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Screening Level Ecological Risk Assessment Protocol for Hazardous Waste Combustion Facilities

Volume One

Peer Review Draft

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Volume One

U.S. EPA, OFFICE OF SOLID WASTE

U.S. ENVIRONMENTAL PROTECTION AGENCY

DISCLAIMER

This document provides guidance to U.S. EPA Regions and States on how best to implement RCRA and U.S. EPA's regulations to facilitate permitting decisions for hazardous waste combustion facilities. It also provides guidance to the public and to the regulated community on how U.S. EPA intends to exercise its discretion in implementing its regulations. The document does not substitute for U.S. EPA's regulations, nor is it a regulation itself. Thus, it cannot impose legally-binding requirements on U.S. EPA, States, or the regulated community. It may not apply to a particular situation based upon the circumstances. U.S. EPA may change this guidance in the future, as appropriate.

ACKNOWLEDGMENTS

Jeff Yurk (U.S. EPA Region 6), the primary author/editor of this document, would like to acknowledge that the development of this document could not have been accomplished without the support, input, and work of a multitude of U.S. EPA and support contractor personnel. The foundation for the combustion-related guidance and methodologies outlined in this document were first developed by the Office of Research and Development (ORD) and the Office of Solid Waste (OSW) in previous versions of combustion risk assessment guidance. The State of North Carolinas' combustion risk assessment methodology was also evaluated in preparation of this document. The foundation for the ecological risk-related procedures and methodologies outlined in this document were based on previous guidance developed by the Office of Research and Development (ORD) and EPA's Superfund program. This version of the protocol was originally initiated in response to the desire of the Region 6 Multimedia Planning and Permitting Division to implement an up-to-date and technically sound hazardous waste combustion permitting program. The decision to incorporate guidance on a full range of national combustion risk assessment issues into the document was encouraged and supported by the Director of the Office of Solid Waste.

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Contributions by Larry Johnson of the National Exposure Research Laboratory of ORD and Jeff Ryan and Paul Lemieux of the National Risk Management Research Laboratory of ORD were significant in providing methodologies for conducting TO analysis and defining appropriate detection limits to be used in the risk assessment. Donna Schwede of the National Exposure Research Laboratory of ORD and Jawad Touma of the Office of Air Quality Planning and Standards provided technical review comments to strengthen the air modeling section of the document. Review and comment on the soil and water fate and transport models was provided by Robert Ambrose of EPA's Environmental Research Laboratory in Athens, GA.

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early document. Region 6 apologizes and bears full responsibility for any mistakes made in the incorporation of comments and input from all reviewers into the document.

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Region 6 looks forward to the insight and input yet to be provided by the public and other interested parties during the full external peer review of the document.

REVIEWERS

Preliminary drafts of this ecological risk assessment document, as well as its companion human health risk assessment document, have received extensive internal Agency and State review. The following is a list of reviewers who have commented on these documents prior to their release as a peer review draft.

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TABLES

LIST OF ACRONYMS

μg	Microgram
μg/kg	Micrograms per kilogram
μg/L	Micrograms per liter
μg/s	Micrograms per second
μm	Micrometer
μm/s	Micrometers per second
μm^2	Square micrometers
°C	Degrees Celsius
°F	Degrees Fahrenheit
°K	Degrees Kelvin
ADOM	Acid Deposition and Oxidant Model
AET	Apparent effects threshold
APCS	Air pollution control system
atm-m^3/mol-K	Atmosphere-cubic meters per mole-degrees Kelvin
ATSDR	Agency for Toxic Substances and Disease Registry
AWFCO	Automatic waste feed cutoff
AWQC	Ambient water quality criteria
BAF	Bioaccumulation factor
BaP	Benzo(a)pyrene
BCF	Bioconcentration factor
BD	Soil bulk density
BEF	Bioaccumulation equivalency factor
BEHP	Bis(2-ethylhexyl)phthalate
BIF	Boiler and industrial furnace
BPIP	Building profile input program
BS	Benthic solids
BSAF	Sediment bioaccumulation factor
BTAG	Biological Technical Assistance Group
BW	Body weight
CARB	California Air Resources Board
CAS	Chemical Abstracts Service
CERM	Conceptual ecological risk model
CKD	Cement kiln dust
COMPDEP	COMPLEX terrain model with DEPosition
COMPLEX I	COMPLEX terrain model, Version 1
COPC	Compound of potential concern
CPF	Cumulative probability density function
CRQL	Contract required quantitation limit
CWA	Clean Water Act

LIST OF ACRONYMS (Continued)

DEHP	Diethylhexylphthalate (same as Bis(2-ethylhexl)phthalate)
DEM	Digital Elevation Model
DNOP	Di(n)octylphthalate
DOE	U.S. Department of Energy
DQL	Data quality level
DRE	Destruction and removal efficiency
EDQL	Ecological data quality levels
EEL	Estimated exposure level
EPA	U.S. Environmental Protection Agency
EPC	Exposure point concentration
EQL	Estimated quantitation limit
EQP	Equilibrium partitioning
ERA	Ecological risk assessment
ERL	Effects range low
ERT	Environmental Research and Technology
ESP	Electrostatic precipitator
ESI	Ecological screening index
ESQ	Ecological screening quotient
FCM	Food chain multiplier
FWS	U.S. Fish and Wildlife Service
g/s	Grams per second
g/cm^3	Grams per cubic centimeter
g/m^3	Grams per cubic meter
GAQM	Guideline on Air Quality Models
GC	Gas chromatography
GEP	Good engineering practice
HBC	Hexachlorobenzene
$HgCl_2$	Mercuric chloride
HQ	Hazard quotient
HSDB	Hazardous substances data base
IDL	Instrument detection limit
IEM	Indirect exposure model
IRIS	Integrated risk information system
ISCST3	Industrial source complex short-term model
ISCSTDFT	Industrial Source Complex Short Term Draft
kg	Kilogram
kg/L	Kilograms per liter

LIST OF ACRONYMS (Continued)

