m^3) for chemical i in exposure scenario j	Tables 9 and 10
Ir_j	Inhalation rate (m^3/hour)	0.3
ET	Exposure time (hour/day)	24
EF	Exposure frequency (day/year)	350
Ed_j	Exposure duration (year) for exposure scenario j	6
BW_j	Body weight (kg) for exposure scenario j	15
AT	Averaging time (day)	25,550
0.001	Unit conversion factor (mg/µg)	

Description

The lifetime individual cancer risk is calculated from the average daily intake via inhalation (ADI). The ADI is calculated for each exposure scenario.

Source: EPA, 1994, *Guidance for Performing Screening Level Risk Analyses at Combustion Facilities Burning Hazardous Wastes*, Draft, U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, December 14.

Table E-5. Intake calculations (mg/day) for child resident.

Chemical	I_{soil}	I_{ag}	I_{dw}	I_{total}
Antimony	1.21E-14	3.82E-14	0.00E+00	5.03E-14
Arsenic	6.48E-18	2.38E-18	0.00E+00	8.86E-18
Barium	4.53E-17	4.31E-17	0.00E+00	8.84E-17
Benzo(a)pyrene	6.59E-09	1.02E-09	0.00E+00	7.61E-09
Beryllium	1.89E-13	2.56E-14	0.00E+00	2.15E-13
Cadmium	6.70E-16	7.77E-16	0.00E+00	1.45E-15
Chromium VI	3.01E-17	2.15E-16	0.00E+00	2.46E-16
1,3-dinitrobenzene(PIC)	9.78E-07	3.24E-05	0.00E+00	3.34E-05
2,4-dinitrotoluene	9.29E-11	1.57E-09	0.00E+00	1.66E-09
2,4-dinitrotoluene(PIC)	3.04E-06	5.13E-05	0.00E+00	5.44E-05
2,6-dinitrotoluene(PIC)	3.62E-06	7.25E-05	0.00E+00	7.61E-05
Di(n)octyl phthalate	1.50E-10	8.43E-11	0.00E+00	2.34E-10
2,3,78-TCDD	3.06E-13	1.51E-14	0.00E+00	3.21E-13
Lead	1.82E-12	2.18E-13	0.00E+00	2.04E-12
Mercury	1.83E-08	8.91E-10	0.00E+00	1.92E-08
Nickel	2.49E-16	4.04E-17	0.00E+00	2.89E-16
Nitrobenzene(PIC)	2.98E-08	6.34E-07	0.00E+00	6.64E-07
Pentachloronitrobenzene(PIC)	1.52E-09	7.91E-10	0.00E+00	2.31E-09
Pentachlorophenol	4.73E-10	1.39E-10	0.00E+00	6.11E-10
Selenium	6.36E-13	6.47E-13	0.00E+00	1.28E-12
Silver	5.75E-20	6.66E-19	0.00E+00	7.23E-19
Thallium	3.32E-12	4.59E-12	0.00E+00	7.91E-12

Appendix F

Risk Characterization Calculations

Table F-1. Excess cancer risk (per chemical) for subsistence farmer from indirect exposure.

Equation

$$Cancer\ Risk_i = \frac{I * ED * EF * CSF}{BW * AT * 365}$$

Parameter	**Definition**	**Value**
Cancer Risk$_i$	Individual lifetime cancer risk from chemical i (unitless)	(Table F-31)
I	Total daily intake of chemical (mg/day)	Calculated (Appendix C)
ED	Exposure duration (year)	40
EF	Exposure frequency (day/year)	350
CSF	Oral cancer slope factor (per mg/kg-day)	Chemical-specific (Appendix B)
BW	Body weight (kg)	70
AT	Averaging time (year)	70
365	Unit conversion factor (day/year)	

Chemicals

Arsenic Beryllium Benzo(a)pyrene toxicity equivalents Bis (2-ethylhexyl) phthalate Hexachlorobenzene	Total polychlorinated biphenyls (PCBs) Pentachloronitrobenzene Pentachlorophenol 2,3,7,8-TCDD toxicity equivalents

Source: EPA, 1994, *Guidance for Performing Screening Level Risk Analyses at Combustion Facilities Burning Hazardous Wastes*, Draft, U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, December 14.

Table F-2. Total excess cancer risk for subsistence farmer from indirect exposure.

Equation

$$Total\ Cancer\ Risk = \sum_i Cancer\ Risk_i$$

Parameter	Definition	Value
Total Cancer Risk	Total individual lifetime cancer risk for all chemicals (unitless)	(Table F-31)
Cancer Risk$_i$	Individual lifetime cancer risk for chemical carcinogen i (unitless)	Calculated (Table F-31)

Chemicals	
Arsenic Beryllium Benzo(a)pyrene toxicity equivalents Bis (2-ethylhexyl) phthalate Hexachlorobenzene	Total polychlorinated biphenyls (PCBs) Pentachloronitrobenzene Pentachlorophenol 2,3,7,8-TCDD toxicity equivalents

Table F-3. Excess cancer risk (per chemical) for subsistence farmer from direct exposure.

Equation

$$Cancer\ Risk(inh)_{i,j} = ADI(inh)_{i,j} * CSF(inh)_i$$

Parameter	Definition	Value
Cancer Risk(inh)$_{i,j}$	Excess lifetime cancer risk via inhalation (unitless) for chemical i in the subsistence-farmer exposure scenario	Table F-34
ADI(inh)$_{i,j}$	Average daily intake via inhalation (mg/kg-day) for chemical i in the subsitence-farmer exposure scenario	Appendix C
CSF(inh)$_i$	Inhalation carcinogenic slope factor (per mg/kg-day) for chemical *i*	Appendix B

Description

The excess lifetime individual cancer risk is calculated from the carcinogenic slope factor (CSF) and the average daily intake via inhalation (ADI).

Source: EPA, 1994, *Guidance for Performing Screening Level Risk Analyses at Combustion Facilities Burning Hazardous Wastes*, Draft, U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, December 14.

Table F-4. Total excess cancer risk for subsistence farmer from direct exposure.

Equation
$Total\ Cancer\ Risk(inh)_j = \sum_i Cancer\ Risk(inh)_{i,j}$

Parameter	Definition	Value
Total Cancer Risk(inh)$_j$	Total excess lifetime cancer risk via inhalation (unitless) for subsistence-farmer exposure scenario	Table F-34
Cancer Risk(inh)$_{ij}$	Excess lifetime cancer risk via inhalation (unitless) for chemical i in subsistence-farmer exposure scenario	Table F-34

Description
The total excess cancer risk from direct exposure is estimated by summing the lifetime cancer risk for all carcinogens via the inhalation route of exposure.

Table F-5. Total excess cancer risk for subsistence farmer.

Equation
$Total\ Excess\ Cancer\ Risk_j = Total\ Cancer\ Risk(inh)_j + Total\ Cancer\ Risk(oral)_j$

Parameter	Definition	Value
Total Excess Cancer Risk$_j$	Excess lifetime cancer risk via all routes (unitless) in the subsistence-farmer exposure scenario	Table F-31
Total Cancer Risk(inh)$_j$	Total excess lifetime risk via inhalation (unitless) in the subsistence-farmer exposure scenario	Table F-34
Total Cancer Risk(oral)$_j$	Total excess lifetime cancer risk via indirect (i.e., oral) exposures (unitless) in subsistence-farmer exposure scenario	Table F-31

Description
To determine the overall carcinogenic risk from all exposure pathways, both the direct (inhalation) and indirect (oral) exposure pathways, the total cancer risk for the direct pathway is added to the total cancer risk for the indirect pathway.

Source: EPA, 1994, *Guidance for Performing Screening Level Risk Analyses at Combustion Facilities Burning Hazardous Wastes*, Draft, U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, December 14.

Table F-6. Excess cancer risk (per chemical) for adult resident from indirect exposure.

Equation
$$Cancer\ Risk_i = \frac{I * ED * EF * CSF}{BW * AT * 365}$$

Parameter	Definition	Value
Cancer $Risk_i$	Individual lifetime cancer risk from chemical i (unitless)	Table F-31
I	Total daily intake of chemical (mg/day)	Calculated (Appendix D)
ED	Exposure duration (year)	30
EF	Exposure frequency (day/year)	350
CSF	Oral cancer slope factor (per mg/kg-day)	Chemical-specific (Appendix B)
BW	Body weight (kg)	70
AT	Averaging time (year)	70
365	Unit conversion factor (day/year)	

Chemicals	
Arsenic Beryllium Benzo(a)pyrene toxicity equivalents Bis (2-ethylhexyl) phthalate Hexachlorobenzene	Total polychlorinated biphenyls (PCBs) Pentachloronitrobenzene Pentachlorophenol 2,3,7,8-TCDD toxicity equivalents

Source: EPA, 1994, *Guidance for Performing Screening Level Risk Analyses at Combustion Facilities Burning Hazardous Wastes*, Draft, U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, December 14.

Table F-7. Total excess cancer risk for adult resident from indirect exposure.

Equation
$Total\ Cancer\ Risk = \sum_i Cancer\ Risk_i$

Parameter	Definition	Value
Total Cancer Risk	Total individual lifetime cancer risk for all chemicals (unitless)	Table F-31
Cancer Risk$_i$	Individual lifetime cancer risk for chemical carcinogen i (unitless)	Calculated (Table F-31)

Chemicals	
Arsenic Beryllium Benzo(a)pyrene toxicity equivalents Bis (2-ethylhexyl) phthalate Hexachlorobenzene	Total polychlorinated biphenyls (PCBs) Pentachloronitrobenzene Pentachlorophenol 2,3,7,8-TCDD toxicity equivalents

Table F-8. Excess cancer risk (per chemical) for adult resident from direct exposure.

Equation
$Cancer\ Risk(inh)_{i,j} = ADI(inh)_{i,j} * CSF(inh)_i$

Parameter	Definition	Value
Cancer Risk(inh)$_{i,j}$	Excess lifetime cancer risk via inhalation (unitless) for chemical i in the adult-resident exposure scenario	Table F-34
ADI(inh)$_{ij}$	Average daily intake via inhalation (mg/kg-day) for chemical i in the adult-resident exposure scenario	Appendix D
CSF(inh)$_i$	Inhalation carcinogenic slope factor (per mg/kg-day) for chemical *i*	Appendix B

Description
The excess lifetime individual cancer risk is calculated from the carcinogenic slope factor (CSF) and the average daily intake via inhalation (ADI).

Source: EPA, 1994, *Guidance for Performing Screening Level Risk Analyses at Combustion Facilities Burning Hazardous Wastes*, Draft, U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, December 14.

Table F-9. Total excess cancer risk for adult resident from direct exposure.

Equation
$$Total\ Cancer\ Risk(inh)_j = \sum_i Cancer\ Risk(inh)_{i,j}$$

Parameter	Definition	Value
Total Cancer Risk(inh)$_j$	Total excess lifetime cancer risk via inhalation (unitless) for adult-resident exposure scenario	Table F-34
Cancer Risk(inh)$_{i,j}$	Excess lifetime cancer risk via inhalation (unitless) for chemical i in adult-resident exposure scenario	Table F-34

Description
The direct cancer risk is estimated by summing the lifetime cancer risk for all chemicals that are carcinogens via the inhalation route of exposure.

Table F-10. Total excess cancer risk for adult resident.

Equation
$$Total\ Excess\ Cancer\ Risk_j = Total\ Cancer\ Risk(inh)_j + Total\ Cancer\ Risk(oral)_j$$

Parameter	Definition	Value
Total Excess Cancer Risk$_j$	Total excess lifetime cancer risk via all routes (unitless) in the adult-resident exposure scenario	Table F-31
Total Cancer Risk(inh)$_j$	Total excess lifetime cancer risk via inhalation (unitless) in the adult-resident exposure scenario	Table F-34
Total Cancer Risk(oral)$_j$	Total excess lifetime cancer risk via indirect (i.e., oral) exposures (unitless) in adult-resident exposure scenario	Table F-31

Description
To determine the overall carcinogenic risk from all exposure pathways, both the direct (inhalation) and indirect (oral) exposure pathways, the total cancer risk for the direct pathway is added to the total cancer risk for the indirect pathway.

Source: EPA, 1994, *Guidance for Performing Screening Level Risk Analyses at Combustion Facilities Burning Hazardous Wastes*, Draft, U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, December 14.

Table F-11. Excess cancer risk (per chemical) for child resident from indirect exposure.

Equation

$$Cancer\ Risk_i = \frac{I * ED * EF * CSF}{BW * AT * 365}$$

Parameter	Definition	Value
Cancer Risk$_i$	Individual lifetime cancer risk from chemical i (unitless)	Table F-31
I	Total daily intake of chemical (mg/day)	Calculated (Appendix E)
ED	Exposure duration (year)	6
EF	Exposure frequency (day/year)	350
CSF	Oral cancer slope factor (per mg/kg-day)	Chemical-specific (Appendix B)
BW	Body weight (kg)	15
AT	Averaging time (year)	70
365	Unit conversion factor (day/year)	

Chemicals

Arsenic
Beryllium
Benzo(a)pyrene toxicity equivalents
Bis (2-ethylhexyl) phthalate
Hexachlorobenzene
Total polychlorinated biphenyls (PCBs)
Pentachloronitrobenzene
Pentachlorophenol
2,3,7,8-TCDD toxicity equivalents

Source: EPA, 1994, *Guidance for Performing Screening Level Risk Analyses at Combustion Facilities Burning Hazardous Wastes*, Draft, U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, December 14.

Table F-12. Total excess cancer risk for child resident from indirect exposure.

Equation
$Total\ Cancer\ Risk = \sum_{i} Cancer\ Risk_i$

Parameter	Definition	Value
Total Cancer Risk	Total individual lifetime cancer risk for all chemicals (unitless)	Table F-31
Cancer Risk$_i$	Individual lifetime cancer risk for chemical carcinogen i (unitless)	Calculated (Table F-31)

Chemicals	
Arsenic Beryllium Benzo(a)pyrene toxicity equivalents Bis (2-ethylhexyl) phthalate Hexachlorobenzene	Total polychlorinated biphenyls (PCBs) Pentachloronitrobenzene Pentachlorophenol 2,3,7,8-TCDD toxicity equivalents

Table F-13. Excess cancer risk (per chemical) for child resident from direct exposure.

Equation
$Cancer\ Risk(inh)_{i,j} = ADI(inh)_{i,j} * CSF(inh)_i$

Parameter	Definition	Value
Cancer Risk(inh)$_{i,j}$	Excess lifetime cancer risk via inhalation (unitless) for chemical i in the child-resident scenario	Table F-34
ADI (inh)$_{i,j}$	Average daily intake via inhalation (mg/kg-day) for chemical i in the child-resident exposure scenario	Appendix E
CSF(inh)$_i$	Inhalation carcinogenic slope factor (per mg/kg-day) for chemical *i*	Appendix B

Description
The excess lifetime individual cancer risk is calculated from the carcinogenic slope factor (CSF) and the average daily intake via inhalation (ADI).

Source: EPA, 1994, *Guidance for Performing Screening Level Risk Analyses at Combustion Facilities Burning Hazardous Wastes*, Draft, U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, December 14.

Table F-14. Total excess cancer risk for child resident from direct exposure.

Equation
$Total\ Cancer\ Risk(inh)_j = \sum_i Cancer\ Risk(inh)_{i,j}$

Parameter	Definition	Value
Total Cancer Risk(inh)$_j$	Total excess lifetime cancer risk via inhalation (unitless) for child-resident exposure scenario	Table F-34
Cancer Risk(inh)$_{i,j}$	Excess lifetime cancer risk via inhalation (unitless) for chemical i in child-resident exposure scenario	Table F-34

Description
The total excess cancer risk from direct exposure is estimated by summing the lifetime cancer risk for all carcinogens via the inhalation route of exposure.

Table F-15. Total excess cancer risk for child resident.

Equation
$Total\ Excess\ Cancer\ Risk_j = Total\ Cancer\ Risk(inh)_j + Total\ Cancer\ Risk(oral)_j$

Parameter	Definition	Value
Total Excess Cancer Risk$_j$	Total excess lifetime cancer risk via all routes (unitless) in the child-resident exposure scenario	Table F-31
Total Cancer Risk(inh)$_j$	Total excess lifetime cancer risk via inhalation (unitless) in the child-resident scenario	Table F-34
Total Cancer Risk(oral)$_j$	Total excess lifetime cancer risk via indirect (i.e., oral) exposures (unitless) in the child-resident exposure scenario	Table F-31

Description
To determine the overall carcinogenic risk from all exposure pathways, both the direct (inhalation) and indirect (oral) exposure pathways, the total cancer risk for the direct pathway is added to the total cancer risk for the indirect pathway.

Source: EPA, 1994, *Guidance for Performing Screening Level Risk Analyses at Combustion Facilities Burning Hazardous Wastes*, Draft, U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, December 14.

Table F-16. Hazard quotient for individual chemicals for subsistence farmer from noncarcinogens (indirect exposure).

Equation

$$HQ = \frac{I}{BW * RfD}$$

Parameter	Definition	Value
HQ	Hazard quotient (unitless)	Table F-32
I	Total daily intake of chemical (mg/day)	Calculated (Appendix C)
BW	Body weight (kg)	70
RfD	Reference dose (mg/kg-day)	Chemical-specific (Appendix B)

Chemicals

- Arsenic
- Beryllium
- Bis (2-ethylhexyl) phthalate
- 1,3-dinitrobenzene
- 2,4-dinitrobenzene
- 2,6-dinitrobenzene
- Di(n)octyl phthalate
- Hexachlorobenzene
- Mercury
- Nitrobenzene
- Pentachloronitrobenzene
- Pentachlorophenol
- Antimony
- Barium
- Cadmium
- Chromium
- Nickel
- Thallium
- Silver
- Selenium

Source: EPA, 1994, *Guidance for Performing Screening Level Risk Analyses at Combustion Facilities Burning Hazardous Wastes*, Draft, U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, December 14.

Table F-17. Hazard index for liver effects for subsistence farmer from noncarcinogens.

Equation
$HI_{liver} = \sum_i HQ_i$

Parameter	Definition	Value
HI_{liver}	Hazard index for liver effects (unitless)	Table F-33
HQ_i	Hazard quotient for chemical i with liver effects (unitless)	Calculated (Table F-33)

Chemicals	
Bis (2-ethlyhexyl) phthalate Di(n)octylphthalate	Hexachlorobenzene Pentachloronitrobenzene Pentachlorophenol

Table F-18. Hazard index for neurotoxic effects for subsistence farmer from noncarcinogens.

Equation
$HI_{neurotoxic} = \sum_i HQ_i$

Parameter	Definition	Value
$Hi_{neurotoxic}$	Hazard index for neurotoxic effects (unitless)	Table F-33
Hq_i	Hazard quotient for chemical i with neurotoxic effects (unitless)	Calculated (Table F-33)

Chemicals
2,4-dinitrotoluene 2,6-dinitrotoluene Mercury

Source: EPA, 1994, *Guidance for Performing Screening Level Risk Analyses at Combustion Facilities Burning Hazardous Wastes*, Draft, U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, December 14.

Table F-19. Hazard quotient for individual chemicals for subsistence farmer from noncarcinogens (direct exposure).

Equation
$HQ(inh)_{i,j} = \frac{C(air)_{i,j} * 0.001}{RFC_i}$

Parameter	Definition	Value
$HQ(inh)_{ij}$	Hazard quotient via inhalation (unitless) for chemical i in the subsistence-farmer exposure scenario	Table F-35
$C(air)_{ij}$	Concentration in air (µg/m^3, from ISC3) for chemical i in the subsistence-farmer exposure scenario	Appendix A
RFC_i	Reference concentration (mg/m^3) for chemical i	Appendix B
0.001	Units conversion factor (mg/µg)	

Description
The hazard quotient for inhalation exposures to chemicals with noncancer health effects is calculated for each exposure scenario.

Table F-20. Hazard index for subsistence farmer from noncarcinogens

Equation
$HI(inh)_{j,k} = \sum_i HQ(inh)i,j,k$

Parameter	Definition	Value
$HI(inh)_{j,k}$	Hazard index via inhalation (unitless) for target organ k in the subsistence-farmer exposure scenario	Table F-35
$HQ(inh)_{i,j,k}$	Hazard quotient via inhalation (unitless) for target organ k for chemical in the subsistence-farmer exposure scenario	Table F-35

Description
For the screening analysis, hazard quotients for inhalation exposures to chemicals that affect the same target organ are added together to obtain a hazard index for the target organ. The hazard quotients affecting the same organ are summed to obtain the hazard index for each exposure scenario.

Source: EPA, 1994, *Guidance for Performing Screening Level Risk Analyses at Combustion Facilities Burning Hazardous Wastes*, Draft, U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, December 14.

Table F-21. Hazard quotient for individual chemicals for adult resident from noncarcinogens (indirect exposure).

Equation

$$HQ = \frac{I}{BW * RfD}$$

Parameter	Definition	Value
HQ	Hazard quotient (unitless)	Table F-32
I	Total daily intake of chemical (mg/day)	Calculated (Appendix D)
BW	Body weight (kg)	70
RfD	Reference dose (mg/kg-day)	Chemical-specific (Appendix B)

Chemicals

Arsenic
Beryllium
Bis (2-ethylhexyl) phthalate
1,3-dinitrobenzene
2,4-dinitrobenzene
2,6-dinitrobenzene
Di(n)octyl phthalate
Hexachlorobenzene
Mercury
Nitrobenzene
Pentachloronitrobenzene
Pentachlorophenol
Antimony
Barium
Cadmium
Chromium
Nickel
Thallium
Silver
Selenium

Source: EPA, 1994, *Guidance for Performing Screening Level Risk Analyses at Combustion Facilities Burning Hazardous Wastes*, Draft, U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, December 14.

Table F-22. Hazard index for liver effects for adult resident from noncarcinogens.

Equation

$$HI_{liver} = \sum_{i} HQ_i$$

Parameter	Definition	Value
HI_{liver}	Hazard index for liver effects (unitless)	Table F-33
HQ_i	Hazard quotient for chemical i with liver effects (unitless)	Calculated (Table F-33)

Chemicals	
Bis (2-ethlyhexyl) phthalate Di(n)octylphthalate	Hexachlorobenzene Pentachloronitrobenzene Pentachlorophenol

Table F-23. Hazard index for neurotoxic effects for adult-resident from noncarcinogens.

Equation

$$HI_{neurotoxic} = \sum_{i} HQ_i$$

Parameter	Definition	Value
$HI_{neurotoxic}$	Hazard index for neurotoxic effects (unitless)	(Table F-33)
HQ_i	Hazard quotient for chemical i with neurotoxic effects (unitless)	Calculated (Table F-33)

Chemicals
2,4-dinitrotoluene 2,6-dinitrotoluene Mercury

Source: EPA, 1994, *Guidance for Performing Screening Level Risk Analyses at Combustion Facilities Burning Hazardous Wastes*, Draft, U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, December 14.

Table F-24. Hazard quotient for adult resident from noncarcinogens (direct exposure).

Equation

$$HQ(inh)_{i,j} = \frac{C(air)_{i,j} * 0.001}{RFC_i}$$

Parameter	Definition	Value
$HQ(inh)_{i,j}$	Hazard quotient via inhalation (unitless) for chemical i in the adult resident exposure scenario	(Table F-35)
$C(air)_{i,j}$	Concentration in air ($\mu g/m^3$, from ISC3) for chemical i in the adult resident exposure scenario	(Appendix A)
RFC_i	Reference concentration (mg/m^3) for chemical i	(Appendix B)
0.001	Units conversion factor (mg/μg)	

Description

The hazard quotient for inhalation exposures to chemicals with noncancer health effects is calculated for each exposure scenario.

Table F-25. Hazard index for adult resident from noncarcinogens.

Equation

$$HI(inh)_{j,k} = \sum_i HQ(inh)_{i,j,k}$$

Parameter	Definition	Value
$HI(inh)_{j,k}$	Hazard index via inhalation (unitless) for target organ k in the adult-resident exposure scenario	Table F-35
$HQ(inh)_{i,j,k}$	Hazard quotient via inhalation (unitless) for target organ k for chemical in the adult-resident exposure scenario	Table F-35

Description

For the screening analysis, the hazard quotients for inhalation exposures to chemicals that affect the same target organ are added together to obtain a hazard index for the target organ. The hazard quotients affecting the same organ are summed to obtain the hazard index for each exposure scenario.

Source: EPA, 1994, *Guidance for Performing Screening Level Risk Analyses at Combustion Facilities Burning Hazardous Wastes*, Draft, U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, December 14.

Table F-26. Hazard quotient for child resident from noncarcinogens (indirect exposure)

Equation

$$HQ = \frac{I}{BW * RfD}$$

Parameter	Definition	Value
HQ	Hazard quotient (unitless)	(Table F-32)
I	Total daily intake of chemical (mg/day)	Calculated
BW	Body weight (kg)	15
RfD	Reference dose (mg/kg-day)	Chemical-specific (Appendix B)

Chemicals

Arsenic
Beryllium
Bis (2-ethylhexyl) phthalate
1,3-dinitrobenzene
2,4-dinitrobenzene
2,6-dinitrobenzene
Di(n)octyl phthalate
Hexachlorobenzene
Mercury
Nitrobenzene
Pentachloronitrobenzene
Pentachlorophenol
Antimony
Barium
Cadmium
Chromium
Nickel
Thallium
Silver
Selenium

Source: EPA, 1994, *Guidance for Performing Screening Level Risk Analyses at Combustion Facilities Burning Hazardous Wastes*, Draft, U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, December 14.

Table F-27. Hazard index for liver effects for child resident from noncarcinogens.

Equation
$$HI_{liver} = \sum_{i} HQ_i$$

Parameter	Definition	Value
HI_{liver}	Hazard index for liver effects (unitless)	(Table F-33)
HQ_i	Hazard quotient for chemical i with liver effects (unitless)	Calculated (Table F-33)

Chemicals	
Bis (2-ethlyhexyl) phthalate Di(n)octylphthalate	Hexachlorobenzene Pentachloronitrobenzene Pentachlorophenol

Table F-28. Hazard index for neurotoxic effects for child resident from noncarcinogens.

Equation
$$HI_{neurotoxic} = \sum_{i} HQ_i$$

Parameter	Definition	Value
$HI_{neurotoxic}$	Hazard index for neurotoxic effects (unitless)	Table F-33
HQ_i	Hazard quotient for chemical i with neurotoxic effects (unitless)	Table F-33

Chemicals
2,4-dinitrotoluene 2,6-dinitrotoluene Mercury

Source: EPA, 1994, *Guidance for Performing Screening Level Risk Analyses at Combustion Facilities Burning Hazardous Wastes*, Draft, U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, December 14.

Table F-29. Hazard quotient for child resident from noncarcinogens (direct exposure).

