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REVIEW OF STATE SOIL CLEANUP LEVELS FOR DIOXIN

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REVIEW OF STATE SOIL CLEANUP LEVELS FOR DIOXIN

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REVIEW OF STATE SOIL CLEANUP LEVELS FOR DIOXIN

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NOTATION

(This list includes many of the acronyms and abbreviations used in the report. Other terms used in equations are defined with those equations. Note that certain state agencies use the same acronyms for departments or divisions, so to avoid duplication in this report, acronyms are not necessarily the standard agency acronyms.)

ADEC	Alaska Department of Environmental Conservation
ADEM	Alabama Department of Environmental Management
ADHS	Arizona Department of Health Services
AFB	Air Force base
AK	Alaska
AL	Alabama
AMD	amendment (to record of decision)
APEC	Arkansas Pollution Control and Ecology Commission
AR	Arkansas
ARAR	applicable or relevant and appropriate requirement
ARBCA	Alabama Risk-Based Corrective Action Guidance Manual
ARDEQ	Arkansas Department of Environmental Quality
AS	American Samoa
ASTM	American Society for Testing and Materials
AT	averaging time
ATSDR	Agency for Toxic Substances and Disease Registry (DHHS)
AZ	Arizona
AZDEQ	Arizona Department of Environmental Quality
BHRG	baseline human health potential remediation goal
BCL	basic comparison level (NV)
BRA	baseline risk assessment
BW	body weight
c	cancer
CA	California
CAG	Carcinogen Assessment Group (U.S. EPA)
CalEPA	California EPA
CARB	California Air Resources Board
CCME	Canadian Council of Ministers of the Environment
CDC	Center for Disease Control and Prevention (DHHS)
CDHS	California Department of Health Services
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act, as amended
CEHTUF	Center for Environmental and Human Toxicology at the University of Florida
CLARC	cleanup levels and risk calculation (WA)
CO	Colorado
CODPHE	Colorado Department of Public Health and the Environment
conc	concentration
CSEV	Colorado soil evaluation value
CSF	cancer slope factor
CT	Connecticut
CTL	cleanup target level (FL)
CWLP	City Water, Light, and Power (Springfield, IL)

NOTATION *(Cont'd.)*

d	day(s)
DAF	dilution attenuation factor
DC	District of Columbia
DCC	direct contact criteria(on) (MI)
DCV	direct contact value
DE	Delaware
DEC	Department of Environmental Conservation; also Department of Ecology (WA)
DEDNREC	Delaware Department of Natural Resources and Environmental Control
DEM	Department of Environmental Management
DEP	Department of Environmental Protection
Dept	Department
DEQ	Department of Environmental Quality (AZ, AR, MI, MS, MT, OK, OR)
DES	Department of Environmental Services
DHHS	U.S. Department of Health and Human Services
DLC	dioxin-like compound(s)
DoA	U.S. Department of the Army
DoD	U.S. Department of Defense
DOE	U.S. Department of Energy
DoN	U.S. Department of the Navy
DOT	U.S. Department of Transportation
DTSC	Department of Toxic Substances Control (CalEPA)
EAL	environmental action level
EC	Ecology Center
eco	ecological
ECOS	Environmental Council of the States
ED	exposure duration
EF	exposure frequency
EFH	Exposure Factors Handbook (U.S. EPA NCEA)
ELCR	excess lifetime cancer risk
EPA	Environmental Protection Agency (U.S. unless otherwise indicated)
ERP	Environmental Restoration Program
ESD	explanation of significant difference
ESL	environmental screening level (AS, GM, HI, NMI, TT)
ET	exposure time
EVS	Environmental Science Division (DOE/Argonne)
FDA	U.S. Food and Drug Administration
FDEP	Florida Department of Environmental Protection
FL	Florida
FS	feasibility study
GA	Georgia
GADNR	Georgia Department of Natural Resources
GCN	generic cleanup number (OH)
GEPA	Guam Environmental Protection Agency
GM	Guam
GW	groundwater

NOTATION *(Cont'd.)*

HDOH	Hawaii Department of Health
HEAST	Health Effects Assessment Summary Table
HEER	Hazard Evaluation and Emergency Response (Office) (HI)
HHSL	human health screening level (CalEPA)
HI	Hawaii
HSRA	Hazardous Site Response Act (GA)
HWS	Hazardous Waste Section (NC)
IA	Iowa
IADNR	Iowa Department of Natural Resources
IAG	interagency agreement
ID	Idaho
IDEM	Indiana Department of Environmental Management
IL	Illinois
ILCR	individual lifetime cancer risk
IN	Indiana
IR	intake rate
IRIS	Integrated Risk Information System (U.S. EPA NCEA database)
ISL	initial screening level (UT)
KDHE	Kansas Department of Health and Environment
kg	kilogram
KS	Kansas
KY	Kentucky
LA	Louisiana
LDEQ	Louisiana Department of Environmental Quality
LOAEL	lowest observed adverse effect level
LRP	Land Recycling Program (IA)
LUST	leaking underground storage tank
MA	Massachusetts
MADEP	Massachusetts Department of Environmental Protection
MADL	maximum allowable dose level
ME	Maine
MEDEP	Maine Department of Environmental Protection
MD	Maryland
MDHSS	Missouri Department of Health and Senior Services
MDNR	Missouri Department of Natural Resources
mg	milligram)(s)
mg/kg-d	milligram(s) per kilogram (body weight) per day
MI	Michigan
MIDEQ	Michigan Department of Environmental Quality
MLE	maximum likelihood estimate
MN	Minnesota
MNDOH	Minnesota Department of Health
MO	Missouri
MPCA	Minnesota Pollution Control Agency

NOTATION *(Cont'd.)*

MRBCA	Missouri Risk-Based Corrective Action
MRL	minimal risk level (ATSDR)
MS	Mississippi
MSC	medium-specific concentration (PA)
MSDEQ	Mississippi Department of Environmental Quality
MSSL	medium-specific screening level (U.S. EPA Region 6)
MT	Montana
MTCA	Model Toxics Control Act
MTDEQ	Montana Department of Environmental Quality
n	noncancer
NAS	National Academy of Sciences
NAVFAC	Naval Facilities Engineering Command
NC	North Carolina
NCDENR	North Carolina Department of Environment and Natural Resources
NCEA	National Center for Environmental Assessment (U.S. EPA)
ND	North Dakota
NDEQ	Nebraska Department of Environmental Quality
NDEP	Nevada Department of Environmental Protection
NE	Nebraska
NH	New Hampshire
NHDES	New Hampshire Department of Environmental Services
NIH	National Institutes of Health
NJ	New Jersey
NJDHSS	New Jersey Department of Health and Senior Services
NM	New Mexico
NMED	New Mexico Environment Department
NMI	Northern Mariana Islands
NOAEL	no observed adverse effect level
NSRL	no significant risk level
NTP	National Toxicology Program (DHHS)
NV	Nevada
NY	New York
NYDEC	New York Department of Environmental Conservation
OEHHA	Office of Environmental Health Hazard Assessment (CalEPA)
OH	Ohio
OK	Oklahoma
OKDEQ	Oklahoma Department of Environmental Quality
OR	Oregon
ORDEQ	Oregon Department of Environmental Quality
ORNL	Oak Ridge National Laboratory
OSWER	Office of Solid Waste and Emergency Response (U.S. EPA)
OU	operable unit
p	*para*
PA	Pennsylvania
PADEP	Pennsylvania Department of Environmental Protection
PBT	persistent, bioaccumulative and toxic

NOTATION *(Cont'd.)*

PCB	polychlorinated biphenyl(s)
PCL	protective concentration level (TX)
PEC	probable effect concentration
PHAGM	Public Health Assessment Guidance Manual
PHG	public health goal
POTW	publicly owned treatment works
ppb	part(s) per billion
ppm	part(s) per million
PPRTV	provisional peer-reviewed toxicity value (U.S. EPA)
ppt	part(s) per trillion
PR	Puerto Rico
PRG	preliminary remediation goal (U.S. EPA OSWER; Region 9)
PWG	Pathology Working Group
RAGS	Risk Assessment Guidance for Superfund
RAIS	Risk Assessment Information System (online ORNL database)
RBC	risk-based concentration (U.S. EPA Region 3, AK, OR, others)
RBSC	risk-based screening concentration
RBSL	risk-based screening level (MI)
RCRA	Resource Conservation and Recovery Act, as amended
RG	remediation goal (NE)
RGO	remedial goal objective
RI	Rhode Island
RIDEM	Rhode Island Department of Environmental Management
RME	reasonable maximum exposure
ROD	record of decision
RODS	Record of Decision System (U.S. EPA database)
RSL	regional screening level (U.S. EPA)
SC	South Carolina
SCDHEC	South Carolina Department of Health and Environmental Control
SCTL	soil cleanup target level (FL)
SD	South Dakota
sed	sediment
SF	slope factor
SF_d	dermal slope factor
SF_i	inhalation slope factor
SF_o	oral slope factor
SPHEM	Superfund Public Health Evaluation Manual
SPS	soil performance standard
SRL	soil remediation level (AZ)
SRSNE	Solvents Recovery Service of New England
SRV	soil reference value (MN)
SSL	soil screening level (MI, U.S. EPA, others)
ST	state
TAC	Toxic Air Contaminant Program (CA)
TAGM	Technical and Administrative Guidance Memorandum (NY)
TCDD	2,3,7,8-tetrachlorodibenzo-*p*-dioxin