L	Liter
LC_{50}	Lethal concentration to 50 percent of the test population
LCD	Local Climatological Data Annual Summary with Comparative Data
LD_{50}	Lethal dose to 50 percent of the test population
LEL	Lowest effect level
LFI	Log fill-in
LOAEL	Lowest observed adverse effect level
LOD	Level of detection
LOEL	Lowest observed effect level
m	Meter
m/s	Meters per second
mg	Milligram
mg/kg	Milligrams per kilogram
mg/kg/day	Milligrams per kilogram per day
mg/L	Milligrams per liter
mg/m^3	Milligrams per cubic meter
MACT	Maximum achievable control technology
MDL	Method detection limit
MLE	Maximum likelihood estimation
MPRM	Meterological Processor for Regulatory Models
MPTER	Air quality model for multiple point source gaussian dispersion algorithm with terrain adjustments
MPTER-DS	Air quality model for multiple point source gaussian dispersion algorithm with terrain adjustments including deposition and sedimentation
NC DEHNR	North Carolina Department of Environment, Health, and Natural Resources
NCDC	National Climatic Data Center
NCEA	National Center for Environmental Assessment
NEL	No effect level
NFI	Normal fill-in
NOAA	National Oceanic and Atmospheric Administration
NOAEL	No observed adverse effect level
NOEC	No observed effect concentration
NOEL	No observed effect level
NRC	U.S. Nuclear Regulatory Commission
NTIS	National technical information service
NWS	National weather service
OAQPS	Office of Air Quality Planning and Standards
OAQPS TTN	Office of Air Quality and Planning Standards and Technology Transfer Network
OC	Organic carbon
OCDD	Octachlorodibenzodioxin
ORD	Office of Research and Development
ORNL	Oak Ridge National Laboratory
OSW	Office of Solid Waste

LIST OF ACRONYMS (Continued)

OV	Deposition output values
PAH	Polycyclic aromatic hydrocarbon
PCB	Polychlorinated biphenyl
PCDD	Polychlorinated dibenzo(p)dioxin
PCDF	Polychlorinated dibenzofuran
PCRAMMET	Personal computer version of the meterological preprocessor for the old RAM program
PDF	Probability density function
PIC	Product of incomplete combustion
PM	Particulate matter
PM10	Particulate matter less than 10 micrometers in diameter
POHC	Principal organic hazardous constituent
PQL	Practical quantitation limit
PRC	PRC Environmental Management, Inc.
PU	Polyurethane
QA/QC	Quality assurance/Quality control
QAPjP	Quality assurance project plan
QSAR	Quantitative structure activity relationship
RCRA	Resource Conservation and Recovery Act
REACH	
RME	Reasonable maximum exposure
RTDM	Rough terrain diffusion model
RTDMDEP	Rough terrain diffusion model deposition
RTECS	Registry of Toxic Effects of Chemical Substances
SAMSON	Solar and Meterological Surface Observational Network
SCRAM BBS	Support Center for Regulatory Air Models Bulletin Board System
SFB	San Francisco Bay
SMDP	Scientific management decision point
SO	Source
SQL	Sample quantitation limit
SVOC	Semivolatile organic compound
TAL	Target analyte list
TCDD	Tetrachlorodibenzo(p)dioxin
TDA	Toluene diisocyanate
TEF	Toxicity equivalent factor
TG	Terrain grid
TIC	Tentatively identified compound
TL	Trophic level
TOC	Total organic carbon
TRV	Toxicity reference value
TSS	Total suspended solids

LIST OF ACRONYMS (Continued)

UF	Uncertainty factor
UFI	Uniform fill-in
USGS	U.S. Geological Survey
USLE	Universal soil loss equation
UTM	Universal transverse mercator
VOC	Volatile organic compound
watts/m^2	Watts per square meter
WRPLOT	Wind Rose PLOTing program

LIST OF VARIABLES

λ_z	=	Dimensionless viscous sublayer thickness (unitless)
μ_a	=	Viscosity of air (g/cm-s)
μ_w	=	Viscosity of water corresponding to water temperature (g/cm-s)
ρ_a	=	Air density (g/cm^3 or g/m^3)
ρ_s	=	Bed sediment density (kg/L)
ρ_w	=	Density of water corresponding to water temperature (g/cm^3)
θ	=	Temperature correction factor (unitless)
θ_{bs}	=	Bed sediment porosity (unitless)
θ_s	=	Soil volumetric water content (mL/cm^3 soil)
a	=	Empirical intercept coefficient (unitless)
A	=	Surface area of affected area (m^2)
b	=	Empirical slope coefficient (unitless)
BAF_l	=	Bioaccumulation factor reported on a lipid-normalized basis using the freely dissolved concentration of a chemical in the water (L/kg)
$BCF_{a/s}$	=	Aquatic-sediment bioconcentration factor (unitless)
BCF_l	=	Bioconcentration factor reported on a lipid-normalized basis using the freely dissolved concentration of a chemical in the water (L/kg)
$BCF_{Pi\text{-}H}$	=	Bioconcentration factor for plant-to-herbivore for *i*th plant food item (unitless)
BCF_i	=	Soil-to-soil invertebrate bioconcentration factor (unitless)
$BCF_{Pi\text{-}OM}$	=	Bioconcentration factor for plant-to-omnivore for *i*th plant food item (unitless)
$BCF_{S/BS\text{-}C}$	=	Bioconcentration factor for soil- or bed sediment-to-carnivore (unitless)
$BCF_{S/BS\text{-}H}$	=	Bioconcentration factor for soil-to-plant or bed sediment-to-plant (unitless)
$BCF_{W\text{-}C}$	=	Bioconcentration factor for water-to-carnivore (L/kg)
$BCF_{W\text{-}HM}$	=	Bioconcentration factor for water-to-herbivore (L/kg)
BCF_{WI}	=	Bioconcentration factor for water-to-invertebrate (L/kg)
BCF_r	=	Plant-soil biotransfer factor (unitless)
BD	=	Soil bulk density (g soil/cm^3 soil)
BMF_n	=	Biomagnification factor for *n*th trophic level
BS	=	Benthic solids concentration (kg/L or g/cm^3)
$BSAF$	=	Sediment bioaccumulation factor (unitless)
Bv	=	Air-to-plant biotransfer factor (µg COPC/g DW plant)/(µg COPC/g air)
BW	=	Body weight (kg)
C	=	USLE cover management factor (unitless)
C_{Ai}	=	COPC concentration in *i*th animal food item (mg/kg)
C_C	=	COPC concentration in carnivore (mg/kg)
C_d	=	Drag coefficient (unitless)
C_{dw}	=	Dissolved phase water concentration (mg/L)
C_F	=	COPC concentration in fish (mg/kg)
CFO_2	=	Correction factor for conversion to 4.5 percent O_2 (unitless)
C_{gen}	=	Generic chemical concentration (mg/kg or mg/L)
C_H	=	COPC concentration in herbivore (mg/kg)
C_i	=	Stack concentration of *i*th identified COPC (carbon basis) (mg/m^3)