Equation

$$HQ(inh)_{i,j} = \frac{C(air)_{i,j} * 0.001}{RFC_i}$$

Parameter	Definition	Value
$HQ(inh)_{ij}$	Hazard quotient via inhalation (unitless) for chemical i in the child resident exposure scenario	Table F-35
$C(air)_{ij}$	Concentration in air ($\mu g/m^3$, from ISC3) for chemical i in the child resident exposure scenario	Appendix A
RFC_i	Reference concentration (mg/m^3) for chemical i	Appendix B
0.001	Units conversion factor ($mg/\mu g$)	

Description

The hazard quotient for inhalation exposures to chemicals with noncancer health effects is calculated for each exposure scenario.

Table F-30. Hazard index for child resident from noncarcinogens.

Equation

$$HI(inh)_{j,k} = \sum_i HQ(inh)i, j, k$$

Parameter	Definition	Value
$HI(inh)_{j,k}$	Hazard index via inhalation (unitless) for target organ k in the child resident exposure scenario	(Table F-36)
$HQ(inh)_{i,j,k}$	Hazard quotient via inhalation (unitless) for target organ k for chemical in the child resident exposure scenario	(Table F-36)

Description

For the screening analysis, the hazard quotients for inhalation exposures to chemicals that affect the same target organ are added together to obtain a hazard index for target organ. This is done for each exposure scenario.

Source: EPA, 1994, *Guidance for Performing Screening Level Risk Analyses at Combustion Facilities Burning Hazardous Wastes*, Draft, U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, December 14.

Table F-31. Indirect exposure excess cancer risk.

Chemical	Subsistence-Farmer Cancer Risk	Adult-Resident Cancer Risk	Child-Resident Cancer Risk
Arsenic	1E-17	8E-20	7E-20
Benzo(a)pyrene	1E-08	3E-11	7E-11
Beryllium	3E-14	3E-15	5E-15
Coplaner PCBs	9E-12	3E-13	1E-12
2,3,7,8-TCDD	2E-08	8E-11	4E-10
Pentachloronitrobenzene(PIC)	1E-11	3E-12	3E-12
Pentachlorophenol	3E-12	2E-13	4E-13
Total indirect cancer risk	**3E-08**	**1E-10**	**5E-10**
Total inhalation risk (see Table F-34)	**2E-07**	**2E-07**	**2E-07**
Total excess cancer risk	**2E-07**	**2E-07**	**2E-07**

Table F-32. Indirect exposure hazard quotients.

Chemical	Subsistence-Farmer Hazard Quotient	Adult-Resident Hazard Quotient	Child-Resident Hazard Quotient
Antimony	6E-11	6E-12	9E-12
Arsenic	4E-14	4E-16	2E-15
Barium	8E-17	2E-17	8E-17
Beryllium	2E-12	3E-13	3E-12
Cadmium	2E-12	2E-14	1E-13
Chromium VI	1E-14	1E-15	3E-15
1,3-dinitrobenzene(PIC)	2E-03	7E-04	3E-03
2,4-dinitrotoluene(PIC)	1E-04	4E-05	2E-04
2,6-dinitrotoluene(PIC)	2E-04	7E-05	3E-04
Di(n)octyl phthalate	1E-09	4E-10	8E-10
Mercury	3E-04	3E-07	4E-06
Nickel	2E-15	5E-16	5E-15
Nitrobenzene(PIC)	9E-05	3E-05	9E-05
Pentachloronitrobenzene(PIC)	3E-08	8E-09	5E-08
Pentachlorophenol	1E-09	2E-10	1E-09
Selenium	2E-09	1E-11	2E-11
Silver	5E-15	9E-18	1E-17
Thallium	8E-08	1E-09	7E-09
Total Hazard Index[a]	**0.002**	**0.0007**	**0.003**

a. The total hazard index is irrespective of specific toxic effects (i.e., liver or neurotoxin). Also, the total hazard index only includes the nitroaromatic PIC with the highest hazard quotient (1,3-dinitrobenzene).

Table F-33. Indirect exposure hazard quotient and hazard index for chemicals with liver or neurotoxin effects.

	Subsistence-Farmer HQ		Adult-Resident HQ		Child-Resident HQ	
Chemical	Liver	Neurotoxin	Liver	Neurotoxin	Liver	Neurotoxin
2,4-Dinitrotoluene		6E-08		2E-08		6E-08
2,6-Dinitrotoluene(PIC)		5E-03		2E-03		5E-03
Di(n)octyl phthalate	1E-09		4E-10		8E-10	
Mercury		3E-04		3E-07		4E-06
Pentachloronitrobenzene(PIC)	3E-08		8E-09		5E-08	
Pentachlorophenol	1E-09		2E-10		1E-09	
Total Hazard Index	**3E-08**	**5E-03**	**9E-09**	**2E-03**	**5E-08**	**5E-03**

Table F-34. Cancer risk estimates for inhalation route of exposure at the INEEL boundary.

	Air Conc. (ug/m^3)	URF	Inhala Cancer risk
Aniline	8.45E-06	1.63E-06	1E-11
Arsenic	7.33E-14	4.30E-03	3E-16
Benzene	5.21E-08	7.80E-06	4E-13
Benzo(a)pyrene	1.04E-07	8.86E-04	9E-11
Beryllium	9.94E-10	2.40E-03	2E-12
Bromoform	5.21E-08	1.10E-06	6E-14
Cadmium	1.55E-12	1.80E-03	3E-15
Carbon tetrachloride	5.21E-08	1.50E-05	8E-13
Chloroform	5.21E-08	2.30E-05	1E-12
Chromium	5.53E-13	1.20E-02	7E-15
1,2-Dichloroethane	5.21E-08	2.60E-05	1E-12
1,4-Dioxane	3.91E-05	3.14E-06	1E-10
Formaldehyde	4.53E-08	1.30E-05	6E-13
2,3,7,8-TCDD	6.83E-12	3.43E+01	2E-10
Hydrazine	1.77E-06	4.90E-03	9E-09
(Iso)thiourea	2.20E-07	5.56E-04	1E-10
Methylene chloride	5.21E-08	4.70E-07	2E-14
Nickel	5.30E-13	2.40E-04	1E-16
Pentachloronitrobenzene(PIC)	2.49E-03	7.43E-05	2E-07
Pentachlorophenol	1.04E-07	3.43E-05	4E-12
Tetrachloroethylene	5.21E-08	3.14E-05	2E-12
1,1,2-Trichloroethane	5.21E-08	1.60E-05	8E-13
Total Cancer Risk			**2E-07**

Table F-35. Noncarcinogenic hazard quotient estimates for inhalation exposure at INEEL boundary.

	Air Conc. (ug/m^3)	RfC (mg/m^3)	HQ
Acetonitrile	5.00E-07	5.00E-02	1E-08
Aniline	8.45E-06	1.00E-03	8E-06
Antimony	1.86E-09	2.50E-02	7E-11
Barium	4.35E-14	5.00E-04	9E-14
Benzene	5.21E-08	9.00E-03	6E-09
Beryllium	9.94E-10	2.00E-05	5E-08
Bromoform	5.21E-08	7.00E-02	7E-10
Butylbenzylphthalate	1.04E-09	7.00E-01	1E-12
Cadmium	1.55E-12	2.00E-04	8E-12
Carbon disulfide	4.14E-06	7.30E-01	6E-09
Carbon monoxide	1.90E+00	1.00E+01	2E-04
Carbon tetrachloride	5.21E-08	2.00E-03	3E-08
Chlorobenzene	5.21E-08	2.00E-02	3E-09
Chloroform	5.21E-08	3.01E-03	2E-08
Chromium	5.53E-13	1.02E-04	5E-12
Dibutylphthalate	1.04E-09	3.50E-01	3E-12
1,2-Dichloroethane	5.21E-08	1.02E-02	5E-09
Diethylphthalate	1.34E-08	2.80E+00	5E-12
1,3-Dinitrobenzene(PIC)	2.98E-02	3.50E-04	9E-02
2,4-Dinitrophenol	8.45E-07	7.00E-03	1E-07
2,4-Dinitrotoluene	9.88E-07	7.00E-03	1E-07
2,4-Dinitrotoluene(PIC)	3.23E-02	7.00E-03	5E-03
2,6-Dinitrotoluene(PIC)	3.23E-02	3.50E-03	9E-03
Di(n)octyl phthalate	1.04E-09	7.00E-02	1E-11
Ethylene glycol	6.52E-06	7.00E+00	9E-10
Formic acid	2.52E-06	7.00E+00	4E-10
Hydrogen chloride	5.61E-03	1.99E-02	3E-04
Hydrogen fluoride	3.19E-03	2.60E-02	1E-04
Lead	8.70E-10	1.50E-03	6E-10
Mercury	9.94E-05	3.00E-04	3E-04
Methyl ethyl ketone	1.77E-06	1.00E+00	2E-09
Methylene chloride	5.21E-08	3.00E+00	2E-11

Table F-35. (continued).

	Air Conc. (ug/m^3)	RfC (mg/m^3)	HQ
Naphthalene	1.04E-07	3.01E-03	3E-08
Nitric acid	8.64E-01	2.50E-01	3E-03
Nitrobenzene(PIC)	2.17E-02	2.00E-03	1E-02
Nitrogen dioxide	3.03E+00	3.50E+00	9E-04
Pentachloronitrobenzene(PIC)	2.49E-03	1.05E-02	2E-04
Pentachlorophenol	1.04E-07	1.05E-01	1E-09
Phenol	1.77E-06	2.10E+00	8E-10
Pyridine	1.51E-04	3.50E-03	4E-05
Selenium	4.72E-08	1.00E-02	5E-09
Silver	3.54E-14	5.00E-03	7E-15
Sulfur dioxide	1.42E-02	8.00E-02	2E-04
Tetrachloroethylene	5.21E-08	2.70E-01	2E-10
Thallium	1.55E-08	2.80E-04	6E-08
Toluene	5.21E-08	4.00E-01	1E-10
1,2,4-Trichlorobenzene	1.04E-07	2.00E-01	5E-10
1,1,1-Trichloroethane	5.21E-08	1.02E-01	5E-10
1,1,2-Trichloroethane	5.21E-08	1.40E-02	4E-09
Trichloroethylene	5.21E-08	2.10E-02	2E-09
Uranium	4.91E-13	1.00E-02	5E-14
Total Hazard Index[a]			0.09

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[a] Includes only the PIC with the highest HQ (1,3-dinitrobenzne).

Table F-36. Direct exposure (inhalation) hazard quotient and hazard index for chemicals with liver or neurotoxin effects.

	Subsistence-Farmer HQ		Adult-Resident HQ		Child-Resident HQ	
Chemical	Liver	Neurotoxin	Liver	Neurotoxin	Liver	Neurotoxin
2,4-Dinitrotoluene		1E-07		1E-07		1E-07
2,4-Dinitrotoluene (PIC)		4E-03		4E-03		4E-03
2,6-Dinitrotoluene (PIC)		9E-03		9E-03		9E-03
Di(n)octylphthalate	1E-11		1E-11		1E-11	
Mercury		3E-04		3E-04		3E-04
Pentachloronitrobenzene (PIC)	2E-04		2E-04		2E-04	
Pentachlorophenol	1E-09		1E-09		1E-09	
Total hazard index	**2E-04**	**1E-02**	**2E-04**	**1E-02**	**2E-04**	**1E-02**

Table F-37. Acute inhalation exposure to transient travelers on U.S. Highway 20.

Chemical	U.S. 20 Chemical Air Concentration (ug/m^3)	State of ID AAC/AACC or EPA 9 PRG (ug/m^3)		Ratio of air concentration to AAC/AACC or PRG
Acetonitrile	3.72E-06	3.35E+03		1.11E-09
Aniline	8.69E-06	1.40E-01		6.21E-05
Antimony	1.38E-08	2.50E+01		5.54E-10
Arsenic	7.54E-14	2.30E-04		3.28E-10
Barium	3.23E-13	2.50E+01		1.29E-14
Benzene	5.36E-08	1.20E-01		4.47E-07
Benzo(a)pyrene	1.07E-07	3.00E-04		3.58E-04
Beryllium	1.02E-09	4.20E-03		2.43E-07
Bromoform	3.87E-07	2.50E+02		1.55E-09
Butylbenzylphthalate	7.75E-09	7.30E+02	PRG	1.06E-11
Cadmium	1.60E-12	5.60E-04		2.85E-09
Carbon disulfide	3.07E-05	1.50E+03		2.05E-08
Carbon monoxide	1.41E+01	1.00E+04	NAAQS	1.41E-03
Carbon tetrachloride	5.36E-08	6.70E-02		8.00E-07
Chlorobenzene	3.87E-07	1.75E+04		2.21E-11
Chloroform	5.36E-08	4.30E-02		1.25E-06
Chromium	5.69E-13	8.30E-05		6.85E-09
Dibutylphthalate	7.75E-09	2.50E+02		3.10E-11
1,2-Dichloroethane	5.36E-08	2.00E+03		2.68E-11
Diethylphthalate	9.92E-08	2.50E+02		3.97E-10
1,3-Dinitrobenzene(PIC)	2.22E-01	5.00E+01		4.43E-03
2,4-Dinitrophenol	6.28E-06	7.30E+00	PRG	8.60E-07
2,4-Dinitrotoluene	7.34E-06	7.30E+00	PRG	1.01E-06
2,4-Dinitrotoluene(PIC)	2.40E-01	7.30E+00	PRG	3.29E-02
2,6-Dinitrotoluene(PIC)	3.32E-02	3.70E+00	PRG	8.98E-03
Di(n)octyl phthalate	7.75E-09	7.30E+01	PRG	1.06E-10
1,4-Dioxane	4.02E-05	7.10E-01		5.66E-05
Ethylene glycol	4.85E-05	6.35E+03		7.63E-09
Formaldehyde	4.66E-08	7.70E-02		6.05E-07
Formic acid	1.87E-05	4.70E+02		3.99E-08

Table F-37. (continued).

Chemical	U.S. 20 Chemical Air Concentration (ug/m^3)	State of ID AAC/AACC or EPA 9 PRG (ug/m^3)		Ratio of air concentration to AAC/AACC or PRG
2,3,7,8-TCDD	7.03E-12	2.20E-08		3.20E-04
Hydrazine	1.82E-06	3.40E-04		5.36E-03
Hydrogen chloride	4.17E-02	3.75E+02		1.11E-04
Hydrogen fluoride	2.37E-02	2.60E+01		9.12E-04
(Iso)thiourea	1.63E-06	1.80E-03		9.08E-04
Lead	6.46E-09	1.50E+00	NAAQS	4.31E-09
Mercury	7.38E-04	2.50E+00		2.95E-04
Methyl ethyl ketone	1.32E-05	2.95E+04		4.46E-10
Methylene chloride	5.36E-08	2.40E-01		2.23E-07
Naphthalene	7.75E-07	2.50E+04		3.10E-11
Nickel	5.45E-13	4.20E-03		1.30E-10
Nitric acid	6.42E+00	2.50E+02		2.57E-02
Nitrobenzene(PIC)	1.62E-01	2.50E+02		6.46E-04
Nitrogen dioxide	2.25E+01	1.00E+02		2.25E-01
Pentachloronitrobenzene(PIC)	1.85E-02	2.50E+01		7.38E-04
Pentachlorophenol	7.75E-07	2.50E+01		3.10E-08
Phenol	1.32E-05	9.50E+02		1.38E-08
Pyridine	1.12E-03	7.50E+02		1.50E-06
Selenium	3.51E-07	1.00E+01		3.51E-08
Silver	2.63E-13	5.00E+00		5.26E-14
Sulfur dioxide	1.06E-01	8.00E+01		1.32E-03
Tetrachloroethylene	5.36E-08	2.10E+00		2.55E-08
Thallium	1.15E-07	5.00E+00		2.31E-08
Toluene	3.87E-07	1.88E+04		2.07E-11
1,2,4-Trichlorobenzene	7.75E-07	1.85E+03		4.19E-10
1,1,1-Trichloroethane	3.87E-07	9.55E+04		4.05E-12
1,1,2-Trichloroethane	5.36E-08	6.20E-02		8.65E-07
Trichloroethylene	3.87E-07	1.35E+04		2.88E-11
Uranium	3.65E-12	1.00E+01		3.65E-13

Appendix G

WAG 5 Fauna and Functional Groups

Table G-1. Faunal functional groups and species potentially present in the NWCF assessment area..

Class	Functional Group	Taxonomic Name	Common Name	Distribution/ Status[a]	Abundance/ Sseason/stat[b]
Aves	AV121	*Carduelis pinus*	Pine siskin	f, d	S5, M3
		Carduelis tristis	American goldfinch	d, ss	M5
		Coccothraustes vespertinus	Evening grosbeak	d	S5, M3
		Bombycilla cedrorum	Cedar waxwing	f, d	S5,M3,W5
Aves	AV122	*Passer domesticus*	House sparrow	f, d	B2, M1, W3
		Selasphorus rufus	Rufous hummingbird	d	S3, M3
		Zenaida macroura	Mourning dove	sw	B1, M3, W5
		Chondestes grammacus	Lark sparrow	sw	S3, M5
		Plectrophenax nivalis	Snow bunting	g, ss	W5
		Leucosticte arctoa	Rosy finch	ss	M5, W5
		Carpodacus mexicanus	House finch	f, d	S3, M3
		Perdix perdix	Gray partridge	g, ss, f	R3
		Alectoris chukar	Chukar	g, ss	R3
		Dendragapus obscurus	Blue grouse	f	S6
		Centrocercus urophasianus	Sage grouse	ss, g, f	R2
		Eremophila alpestris	Horned lark	g, ss	R2
		Junco hyemalis	Dark-eyed junco	sw	M3
		Columba livia	Rock dove	sw	R2
Aves	AV132	*Porzana carolina*	Sora	w, f	B5, M5
Aves	AV210	*Contopus borealis*	Olive-sided flycatcher	d	S5, M5
		Empidonax difficilis	Western flycatcher	d	S5
		Myiarchus cinerascens	Ash-throated flycatcher	d	S5
		Tyrannus verticalis	Western kingbird	f, d, j	B3, M3
		Tyrannus tyrannus	Eastern kingbird	f, d, j	B3, M3
		Tachycineta bicolor	Tree swallow	d, j	B3, M3
		Tachycineta thalassina	Violet-green swallow	d, j	B4, M4
		Myadestes townsendi	Townsend's Solitaire	d	S5, M5
		Chordeiles minor	Common nighthawk	sw	B2, M3
		Aeronautes saxatalis	White-throated swift	d	S5
		Sayornis saya	Say's phoebe	ss, d, f, j	B3, M3
Aves	AV210A	*Stelgidopteryx serripennis*	Northern rough-winged swallow	d, j	B3, M3
		Riparia riparia	Bank swallow	d, j	B5, M3
		Hirundo pyrrhonota	Cliff swallow	d, j	B2, M2
		Hirundo rustica	Barn swallow	d, j	B2, M3
Aves	AV221	*Regulus calendula*	Ruby-crowned kinglet	d	M3, W6
		Sialia mexicana	Western bluebird	ss	S5, M5
		Bombycilla garrulus	Bohemian waxwing	f, d	S3, M2, W3
		Vireo gilvus	Warbling vireo	d	S5, M5

Table G-1. (continued).

Class	Functional Group	Taxonomic Name	Common Name	Distribution/ Status[a]	Abundance/ Sseason/stat[b]
		Dendroica petechia	Yellow warbler	d	B5, M3
		Dendroica coronata	Yellow-rumped warbler	d	S3, M3
		Dendroica townsendi	Townsend's warbler	d	M5
		Geothlypis trichas	Common yellowthroat	d	S5
		Wilsonia pusilla	Wilson's warbler	d	S5, M5
		Icteria virens	Yellow-breasted chat	d	S5
		Piranga ludoviciana	Western tanager	d	S3, M3
		Pheucticus melanocephalus	Black-headed grosbeak	sw	S5, M5
		Icterus galbula	Northern oriole	d	S3, M3
		Picoides pubescens	Downy woodpecker	d	B5, M5
		Colaptes auratus	Northern flicker	d	B3, M3
Aves	AV222	*Larus pipixcan*	Franklin's gull	w, ss	S3, M3
		Larus californicus	California gull	w, ss	S5, M3
		Sturnus vulgaris	European starling	sw	R3
		Troglodytes aedon	House wren	d	R3
		Sialia currucoides	Mountain bluebird	ss	S3, M3
		Turdus migratorius	American robin	sw	B2, M2
		Oreoscoptes montanus	Sage thrasher	ss	B2, M2
		Passerina amoena	Lazuli bunting	d	S5, M5
		Spizella passerina	Chipping sparrow	f, d, ss	M5
		Spizella breweri	Brewer's sparrow	ss	B2, M2
		Amphispiza bilineata	Black-throated sparrow	ss	S5, M5
		Amphispiza belli	Sage sparrow	ss	B2, M2
		Passerculus sandwichensis	Savannah sparrow	d, g	S5, M3
		Zonotrichia leucophrys	White-crowned sparrow	ss	M4
		Sturnella neglecta	Western meadowlark	g, ss	B2, M2, W3
		Euphagus cyanocephalus	Brewer's blackbird	sw	B2, M2, W5
		Molothrus ater	Brown-headed cowbird	ss	B3, M3
		Charadrius vociferus	Killdeer	sw	B2, M2
		Anthus spinoletta	Water pipit	ss	M5
		Pipilo chlorurus	Green-tailed towhee	ss	S3, M3
		Pipilo erythrophthalmus	Rufous-sided towhee	sw	S3, M3
		Pooecetes gramineus	Vesper sparrow	g, ss	B3, M3
		Calamospiza melanocorys	Lark bunting	ss	S5, M5
		Melospiza melodia	Song sparrow	d	S5, M3
Aves	AV222A	*Salpinctes obsoletus*	Rock wren	ss	B3, M3
		Catherpes mexicanus	Canyon wren	ss	S5, M5
Aves	AV232	*Agelaius phoeniceus*	Red-winged blackbird	w, ss	B3, M3
		Xanthocephalus	Yellow-headed blackbird	w, d	B4, M3

Table G-1. (continued).

Class	Functional Group	Taxonomic Name	Common Name	Distribution/ Status[a]	Abundance/ Sseason/stat[b]
		xanthocephalus			
Aves	AV310	*Accipiter striatus*	Sharp-shinned hawk	sw	S5, M5, W5
		Accipiter cooperii	Cooper's hawk	sw	S3, M5, W5
		Accipiter gentilis	Northern goshawk	sw	S5, M5, W5
		Falco columbarius	Merlin	sw	R5
		Falco peregrinus	Peregrine falcon	sw	S5, M5, W5
		Falco mexicanus	Prairie falcon	sw	R3
Aves	AV322	*Nyctea scandiaca*	Snowy owl	sw	W5
		Haliaeetus leucocephalus	Bald eagle	sw	M5, W3
		Falco sparverius	American kestrel	sw	B2, M2, W3
		Circus cyaneus	Northern harrier	sw	R2
		Buteo swainsoni	Swainson's hawk	sw	B3, M3, W5
		Buteo jamaicensis	Red-tailed hawk	sw	B3, M3, W5
		Buteo regalis	Ferruginous hawk	sw	B3, M3, W5
		Lanius excubitor	Northern shrike	sw	M3, W5
		Lanius ludovicianus	Loggerhead shrike	ss	B3
		Bubo virginianus	Great horned owl	sw	R3
		Asio otus	Long-eared owl	d	B4, M4
		Asio flammeus	Short-eared owl	ss, g	B3, M3
		Aegolius acadicus	Northern saw-whet owl	sw	S6, M6, W6
		Aquila chrysaetos	Golden eagle	sw	B3, M4, W2
		Cathartes aura	Turkey vulture	sw	S3, M3, W6
		Buteo lagopus	Rough-legged hawk	sw	S6, M2, W2
Aves	AV322A	*Athene cunicularia*	Burrowing owl	ss, g	B3, M3, W6
Aves	AV422	*Aphelocoma coerulescens*	Scrub jay	U	U
		Pica pica	Black-billed magpie	sw	R2
		Corvus brachyrhynchos	American crow	sw	R3
		Phasianus colchicus	Ring-necked pheasant	g, ss	R3
		Corvus corax	Common raven	sw	R3
		Larus argentatus	Herring gull	w, ss, g	S3, M3
Aves	AV432	*Larus delawarensis*	Ring-billed gull	w, ss, g	S3, M3
Mammalia	M121	*Erethizon dorsatum*	Porcupine	r, f	I4
Mammalia	M122	*Lepus townsendii*	White-tailed jackrabbit	sw, ss	R4
		Lepus californicus	Black-tailed jackrabbit	sw, ss	R1,R4 (cyclic)
		Reithrodontomys megalotis	Western harvest mouse	sw, ss, g	R2
		Cervus elaphus	Elk	sw	R4
		Odocoileus hemionus	Mule deer	sw, ss, g	R3
		Antilocapra americana	Pronghorn	sw, ss, f	R1
Mammalia	M122A	*Sylvilagus nuttallii*	Nuttall's cottontail	sw, ss, f	R2

Table G-1. (continued).

Class	Functional Group	Taxonomic Name	Common Name	Distribution/ Status[a]	Abundance/ Sseason/stat[b]
		Brachylagus idahoensis	Pygmy rabbit	ss, ro	R2
		Marmota flaviventris	Yellow-bellied marmot	sw, ro	R3
		Spermophilus townsendii	Townsend's ground squirrel	sw, ss, f	R2
		Perognathus parvus	Great basin pocket mouse	sw, ss	R3
		Dipodomys ordii	Ord's kangaroo rat	sw, ss, g	R2
		Neotoma cinerea	Bushy-tailed woodrat	sw, ro	R2
		Microtus montanus	Montane vole	sw, g, f	R1,R4 (cyclic)
		Lagurus curtatus	Sagebrush vole	ss	R3
Mammalia	M123	*Thomomys talpoides*	Northern pocket gopher	ss	R4
Mammalia	M210	*Lasiurus cinereus*	Hoary bat	d, j	U3
		Lasionycteris noctivagans	Silver-haired bat	sw	M4
Mammalia	M210A	*Myotis leibii*	Small-footed myotis	sw, ro	R2
		Eptesicus fuscus	Big-brown bat	sw, f, c	R3
		Plecotus townsendii	Townsend's western big-eared bat	sw, c	R2
		Myotis lucifugus	Little Brown myotis	sw, f	I2
		Myotis californicus	California myotis	sw	U2
Mammalia	M222	*Sorex merriami*	Merriam's shrew	sw, ss	R4
		Onychomys leucogaster	Northern grasshopper mouse	sw, ss	R4
Mammalia	M322	*Mustela frenata*	Long-tailed weasel	sw, ss	R2
		Taxidea taxus	Badger	sw	R3
		Felis rufus	Bobcat	sw, ss, j	R4
Mammalia	M422	*Tamias minimus*	Least chipmunk	sw, ss	R1
		Peromyscus maniculatus	Deer mouse	sw	R1
		Rattus norvegicus	Norway rat	NW/NE INEEL; ag	R5 (?)
		Mus musculus	House mouse	f	R5 (?)
		Spilogale gracilis	Western spotted skunk	sw, ro	R5
Mammalia	M422A	*Canis latrans*	Coyote	sw	R2
Reptilia	R222	*Phrynosoma douglasii*	Short-horned lizard	sw, ss	R1
		Sceloporus graciosus	Sagebrush lizard	sw, ss	R1
		Eumeces skiltonianus	Western skink	South INEEL	R5
Reptilia	R322	*Masticophis taeniatus*	Desert striped whipsnake	NE INEEL, ss	R3
		Pituophis melanoleucus	Gopher snake	sw, ss	R2
		Thamnophis elegans	Western garter snake	sw	R3
		Coluber constrictor	Western racer	sw	I5
		Crotalus viridis	Western rattlesnake	sw, ss	R2

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a.	w	On or near water
	ss	Shrub-steppe
	d	Deciduous or riparian
	j	Juniper woodland
	g	Grassland

Table G-1. (continued).