NOTATION *(Cont'd.)*

TCEQ	Texas Commission on Environmental Quality
TDH	Texas Department of Health
TEC	toxic equivalency concentration
TEF	toxic equivalency factor
TEQ	toxic equivalent(s)
TMDL	target method detection limit
TN	Tennessee
TPH	total petroleum hydrocarbons
TRG	target remediation goal (MS)
TRRP	Texas Risk Reduction Program
TRW	Tittabawassee River Watch
TSG	Toxic Steering Group
TT	Trust Territories
TX	Texas
TXNRCC	Texas Natural Resource Conservation Commission
UCL	upper concentration limit
μg	microgram(s)
μg/kg-d	microgram(s) per kilogram (body weight) per day
URS	uniform risk-based remediation standard (DE)
USACE	U.S. Army Corps of Engineers
USAF	U.S. Air Force
USEPA	U.S. Environmental Protection Agency
UT	Utah
UTDEQ	Utah Department of Environmental Quality
VA	Virginia
VCP	Voluntary Cleanup Program (NE)
VDEQ	Virginia Department of Environmental Quality
VI	Virgin Islands
VRP	Voluntary Remediation Program (NM, VA, WY)
VT	Vermont
WA	Washington
WADEC	Washington State Department of Ecology
WHO	World Health Organization
WI	Wisconsin
WIDNR	Wisconsin Department of Natural Resources
WV	West Virginia
WVDEP	West Virginia Department of Environmental Protection
WY	Wyoming
WYDEQ	Wyoming Department of Environmental Quality
y	year(s)

EXECUTIVE SUMMARY

S.1 OBJECTIVE

This report summarizes existing state cleanup levels for dioxin in soil, together with their scientific bases where available. It is part of the *Science Plan for Activities Related to Dioxins in the Environment*, which was announced by the U.S. Environmental Protection Agency (U.S. EPA) Administrator in May 2009. The objective is to inform an interim recommended preliminary remediation goal (PRG) for dioxin in soil, which is to be developed by the Office of Solid Waste and Emergency Response (OSWER).

As context, the extant OSWER PRG or starting point for setting a cleanup level for residential scenarios is 1 part per billion (ppb) or 1,000 parts per trillion (ppt) as dioxin toxic equivalents (TEQ) in surface soil. The TEQ reflects the combined toxicity of the dioxin mixture for which individual toxicities are weighted relative to the most potent form, 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (hereafter referred to as TCDD) using toxic equivalency factors (TEFs). This cleanup level considers a reasonable maximum exposure that emphasizes a childhood pattern of incidental soil ingestion, and a TCDD cancer slope factor based on a scientific evaluation of rodent bioassay data published in 1978. The parallel recommended starting points for commercial/ industrial scenarios are in the range of 5 to 20 ppb, or 5,000 to 20,000 ppt.

S.2 APPROACH

State agency websites and other online resources were searched for all 50 states to identify soil cleanup levels for dioxin, as well as their scientific bases. The District of Columbia (DC), Puerto Rico, the Virgin Islands, and four Pacific Rim territories – American Samoa, Guam, Northern Mariana Islands, and the Trust Territories – were also included in this review, bringing the total entities checked to 57. The primary focus was levels for unrestricted/residential land use; values for commercial/industrial (restricted) use were also compiled where readily available. Because a number of states call for site-specific determinations of cleanup levels, context was also pursued for recent cleanup decisions where generic state values were not found. The combined data were tabulated and provided to technical contacts across the ten U.S. EPA Regions to coordinate field reviews.

S.3 RESULTS

Nearly half the states and territories (26) have identified a cleanup level or guideline for dioxin in soil. About 60 percent of these levels are as TCDD, with the rest as dioxin or TCDD TEQ.

The concentrations identified across these states and territories, as well as the scientific bases in terms of the exposure calculations, target risks, and toxicity values used, are highlighted in the following sections. Also summarized is context for four evaluation criteria considered for these health-based values. (Note that to simplify this presentation, specific references are not cited in the summary; citations are included in the body of the report and in the appendices.)

Some states list multiple dioxin concentrations that address different land use scenarios and assumptions, such as extent of exposure and target risk level. About 280 values were identified in this review, so to simplify comparisons the key figures and tables in this report emphasize a representative value per state and land use category, grouped as unrestricted/residential and commercial/industrial land use. More detailed data are available in Appendix B.

S.3.1 Soil Cleanup Levels

Soil cleanup levels have been identified for unrestricted/residential use by 26 states and territories, ranging from nearly 4 to 1,000 ppt as shown in Figure S-1. Some values are not yet available online, and parenthetical dates accompany those identified by the field during the review phase (such as internal and provisional concentrations). Frequency distributions of the cleanup levels for both unrestricted and restricted scenarios are presented in Figure S-2. The commercial/industrial cleanup levels range from 18 to 5,000 ppt, differing by a factor of about 270, compared to 250 for the unrestricted/residential cleanup levels.

For unrestricted/residential use, more than 75 percent of the values (20) fall at or below 120 ppt, and most (15) are less than 40 ppt. While values reported as TEQ may be expected to be somewhat higher than those based on TCDD, and several are, half of the ten TEQ-based cleanup levels are in the group below 120 ppt, and 30 percent of those below 36 ppt are TEQs.

At the lowest end of the concentration range are seven states with cleanup levels documented in the last ten years that are the same as soil concentrations commonly used for preliminary screening evaluations, i.e., 3.9 to 4.5 ppt. This suggests that nearly a third of the states with cleanup levels have essentially adopted a value intended for screening purposes (generally based on a target risk of 10^{-6} with default residential assumptions).

In the concentration group above 120 ppt are four cleanup levels that are 100 times higher than the lowest set. These four, which range from 390 to 450 ppt as dioxin TEQ, are for Hawaii and three Pacific Rim territories (documented in 2006 and 2008, respectively).

Topping the range is the cleanup level of 1,000 ppt identified by two states, Alabama and Texas (documented in 2007 and 2009, respectively). This is the recommended OSWER concentration for residential soils, as TEQ. Alabama identifies the basis as TCDD, while Texas indicates TEQ. The five states that join Texas, Hawaii, and three Pacific island territories in reporting cleanup levels as TEQs are Florida, Maine, Michigan, Minnesota, and Ohio. (Wyoming adopts the EPA Regional screening level for TCDD and indicates TEFs may be considered for others.)

All but 5 of the 26 states with unrestricted use levels also identify cleanup levels for commercial/industrial use. (These five are: Alaska, Georgia, Michigan, Ohio, and Wyoming.) For the rest, levels for restricted use are higher than for residential, as expected. This reflects less extensive exposures and in some cases less restrictive target risks. As a group, these concentrations are within a factor of 5 of the residential levels and thus span a wider range. (States use various terms for these scenarios; for simplicity, they are grouped as "commercial/industrial" here.)

Soil concentrations that are not formal cleanup levels but could offer related insights were found for nearly half the remaining states and territories (15 of 31). Most were clarified as screening values during field review; these values are included in the report as potential context for those cases where standard cleanup levels are unavailable. No generic cleanup levels for dioxin were identified for the remaining 15 states and the last territory. In fact, these states (including California and Utah) and the Trust Territories have deferred identifying generic cleanup levels, calling instead for risk-based determinations that can incorporate site-specific factors. This same approach is taken by a number of the states that identify screening values but no cleanup levels. For example, while Arkansas lists concentrations of 4.5 and 18 ppt as screening levels, and Massachusetts lists values of 20, 50, and 300 ppt (TEQ) from essentially a screening approach, both refer to the need for site-specific determinations of an actual cleanup level.

