RCRA DELISTING
TECHNICAL SUPPORT DOCUMENT

Office of Solid Waste

Prepared by

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DISCLAIMER

This document provides describes to U.S. Environmental Protection Agency (U.S. EPA) regions and states on how to use the U.S. EPA Delisting Risk Assessment Software (DRAS) as a tool for the evaluation of hazardous waste delisting petitions. The document is not a substitute for U.S. EPA 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 on the circumstances. U.S. EPA may change the DRAS in the future, as appropriate.

REVISION ACKOWLEDGEMENTS

Development of the latest version of the Delisting Risk Assessment Software (DRAS), version 4, and revisions to the Delisting Technical Support Document (DTSD) and chemical parameter database would not have been possible without the support, input, and resources of numerous scientists, engineers, and environmental specialists around the country. Resources from EPA's Office of Resource Conservation and Recovery (ORCR) and Regions 1, 5, 6, 7, 9, and 10 underwrote the effort to recode DRAS onto an updated software platform and correct technical issues with the previous version. EPA Region 5 staff Lisa Graczyk, Christopher Lambesis, and Todd Ramaly led the effort to guide the modeling and programming contractor, revise documentation, and contribute significant updates to physical, chemical, and toxicological parameters used in the model. Special appreciation is warranted for Michelle Peace, EPA Region 6, for her able leadership and coordination with the National Delisting Workgroup as well as the contracting staff at EPA Region 7, including Cody McLarty, Fritz Koni, Debra Dorsey, and others.

Dr. Varut (Dua) Guvanasen with HydroGeoLogic, Inc. of Reston, Virginia led the contractor effort to produce DRAS version 4, with substantial assistance from programmer Craig Labbe and Dr. Xinyu Wei. The previous version was developed based on the legacy Visual Basic 6.0 code which hadn't had developer support since 2008. The updated version required recoding the entire model into a new "stack" of program components, including a risk computational engine (Fortran), a graphical user interface or GUI (Python), and modern database (SQLite). The components were developed independently with the flexibility that each could be maintained and updated separately, if needed. The recode added a number of improvements to the user interface and restored features of the previous version that no longer functioned.

EPA appreciates the significant and timely contribution of a number professionals with EPA and States in reviewing beta-versions of the model and providing comment, including Dave Bartus, EPA Region 10, Carlyn Chappel, EPA Region 2, Greg Gould, P.E., Washington State Department of Ecology, and Dr. Seth Sadofsky with the Oregon Department of Environmental Quality.

We're also grateful for an intense effort to begin updating the database of physical, chemical, and toxicological parameters that underpin the DRAS model. Lisa Graczyk led the effort to establish an approach based on obtaining recent, high quality experimental values for important parameters in the DRAS database. With help from Sharon Leitch and Alexander "Tristan" Pluta of EPA Region 1, this team assembled, referenced, and documented over 550 revised values for the database. The review covered all toxicity reference data, Henry's Law Constants, Octanol/Water Partitioning Coefficients (Kow) and a small number of other parameters that were derived from these. We also appreciate the assistance of Dr. Mario Mangino, EPA Region 5, who consulted on difficult toxicological reference data.

ORIGINAL ACKNOWLEDGMENTS

The Region 6 Delisting Team and Dr. Michael Morton (U.S. EPA Region 6), the primary author and editor of the Delisting Technical Support Document (DTSD) and the interactive, Windows-based Delisting Risk Assessment Software (DRAS), would like to acknowledge that development of the (RCRA) delisting risk-based program 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 procedures and methodologies outlined in the DRAS and DTSD was first developed by the Office of Research and Development (ORD) and the Office of Solid Waste (OSW) in previous RCRA delisting risk assessment procedures. The risk assessment approach 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 RCRA delisting risk assessment program. The DRAS, which performs risk assessments for wastes petitioned for RCRA delisting, has been developed to facilitate the risk-based evaluation of the wastes by nontechnical personnel. The DTSD was written to describe the technical methodology used by the DRAS to generate risk-based information on wastes petitioned for RCRA delisting.

The development of this document was significantly enhanced by capable organizations and personnel within U.S. EPA. Chichang Chen and Shenyi Yang of the Hazardous Waste Identification Division are to be commended for their technical comments on the overall methodologies presented in the DTSD and their insightful ideas for the DRAS, which led to a more user-friendly software product. In addition, Stephen Kroner and David Cozzie of the Economic Methods and Risk Analysis Division provided significant policy and technical comments on the DTSD and DRAS.

The U.S. EPA regional offices contributed valuable comments that have significantly improved the usability of both the risk-based software and the supporting document. The authors would be remiss if they did not acknowledge significant contributions from Judy Sophianopoulos of Region 4, Todd Ramaly of Region 5, Michael Gansecki of Region 8, and Patrick Wilson of Region 9. Cheryl Overstreet of the Region 6 Base Closure Team also contributed a valuable review of the DTSD.

In addition, Terry Allison of Allison Geoscience Consultants, Inc., provided a significant review of the methodologies used to incorporate waste volume into groundwater fate and transport modeling.

This work could not have been completed without valuable support from contractor personnel. Tetra Tech EM Inc. (Doug Czechowski) and Tech Law (Wally O'Rear) performed the bulk of the project's oversight and coordination. HydroGeoLogic, Inc., under subcontract, provided technical improvements in the modeling approaches used in the risk-based process, such as the EPA's Composite Model for Leachate Migration with Transformation Products (EPACMTP) ground water fate and transport model advancements. HydroGeoLogic, Inc., led by Sam Figuli and Darren Baird, developed the software code that forms the foundation of the Windows-based Delisting Risk Assessment Software (DRAS) program. The work of these contractors was performed under the technical direction of Region 6 Delisting Team staff as well as key Agency project and contracting officers.

More recently, the DRAS has been extensively modified to incorporate updated groundwater modeling, Updated adsorption isotherms for metals from the Metal Speciation Equilibrium Model for Surface and Ground Water (MINTEQA2), new toxicity data, and other technical upgrades or corrections have been incorporated intoDRAS version 3 by the joint efforts of Regions 5 and 6 under the direction of Todd Ramaly (R5) and Michelle Peace (R6) . The improvements were made possible by the generous contribution of technical, financial, and contractor support of other EPA Regions including Region 3's Dave Friedman, Region 7's Jim Seiler, and Region 9's Cheryl Nelson. The revised groundwater modeling was provided by HydroGeoLogic, Inc., led by Dr. Varut (Dua) Guvanasen with computer programming changes under subcontract to AMEC's Darren Baird. The work was continued by TechLaw, Inc. led by Kristi Hogan and Nicole Guyer with updates to the software code by Amy Lu.

All remaining updates were finalized by Dr. Guvanasen of HydroGeoLogic, Inc. in 2008 with major contributions from his team members Prashanth Khambhammettu (programming) and Dr. Xinyu Wei (calculation verification).