LIST OF VARIABLES (Continued)

C_i	=	COPC concentration in *i*th plant or animal food item (mg COPC/kg)
C_I	=	COPC concentration in soil or benthic invertebrate (mg/kg)
C_{IW}	=	COPC concentration in soil or sediment interstitial water (mg/L)
C_M	=	COPC concentration in media (mg COPC/kg [soil, sediment] or mg COPC/L [water])
C_{OM}	=	COPC concentration in omnivore (mg/kg)
C_{Pi}	=	COPC concentration in *i*th plant food item (mg/kg)
C_{PREY}	=	Concentration in prey
C_{sed}	=	COPC concentration in bed sediment (g COPC/cm^3 sediment or mg COPC/kg sediment)
$C_{s/sed}$	=	COPC concentration in soil or bed sediment (mg/kg)
C_{TOC}	=	Stack concentration of TOC, including speciated and unspeciated compounds (mg/m^3)
C_{TP}	=	COPC concentration in terrestrial plants (mg COPC/kg WW)
C_{wctot}	=	Total COPC concentration in water column (mg/L)
C_{wtot}	=	Total water body COPC concentration (including water column and bed sediment) (g/m^3 or mg/L)
Cyp	=	Unitized yearly air concentration from particle phase (μg-s/g-m^3)
Cyv	=	Unitized yearly air concentration from vapor phase (μg s/g m^3)
Cywv	=	Unitized yearly watershed air concentration from vapor phase (μg-s/g-m^3)
D_1	=	Lower bound of a particle size density for a particular filter cut size
D_2	=	Upper bound of a particle size density for a particular filter cut size
D_a	=	Diffusivity of COPC in air (cm^2/s)
d_{bs}	=	Depth of upper benthic sediment layer (m)
DD_{TEQ}	=	Daily dose of 2,3,7,8-TCDD *TEQ* (μg/kg BW/d)
DD_i	=	Daily dose of *i*th congener (μg/kg BW/d)
D_{mean}	=	Mean particle size density for a particular filter cut size
Ds	=	Deposition term (mg/kg-yr)
D_w	=	Diffusivity of COPC in water (cm^2/s)
d_{wc}	=	Depth of water column (m)
Dyd	=	Unitzed yearly dry deposition rate of COPC (g/m^2-yr)
Dydp	=	Unitized yearly dry deposition from particle phase (s/m^2-yr)
Dytwp	=	Unitized yearly watershed total deposition (wet and dry) from particle phase (s/m^2-yr)
Dywp	=	Unitized yearly wet deposition from particle phase (s/m^2-yr)
Dywv	=	Unitized yearly wet deposition from vapor phase (s/m^2-yr)
Dywwv	=	Unitized yearly watershed wet deposition from vapor phase (s/m^2-yr)
d_z	=	Total water body depth (m)
E_v	=	Average annual evapotranspiration (cm/yr)
ER	=	Soil enrichment ratio (unitless)

LIST OF VARIABLES (Continued)

F_{Ai}	=	Fraction of diet consiting of *i*th animal food item (unitless)
f_{bs}	=	Fraction of total water body COPC concentration in benthic sediment (unitless)
FCM	=	Trophic level-specific food-chain multiplier (unitless)
FCM_{TLn}	=	Food chain multiplier for *n*th trophic level
$FCM_{TLn\text{-}Ai}$	=	Food chain multiplier for trophic level of *i*th animal food item (unitless)
FCM_{TL3}	=	Food chain multiplier for trophic level 3 (unitless)
f_{wc}	=	Fraction of total water body COPC concentration in the water column (unitless)
F_v	=	Fraction of COPC air concentration in vapor phase (unitless)
F_{OC}	=	Fraction of organic carbon (unitless)
F_{Pi}	=	Fraction of diet consisting of *i*th plant food item (unitless)
Fw	=	Fraction of COPC wet deposition that adheres to plant surfaces (unitless)
H	=	Henry's law constant (atm-m^3/mol)
Ir_{MEDIUM}	=	Ingestion rate of soil, surface water, or sediment
I	=	Average annual irrigation (cm/yr)
IR	=	Ingestion rate (kg/day)
k	=	von Karman's constant (unitless)
K	=	USLE erodibility factor (ton/acre)
k_b	=	Benthic burial rate (yr^{-1})
K_G	=	Gas phase transfer coefficient (m/yr)
K_L	=	Liquid phase transfer coefficient (m/yr)
Kd_{bs}	=	Bed sediment/sediment pore water partition coefficient (L/kg or cm^3/g)
Kd_{ij}	=	Partition coefficient for COPC i associated with sorbing material j (unitless)
Kd_s	=	Soil-water partition coefficient (cm^3/g or mg/L)
Kd_{sw}	=	Suspended sediments/surface water partition coefficient (L/kg)
K_{oc}	=	Organic carbon partition coefficient (mg/L)
K_{ocj}	=	Sorbing material-independent organic carbon partition coefficient for COPC j
K_{ow}	=	Octanol-water partition coefficient (unitless)
kp	=	Plant surface loss coefficient (yr^{-1})
ks	=	COPC soil loss constant due to all processes (yr^{-1})
kse	=	COPC loss constant due to soil erosion (yr^{-1})
ksg	=	COPC loss constant due to biotic and abiotic degradation (yr^{-1})
ksl	=	COPC loss constant due to leaching (yr^{-1})
ksr	=	COPC loss constant due to runoff (yr^{-1})
ksv	=	COPC loss constant due to volatilization (yr^{-1})
kv	=	Water column volatilization rate constant (yr^{-1})
Kv	=	Overall transfer rate coefficient (m/yr)
k_{wt}	=	Overall total water body COPC dissipation rate constant (unitless)
L	=	Monin-Obukhov Length (m)

LIST OF VARIABLES (Continued)