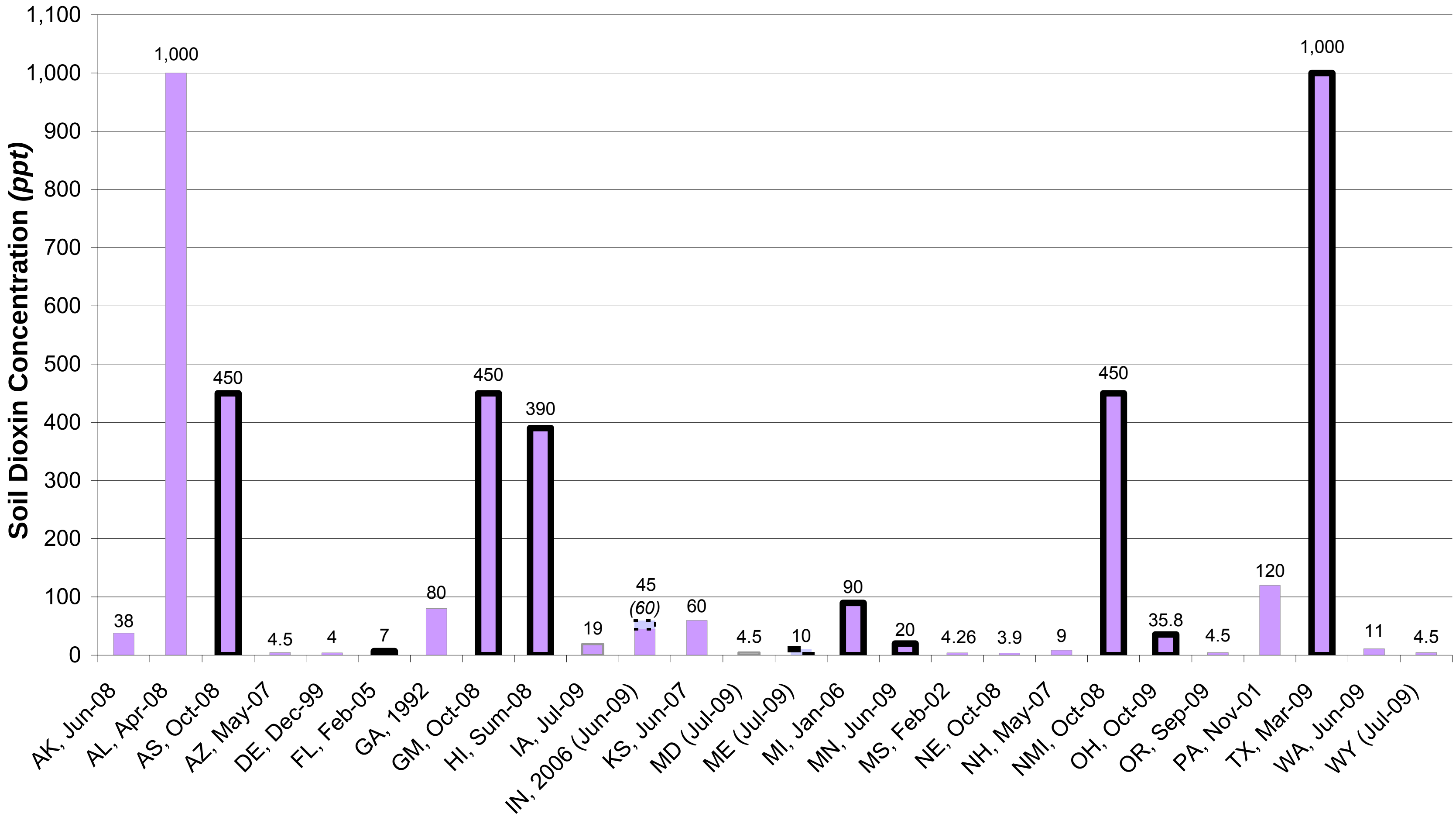

FIGURE S-1 Soil Cleanup Levels: Unrestricted/Residential Use, by State

(A dark border indicates the basis is TEQ rather than TCDD; a dashed border and lighter shading indicates a draft value; parenthetical dates reflect field inputs for values not yet available online.)

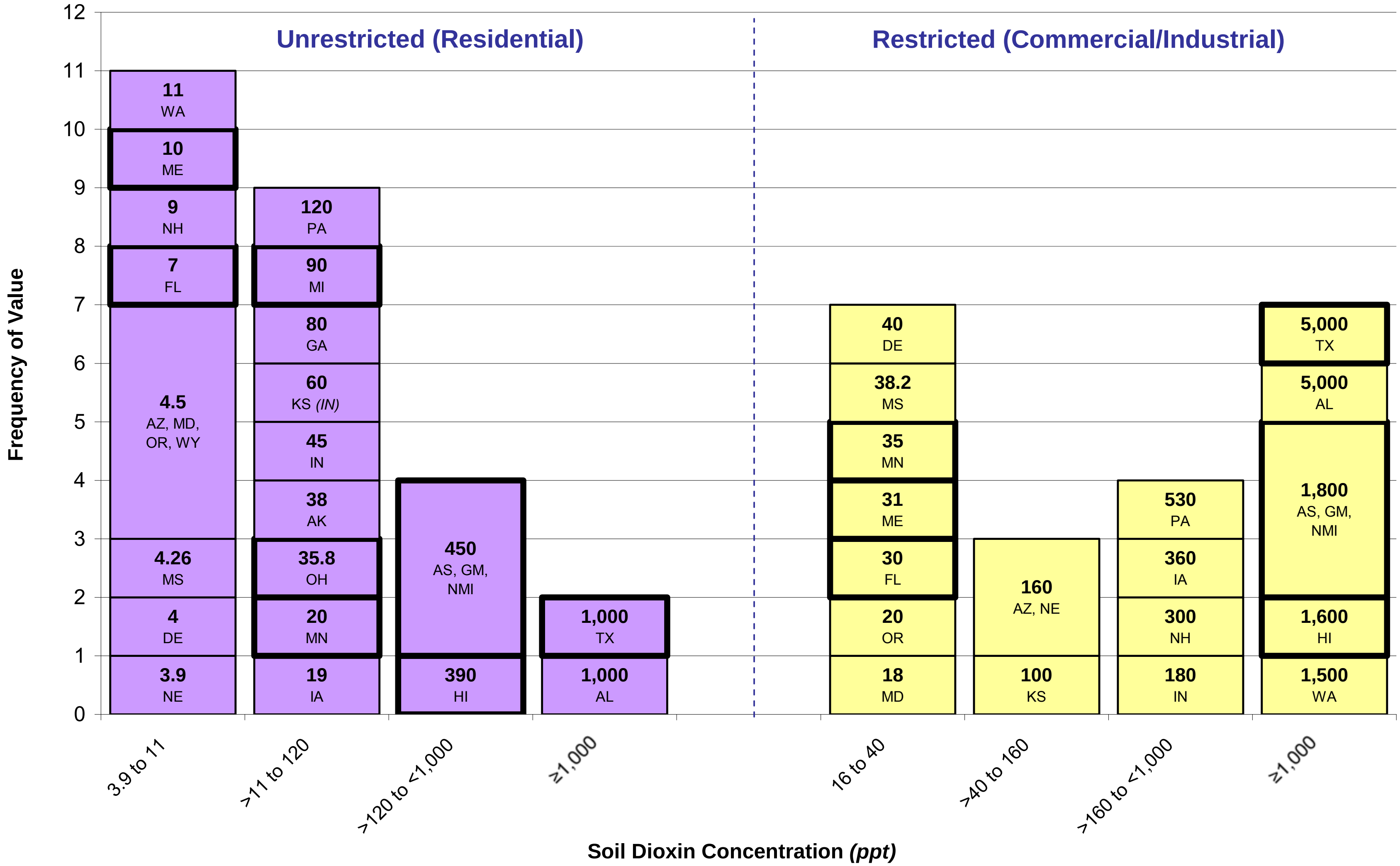

FIGURE S-2 Distribution of Soil Cleanup Levels by Concentration: Unrestricted and Restricted Uses

(A dark border indicates the basis is TEQ rather than TCDD; parenthetical italics indicate a draft value)

S.3.2 Exposure Calculations

The exposure calculation is central to the determination of health-based cleanup levels. The current review of soil cleanup levels for dioxin indicates that states generally follow the standard EPA approach for deriving such concentrations, tapping the standard equation from the EPA 1989 risk assessment guidance for Superfund or 1996 soil screening guidance. The same basic equation also underlies the EPA Regional screening levels (RSLs), which have been adopted as cleanup levels by several states.

In most cases, dioxin is one of many chemicals for which states have derived soil cleanup levels, so the agencies have identified generic exposure calculations for broad application. Although individual terms vary, the basic structure and concepts are similar across organizations. For dioxin, incidental ingestion is the dominant exposure route for unrestricted/ residential use, and four states (Delaware, Mississippi, Pennsylvania, and Washington) base their cleanup levels on this pathway alone. Most others incorporate inhalation and/or dermal exposures, but those contributions tend to be relatively small. However, under certain scenarios (such as for excavation workers), these additional exposure routes can contribute substantially to the derived cleanup level.