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ACRONYMS AND ABBREVIATIONS

μg	Microgram
μm	Micron
AADM	Ambient Air Dispersion Model
ADD	Average daily dose
AP-42	"Title"
API	American Petroleum Institute
AT	Averaging time
atm	Atmosphere
BAF	Bioaccumulation factor
BaP	Benzo(a)pyrene
BCF	Bioconcentration factor
BOD	Biochemical oxygen demand
BSAF	Biota-sediment bioaccumulation factor
BW	Body weight
CAS	Chemical Abstracts Service
CFR	*Code of Federal Regulations*
CLP	Contract Laboratory Program
cm	Centimeter
CSF	Cancer slope factor
DAD	Personally absorbed dose
DAF	Dilution attenuation factor
DF	Dilution factor
DRAS	Delisting Risk Assessment Software
DTSD	Delisting Technical Support Document
DW	Dry weight of soil or plant or animal tissue
EFH	Exposure Factors Handbook
EPACML	U. S. EPA Composite Model for Landfill
EPACMTP	U. S. EPA Composite Model for Leachate Migration with Transformation Products
EQL	Estimated quantitation limit
FR	*Federal Register*
g	Gram
GC	Gas chromatography
HBN	Health-based number
HEAST	Health Effects Assessment Summary Tables
HELP	Hydrologic Evaluation of Landfill Performance
HI	Hazard index
HQ	Hazard quotient
hr	Hour
HSWA	Hazardous and Solid Waste Amendments

ACRONYMS AND ABBREVIATIONS (Continued)

HWIR	Hazardous Waste Identification Rule
IDL	Instrument detection limit
IEUBK	Integrated Exposure Uptake Biokenitc Model
IRIS	Integrated Risk Information System
ISC	Industrial Source Complex
ISCST3	Industrial Source Complex Short Term 3
ISCSTDFT	Industrial Source Complex Short Term Draft
K	Kelvin
kg	Kilogram
km	Kilometer
L	Liter
LADD	Lifetime average daily dose
lb	Pound
m	Meter
MCL	Maximum contaminant level
MCLG	Maximum contaminant level goal
MDL	Method detection limit
Mg	Megagram
mg	Milligram
MIR	Maximum individual risk
mL	Milliliter
mm	Millimeter
MSWLF	Municipal solid waste landfill
NAPL	Nonaqueous-phase liquid
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NCEA	U. S. EPA National Center for Environmental Assessment
NPDES	National Pollutant Discharge Elimination System
NRC	National Research Council
NWT	Nonwastewater leachate
OAQPS	U. S. EPA Office of Air Quality Planning and Standards
OPPI	U. S. EPA Office of Policy Planning and Implementation
ORD	U. S. EPA Office of Research and Development
OSW	U. S. EPA Office of Solid Waste
PAH	Polynuclear aromatic hydrocarbon
PCB	Polychlorinated biphenyl
PCDD	Polychlorinated dibenzo(p)dioxin
PCDF	Polychlorinated dibenzofuran
PDF	Probability density function
pg	Picogram
PM	Particulate matter

ACRONYMS AND ABBREVIATIONS (Continued)

PM10	Particulate matter less than 10 microns in diameter
POE	Point of exposure
ppb	Parts per billion
ppm	Parts per million
ppmv	Parts per million by volume
ppt	Parts per trillion
PQL	Practical quantitation limit
QA	Quality assurance
QAPP	Quality assurance project plan
QC	Quality control
RAEPE	"Rapid Assessment of Exposure to Particulate Emissions from Surface Contamination Sites"
RAGS	"Risk Assessment Guidance for Superfund"
RCRA	Resource Conservation and Recovery Act
RfC	Reference concentration
RfD	Reference dose
RMC	Reynolds Metals Company
RME	Reasonable maximum exposure
RPF	Relative potency factor
s	Second
SIMS	Surface Impoundment Modeling System
SQL	Sample quantitation limit
STORET	Database Utility for STOrage and RETrieval of Chemical, Physical, and Biological Data for Water Quality
SVOC	Semivolatile organic compound
SW-846	"Test Methods for Evaluating Solid Waste"
TCDD	Tetrachlorodibenzo(p)dioxin
TCLP	Toxicity characteristic leaching procedure
TC Rule	Toxicity characteristics Rule
TDA	Toluenediamine
TDI	Toluene diisocyanate
TEF	Toxicity equivalent factor
TEQ	Toxicity equivalent quotient
Tetro Tech	Tetro Tech EM Inc.
THQ	Target hazard quotient
TIC	Tentatively identified compound
TLV	Threshold limit value
TOC	Total organic carbon
TSD	Treatment, storage, or disposal
TWA	Time-weighted average
UCL_{95}	95^{th} percentile upper confidence limit
U.S. DOE	U. S. Department of Energy

ACRONYMS AND ABBREVIATIONS (Continued)

U.S. EPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey
USLE	Universal soil loss equation
VOC	Volatile organic compound
WQC	Water quality criteria
yd	Yard
yr	Year

VARIABLES

A	=	area of waste management unit (acres)
a	=	coefficient for Stability Class D = 32.093
A_{eroded}	=	amount of soil and waste eroded (tons/acre/yr)
$A_{exposed}$	=	area of waste management unit exposed (acres)
A_s	=	waste mass delivered to surface water (kg/acre/yr)
A_{si}	=	area of surface impoundment (m^2)
A_{skin}	=	exposed skin surface area (cm^2)
A_w	=	rate of waste erosion from landfill (kg/acre/yr)
ADD	=	average daily dose (mg waste constituent/kg BW/day)
$ADD_{c,p}$	=	average daily dose for waste constituent *c* for pathway *p* (mg/kg-day)
AT	=	averaging time (days or yrs)
$\hat{a}$	=	Proportionality constant $(cm/sec)^{-1/3}$
B	=	Bunge constant (unitless)
b	=	coefficient for Stability Class D = 0.81066
BAF	=	bioaccumulation factor (L/kg)
BD	=	soil dry bulk density (g soil/cm^3 soil)
BW	=	body weight (kg)
C	=	constant $(m^2/s)^{-2/3}$
C_{air}	=	constituent's maximum allowable respirable air concentration at POE (mg/m^3)
$C_{air\text{-}I}$	=	constituent air concentration from compartments: shower, bathroom, and house (mg/L)
$C_{air\text{-}max}$	=	maximum possible air concentration of waste constituent based on Henry's Law (mol/L)
C_{avg}	=	downwind concentration of waste constituent at POE (mg/m^3)
$C_{avg,s}$	=	average constituent air concentration in shower (mg/L)
$C_{avg,b}$	=	average constituent air concentration in bathroom (mg/L)
$C_{avg,h}$	=	average constituent air concentration in house (mg/L)
$C_{dl\text{-}air\text{-}p}$	=	pathway total concentration delisting level for respirable landfill air particulates (mg/kg)
$C_{di\text{-}air\text{-}si}$	=	pathway leachate concentration delisting level for volatiles from surface impoundment (mg/L)
$C_{dl\text{-}air\text{-}v}$	=	pathway total concentration delisting level for volatiles from landfill (mg/L)
$C_{dl\text{-}dermal}$	=	pathway leachate concentration delisting level for groundwater dermal contact (mg/L)
$C_{dl\text{-}fish}$	=	pathway total concentration delisting level for fish ingestion (mg/kg)
$C_{dl\text{-}ingest}$	=	pathway leachate concentration delisting level for groundwater ingestion (mg/L)
$C_{dl\text{-}inhale}$	=	pathway leachate concentration delisting level for shower inhalation (mg/L)
$C_{dl\text{-}soil}$	=	pathway total concentration delisting level for soil ingestion (mg/kg)
$C_{dl\text{-}water}$	=	pathway total concentration delisting level for ingestion of surface water (mg/kg)
C_{dw}	=	dissolved-phase water concentration (mg waste constituent/L water)
C_{fish}	=	maximum allowable concentration of waste constituent in fish tissue (mg/kg)
$C_{5th\text{-}stream}$	=	concentration of waste in fifth-order stream (kg/L)