	Class	Functional Group	Taxonomic Name	Common Name	Distribution/ Status[a]	Abundance/ Sseason/stat[b]
	sw	Sitewide				
	f	Facility complexes				
	c	Cave				
	ro	rocky outcrop				
	U	Unknown				
	r	Riparian				
	ag	Agricultural area				
b.	1	Abundant—very numerous and certain to be seen or sampled				
	2	Common—likely but not certain to be observed or sampled				
	3	Uncommon—found in limited numbers, not likely to be sampled or observed				
	4	Occasional or local—a species that is not always present or is restricted in distribution				
	5	Rare—a species that has a range including all or part of INEEL, but has been documented ≤ seven times on INEEL				
	6	Vagrant or accidental—a species that is not expected to occur on INEEL, but has been recorded there				
	7	Possible occurrence—species for which sightings have been unverified or geographical range overlaps INEEL (and preferred habitat occurs on INEEL.				
	R	Breeder and year-round resident				
	B	Summer breeder				
	M	Migrant				
	I	Incidental species				
	W	Winter visitor				
	S	Summer visitor: no breeding records				
	U	Unknown				

Table G-2. Functional groups and species not included in the literature search or individually evaluated for the WAG 5 ERA.

Functional Group	Common Name	Habitat[a]	Abundance/ Seasons[b]	Regulatory Status[c]	Criteria for Exclusion
A232	Great basin spadefoot toad	w	R2		Geographic—aquatic, sinks, and spreading areas
	Boreal chorus frog	W	R4		Geographic—aquatic
	Western toad	w,d	U7		Incidental species
AV122	Black-chinned hummingbird	ag,d	U7		Possible but not recorded on INEEL
	Calliope hummingbird	ag,d	U7		Possible but not recorded on INEEL
	Sharp-tailed grouse	g, ss	I6		Incidental species
AV122	Broad-tailed hummingbird	ag,d	U7		Possible but not recorded on INEEL
	Blue grouse	F	S6		Vagrant species
AV142	Snow goose	W	M5		Geographic—on or near water
	Green-winged teal	W	S5, M5		Geographic—on or near water
	Redhead	W	S5, M5, W5		Geographic—on or near water
	Ring-necked duck	W	S5, M5		Geographic—on or near water
AV143	Tundra swan	W	M5		Geographic—on or near water
	Canada goose	W	S3, M3		Geographic—on or near water
	Mallard	W	B2, M2, W3		Geographic—on or near water
	Northern pintail	W	S3, M3		Geographic—on or near water
	Blue-winged teal	W	B2, M3		Geographic—on or near water
	Cinnamon teal	W	S3, M3		Geographic—on or near water
	Northern shoveler	W	B3, M3		Geographic—on or near water
	Gadwall	W	S3, M3		Geographic—on or near water
	American wigeon	W	S3, M3		Geographic—on or near water
	Canvasback	W	B5, M5		Geographic—on or near water
	Ross' goose	W	I6		Incidental species
	White-fronted goose	W	I6		Incidental species
AV210	Gray flycatcher	g,ss,j	U7		Incidental species
	Western wood-pewee	D	I6		Incidental species
	Willow flycatcher	D	U7		Incidental species
	Dusky flycatcher	D	U7		Incidental species
	Common poor-will	J	I6		Incidental species
AV221	Black-and-white warbler	U	I6		Incidental species
	Swainson's thrush	U	I6		Incidental species
	Blue-gray gnatcatcher	U	I6		Incidental species
	Red-naped sapsucker	U	I6		Incidental species
	Lewis' woodpecker	U	I6		Incidental species
	MacGillivray's warbler	U	I6		Incidental species
	Orange-crowned warbler	U	I6		Incidental species
	American redstart	F	M6		Vagrant species
	Mountain chickadee	d,j	U7		Incidental species

Table G-2. (continued).

Functional Group	Common Name	Habitat[a]	Abundance/ Seasons[b]	Regulatory Status[c]	Criteria for Exclusion
	Lapland longspur	g,ss	U7		Incidental species
	Hairy woodpecker	ag,d	U7		Incidental species
	Black-capped chickadee	d,j	U7		Incidental species
AV222	Varied thrush	Ss	W6		Vagrant species (winter)
	Flammulated owl		I6		Incidental species
	Harris' sparrow		I6		Incidental species
	Hermit thrush		I6		Incidental species
	Lincoln's sparrow		I6		Incidental species
	Northern mockingbird	J	S6		Geographical—juniper woodland habitat
	Lapland longspur	g,ss	I7		Incidental species
	Western sandpiper	W	I6		Incidental species
	Semipalmated plover	W	I6		Incidental species
AV232	Virginia rail	W	U7		Incidental species
	Marsh wren	W	U7		Incidental species
	Baird's sandpiper	W	I6		Incidental species
	Mountain plover	U	I6		Incidental species
	Orchard oriole	U	I6		Incidental species
	Spotted sandpiper	W	S3, M3		Geographic—on or near water
	Least sandpiper	W	S5, M5		Geographic—on or near water
AV233	Cattle egret	W	I6		Incidental species
	Black-necked stilt	W	I6		Incidental species
	Snowy egret	w	I6		Incidental species
	Solitary sandpiper	w	S5, M3		Geographic—on or near water
	Marbled godwit	w	S3, M5		Geographic—on or near water
	Long-billed dowitcher	w	M5		Geographic—on or near water
	Common snipe	w	S5, M5		Geographic—on or near water
	White-faced ibis	w	S5, M5		Geographic—on or near water
	Long-billed curlew	w	S3, M3		Geographic—on or near water
AV241	Wood duck	w	S6, M5		Geographic—on or near water
	Red-necked phalarope	w	M5		Geographic—on or near water
	Wilson's phalarope	w	S3, M3		Geographic—on or near water
AV242	Surf scoter	w	I6		Incidental species
	Barrow's goldeneye	w	S6, M5		Vagrant species
	Lesser scaup	w	S5, M3, W3		Geographic—on or near water
	Common goldeneye	w	S5, M3, W3		Geographic—on or near water
	Barrow's goldeneye	w	S6, M5		Geographic—on or near water
	Ruddy duck	w	B5, M3		Geographic—on or near water
	Lesser yellowlegs	w	S5, M5		Geographic—on or near water
	Bonaparte's gull	w	M5		Geographic—on or near water

Table G-2. (continued).

Functional Group	Common Name	Habitat[a]	Abundance/ Seasons[b]	Regulatory Status[c]	Criteria for Exclusion
	Bufflehead	w	S5, M3		Geographic—on or near water
	Pied-billed grebe	w	S5, M5		Geographic—on or near water
	Horned grebe	w	M5		Geographic—on or near water
	Eared grebe	w	B5, M3, W3		Geographic—on or near water
AV310	Gyrfalcon	sw	M6	SSC,S	Incidental species
AV322	Northern pygmy owl	d	U7	SSC	Incidental species
	Boreal owl		I6		Incidental species
	Western screech owl	d	U7		Incidental species
AV332	Northern saw-whet owl	sw	S6, M6, W6		Vagrant species
AV333	Green-backed heron	w	S6, M6		Vagrant species
AV342	Red-breasted merganser	w	I6		Incidental species
	Black-legged kittiwake	w	W6		Vagrant species (winter)
AV422	Hooded merganser	w	I6		Incidental species
	Double-crested cormorant	w	I6		Incidental species
	Blue jay	U	I6		Incidental species
	Clark's nutcracker	j	S4, M4, W5		Geographical—juniper woodland habitat
AV432	American avocet	w	S2, M3		Geographic—on or near water
AV433	Sandhill crane	U	I6		Incidental species
	Great egret	w	S5, M5		Geographic—on or near water
AV442	American coot	w	R3		Geographic—on or near water
M122	Moose	sw	T6		Transient species - Rare
	Mountain sheep	N INEEL	T6		Transient species - Rare
M132	Muskrat	w	S5,W5 (cyclic)		Geographical—aquatic habitat (Big Lost River)
	Beaver	w	R4,S,W		Geographical—aquatic habitat (Big Lost River)
M210	Yuma myotis	sw	U7		Incidental species
	Silver-haired bat	sw	U7		Incidental species
	Western pipistrelle	sw	U7	C2,SSC,S	Incidental species
	Fringed myotis	sw	U7	SSC	Incidental species
M210A	Long-legged myotis	sw	U7		Incidental species
	Pallid bat	sw	U7		Incidental species
M322	Mountain lion	sw	T6		Transient species—Rare
	Striped skunk	ag,d	U7		Incidental species
	Short-tailed weasel (ermine)	ag,d	U7		Incidental species
	Red fox	ag,d	U7		Incidental species
M422	Racoon	ag,d	U7		Incidental species
0242	Shorthead sculpin	w	R2		Geographical—aquatic species (Big Lost River)
0243	Mountain whitefish	w	R2		Geographical—aquatic species (Big Lost River)
	Speckled dace	w	R3		Geographical—aquatic species (Big Lost River)
	Cutthroat trout	w	U7		Geographical—aquatic species (Big Lost River)

Table G-2. (continued).

Functional Group	Common Name	Habitat[a]	Abundance/ Seasons[b]	Regulatory Status[c]	Criteria for Exclusion
0342	Rainbow trout	w	R2		Geographical—aquatic species (Big Lost River)
	Brook trout	w	R3		Geographical—aquatic species (Big Lost River)
	Utah chub	w	U7		Geographical—aquatic species (Big Lost River)
0442	Kokanee salmon	w	M3		Geographical—aquatic species (Big Lost River)
R222	Leopard lizard	NE INEEL	R4		Geographical—observations restricted to NE INEEL
R232	Tiger salamander	w	U7		Incidental species
R322	Rubber boa	U	I6		Incidental species
	Ringneck snake	sw	U7	NL,SSC	Incidental species
	Common garter Snake	sw	U7		Incidental species
	Night snake	sw	U7	S	Incidental species

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a. ag Agriculture
w On or near water
ss Shrub-steppe
d Deciduous or riparian
j Juniper woodland
g Grassland
sw Sitewide
f Facility complexes
U Unknown
r Riparian

b. 1 Abundant—very numerous and certain to be seen or sampled.
2 Common—likely but not certain to be observed or sampled.
3 Uncommon—found in limited numbers, not likely to be sampled or observed.
4 Occasional or local—a species that is not always present or is restricted in distribution.
5 Rare—a species that has a range including all or part of INEEL, but has been documented ≤ seven times on INEEL.
6 Vagrant or accidental—a species that is not expected to occur on INEEL, but has been recorded there.
7 Possible occurrence—species for which sightings have been verified or geographical range overlaps INEEL (and preferred habitat
R occurs on INEEL)
I Breeder and year-round resident.
M Incidental.
W Migrant.
S Winter visitor.
T Summer visitor—no breeding records.
U Transient.
Unknown

c. Species management codes for federal (FED) listing, Bureau of Land Management (BLM), U.S. Forest Service Region 4 (USFS), and Audubon Blue List (AUDBL): C2 = category 2 species; 3c = no longer considered for listing; E = endangered species; NL = not listed; SSC = species of special concern; T = threatened species; S = sensitive

COPC: **Antimony (Antimony Potassium Tartrate)** CAS 7440-36-0

Test Organisms: Mouse (Omnivore, Order-Rodentia)
Exposure Medium: Drinking water
Test Endpoint: LOAEL Apparent slight decrease in life span of female CD-1 mice (significance unknown)
Reference: Schroeder, H.A., M. Mitchner, and J.J. Balassa, 1968, *Zirconium, Niobium, Antimony and Fluorine in Mice: Effects of Growth Survival and Tissue Levels,* Journal of Nutrition, 95:95-101.
Kanisawa, M. and H.A. Schroeder, 1969, "Life term studies on the effect of trace elements on spontaneous tumor in mice and rats." Cancer Research, 29(4):892-895.
QCE: 1.25 mg/kg-day (5 mg/L water)(7.5 mL water/day)(1L/1000mL)/ 0.03 kg BW

Adjustment Factors (AF)				Justification for adjustment factor
R	1	2	3	R = 1 is AF for same order and trophic level R = 2 is AF for different order and same trophic level R = 3 is AF for different order and trophic level
I	1	1	1	Chronic toxicity studies with adequate numbers of animals.
Q_1	0.5	0.5	0.5	Endpoint could occur (lifespan, longevity), but of uncertain ecological significance
Q_2	1	1	1	Chronic study
Q_3	2	2	2	LOAEL endpoint
U	2	2	2	Large chronic study, but no reproductive endpoints examined.
M	0.5	0.5	0.5	Soluble salts in the drinking water were used
Total AF	1	2	3	$R * I * Q_1 * Q_2 * Q_3 * U * M$ = Total AF
QCE (mg/kg-day)	1.25	1.25	1.25	QCE = quantified critical endpoint
TRV	1.25	0.625	0.417	Toxicity Reference Value = QCE/Total AF

R Value	TRV (mg/kg-day)	Justification	Appropriate Functional Group
1	1.25	Test organism is in the same order and trophic level as the functional group members	none
2	0.625	Test organism is in a different order and same trophic level from the functional group members	M422, M422A
3	0.417	Test organism is in a different order and trophic level from the functional group members	M122, M122A, M121, M123, M132 M210, M210A, M222, M322

COPC: **Arsenic** CAS 7778-43-0

Test Organisms: Mallard (Herbivore, Order-Anseriformes)
Exposure Medium: Oral in diet (Arensic as sodium arsenite)
Test Endpoint: NOAEL
Reference: U.S. Fish and Wildlife Service. 1964. Pesticide-wildlife studies, 1963: a review of Fish and Wildlife Service investigations during the calendar year. FWS Circular 199.
QCE: 5.14 mg/kg-day ((51.35mg As/kg food)*(0.1 kg food/day))/(1kg BW)

Adjustment Factors (AF)				Justification for adjustment factor
R	1	2	3	Same trophic level but different order than members of functional groups
I	2	2	2	Reasonable number of animals tested
Q_1	1	1	1	Mortality, is ecologically relevant
Q_2	1	1	1	Chronic duration (over 128 days)
Q_3	1	1	1	NOAEL
U	2	2	2	Multiple doses (100, 250, 500, and 1000 ppm sodium arsenite) examined with both a NOAEL and a LOAEL established. However, no reproductive endpoints examined.
Total AF	4	8	12	R * I * Q_1 * Q_2 * Q_3 * U = Total AF
QCE (mg/kg-day)	5.14	5.14	5.14	QCE = quantified critical endpoint
TRV	1.29	0.64	0.43	Toxicity Reference Value = QCE/Total AF

R Value	TRV (mg/kg-day)	Justification	Appropriate Functional Group
1	1.29	Test organism is in the same order and trophic level as the functional group members	AV142, AV143
2	0.64	Test organism is in a different order and same trophic level from the functional group members	AV121, AV122, AV132
3	0.43	Test organism is in a different order and trophic level from the functional group members	AV210, AV210A, AV221, AV222, AV222A, AV232, AV233, AV241, AV242, AV310, AV322, AV333, AV342, AV422, AV432, AV433, AV442

COPC:	**Arsenic** CAS 7778-43-0
Test Organisms:	Rat (Omnivore, Order-Rodentia)
Exposure Medium:	Diet as sodium arsenate or sodium arsenite
Test Endpoint:	NOAEL
Reference:	Byron, W.R., et al., 1967, "Pathologic changes in rats and dogs from two-year feeding of sodium arsenite or sodium arsenate," *Toxicology and Applied Pharmacology*, 10:132-147.
QCE:	3.1mg/kg-day (62.5 mg/kg food)*(0.0189kg/day)/(0.382 kg BW)

Adjustment Factors (AF)				Justification for adjustment factor
R	1	2	3	Different trophic level and order than members of functional groups.
I	2	2	2	300 weanling rats. Data does not show a good dose-response curve low-dose range.
Q_1	1	1	1	Levels of 62.5 ppm arsenic as arsenite and 125 ppm arsenic as arsenate did not cause common bile duct enlargement and did not affect survival. Weight was slightly reduced in females at the 62.5 ppm arsenic as arsenite.
Q_2	1	1	1	Chronic study.
Q_3	1	1	1	NOAEL using lowest NOAEL from either arsenite or arsenate
U	2	2	2	Good overall design, but no reproductive studies in the two years.
Total AF	4	8	12	$R * I * Q_1 * Q_2 * Q_3 * U$ = Total AF
QCE (mg/kg-day)	3.1	3.1	3.1	QCE = quantified critical endpoint
TRV	0.78	0.39	0.26	Toxicity Reference Value = QCE/Total AF

R Value	TRV (mg/kg-day)	Justification	Appropriate Functional Group
1	0.78	Test organism is in the same order and trophic level as the functional group members	none
2	0.39	Test organism is in a different order and same trophic level from the functional group members	M422, M422A
3	0.27	Test organism is in a different order and trophic level from the functional group members	M122, M122A, M121, M123, M132 M210, M210A, M222, M322

COPC:	**Barium** CAS 7440-39-3
Test Organisms:	Rat (Omnivore, Order-Rodentia)
Exposure Medium:	Drinking water
Test Endpoint:	NOAEL
Reference:	Perry, H.M. et al. 1989, "Hypertension and associated cardiovascular abnormalities induced by chronic barium feeding," Journal of Toxicology and Environmental Health, 28(3):373-388. Kopp, S.J. et al. 1985, "Cardiovascular dysfunction and hypersensitivity to sodium pentobarbital induced by chronic barium chloride ingestion, Toxicology and Applied Pharmacology, 77(23):303-314.
QCE:	5.1 mg/kg-day (100 mg/L)*(0.022L/day)/0.435kg BW*

Adjustment Factors (AF)				Justification for adjustment factor
R	1	2	3	R = 1 is AF for same order and trophic level R = 2 is AF for different order and same trophic level R = 3 is AF for different order and trophic level
I	1	1	1	Chronic toxicity studies with adequate numbers of animals
Q_1	1	1	1	Although endpoint examined (increased blood pressure at higher doses) could occur in ecological receptors, the absence of any effects on growth and longevity at any dose argues against its ecological relevance. But at the NOAEL dose, no hypersensitivity was observed.
Q_2	1	1	1	Chronic study (16 months)
Q_3	1	1	1	NOAEL
U	1	1	1	Concordant results in several detailed studies
M	0.5	0.5	0.5	Soluble salt in the drinking water was used
Total AF	0.5	1.0	1.5	$R * I * Q_1 * Q_2 * Q_3 * U*M$ = Total AF
QCE (mg/kg-day)	5.1	5.1	5.1	QCE = quantified critical endpoint
TRV	10.2	5.1	3.4	Toxicity Reference Value = QCE/Total AF

R Value	TRV (mg/kg-day)	Justification	Appropriate Functional Group
1	10.2	Test organism is in the same order and trophic level as the functional group members	none
2	5.1	Test organism is in a different order and same trophic level from the functional group members	M422, M422A
3	3.4	Test organism is in a different order and trophic level from the functional group members	M121, M122, M122A, M132, M210, M210A, M222, M322

*BW given by an earlier Perry article, ingestion rate specified in the article

**note-10ppm had some adverse effects such as an increase in blood pressure and tissue concentration.

COPC: **Beryllium** (Beryllium sulfate) CAS 7440-41-7

Test Organisms: Rat (Omnivore, Order-Rodentia)
Exposure Medium: Drinking water
Test Endpoint: NOAEL
Reference: Schroeder, H.A., and M. Mitchner, 1975, *Life-Term Studies in Rats: Effects of Aluminum, Barium, Beryllium and Tungsten,* J. Nutr. 105: 421-427.
QCE: 0.66mg/kg-day (5mg/L water)*(0.046L/day)/0.35 kg BW

Adjustment Factors (AF)				Justification for adjustment factor
R	1	2	3	R = 1 is AF for same order and trophic level R = 2 is AF for different order and same trophic level R = 3 is AF for different order and trophic level
I	1	1	1	Chronic toxicity studies with adequate numbers of animals
Q_1	1	1	1	Ecologically relevant endpoint (life-span, growth).
Q_2	1	1	1	Chronic study
Q_3	1	1	1	NOAEL endpoint
U	2	2	2	Large chronic study, but no reproductive endpoints examined
M	0.5	0.5	0.5	Soluble salt in the drinking water used
Total AF	1	2	3	$R * I * Q_1 * Q_2 * Q_3 * U * M$ = Total AF
QCE (mg/kg-day)	0.66	0.66	0.66	QCE = quantified critical endpoint
TRV	0.66	0.33	0.22	Toxicity Reference Value = QCE/Total AF

R Value	TRV (mg/kg-day)	Justification	Appropriate Functional Group
1	0.66	Test organism is in the same order and trophic level as the functional group members	None
2	0.33	Test organism is in a different order and same trophic level from the functional group members	M422, M422A
3	0.22	Test organism is in a different order and trophic level from the functional group members	M121, M122, M122A, M132, M210, M210A, M222, M322

*Ingestion rate specified by EPA (EPA, 1985a).

COPC: **Cadmium** CAS 7440-43-9

Test Organisms: Black Duck (Herbivore, Order-Anseriformes)
Exposure Medium: Diet
Test Endpoint: LOAEL
Reference: Heinz, G.H. and Haseltine, S.D., 1983, "Altered Avoidance Behavior of Young Black Ducks Fed Cadmium". *Environ. Toxicol. Chem.* 2:419-421. As cited in Eisler, 1985.
QCE: 0.14 mg/kg-day (4 mg/kg)*(0.06 kg/day)/1.7 kg BW

Adjustment Factors (AF)				Justification for adjustment factor
R	1	2	3	R = 1 is AF for same order and trophic level R = 2 is AF for different order and same trophic level R = 3 is AF for different order and trophic level
I	1	1	1	Adequate numbers tested, males, females and juveniles given the doses.
Q_1	1	1	1	Ecologically relevant endpoint (behavior).
Q_2	1	1	1	Chronic (90-day) exposure
Q_3	2	2	2	LOAEL endpoint
U	2	2	2	Reproductive endpoints and sensitive life stage examined, but only data given was on the flight response of the juveniles.
M	0.5	0.5	0.5	Cadmium chloride in the feed
Total AF	2	4	6	$R * I * Q_1 * Q_2 * Q_3 * U * M$ = Total AF
QCE (mg/kg-day)	0.14	0.14	0.14	QCE = quantified critical endpoint
TRV	0.07	0.04	0.2	Toxicity Reference Value = QCE/Total AF

R Value	TRV (mg/kg-day)	Justification	Appropriate Functional Group
1	0.07	Test organism is in the same order and trophic level as the functional group members	AV142, AV143
2	0.04	Test organism is in a different order and same trophic level from the functional group members	AV121, AV122, AV132
3	0.02	Test organism is in a different order and trophic level from the functional group members	AV210, AV210A, AV221, AV222, AV222A, AV232, AV233, AV242, AV310, AV322, AV333, AV342, AV422, AV432, AV433, AV442

COPC:	**Cadmium** CAS 7440-43-9
Test Organisms:	Rat (Omnivore, Order-Rodentia)
Exposure Medium:	Diet
Test Endpoint:	LOAEL
Reference:	Wills, J.H., Groblewski, G.E., Coulston, F., 1981, *Chronic and Multigeneration Toxicities of Small Concentrations of Cadmium in the Diet of Rats,* Ecotoxicol. Environ. Safety. 5:452-464. ATSDR, Agency for Toxic Substance Disease Registry, 1989, *Toxicological Profile for Cadmium,* March, 1989.
QCE:	5.5 E-3 mg/kg-day Specified

Adjustment Factors (AF)				Justification for adjustment factor
R	1	2	3	R = 1 is AF for same order and trophic level R = 2 is AF for different order and same trophic level R = 3 is AF for different order and trophic level
I	1	1	1	Adequate numbers of males females and juveniles tested.
Q_1	1	1	1	Ecologically relevant endpoint (growth, mortality).
Q_2	1	1	1	Chronic study
Q_3	2	2	2	LOAEL
U	1	1	1	Excellent design, four-generational study.
Total AF	2	4	6	$R * I * Q_1 * Q_2 * Q_3 * U$ = Total AF
QCE (mg/kg-day)	5.5E-3	5.5E-3	5.5E-3	QCE = quantified critical endpoint
TRV	3E-3	1E-3	8E-4	Toxicity Reference Value = QCE/Total AF

R Value	TRV (mg/kg-day)	Justification	Appropriate Functional Group
1	3E-3	Test organism is in the same order and trophic level as the functional group members	none
2	1E-3	Test organism is in a different order and same trophic level from the functional group members	M422, M422A
3	8E-4	Test organism is in a different order and trophic level from the functional group members	M121, M122, M122A, M132, M210, M210A, M222, M322

COPC: **Chromium (III)** CAS 7440-47-3

Test Organisms: Chicken (Omnivore, Order-Galliformes)
Exposure Medium: Diet
Test Endpoint: NOAEL
Reference: Romoser, G.L., W.A. Dudley, L.J. Machlin, and L. Loveless, 1961, *Toxicity of Vanadium and Chromium for the Growing Chick*, Poultry Science, 40:1171-1173.
QCE: 49 mg/kg-day

Adjustment Factors (AF)				Justification for adjustment factor
R	1	2	3	R = 1 is AF for same order and trophic level R = 2 is AF for different order and same trophic level R = 3 is AF for different order and trophic level
I	2	2	2	Primary source unavailable
Q_1	1	1	1	Ecologically relevant endpoint (growth, mortality).
Q_2	2	2	2	Subchronic exposure duration
Q_3	1	1	1	NOAEL endpoint
U	3	3	3	Old study, limited endpoints
Total AF	12	24	36	$R * I * Q_1 * Q_2 * Q_3 * U$ = Total AF
QCE (mg/kg-day)	49	49	49	QCE = quantified critical endpoint
TRV	4.1	2.0	1.4	Toxicity Reference Value = QCE/Total AF

R Value	TRV (mg/kg-day)	Justification	Appropriate Functional Group
1	4.1	Test organism is in the same order and trophic level as the functional group members	none
2	2.0	Test organism is in a different order and same trophic level from the functional group members	AV422, AV432, AV433,AV442
3	1.4	Test organism is in a different order and trophic level from the functional group members	AV121, AV122, AV132, AV142, AV143, AV210, AV210A, AV221, AV222, AV222A, AV232, AV233, AV241, AV242, AV310, AV322, AV333, AV342

COPC:	**Chromium(III)** CAS 7440-47-3	
Test Organisms:	Rat (Omnivore, Order-Rodentia)	
Exposure Medium:	Diet	
Test Endpoint:	NOAEL	
Reference:	Ivankovic and Preussmann, 1975, *Absence of Toxic and Carcinogenic Effects After Administration of High Doses of Chromic Oxide Pigment in Subacute and Long-Term Feeding Experiments in Rats,* Food Cosmet. Toxicol., 13(3): 347-351.	
QCE:	1500 mg/kg-day	1800 g/kg total dose consumed at highest dose rate, administered 5 days/week for 120 weeks (~840 days total), corrected for % Cr.