Regarding the parameter values, most states apply common EPA default assumptions so the exposure factors are generally similar. However, relatively minor differences exist, with some reflecting state-specific context. For example, the Washington averaging time and the Minnesota exposure duration are slightly longer than the traditional EPA default residential values. The equations and values used by states to derive dioxin cleanup levels are presented in the body of the report and Appendix B. The combined exposure factors generally produce differences within a factor of ten. For example, values used for exposure frequency differ by about 2.4-fold, and those for the age-adjusted soil ingestion factor differ by less than 3-fold.

S.3.3 Target Risks

Target risks used to derive state cleanup levels for both unrestricted and restricted use range from 10^{-4} to 10^{-6} (which is also the EPA target incremental risk range for contaminated sites). These risks are shown in Table S-1 and Figures S-3 and S-4. Almost half the states that indicate a target risk for their unrestricted cleanup levels (11 of 24) use a value of 10^{-6}. Eight use 10^{-5}, and one (Iowa) uses a value halfway between the two, at 5×10^{-6}. The last four (Hawaii, American Samoa, Guam, and the Northern Mariana Islands) use the upper-end value of 10^{-4}. The same target risks are used for the commercial/industrial cleanup levels, except 2 of the 11 states that apply 10^{-6} for residential levels (Nebraska and Washington) use a value ten times higher for the restricted scenarios.

S.3.4 Toxicity Values

Nearly all states that identify dioxin cleanup levels (24 of 26) indicate the health endpoint, and all but one are based on cancer. This one level is the Iowa soil standard for nonresidential use, which applies if dioxin is the only chemical of concern. The reference dose used to derive this value is 10^{-9} mg/kg-d (which is the same as the chronic oral minimal risk level [MRL] established by the Agency for Toxic Substances and Disease Registry [ATSDR] in 1998). For all other state cleanup levels, including the standard residential level for Iowa, cancer is the limiting effect and the oral slope factor is the toxicity value of interest.
(As a note, an online file for Texas indicates the cleanup levels are based on a noncancer effect ["n"] but no toxicity value is provided; field followup clarified that the basis is cancer.)

TABLE S-1 Target Risks for the State Cleanup Levels

State per Risk Level	Soil Concentration per Land Use Scenario *(ppt)*		Terminology for Dioxin Cleanup Level *(as TCDD or Dioxin TEQ)*
	Unrestricted/Residential	***Commercial/Industrial***	
10^{-6} Incremental Lifetime Cancer Risk			
NE	3.9	(see entry under 10^{-5})	Remediation goal for TCDD
DE	4	40	Uniform risk-based remediation standard for TCDD
MS	4.26	38.2	Target remediation goal for TCDD
AZ	4.5	(see notes below)	Soil remediation level for TCDD
MD	4.5	18	Cleanup level for TCDD
OR	4.5	20	Risk-based concentration for TCDD
WY	4.5	-	Cleanup level for TCDD
FL	7	30	Soil cleanup target level for TCDD TEQ
NH	9	300	Risk-based soil standard for TCDD
ME	10	31	Generic soil cleanup level for dioxin TEQ
WA	11	(see entry under 10^{-5})	Cleanup level for TCDD
5×10^{-6} Incremental Lifetime Cancer Risk			
IA	19	(see notes below)	Cleanup level for TCDD
10^{-5} Incremental Lifetime Cancer Risk			
MN	20	35	Soil reference value for TCDD or TEQ
OH	35.8	-	Generic cleanup number for TCDD TEQ
AK	38	-	Risk-based concentration for TCDD
IN	45 *(60)*	180	Soil default closure level for TCDD
KS	60	100	Risk-based standard for TCDD
GA	80	-	Notifiable concentration for TCDD
MI	90	-	Direct contact criterion; risk-based screening level for TCDD TEQ
PA	120	530	Medium-specific concentration for TCDD
NE	(see entry under 10^{-6})	160	Remediation goal for TCDD
WA	(see entry under 10^{-6})	1,500	Cleanup level for TCDD
10^{-4} Incremental Lifetime Cancer Risk			
HI	390	1,600	Action level for dioxin TEQ
AS	450	1,800	Action level for dioxin TEQ
GM	450	1,800	Action level for dioxin TEQ
NMI	450	1,800	Action level for dioxin TEQ

Notes: TCDD = tetrachlorodibenzo-*p*-dioxin; TEQ = toxicity equivalent(s). Values are for states that indicate a target risk. AL adopted cleanup levels from the 1998 OSWER directive; TX adopted similar values without explicitly stating they are from the directive. Although the AZ nonresidential remediation level of 160 ppt is not accompanied by an explicit target risk, but general language in the regulation indicates the cumulative excess lifetime cancer risk should not exceed 10^{-4}. The IA nonresidential cleanup level for dioxin is based on the noncancer endpoint. The IN draft provisional value for unrestricted use is in parentheses. The OR value is for the occupational scenario, direct contact.

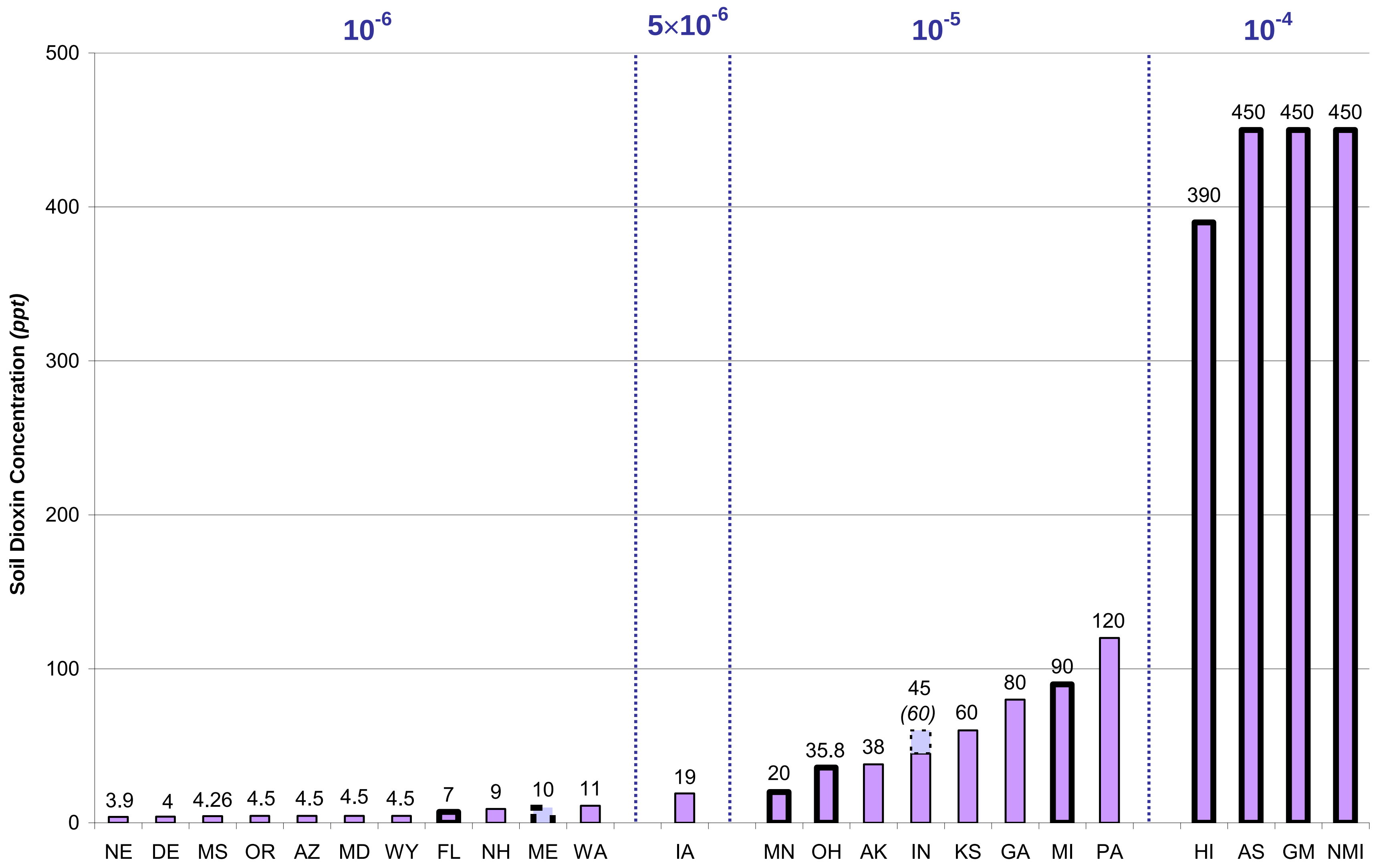

FIGURE S-3 Distribution of States with Specific Risk Targets for Dioxin Cleanup Levels: Unrestricted/Residential Use

(A dark border indicates the basis is TEQ rather than TCDD; a dashed border and lighter shading indicate a draft value.)