VARIABLES (Continued)

C_{gen}	=	generic constituent concentration — the medium average concentration contacted over the exposure period (for example, mg/kg for soil and mg/L for water)
C_{gw}	=	waste constituent concentration in groundwater (mg/L)
$C_{gw\text{-}dermal}$	=	maximum allowable constituent concentration in groundwater for dermal exposure (mg/L)
$C_{gw\text{-}ingest}$	=	maximum allowable constituent concentration in groundwater for ingestion (mg/L)
$C_{\text{gw-inhale}}$	=	maximum allowable constituent concentration in groundwater used for showering (mg/L)
C_i	=	vapor-phase concentration of *I* in landfill (g/m^3)
c_i	=	maximum allowable vapor-phase concentration of constituent in landfill (g/m^3)
C_{inh}	=	mass of waste constituent inhaled (mg/day)
C_L	=	leachate concentration (TCLP concentration) (mg/L)
C_l	=	Concentration of constituent *I* in liquid phase ($mol.m^{-3}$)
C_{LMAX}	=	maximum allowable waste leachate (TCLP) concentration (mg/L)
C_s	=	vapor-phase concentration of *constituent I* at surface (g/m^3)
C_{sat}	=	soil saturation concentration (mg/kg)
C_{soil}	=	resulting soil concentration (mg/kg soil/yr)
$C_{soluble}$	=	concentration of soluble fraction of constituent in waste (mg/kg)
C_{sw}	=	concentration of waste constituent in surface water (mg/L)
$C_{total\ waste}$	=	total concentration of constituent in waste (mg/kg)
$Cancer\ Risk_i$	=	individual lifetime risk indirect exposure to waste constituent *I* (unitless)
$Cancer\ Risk_{inh(I)}$	=	individual lifetime cancer risk from direct inhalation of carcinogen waste constituent *I* (unitless)
CM	=	USLE cover management factor (unitless)
CR	=	water consumption rate (L/day)
CR_{fish}	=	fish water consumption rate (kg/day)
CR_{gen}	=	contact rate — the amount of contaminated medium contacted per unit time or per event (for example, kg/day for soil and L/day for water) (upper-bound value)
CR_{soil}	=	soil consumption rate (mg/day)
Cs	=	average soil concentration over exposure duration (mg waste constituent/kg soil)
C_{si}	=	saturation vapor concentration of *I* in landfill
CSF_c	=	cancer slope factor for waste constituent *c* $(mg/kg\ day)^{-1}$
CSF_{inhal}	=	constituent inhalation cancer slope factor $(mg/kg\ day)^{-1}$
CSF_{oral}	=	constituent oral cancer slope factor $(mg/kg\ day)^{-1}$
D	=	100, distance to stream or river (m)
d	=	depth of soil cover (m)
D_a	=	diffusivity of constituent in air (cm^2/s)
D_{air}	=	diffusion coefficient of constituent in air (m^2/s)
d_e	=	effective diameter of surface impoundment (m)
D_{ether}	=	diffusion coefficient of ether (cm^2/s)
D_i	=	gas-phase diffusion coefficient (m^2/s)
D_l	=	diffusivity in water of a chemical (m^2/s)
D_w	=	diffusion coefficient in water (cm^2/s)
DA_{event}	=	dose absorbed per unit area per event (mg/cm^2-event)

VARIABLES (Continued)

DAD = dermally absorbed dose (mg/kg-day)
DAF = dilution attenuation factor (unitless)
DAF_{sf} = DAF scaling factor (unitless)
DAF_{va} = waste volume-adjusted DAF (unitless)
DH = drop height of material from truck (m)
d_p = droplet diameter (cm)

E_i = landfill volatile emission flux of constituent (g/s)
E_l = particulate emissions from waste loading and unloading operations (kg/ton)
E_{l10} = waste loading and unloading emission rate of particulates up to 10 μm (kg/ton)
E_{l30} = waste loading and unloading emission rate of particulates up to 10 μm (kg/ton)
E_T = total emission rate of particulates that may be inhaled (g/hr)
E_{T10} = total emission rate of particulates up to 10 μm (g/hr)
E_{T30} = total emission rate of particulates up to 30 μm (g/hr)
E_v = particulate emissions from vehicle travel (g/hr)
E_{v10} = vehicle travel emission rate of particulates up to 10 μm (g/hr)
E_{v30} = vehicle travel emission rate of particulates up to 30 μm (g/hr)
E_w = particulate emissions from wind erosion (g/hr)
E_{w10} = wind erosion emission rate of particulates up to 10 μm (g/hr)
E_{w30} = wind erosion emission rate of particulates up to 30 μm (g/hr)
ED = exposure duration (yr)
EF = exposure frequency (days/yr)
ET_{comp} = exposure time in each compartment (bath, shower, or house) (days/shower)
EV = event frequency (events/day)

F = frequency that wind blows from sector of interest (unitless)
F_c = fraction contaminated (unitless)
$\mathrm{f}_{em,b}$ = fraction of constituent emitted from bathroom water use (unitless)
f_{emh} = fraction of constituent emitted from house water use (unitless)
$\mathrm{f}_{em,s}$ = fraction of constituent emitted from shower water use (unitless)
$F_{exposed}$ = fraction of area exposed to erosion (unitless)
F_{inhal} = fraction of particulates inhaled (Unitless)
f_{oc} = fraction organic carbon content of soil (g/g)
$f_{sat,\,I}$ = Fraction of gas phase saturation for each shower inhalation compartment I
$F(X)$ = dimensionless function obtained from plot in RAEPE

h = nozzle height (cm)
H = Henry's Law constant (atm-m^3/mol)
H' = dimensionless Henry's Law constant
HBN = health-based number (or MCL) (mg/L)
HI = hazard index (unitless)
HI_p = total hazard index for all waste constituents for specific exposure pathway p
HQ = hazard quotient (unitless