L_{DEP}	=	Total (wet and dry) particle phase and wet vapor phase direct deposition load to water body (g/yr)
L_{dif}	=	Dry vapor phase diffusion load to water body (g/yr)
L_E	=	Soil erosion load (g/yr)
L_R	=	Runoff load from pervious surfaces (g/yr)
L_{RI}	=	Runoff load from impervious surfaces (g/yr)
L_T	=	Total COPC load to water body (g/yr)
LS	=	USLE length-slope factor (unitless)
MW	=	Molecular weight of COPC (g/mol)
OC_i	=	Organic carbon content of sorbing material *I* (unitless)
OV	=	Deposition output values
P	=	Average annual precipitation (cm/yr)
P_{Ai}	=	Proportion of *i*th animal food item in diet that is contaminated (unitless)
Pd	=	COPC concentration in plant due to to direct deposition (mg/kg WW)
PF	=	USLE supporting practice factor (unitless)
P_{Pi}	=	Proportion of *i*th plant food item in diet that is contaminated (unitless)
Pr	=	COPC concentration in plant due to root uptake (mg/kg WW)
$P_{S/BS}$	=	Proportion of soil or bed sediment in diet that is contaminated (unitless)
Pv	=	COPC concentration in plant due to air-to-plant transfer (mg/kg WW)
P_W	=	Proportion of water in diet that is contaminated (unitless)
Q	=	COPC emission rate (g/s)
Q_i	=	Emission rate of COPC *(i)* (g/s)
$Q_{i(adj)}$	=	Adjusted emission rate of COPC *(i)* (g/s)
Q_f	=	Anthropogenic heat flux (W/m^2)
Q_*	=	Net radiation absorbed (W/m^2)
r	=	Interception fraction-the fraction of material in rain intercepted by vegetation and initially retained (unitless)
R	=	Universal gas constant (atm-m^3/mol-K)
RO	=	Average annual runoff (cm/yr)
RF	=	USLE rainfall (or erosivity) factor (yr^{-1})
Sc	=	Average soil concentration over exposure duration (mg/kg)
Sc_{Tc}	=	Soil concentration at time *Tc* (mg/kg)
SD	=	Sediment delivery ratio (unitless)
SGC	=	COPC stack gas concentration as measured in the trial burn (µg/dscm)
SGF	=	Stack gas flow rate at 7 percent O_2 (dscm/s)
T_a	=	Ambient air temperature (K) = 298.1 K
Tp	=	Length of plant exposure to deposition per harvest of the edible portion of the *i*th plant group (yr)

LIST OF VARIABLES (Continued)

tD	=	Total time period over which deposition occurs (time period of combustion) (yr)
T_m	=	Melting point temperature (K)
TSS	=	Total suspended solids concentration (mg/L)
T_w	=	Water body temperature (K)
u	=	Current velocity (m/s)
V	=	Volume
Vdv	=	Dry deposition velocity (cm/s)
Vf_x	=	Average volumetric flow rate through water body (m^3/yr)
VG_{ag}	=	Empirical correction factor for aboveground produce (unitless)
VP	=	Vapor pressure (atm)
W	=	Average annual wind velocity (m/s)
WA_I	=	Area of impervious watershed receiving COPC deposition (m^2)
WA_L	=	Area of watershed receiving COPC deposition (m^2)
WA_w	=	Water body surface area (m^2)
X_e	=	Unit soil loss ($kg/m^{2-}yr$)
Yp	=	Standing crop biomass (productivity) (kg/m^2 DW)
Z_s	=	Soil mixing zone depth (cm)

CONVERSIONS

0.001	=	Units conversion factor (g/mg)
10^6	=	Units conversion factor (μg/g)
907.18	=	Units conversion factor (kg/ton)
3.1536×10^7	=	Conversion constant (s/year)
4,047	=	Units conversion factor (m^2/acre)
100	=	Units conversion factor (m^2-mg/cm^2-kg)
10^{-6}	=	Units conversion factor (g/μg)
0.12	=	Dry weight to wet weight (plants) conversion factor (unitless)

Chapter 1
Introduction

What's Covered in Chapter 1:

Risk assessment is a science used to evaluate the potential hazards to the environment that are attributable to emissions from hazardous waste combustion units. There is general guidance available regarding the general ecological risk assessment process including problem formulation, analysis, and risk characterization (U.S. EPA 1997c; 1998d). This document expands on that general guidance with respect to the ecological screening level procedures and provides a prescriptive tool to support permitting of hazardous waste burning combustion facilities under the Resource Conservation and Recovery Act (RCRA). It is not intended to be used to perform screening or baseline ecological risk assessments (ERA) in other areas of the RCRA program, such as corrective action.

The following definitions were adopted from *Superfund: Process for Designing and Conducting Ecological Risk Assessments. Interim Final* (U.S. EPA 1997c) and *Guidelines For Ecological Risk Assessment* (U.S. EPA 1998d), and identify key terms used throughout this guidance. Some of the terms are annotated with additional information to clarify the definition and explain its use in this protocol.

Area Use Factor: A ratio of an organism's home range, breeding range, or feeding and foraging range to the area of contamination of the assessment area.

Assessment Endpoint: An explicit expression of the environmental value that is to be protected; it includes both an ecological entity and specific attributes of that entity. The assessment endpoint in this protocol is used to link the risk assessment to management concerns and ultimately development of a protective RCRA operating permit. One or more assessment endpoints may be selected for performing a risk assessment.

Bioaccumulation: The net accumulation of a substance by an organism as a result of uptake directly from all environmental sources, including food. Bioaccumulation occurs through all exposure routes.

Bioaccumulation Factor (*BAF*): *BAF* represents the ratio of the concentration of a chemical to its concentration in a medium. The factor must be measured at steady-state when the rate of uptake is balanced by the rate of excretion. In this protocol a bioaccumulation factor (*BAF*) is estimated by multiplying a bioconcentration factor (*BCF*) by a food chain multiplier (FCM) derived based on the trophic level of the prey ingested by a measurement receptor.

Bioconcentration: A process by which there is a net accumulation of a chemical directly from an exposure medium into an organism.

Bioconcentration Factor (*BCF*): *BCF* represents the ratio of the concentration of a chemical in an aquatic organism to the concentration of the chemical in surface water, sediment, or soil. The factor must be measured at steady-state when the rate of uptake is balanced by the rate of excretion. BCFs are used in this protocol to estimate the body burden of a COPC in producers, primary consumers, and fish consumed by mid- or upper-trophic level measurement receptors.

Biomagnification: The process by which the concentration of some chemicals increase with increasing trophic level; that is, the concentration in a predator exceeds the concentration in its prey. In this protocol, a ratio of FCM's are used to account for biomagnification.

Biotransfer Factor: COPC accumulation factor between a food item and its consumer. In this protocol biotransfer factors are used to evaluate transport of contaminants in plants to mammals and birds.