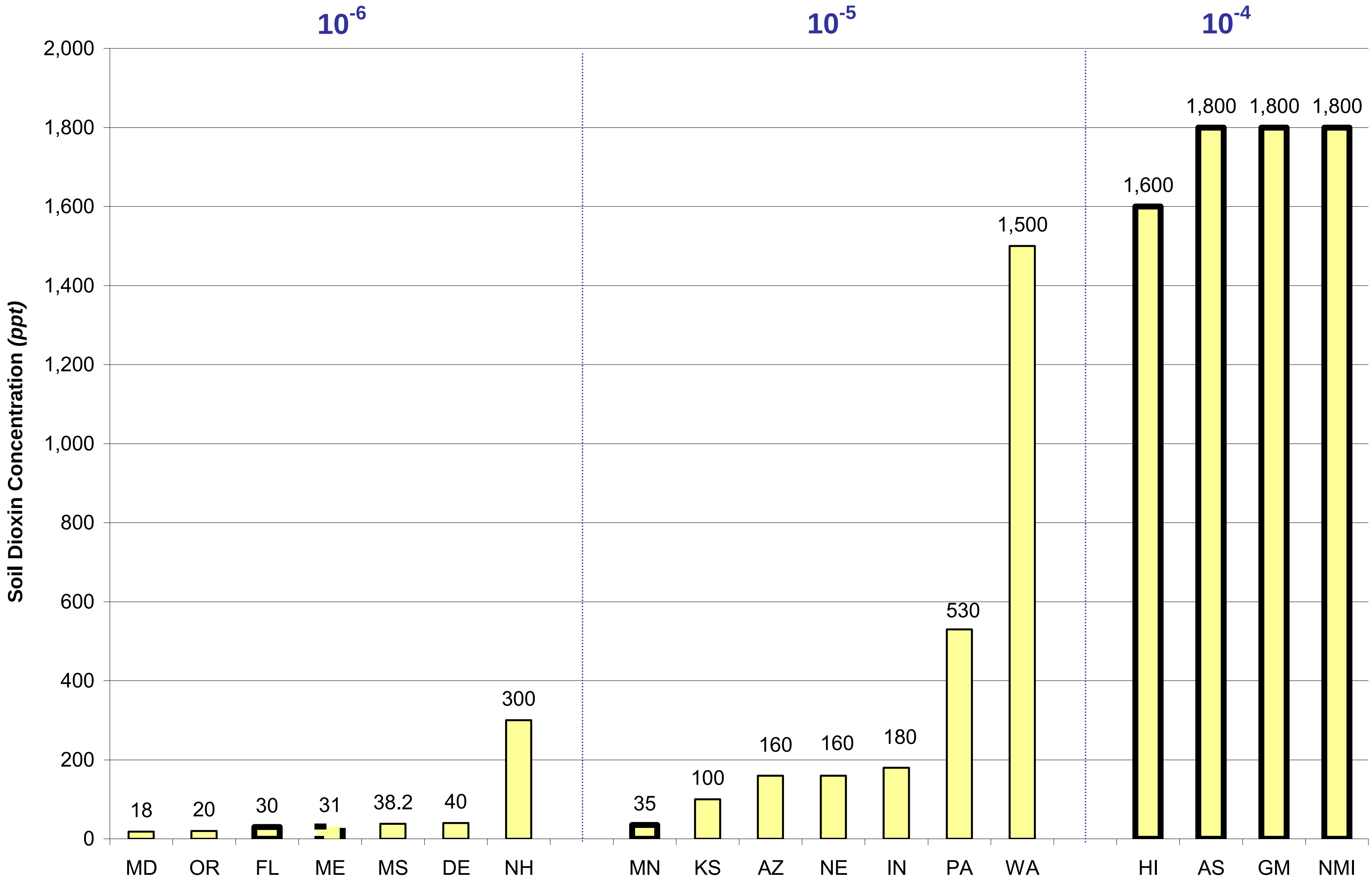

FIGURE S-4 Distribution of States Listing Specific Risk Targets for Dioxin Cleanup Levels: Commercial/Industrial Use

(A dark border indicates the basis is TEQ rather than TCDD; a dashed border indicates a draft value.)

(More information is summarized for toxicity values than for the other topics in this report because of broad interest, considering the availability of more recent toxicological data and ongoing evaluations by EPA and other agencies.)

Across the 24 states and territories (hereafter generally referred to as states), four different slope factors have been used to determine dioxin cleanup levels: 75,000; 130,000; 150,000; and 1,400,000 $(mg/kg\text{-}d)^{-1}$. These toxicity values are presented in Figure S-5 and Table S-2, together with the states that use them. They were derived using toxicity data from one of two rodent bioassays published more than 25 years ago, combined with modeling conducted by U.S. EPA work groups, California EPA (CalEPA), and other scientific groups to estimate the incremental lifetime risk of cancer incidence for humans. Cited sources range from old EPA Health Effects Assessment Summary Tables (HEAST) to former and current U.S. EPA Regional screening level tables, the 2003 draft EPA dioxin reassessment, and CalEPA documents.

All but two of the 24 states use a slope factor of either 150,000 or 130,000 $(mg/kg\text{-}d)^{-1}$. Although very similar, each value is based on a different bioassay: the 1978 study by Kociba and colleagues, and the 1982 National Toxicology Program (NTP) study, respectively. These original toxicity studies were independently peer reviewed as part of their publication process, as were the evaluations conducted to derive the slope factors. Three of the four slope factors listed above are based on the Kociba study, and these three are summarized first below.

The slope factor of 150,000 $(mg/kg\text{-}d)^{-1}$ is used most often, underlying more than half the state cleanup levels that include a toxicity value (13 of 24). It is based on the two-year dietary study of Sprague-Dawley rats by Kociba et al., which showed a higher incidence of hepatocellular carcinoma and squamous cell carcinoma of lungs, hard palate, nasal turbinates, and tongue at the highest dose, yet a decreased incidence of other tumors. This slope factor has also been applied by other states to establish supporting concentrations for dioxin in soil, such as the Nevada basic comparison levels (which are screening values rather than cleanup levels).

Updated evaluations of these same data were used by Michigan and Minnesota, the two states with different slope factors than the rest. In 1986, the NTP revised its tumor classification scheme, and scientists (including Kociba and his colleague Squire, as well as EPA work groups) used the new method to reevaluate the incidence of female rat liver tumors and other tumors from the 1978 data. This reevaluation identified a lower tumor incidence, which produced a lower toxicity value. A slope factor of 52,000 $(mg/kg\text{-}d)^{-1}$ was determined based on liver tumors alone, and a slope factor of 75,000 $(mg/kg\text{-}d)^{-1}$ was determined based on total significant tumors. Michigan used the latter (half the older slope factor) to determine its soil cleanup level.

In 2003, the Minnesota Department of Health (MNDOH) selected the draft slope factor of 1,400,000 $(mg/kg\text{-}d)^{-1}$ from the range of values presented in the EPA 2003 draft dioxin reassessment. This value, derived from the Kociba study, was identified as the upper bound for animal bioassays. At roughly 10 times the two most commonly applied values (and nearly 20 times the Michigan value), this slope factor was also used in a supporting role by the Pacific island group (American Samoa, Guam, Hawaii, and the Northern Mariana Islands). That is, it was used to estimate a concentration that could be applied for the lower bound of an operational cleanup range, as a companion to the standard cleanup levels above which remedial action should be considered. Those main cleanup levels (which are the representative concentrations shown in key figures and tables of this report) were derived using the toxicity value of either 150,000 $(mg/kg\text{-}d)^{-1}$ (for Hawaii) or 130,000 $(mg/kg\text{-}d)^{-1}$ (for the three Pacific island territories).