Adjustment Factors (AF)				Justification for adjustment factor
R	1	2	3	R = 1 is AF for same order and trophic level R = 2 is AF for different order and same trophic level R = 3 is AF for different order and trophic level
I	1	1	1	Chronic toxicity study with adequate numbers of animals
Q_1	2	2	2	No endpoint affected (treatments had no effect on life expectancy, food consumption, growth rate, or cancer incidence).
Q_2	1	1	1	Chronic study
Q_3	1	1	1	NOAEL endpoint
U	1	1	1	Large chronic study
Total AF	2	4	6	$R * I * Q_1 * Q_2 * Q_3 * U$ = Total AF
QCE (mg/kg-day)	1500	1500	1500	QCE = quantified critical endpoint
TRV	750	375	250	Toxicity Reference Value = QCE/Total AF

R Value	TRV (mg/kg-day)	Justification	Appropriate Functional Group
1	750	Test organism is in the same order and trophic level as the functional group members	none
2	375	Test organism is in a different order and same trophic level from the functional group members	M422, M422A
3	250	Test organism is in a different order and trophic level from the functional group members	M121, M122, M122A, M132, M210, M210A, M222, M322

COPC: **Chromium (VI)** CAS 7440-47-3

Test Organisms: Dog (Omnivore, Order-Carnivora)
Exposure Medium: Drinking water
Test Endpoint: NOAEL
Reference: Steven et al. (1976) cited in Eisler (1986)
Anwar, R.A., et al., 1961, "Chronic Toxicity Studies. Part III. Chronic Toxicity of Cadmium and Chromium in Dogs", *Archives of Environmental Health,* 3:456-460.
Steven, J.D. et al., 1976, *Effects of Chromium in the Canadian Environment,* RCC No. 15017, National Resources Council, Ottawa, Canada.

QCE: 0.30 mg/kg-day (11.2 mg/L)(3.1mL/100g-day)(8730g)(1L/1000mL)/8.73 kg BW

Adjustment Factors (AF)				Justification for adjustment factor
R	1	2	3	R = 1 is AF for same order and trophic level R = 2 is AF for different order and same trophic level R = 3 is AF for different order and trophic level
I	2	2	2	Smaller number of female dogs only. No males tested.
Q_1	1	1	1	No endpoint observed
Q_2	1	1	1	Chronic duration (4 years)
Q_3	1	1	1	NOAEL
U	2	2	2	No reproductive endpoint studied, but good duration of testing.
M	0.5	0.5	0.5	Soluble salt placed in the drinking water.
Total AF	2	4	6	$R * I * Q_1 * Q_2 * Q_3 * U * M$ = Total AF
QCE (mg/kg-day)	0.30	0.30	0.30	QCE = quantified critical endpoint
TRV	0.15	0.08	0.05	Toxicity Reference Value = QCE/Total AF

R Value	TRV (mg/kg-day)	Justification	Appropriate Functional Group
1	0.15	Test organism is in the same order and trophic level as the functional group members	M422A
2	0.08	Test organism is in a different order and same trophic level from the functional group members	M422
3	0.05	Test organism is in a different order and trophic level from the functional group members	M121, M122, M122A, M123, M210, M210A, M222, M322

COPC: **Lead** CAS 7439-92-1

Test Organisms: Chicken (Omnivore, Order-Galliformes)
Exposure Medium: Diet
Test Endpoint: NOAEL
Reference: Eisler, R., 1988, *Lead Hazards to Fish, Wildlife, and Invertebrates: A Synoptic Review,* Fish and Wildlife Service. Bio. Rep. No. 14. April, 1985.
QCE: 26 mg/kg-day 500 mg/kg in diet converted to dose by multiplying by 0.105 kg/day ingestion rate and dividing by 2 kg BW

Adjustment Factors (AF)				Justification for adjustment factor
R	1	2	3	R = 1 is AF for same order and trophic level R = 2 is AF for different order and same trophic level R = 3 is AF for different order and trophic level
I	3	3	3	Secondary source
Q_1	1	1	1	Endpoint ecologically relevant (growth)
Q_2	2	2	2	Subchronic study
Q_3	1	1	1	NOAEL endpoint
U	3	3	3	Limited information. Dietary NOAEL appears consistent for a variety of species.
Total AF	18	36	54	$R * I * Q_1 * Q_2 * Q_3 * U$ = Total AF
QCE (mg/kg-day)	26	26	26	QCE = quantified critical endpoint
TRV	1.4	0.72	0.48	Toxicity Reference Value = QCE/Total AF

R Value	TRV (mg/kg-day)	Justification	Appropriate Functional Group
1	1.4	Test organism is in the same order and trophic level as the functional group members	none
2	0.72	Test organism is in a different order and same trophic level from the functional group members	AV422, AV432, AV433,AV442
3	0.48	Test organism is in a different order and trophic level from the functional group members	AV121, AV122, AV132, AV142, AV143, AV210, AV210A, AV221, AV222, AV222A, AV232, AV233, AV241, AV242, AV310, AV322, AV333, AV342

COPC:	**Lead** CAS 7439-92-1
Test Organisms:	Rat (Omnivore, Order-Rodentia)
Exposure Medium:	Oral in diet as lead acetate
Test Endpoint:	NOAEL
Reference:	Azar, A., H.J. Trochimowicz, M.E. Maxfield, 1973, "Review of Lead Studies in Animals Carried Out at Haskell Laboratory: Two-Year Feeding Study and Response to Hemorrhage Study", In *Environmental Health Aspects of Lead: Proceedings, International Symposium,* D. Barth et al. (ed.) Commission of European Communities, pp 199-210.
QCE:	8.0 mg/kg-day (100 mg/kg food)*(.028 kg/day)/0.35 kg BW

Adjustment Factors (AF)				Justification for adjustment factor
R	1	2	3	R = 1 is AF for same order and trophic level R = 2 is AF for different order and same trophic level R = 3 is AF for different order and trophic level
I	1	1	1	50 male and 50 female rats per dose level. Reproductive three generation (during critical life stage) study.
Q_1	1	1	1	Mortality, # of tumors, weight gain, # or pregnancies, # of pups born alive, fertility index, gestation index, viability index or lactation index. Ecologically relevant endpoint.
Q_2	1	1	1	Chronic
Q_3	1	1	1	NOAEL
U	1	1	1	Pb as lead acetate was fed for a three-generation six-litter study at multiple dosages (0, 10, 50, 100, 1000, 2000 ppm). At 1000 and 2000 ppm dietary Pb, the average weight of weanling rats was slightly decreased. At 10 ppm stippled cells were increased. A decrease in ALAD activity was seen at 50 ppm (however these are not considered adverse effects). 100 ppm Pb is considered the NOAEL.
Total AF	1	2	3	$R * I * Q_1 * Q_2 * Q_3 * U$ = Total AF
QCE (mg/kg-day)	8.0	8.0	8.0	QCE = quantified critical endpoint
TRV	8.0	4.0	2.7	Toxicity Reference Value = QCE/Total AF

R Value	TRV (mg/kg-day)	Justification	Appropriate Functional Group
1	8.0	Test organism is in the same order and trophic level as the functional group members	None
2	4.0	Test organism is in a different order and same trophic level from the functional group members	M422, M422A
3	2.7	Test organism is in a different order and trophic level from the functional group members	M121, M122, M122A, M132, M210, M210A, M222, M322

* Wiseman, J., "Feeding of Non-ruminant Livestock." Butterworths; Boston, MA. 1987.

COPC:	**Mercury (Inorganic)** CAS 7439-97-6
Test Organisms:	Chickens (Omnivore, Order-Galliformes)
Exposure Medium:	Oral in drinking water
Test Endpoint:	NOAEL
Reference:	Thaxton, P., L.A. Cogburn, and C.R. Parkhurst, 1973. *Dietary mercury as related to the blood chemistry in young chickens.* Poultry Science 52:1212-1214 (cited in National Academy of Sciences, 1980. Mineral Tolerance of Domestic Animals. Washington, DC).
QCE:	12.1 mg/kg-day (125mg/L)*(0.097 kg diet/kg bw/day)*

Adjustment Factors (AF)				Justification for adjustment factor
R	1	2	3	R = 1 is AF for same order and trophic level R = 2 is AF for different order and same trophic level R = 3 is AF for different order and trophic level
I	2	2	2	Results were inconsistent, however a similar study by Parkhurst and Thaxton, 1973[a] reported toxic effects in young boilers at 250 ppm (similar study) including growth reduction, decreased feed and water efficiencies, alterations in the sizes of certain organs, immunosuppression, & mortality at 250 ppm as LOAEL.
Q_1	1	1	1	Study determined minor effects of dietary Hg on plasma levels of glucose, total protein, total lipids and other blood chemistry. Endpoint is possible in receptor in the field.
Q_2	1	1	1	Chronic exposure (6 weeks)
Q_3	1	1	1	NOAEL (125 ppm see discussion above)
U	2	2	2	Adequate numbers of test animals, 120 young chickens at each 5 dose levels. Reasonable design. Multiple doses assessed (0, 5, 25, 125, 250 ppm) and NOAEL established but no LOAEL and results were inconsistent..
M	0.5	0.5	0.5	Administered as $HgCl_2$ in drinking water.
Total AF	2	4	6	R * I * Q_1 * Q_2 * Q_3 * U = Total AF
QCE (mg/kg-day)	12.1	12.1	12.1	QCE = quantified critical endpoint
TRV	6.05	3.03	2.02	Toxicity Reference Value = QCE/Total AF

R Value	TRV (mg/kg-day)	Justification	Appropriate Functional Group
1	6.05	Test organism is in the same order and trophic level as the functional group members	none
2	3.03	Test organism is in a different order and same trophic level from the functional group members	AV422, AV432, AV433, AV442
3	2.02	Test organism is in a different order and trophic level from the functional group members	AV121, AV122, AV132, AV142, AV143, AV210, AV210A, AV221, AV222, AV222A, AV232, AV233, AV241, AV242, AV310, AV322, AV333, AV342

Parkhurst, C.R., and P. Thaxton, 1973. *Toxicity of mercury to young chickens: 1. Effect on growth and mortality.* Poultry Science 52:273-276.

* Wiseman, J., "Feeding of Non-ruminant Livestock." Butterworths; Boston, MA. 1987.

COPC: **Mercury (Inorganic)** CAS 7439-97-6

Test Organisms: Mouse (Omnivore, Order-Rodentia)
Exposure Medium: Oral in drinking water
Test Endpoint: NOAEL
Reference: Schroeder and Mitchner, 1975. "Life-term effects of mercury, methylmercury and nine other trace metals on mice" *J. Nutr.* 105:452.

QCE: 0.68 mg/kg-day Calculated 5 ppm Hg as mercuric chloride*.

Adjustment Factors (AF)				Justification for adjustment factor
R	1	2	3	R = 1 is AF for same order and trophic level R = 2 is AF for different order and same trophic level R = 3 is AF for different order and trophic level
I	2	2	2	Groups of 36 to 54 mice of each sex were exposed. One control group. At 5 ppm longevity tended to decrease in males and increase in females.
Q_1	1	1	1	Body weight, tumors, edema, blanching of incisor teeth, life-spans and longevities
Q_2	1	1	1	Lifetime exposure
Q_3	1	1	1	NOAEL
U	2	2	2	No reproductive endpoint or sensitive life stage examined. Random-bred white Swiss mice of Charles River CD strain. 5 ppm Hg as mercuric chloride in the basal drinking water. Only one dose tested and no LOAEL established.
M	0.5	0.5	0.5	Placed in drinking water.
Total AF	2	4	6	R * I * Q_1 * Q_2 * Q_3 * U = Total AF
QCE (mg/kg-day)	0.68	0.68	0.68	QCE = quantified critical endpoint
TRV	0.34	0.17	0.11	Toxicity Reference Value = QCE/Total AF

R Value	TRV (mg/kg-day)	Justification	Appropriate Functional Group
1	0.34	Test organism is in the same order and trophic level as the functional group members	none
2	0.17	Test organism is in a different order and same trophic level from the functional group members	M422, M422A
3	0.11	Test organism is in a different order and trophic level from the functional group members	M121, M122, M122A, M132, M210, M210A, M222, M322

* [(5 mg Hg_2/L water)*((0.0051 L water/day**)/0.0373 kg BW]

Ingestion rate of water calculated using allometric equation from the Wildlife Factors Handbook (EPA 1993)
$WI=0.099BW^{0.9}$

COPC:	**Mercury (Organic)** CAS 7439-97-6
Test Organisms:	Mallard Duck (Herbivore, Order-Anseriformes, *Anas platyrhynchos*)
Exposure Medium:	Oral in diet
Test Endpoint:	LOAEL
Reference:	Heinz, G. H. 1979. Methyl mercury: reproductive and behavioral effects on three generations of mallard ducks. J. Wildl. Mgmt. 43:394-401.
QCE:	0.064 mg/kg-day (0.5mg/kg food)(128g food/day)(1kg/1000g)/1 kg BW

Adjustment Factors (AF)				Justification for adjustment factor
R	1	2	3	R = 1 is AF for same order and trophic level R = 2 is AF for different order and same trophic level R = 3 is AF for different order and trophic level
I	2	2	2	Only one dose level, however, this was a three generation study that showed significant effects from control.
Q_1	1	1	1	Endpoints include reproductive endpoints (i.e. # of eggs and hatchlings). Ecologically relevant endpoint
Q_2	1	1	1	Chronic
Q_3	2	2	2	LOAEL - one dose only
U	2	2	2	3 generations (>1 yr. and during a critical life stage) and reproductive endpoints examined. However, only 1 dose considered.
Total AF	8	16	24	$R * I * Q_1 * Q_2 * Q_3 * U$ = Total AF
QCE (mg/kg-day)	0.064	0.064	0.064	QCE = quantified critical endpoint
TRV	0.008	0.004	0.003	Toxicity Reference Value = QCE/Total AF

R Value	TRV (mg/kg-day)	Justification	Appropriate Functional Group
1	0.008	Test organism is in the same order and trophic level as the functional group members	AV142, AV143
2	0.004	Test organism is in a different order and same trophic level from the functional group members	AV121, AV122, AV132
3	0.003	Test organism is in a different order and trophic level from the functional group members	AV210, AV210A, AV221, AV222, AV222A, AV232, AV233, AV241, AV242, AV310, AV322, AV333, AV342, AV422, AV432, AV433, AV442

COPC:	**Mercury (Organic)** CAS 7439-97-6
Test Organisms:	Mouse (Omnivore, Order-Rodentia)
Exposure Medium:	Oral in drinking water
Test Endpoint:	NOAEL
Reference:	Schroeder and Mitchner, 1975. "Life-term effects of mercury, methylmercury and nine other trace metals on mice" *J. Nutr.* 105:452.
QCE:	0.14 mg/kg-day Calculated, 1 ppm Hg as methylmercury acetate*

Adjustment Factors (AF)				Justification for adjustment factor
R	1	2	3	R = 1 is AF for same order and trophic level R = 2 is AF for different order and same trophic level R = 3 is AF for different order and trophic level
I	2	2	2	Groups of 36 to 54 mice of each sex were exposed. One control group. 5 ppm Hg as methylmercury acetate for 70 days and 1 ppm subsequently in the drinking water. 5 ppm was toxic but 1 ppm appears to have beneficial effects, with the mice that survived gaining weight and living longer than litter mates given 1 ppm from time of weaning.
Q_1	1	1	1	Body weight, tumors, edema, blanching of incisor teeth, life-spans and longevities.
Q_2	1	1	1	Lifetime exposure
Q_3	1	1	1	NOAEL
U	2	2	2	Average study design with limited number of doses, and no reproductive endpoint or sensitive life stage examined. Random-bred white Swiss mice of Charles River CD strain. Both a NOAEL and LOAEL established.
M	0.5	0.5	0.5	Methylmercury acetate placed in drinking water.
Total AF	2	4	6	$R * I * Q_1 * Q_2 * Q_3 * U$ = Total AF
QCE (mg/kg-day)	0.14	0.14	0.14	QCE = quantified critical endpoint
TRV	0.07	0.04	0.02	Toxicity Reference Value = QCE/Total AF

R Value	TRV (mg/kg-day)	Justification	Appropriate Functional Group
1	0.07	Test organism is in the same order and trophic level as the functional group members	none
2	0.04	Test organism is in a different order and same trophic level from the functional group members	M422, M422A
3	0.02	Test organism is in a different order and trophic level from the functional group members	M121, M122, M122A, M132, M210, M210A, M222, M322

[(1 mg Hg_2/ L)(0.0051 L water/day**)/0.0373 kg BW]=0.14 mg/kg BW-day

**Ingestion rate of water calculated using allometric equation from the Wildlife Factors Handbook (EPA 1993) $WI=0.099BW^{0.9}$

COPC:	**Nickel** CAS 7440-02-0
Test Organisms:	Mallard Duck (Herbivore, Order-Anseriformes)
Exposure Medium:	Oral in diet
Test Endpoint:	NOAEL
Reference:	Cain, B.W. and E.A. Pafford, 1981, "Effects of Dietary Nickel on Survival and Growth of Mallard Duckling", *Arch. Environm. Contam. Toxicol.* 10, 737-745.
QCE:	77.4 mg/kg-day (774mg/kg food)(78.2g food/day)(1kg/1000g)/0.782 kg BW

Adjustment Factors (AF)				Justification for adjustment factor
R	1	2	3	R = 1 is AF for same order and trophic level R = 2 is AF for different order and same trophic level R = 3 is AF for different order and trophic level
I	2	2	2	36 ducklings divided into 6 cages with 6 birds per cage (3 male 3 female). 12 birds were given a dose of either 176, 774, or 1069 ppm.
Q_1	1	1	1	Development endpoints measured (body weight, bill length, humerus, heart, liver, gizzard, kidneys).
Q_2	1	1	1	Chronic study (60-90 days)
Q_3	1	1	1	NOAEL
U	1	1	1	The study considered exposure over 90 days, the 774 ppm dose was considered a NOAEL and the 1069 ppm was the LOAEL.
Total AF	2	4	6	$R * I * Q_1 * Q_2 * Q_3 * U$ = Total AF
QCE (mg/kg-day)	77.4	77.4	77.4	QCE = quantified critical endpoint
TRV	38.7	19.4	12.9	Toxicity Reference Value = QCE/Total AF

R Value	TRV (mg/kg-day)	Justification	Appropriate Functional Group
1	38.7	Test organism is in the same order and trophic level as the functional group members	AV142, AV143
2	19.4	Test organism is in a different order and same trophic level from the functional group members	AV121, AV122, AV132
3	12.9	Test organism is in a different order and trophic level from the functional group members	AV210, AV210A, AV221, AV222, AV222A, AV232, AV233, AV241, AV242, AV310, AV322, AV333, AV342, AV422, AV432, AV433, AV442

COPC:	**Nickel** CAS 7440-02-0
Test Organisms:	Beagle Dog (Omnivore, Order-Carnivora)
Exposure Medium:	Diet
Test Endpoint:	NOAEL
Reference:	Ambrose, A.M. et al. 1976, *Long-Term Toxicologic Assessment of Nickel in Rats and Dogs,* J. Food Sci. Technol. 13:181-187.
QCE:	114 mg/kg-day (2500mg/kg)(430g/day)(1kg/1000g)/9.41 kg BW

Adjustment Factors (AF)				Justification for adjustment factor
R	1	2	3	R = 1 is AF for same order and trophic level R = 2 is AF for different order and same trophic level R = 3 is AF for different order and trophic level
I	1	1	1	Chronic toxicity study with adequate numbers of animals
Q_1	1	1	1	Body weight gain
Q_2	1	1	1	Chronic study
Q_3	1	1	1	NOAEL endpoint
U	2	2	2	Doses given to both males and females at: 0, 100, 1000, and 2500 ppm. No effects for dogs on diets at 100 and 1000 ppm.
Total AF	2	4	6	$R * I * Q_1 * Q_2 * Q_3 * U$ = Total AF
QCE (mg/kg-day)	114	114	114	QCE = quantified critical endpoint
TRV	57.0	28.5	19.0	Toxicity Reference Value = QCE/Total AF

R Value	TRV (mg/kg-day)	Justification	Appropriate Functional Group
1	57.0	Test organism is in the same order and trophic level as the functional group members	M422A
2	28.5	Test organism is in a different order and same trophic level from the functional group members	M422
3	19.0	Test organism is in a different order and trophic level from the functional group members	M121, M122, M122A, M123, M210, M210A, M222, M322

COPC:	**Selenium (Sodium selenite)** CAS 7782-49-2
Test Organisms:	Mallard (Herbivore, Order-Anseriformes)
Exposure Medium:	Diet
Test Endpoint:	NOAEL
Reference:	Heinz, G.H. et al. 1987, "Reproduction in mallards fed selenium," Environmental Toxicology and Chemistry, 6:423-433. Eisler, R. 1985, Selenium Hazards to Fish, Wildlife, and Invertebrates: A Synoptic Review, U.S. Fish and Wildlife Service, Biological Report, 85(1.5). EPA. 1993, Ch. 9. Selenium Effects at Kesterson Reservoir, A Review of Ecological Assessment Case Studies from a Risk Assessment Perspective, EPA/630/R-92/005.
QCE:	0.5 mg/kg-day (5 mg/kg * 0.1 kg feed)/ 1 kg bird

Adjustment Factors (AF)				Justification for adjustment factor
R	1	2	3	R = 1 is AF for same order and trophic level R = 2 is AF for different order and same trophic level R = 3 is AF for different order and trophic level
I	2	2	2	10 pairs for five doses tested, study results consistent with other studies in chickens and quail, repro/devel. toxicity analysis only.
Q_1	1	1	1	Ecologically relevant endpoint (reproduction)
Q_2	1	1	1	Chronic study (2-4 mos.)
Q_3	1	1	1	NOAEL endpoint
U	1	1	1	Reproductive study only with different forms of selenium
Total AF	2	4	6	$R * I * Q_1 * Q_2 * Q_3 * U$ = Total AF
QCE (mg/kg-day)	0.5	0.5	0.5	QCE = quantified critical endpoint
TRV	0.25	0.13	0.08	Toxicity Reference Value = QCE/Total AF

R Value	TRV (mg/kg-day)	Justification	Appropriate Functional Group
1	0.25	Test organism is in the same order and trophic level as the functional group members	AV142, AV143
2	0.13	Test organism is in a different order and same trophic level from the functional group members	AV121, AV122, AV132
3	0.08	Test organism is in a different order and trophic level from the functional group members	AV210, AV210A, AV221, AV222, AV222A, AV232, AV233, AV241, AV242, AV310, AV322, AV333, AV342, AV422, AV432, AV433, AV442

COPC:	**Selenium** CAS 7782-49-2
Test Organisms:	Rat (Omnivore, Order-Rodentia)
Exposure Medium:	Drinking water
Test Endpoint:	NOAEL
Reference:	Rosenfeld, I. and O.A. Beath. 1954. Effect of selenium on reproduction in rats. Proc. Soc. Exp. Biol. Med. 87:295-297.
QCE:	0.20 mg/kg-day (1.5mg/L water)(46mL water/day)(1L/1000mL)/0.35kg BW

Adjustment Factors (AF)				Justification for adjustment factor
R	1	2	3	R = 1 is AF for same order and trophic level R = 2 is AF for different order and same trophic level R = 3 is AF for different order and trophic level
I	1	1	1	Chronic toxicity studies with adequate numbers of animals
Q_1	1	1	1	Ecologically relevant endpoint (reproduction, number of young reared)
Q_2	1	1	1	Chronic study
Q_3	1	1	1	NOAEL endpoint
U	1	1	1	Older study, but analyzed 5 breeding cycles and 2 generations. A more recent study by Nobunaga et al. (1979) reports a NOAEL of 390 ug/kg/day selenite for mice reproductive success.
M	0.5	0.5	0.5	Placed in drinking water
Total AF	0.5	1.0	1.5	$R * I * Q_1 * Q_2 * Q_3 * U * M$ = Total AF
QCE (mg/kg-day)	0.20	0.20	0.20	QCE = quantified critical endpoint
TRV	0.40	0.20	0.13	Toxicity Reference Value = QCE/Total AF

R Value	TRV (mg/kg-day)	Justification	Appropriate Functional Group
1	0.40	Test organism is in the same order and trophic level as the functional group members	none
2	0.20	Test organism is in a different order and same trophic level from the functional group members	M422, M422A
3	0.13	Test organism is in a different order and trophic level from the functional group members	M121, M122, M122A, M132, M210, M210A, M222, M322

COPC: **Silver** CAS 7440-22-4

Test Organisms: Turkey (Omnivore, Order-Galliformes)
Exposure Medium: Oral
Test Endpoint: LOAEL
Reference: Friberg, L., et al., 1979. *Handbook on the Toxicology of Metals*; Elsevier/North Holland Biomedical Press. Pp. 57-586.
QCE: 87.3 mg/kg-day (900 ppm converted with 0.097 kg/kg bw/d from Wiseman, 1987)*

Adjustment Factors (AF)				Justification for adjustment factor
R	1	2	3	R = 1 is AF for same order and trophic level R = 2 is AF for different order and same trophic level R = 3 is AF for different order and trophic level
I	1	1	1	Adequate number of organisms used with effects exerted on the cardiovascular, hepatic, and hematopoietic systems
Q_1	1	1	1	Ecologically relevant endpoint (mortality)
Q_2	1	1	1	Chronic duration (18 weeks)
Q_3	2	2	2	LOAEL
U	1	1	1	Good study design
Total AF	2	4	6	$R * I * Q_1 * Q_2 * Q_3 * U$ = Total AF
QCE (mg/kg-day)	87.3	87.3	87.3	QCE = quantified critical endpoint
TRV	43.7	21.8	14.6	Toxicity Reference Value = QCE/Total AF

R Value	TRV (mg/kg-day)	Justification	Appropriate Functional Group
1	43.7	Test organism is in the same order and trophic level as the functional group members	none
2	21.8	Test organism is in a different order and same trophic level from the functional group members	AV422, AV432, AV433,AV442
3	14.6	Test organism is in a different order and trophic level from the functional group members	AV121, AV122, AV132, AV142, AV143, AV210, AV210A, AV221, AV222, AV222A, AV232, AV233, AV241, AV242, AV310, AV322, AV333, AV342

* Wiseman, J., "Feeding of Non-ruminant Livestock." Butterworths; Boston, MA. 1987.