Depuration: The loss of a compound from an ecological receptor as a result of any active or passive process.

Direct Uptake: Direct uptake is a term applied to producers, primary consumers, and detritivores. Direct uptake includes all exposure routes for aquatic receptors, benthic receptors, soil invertebrates, and terrestrial plants. Direct uptake is used in this manner because it is difficult, given feeding and habitat niches of these receptors and limited availability of empirical information, to discern the relative importance of exposure through ingestion, respiration, dermal uptake, or root uptake. In addition, toxicity tests (used as the basis of risk assessment toxicity reference values) on these receptors (except some aquatic fauna) usually do not make a distinction between exposure routes or tend to overemphasize or isolate a particular route.

Ecological Effects Assessment: A portion of the analysis phase of the risk assessment that evaluates the ability of a stressor to cause adverse effects under a particular set of circumstances. Toxicity reference values identified in ecological effects assessment are used in risk characterization.

Ecological Risk Assessment: The process that evaluates the likelihood that adverse ecological effects may occur or are occurring as a result of exposure to one or more stressors.

Ecological Screening Quotient (ESQ): A quotient used to assess risk during the risk assessment in which protective assumptions are used. Generally, the numerator is the reasonable worst-case COPC concentration at the point of exposure, and the denominator is the no-adverse-effects-based toxicity reference value.

Environmental Attribute: Characteristic of a food web functional group (e.g., herbivorous mammal) that is relevant to the ecosystem. Examples of environmental attributes include seed dispersal, decompositon, pollination, and food source.

Exposure Assessment: A portion of the analysis phase of ERA that evaluates the interaction of the stressor with one or more ecological components. Exposure can be expressed as co-occurrence or contact, depending on the stressor and ecological component involved. Information from the exposure assessment is used in risk characterization.

Exposure Pathway: A pathway by which a compound travels from a combustion facility to an ecological receptor. A complete exposure pathway occurs when a chemical enters or makes contact with an ecological receptor through one or more exposure routes.

Exposure Route: A point of contact or entry of a chemical from the environment into an organism. The exposure routes for terrestrial wildlife are ingestion, dermal absorption, and inhalation. The exposure routes for aquatic fauna are ingestion, dermal absorption, and respiration. The exposure routes for terrestrial plants are root absorption or foliar uptake. Exposure routes for aquatic plants are direct contact with water and sediments.

Food Chain: The transfer of food energy from the source in plants through a series of organisms with repeated eating and being eaten (Odum 1971).

Food Web: The interlocking patterns of food chains (Odum 1971).

Food-Chain Multiplier (FCM): The FCM is used to account for dietary uptake of a compound by an ecological receptor. It may be used to estimate a *BAF* from a *BCF* in the absence of reliable *BAF* data. The FCM values in Table 5-1 have been adopted from *Water Quality Guidance for the Great Lakes System* (U.S. EPA 1995j).

Guild: A group of species occupying a particular trophic level and exploiting a common resource base in a similar fashion (Root 1967).

Habitat: The physical environment in which a species is distributed. Habitat location depends on several factors, such as chemical conditions, physical conditions, vegetation, species eating strategy, and species nesting strategy. By analogy, the habitat is an organism's "address."

Measure of Effect: A measurable ecological characteristic that is related to the valued characteristic chosen as the assessment endpoint. It is the measure used to evaluate the response of the assessment endpoint when exposed to a chemical (U.S. EPA 1998d). This protocol proposes, for each class/guild, representative receptors (measurement receptors) for characterizing risk from exposure to compounds emitted from a combustion facility.

Measure of Effect: A measurable ecological characteristic that is related to the valued characteristic chosen as the assessment endpoint.

Measure of Exposure: A measurable stressor characteristic that is used to help quantify exposure.

Measurement Receptor: A species, population, community, or assemblage of communities (such as "aquatic life") used to characterize ecological risk to an assessment endpoint.

Problem Formulation: A systematic planning step that identifies the focus and scope of the risk assessment. Problem formulation includes ecosystem characterization, pathway analysis, assessment endpoint development, and measurement endpoint identification. Problem formulation results in the development of a problem statement that is addressed in the analysis step.

Scientific and Management Decision Point: A point during the risk assessment at which the risk assessor and risk manager discuss results. The risk manager determines whether the information is sufficient to arrive at a decision regarding the significance of the results and whether additional information is needed before proceeding forward in the risk assessment.

Special Ecological Area: Habitats and areas for which protection and special consideration has been conferred legislatively (federal or state), such as critical habitat for federally or state-designated endangered or threatened species. In characterizing media concentrations of COPCs, special emphasis is placed on estimating concentrations and, therefore, exposure potential, in sensitive areas.

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

Trophic Level: One of the successive levels of nourishment in a food web or food chain. Plant producers constitute the first (lowest) trophic level, and dominant carnivores constitute the last (highest) trophic level.

Uncertainty Factor: Quantitative values used to adjust toxicity values from laboratory toxicity tests to toxicity values representative of chronic no-observed-adverse-effect-levels (NOAELs). In this guidance, uncertainty factors (UF) are used to extrapolate from acute and subchronic test duration to chronic duration, and to extrapolate from point estimated (e.g., LD50) and lowest-observed-adverse-effect-level (LOAEL) endpoints to an NOAEL endpoint.

Uptake: Acquisition by an ecological receptor of a compound from the environment as a result of any active or passive process.

This Screening Level Ecological Risk Assessment Protocol (SLERAP) has been developed as national guidance to consolidate information presented in other risk assessment guidance and methodology documents previously prepared by U.S. EPA and state environmental agencies. In addition, this guidance also addresses issues that have been identified while conducting risk assessments for existing hazardous waste combustion units. The overall purpose of this document is to explain how ecological risk assessments should be performed at hazardous waste combustion facilities. This document is intended as

(1) guidance for personnel conducting risk assessments, and (2) an information resource for permit writers, risk managers, and community relations personnel.