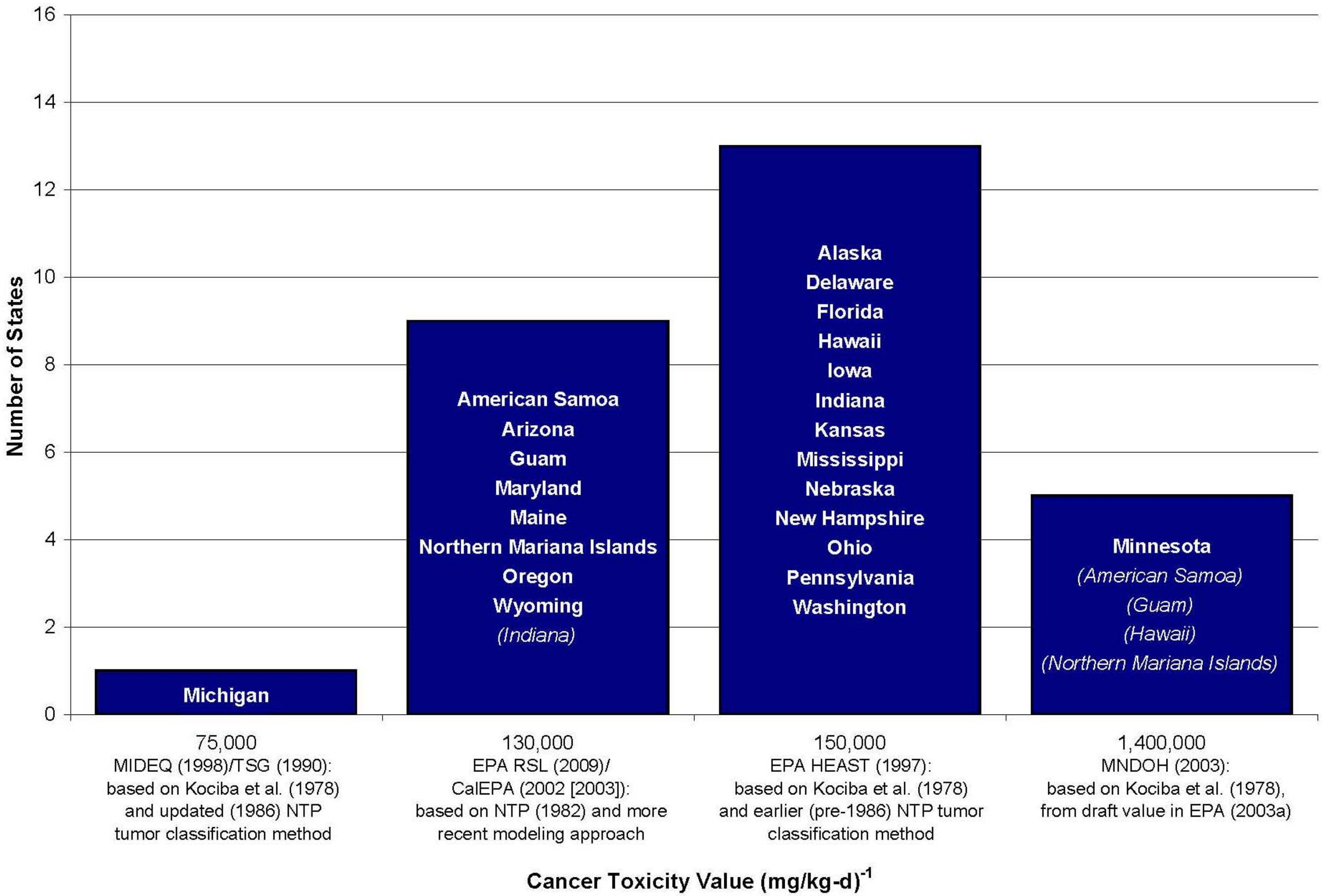

FIGURE S-5 Dioxin Toxicity Values Underlying the State Cleanup Levels

(Italics indicate the value is used for a draft or supporting level; see Notation and body for acronyms and references.)

TABLE S-2 Dioxin Toxicity Values Underlying the State Cleanup Levels[a]

Cancer Toxicity Value *(mg/kg-d)$^{-1}$*	Number of States	Specific States	Scientific Basis	Nature of Value and Peer Review
150,000	13	AK, DE, FL, HI, IA, IN, KS, MS, NE, NH, OH, PA, WA	The source of this value is commonly given as EPA HEAST from 1997, which lists several citations including the 1985 EPA *Health Assessment Document for Polychlorinated Dibenzo-p-dioxin*. This slope factor is based on the female rat bioassay by Kociba et al. from 1978. The two-year dietary study of TCDD in female Sprague-Dawley rats indicated the highest dose (0.1 µg/kg-d, or estimated dietary amount 2,200 ppt) produced multiple toxicological effects, with lesser effects reported at 0.01 µg/kg-d (210 ppt). (This was considered to support a previous study indicating chronic ingestion of 5,000 ppt caused many toxicological effects.) No adverse effects were reported at 0.001 µg/kg-d (22 ppt), and no carcinogenic effects reported at 0.01 or 0.001 µg (210 or 22 ppt). This older toxicity value reflects earlier methodology for classifying liver tumors, which was updated by the National Toxicology Program (NTP) in 1986. Many states cite the (outdated, indirect) EPA HEAST as the source. (Note this earlier EPA value from HEAST was also listed in the previous Region 9 PRG table – which preceded the 2008 harmonization of regional screening levels, or RSLs.)	HEAST identified this as a provisional value, and qualified it as being under further evaluation. Specific peer review information was not found; however, the 1985 EPA *Health Assessment* document (listed as one of the sources) underwent external peer review. (It is not clear that the HEAST value was based solely on this document, however, since that lists a cancer slope factor of 156,000 per mg/kg-d.) The HEAST tables are now outdated. (From the HEAST introduction: "The HEAST is a comprehensive listing consisting almost entirely of provisional risk assessment information …. Although these entries in the HEAST have undergone review and have the concurrence of individual Agency Program Offices, and each is supported by an Agency reference, they have not had enough review to be recognized as high quality, Agency-wide consensus information." The HEAST document also states that when used, "the provisional nature of the value should be noted.")

TABLE S-2 Dioxin Toxicity Values Underlying the State Cleanup Levels[a]

Cancer Toxicity Value *(mg/kg-d)$^{-1}$*	Number of States	Specific States	Scientific Basis	Nature of Value and Peer Review
75,000	1	MI	This value is based on a reevalution of tumor data from the 1978 rat study by Kociba et al. (see above), using the 1986 NTP update of the liver tumor classification scheme. This reevaluation indicated lower tumor incidence rates, which resulted in a slope factor of 52,000 (mg/kg-d)$^{-1}$ based on liver tumors alone, and a slope factor of 75,000 (mg/kg-d)$^{-1}$ based on total significant tumors – which updated the factor of 150,000 (mg/kg-d)$^{-1}$ that had been based on the older methodology.	Seven independent pathologists reassessed the tumor data from the Kociba study and subsequent analyses by Squire, a pathologist consultant to the EPA Carcinogen Assessment Group.
1,400,000	1	MN	MN adopted this draft value, the upper bound slope factor based on animal data that was included in the EPA (2003) draft reassessment, which was derived from the Kociba et al. (1978) bioassay described above. (This value is 40 percent higher than the draft upper bound slope factor in the reassessment based on epidemiological data.) The MNDOH documentation notes: driving pathway-oral; endpoints-immune, repro, cancer; cancer target organ-liver; class-human carcinogen. Per the MNDOH overview, concerns about the quality of exposure estimates in human epidemiological studies preclude quantitative use of these data in developing a slope factor, but results from modeling the human studies are consistent with the cancer slope derived by modeling data from animal studies. MNDOH also notes this slope factor was derived from the same study as the previous value of 156,000 (mg/kg-d)$^{-1}$, and that its development utilized current methods of analysis, including use of body burden as the dose metric for animal-to-human dose equivalence calculations (i.e., adjustments to account for the differences in half-life of dioxins in the bodies of laboratory animals and humans), and a re-evaluation of liver tumors in the Kociba study using the latest pathology criteria.	The EPA draft reassessment underwent extensive internal and external agency peer review, and subsequent peer review by an independent NAS committee from 2004 to 2006. In noting this draft basis, MNDOH indicated it will update its guidance and recommendations if appropriate, but at this time continues to recommend using its current guidance for assessing potential carcinogenic health risks (which includes not recommending early-life adjustment for cancer potency).
	(+4, to derive a supporting lower bound for a cleanup range)	*(AS, GM, HI, NMI)*	These four entries are shown in parenthetical italics because this value only underlies supporting soil concentrations, not the basic cleanup levels for this Pacific island set. That is, this draft toxicity value was used to generate a lower bound as a companion to the standard cleanup levels based on 150,000 (mg/kg-d)$^{-1}$ for HI, and on 130,000 (mg/kg-d)$^{-1}$ for the other three islands. This toxicity value supports the lower end of the cleanup range, while the main cleanup level above which remedial action is to be considered is based on these two other slope factors applied by nearly all other states.	