COPC: **Silver** CAS 7440-22-4

Test Organisms: Swine (Omnivore, Order-Artiodactyla)
Exposure Medium: Oral
Test Endpoint: NOAEL
Reference: Van Vleet, J.F., 1976. *Induction of Lesions of Selenium-Vitamin E Deficiency in Pigs Fed Silver*; American Journal of Veterinary Research, 37:1415-1420.
QCE: 68.0 mg/kg-day (converted with 0.034 kg/kg bw/d, Wiseman 1987)*

Adjustment Factors (AF)				Justification for adjustment factor
R	1	2	3	R = 1 is AF for same order and trophic level R = 2 is AF for different order and same trophic level R = 3 is AF for different order and trophic level
I	1	1	1	Two experiments with multiple test groups fed differing diets and supplemented with varying concentrations of silver acetate
Q_1	1	1	1	Endpoints relevant (growth, mortality)
Q_2	2	2	2	Subchronic study (4 weeks)
Q_3	1	1	1	NOAEL
U	1	1	1	Good study design with adequate supporting sources (Walker, 1971)**
Total AF	2	4	6	$R * I * Q_1 * Q_2 * Q_3 * U$ = Total AF
QCE (mg/kg-day)	68.0	68.0	68.0	QCE = quantified critical endpoint
TRV	34.0	17.0	11.3	Toxicity Reference Value = QCE/Total AF

R Value	TRV (mg/kg-day)	Justification	Appropriate Functional Group
1	34.0	Test organism is in the same order and trophic level as the functional group members	None
2	17.0	Test organism is in a different order and same trophic level from the functional group members	M422, M422A
3	11.3	Test organism is in a different order and trophic level from the functional group members	M121, M122, M122A, M123, M210, M210A, M222, M322

* Wiseman, J., "Feeding of Non-ruminant Livestock." Butterworths; Boston, MA. 1987.

**Walker, F., 1971. Experimental Argyria: A Model for Basement Membrane Studies; British Journal of Experimental Pathology, 52:589-593.

COPC: **Thallium** CAS 7440-28-0

Test Organisms: Quail (Omnivore, Order-Galliformes)
Exposure Medium: Oral in diet (bread)
Test Endpoint: FEL

Reference:	Shaw, P.A., 1933, "Toxicity and deposition of thallium in certain game birds," Journal of Pharmacology and Experimental Therapeutics, 48(4):478-487.
QCE:	12 mg/kg-day

Adjustment Factors (AF)				Justification for adjustment factor
R	1	2	3	R = 1 is AF for same order and trophic level R = 2 is AF for different order and same trophic level R = 3 is AF for different order and trophic level
I	3	3	3	Very old study, doses and effects poorly characterized, only high doses and lethal endpoints considered
Q_1	1	1	1	Ecologically relevant endpoint (lethality)
Q_2	3	3	3	Acute duration
Q_3	3	3	3	FEL for lethality
U	3	3	3	Very old study, poorly designed and analyzed
Total AF	81	162	243	$R * I * Q_1 * Q_2 * Q_3 * U$ = Total AF
QCE (mg/kg-day)	12	12	12	QCE = quantified critical endpoint
TRV	0.15	0.07	0.05	Toxicity Reference Value = QCE/Total AF

R Value	TRV (mg/kg-day)	Justification	Appropriate Functional Group
1	0.15	Test organism is in the same order and trophic level as the functional group members	none
2	0.07	Test organism is in a different order and same trophic level from the functional group members	AV422, AV432, AV433,AV442
3	0.05	Test organism is in a different order and trophic level from the functional group members	AV121, AV122, AV132, AV142, AV143, AV210, AV210A, AV221, AV222, AV222A, AV232, AV233, AV241, AV242, AV310, AV322, AV333, AV342

COPC:	**Thallium** CAS 7440-28-0
Test Organisms:	Rat (Omnivore, Order-Rodentia)
Exposure Medium:	Oral in Diet
Test Endpoint:	LOAEL Hair loss
Reference:	Downs, W., Scott, J., Steadman, L., Maynard, E., 1960, "Acute and Sub-acute Toxicity Studies of Thallium Compounds", *Industrial Hygiene Journal*, pp. 399-406.
QCE:	1.8mg/kg-day Specified (Average between 1-3 depending on the BW)

Adjustment Factors (AF)				Justification for adjustment factor
R	1	2	3	R = 1 is AF for same order and trophic level R = 2 is AF for different order and same trophic level R = 3 is AF for different order and trophic level
I	2	2	2	Smaller number of male and female rats tested, no juveniles tested.
Q_1	1	1	1	Ecologically relevant endpoint
Q_2	2	2	2	Subchronic duration
Q_3	2	2	2	LOAEL
U	2	2	2	Good design, a variety of compounds tested, reproductive endpoints not examined. Compound is thallium acetate. Similar responsiveness for thallium oxide.
Total AF	16	32	48	$R * I * Q_1 * Q_2 * Q_3 * U$ = Total AF
QCE (mg/kg-day)	1.8	1.8	1.8	QCE = quantified critical endpoint
TRV	0.11	0.06	0.04	Toxicity Reference Value = QCE/Total AF

R Value	TRV (mg/kg-day)	Justification	Appropriate Functional Group
1	0.11	Test organism is in the same order and trophic level as the functional group members	none
2	0.06	Test organism is in a different order and same trophic level from the functional group members	M422, M422A
3	0.04	Test organism is in a different order and trophic level from the functional group members	M121, M122, M122A, M132, M210, M210A, M222, M322

COPC:	**1,1,1 Trichloroethane** CAS 71-55-6
Test Organisms:	Mouse (Omnivore, Order-Rodentia)
Exposure Medium:	Drinking water
Test Endpoint:	NOAEL
Reference:	Lane, R.W., B.L. Riddle, and J.F. Borzelleca. 1982. "Effects of 1,2-dichloroethane and 1,1,1-trichoroethane in drinking water on reproduction and development in mice." Toxicol. Appl. Pharmacol. 63: 409-421.
QCE:	1000 mg/kg-day body weight 0.035 kg; water consumption: 6ml/d (from study).

Adjustment Factors (AF)				Justification for adjustment factor
R	1	2	3	R = 1 is AF for same order and trophic level R = 2 is AF for different order and same trophic level R = 3 is AF for different order and trophic level
I	1	1	1	Study exposure through 2 generations and included critical life stages.
Q_1	1	1	1	Ecologically relevant endpoint (pup survival, weight gain, fertility, gestation, viability, lactation).
Q_2	1	1	1	Chronic
Q_3	1	1	1	NOAEL
U	2	2	2	Because no significant differences were observed at any dose level the maximum dose considered was a NOAEL.
M	0.5	0.5	0.5	Placed in the drinking water.
Total AF	1	2	3	$R * I * Q_1 * Q_2 * Q_3 * U * M$ = Total AF
QCE (mg/kg-day)	1000	1000	1000	QCE = quantified critical endpoint
TRV	1000	500	333	Toxicity Reference Value = QCE/Total AF

R Value	TRV (mg/kg-day)	Justification	Appropriate Functional Group
1	1000	Test organism is in the same order and trophic level as the functional group members	none
2	500	Test organism is in a different order and same trophic level from the functional group members	M422, M422A
3	333	Test organism is in a different order and trophic level from the functional group members	M122, M122A, M121, M123, M132 M210, M210A, M222, M322

COPC:	**1,2,4-Trichlorobenzene** CAS 120-82-1
Test Organisms:	Rat (Omnivore, Order-Rodentia)
Exposure Medium:	Oral
Test Endpoint:	NOAEL
Reference:	Carlson, G.P., and R.G., Tardiff, 1976, *Effect of Chlorinated Benzenes on the Metabolism of Foreign Organic Compounds,* Toxicology and Applied Pharmacology, 36:383-394. Kitchin, K.T. and M.T. Ebron, 1980, "Maternal hepatic and embryonic effects of 1,2,4-trichlorobenzene in the rat, rabbit, and beagle dog," *Environmental Res.*, 31:362-373.
QCE:	20 mg/kg-day

Adjustment Factors (AF)				Justification for adjustment factor
R	1	2	3	R = 1 is AF for same order and trophic level R = 2 is AF for different order and same trophic level R = 3 is AF for different order and trophic level
I	2	2	2	Only males tested in Carlson and Tardiff (1976). Only females in Kitchin and Ebron (1980).
Q_1	1	1	1	Ecologically relevant endpoint (metabolism).
Q_2	2	2	2	90 day chronic exposure and 14 day acute exposure
Q_3	1	1	1	NOAEL
U	3	3	3	Long-term effects in parents not studied. Small number of animals tested. No follow up studies of dosing for good NOAEL.
Total AF	12	24	36	$R * I * Q_1 * Q_2 * Q_3 * U$ = Total AF
QCE (mg/kg-day)	20	20	20	QCE = quantified critical endpoint
TRV	1.7	0.83	0.56	Toxicity Reference Value = QCE/Total AF

R Value	TRV (mg/kg-day)	Justification	Appropriate Functional Group
1	1.7	Test organism is in the same order and trophic level as the functional group members	none
2	0.83	Test organism is in a different order and same trophic level from the functional group members	M422, M422A
3	0.56	Test organism is in a different order and trophic level from the functional group members	M122, M122A, M121, M123, M132 M210, M210A, M222, M322

COPC: **1,2-Dichloroethane** CAS 107-06-2

Test Organisms: Mouse (Omnivore, Order-Rodentia)
Exposure Medium: Drinking water
Test Endpoint: NOAEL
Reference: Lane, R.W., B.L. Riddle, and J.F. Bozelleca. 1982. Effects of 1,2-dichloroehtane and 1,1,1-trichloroethane in drinking water on reproduction and development in mice. Toxicol. Appl. Pharmacol. 63:409-421.
QCE: 50 mg/kg-day

Adjustment Factors (AF)				Justification for adjustment factor
R	1	2	3	R = 1 is AF for same order and trophic level R = 2 is AF for different order and same trophic level R = 3 is AF for different order and trophic level
I	1	1	1	Study exposure through 2 generations and included critical life stages. Three dose levels: 5, 15, and 50 mg/kg/day.
Q_1	1	1	1	Ecologically relevant endpoint (pup survival, weight gain, fertility, gestation, viability, lactation, reproduction).
Q_2	1	1	1	Chronic study (2 generations)
Q_3	1	1	1	NOAEL
U	2	2	2	Because no significant differences were observed at any dose level the maximum dose considered was a NOAEL.
M	0.5	0.5	0.5	Placed in the drinking water.
Total AF	1	2	3	R * I * Q_1 * Q_2 * Q_3 * U * M = Total AF
QCE (mg/kg-day)	50	50	50	QCE = quantified critical endpoint
TRV	50	25	17	Toxicity Reference Value = QCE/Total AF

R Value	TRV (mg/kg-day)	Justification	Appropriate Functional Group
1	50	Test organism is in the same order and trophic level as the functional group members	none
2	25	Test organism is in a different order and same trophic level from the functional group members	M422, M422A
3	17	Test organism is in a different order and trophic level from the functional group members	M121, M122, M122A, M132, M210, M210A, M222, M322

COPC:	**1,2-Dichloroethane** CAS 107-06-2
Test Organisms:	Chicken (Omnivore, Order-Galliformes)
Exposure Medium:	Oral in diet
Test Endpoint:	NOAEL
Reference:	Alumot, E., M. Meidler, and P. Holstein. 1976. Tolerance and acceptable daily intake of ethylene dichloride in the chicken diet. FD. Cosmet. Toxicol. 14:111-114.
QCE:	17.2 mg/kg-day (250mg/kg food)(0.11kg food/day)/1.6kg BW

Adjustment Factors (AF)				Justification for adjustment factor
R	1	2	3	R = 1 is AF for same order and trophic level R = 2 is AF for different order and same trophic level R = 3 is AF for different order and trophic level
I	2	2	2	Chickens given 1,2-dichloroehtane at two doses: 250 and 500 ppm.
Q_1	1	1	1	Ecologically relevant endpoint (reproduction)
Q_2	1	1	1	Chronic study (2 years and during a critical lifestage)
Q_3	1	1	1	NOAEL
U	1	1	1	Egg production was reduced at the 500 ppm dose but was not affected at the 250 ppm dose, due to this result the 250 ppm was considered the NOAEL and the 500 ppm dose the LOAEL.
Total AF	2	4	6	$R * I * Q_1 * Q_2 * Q_3 * U$ = Total AF
QCE (mg/kg-day)	17.2	17.2	17.2	QCE = quantified critical endpoint
TRV	8.6	4.3	2.9	Toxicity Reference Value = QCE/Total AF

R Value	TRV (mg/kg-day)	Justification	Appropriate Functional Group
1	8.6	Test organism is in the same order and trophic level as the functional group members	none
2	4.3	Test organism is in a different order and same trophic level from the functional group members	AV422, AV432, AV433,AV442
3	2.9	Test organism is in a different order and trophic level from the functional group members	AV121, AV122, AV132, AV142, AV143, AV210, AV210A, AV221, AV222, AV222A, AV232, AV233, AV241, AV242, AV310, AV322, AV333, AV342

COPC: **1,4-Dioxane** CAS 123-91-1

Test Organisms: Rat (Omnivore, Order-Rodentia)
Exposure Medium: Oral intubation
Test Endpoint: NOAEL
Reference: Giavini, E., C. Vismara, and L. Broccia. 1985. Teratogenesis study of dioxane in rats. Toxicol. Lett. 26:85-88.
QCE: 0.5 mg/kg-day

Adjustment Factors (AF)				Justification for adjustment factor
R	1	2	3	R = 1 is AF for same order and trophic level R = 2 is AF for different order and same trophic level R = 3 is AF for different order and trophic level
I	1	1	1	Rats were given 1,4-dioxane at three dose levels: 0.25, 0.5, and 1.0 mg/kg/day.
Q_1	1	1	1	Ecologically relevant endpoint (reproduction)
Q_2	1	1	1	Chronic study (days 6-15 of gestation)
Q_3	1	1	1	NOAEL
U	1	1	1	Maternal toxicity and reduced fetal weights were observed among the rats receiving the 1.0 mg/kg/day dose while the other two doses had no effects on the rats. The 0.5 mg/kg/day dose was thus considered the NOAEL and the 1.0 mg/kg/day dose was considered the LOAEL.
Total AF	1	2	3	$R * I * Q_1 * Q_2 * Q_3 * U$ = Total AF
QCE (mg/kg-day)	0.5	0.5	0.5	QCE = quantified critical endpoint
TRV	0.50	0.25	0.17	Toxicity Reference Value = QCE/Total AF

R Value	TRV (mg/kg-day)	Justification	Appropriate Functional Group
1	0.50	Test organism is in the same order and trophic level as the functional group members	none
2	0.25	Test organism is in a different order and same trophic level from the functional group members	M422, M422A
3	0.17	Test organism is in a different order and trophic level from the functional group members	M121, M122, M122A, M132, M210, M210A, M222, M322

COPC: **Acetonitrile** CAS 75-05-8

Test Organisms: Rat (Omnivore, Order-Rodentia)

Exposure Medium:	Oral (gavage)
Test Endpoint:	NOAEL
Reference:	International Research and Development Corp., IRDC, 1981, "Acetonitrile, Teratology study in rats," Unpublished study sponsored by Monsanto Company.
QCE:	190 mg/kg-day

Adjustment Factors (AF)				Justification for adjustment factor
R	1	2	3	R = 1 is AF for same order and trophic level R = 2 is AF for different order and same trophic level R = 3 is AF for different order and trophic level
I	2	2	2	Groups of 25 Charles River rats treated by gavage with 0, 124, 190, or 275 mg/kg-day of acetonitrile on gestation days 6 to 19.
Q_1	1	1	1	Ecologically relevant endpoint
Q_2	2	2	2	Subchronic (14 day) study
Q_3	1	1	1	NOAEL
U	3	3	3	Inadequate information, unpublished study.
Total AF	12	24	36	$R * I * Q_1 * Q_2 * Q_3 * U$ = Total AF
QCE (mg/kg-day)	190	190	190	QCE = quantified critical endpoint
TRV	16	7.9	5.3	Toxicity Reference Value = QCE/Total AF

R Value	TRV (mg/kg-day)	Justification	Appropriate Functional Group
1	16	Test organism is in the same order and trophic level as the functional group members	none
2	7.9	Test organism is in a different order and same trophic level from the functional group members	M422, M422A
3	5.3	Test organism is in a different order and trophic level from the functional group members	M122, M122A, M121, M123, M132 M210, M210A, M222, M322

COPC:	**Benzene** CAS 71-43-2
Test Organisms:	Mouse (Omnivore, Order-Rodentia)
Exposure Medium:	Oral (gavage)
Test Endpoint:	LOAEL
Reference:	Nawrot, P.S. and R.E. Staples. 1979. "Embryofetal toxicity and teratogenicity of benzene and toluene in the mouse." *Teratology*. 19: 41A.
QCE:	263.6 mg/kg-day (0.3mL Benzene/kg BW)(0.8787 g Benzene/mL Benzene)(1000mg/g) = 263.6 mg/kg-day

Adjustment Factors (AF)				Justification for adjustment factor
R	1	2	3	R = 1 is AF for same order and trophic level R = 2 is AF for different order and same trophic level R = 3 is AF for different order and trophic level
I	2	2	2	Days 6-12 of gestation
Q_1	1	1	1	Ecologically relevant endpoint (reproduction).
Q_2	3	3	3	Short duration
Q_3	2	2	2	LOAEL
U	2	2	2	Three dose levels, exposure at highest two doses (0.5 and 1.0 mL/kg/d significantly increased maternal mortality and embryonic resorption. Fetal weights were significantly reduced by all three dose levels.
Total AF	24	48	72	$R * I * Q_1 * Q_2 * Q_3 * U$ = Total AF
QCE (mg/kg-day)	263.6	263.6	263.6	QCE = quantified critical endpoint
TRV	10.98	5.49	3.66	Toxicity Reference Value = QCE/Total AF

R Value	TRV (mg/kg-day)	Justification	Appropriate Functional Group
1	10.98	Test organism is in the same order and trophic level as the functional group members	none
2	5.49	Test organism is in a different order and same trophic level from the functional group members	M422, M422A
3	3.66	Test organism is in a different order and trophic level from the functional group members	M121, M122, M122A, M132, M210, M210A, M222, M322

COPC: **Benzo(a)pyrene** CAS 50-32-8

Test Organisms: Mouse (Omnivore, Order-Rodentia)
Exposure Medium: Oral (gavage)
Test Endpoint: FEL
Reference: Klein, M., 1963. "Susceptibility of Strain B6AF/j Hybrid Infant Mice to Tumorigenesis with 1,2-Benxanthracene, deoxycyclic acid, and 3-methylcholanthrene", *Cancer Research,* 23:1701-1707.
QCE: 500 mg/kg-day

Adjustment Factors (AF)				Justification for adjustment factor
R	1	2	3	R = 1 is AF for same order and trophic level R = 2 is AF for different order and same trophic level R = 3 is AF for different order and trophic level
I	2	2	2	Infant males tested.
Q_1	1	1	1	Cancer endpoint
Q_2	1	1	1	Chronic (547-day) study
Q_3	3	3	3	FEL
U	3	3	3	Statistical evaluation of data not reported. Number of animals tested not reported.
Total AF	18	36	54	$R * I * Q_1 * Q_2 * Q_3 * U$ = Total AF
QCE (mg/kg-day)	500	500	500	QCE = quantified critical endpoint
TRV	27.8	13.9	9.26	Toxicity Reference Value = QCE/Total AF

R Value	TRV (mg/kg-day)	Justification	Appropriate Functional Group
1	27.8	Test organism is in the same order and trophic level as the functional group members	none
2	13.9	Test organism is in a different order and same trophic level from the functional group members	M422, M422A
3	9.26	Test organism is in a different order and trophic level from the functional group members	M121, M122, M122A, M132, M210, M210A, M222, M322

COPC:	**Butylbenzylphthalate (BBP)** CAS 85-68-7
Test Organisms:	Rat (Omnivore, Order-Rodentia)
Exposure Medium:	Diet
Test Endpoint:	NOAEL
Reference:	National Toxicology Program (NTP), 1985, Twenty-six week subchronic study and modified mating trial in F344 rats. Butyl benyl phthalate. Final Report. Project No. 12307-02-03, Hazelton Laboratories America, unpublished study, cited in IRIS.
QCE:	159 mg/kg-day

Adjustment Factors (AF)				Justification for adjustment factor
R	1	2	3	R = 1 is AF for same order and trophic level R = 2 is AF for different order and same trophic level R = 3 is AF for different order and trophic level
I	3	3	3	Only 15 males per group were tested. No females or juveniles tested.
Q_1	1	1	1	Ecologically relevant endpoint
Q_2	2	2	2	Subchronic study
Q_3	1	1	1	NOAEL endpoint
U	2	2	2	Good overall design but no supporting studies of chronic duration available
Total AF	12	24	36	$R * I * Q_1 * Q_2 * Q_3 * U$ = Total AF
QCE (mg/kg-day)	159	159	159	QCE = quantified critical endpoint
TRV	13.3	6.63	4.42	Toxicity Reference Value = QCE/Total AF

R Value	TRV (mg/kg-day)	Justification	Appropriate Functional Group
1	13.3	Test organism is in the same order and trophic level as the functional group members	none
2	6.63	Test organism is in a different order and same trophic level from the functional group members	M422, M422A
3	4.42	Test organism is in a different order and trophic level from the functional group members	M121, M122, M122A, M132, M210, M210A, M222, M322

COPC:	**Carbon disulfide** CAS 75-15-0
Test Organisms:	Rabbit and rat (Herbivore, Order-Lagomorpha; Omnivore, Order-Rodentia)
Exposure Medium:	Inhalation
Test Endpoint:	NOAEL
Reference:	Hardin, B.D., et al., 1981. "Testing of Selected Workplace Chemicals for Teratogenic Potential", *Scandinavian Journal of Work and Environmental Health,* 7(4):66-75.
QCE:	11 mg/kg-day (62.3 mg/m^3)*(1.6m^3/day)(6h/24h)(0.5 adsorption)/ (1.13 kg BW)

Adjustment Factors (AF)				Justification for adjustment factor
R	1	2	3	R = 1 is AF for same order and trophic level R = 2 is AF for different order and same trophic level R = 3 is AF for different order and trophic level
I	3	3	3	Low number (29) of female rats tested.
Q_1	1	1	1	Ecologically relevant endpoint (reproduction).
Q_2	2	2	2	Subchronic exposure
Q_3	1	1	1	NOAEL
U	2	2	2	Multispecies study that evaluated reproductive toxicological endpoints, such as reproduction. Supporting oral chronic toxicity studies are lacking, actual data not presented.
Total AF	12	24	36	$R * I * Q_1 * Q_2 * Q_3 * U$ = Total AF
QCE (mg/kg-day)	11	11	11	QCE = quantified critical endpoint
TRV	0.92	0.46	0.31	Toxicity Reference Value = QCE/Total AF

R Value	TRV(mg/kg-day)	Justification	Appropriate Functional Group
1	0.92	Test organism is in the same order and trophic level as the functional group members	none
2	0.46	Test organism is in a different order and same trophic level from the functional group members	M121, M122, M122A, M123, M132
3	0.31	Test organism is in a different order and trophic level from the functional group members	M210, M210A, M222, M322, M422, M422A

*Data of inhalation, BW and adsorption acquired from IRIS.