$HQ_{c,p}$	=	hazard quotient for waste constituent *c* for exposure pathway *p* (unitless)
HI_{cu}	=	aggregate hazard index for all constituents and all exposure pathways
I	=	intake — amount of constituent at exchange boundary (mg/kg-day); for evaluating exposure to noncarcinogenic constituents, this intake is referred to as ADD; for evaluating exposure to carcinogenic constituents, this intake is referred to as LADD
I_b	=	bathroom water use (L/min)
I_h	=	house water use (L/min)
I_s	=	shower water use (L/min)
IFA_{adj}	=	inhalation factor, age-adjusted ([m^3-year]/[kg-day])
IFS_{adj}	=	soil ingestion factor ([mg-year]/[kg-day])
IFW_{adj}	=	water ingestion factor, age-adjusted [L•year]/[kg•day]
IR	=	inhalation rate (m^3/day or m^3/hr)
J_i	=	volatile emission flux of constituent (g/m^2/s)
k	=	constant— 0.36 for particulates up to 10 μm and 0.8 for particulates up to 30 μm
K	=	overall mass transfer coefficient (m/s)
K_d	=	soil-water partition coefficient (cm^3 water/g or L/kg)
K_{ef}	=	USLE erodibility factor (ton/acre)
K_{eq}	=	equilibrium constant (unitless)
K_G	=	gas-phase transfer coefficient (m/yr)
K_g	=	gas-phase mass transfer coefficient (m/s)
K_L	=	liquid-phase transfer coefficient (m/yr)
K_l	=	liquid-phase mass transfer coefficient (m/s)
K_{oc}	=	soil organic carbon-water partition coefficient (mL water/g soil)
k_{oc}	=	normalized distribution coefficient (L/kg)
K_{ol}	=	overall mass transfer coefficient (cm/sec)
K_{ow}	=	octanol-water partition coefficient (mg waste constituent/L octanol)/(mg waste constituent/L water)
K_p	=	batch drop particle size multiplier (dimensionless)
K_p^w	=	skin permeability constant in water (cm/hr)
Ke	=	equilibrium coefficient (s/cm-yr)
L	=	distance from center of uncovered waste area to compliance point 1,000 feet (304.8 m) downwind (km)
L'	=	virtual distance (the distance necessary to convert from an ideal point source to a volume source) (km)
L_v	=	distance from virtual point to compliance point located 1,000 feet (304.8 m) downwind (m)
$LADD$	=	lifetime average daily dose (mg waste constituent/kg BW/day)
$LADD_{c,p}$	=	lifetime average daily dose for waste constituent *c* (mg/kg-day) via pathway *p*
LS	=	USLE length-slope factor (unitless)
M	=	moisture content of waste (percent)
M_i	=	molecular weight ($g.mol^{-1}$)
MW	=	molecular weight
n	=	total soil porosity (L_{pore}/L_{soil})
N_p	=	number of days per year with at least 0.01 inch of precipitation (days per year)

VARIABLES (Continued)

P = support practice factor (dimensionless)
p = Pasquill Stability coefficient for Category D (unitless)
P_a = air-filled sand porosity (dimensionless)
P_p = partial pressure of constituent (atm)
P_T = total sand porosity (dimensionless)
PF = USLE supporting practice factor (unitless)

q = Pasquill Stability coefficient for Category D (unitless)
q_d = rate of deposition ($mg/m^2/s$)
Q = surface impoundment exfiltration rate at bottom (m^3/day)
Q_{gs} = volumetric gas exchange rate between shower and bathroom (L/min)
Q_{gb} = volumetric gas exchange rate between bathroom and house (L/min)
Q_{gh} = volumetric gas exchange rate between house and atmosphere (L/min)
Q_p = emission rate of waste constituent particluates (mg/s)
Q_{p10} = emission rate of waste constituent particulates up to 10 μm (mg/s)
Q_{p30} = emission rate of waste constituent particulates up to 30 μm (mg/s)
Q_v = volatile emission rate (mg/s)
Q_{2nd} = flux of water in second-order stream (L/year)
Q_{stream} = volumetric flow of stream (L/year)

R = universal gas constant (atm-m^3/mol-K)
RF = rainfall erosion factor (1/year)
RfC = reference concentration (mg/kg)
RfD = reference dose (mg/kg-day)
RfD_c = reference dose for waste constituent *c* (mg/kg-day)
Risk = cancer risk for carcinogens (unitless)
$Risk_{c,p}$ = risk for waste constituent *c* for specific exposure pathway *p*
$Risk_{cum}$ = aggregate risk for all constituents and all exposure pathways
$Risk_p$ = total risk for all constituents for specific exposure pathway *p*

S = mean vehicle speed (km/hr)
s = silt content of waste (percent)
S_{cg} = Schmidt number on gas side (unitless)
S_d = sediment delivery ratio (unitless)
SF = slope factor $(mg/kg\text{-}day)^{-1}$
Sol = solubility in water (mg/L water)

T = standard temperature (K)
t = soil thickness from which particles can be ingested (m)
$(t_{t+1} - t_t)$ = calculational time step (min)
t_{event} = duration of event (hr/event)
TCLP = TCLP concentration of waste constituent (mg/L)
tf = time for constituent concentration to reach 1 percent of C_L
tr = surface impoundment retention time (days)
tp = time period for mass emission from surface impoundment (days)
THQ = target hazard quotient (unitless)
TPD_{min} = minimum round trips per day

TR = individual target risk level (unitless)

VARIABLES (Continued)

TSS	=	total suspended solids concentration (mg/L)
U	=	mean annual wind speed (m/s)
U_{10}	=	wind speed at 10 m (m/s)
U_t	=	threshold value of wind speed at 7 m (m/s)
V	=	lifetime volume of landfilled waste or surface impoundment liquid (yd^3)
V_A	=	annual volume of landfilled waste or surface impoundment liquid (yd^3)
V_b	=	volume of bathroom (L)
V_h	=	volume of house (L)
V_s	=	volume of shower (L)
V_{si}	=	volume of liquid in surface impoundment (m^3)
$\mathrm{v_d}$	=	deposition velocity (m/s)
v_t	=	terminal velocity (cm/sec)
Vf	=	fraction of disposal site covered with vegetation (unitless)
VKT	=	vehicle kilometers traveled-km trip x number of trips
VR_{comp}	=	ventilation rate for compartment (shower, bathroom, house) (L/hr)
W	=	mean vehicle weight (tons)
w	=	mean number of wheels per vehicle
W_{comp}	=	water used in one of three compartments (shower, bathroom, house) (L/hr)
X	=	dimensionless ratio
x	=	½ width of area exposed (m)
$\mathrm{y_{b,t}}$	=	gas phase constituent concentration in the bathroom (mg/L)
$\mathrm{y_{h,t}}$	=	gas phase constituent concentration in the house (mg/L)
$\mathrm{y_{s,t}}$	=	gas phase constituent concentration in the shower (mg/L)
Yd	=	dumping device capacity (m^3)
á	=	mass fraction of constituent in waste (unitless)
Ö	=	mass transfer efficiency of chemical (unitless)
$\ddot{O}_{Rn}$	=	mass transfer efficiency of radon (unitless)
r_a	=	density of air (g/cm^3)
$\tilde{n}_b$	=	soil bulk density (mg/m^3)
$\tilde{n}_{db}$	=	dry soil bulk density (kg/L)
$\tilde{n}_s$	=	soil particle density (kg/L)
$\tilde{\mathrm{n}}_\mathrm{w}$	=	waste density (tons per cubic yard)
$\grave{E}_a$	=	air-filled soil porosity (L_{air}/L_{soil})
$\grave{E}_w$	=	water-filled soil porosity (L_{water}/L_{soil})
ô	=	lag time (hr)
m_a	=	viscosity of air (gm/cm-s)
$\sum_z$	=	vertical dispersion coefficient (m)
10^{-2}	=	unit conversion factor ($kg\text{-}cm^2/mg\text{-}m^2$)
10^{-3}	=	unit conversion factor ($kg\text{-}\mu g/g^2$)
10^{-4}	=	unit conversion factor (m^2/cm^2)