TABLE S-2 Dioxin Toxicity Values Underlying the State Cleanup Levels[a]

Cancer Toxicity Value *(mg/kg-d)$^{-1}$*	Number of States	Specific States	Scientific Basis	Nature of Value and Peer Review
130,000	8	AS, AZ, GM, MD, ME, NMI, OR, WY	This slope factor is listed in the current EPA Regional screening level table for residential soil, with the source given as CalEPA; its derivation is documented by California EPA (CalEPA). (As a note, the CalEPA soil screening level for 2,3,7,8-TCDD is 4.6 ppt.) The asterisk * in the RSL table for the cancer basis indicates that a screening level based on the noncancer endpoint is <1% of that based on the cancer endpoint (indicated as "[n SL < 100X c SL]"). This toxicity value is based on the NTP rat gavage studies from 1982. Summarizing from the CalEPA derivation document: A linearized multistage model was used with the NTP male mouse hepatocellular adenoma/carcinoma tumor data for TCDD, providing point estimates of extra risk for both maximum likelihood estimate (MLE) and linearized 95% upper confidence value (UCL); the UCL was calculated by maximizing the linear term, or forcing a best fit (method consistent both with expected low-dose linearity and linear nonthreshold theory). The slope of 95% UCL (q1*) was taken as the plausible upper bound cancer potency of TCDD at low doses. Rodent exposure data were converted to equivalent human exposures with scaling factors. Assumptions include: oral and inhalation routes are equivalent, air concentration is assumed to be daily oral dose, route of exposure does not affect absorption, and no difference exists in metabolism/ pharmacokinetics between animals and humans. Total weekly dose levels were averaged for a daily dose level; this assumes daily dosing in the NTP studies would give the same results as the actual twice weekly dosing schedule (as described, the TCDD half-life is relatively long so both schedules should give similar tissue concentrations). A significant increase in hepatocellular hyperplastic nodules was observed in female rats exposed to 0.1 or 0.01 µg/kg-d, while the next lower dose (0.001 µg/kg-d) showed no effect. (Note CalEPA is currently evaluating more recent toxicity data, notably the 2004 NTP study. Implications for an updated oral toxicity value are anticipated to be available later in 2009 or early 2010, following completion of the external review process.)	This value was developed by the California Department of Health Services in 1986, as documented in the derivation report developed for the California Toxic Air Contaminant program. It underwent external peer review by the California Air Resources Board (CARB) scientific review panel and was endorsed in 2002 when it was summarized and included in the 2002 CalEPA Hot Spots document. External review by the scientific panel (primarily from academia) was in accordance with a process that has been in place since 1983, per the original state air toxics legislation from the early 1980s. As described in the CalEPA overview of this value, comprehensive reviews of human studies available when the evaluation was written for the Toxic Air Contaminant (TAC) program are found in 1980s documents from the U.S. EPA and Veterans Administration.
	(+1)	*(IN)*	This entry is in parenthetical italics because 130,000 (mg/kg-d)$^{-1}$ underlies the internal draft cleanup level being considered by Indiana (60 ppt), based on field input during the review phase of this data compilation effort. The slope factor of 150,000 (mg/kg-d)$^{-1}$ underlies the current provisional level of 45 ppt.	

[a] See the Notation section and report body for acronyms; see the body and references for the documentation indicated in this summary table.

The slope factor of 130,000 $(mg/kg\text{-}d)^{-1}$ is used by one-third of the states and is being considered by an additional state. This value was derived from the 1982 chronic NTP study of rats and mice (Osborne-Mendel, dosed by gavage 3 times/week and B6C3F1, gavaged 2 days/week, respectively). This toxicity value underlies the cleanup levels identified for Arizona and Oregon, as well as the three Pacific island territories as noted above. This value also underlies the current EPA Regional screening levels (RSLs) for dioxin, which have been adopted by Maryland and Wyoming. In addition, it underlies the draft cleanup level recently identified by Maine and the internal draft provisional value developed by Indiana – bringing the total number (including draft values) considering this slope factor to nine.

The following summary of the toxicity basis for this slope factor is taken from the 1998/2008 ATSDR toxicological profile for chlorinated dibenzo-*p*-dioxins. About 0.007 µg/kg-d significantly increased the incidence of thyroid follicular cell adenoma, and a dose 10 times higher increased the incidence of neoplastic nodules in the liver and hepatocellular carcinoma in females. Doses of 0.1 and 0.01 µg/kg-d resulted in a significant increase in hepatocellular hyperplastic nodules for females, while the next lower dose (0.001 µg/kg-d) did not. Total weekly doses were averaged to estimate a daily dose, which assumes daily dosing would give the same results. (The TCDD half-life is relatively long so both schedules were expected to give similar tissue concentrations.) These rodent data were converted to equivalent human exposures using basic scaling factors; assumptions included: oral and inhalation routes are equivalent, the air concentration is assumed to be the daily oral dose, the route of exposure does not affect absorption, and TCDD metabolism/pharmacokinetics do not differ between animals and humans. CalEPA has documented the application of the linearized multistage model to these rodent hepatocellular adenoma/carcinoma tumor data to derive the cancer slope factor.

S.3.4 Key Differences

Differences among state values used to calculate exposures from incidental ingestion are illustrated in Table S-3, together with the slope factors and target risks applied. While the averaging time is generally the same (Washington uses a slightly higher value), the exposure frequency can differ by about 2.4-fold, the soil ingestion factor by nearly 3-fold, the slope factor by about 20-fold, and the target risk by 100-fold. The input from inhalation and/or dermal exposures also contributes somewhat to the range of cleanup levels across states. Additional factors include the chemical basis (TCDD only, or dioxin TEQ), as well as whether the state has derived a soil concentration or adopted an existing (e.g., screening) value as the cleanup level.

S.3.5 Evaluation Criteria

The information compiled for state cleanup levels was considered in terms of four evaluation criteria commonly used to assess health-based values (including by OSWER). These criteria are: (1) nature of peer review, (2) transparency-public availability, (3) scientific basis, and (4) incorporation of most recent science.

In many cases, only limited information was found during the online searches to address these criteria , and little more was obtained from field review inputs. This was particularly an issue for transparency and the nature of peer review, but in several cases it also extended to documentation of the scientific basis, notably for derivation of the underlying toxicity value. The CalEPA toxicity values tend to address these criteria fairly well because of the extensive peer review by external experts in accordance with a long-standing process, public availability, and typical scientific rigor.

TABLE S-3 Summary Comparison of State Derivations for Incidental Soil Ingestion *(main route for residential cleanup levels)*[a]

Generic equation for residential/unrestricted scenario,(incidental ingestion: $C_{res\_ing} = TR{\times}AT / SF_o{\times}EF{\times}IFS_{adj}{\times}10^{-6}$ kg/mg						
State	**Conc** *(ppt)*	**Oral Cancer Slope Factor. SF_o** *(mg/kg-d)$^{-1}$*	**Target Cancer Risk, TR**	**Averaging Time** *(d)*	**Exposure Frequency, EF** *(d/y)*	**Soil Ingestion Factor, IFS_{adj} or (IR×ED)/BW** *(mg-y/kg-d)*
NE	3.9	150,000	10^{-6}	25,550	350	114
DE	4	150,000	10^{-6}	25,550	350	114
MS	4.26	150,000	10^{-6}	25,550	350	114
AZ	4.5	130,000	10^{-6}	25,550	350	114
MD	4.5	130,000	10^{-6}	25,550	350	114
OR	4.5	130,000	10^{-6}	25,550	350	114
WY	4.5	130,000	10^{-6}	25,550	350	114
FL	7	150,000	10^{-6}	25,550	350	69
NH	9	150,000	10^{-6}	25,550	160	105
ME	10	130,000	10^{-6}	25,550	150	120
WA	11	150,000	10^{-6}	27,375	365	75
IA	19	150,000	$5{\times}10^{-6}$	25,550	350	114
MN	20	1,400,000	10^{-5}	25,550	350	45
OH	35.8	150,000	10^{-5}	25,550	350	114
AK	38	150,000	10^{-5}	25,550	330	114
IN	45	150,000	10^{-5}	25,550	250	114
KS	60	150,000	10^{-5}	25,550	350	42
GA	80	(not specified)	10^{-5}	25,550	350	48
MI	90	75,000	10^{-5}	25,550	350	114
PA	120	150,000	10^{-5}	25,550	250	57
HI	390	150,000	10^{-4}	25,550	350	114
AS	450	130,000	10^{-4}	25,550	350	114
GM	450	130,000	10^{-4}	25,550	350	114
NMI	450	130,000	10^{-4}	25,550	350	114

[a] Shading highlights variations within related entries. Note the internal draft provisional value of 60 ppt for Indiana uses a SF value of 130,000. AL and TX identify a cleanup level of 1,000 ppt, which is the concentration recommended in the OSWER directive for a residential scenario.

For dioxin, the CalEPA slope factor of 130,000 $(mg/kg\text{-}d)^{-1}$ used by eight states (and being considered by a ninth) is well documented in terms of scientific basis, methodology, and peer review. This value was derived using the linearized multistage model with slightly more recent bioassay data (1982 NTP study) than used for the other slope factors (which are based on the 1978 Kociba data), and its derivation and review process are publicly available online.

In contrast, documentation for the slope factor of 150,000 $(mg/kg\text{-}d)^{-1}$ used by more than half the states is limited. It is based on an outdated methodology, and the common citation is an outdated EPA HEAST source. That HEAST cancer slope factor was indicated as being a provisional value and was qualified as being under further evaluation. The HEAST tables were described in the 1997 EPA document as containing "provisional risk assessment information" that "have not had enough review to be recognized as high quality, Agency-wide consensus information." Specific peer review information for this earlier slope factor is not readily available; however, the 1985 EPA *Health Assessment Document* (which is listed as one of the sources for the HEAST value) underwent external peer review. Note it is not clear that the HEAST value was based solely on this document, since the 1985 EPA health assessment document lists a cancer slope factor of 156,000 $(mg/kg\text{-}d)^{-1}$, while the HEAST value is 150,000 $(mg/kg\text{-}d)^{-1}$. Thus, this value is considered relatively weak in terms of the evaluation criteria.