COPC:	**Carbon tetrachloride** CAS 56-23-5	
Test Organisms:	Rat (Omnivore, Order-Rodentia)	
Exposure Medium:	Oral in diet	
Test Endpoint:	NOAEL	Reproduction
Reference:	Alumot, E., Nachtomi, E., Mandel. E., and Holstein, P., 1976, "Tolerance and Acceptable Daily Intake of Chlorinated Fumigants in the Rat Diet", *Fd. Cosmet. Toxicol.*, 14:105-110.	
QCE:	10 mg/kg-day	Average of 10-18 mg/kg bw-day specified in article

Adjustment Factors (AF)				Justification for adjustment factor
R	1	2	3	R = 1 is AF for same order and trophic level R = 2 is AF for different order and same trophic level R = 3 is AF for different order and trophic level
I	1	1	1	Adequate numbers of male and females tested (180)
Q_1	1	1	1	Ecologically relevant endpoint (reproduction, growth, fertility).
Q_2	1	1	1	Chronic (2 year) study
Q_3	1	1	1	NOAEL endpoint
U	1	1	1	Reproductive endpoints and sensitive life stage examined.
Total AF	1	2	3	$R * I * Q_1 * Q_2 * Q_3 * U$ = Total AF
QCE (mg/kg-day)	10	10	10	QCE = quantified critical endpoint
TRV	10	5.0	3.3	Toxicity Reference Value = QCE/Total AF

R Value	RV (mg/kg-day)	Justification	Appropriate Functional Group
1	10	Test organism is in the same order and trophic level as the functional group members	None
2	5.0	Test organism is in a different order and same trophic level from the functional group members	M422, M422A
3	3.3	Test organism is in a different order and trophic level from the functional group members	M121, M122, M122A, M132, M210, M210A, M222, M322

COPC: **Chloroform** CAS 67-66-3

Test Organisms: Rat (Omnivore, Order-Rodentia)
Exposure Medium: Gavage
Test Endpoint: NOAEL
Reference: Palmer, A.K. et al., 1979, "Safety Evaluation of Toothpaste Containing Chloroform II. Long Term Studies in Rats", *Journal of Environmental Pathology and Toxicology* 2:821-833.
QCE: 150 mg/kg-day

Adjustment Factors (AF)				Justification for adjustment factor
R	1	2	3	R = 1 is AF for same order and trophic level R = 2 is AF for different order and same trophic level R = 3 is AF for different order and trophic level
I	2	2	2	Groups of 50 cesarean-derived SPF Sprague-Dawley rats of each sex administered received the one dose.
Q_1	1	1	1	Ecologically relevant endpoints (liver, kidney, gonads)
Q_2	1	1	1	Long-term chronic study (94 weeks)
Q_3	1	1	1	NOAEL
U	2	2	2	Depression of food consumption in females only. Four dose levels tested: 15, 30, 150, and 410 mg/kg-day.
Total AF	4	8	12	$R * I * Q_1 * Q_2 * Q_3 * U$ = Total AF
QCE (mg/kg-day)	150	150	150	QCE = quantified critical endpoint
TRV	37.5	18.8	12.5	Toxicity Reference Value = QCE/Total AF

R Value	TRV (mg/kg-day)	Justification	Appropriate Functional Group
1	37.5	Test organism is in the same order and trophic level as the functional group members	none
2	18.8	Test organism is in a different order and same trophic level from the functional group members	M422, M422A
3	12.5	Test organism is in a different order and trophic level from the functional group members	M121, M122, M122A, M132, M210, M210A, M222, M322

COPC: **Diethylphthalate** CAS 84-66-2

Test Organisms: Rat (Omnivore, Order-Rodentia)
Exposure Medium: Oral
Test Endpoint: NOAEL
Reference: Brown, D., et al., 1978, "Short-term oral toxicity study of diethylphthalate in the rat," *Food Cosmet. Toxicol.*, 16:415-422.
QCE: 750 mg/kg-day

Adjustment Factors (AF)				Justification for adjustment factor
R	1	2	3	R = 1 is AF for same order and trophic level R = 2 is AF for different order and same trophic level R = 3 is AF for different order and trophic level
I	2	2	2	CD rats (15/sex) evaluated. Additional groups of five rats/sex fed similar diets.
Q_1	1	1	1	Ecologically relevant endpoint
Q_2	1	1	1	Chronic (16-weeks) study
Q_3	1	1	1	NOAEL
U	2	2	2	Sufficient numbers of rats of both sexes employed and multiple endpoints studied.
Total AF	4	8	12	$R * I * Q_1 * Q_2 * Q_3 * U$ = Total AF
QCE (mg/kg-day)	750	750	750	QCE = quantified critical endpoint
TRV	188	93.8	62.5	Toxicity Reference Value = QCE/Total AF

Appropriate Functional Groups:

R Value	TRV (mg/kg-day)	Justification	Appropriate Functional Group
1	188	Test organism is in the same order and trophic level as the functional group members	none
2	93.8	Test organism is in a different order and same trophic level from the functional group members	M422, M422A
3	62.5	Test organism is in a different order and trophic level from the functional group members	M121, M122, M122A, M132, M210, M210A, M222, M322

COPC: **Di-n-butylphthalate** CAS 84-74-2

Test Organisms: Rat (Omnivore, Order-Rodentia)
Exposure Medium: Oral
Test Endpoint: NOAEL
Reference: Smith, C.C., 1953, "Toxicity of butyl stearate, dibutyl sebacate, dibutyl phthalate, and methoxyethyl oleate," Archives of Hygiene and Occupational Medicine, 7:310-318.
QCE: 125 mg/kg-day

Adjustment Factors (AF)				Justification for adjustment factor
R	1	2	3	R = 1 is AF for same order and trophic level R = 2 is AF for different order and same trophic level R = 3 is AF for different order and trophic level
I	3	3	3	Only one sex tested. No juveniles tested.
Q_1	1	1	1	Ecologically relevant endpoint
Q_2	1	1	1	Long-term (1-year) study
Q_3	1	1	1	NOAEL endpoint
U	3	3	3	No histopathologic evaluation reported. Existence of other subchronic studies to support the critical effect and the magnitude of the LOAEL are not available. Not clear if effects observed at higher treatment doses were dose-related.
Total AF	9	18	27	$R * I * Q_1 * Q_2 * Q_3 * U$ = Total AF
QCE (mg/kg-day)	125	125	125	QCE = quantified critical endpoint
TRV	13.9	6.94	4.63	Toxicity Reference Value = QCE/Total AF

R Value	TRV (mg/kg-day)	Justification	Appropriate Functional Group
1	13.9	Test organism is in the same order and trophic level as the functional group members	none
2	6.94	Test organism is in a different order and same trophic level from the functional group members	M422, M422A
3	4.63	Test organism is in a different order and trophic level from the functional group members	M121, M122, M122A, M132, M210, M210A, M222, M322

COPC:	**Di-n-octylphthalate** CAS 117-84-0
Test Organisms:	Rat (Omnivore, Order-Rodentia)
Exposure Medium:	Diet
Test Endpoint:	LOAEL
Reference:	Piekacz, H., 1971, "Effect of dioctyl and dibutyl phthalates on the organisms of rats after oral administration in prolonged experiment. II. Subacute and chronic toxicity," Rocz. Panstw. Zakl. Higl., 22(3): 295-307. *
QCE:	174 mg/kg-day (3500mg/kg food)(0.0189kg food/day)/0.38kg BW

Adjustment Factors (AF)				Justification for adjustment factor
R	1	2	3	R = 1 is AF for same order and trophic level R = 2 is AF for different order and same trophic level R = 3 is AF for different order and trophic level
I	2	2	2	100 rats (20/dose) male and females tested
Q_1	0.5	0.5	0.5	Ecological relevance questionable (liver and kidney weights)
Q_2	1	1	1	Chronic duration
Q_3	2	2	2	LOAEL
U	2	2	2	Good design, but no reproductive endpoints evaluated.
Total AF	4	8	12	$R * I * Q_1 * Q_2 * Q_3 * U$ = Total AF
QCE (mg/kg-day)	174	174	174	QCE = quantified critical endpoint
TRV	43.5	21.8	14.5	Toxicity Reference Value = QCE/Total AF

R Value	TRV (mg/kg-day)	Justification	Appropriate Functional Group
1	43.5	Test organism is in the same order and trophic level as the functional group members	none
2	21.8	Test organism is in a different order and same trophic level from the functional group members	M422, M422A
3	14.5	Test organism is in a different order and trophic level from the functional group members	M121, M122, M122A, M132, M210, M210A, M222, M322

*Entire article is in Polish-there is a summary on the last page in English

COPC: **Formaldehyde** CAS 50-00-0

Test Organisms: Rat (Omnivore, Order-Rodentia)
Exposure Medium: Oral (drinking water)
Test Endpoint: NOAEL
Reference: Til, H.P., et al., 1989, "Two-Year Drinking Water Study of Formaldehyde in Rats", *Food Chemical Toxicol,* 27: 77–87.
QCE: 15 mg/kg-day

Adjustment Factors (AF)				Justification for adjustment factor
R	1	2	3	R = 1 is AF for same order and trophic level R = 2 is AF for different order and same trophic level R = 3 is AF for different order and trophic level
I	1	1	1	140 males and females tested.
Q_1	1	1	1	Ecologically relevant endpoint
Q_2	1	1	1	Chronic study (2 years).
Q_3	1	1	1	NOAEL
U	2	2	2	High quality study, four dosing groups, but no reproductive endpoints examined.
M	0.5	0.5	0.5	Placed in drinking water.
Total AF	1	2	3	$R * I * Q_1 * Q_2 * Q_3 * U * M$ = Total AF
QCE (mg/kg-day)	15	15	15	QCE = quantified critical endpoint
TRV	15	7.5	5.0	Toxicity Reference Value = QCE/Total AF

R Value	TRV (mg/kg-day)	Justification	Appropriate Functional Group
1	15	Test organism is in the same order and trophic level as the functional group members	none
2	7.5	Test organism is in a different order and same trophic level from the functional group members	M422, M422A
3	5.0	Test organism is in a different order and trophic level from the functional group members	M121, M122, M122A, M132, M210, M210A, M222, M322

COPC:	**Methyl ethyl ketone (2-Butanone)** CAS 78-93-3
Test Organisms:	Rat (Omnivore, Order-Rodentia)
Exposure Medium:	Oral via drinking water
Test Endpoint:	NOAEL
Reference:	Cox, G.E., D.E. Barley, and K. Morganreidge, 1975, *Toxicity Studies in Rats With 2-Butanol Including Growth, Reproduction, and Teratologic Observations,* Food and Drug Research Laboratories, Inc., Report No. 91MR R 1673, Waverly, New York.
QCE:	1771 mg/kg-day

Adjustment Factors (AF)				Justification for adjustment factor
R	1	2	3	R = 1 is AF for same order and trophic level R = 2 is AF for different order and same trophic level R = 3 is AF for different order and trophic level
I	1	1	1	Multigenerational, multi-sex study
Q_1	1	1	1	Ecologically relevant endpoint
Q_2	2	2	2	Subchronic study, 9 weeks per generation
Q_3	1	1	1	NOAEL
U	2	2	2	Numerous development endpoints measured. Long-term effects in parents not studied. Adequate number of animals tested. Supporting chronic toxicity studies with other species are lacking.
M	0.5	0.5	0.5	Placed in the drinking water.
Total AF	2	4	6	$R * I * Q_1 * Q_2 * Q_3 * U * M$ = Total AF
QCE (mg/kg-day)	1771	1771	1771	QCE = quantified critical endpoint
TRV	885.5	442.8	295.2	Toxicity Reference Value = QCE/Total AF

R Value	TRV (mg/kg-day)	Justification	Appropriate Functional Group
1	885.5	Test organism is in the same order and trophic level as the functional group members	none
2	442.8	Test organism is in a different order and same trophic level from the functional group members	M422, M422A
3	295.2	Test organism is in a different order and trophic level from the functional group members	M122, M122A, M121, M123, M132, M210, M210A, M222, M322

COPC:	**Methylene chloride (dichloromethane)** CAS 75-09-2
Test Organisms:	Rat (Omnivore, Order-Rodentia)
Exposure Medium:	Drinking water
Test Endpoint:	NOAEL
Reference:	National Cancer Association, 1982, *24-Month Chronic Toxicity and Oncogenicity Study of Methylene Chloride in Rats*, prepared by Hazleton Laboratories, Inc. Vienna, VA, unpublished data cited in IRIS.
QCE:	5.85 mg/kg-day

Adjustment Factors (AF)				Justification for adjustment factor
R	1	2	3	R = 1 is AF for same order and trophic level R = 2 is AF for different order and same trophic level R = 3 is AF for different order and trophic level
I	2	2	2	Both sexes tested. No juveniles tested.
Q_1	1	1	1	Ecologically relevant endpoint (liver histology)
Q_2	1	1	1	Long-term (2-year) study
Q_3	1	1	1	NOAEL
U	1	1	1	Well-conducted study, four doses tested: 5.85, 50, 125, and 250 mg/kg-day.
M	0.5	0.5	0.5	Placed in drinking water
Total AF	1	2	3	$R * I * Q_1 * Q_2 * Q_3 * U * M$ = Total AF
QCE (mg/kg-day)	5.85	5.85	5.85	QCE = quantified critical endpoint
TRV	5.85	2.93	1.95	Toxicity Reference Value = QCE/Total AF

R Value	TRV (mg/kg-day)	Justification	Appropriate Functional Group
1	5.85	Test organism is in the same order and trophic level as the functional group members	none
2	2.93	Test organism is in a different order and same trophic level from the functional group members	M422, M422A
3	1.95	Test organism is in a different order and trophic level from the functional group members	M121, M122, M122A, M132, M210, M210A, M222, M322

COPC:	**Naphthalene** CAS 91-20-3
Test Organisms:	Mouse (Omnivore, Order-Rodentia)
Exposure Medium:	Oral
Test Endpoint:	NOAEL
Reference:	Shopp et al., 1984, "Naphthalene toxicity in CD-1 mice: General toxicology and immunotoxicology," *Fundamental and Applied Toxicology*, 4:406-419.
QCE:	5.3 mg/kg-day

Adjustment Factors (AF)				Justification for adjustment factor
R	1	2	3	R = 1 is AF for same order and trophic level R = 2 is AF for different order and same trophic level R = 3 is AF for different order and trophic level
I	2	2	2	Adequate numbers of male and females tested (40-112 of each sex), no juveniles tested.
Q_1	1	1	1	Ecologically relevant endpoint
Q_2	1	1	1	Chronic (90-day) study
Q_3	1	1	1	NOAEL endpoint
U	2	2	2	Reasonable design, but no reproductive endpoints or sensitive life stages examined.
Total AF	4	8	12	$R * I * Q_1 * Q_2 * Q_3 * U$ = Total AF
QCE (mg/kg-day)	5.3	5.3	5.3	QCE = quantified critical endpoint
TRV	1.3	0.66	0.44	Toxicity Reference Value = QCE/Total AF

R Value	TRV (mg/kg-day)	Justification	Appropriate Functional Group
1	1.3	Test organism is in the same order and trophic level as the functional group members	none
2	0.66	Test organism is in a different order and same trophic level from the functional group members	M422, M422A
3	0.44	Test organism is in a different order and trophic level from the functional group members	M121, M122, M122A, M132, M210, M210A, M222, M322

COPC: **Pentachlorophenol (PCP)** CAS 87-86-5

Test Organisms: Rat (Omnivore, Order-Rodentia)
Exposure Medium: Oral in diet
Test Endpoint: NOAEL
Reference: Schwetz, B.A. et al. 1978. Results of two-year toxicity and reproduction studies on pentachlorophenol in rats. pp. 301-309 in R. Rao, ed., Pentachlorophenol: Chemistry, Pharmacology, and Environmental Toxicology. Plenum Press, New York. 401 pp.
QCE: 0.24 mg/kg-day

Adjustment Factors (AF)				Justification for adjustment factor
R	1	2	3	R = 1 is AF for same order and trophic level R = 2 is AF for different order and same trophic level R = 3 is AF for different order and trophic level
I	2	2	2	Rats tested at two dose levels: 3 and 30 ppm
Q_1	1	1	1	Ecologically relevant endpoint (reproduction)
Q_2	1	1	1	Chronic study (62 days prior to mating, 15 days during mating, and through gestation and lactation).
Q_3	1	1	1	NOAEL
U	1	1	1	No adverse effects were observed at the 3 ppm level while survival and growth were significantly reduced, greater than 20%, in rats fed the 30 ppm dose. The 3 ppm dose was considered the NOAEL and the 30 ppm dose was considered the LOAEL.
Total AF	2	4	6	$R * I * Q_1 * Q_2 * Q_3 * U$ = Total AF
QCE (mg/kg-day)	0.24	0.24	0.24	QCE = quantified critical endpoint
TRV	0.12	0.06	0.04	Toxicity Reference Value = QCE/Total AF

R Value	TRV (mg/kg-day)	Justification	Appropriate Functional Group
1	0.12	Test organism is in the same order and trophic level as the functional group members	none
2	0.06	Test organism is in a different order and same trophic level from the functional group members	M422, M422A
3	0.04	Test organism is in a different order and trophic level from the functional group members	M121, M122, M122A, M132, M210, M210A, M222, M322

COPC:	**Phenol** CAS 108-95-2
Test Organisms:	Rat (Omnivore, Order-Rodentia)
Exposure Medium:	Oral in water
Test Endpoint:	NOAEL
Reference:	NTP, 1983, *Teratologic Evaluation of Phenol in CD Rats and Mice.* Report prepared by Research Triangle Institute, Research Triangle Park, NC. NTIS PB83-247726, Gov. Rep. Announce Index 83(25):6247.
QCE:	60 mg/kg-day

Adjustment Factors (AF)				Justification for adjustment factor
R	1	2	3	R = 1 is AF for same order and trophic level R = 2 is AF for different order and same trophic level R = 3 is AF for different order and trophic level
I	1	1	1	Low variability because similar studies exhibited no effects at a dose rate on order of magnitude higher that the NOAEL
Q_1	1	1	1	Ecologically relevant endpoint (reduced fetal body weight).
Q_2	3	3	3	Acute (9 days)
Q_3	1	1	1	NOAEL
U	1	1	1	High quality studies with four dose levels and during a critical life stage (gestation).
M	0.5	0.5	0.5	Placed in drinking water
Total AF	1.5	3	4.5	$R * I * Q_1 * Q_2 * Q_3 * U * M$ = Total AF
QCE (mg/kg-day)	60	60	60	QCE = quantified critical endpoint
TRV	40	20	13	Toxicity Reference Value = QCE/Total AF

Appropriate Functional Groups:

R Value	TRV (mg/kg-day)	Justification	Appropriate Functional Group
1	40	Test organism is in the same order and trophic level as the functional group members	none
2	20	Test organism is in a different order and same trophic level from the functional group members	M422, M422A
3	13	Test organism is in a different order and trophic level from the functional group members	M121, M122, M122A, M132, M210, M210A, M222, M322

COPC:	**Tetrachloroethylene** CAS 127-18-4
Test Organisms:	Mouse (Swiss-cox) (Omnivore, Order-Rodentia)
Exposure Medium:	Gavage (in corn oil)
Test Endpoint:	NOAEL (hepatoxicity)
Reference:	Buben, J.A., and E.J. O'Flaherty, 1985, *Delineation of the Role of Metabolism in the Hepatotoxicity of Trichloroethylene and Perchloroethylene: A Dose-Effect Study,* Toxicol. and Appl. Pharmacol. 78:105-122.
QCE:	14 mg/kg-day Adjusted from 5 to 7 times per week.

Adjustment Factors (AF)				Justification for adjustment factor
R	1	2	3	R = 1 is AF for same order and trophic level R = 2 is AF for different order and same trophic level R = 3 is AF for different order and trophic level
I	2	2	2	Exposure not during critical time frame, males only
Q_1	1	1	1	Ecologically relevant endpoint (hepatotoxicity)
Q_2	1	1	1	Chronic (6 weeks)
Q_3	1	1	1	NOAEL
U	2	2	2	Mice were exposed for 5 days/week. 7 day/week exposure was estimated. Hepatoxicity was observed at doses of 100mg/kg-day (probably increased triglycerides is adverse effect).
Total AF	4	8	12	$R * I * Q_1 * Q_2 * Q_3 * U$ = Total AF
QCE (mg/kg-day)	14	14	14	QCE = quantified critical endpoint
TRV	3.5	1.8	1.2	Toxicity Reference Value = QCE/Total AF

R Value	TRV (mg/kg-day)	Justification	Appropriate Functional Group
1	3.5	Test organism is in the same order and trophic level as the functional group members	none
2	1.8	Test organism is in a different order and same trophic level from the functional group members	M422, M422A
3	1.2	Test organism is in a different order and trophic level from the functional group members	M121, M122, M122A, M132, M210, M210A, M222, M322

COPC:	**Toluene** CAS 108-88-3
Test Organisms:	Rat (Omnivore, Order-Rodentia)
Exposure Medium:	Oral (corn oil)
Test Endpoint:	NOAEL
Reference:	National Toxicology Program (NTP), 1989, *Toxicology and Carcinogenesis Studies of Toluene in F/344 Rats and B6C3F1 Mice,* Technical Report Series No. 371, Research Triangle Park, NC.
QCE:	223 mg/kg-day (312 mg/kg-day)(5days fed/7 days in week)

Adjustment Factors (AF)				Justification for adjustment factor
R	1	2	3	R = 1 is AF for same order and trophic level R = 2 is AF for different order and same trophic level R = 3 is AF for different order and trophic level
I	2	2	2	Males and females tested. No juveniles tested.
Q_1	1	1	1	Ecologically relevant endpoint
Q_2	1	1	1	Chronic (13-week) exposure
Q_3	1	1	1	NOAEL
U	2	2	2	Good number of animals per treatment group tested (20 per dose). Supporting chronic toxicity studies for reproductive and development effects are lacking.
Total AF	4	8	12	$R * I * Q_1 * Q_2 * Q_3 * U$ = Total AF
QCE (mg/kg-day)	223	223	223	QCE = quantified critical endpoint
TRV	55.8	27.9	18.6	Toxicity Reference Value = QCE/Total AF

R Value	TRV (mg/kg-day)	Justification	Appropriate Functional Group
1	55.8	Test organism is in the same order and trophic level as the functional group members	none
2	27.9	Test organism is in a different order and same trophic level from the functional group members	M422, M422A
3	18.6	Test organism is in a different order and trophic level from the functional group members	M121, M122, M122A, M132, M210, M210A, M222, M322

COPC: **Trichloroethylene** CAS 79-01-6

Test Organisms: Rat (Omnivore, Order-Rodentia)
Exposure Medium: Oral
Test Endpoint: NOAEL
Reference: Manson, J. M. et al., 1984, "Effect of Oral Exposure to Trichloroethylene on Female Reproduction Function" *Toxicology* 32:229-242.
QCE: 100 mg/kg-day

Adjustment Factors (AF)				Justification for adjustment factor
R	1	2	3	R = 1 is AF for same order and trophic level R = 2 is AF for different order and same trophic level R = 3 is AF for different order and trophic level
I	2	2	2	Secondary source so information on number and sexes of animals tested unknown.
Q_1	1	1	1	Ecologically relevant endpoint (reproduction)
Q_2	2	2	2	Subchronic exposure
Q_3	1	1	1	NOAEL - no effects on female fertility or neonatal survival
U	1	1	1	Limited information and reproductive endpoints and sensitive life stages examined.
Total AF	4	8	12	$R * I * Q_1 * Q_2 * Q_3 * U$ = Total AF
QCE (mg/kg-day)	100	100	100	QCE = quantified critical endpoint
TRV	25	13	8.3	Toxicity Reference Value = QCE/Total AF

R Value	TRV (mg/kg-day)	Justification	Appropriate Functional Group
1	25	Test organism is in the same order and trophic level as the functional group members	none
2	13	Test organism is in a different order and same trophic level from the functional group members	M422, M422A
3	8.3	Test organism is in a different order and trophic level from the functional group members	M121, M122, M122A, M132, M210, M210A, M222, M322

COPC: **2,3,7,8-Tetracloro Dibenzodioxin (TCDD)** CAS 51207-31-9

Test Organisms: Ring-necked pheasants (Omnivore, Order-Galliformes)
Exposure Medium: Intraperitoneal injection (weekly)
Test Endpoint: NOAEL
Reference: Nosek, J.A., S.R. Craven, J.R. Sullivan, S.S. Hurley, and R.E. Peterson, 1992, "Toxicity and reproductive effects of 2,3,7,8-tetrachlorodibenzo-p-dioxin in ring-necked pheasant hens," *J. Toxicol. Environ. Health.*, 35:187-198.
QCE: 1.4E-5 mg/kg-day

Adjustment Factors (AF)				Justification for adjustment factor
R	1	2	3	R = 1 is AF for same order and trophic level R = 2 is AF for different order and same trophic level R = 3 is AF for different order and trophic level
I	1	1	1	7 females per dose tested. Three dose levels tested: 0.01, 0.1, 1 µp/kg BW/week.
Q_1	0.1	0.1	0.1	Intraperitoneal injection unlikely in field (mortality, egg production, hatchability).
Q_2	1	1	1	10 weeks and during a critical life stage (reproduction)
Q_3	1	1	1	NOAEL
U	2	2	2	Egg production and hatchability was significantly reduced among birds receiving 1 µp/kg/week dose. No significant effects were observed among the other two dose levels so the 0.1 µp/kg/week was considered the NOAEL.
Total AF	0.2	0.4	0.6	$R * I * Q_1 * Q_2 * Q_3 * U$ = Total AF
QCE (mg/kg-day)	1.4E-5	1.4E-5	1.4E-5	QCE = quantified critical endpoint
TRV	7.0E-5	3.5E-5	2.3E-5	Toxicity Reference Value = QCE/Total AF

R Value	TRV (mg/kg-day)	Justification	Appropriate Functional Group
1	7.0E-5	Test organism is in the same order and trophic level as the functional group members	none
2	3.5E-5	Test organism is in a different order and same trophic level from the functional group members	AV422, AV432, AV433,AV442
3	2.3E-5	Test organism is in a different order and trophic level from the functional group members	AV121, AV122, AV132, AV142, AV143, AV210, AV210A, AV221, AV222, AV222A, AV232, AV233, AV241, AV242, AV310, AV322, AV333, AV342

COPC:	**2,3,7,8-Tetrachloro Dibenzodioxin (TCDD)** CAS 51207-31-9
Test Organisms:	Rat (Omnivore, Order-Rodentia)
Exposure Medium:	Oral in diet
Test Endpoint:	NOAEL
Reference:	Murray, F.J. et al. 1979, "Three-generation reproduction study of rats given 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) in the diet," *Toxicol. Appl. Pharmacol.*, 50:241-252.
QCE:	1E-6 mg/kg-day

Adjustment Factors (AF)				Justification for adjustment factor
R	1	2	3	R = 1 is AF for same order and trophic level R = 2 is AF for different order and same trophic level R = 3 is AF for different order and trophic level
I	1	1	1	Adequate number of male and female rats, and juveniles were also tested (three generations) at three dose levels: 0.001, 0.01, and 0.1 μp/kg BW/d.
Q_1	1	1	1	Ecologically relevant endpoint (fertility, neonatal survival).
Q_2	1	1	1	Long-term (3 generations, > 1 year) including critical life stages (reproduction).
Q_3	1	1	1	NOAEL
U	1	1	1	Fertility and neonatal survival was significantly reduced among rats receiving 0.1 μp/kg/d and 0.01 μp/kg/d. The 0.001 μp/kg/d dose showed no significant differences and was considered the NOAEL and the 0.01 μp/kg/d was the LOAEL.
Total AF	1	2	3	$R * I * Q_1 * Q_2 * Q_3 * U$ = Total AF
QCE (mg/kg-day)	1E-6	1E-6	1E-6	QCE = quantified critical endpoint
TRV	1E-6	5E-7	3E-7	Toxicity Reference Value = QCE/Total AF

R Value	TRV (mg/kg-day)	Justification	Appropriate Functional Group
1	1E-6	Test organism is in the same order and trophic level as the functional group members	none
2	5E-7	Test organism is in a different order and same trophic level from the functional group members	M422, M422A
3	3E-7	Test organism is in a different order and trophic level from the functional group members	M122, M122A, M121, M123, M132 M210, M210A, M222, M322

COPC:	**1,3-Dinitrobenzene** CAS 99-65-0
Test Organisms:	Rat (Omnivore, Order-Rodentia)
Exposure Medium:	Drinking water
Test Endpoint:	NOAEL
Reference:	Cody, T.E., et al., 1981. 1,3-Dinitrobenzene: Toxic Effects *In Vivo* and *In Vitro,* Journal of Toxicology and Environmental Health, 7:829-847.
QCE:	0.4 mg/kg-day

Adjustment Factors (AF)				Justification for adjustment factor
R	1	2	3	R = 1 is AF for same order and trophic level R = 2 is AF for different order and same trophic level R = 3 is AF for different order and trophic level
I	1	1	1	4 groups of 20 male and 20 female weanling rats
Q_1	1	1	1	Ecologically relevant endpoint (reproduction)
Q_2	1	1	1	Chronic study (16 weeks)
Q_3	1	1	1	NOAEL
U	2	2	2	Slight to moderate decrease in spermatogenesis; middle exposure level was associated with increased spleen weights; this reaction may be related to handling stress rather than compound administration, it was difficult to classify the exposure level as a NOAEL or a LOAEL
M	0.5	0.5	0.5	Placed in the drinking water
Total AF	1	2	3	$R * I * Q_1 * Q_2 * Q_3 * U * M$ = Total AF
QCE (mg/kg-day)	0.4	0.4	0.4	QCE = quantified critical endpoint
TRV	0.4	0.2	0.1	Toxicity Reference Value = QCE/Total AF

R Value	TRV (mg/kg-day)	Justification	Appropriate Functional Group
1	0.4	Test organism is in the same order and trophic level as the functional group members	none
2	0.2	Test organism is in a different order and same trophic level from the functional group members	M422, M422A
3	0.1	Test organism is in a different order and trophic level from the functional group members	M121, M122, M122A, M132, M210, M210A, M222, M322

COPC:	**Nitrobenzene** CAS 98-95-3
Test Organisms:	Rat (Omnivore, Order-Rodentia)

Exposure Medium: Oral (gavage)
Test Endpoint: FEL
Reference: Levin, A.A. 1988, "The Reversibility of Nitrobenzene Induced Testicular Toxicity: Continuous Monitoring of Sperm Output from Vasocystotomized Rats", *Toxicology* 53:219-230.
QCE: 300 mg/kg-day

Adjustment Factors (AF)				Justification for adjustment factor
R	1	2	3	R = 1 is AF for same order and trophic level R = 2 is AF for different order and same trophic level R = 3 is AF for different order and trophic level
I	2	2	2	Only males tested, but numbers were adequate. Observed effects in the study were noted at lower levels via inhalation
Q_1	1	1	1	Ecologically relevant endpoint (Decreased sperm production).
Q_2	3	3	3	Acute study duration
Q_3	3	3	3	FEL
U	3	3	3	Reasonable design, looked at reproductive (sperm generation) endpoint and morphological endpoints. No NOAEL and LOAEL established, only one dose tested.
Total AF	54	108	162	$R * I * Q_1 * Q_2 * Q_3 * U$ = Total AF
QCE (mg/kg-day)	300	300	300	QCE = quantified critical endpoint
TRV	5.56	2.78	1.85	Toxicity Reference Value = QCE/Total AF

Appropriate Functional Groups:

R Value	TRV (mg/kg-day)	Justification	Appropriate Functional Group
1	5.56	Test organism is in the same order and trophic level as the functional group members	none
2	2.78	Test organism is in a different order and same trophic level from the functional group members	M422, M422A
3	1.85	Test organism is in a different order and trophic level from the functional group members	M121, M122, M122A, M132, M210, M210A, M222, M322

COPC: **2,4-Dinitrotoluene** CAS 121-14-2

Test Organisms: Mouse (Omnivore, Order-Rodentia)
Exposure Medium: Diet

Test Endpoint: LOAEL

Reference: Hong, C.B., et al., 1985. Subchronic and Chronic Toxicity Studies of 2,4-Dinitrotoluene. Part III. CD-1 Mice, Journal of the American College of Toxicology, 4(4):257-269.