The RCRA "omnibus" authority of §3005(c)(3) of RCRA, 42 U.S.C. §6925(c)(3) and 40 CFR §270.32(b)(2) gives the Agency both the authority and the responsibility to establish risk-based permit conditions on a case-by-case basis as necessary to protect human health and the environment. These risk-based site-specific permit conditions are in addition to the national technical standards required in the hazardous waste incinerator and boiler/industrial furnace regulations of 1981 and 1991, respectively. Often, the determination of whether or not a permit is sufficiently protective can be based on its conformance to the technical standards specified in the regulations. Since the time that the regulations for hazardous waste incinerators and boilers/industrial furnaces were issued, however, additional information became available which suggested that technical standards may not fully address potentially significant risks. For example, many studies (including the *Draft Health Reassessment of Dioxin-Like Compounds*, *Mercury Study Report to Congress*, *Risk Assessment Support to the Development of Technical Standards for Emissions from Combustion Units Burning Hazardous Wastes: Background Information Document*, and the *Waste Technologies Industries (WTI) Risk Assessment*) indicate that there can be significant risks from indirect exposure pathways (e.g., pathways other than direct inhalation). The food chain pathway appears to be particularly important for bioaccumulative pollutants which may be emitted from hazardous waste combustion units. In many cases, risks from indirect exposure may constitute the majority of the risk from a hazardous waste combustor. This key portion of the risk from hazardous waste combustor emissions was not directly taken into account when the hazardous waste combustion standards were developed. In addition, uncertainty remained regarding the types and quantities of non-dioxin products of incomplete combustion emitted from combustion units and the risks posed by these compounds.

As a result, until such time that the technical standards could be upgraded to more completely address potential risk from hazardous waste combustion, U.S. EPA recommended, pursuant to the "omnibus" authority, that site-specific risk assessments be performed for all combustion facilities as a part of the RCRA permitting process. Performance of a site-specific risk assessment can provide the information necessary to determine what, if any, additional permit conditions are necessary for each situation to ensure that operation of the combustion unit is protective of human health and the environment. Under 40 C.F.R. §270.10(k), U.S. EPA may require a permit applicant to submit additional information (e.g., a site-specific risk assessment) that the Agency needs to establish permit conditions under the omnibus authority. In certain cases, the Agency may also seek additional testing or data under the authority of RCRA §3013 (where the presence or release of a hazardous waste "may present a substantial hazard to human health or the environment") and may issue an order requiring the facility to conduct monitoring, testing, analysis, and reporting. Any decision to add permit conditions based on a site-specific risk assessment under this authority must be justified in the administrative record for each facility, and the implementing agency should explain the basis for the conditions.

U.S. EPA promulgation of the Maximum Achievable Control Technology (MACT) standards for hazardous waste incinerators, cement kilns and light-weight aggregate kilns effectively upgraded the existing national technical standards for these combustion units. U.S. EPA intends to similarly upgrade the technical standards for other types of hazardous waste combustors in a later rulemaking. Since the MACT standards are more protective than the original standards for incinerators, cement kilns and light-weight aggregate kilns, U.S. EPA revised its earlier recommendation regarding site-specific risk assessments. As discussed in the preamble to the final MACT rule, U.S. EPA recommended that the permitting authority determine if a site-specific risk assessment is needed in addition to the MACT standards in order to meet the RCRA statutory obligation of protection of human health and the environment. For hazardous waste combustors not subject to the Phase I MACT standards, U.S. EPA continues to recommend that site-specific risk assessments be conducted as part of the RCRA permitting process. If the permitting authority determines a risk assessment is warranted, it should be conducted as part of the RCRA permitting process.

The permitting agency should consider several factors in its evaluation of the need to perform a risk assessment (human health and ecological). These factors include:

- whether any proposed or final regulatory standards exist that U.S. EPA has shown to be protective for site-specific receptors
- whether the facility is exceeding any final technical standards
- the current level of hazardous constituents being emitted by a facility, particularly in comparison to proposed or final technical standards, and to levels at other facilities where risks have been estimated
- the scope of waste minimization efforts and the status of implementation of a facility waste minimization plan

- particular site-specific considerations related to the exposure setting (such as physical, land use, presence of threatened or endangered species and special subpopulation characteristics) and the impact on potential risks
- the presence of significant ecological considerations (e.g., high background levels of a particular contaminant, proximity to a particular sensitive ecosystem)
- the presence of nearby off-site sources of pollutants
- the presence of other on-site sources of pollutants
- the hazardous constituents most likely to be found and those most likely to pose significant risk
- the identity, quantity, and toxicity of possible non-dioxin PICs
- the volume and types of wastes being burned
- the level of public interest and community involvement attributable to the facility

This list is by no means exhaustive, but is meant only to suggest significant factors that have thus far been identified. Others may be equally or more important.

The companion document of the SLERAP is the Human Health Risk Assessment Protocol (HHRAP) (U.S. EPA 1998c). U.S. EPA OSW has prepared these guidance documents as a resource to be used by authorized agencies developing risk assessment reports to support permitting decisions for facilities with hazardous waste combustion units.

1.1 OBJECTIVE AND PURPOSE

This protocol is a multipathway screening tool based on reasonable, protective assumptions about the potential for ecological receptors to be exposed to, and to be adversely affected by, compounds of potential concern (COPC) emitted from hazardous waste combustion facilities. The U.S. EPA OSW risk assessment process is a prescriptive analysis intended to be performed expeditiously using (1) measurement receptors representing food web-specific class/guilds and communities, and (2) readily available exposure and ecological effects information. To avoid the time-intensive and resource-consuming process of collecting site-specific information on numerous constituents, this guidance provides a process to obtain and evaluate various types of technical information that will enable a risk assessor to perform a risk assessment relatively quickly. Additionally this guidance provides: (1) example food webs; (2) example measurement receptor natural history information; (3) fate and transport data, bioconcentration factors, and toxicity reference values for 38 COPCs. In lieu of this information, a facility may substitute site-specific information where appropriate and approved by the applicable permitting authority.

U.S. EPA OSW's objective is to present a user-friendly set of procedures for performing risk assessments, including (1) a complete explanation of the basis of those procedures, and (2) a comprehensive source of data needed to complete those procedures. The first volume of this document provides the explanation (Chapters 1 through 6); and the second and third volumes (Appendices A-H) provides the data sources. Appendix A presents compound-specific information necessary to complete the risk assessment. Appendix B presents equations for calculating media concentrations. Appendices C and D provide chemical and media-specific bioconcentration factors (BCFs). Appendix E provides toxicity reference values (TRVs) for 38 compounds of potential concern (COPCs) and several possible measurement receptors. Appendix F presents equations for calculating risk. Appendix G provides contact information for obtaining site-specific species information, and Appendix H provides toxicological profiles for 38 COPCs. Figure 1-1 summarizes the steps needed to complete a screening level ecological risk assessment.