10^{-6}	=	unit conversion factor (g/µg)
10^{-6}	=	unit conversion factor (kg/mg)
0.001	=	unit conversion factor (g/mg)
0.004047	=	unit conversion factor (km^2/acre)
0.31536	=	unit conversion factor (m-g-s/cm-µg-yr)
365	=	unit conversion factor (days/yr)
907.18	=	unit conversion factor (kg/ton)
3.1536×10^7	=	unit conversion factor (s/yr)

Chapter 1
Introduction

What's covered in Chapter 1:

- Document Objective and Purpose
- Background
- Delisting Reference Documentation
- Document Organization

Under the regulations implementing Subtitle C of the Resource Conservation and Recovery Act (RCRA), wastes are designated as hazardous in two ways: (1) solid wastes that exhibit certain characteristics (those listed in 40 *Code of Federal Regulations* [CFR] Part 261, Subpart C) and (2) solid wastes that are specifically listed as hazardous (those listed in 40 CFR Part 261, Subpart D). As set forth in Subpart C, wastes that are characteristically hazardous remain so until they no longer exhibit any characteristic for which they are listed. Toxicity is one of the characteristics for which Subtitle C wastes are listed as hazardous. This document outlines a risk assessment procedure for determining whether a Subtitle C listed waste exceeds the U.S. Environmental Protection Agency (U.S. EPA) criteria for toxicity, a characteristic of RCRA listed wastes. Risk assessment is a science used to evaluate the carcinogenic risks and noncarcinogenic hazards to human health that are attributable to releases of hazardous chemicals. Risk assessments conducted for the delisting include evaluation of risks associated with direct and indirect exposures to waste constituents. The following definitions are adopted from the National Research Council's (NRC) 1983 report titled "Risk Assessment in the Federal Government: Managing the Process" (NRC 1983) for use throughout this guidance:

Risk assessment	The scientific evaluation of potential health impacts that may result from exposure to a particular substance or mixture of substances under specified conditions
Hazard	An impact to human health by waste constituents of concern
Risk	An estimation of the probability that an adverse health impact may occur as a result of exposure to chemicals in the amount and by the pathways identified

Dose	Constituent mass administered into the body per unit body weight per unit time (for example, in milligrams per kilogram per day)
Exposure	Exposure of identified receptors to chemicals via relevant pathways
Direct exposure	Exposure via immediate inhalation from a contaminated source
Indirect exposure	Exposure resulting from contact of human and ecological receptors with soil or water bodies on which an emitted chemical has been deposited or into which an emitted chemical has leached
Secondary exposure	Synonymic phrase for indirect exposure

This Delisting Technical Support Document (DTSD) was developed to be an integral part of and to provide the technical background for the Delisting Risk Assessment Software (DRAS). The DRAS can aid in determining whether a waste qualifies as being not characteristically toxic for the purposes of delisting under 40 CFR 260.20 and 260.22. The DRAS was developed to compute the risks and hazards associated with a specific waste stream for which a delisting petition has been submitted. The DRAS assesses the toxicity of a petitioned waste by estimating (1) chemical- and waste volume-specific screening exit values and (2) aggregate cancer risks and noncarcinogenic hazard indices (HI). To calculate the potential risks associated with a particular waste stream petitioned for delisting, specific information about the petitioned waste is required. U.S. EPA requires the following waste-specific information for DRAS in order to estimate risks and hazards associated with potential exposure to the petitioned waste stream:

- The maximum annual or total waste volume of the petitioned waste;
- The maximum total concentration of each chemical constituent in the petitioned waste;
- The maximum Toxicity Characteristic Leaching Procedure (TCLP) concentration of each chemical constituent in the petitioned waste; and
- The number of years the petitioned waste is projected to be generated

Section 1.1 discusses the objectives and purpose of this document. Section 1.2 provides background on the Hazardous Waste Delisting Program. Section 1.3 summarizes delisting reference documentation. An overview of the organization of this DTSD is provided in Section 1.4.

1.1 DOCUMENT OBJECTIVES

The objectives of the DTSD are to (1) describe the human health risk-based delisting methodology developed to perform a screening-level analysis and to compute aggregate risks and HIs for petitioned wastes and (2) provide documentation of data and default parameters selected for the risk analysis. The DTSD provides background information about the algorithms and equations used in conjunction with dilution attenuation factors (DAF) to compute cancer risks and hazard quotients (HQ) for individual chemicals. This information is intended to assist regulatory authorities, petitioners, and decision-makers in making hazardous waste delisting determinations.

1.2 BACKGROUND

Section 1004(5) of RCRA as amended by the Hazardous and Solid Waste Amendments (HSWA) of 1984 defines "hazardous waste" as "a solid waste, or combination of solid waste, which because of its quantity, concentration, or physical, chemical, or infectious characteristics may (a) cause, or significantly contribute to an increase in the mortality or an increase in serious irreversible, or incapacitating reversible, illness; or (b) pose a substantial present or potential hazard to human health or the environment when improperly treated, stored, transported, or disposed of, or otherwise managed."

Section 3001 of RCRA requires U.S. EPA to identify those wastes that should be classified as "hazardous." The Agency's hazardous waste identification rules designate wastes as hazardous in one of two ways. First, the Agency has established four hazardous waste characteristics that identify properties or attributes of wastes that would pose a potential hazard if the wastes are improperly managed (see 40 CFR 261.21 through 261.24). Any generator of a solid waste is responsible for determining whether a solid waste exhibits any of these characteristics (see 40 CFR 262.11). Any solid waste that exhibits any of the characteristics remains hazardous until it no longer exhibits the characteristics (see 40 CFR 261.4(d)(1)).