QCE: 14 mg/kg-day

Adjustment Factors (AF)				Justification for adjustment factor
R	1	2	3	R = 1 is AF for same order and trophic level R = 2 is AF for different order and same trophic level R = 3 is AF for different order and trophic level
I	1	1	1	Groups of 38 male and female weanling mice (CD-1 strain)
Q_1	1	1	1	Ecologically relevant endpoint (reproduction)
Q_2	1	1	1	Chronic study (2 years)
Q_3	2	2	2	LOAEL
U	2	2	2	Males exposed to this dose equivalent had a decreased body weight gain. No NOAEL was established.
Total AF	4	8	12	$R * I * Q_1 * Q_2 * Q_3 * U$ = Total AF
QCE (mg/kg-day)	14	14	14	QCE = quantified critical endpoint
TRV	3.5	1.8	1.2	Toxicity Reference Value = QCE/Total AF

R Value	TRV (mg/kg-day)	Justification	Appropriate Functional Group
1	3.5	Test organism is in the same order and trophic level as the functional group members	none
2	1.8	Test organism is in a different order and same trophic level from the functional group members	M422, M422A
3	1.2	Test organism is in a different order and trophic level from the functional group members	M121, M122, M122A, M132, M210, M210A, M222, M322

COPC: **2,6-Dinitrotoluene** CAS 606-20-2

Test Organisms: Dog (Omnivore, Order-Carnivora)
Exposure Medium: Diet
Test Endpoint: LOAEL

Reference: Lee, C.C. et al. 1976. *Mammalian Toxicity of Munitions Compounds, Phase II, Effects of Multiple Doses, Part III: 2,6-Dinitrotoluene, Progress Report No. 4*, Midwest Research Report Institute Project No. 3900-B, Contract No. DAMD-17-74-C-4073.

QCE: 20 mg/kg-day

Adjustment Factors (AF)				Justification for adjustment factor
R	1	2	3	R = 1 is AF for same order and trophic level R = 2 is AF for different order and same trophic level R = 3 is AF for different order and trophic level
I	1	1	1	4 groups of 4 females and 4 male beagle dogs were given 4, 20, or 100 mg/kg/day of 2,6-DNT in capsules.
Q_1	1	1	1	Ecologically relevant endpoints (weight gain, reproductive effects)
Q_2	1	1	1	Chronic study (13 weeks)
Q_3	2	2	2	LOAEL
U	2	2	2	The 4 mg/kg/day dose showed little if any toxic effects while the 20 and 100 mg/kg/day doses showed more severe effects. The latter two doses produced decreased feed intake and atrophy of the testes. All dogs in the 100 mg/kg/day dose group died so the 20 mg/kg/day was considered the LOAEL.
Total AF	4	8	12	$R * I * Q_1 * Q_2 * Q_3 * U$ = Total AF
QCE (mg/kg-day)	20	20	20	QCE = quantified critical endpoint
TRV	5.0	2.5	1.7	Toxicity Reference Value = QCE/Total AF

R Value	TRV (mg/kg-day)	Justification	Appropriate Functional Group
1	5.0	Test organism is in the same order and trophic level as the functional group members	M422A
2	2.5	Test organism is in a different order and same trophic level from the functional group members	M422
3	1.7	Test organism is in a different order and trophic level from the functional group members	M121, M122, M122A, M123, M210, M210A, M222, M322

COPC: **Pentachloronitrobenzene (PCNB)** CAS 82-68-8

Test Organisms: Chicken (Omnivore, Order-Galliformes)
Exposure Medium: Oral in diet
Test Endpoint: NOAEL
Reference: Dunn, J.S. et al. 1979. Effect of pentachloronitrobenzene upon egg production, hatchability, and residue accumulation in the tissues of White Leghorn hens. Toxicol. Appl. Pharmacol. 48: 425-433.

QCE: 7.07 mg/kg-day (100mg/kg food)(106g food/day)(1kg/1000g)/1.5kg BW

Adjustment Factors (AF)				Justification for adjustment factor
R	1	2	3	R = 1 is AF for same order and trophic level R = 2 is AF for different order and same trophic level R = 3 is AF for different order and trophic level
I	1	1	1	Hens tested at four dose levels: 10, 50, 100, and 1000 ppm.
Q_1	1	1	1	Ecologically relevant endpoint (reproduction)
Q_2	1	1	1	Chronic study, 35 weeks (>10 during a critical lifestage)
Q_3	1	1	1	NOAEL
U	2	2	2	Egg production and egg hatchability was reduced among birds receiving the 1000 ppm dose. No effects were observed at the other dose levels so the 100 ppm dose was considered the NOAEL.
Total AF	2	4	6	$R * I * Q_1 * Q_2 * Q_3 * U$ = Total AF
QCE (mg/kg-day)	7.07	7.07	7.07	QCE = quantified critical endpoint
TRV	3.54	1.77	1.18	Toxicity Reference Value = QCE/Total AF

R Value	TRV (mg/kg-day)	Justification	Appropriate Functional Group
1	3.54	Test organism is in the same order and trophic level as the functional group members	none
2	1.77	Test organism is in a different order and same trophic level from the functional group members	AV422, AV432, AV433,AV442
3	1.18	Test organism is in a different order and trophic level from the functional group members	AV121, AV122, AV132, AV142, AV143, AV210, AV210A, AV221, AV222, AV222A, AV232, AV233, AV241, AV242, AV310, AV322, AV333, AV342

Appendix H

Revised Responses to Technical Review Comments for the Screening Level Risk Assessment (SLRA) for the New Waste Calcining Facility

December 1998

Revised April 1999

REVISED RESPONSES TO TECHNICAL REVIEW COMMENTS FOR THE SCREENING LEVEL RISK ASSESSMENT (SLRA) FOR THE NEW WASTE CALCINING FACILITY IDAHO NATIONAL ENGINEERING AND ENVIRONMENTAL LABORATORY (INEEL)

December 1998

Revised April 1999

INTRODUCTION

This document provides revised responses to Technical Review Comments for the *Screening Level Risk Assessment (SLRA) for the New Waste Calcining Facility* (Draft Revision 2, September 1997), EPA ID No. ID4890008952, received on March 18, 1998 from the DEQ Hazardous Waste Permitting Bureau (HWPB)[a]. A response to these NOD comments and a revised SLRA (Revision 3) was submitted to DEQ in May 1998. In November 1998, a letter was received from DEQ stating that the NOD responses were not acceptable, the SLRA was not reviewed by EPA or DEQ, and a final SLRA be submitted to DEQ no later than December 31, 1998. This document provides revised NOD responses which describe the additional revisions made for this SLRA submittal (Revision 4a). Included are a general discussion of the SLRA process as specified in EPA guidance, description of some revisions made after submittal of the Revision 2 that were not identified in the review comments, and DOE's revised responses to the general and specific review comments included in the March NOD. The current revision of the SLRA contains significant additional analyses and discussion relating to the NOD comments.

For this SLRA and all previous versions, Contaminants of Potential Concern (COPCs) were determined and emission rates were calculated using best available process knowledge rather than trial burn measurements, which have proven impossible in the past due to the high acid environment of the NWCF offgas. This process knowledge consisted of conservative feed rate concentrations, conservative estimates of offgas partitioning and HEPA filtration, and conservative estimates Products of Incomplete Combustion (PIC) formation using worst-case combinations of known PIC precursors in the feed. New emissions testing is planned for the NWCF in an Offgas Demonstration Project (ODP) during the period January through April, 1999, after which it is planned to shutdown the NWCF. The results of the ODP, which are estimated to be available by the end of June 1999, will be used to determine whether the COPC emission rates evaluated in this SLRA conservatively bound the impacts from NWCF operations. If the ODP results show that actual emissions are higher than those evaluated in the SLRA, or if significant additional COPCs are detected, then DOE may decide to further revise this SLRA. This decision will also be based on the results of the High Level Waste Environmental Impact Statement (HLWEIS) which will determine whether or not the NWCF will be restarted. If a decision is made to restart the NWCF, then the SLRA may be further revised using the COPC emission rates determined in the ODP and new risk assessment guidance published in EPA's draft *Human Health Protocol for Hazardous Waste Combustion Facilities* (EPA530-D-98-001A, July 1998) (HHRAP). The decision on the future of the NWCF is scheduled to be made by June 1, 2000.

This revision of the SLRA was completed in accordance with concise guidelines specified in 1) *Guidance for Performing Screening Level Risk Analyses at Combustion Facilities Burning Hazardous Waste*, EPA Draft Attachment C, December 14, 1998 and 2) *Exposure Assessment Guidance for RCRA Hazardous Waste Combustion Facilities*, EPA530-R-94-021, April 1994. Since submittal of Revision 3 of the SLRA in May 1998, The new HHRAP was published by EPA in July 1998. Significant efforts were made in

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[a] Letter from Randal W. Steger, Manager, DEQ Hazardous Waste Permitting Bureau, to Donald N. Rasch, DOE – Idaho Operations Office, March 16, 1998.

Revision 4 of the SLRA to incorporate some of these new risk assessment methods. However, because this guidance was not released by EPA until after submittal of Revision 3 and because the State response to the May 1998 Revision 3 was not received from DEQ until November 22, 1998, not all of the new HHRAP requirements could be incorporated in time to meet the DEQ's December 31, 1998 "final" SLRA submittal date.

A major concern expressed by DEQ in their November letter response was that the qualitative ecological risk discussion included as part of Revision 3 (Section 8) was not adequate. The letter stated, "an ecological component to the risk assessment is required" and that the SLRA must evaluate the "potential magnitude of the ecological effects" from NWCF emissions. DOE believes that the qualitative ecological risk discussion in Revision 3 was done in accordance with the most current EPA SLRA guidance (1994) available at the time (which specifies a qualitative ecological risk assessment) and that it was also a "component" of the May 1998 Revision 3 of the SLRA. Although EPA has not currently published new quantitative ecological risk assessment guidelines, a Risk Assessment Work Plan (RAWP) that describes quantitative ecological risk assessment methods done for another EPA Region X combustion unit[b] was received by DOE in early December 1998. This RAWP is reportedly based on new ecological risk assessment methods for combustion units which may be published by the EPA's Office of Solid Waste (OSW) in the Spring of 1999. However, although this RAWP list critical input parameters and methods required to do an adequate quantitative assessment, there was not adequate time to perform this assessment for the NWCF SLRA by December 31, 1998. DOE will re-examine the need to do a full quantitative ecological risk assessment after the HLWEIS is published and a decision is made on whether to restart and permit the NWCF. This decision will be made by June 1, 2000, in accordance with the Notice of Noncompliance Consent Order.

Revision 5 Addendum (April 1999) - A quantitative Screening Level Ecological Risk Assessment (SLERA) was completed for revision 5 of the SLRA (Section 8).

GENERAL RESPONSE TO THE NOD

The 1994 EPA risk assessment guidance that was followed for this SLRA was developed with conservative assumptions to adequately bound investigation of refined exposure scenarios or additional detailed assessment. As the guidance states (p. C-1-1), "The screening procedure is intended to give a conservative estimate of the potential risk in order to determine whether a more detailed site-specific assessment is warranted...If the final estimated risk is below levels of concern, then there is good reason to conclude that further analysis of the risk from stack emissions is unnecessary." Since the results of the NWCF SLRA indicate that potential health impacts are significantly less than health criteria, additional refined investigations beyond the scope of the guidance should not be necessary. However, for this revision, effort was made to address additional exposure concerns that would not necessarily affect the final risk results.

Based on both the 1994 EPA risk assessment guidance and the new HHRAP, the objectives of the NWCF SLRA were to demonstrate that maximum potential risk from NWCF emissions is less than the 10^{-5} cancer risk criteria and 0.25 non-cancer hazard index. Efforts to develop best-estimate predictions at significantly less impact levels than these criteria were not considered to be justified. Since the maximum risk estimate determined in the SLRA is a factor of 10 less than the risk criteria, additional refinements that would likely reduce the risk estimate were not done. An example of this would be the very difficult investigation of all

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b. Allied Technology Group, Inc. (ATG) Risk Assessment Work Plan for the ATG Richland Mixed Waste Facility, October 9, 1998.

Products of Incomplete Combustion (PICs) when it can be demonstrated through conservative assumptions of feed materials and conservation of mass that worst-case production of a subset of highly toxic indicator PICs (dioxins/furans and nitroaromatics) would bound the impacts from all PICs actually emitted.

REVISIONS NOT IDENTIFIED IN TECHNICAL REVIEW COMMENTS

An error was identified in a parameter value input for soil volatilization loss (rainfall rate was mistakenly used for the universal gas constant). Correction of this error resulted in a significant decrease in indirect impacts for volatile constituents. As a result, indirect risk decreased from 1E-06 to 1E-07 and the indirect hazard index decreased from 0.07 to 0.02.

Mercury (Hg) emission estimates were increased based on Hg analyses of charcoal beds in the main stack radioiodine sampler during NWCF campaign H-4 from June 25, 1997 through December 23, 1997. These measurements indicated 2.9% to 3.24% of the Hg in the feed was being released out the main stack, which is higher than the 1% assumed in the SLRA. As a result, Hg releases were increased in the SLRA from 28 kg/y to 100 kg/y (corresponds to a 3.57% Hg release rate). This increased the SLRA hazard quotient for Hg from 0.0003 to 0.001 (indirect). The SLRA health criteria for hazard index is 0.25. **Revision 5 Addendum** – Mercury emission estimates (and the resulting hazard) were recalculated based on analysis of three charcoal filter samples (see section 2).

The 1996 main stack emissions of iodine-129 (^{129}I) was corrected from 0.0554 Ci to 0.106 Ci to account for an undetected increase in dilution air entering the main stack gaseous monitoring system[c]. This increased the maximum calculated risk from 8E-07 to 1E-6 (Section 6.4).

The Idaho Chemical Processing Plant (ICPP) changed its name to the Idaho Nuclear Technology and Engineering Center (INTEC) after transmittal of Revision 3 of the SLRA. This revision has replaced ICPP with INTEC.

GENERAL COMMENTS

1. Certain significant gaseous emissions are not considered in the SLRA beyond the acute inhalation effects. These emissions which include some highly noxious materials such as oxides of nitrogen (NO_x) nitric acid (HNO_3) sulfur dioxide (SO_2), and hydrogen fluoride (HF) must be evaluated in the SLRA (see **Specific Comment #13,** below).

Response: The SLRA was revised as requested. The gases listed in the comment (NO_2, HNO_3, SO_2, and HF) were not evaluated in the original calculations because EPA inhalation toxicity criteria (URFs and RfCs) were not available. In the revised SLRA, toxicity criteria are calculated from either EPA Region III Risk Based Concentrations (RBCs) or State of Idaho AACCs/AACs. The resulting risk or HQ for each gas is now included in the inhalation risk (Table 8) and the inhalation HQ calculations (Table 9). **Revision 5 Addendum** – new toxicity values were used (see section 5).

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[c] LMITCO letter from S.K. Zohner to J.P. Law, *^{129}I CORRECTION TO THE 1996 RADIOACTIVE NESHAP REPORT FOR THE INEEL – SKZ-05-98*, July 28, 1998.

2. The assumption that the composition of the emissions from the calciner is inert with respect to the other off-gas streams is not appropriate. The air pollution control devices and stack are ancillary equipment to the calciner and the potential for reactions that result in toxic emissions as a result of the mixing of many off-gas streams must be evaluated and incorporated in the SLRA.

Response: The SLRA was revised to include a discussion of the potential for additional reactions in the off-gas streams and resulting PIC emissions. The NWCF operates continually and contributes the vast majority of radionuclide, gases, chlorine, metals, and organic emissions to the main stack. Other significant off-gas waste streams which are intermittently vented to the main stack include the High Level Liquid Waste Evaporator (HLWE) and the Liquid Effluent Treatment and Disposal facility (LET&D). The HLWE does not operate at the same time as the NWCF. The LET&D has smaller emission rates of the same general types of contaminants as the NWCF, and, as a result, would not contribute appreciably to formulation of additional contaminants as a result of mixing in the off-gas stream. In addition, the general possibility of additional reactions in the offgas and main stack are extremely remote because of the ambient temperature, high flow rate (123,000 acfm), and low contaminant concentrations in the offgas. Therefore, detailed evaluation of these other off-gas streams would not result in appreciable change to the COPC list and the respective COPC emission rates. **Revision 5 Addendum** – quantitative estimates of emission rates from other NWCF/main stack sources have been made and assessed in the risk assessment (see section 2).

3. Potentially significant on-site receptors have not been evaluated. The adult resident scenario does not factor in the highly likely combination of residence and worker exposures (see Specific Comments 9 and 10 below). On-site hunter and herder scenarios shall be added to the SLRA (see Specific Comments 1 and 10 below).

Response: The SLRA was revised as follows:

Onsite Worker Impacts. Maximum inhalation impacts for an INEEL worker at any adjacent on-site INEEL facility (excluding INTEC) were evaluated by examining the maximum air concentration isopleths shown in Figure 7 and the inhalation toxicity criteria given in Tables 8 and 9. The maximum air concentration at any adjacent facility is 0.025 ug/m^3 per g/s at the northwest corner of the Central Facilities Area (CFA) (UTM location 342630 East and 4821520 North) which is 40% of the maximum off-site concentration (0.062 ug/m^3 per g/s) (the off-site concentration is higher because of elevated terrain) Using the off-site risk results from Table 8, the maximum cancer risk to an individual that continuously resided at the worst-case CFA location would be 3.2E-07 (40% of the maximum offsite cancer risk). Since workers are only present for 2000 hours per year (out of the total 8760 hours per year), the maximum cancer risk scaled for worker residence time (x 2000 hrs/8760 hrs) is 7.3E-08. The maximum total hazard index was calculated to be 0.036, or 40% of the maximum offsite hazard index (0.09) in Table 9. Indirect (ingestion) impacts to workers were not assessed because there is no food grown or produced at the INEEL. **Revision 5 Addendum** – the worker and herdsman cancer risks and hazard quotients were revised based on revised emission rate data (see Section 6).

On-site Herdsman Scenario. A hypothetical herdsman was assumed to reside for 1/3 of a year at the point of maximum deposition on the INEEL south of US20 (where grazing is allowed). The herdsman is assumed to be exposed to contaminants through inhalation and consumption of meat from livestock (sheep or cattle) that have been raised at that location and incidental soil ingestion. The herdsman consumption rates for these media and the years of exposure are assumed to be the same as those evaluated for subsistence farmer scenario. The herdsman consumes no contaminated milk or produce because dairy cows or produce production are not allowed on the INEEL.

The maximum inhalation impacts at this location were evaluated in a similar manner to the on-site worker (above) by scaling the maximum off-site inhalation impacts given in Tables 8 and 9 based on the ratio of air concentrations between the herdsman location and the maximum off-site impact location. Using Figure 7, the maximum air concentration at any location south of U.S. highway 20 is 0.065 ug/m^3 per g/s which is almost the same as the maximum off-site location (0.062 ug/m^3 per g/s) (the off-site value is relatively high because of elevated terrain). Accounting for the assumed 1/3 year residence time at the grazing location, the maximum risk due to inhalation would be 8E-07/3, or 2.7E-07. The maximum total Hazard Index would be approximately the same as that at the maximum offsite location in Table 9, 0.09. **Revision 5 Addendum** – the worker and herdsman cancer risks and hazard quotients were revised based on revised emission rate data (see Section 6).

An upper-bound estimate of the indirect (ingestion) impacts for the herdsman were assessed by assuming that the indirect fate/transport equations and parameter values used for the subsistence farmer bound the herdsman's potential intake. Since total intake (and therefore risk) is directly proportional to deposition rate (deposition rate is in the numerator of the soil equation) and the exposure time, the calculated subsistence farmer total indirect cancer risk from Table 12 (1E-07) can be scaled to upper-bound herdsman risk by multiplying by the ratio of deposition rates at the two locations (D_{herd}/D_{farm}) and the ratio of the annual residence times for the two scenarios (T_{herd}/T_{farm} = 4 months/12 months = 1/3). Using Figure 8, the maximum deposition rate at any herdsman location south of U.S. highway 20 is 1.3E-03 g/m^2-year per g/s. Dividing this value by the maximum off-site deposition rate (at which the subsistence farmer was evaluated) of 6.9E-04 g/m^2-year per g/s gives a D_{herd}/D_{farm} value of 1.9. Multiplying the subsistence farmer risk from Table 12 (1E-07) by these factors (0.33 x 1.9 = 0.63) gives an estimated total indirect cancer risk estimate for the herdsman of 6.3E-08. The indirect exposure hazard index for the herdsman was calculated to be 0.011, by multiplying the indirect hazard index for the farmer (6E-03, Table 13) by the ratio of the deposition rates at the two locations (1.9). By scaling the subsistence farmer total impacts, both the cancer risk estimate and the hazard index estimate for the herdsman are overestimates of any potential herdsman risk because the herdsman does not consume contaminated milk or produce (as assumed for the farmer). **Revision 5 Addendum** – the worker and herdsman cancer risks and hazard quotients were revised based on revised emission rate data (see Section 6).

On-site hunter scenarios south of the NWCF facility are not considered a significant exposure scenario (relative to other assessed scenarios) because:

1) Controlled hunting access is allowed only within one-half mile of the INEEL boundary on infrequent occasions and usually only occurs on the north end of the site adjacent to the farms west of Mud Lake (approximately 50 km northeast of NWCF) and on the northwest site boundary on the southern terminus of the Lemhi Range. A revised figure (Figure 1) was added to the SLRA to show these areas.

2) The Environmental Science and Research Foundation (Warren and Mitchell, in press) recently completed a major big game dose study on the INEEL that examined measured radionuclide concentrations in deer and pronghorn antelope on the INEEL over the period 1972 through 1996. In the vast majority of animals examined, tissue concentrations were similar to background levels and were attributed to global fallout from nuclear weapons testing. Although this study did not examine organic or metal contaminant concentrations, it indicates that this exposure pathway is not likely to be significant at the INEEL.

3) Calculated impacts for a hypothetical hunter are bounded by the subsistence farmer scenario because of the relative ingestion rates of contaminated meat assumed in the exposure equations (the hunter eats limited amounts of potentially contaminated game while the farmer continuously consumes contaminated beef, milk, and vegetables). Since the calculated subsistence farmer risk (1E-07) and hazard index (0.006) were significantly less than the SLRA criteria (1E-05 risk and 0.25 hazard index), the calculated hypothetical hunter impacts would also be less than these criteria.

4. Based on the modeling described in the SLRA, it is unclear whether the areas of highest deposition were outside the boundaries of the INEEL or whether only the highest areas outside the boundaries of the INEEL were considered. The text shall identify the areas of highest deposition and adjust the SLRA as appropriate. Figures 4, 5, 6, and 7 should be revised to present this information more clearly. Scales should be added and, where appropriate, landmarks other than the gross UTM coordinates included.

Response: The SLRA was revised. It is stated in Chapter 3 that only off-INEEL locations and U.S. public highways that traverse the INEEL were evaluated in the refined grid modeling. All maximum off-site deposition results occurred on the north end of Big Southern Butte which is shown in Figure 5. Figure 5 has been modified to more clearly identify INEEL landmarks. Figures 7 and 8 were included as an aid to the reader to demonstrate that 1) the maximum vapor concentration and particulate deposition rate values occurred on the same (Big Southern Butte) refined grid and 2) the grid boundaries adequately encompassed the maximum values (the maximum value was centered in the grid). A larger scale landmark map is included with each of these figures.

5. The dispersion modeling analysis that was conducted using the 50-kilometer coarse grid evaluated only annual average concentrations for the particulate and vapor scenarios. The results of these modeling runs were used to select the location of the fine receptor grids. Because maximum short-term impacts can occur in different locations than maximum annual impacts, short-term concentrations should be evaluated in the coarse grid model runs. The results of these model runs should be used to develop additional fine receptor grids, if necessary.

Response: The SLRA was revised to better explain why a coarse grid is not needed to assess short-term impacts. Maximum short-term impacts for the public will occur on U.S. highway 20 (a line) which is adequately assessed using a string of discrete receptors (shown in Figure 6).

6. Emissions of radionuclides from the calciner must be accounted for in terms of overall risk, even though radiation releases are not a direct subject of the RCRA Part B permit application. Because those releases contribute to the overall risk posed by the calciner, they must be accounted for to assess whether releases from the calciner pose no unacceptable risks to human health or the environment (see Section 2.2.5). Slope values for individual radionuclides are available in Health Effects Assessment Summary Tables (HEAST). A methodology for estimating excess cancer risks from radioactive materials is detailed in EPA document, "Radiation Exposure and Risk Assessment Manual (RERAM): Risk Assessment Using Radionuclide Slope Factors, Office of Radiation and

Indoor Air, June 1996, EPA 402-R-96-016." A summary of this approach can also be found in EPA document "A Summary of Radiation Risk Assessment Using Radionuclide Slope Factors," August 1996. Application of this approach is also addressed in OSWER No. 9200.4-18.