Implementation of this guidance will demonstrate that developing defensible estimates of compound emission rates is one of the most important elements of the risk assessment. As described in Chapter 2, traditional trial burns conducted to measure destruction and removal efficiency (DRE) do not sufficiently characterize organic products of incomplete combustion (PIC) and metal emissions for use in performing risk assessments. In some instances, a facility or regulatory agency may want to perform a pretrial burn risk assessment, following the procedures outlined in this document, to ensure that sample collection times during the trial burn or risk burn are sufficient to collect the sample volumes needed to meet the detection limits required for the risk assessment. The decision to perform such an assessment should consider regulatory permitting schedules and other site-specific factors.

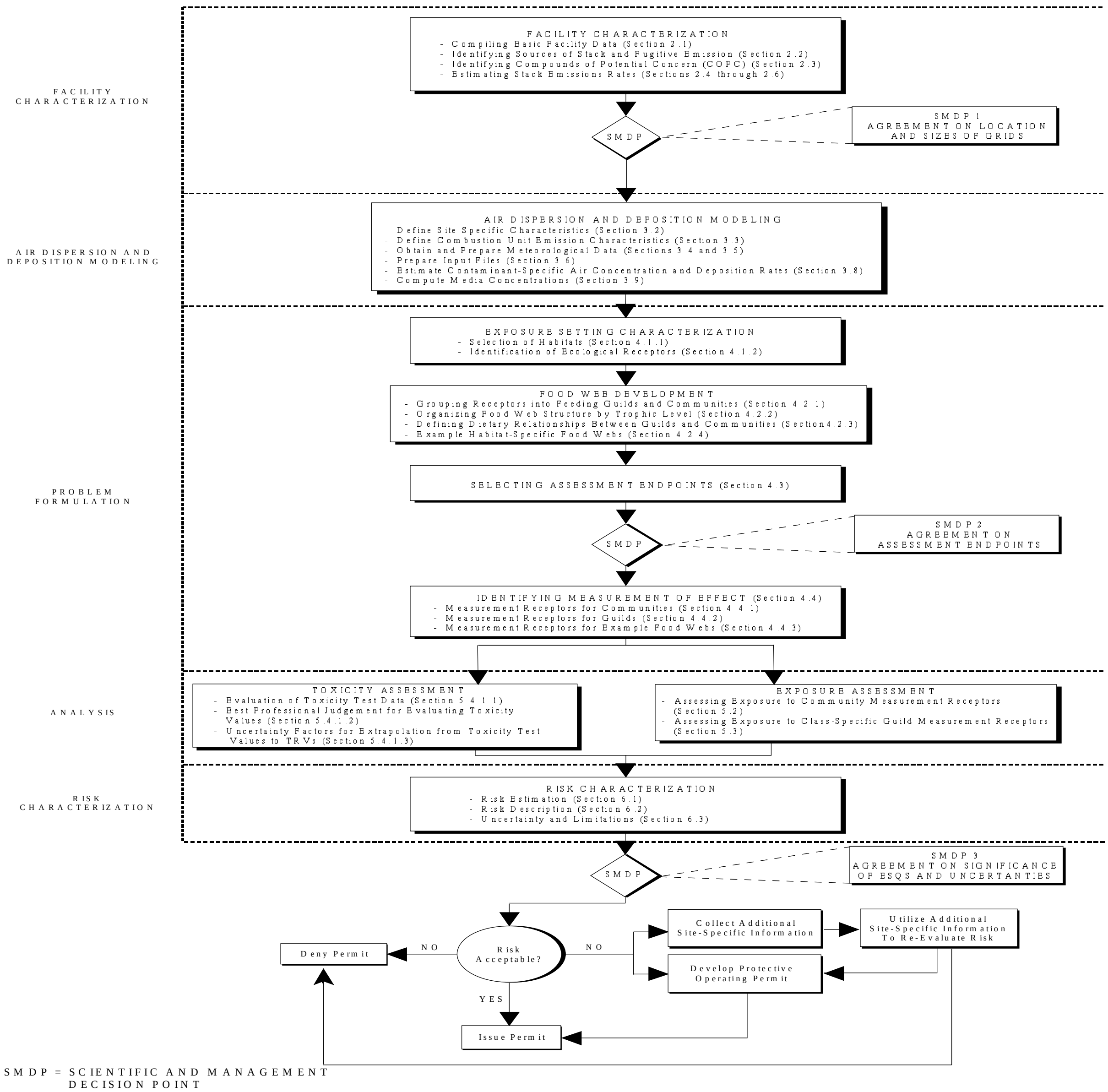
U.S. EPA OSW anticipates that ecological risk assessments will be completed for new and existing facilities as part of the permit application process. The SLERAP recommends a process for evaluating *reasonable*—not theoretical worst-case maximum—potential risks to receptors posed by emissions from RCRA regulated units. The use of existing and site-specific information early in, and throughout, the risk assessment process is encouraged; protective assumptions should be made only when needed to ensure that emissions from combustion units do not pose unacceptable risks. More protective assumptions may be incorporated to make the process fit a classical "screening level" approach that is more protective and may be easier to complete.

Regardless of whether theoretical worst case or more reasonable protective assumptions are used in completing the risk assessment process, every risk assessment is limited by the quantity and quality of:

- site-specific environmental data
- emission rate information
- other assumptions made during the risk estimation process (for example, fate and transport variables, exposure assumptions, and receptor characteristics)

These limitations and uncertainties are described throughout this document and the appendixes, and are summarized in Chapter 6.

FIGURE 1-1
SCREENING-LEVEL ECOLOGICAL RISK ASSESSMENT PROCESS



Potentially, unacceptable risks or other significant issues identified by collecting preliminary site information and completing risk assessment calculations can be addressed by the permitting process or during an iteration of the risk assessment. After the initial ecological risk assessment has been completed, it may be used by risk managers and permit writers in several ways:

- If the initial risk assessment indicates that estimated ecological risks are below regulatory levels of concern, risk managers and permit writers will likely proceed through the permitting process without adding any risk-based unit operating conditions to the permit.

- If the initial ecological risk assessment indicates potentially unacceptable risks, additional site-specific information demonstrated to be more representative of the exposure setting may be collected and additional iterations of risk assessment calculations can then be performed.