The other mechanism that U.S. EPA uses to designate wastes as hazardous is "listing." The Agency has reviewed data on specific waste streams generated from a number of industrial processes and has determined that these wastes, if mismanaged, would pose hazards for one or more reasons, including (1) the presence of significant levels of hazardous constituents listed in Appendix VIII to 40 CFR Part 261, (2) manifestation of one or more of the hazardous waste characteristics, or (3) the potential to impose detrimental effects on the environment (see generally 40 CFR 261.11). U.S. EPA has generally determined that these wastes contain toxic constituents at concentrations that potentially pose risks that are unacceptable for human or environmental exposure and that these constituents are mobile and persistent to the degree that they can reach environmental or human receptors.

As part of its RCRA Subtitle C hazardous waste regulations, U.S. EPA's Office of Solid Waste (OSW) gives facilities the flexibility to petition the Agency to exempt low-risk listed hazardous wastes that may not actually pose a threat to human health or the environment under the provisions of 40 CFR 260.20 and 260.22. This process is referred to as the "delisting" of a specific generator's listed waste. U.S. EPA's OSW was directed by statute to review petitions in order to determine whether the wastes may be delisted. The overall intent of the delisting process is to ease the regulatory burden on handlers of listed wastes that may have been improperly classified as hazardous by the broad listing definitions. In addition, the delisting process can be used to exclude listed wastes that are sufficiently treated, that they no longer pose a threat to human health or the environment. Listed hazardous wastes that exhibit any of the characteristics will continue to be regulated as hazardous wastes until the characteristic is removed. In a number of cases, wastes were listed because they contained toxic hazardous constituents and exhibited one or more of the hazardous waste characteristics that do not relate to chemical toxicity (for example, ignitability, corrosivity, and reactivity). If such a waste still exhibits any characteristic after the delisting criteria described herein have been applied, it must continue to be managed as a characteristically hazardous waste.

1.2.1 U.S. EPA OSW Hazardous Waste Delisting Program

The U.S. EPA OSW developed the Hazardous Waste Delisting Program to allow facilities that generate Subtitle C hazardous wastes to petition to have their wastes exempted from the requirements of the Subtitle C hazardous waste program (see 40 CFR 260.22). The delisting process evaluates whether a waste would release hazardous chemicals to groundwater at concentrations exceeding acceptable levels (health-based numbers or HBNs). Generally, the greatest risks determined for waste constituents considered for delisting resulted from potential groundwater exposure— that is, chemical releases to groundwater and subsequent exposure via groundwater exposure pathways. The U.S. EPA OSW originally applied the U.S. EPA Composite Model for Landfills (EPACML) fate and transport model to estimate constituent concentrations in groundwater at a receptor well located downgradient from a landfill or surface impoundment (U.S. EPA 1990c and 1990h). The EPACML fate and transport model was used to determine a Dilution-Attenuation Factor (DAF), which estimates the degree of dilution and attenuation that a constituent would undergo as it leaches from a waste management unit and is transported in the subsurface, into the saturated zone, and to a theoretical downgradient receptor well. The results of the EPACML analyses, the DAFs, were used to compute the maximum acceptable constituent concentration (that is, the exit level) in the leachate of a waste proposed for delisting.

The EPACML was originally developed to compute DAFs and set regulatory levels for specific constituents for the Toxicity Characteristics Rule (TC Rule) (U.S. EPA 1990d). Since the application of the EPACML to the TC Rule and to delisting, the Agency has developed a number of improvements in the modeling method and the input data. The U.S. EPA Composite Model for Leachate Migration with Transformation Products (EPACMTP) is the product of these improvements made to the EPACML fate and transport model.

1.2.2 Regional Authorization

On October 10, 1995, U.S. EPA Administrator Carol M. Browner delegated authorization of the Hazardous Waste Delisting Program to U.S. EPA's 10 regional offices (61 *Federal Register* [FR] 32798). The U.S. EPA OSW in Washington, DC, had previously administered the Delisting Program. As a result of the Administrator's action, delisting petitions that require a federal decision are now being reviewed by the appropriate U.S. EPA regions, and the regions, as of October 10, 1995, have the authority to make decisions on delisting petitions. The Agency believes that decentralizing the delisting authority to the Regional Administrators will result in more timely responses to delisting petitions.

Under RCRA, states authorized to administer a delisting program in lieu of the federal program also may exclude wastes from hazardous waste regulations. Facilities that manage their wastes in a state with RCRA delisting authorization should petition that state rather than U.S. EPA for an exclusion. Even in unauthorized states, U.S. EPA encourages petitioners to contact state authorities to determine what procedures might be necessary for delisting under state laws.

1.2.3 Regional Program Modifications

Previously, U.S. EPA OSW delisting evaluations applied the EPACML fate and transport model for determining potential chemical releases to groundwater (U.S. EPA 1991b). However, the EPACML had limitations, such as the inability to predict DAFs on a chemical-specific basis. After receiving authority to administer the Delisting Program, U.S. EPA Region 6 initially made two enhancements to the delisting process: (1) application of a new fate and transport model to calculate waste volume-specific DAFs, and (2) evaluation of additional exposure pathways. U.S. EPA Region 6 maintained the U.S. EPA OSW requirement to evaluate petitioned wastes on the basis of waste volume and investigated improvements made to the

EPACML that had been incorporated into the EPACMTP. Following review of the EPACMTP and the available literature, U.S. EPA Region 6 adopted the EPACMTP fate and transport model to develop DAFs in order to estimate the risk associated with exposure via groundwater pathways for delisting purposes.

The EPACMTP has been used to compute DAFs for the proposed Hazardous Waste Identification Rule (HWIR) (U.S. EPA 1995a) and the proposed Petroleum Refining Listing Rule (U.S. EPA 1998c). For the HWIR, the EPACMTP was used to determine (for 192 chemicals) waste volume-generic DAFs, which are based on a range of waste management unit areas (waste volumes) identified in a national survey of waste management units (including landfills and surface impoundments). A DAF represents the amount of dilution and attenuation expected to occur in groundwater as a chemical migrates to a potential exposure point at a downgradient receptor well.

The U.S. EPA evaluates petitions on the basis of a specific volume of waste. To do so, U.S. EPA Region 6 revised the EPACMTP to develop waste volume-specific DAFs. This was accomplished by using the EPACMTP to compute DAFs for a range of waste volumes for each waste disposal scenario (landfill and surface impoundment) and then developing regression equations for each disposal scenario that can be used to compute a DAF as a function of a specific waste volume (see Section 2.2.4). The U.S. EPA Region 6 Delisting Program performs two analyses of a petitioned waste: (1) a screening analysis that uses waste volume-specific DAFs to back-calculate maximum TCLP waste constituent concentrations at the prescribed risk levels for groundwater exposure pathway analyses and (2) an aggregate risk and hazard analysis that uses the waste volume-specific DAFs described herein. For further information on the development of waste volume-specific DAFs, refer to the document titled "Application of EPACMTP to Region 6 Delisting Program: Development of Waste Volume-Specific Dilution Attenuation Factors" (U.S. EPA 1996a).