Response: The SLRA was revised. Radionuclides were evaluated for lifetime excess cancer risk using the 1997 INEEL National Emission Standards for Hazardous Air Pollutants (NESHAP) dose rate from the INTEC main stack (0.316 mrem/yr), current EPA risk factors for morbidity taken from *Estimating Radiogenic Cancer Risk* (EPA 402-R-93-076), which is the basis for the RERAM document, and conservative assumptions of exposure duration. Radionuclide risk was not calculated using radionuclide slope factors because: (1) the current exposure equations given in the combustion guidance need to be revised by EPA to include the effects of decay and ingrowth and the fate and transport parameter values for common radionuclides, (2) there are several technical problems with using slope factors, which were developed for buried waste at CERCLA sites, to assess surface fallout from combustion facilities (e.g. the ground surface external exposure slope factor assumes an infinite thickness of the radionuclide in the soil while fallout remains mostly on the surface), and 3) risk from radionuclides should be calculated consistently with the EPA NESHAP requirements, which uses the fate and transport equations in the CAP-88 code. Both are EPA assessments for the same facility releases, and both are subject to public review. It is generally recognized that the CAP-88 fate and transport equations are conservative compared to those in the combustion guidance. For instance, CAP-88 defaults to a 100-yr-soil buildup time for surface deposition resulting in much higher indirect intake (from food products and ground surface gamma pathways).

SPECIFIC COMMENTS

1. **Section 1.3, page 4.** The text states that stock herdsmen and hunters are permitted within the INEEL boundary; however, short-term modeled impacts have not been evaluated inside the facility boundary. The dispersion modeling should include receptors to evaluate potential short-term impacts to herdsmen and hunters.

Response: The SLRA was revised to include a on-site herdsman scenario. The hunter scenario was examined and determined not to be a significant scenario. The basis for this determination was added to the SLRA (see response to **General Comment # 3**)

2. **Section 2.** This section of the SLRA must be amended to discuss the potential for fugitive emissions from the facility (i.e., tank farm facility, etc.) and any potential air pollution control equipment bypass events. Any fugitive emissions or bypass events identified should be estimated and incorporated into the risk assessment. Also, as this is an operating facility, a discussion of actual upset operating events that have occurred (e.g., problems with the fluidized bed or temperature excursions) should be included and compared with the upset factors used in the risk assessment.

Response: The SLRA was revised to include the following discussion of the potential for fugitive emissions, air pollution control by-pass events, and upset operating events:

Fugitive emissions are prevented by operating the INTEC processes, including the tank farm, under vacuum so that leakage is inward. The process equipment is located in cells whose exiting ventilation air is monitored to verify the absence of leakage from the process equipment. The cell ventilation air is discharged to the stack.

The most significant air pollution control by-pass event is filter deterioration that is a partial by-pass. Filter deterioration is considered in Appendix C of Appendix A and averaged into the average filter efficiency used for the calculations (see discussion on upset factors, below). The silica-gel adsorbers can be by-passed. The emission rate calculations took no credit for the adsorbers (DF=1) to conservatively account for this. The scrub system cannot be bypassed. Its loss of scrub solution leads to a rapid shutdown.

Most operating upsets result in reduced feed rates or shutdown thus reducing emissions. Maximum emissions of the most significant species (e.g., Hg) occur with smooth operation at the maximum feed rate. Temperature excursions have not been observed. The controller is programmed to shut off feed if a temperature excursion occurs. Inadequate fluidization leads to reduced feed rates and often to shutdown. Plugging of the solids discharge from the product removal cyclone leads to increased solids flow into the scrub system. The incremental solids from the cyclone are relatively large and readily removed by the scrubber. The increased solids to the scrubber usually leads to increased scrub solution purging which reduces the Hg emission. Excessive fines generation from improper feed composition results in increased fines to the scrub system and possibly to increased solids emissions. Improper feed formulations usually lead to reduced feed rates and they are normally corrected when the problem is recognized.

No upset factors (increases in the calculated emission rates modeled in the risk assessment) were used or needed for most of the organic and volatile metal constituents (those with an assumed DF of 1) because 100% of the feed constituents were assumed to be released (what goes out cannot be greater than what goes in). An upset factor of 1.45 was applied to the five organic constituents with an assumed DF of 100. No upset factors were used or needed for the PICs that were evaluated because PIC emissions assumed 100% of the necessary precursors were converted to a worst-case PIC release rate (please read section 2.2.4). An upset factor was indirectly incorporated for non-volatile metal emissions by using a "degraded" NWCF (3 bank) HEPA filter decontamination factor (DF=1E+5, penetration=1E-5). This DF was determined by examining 3 years of on-line filter performance measurements (see Appendix A). The NWCF HEPA filters always meet a maximum test criteria of DF>1E+7 (penetration < 9E-8) at installation and normally meet this criteria in annual tests thereafter. The use of the degraded DF (1E+5) in the risk assessment is equivalent to a "filtration upset factor" of 100 (1E+7/1E+5), which conservatively bounds the EPA default upset factors. **Revision 5 Addendum** – the particulate DF has been revised (see Section 2).

3. **Section 2.2.1, page 13**. Most of the "decontamination factors" for metals discussed in this section are derived from the effects of the high-efficiency particulate air (HEPA) filters; however, HEPA filters are effective only for particles over a certain size, typically 0.1 micrometers. The filters have little effect on smaller particles including volatilized chemicals that are present in molecular-sized particles. Although the volatile metal compounds are handled acceptably, there is no mention here or in Appendix A of any determination of the actual size distribution of the particles containing the nonvolatile metals. If any part of that size distribution is less than the effective cutoff point of the HEPA filters, the actual emissions can be 9 to 11 orders of magnitude higher than the assumed worst-case emissions used in the SLRA and still be consistent with the measured emission rates. The revised SLRA must contain information on particle size distribution

that will support the conclusions on the efficacy of the filters or must include suitably larger emission estimates of the nonvolatile metals.

Response: This comment is based on an incorrect premise that HEPA filters do not remove fine particles. HEPA filters do remove effectively particles smaller than 0.1 micron diameter, although by a different removal mechanisms than the larger particles (if this were not true, industrial clean rooms would not be possible). HEPA filters have a minimum removal efficiency at a particle diameter, which depends on particle size and shape, between 0.1 and 0.3 microns. HEPA filters are normally rated for a test aerosol approximating the most-penetrating particle size (e.g., 0.3 micron DOP particles). Both larger and smaller particle sizes are removed at a higher efficiency than the rated efficiency. See reference: A. Lieberman, & R. D. Scott, "Atmospheric Particle Penetration through High Efficiency Filters", Proceedings of the 11th AEC Air Cleaning Conference, (1970), Conf 700816, p. 751-764. Also, please see the discussion on non-volatile metal filter upset factors in the previous comment.

The size of the particles in the NWCF effluent containing the metals cannot be measured because concentrations are too small to measure. The particle size distribution expected to be discharging from a series of HEPA filters centers on the particle size for which the filters are least efficient. For air modeling purposes, particle sizes were calculated from published emissions data from medical waste incinerators and penetration through three HEPA filters (see comment #8). This was the same method used to calculate the particle size distribution for the Waste Experimental Reduction Facility (WERF).

4. **Section 2.2.1, page 14, Table 2.** The metals presented in this table are based on guidance for human health effects. Additional metals such as aluminum, copper, and zinc can have a significant effect on environmental receptors. While the NWCF waste feed is known to contain aluminum complexes, the waste composition data does not contain information on these elements. These additional metals shall be added as appropriate to the list of. chemicals emitted from the calciner and included as appropriate in the SLRA.

Response: The SLRA was revised to include the following discussion:

> Other low-toxicity metals (e.g. zinc and copper) are present in some the waste. The aluminum species in the NWCF feed all become inert solids (Al_2O_3 or $NaAlO_2$) which are emitted only in small quantities. Copper and zinc are present in the waste only in trace concentrations (from their use in chemical analyses) and are likewise emitted only as solids. The trace emissions of all these metals are then subject to removal by four banks of HEPA filters (overall decontamination factor of 6E+11; see section 2.2.1). **Revision 5 Addendum** – Zine and manganese were evaluated for the ecological risk assessment (section 8) using preliminary offgas emissions sampling results. Also, the particulate DF has been revised (see section 2).

5. **Section 2.23.** A copy of reference, Schindler, R.E., 1995, should be provided so it may be reviewed in support of the proposed characterization of organic emissions from the burning of kerosene fuel. Schindler states that the primary organic emissions of burning kerosene fuel consist of CO, $C0_2$, and some unburned fuel consisting mostly of nontoxic light hydrocarbons (methane and ethane). This statement is not consistent with the emission data reported to the air program, which indicates stack emissions of 1.38 tons per year of hexone, (4-methyl-2-pentanone or methyl isobutyl ketone) and 2.37 tons per year of methanol. Further, chloromethane and dichloromethane (methylene chloride) are

potential emissions from the burning of kerosene fuel with chlorine bearing materials (see Specific Comment 7 below).

Response: The emissions of MIBK and methanol reported in the air program are earlier worst-case estimates of maximum potential concentrations in one out of six waste tanks that will be calcined. They have not been identified as COPCs through sampling of the NWCF feed. The ODP may provide some additional information on these low toxicity compounds when it is performed in early 1999. However, the potential formation of chemicals like chloromethane and methylene chloride is conservatively accounted for by assuming all available chlorine in the feed forms the much more toxic PIC, pentachloronitrobenzene (see response to comment 7, below). This assumption conservatively bounds the risk from any combination of PICs that require chlorine to form (including chloromethane and methylene chloride).

6. **Sections 2.2.3 and 2.2.4.** The SLRA must include a factor to account for the mass of the unknown organic compounds in the stack emissions.

Response: The "unknown organic emissions factor" referred to in the comment is used when the risk assessment is based on measured stack emissions, only a portion of which are identified compounds. Since the NWCF emissions are based on conservative assumptions of 100% release of organics in the feed and 100% conversion of the unburned fuel to a toxic indicator PIC (see response to comment 7, below) rather than stack emissions testing and since there are no significant unknown organics in the feed, no unknown organic emissions factor is required. The SLRA was therefore not revised.

7. **Section 2.2.4, page 18, paragraph 4.** This paragraph states that chlorinated organic compounds were eliminated from consideration because of process knowledge and the limited availability of chlorine; however, Section 2.2.2, page 15, states that hydrogen chloride is one of the acids emitted from calciner operations. The presence of available chlorine is further indicated by the combined emission rate of 3.36 tons per year Cl_2/HCl reported in the emission inventory for the CCP main stack. If hydrogen chloride is emitted from the calciner, chlorine is available to serve as a precursor for chlorinated organic compounds. Chlorinated organic compounds must be added back to the assessment. The presence of fluorine in the stack emissions indicates that fluorinated (and chloro-fluoro) organic compounds must also be evaluated in the assessment. The SLRA shall include potential emissions of PAHs, PCBs, and phthalates because the data provided in the Appendices indicates the presence of precursors (i.e., benzene, chlorine, etc) for these compounds.

Response: The SLRA text was revised. The statement that "chlorinated organic compounds were eliminated from consideration" was in error and was removed from the SLRA text. Chlorinated organic compounds were conservatively assessed for dioxins and furans (section **2.2.4.1**) and the nitroaromatics (section **2.2.4.2**) which are the primary PICs of concern in the high NO_x atmosphere of the NWCF offgas. **Revision 5 Addendum** – PAHs, coplaner PCBs, and phthalates were evaluated.

The following additional discussion concerning chlorinated organic emissions was added to section 2.2.4.2:

> Since it not known which specific chlorinated organic PICs might be formed in the offgas, it was conservatively assumed that assumed all of the chlorine in the feed (0.18 g/s) reacted to form the

highly toxic pentachloronitrobenzene (PCNB). Assessment of the maximum potential formation of PCNB provides a reasonably conservative bound for impacts from any combination of potential PICs that are of concern in the NWCF offgas because of its relatively high toxicity. For example, PCNB has an EPA Region III Risk Based Concentration (RBC) in air of 0.024 ug/m^3 compared to 3.8 ug/m^3 for dichloromethane and 0.99 ug/m^3 for methylene chloride. The lower RBC for PCNB indicates that this compound is from 41 to 158 times as toxic and therefore provides a conservative bound to the health impact assessment. **Revision 5 Addendum** – the chlorine emission rate and therefore the maximum potential formation of PCNB have been revised (see Section 2).

An additional section (2.2.4.3) was added to discuss the potential formation, release, and relative impacts from other organic PICs:

> Fluorinated (and chloro-fluoro) compounds were not evaluated in the SLRA for the following reasons: 1) reasonably conservative estimates of fluorine in the offgas are extremely low (5E-02 g/s), 2) the only fluorinated (and chloro-fluoro) compounds listed on the EPA PIC list are freon species that have very low toxicity values compared to the PICs evaluated, and 3) evaluation is not justified based on the overall results of the SLRA.
>
> PAHs, PCBs, and phthalates are not evaluated in the SLRA because 1) they are not present in significant quantities in the waste feed, 2) the potential for PIC formation of these compounds in the NWCF offgas is much less than the nitroaromatics (PCBs are difficult to synthesize), 3) the SLRA uses very conservative assumptions on nitroaromatic PIC formation (all available benzene/toluene and chlorine react to form all species of nitroaromatics) which provides a reasonable bound for these compounds, 4) no reliable method is available to calculate the offgas reaction rates for these compounds, and 5) stack gas sampling for PICs has not proven feasible due to the highly acidic offgas (see section **2.2.4**). **Revision 5 addendum** – This paragraph was deleted, and quantitative estimates of PAHs, coplaner PCBs, and phthalates were evaluated.

8. **Section 3.2, pages 24 and 25.** This section provides model-input values for particulate diameter and mass fraction. Justification for these values should be provided.

Response: The SLRA was revised. No particle size data for NWCF emissions were available for air modeling input. Therefore, a method developed for the WERF SLRA was used. This method uses particle size distribution data from tests conducted on a medical waste incinerator with no APCE, as reported in California Air Resources Board (CARB) Test Report C-87-122, 1/31/90. The midpoint of the size distribution categories are then combined with HEPA filter removal efficiency data from Dennis et al. 1980, Industrial Filter 1992, & Bergman et al. 1990. The method produces a size distribution that is smaller than the generic default values given in the combustion guidance. Smaller particulate sizes have been shown to be more conservative for INEEL assessments because the particulate are transported the longer distances required to reach the relatively distant INEEL receptor locations (less particulate falls out near the facility).

9. **Section 4.0, page 32.** The receptors considered here (and the supporting modeling discussed in Section 3.3) consider only off-INEEL residents and travelers on Highway 20. Because of the size of the buffer zones around the Idaho Chemical Processing Plant (ICPP) and other INEEL facilities, adult residents that are also highly likely to be INEEL workers at the ICPP and the Central Facilities Area (CFA) will receive greater chronic exposures, even from 45 to 50 hours per week exposures, than the off-site residents who

are exposed for 168 hours per week In addition, acute exposures for adult resident/INEEL workers at the ICPP and the CFA will exceed those receptors on Highway 20. The revised SLRA must include an evaluation of these adult resident/INEEL worker scenarios.

Response: Workers at INTEC (ICPP) and CFA are exposed to lower chronic air concentrations than those evaluated at the maximum off-site impact location because of the elevated (72 m) plume height, their off-centerline plume location, and because of the elevated terrain and plume centerline location of the maximum off-site location (please see Figure 7). In response to the comment, maximum inhalation impacts for a worker at CFA was determined to be 9% of the maximum off-site cancer risk and 40% of the maximum off-site hazard index evaluated (see response to **General Comment #3**). Therefore, a worker who works 2000 hours per year at the maximum INEEL facility impact location and resides the remaining portion of the year at the maximum off-site impact location will be less impacted than the assessed off-site scenarios which assumed continuous exposure at the maximum off-site impact location.

10. **Section 4.1.** The following exposure scenarios should be added to the SLRA to assume that all receptors that may be significantly exposed to emissions for the facility are evaluated:

    - Subsistence farmer child
    - Infant exposure to dioxins and furans via the ingestion of their mother's breast milk
    - Adult resident/INEEL worker scenario
    - Herdsman/hunter scenarios

Response: The SLRA was revised. An INEEL worker, on-site herdsman, and the breast milk pathway were assessed. The impacts from all of these scenarios were found to be negligible compared to the assessed scenarios. The hunter scenario was investigated and determined to be an insignificant (or non-existent) exposure pathway on the south end of the INEEL. It was found that the HHRAP methods defined for the new subsistence farmer child scenario (e.g. ingestion rates) are inconsistent with the 1994 guidance methods used to evaluate the other scenarios in this SLRA and would result in calculated impacts that are not comparable with these other scenarios. Since there was not time to re-evaluate all of the scenarios using the new guidance, the subsistence farmer child was not assessed. **Revision 5 addendum –** a subsistence farmer child scenario was evaluated.

11. **Section 4.2.2, page 33**. The beef and dairy exposure route assumes all contaminants of concern bioaccumulate in the muscle tissue. The SLRA should include a justification why this assumption is appropriate.

Response: The SLRA was revised. Text was changed to indicate for beef exposure contaminants bioaccumulate in the muscle tissue while for dairy exposure the contaminants bioaccumulate in the cow's milk.

12. **Section 5.0, page 35**. The 1997 edition (most recent edition) of HEAST should be used and referenced in this section.

Response: The SLRA was revised. The SLRA will be updated to reflect the 1997 edition of HEAST and will be referenced in this section of the SLRA. **Revision 5 Addendum -** additional sources of toxicity data were used including those listed in the ATG RAWP and those from EPA Region 9 (on-line).

13. The text states that chemicals lacking EPA toxicity values were not assessed in this SLRA. This policy led to the omission from the SLRA risk estimation of the six chemicals that comprise the gaseous emissions listed in Table 3 and make up more than 95% of the total emissions. There are non-EPA inhalation toxicity values for these noxious gases, both permissible exposure levels from the Occupational Safety and Health Administration and threshold limit values from the American Conference of Governmental Industrial Hygienists. These human-derived toxicity values, adjusted by appropriate uncertainty factors, should be used to estimate risk from the gaseous emissions.

    For the Toxicity Assessment, EPA Region 10 risk assessors (Marcia Bailey) can be of assistance in obtaining provisional toxicity values for many chemicals and/or exposure routes from the EPA's National Center for Environmental Assessment when such values are not available on Integrated Risk Information Service (IRIS) or in HEAST. ATSDR Minimal Risk Values may also be used as a fourth source of values. However, none of the four will contain the acute values needed to assess that risk. Other sources such as those used for occupational protection may be consulted. EPA Region 10 risk assessors can assist in identifying sources of appropriate acute toxicity values.

    PCBs should be evaluated pursuant to the new toxicity criteria available on IRIS since October 1, 1996.

Response: The SLRA was revised. Risks and hazard quotients for chemicals without verified EPA toxicity values will be calculated using EPA Region III Risk Based Concentrations (RBCs) for air or State of Idaho acceptable ambient concentrations (AACs) for non-carcinogens, as published in the Section 585 of the *Rules for the Control of Air Pollution in Idaho* (IDAPA 16.01.01). The State of Idaho AACs are calculated as 1/100 of the OSHA Permissible Exposure Level (PEL) and were only used for five contaminants that did not have RBCs. **Revision 5 Addendum** – revised toxicity values from the ATG RAWP and EPA Region 9 (on-line) have been used.

Comparisons of short-term impacts to acute toxicity values are not necessary if it can be shown that maximum impacts are less than more conservative (lower) chronic toxicity criteria. PCBs are not evaluated in the SLRA (see response to **Specific Comment #7**). **Revision 5 addendum** – coplaner PCBs were evaluated in the SLRA.

14. **Section 6, page, 39**. An evaluation of the noncancer effects of dioxin should also be performed in SLRA. A "margin of exposure" approach should be used for estimating potential noncancer health effects arising from incremental exposures to dioxins. Using this approach, one determines the ratio of the estimated daily dose of dioxins from a particular source to the average daily intake of dioxins in the general population. The general background level of exposure of adults to dioxins is estimated at 1 to 3 picograms

(pg)kilograms (kg)/day. Current U.S. EPA guidance recommends that, if the ratio of exposure to this background level is "very small," the noncancer effects from the incremental exposure are to be judged as negligible.

Response: The SLRA was revised. An evaluation of noncancer effects of dioxin has been added to the SLRA and was found to be negligible.

15. **Section 6.1, page 41**. The discussion of mercury and its different Hazard Index due to neurotoxic effects should be expanded. A risk assessment is expected to be reviewed by the public and should, therefore, be as clear as possible. In Appendix A, p A-16, it is stated that the "largest and probably dominant hazardous emission" is mercury, due to its "volatility as $HgCl_2$ and relatively high concentration in the tank farm."

Response: The SLRA was revised. Additional chemicals with neurotoxic effects have been added to the discussion.

16. **Section 6.3, page 47**. A reference should be provided for the EPA air and soil lead levels cited.

Response: The SLRA was revised. Reference to EPA Region III, 1996 has been added to the text.

17. **Section 6.4, page 47, second paragraph**. This paragraph states that the SLRA for the calciner demonstrates that the facility meets all EPA requirements for the operation of a combustion facility and that no further analysis of the risk is necessary. Based on this review, significant issues still remain to be resolved, particularly involving radionuclides, ecological risk, additional exposure scenarios, and reflecting actual performance testing missions data.

Response: The SLRA was revised. Assessment of potential radionuclide risk has been added to SLRA. Additional exposure scenarios were assessed (see response to **General Comment #3**). A statement was added to the conclusions that the results of this risk assessment were based of conservative estimates of emissions calculated using the best-available process knowledge and that additional assessment may be performed based on the results of the planned Offgas Demonstration Project (ODP) scheduled for January through April, 1999. **Revision 5 addendum** – In addition to the above, a quantitative ecological risk assessment was performed.

18. **Section 7**. The source term and exposure assessment discussions focus solely upon uncertainties that would tend to bias the SLRA to the conservative side. All known or potential uncertainties must be discussed. (An obvious example for this draft SLRA is not knowing what products of incomplete combustion might be produced from chemical reactions between the feedstock and the kerosene and the possible recombination products from reactions in the mixing of the various stack gases, since emissions have yet to be sampled and analyzed.)

Response: The SLRA was revised to better describe the uncertainty associated with types and quantities of specific PICs that may be formed in the offgas and why this uncertainty exists (inability to sample the highly acidic offgas and the difficulty in predicting PIC formation). However, the methods used in the SLRA to assess the maximum impacts from any possible PIC formation (see response to **Specific Comment #7**) assume a worst-case combination of feed materials to form the maximum possible formation rate of indicator PICs (dioxins/furans and nitroaromatics) that are both likely to be formed in the NWCF offgas and are highly toxic. Similar assumptions could be used to calculate upper bound formation of other chlorinated organic PICs which are less likely to be formed in the offgas and which are likely to be less toxic. However, conservation of mass (in the benzene and chlorine feed rates) would require that the nitroaromatic emission rates be reduced, and it is unlikely that the total hazard (emission rate times toxicity summed across all PICs) would be increased. It is important to stress that the purpose of this SLRA is to provide a high level of confidence that no unacceptable health impacts will occur as a result of NWCF operations, not necessarily to predict exactly what is going on in the offgas.

An additional section on radionuclides was added to the exposure assessment uncertainty (section **7.3**). In the radionuclide exposure assessment (section **6.4**), the annual risk determined from the 1997 NESHAPS dose was multiplied by exposure duration of 40 years for the subsistence farmer and 30 years for the adult resident to obtain lifetime risk. This is conservative because the vast majority of the dose (and therefore risk) will occur during the 16-year time period that the NWCF will actually operate. After NWCF operations cease, the residual dose from activity remaining in the soil will be significantly less than the dose calculated in the NESHAPS assessment, which is largely a result of ingestion of food products that are contaminated on the surface by fallout during facility operations. These exposure duration assumptions will overpredict lifetime risk for the subsistence farmer and adult resident by a factor of approximately 2.

19. **Section 7.0, Tables 6 and 7**. The toxicity values listed in these tables were current through 1996. The primary source, EPA's IRIS, is updated at least once per month and is now available, without a fee, on the Internet. During preparation of the revised SLRA, IRIS and other sources should be checked to ensure that current toxicity values are used.

Response: The SLRA was revised. The toxicity data has been updated with data from the 1997 HEAST and on-line IRIS database. **Revision 5 Addendum** – Toxicity values were updated again using additonal sources (ATG RAWP and EPA Region 9 on-line data.

20. **Section 8**. The treatment of ecological receptors is very abbreviated. There should be an identification and discussion of chemicals (e.g., HF, Al) emitted from the calciner that pose particular risks to the flora and fauna described in the text as having been identified as potential receptors at the site. The following statement made in the Conclusions' section of this 3-page chapter, makes it clear that the ecological considerations have been inadequately addressed:

> "Ecological effects are not likely to be significant at the population, community, or ecosystem levels, although measurable effects may be conceivable in individual biota, in areas adjacent to the [facility]."

Insufficient information is provided in the SLRA to evaluate that statement or the potential magnitude of ecological effects that may arise (or which have already occurred) due to emissions from this operating facility. The ecological assessment portion of the SLRA shall consider:

actual contaminants of concern,
food web interactions,
sensitive receptors, and
ecosystems found in the area of impact.

The SLRA shall be revised, as appropriate, to address these concerns.

Response: DOE believes that the qualitative ecological risk discussion in this SLRA was done in accordance with the most current EPA SLRA guidance (1994) available at the time (which specifies a qualitative ecological risk assessment) and that it was also a "component" of the May 1998 Revision 3 of the SLRA. Although EPA has not currently published new quantitative ecological risk assessment guidelines, a Risk Assessment Work Plan (RAWP) that describes quantitative ecological risk assessment methods done for another EPA Region X combustion unit[d] was received by DOE in early December 1998. This RAWP is reportedly based on new ecological risk assessment methods for combustion units which may be published by the EPA's Office of Solid Waste (OSW) in the Spring of 1999. However, although this RAWP list critical input parameters and methods required to do an adequate quantitative assessment, there was not adequate time to perform this assessment for the NWCF SLRA by December 31, 1998. DOE will re-examine the need to do a full quantitative ecological risk assessment after the HLWEIS is published and a decision is made on whether to restart and permit the NWCF. This decision will be made by June 30, 2000, in accordance with the Notice of Noncompliance Consent Order. **Revision 5 Addendum** – a quantitative ecological risk assessment has been added (section 8).

21. **Appendix A, Section 61 page A-15**. The citations on this page include numbers 20 and 18, however, Section 8 has neither reference, although it does have two versions of reference number 17. This discrepancy should be corrected in the revised SLRA.

Response: The SLRA was revised. The reference discrepancy was corrected.

22. **Appendix E, Table E-4**. Correct the inhalation factor for children to 10 m^3/day for consistency with Risk Assessment Guidance for Superfund: Volume 1. Human Health Evaluation (Part A). OERR. Washington, D.C. OERR 9200 6-303-894 (RAGS-Part A).

Response: The inhalation rate presented is taken from *Guidance for Performing Screening Level Risk Analyses at Combustion Facilities Burning Hazardous Waste* (EPA, 1994). Since, the direct inhalation risks were calculated based on URFs and RfCs (inhalation intakes were not calculated), the inhalation rate is not used in the risk calculation. A note is added in this revision to make this clear.

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[d] Allied Technology Group, Inc. (ATG) Risk Assessment Work Plan for the ATG Richland Mixed Waste Facility, October 9, 1998.