- If the initial risk assessment or subsequent iterations indicate potentially unacceptable risks, risk managers and permit writers may use the results of the risk assessment to revise tentative permit conditions (for example, waste feed limitations, process operating conditions, and expanded environmental monitoring). To determine if the subject hazardous waste combustion unit can be operated in a manner that is protective of the environment, an additional iteration of the risk assessment should be completed using the revised tentative operating conditions. If the revised conditions still indicate unacceptable risks, this process can be continued in an iterative fashion until acceptable levels are reached. In some situations, it may be possible to select target risk levels and back-calculate the risk assessment to determine the appropriate emission and waste feed rate levels. In any case, the acceptable waste feed rate and other appropriate conditions can then be incorporated as additional permit conditions.

- If the initial ecological risk assessment, or subsequent iterations, indicate potentially unacceptable risks, risk managers and permit writers may also choose to deny the permit.

This process is also outlined in Figure 1-1. As stated earlier, in some instances, a facility or regulatory agency may want to perform a pretrial burn risk assessment—following the procedures outlined in this document—to ensure that sample collection times during the trial burn or risk burn are sufficient to collect the sample volumes necessary to meet the appropriate detection limits for the risk assessment. This is expected to reduce the need for additional trial burn tests or iterations of the risk assessment due to problems caused when detection limits are not low enough to estimate risk with certainty sufficient for regulatory decision making.

1.2 RELATED TRIAL BURN ISSUES

In the course of developing this guidance and completing risk assessments across the country, U.S. EPA OSW has learned that developing defensible estimates of compound of potential concern (COPC) emission rates is one of the most important parts of the risk assessment process. As described in Chapter 2, traditional trial burns conducted to measure destruction and removal efficiency (DRE) *do not* sufficiently characterize organic products of incomplete combustion (PIC) and metal emissions for use in performing risk assessments.

U.S. EPA OSW considers the trial burn and risk assessment planning and implementation processes as interdependent aspects of the hazardous waste combustion unit permitting process. In addition, U.S. EPA OSW advocates that facility planning, regulatory agency review, and completion of tasks needed for both processes be conducted simultaneously to eliminate redundancy or the need to repeat activities. U.S. EPA OSW expects that the following guidance documents will typically be used as the main sources of information for developing and conducting appropriate trial burns:

- U.S. EPA. 1989f. *Handbook: Guidance on Setting Permit Conditions and Reporting Trial Burn Results. Volume II of the Hazardous Waste Incineration Guidance Series.* Office of Research and Development (ORD). EPA/625/6-89/019. January.

- U.S. EPA. 1989g. *Handbook: Hazardous Waste Incineration Measurement Guidance Manual. Volume III of the Hazardous Waste Incineration Guidance Series.* Office of Solid Waste and Emergency Response (OSWER). EPA/625/6-89/021. June.

- U.S. EPA. 1992e. *Technical Implementation Document for EPA's Boiler and Industrial Furnace Regulations.* OSWER. EPA-530-R-92-011. March.

- U.S. EPA. 1994n. *Draft Revision of Guidance on Trial Burns. Attachment B, Draft Exposure Assessment Guidance for Resource Conservation and Recovery Act (RCRA) Hazardous Waste Combustion Facilities*. OSWER. April 15.

- U.S. EPA. 1998b. *Guidance on Collection of Emissions Data to Support Site-Specific Risk Assessments at Hazardous Waste Combustion Facilities*. Prepared by EPA Region 4 and the Office of Solid Waste.

- Generic Trial Burn Plan and QAPPs developed by EPA regional offices or states.

1.3 REFERENCE DOCUMENTS

This section describes, in chronological order, the primary guidance documents used to prepare this guidance. Some of the guidance documents received a thorough review from EPA's Science Advisory Board, which mostly supported the work. Additional references used to prepare this guidance are listed in the References chapter of this document. These documents have been developed over a period of several years; in most cases, revisions to the original guidance documents address only the specific issues being revised rather than representing a complete revision of the original document. The following discussion lists and briefly describes each document. Overall, each of the guidance documents reflects a continual enhancing of the methodology.

This ecological assessment portion of this protocol is based on protecting the functions of ecological receptors in ecosystems and protecting special ecological areas around a hazardous waste combustion facility. It is generally consistent with current U.S. EPA guidance, including the Risk Assessment Forum's *Guidelines for Ecological Risk Assessment* (U.S. EPA 1998d), as well as the interim final *Ecological Risk Assessment Guidance for Superfund* (U.S. EPA 1997c) The most current methodology for assessing fate and transport of COPC's frequently referenced in this guidance is the U.S. EPA document, *Methodology for Assessing Health Risks Associated with Multiple Exposure Pathways to Combustor Emissions* (In Press).

The following document was the first U.S. EPA NCEA guidance document for conducting risk assessments at combustion units:

- U.S. EPA. 1990a. *Interim Final Methodology for Assessing Health Risks Associated with Indirect Exposure to Combustor Emissions*. Environmental Criteria and Assessment Office. ORD. EPA-600-90-003. January.

This document outlined and explained a set of general procedures recommended in this guidance for determining media concentrations utilized in ecological risk assessments. This document was subsequently revised by the following:

- U.S. EPA. 1993h. *Review Draft Addendum to the Methodology for Assessing Health Risks Associated with Indirect Exposure to Combustor Emissions*. Office of Health and Environmental Assessment. ORD. EPA-600-AP-93-003. November 10.

U.S. EPA (1993h) outlined recommended revisions to previous U.S. EPA guidance (1990a), which have been used by the risk assessment community since the release of the document; however, these recommended revisions were never formally incorporated into the original document.

Finally, U.S. EPA Region 5 contracted for development of a *Screening Ecological Risk Assessment of Waste Technologies Industries (WTI) Hazardous Waste Incinerator*, in Liverpool, Ohio (U.S. EPA 1995l). This document was extensively peer reviewed and represents the most current application of ecological risk assessment guidance at a combustion facility. The WTI screening ecological risk assessment was reviewed and considered throughout the development of the approach presented in this guidance document.

U.S. EPA. 1998d. *Proposed Guidance for Ecological Risk Assessment*. Risk Assessment Forum, Washington, D.C. EPA/630/R-95/002B. August.

U.S. EPA. 1997c. *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments*. Interim Final. Environmental Response Team, Office of Emergency and Remedial Response, Edison, New Jersey. June 5.

Root, R.B. 1967. “The Niche Exploitation Pattern of the Blue-Gray Gnatcatcher.” *Ecological Monographs*. Volume 37, Pages 317-350.

Odum, E.P. 1971. *Fundamentals of Ecology*. Third Edition. W.B. Saunders Company, Philadelphia. 574 pp.