In developing DRAS version 3, the EPACMTP was rerun with updated parameters, databases, and algorithms consistent with OSW use of the model. In addition, MINTEQA2 adsorption isotherms were used in conjunction with EPACMTP, resulting in some DAFs that vary based on the initial leachate concentration in the landfill or surface impoundment. The algorithms in DRAS have been modified accordingly to handle DAFs that vary by input concentration.

In a second enhancement to the delisting process, U.S. EPA Region 6 included additional exposure pathways in the delisting petition evaluation process to ensure that all potential exposure scenarios are addressed in the risk assessment. These additional pathways include (1) dermal contact with and inhalation of volatiles during bathing or showering with groundwater, (2) ingestion of drinking water from surface water bodies, (3) ingestion of contaminated fish, (4) inhalation of windblown particulates and volatiles from a waste management unit, and (5) ingestion of soils contaminated with windblown waste constituent particulates. These additional pathways allow a more complete evaluation of potential human health risks resulting from potential chemical releases of delisted wastes. For each exposure pathway, the appropriate chemical-specific factors are used to predict the risk to the sensitive receptor from the potential exposure to chemical contaminants. For instance, the effects of indoor inhalation exposure to volatile constituents may be comparable to or greater than those of ingestion exposure through drinking water (McKone 1987), and exposure from ingestion of contaminated fish may be significant because of bioaccumulation of each chemical constituent in fish tissue.

1.2.4 Delisting Risk Assessment Software (DRAS)

To evaluate delisting petitions in a timely manner, the U.S. EPA Region 6 Delisting Program developed a Windows-based program called the Delisting Risk Assessment Software (DRAS), that analyzes the risks and hazards posed by the constituents of a waste petitioned for delisting. Specifically, the DRAS performs two types of analyses: screening-level analyses and aggregate risk and hazard analyses. The results of these analyses may be viewed on screen, imported directly to word processing software, or printed in document- ready form. The screening-level analyses compute chemical-specific exit values or "delisting levels" for multi-year delistings. The aggregate risk and hazard analyses compute the aggregate carcinogenic risk and noncarcinogenic hazard indices (HI) for a waste petitioned for a one-time delisting. The delisting levels and aggregate risk and hazard estimates are calculated using modeled, medium-specific chemical concentrations and standard U.S. EPA exposure assessment and risk characterization algorithms.

Sections 1.2.4.1 and 1.2.4.2 provide additional discussion regarding calculation of delisting levels and calculation of aggregate risks and hazards, respectively.

1.2.4.1 Calculating Delisting Levels for Multi-year Delistings

In addition to alerting the user to the most limiting and most sensitive combination of exposure pathway and receptor, the DRAS provides the back-calculated chemical-specific delisting level for that combination. A delisting level is the maximum allowable concentration for each constituent of a waste petitioned for a multi-year delisting. For each waste constituent, the DRAS computes a total delisting level (in milligrams per kilogram) and a TCLP delisting level (in milligrams per liter). The TCLP delisting levels for the groundwater exposure pathways are calculated with standard risk assessment algorithms and with groundwater chemical concentrations at the point of exposure (POE) derived from waste volume-specific DAFs using the EPACMTP fate and transport model. The chemical-specific total delisting levels for the surface exposure pathways are calculated with standard risk assessment algorithms and with predicted chemical concentrations at the POE.

The analysis identifies the pathway-receptor combination that is the limiting combination or, in the case of multiple pathway-receptor combinations that fail the screening analysis, the most sensitive combination of pathway and receptor. This analysis shows the user the degree to which the waste's TCLP or total waste concentration exceeds the delisting level. The program also provides (in a print-ready summary table) all the calculated delisting levels for all pathway-receptor combinations.

1.2.4.2 Calculating Aggregate Risks and Hazards

In addition to back-calculating delisting levels for multi-year standard delistings, the DRAS performs a forward calculation of aggregate risk assessment for disposal of petitioned wastes in a landfill or surface impoundment waste management unit as a one-time delisting. If the delisting petition is for a one-time exclusion, the results of the aggregate risk assessment may be used in lieu of the delisting levels. A one-time delisting does not require the Agency to establish monitoring concentrations that must be met by each batch of waste to be managed under a promulgated exclusion. Therefore, the user may bypass the delisting levels, which are set at relatively conservative risk levels, in favor of the aggregate risk assessment process that employs the Agency's target risk levels (see Chapter 4 on target levels).

Computing the aggregate risk for a petitioned waste provides the user with detailed analysis of the petitioned waste. The DRAS indicates which chemicals and which pathways and/or receptors are driving the risk for a particular waste. The DRAS computes the aggregate carcinogenic risk by summing the carcinogenic risks for all waste constituents for a given exposure pathway and then summing the carcinogenic risks for each pathway analyzed in the delisting risk assessment. The DRAS computes the aggregate noncarcinogenic risk by summing the noncarcinogenic HQs for all waste constituents for a given exposure pathway and then summing the noncarcinogenic hazards associated with each exposure pathway analyzed. If the aggregate noncarcinogenic hazard exceeds the allowable level, the user should refer to Appendix A-4. Chemical-specific hazards may be apportioned by target organ.

1.3 DELISTING REFERENCE DOCUMENTATION

A number of delisting process documents have been developed to provide guidance specific to elements of the delisting process, including delisting petition preparation, waste sampling, sample quality assurance/quality control (QA/QC), and risk and hazard assessment. Delisting docket materials and other relevant reference documents are available and have also been used to support the delisting process. These documents and materials are briefly described below.

1.3.1 Delisting Process Documents

Documents available to guide a user through the delisting process are described below.

Delisting Guidance Manual. The "U.S. EPA Region 6 RCRA Delisting Program Guidance Manual for the Petitioner" (U.S. EPA 1996e) provides guidance to individuals who may be interested in submitting a petition to exclude or "delist" a listed hazardous waste generated at a particular facility from the lists of hazardous wastes in 40 CFR Part 261, Subpart D. U.S. EPA recognizes that a specific listed waste generated at a particular facility may not meet the criteria for which the waste was originally listed. The manual provides guidance on how to satisfy the procedures set forth in 40 CFR 260.20 and 260.22 whereby any individual can petition the Agency for a regulatory amendment to exclude a listed waste generated at a particular facility.

Risk Assessment Software User's Manual. U.S. EPA Region 6 has developed a separate user's manual to support the DRAS. The "U.S. EPA Region 6 RCRA Delisting Risk Assessment Software User's Manual" (U.S. EPA 1998a) provides the user with the necessary information for installing and running the Windows- based risk assessment software. The user may access this manual directly through the Windows-based risk assessment software or may refer to a hard copy. This User's Guide has been subsequently updated to reflect each new iteration of the software.

Application of Waste Volume-Specific DAF Document. U.S. EPA developed the report titled "Application of EPACMTP to Region 6 Delisting Program: Development of Waste Volume-Specific Dilution Attenuation Factors" to describe its approach for adapting the EPACMTP to the U.S. EPA Region 6 Delisting Program (U.S. EPA 1996a). The EPACMTP model computes individual DAFs that represent the decrease in concentration of a chemical as a result of its leaching from a waste management unit and its subsequent transport in the subsurface unsaturated and saturated zones to a receptor well. The EPACMTP was developed to compute DAFs as a function of a number of input parameters, including waste management unit area. However, waste volume is typically a derived input parameter, and the Delisting Program evaluates wastes based on specific waste volumes. Therefore, U.S. EPA Region 6 modified the EPACMTP model to compute DAFs for the range of waste volumes typically encountered in the evaluation of hazardous waste delisting petitions. The modifications to the EPACMTP and the analyses performed to derive 90th percentile DAFs for 192 chemicals (those listed in the proposed HWIR [U.S. EPA 1995a]) as a function of waste volume for wastes disposed of in landfills and surface impoundments are summarized in the 1996 report.

1.3.2 Delisting Docket Materials

Three delisting risk assessment evaluations have been performed to date by the U.S. EPA OSW to determine the risks and hazards associated with disposing of delisted wastes in nonhazardous waste management units. Specifically, the Agency has evaluated risks and hazards associated with contaminant releases to groundwater, surface water, and air and has documented the calculations performed in these evaluations in the dockets associated with each petition review. These three delisting risk evaluations performed by U.S. EPA are addressed in the following documents:

- U.S. EPA. 1993a. "Docket Report on Evaluation of Contaminant Releases to Surface Water Resulting from Conversion System's Petitioned Waste." August 27.
- U.S. EPA. 1993c. "Docket Report on Evaluation of Air Emissions Resulting from Conversion Systems, Inc.'s, Petitioned Waste." September 9.
- U.S. EPA. 1994a. "Docket Report on Evaluation of Contaminant Releases to Air from U.S. Department of Energy Hanford's Petitioned Waste." May 27.

1.3.3 Other Relevant Reference Documents

The algorithms that the U.S. EPA Region 6 DRAS uses to compute the potential risks to human health associated with a waste petitioned for delisting are adapted from the following documents:

- U.S. EPA. 1988a. "Risk Assessment Guidance for Superfund (RAGS), Volume I: Human Health Evaluation Manual (Part A)." Office of Emergency and Remedial Response. Washington, DC EPA/540-1-89/002.
- U.S. EPA. 1991a. "Risk Assessment Guidance for Superfund (RAGS) Volume I: Human Health Evaluation Manual (Part B, Development of Risk-Based Preliminary Remediation Goals)" (hereinafter referred to as RAGS Part B). Office of Emergency and Remedial Response. Washington, DC Publication No. 9285.7-013.

For dermal pathways, which are not covered in RAGS Part B, the DRAS uses the algorithms presented in the following document:

- U.S. EPA. 1992b. “Dermal Exposure Assessment: Principles and Applications, Interim Report.” Office of Health and Environmental Assessment. Washington, DC. EPA/600/8-91/011B. January.

Additional exposure and risk assessment algorithms for shower inhalation of groundwater were obtained from the nongroundwater pathway risk assessment addressed in the following document:

- U.S. EPA. 1997a. “Supplemental Background Document; NonGroundwater Pathway Risk Assessment; Petroleum Process Waste Listing Determination.” OSW. Research Triangle Park, North Carolina. March 20.

This background document contains the assumptions and equations used to evaluate the shower, bathroom, and house inhalation pathways for groundwater that were in turn used to determine the risks associated with specific petroleum refinery wastes. The docket materials contain the equations and assumptions that the U.S. EPA Headquarters Delisting Program used to evaluate delisting petitions with regard to the surface water and air exposure pathways.

Additional information on multipathway risk assessment algorithms and the EPACMTP fate and transport model used for the proposed HWIR (U.S. EPA 1995a) is provided in the following FR notice and background document for the HWIR:

- U.S. EPA. 1995a. “Hazardous Waste Management System: Identification and Listing of Hazardous Waste—Hazardous Waste Identification Rule (HWIR).” OSW. Washington, DC 60 FR 66344.
- U.S. EPA. 1995b. “Technical Support Document for HWIR: Risk Assessment for Human and Ecological Receptors.” Volumes I and II. OSW. Washington, DC

Details on the assumptions and input parameters used for the EPACMTP are provided in the following documents:

- U.S. EPA. 1997e. *EPA's Composite Model for Leachate Migration with Transformation Products, EPACMTP*: *User's Guide*. Office of Solid Waste, Washington, D.C.
- U.S. EPA. 1996b. *EPACMTP Background Document*. Office of Solid Waste. Washington, D.C. September.
- U.S. EPA. 1996c. *EPACMTP Background Document for the Finite Source Methodology for Chemicals with Transformation Products and Implementation of the HWIR.* Office of Solid Waste. Washington, D.C. September.
- U. S. EPA. 1997h. *Analysis of EPA's Industrial Subtitle D Databases used in Groundwater Pathway Analysis of the Hazardous Waste Identification Rule (HWIR).* Office of Solid Waste, Washington, DC. September.
- U.S. EPA. 1996d. *Background Document for EPACMTP: Metals Transport in the Subsurface, Volume 1: Methodology*. Office of Solid Waste. Washington, D.C. August.

- U.S. EPA. 1999. *EPA's Composite Model for Leachate Migration with Transformation Products (EPACMTP) Background Document for Metals; Volume 2: Sorption Isotherms.* Office of Solid Waste, Washington, DC. August.

Every effort was made to maintain consistency with the U.S. EPA Region 6 "Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities - Peer Review Draft" (U.S. EPA 1998b) at the time DRAS was first released. The contaminant release and risk assessment algorithms and parameter values used for the DRAS have been compared to the draft Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities (HHRAP) in order to ensure consistency between the two approaches. The HHRAP has since been finalized with a number of modifications and updates (U.S. EPA 2005), however, the changes do not impact the methodology used in the DRAS.

1.4 DOCUMENT ORGANIZATION

This section presents an overview of the DTSD's organization. Revisions to the DTSD are inserted in the appropriate locations throughout the document. Elements that are not revised retain the language as originally published. The DTSD is arranged in a user-friendly format to present the technical procedures used to conduct a risk assessment for a petitioned waste:

- Chapter 1 describes the objectives of this DTSD and provides background and reference information for the U.S. EPA Delisting Program.

- Chapter 2 describes the methods used to estimate chemical releases from waste management units to groundwater, soils, air, and surface water as well as the calculation of contaminant concentrations in each of these media.

- Chapter 3 describes the selection of exposure scenarios, including the receptor locations, and the parameters and assumptions used to quantify exposure.

- Chapter 4 describes the methodology used to compute target carcinogenic risks and HQs as well as aggregate carcinogenic risks and HIs.

- Chapter 5 discusses the uncertainties involved in the risk and hazard analyses performed for the U.S. EPA Delisting Program.

- Chapter 6 contains full citations to the items referenced throughout the DTSD. the U.S. EPA Delisting Program.