The third slope factor, 1,400,000 $(mg/kg\text{-}d)^{-1}$ used by Minnesota, was taken from the draft EPA dioxin reassessment, which remains under review. The lack of a final peer-reviewed publication basis for this value limits its broader strength.

The fourth slope factor, 75,000 $(mg/kg\text{-}d)^{-1}$ used by Michigan, is a final published value based on an updated, peer-reviewed evaluation of the Kociba data using the updated NTP tumor classification. However, documentation of its derivation, independent peer review, and public availability of supporting information were not found to be as extensive as for the CalEPA value.

S.4 SUMMARY

Information on soil dioxin cleanup levels was pursued for all 50 states, DC, Puerto Rico, the Virgin Islands, and four Pacific island territories. Nearly half (26 of 57) have established cleanup levels, and another quarter have identified screening levels. The rest call for site-specific determinations (which incorporate relevant conditions) rather than identifying generic values. For those states, additional insights were pursued from site records of decision.

The state cleanup levels for dioxin span three orders of magnitude, reflecting differences in: (1) target risk; (2) cancer slope factor; (3) exposure assumptions; (4) reporting basis (TCDD or TEQ); and (5) whether a value was adopted or derived. More than half the derived cleanup levels reflect an older slope factor of 150,000 $(mg/kg\text{-}d)^{-1}$, which was qualified as provisional and under review. For unrestricted use, two states use the OSWER value of 1,000 ppt. About half the site-specific cleanup decisions also reflect this concentration.

Several state cleanup levels fall in the middle range of around 400 ppt, but most are at or below 120 ppt. More than a quarter (7 of 26) are roughly 4 ppt, which indicates a number of states have essentially adopted values developed for screening purposes (rather than cleanup decisions) as their cleanup level. These low levels match the U.S. EPA Regional screening level for unrestricted use. The scientific basis, external peer review, and transparency of these adopted values do not appear to be well documented for such an application, i.e., for other than the screening purpose for which they were designed.

1 INTRODUCTION

The purpose and scope of this report by the U.S. Environmental Protection Agency (U.S. EPA) National Center for Environmental Assessment (NCEA) is identified in Section 1.1, and the report organization is given in Section 1.2.

1.1 PURPOSE AND SCOPE

The purpose of this report is to provide information on soil cleanup levels for dioxin across the United States. In late May 2009, the U.S. EPA Administrator released the *Science Plan for Activities Related to Dioxins in the Environment* (U.S. EPA, 2009), which includes the following commitments:

> "*EPA will evaluate information about the basis for dioxin soil clean-up levels.*
>
> - *NCEA will review information about the basis for state dioxin soil clean-up levels.*
> - *NCEA will prepare a report for OSWER that includes a survey and evaluation of the clean-up levels in the states.*
> - *The report will characterize the science that these values are based on, as well as the degree of peer review, if any that was done.*
> - *This report will be completed before December 31, 2009, and provided to OSWER.*
> - *OSWER will announce an updated interim dioxin soil clean-up level to the public by December 31, 2009."*

The extant directive from the Office of Solid Waste and Emergency Response (OSWER) for dioxin in soil identifies a cleanup level of 1,000 parts per trillion (ppt) for unrestricted land use (U.S. EPA, 1998). In the time since this directive was released, several states have developed their own values to guide the cleanup of contaminated sites, which are lower than the OSWER value. Many in the broader community are interested in updated U.S. EPA guidance to support cleanup activities that are under way or being planned. The Agency is responding to this need through the commitments outlined above.

The scope of this evaluation focuses on 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (TCDD) or total dioxins as toxic equivalents (TEQ). It does not include dioxin-like compounds, such as polychlorinated biphenyls. Further details on the scope are given in Chapter 2.

1.2 REPORT ORGANIZATION

This report is organized as follows:

- Chapter 2 outlines the approach for identifying soil cleanup levels across states.
- Chapter 3 presents the results, including the scientific basis where available.
- Chapter 4 provides a brief discussion of the results.
- Chapter 5 acknowledges contributors, and Chapter 6 lists references for the main report.
- Appendices present supporting information on the approach (Appendix A) and detailed data for individual states, organized by U.S. EPA Region (Appendix B).

2 APPROACH

The identification of state soil cleanup levels for dioxin involved three main phases:

- Survey existing information sources including the scientific literature to identify state cleanup levels for dioxin-contaminated soil, and supporting documentation, including for the toxicity value applied.
- Compile the state levels and their scientific bases, and provide to applied experts across states and U.S. EPA Regions for review and input; include in this compilation information for several criteria used to evaluate health-based levels.
- Integrate the information into a summary technical report.

These phases are illustrated in Figure 1. Information for Phases I and II is highlighted in Sections 2.1 and 2.2, respectively. Supporting details for the approach are provided in Appendix A.

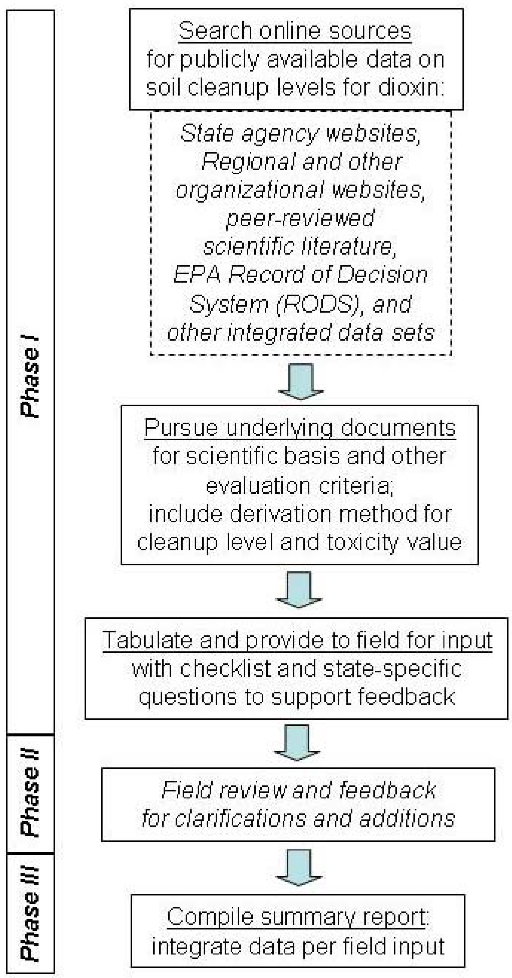

FIGURE 1 Phased Approach for Identifying Soil Dioxin Cleanup Levels

Note that "state" is used as a broad term to include entities such as U.S. territories for which information on soil cleanup levels was also pursued. That is, the scope extends beyond the 50 states, DC, and Puerto Rico to the Virgin Islands, American Samoa, Guam, Northern Mariana Islands, and the Trust Territories (the last four are in EPA Region 9; see Table B.9).

2.1 DOCUMENT/LITERATURE SEARCH

The scope of the literature survey to identify state soil cleanup levels for dioxin is summarized in Table 1. The information resources pursued in this search are highlighted in Table 2.

TABLE 1 Scope of the Survey for Dioxin Soil Cleanup Levels by State

Component	Focus	Note
Benchmark type	Cleanup level, not screening value	While many states identify screening values, this effort focuses on soil cleanup levels.
Contaminant	2,3,7,8-tetrachlorodibenzo-*p*-dioxin (TCDD) or toxic equivalents (TEQ), total dioxins	Dioxin-like compounds (DLCs) such as polychlorinated biphenyls are not included.
Environmental medium	Soil	When soil data are limited for a given state, other data are collected for potential insight (e.g., values for related use such as amendments for surface soil).
Scenario (land use)	Primary focus: Unrestricted, residential use Also considered: Commercial/industrial use	Where a data source includes other scenarios (e.g., combined ecological-health protection), those are also collected for potential insight.
Receptor	Primary focus: Most exposed human (e.g., resident/child) Also considered: Other human receptors for other scenarios	A key interest is on the receptor assumed to be most exposed, to represent a level considered protective for others.
Exposure route	Primary focus: Soil direct contact, oral (incidental ingestion) Also considered: Other routes (e.g., inhalation, dermal) that contribute but to a lesser extent to unrestricted/residential and other land use scenarios	The dominant exposure route for unrestricted use (residential) is oral/ incidental ingestion. The equations and parameter values highlighted in the data tables focus on this route to simplify presentation and field review.
Toxicity value	Slope factor or similar term (cancer) Reference dose or similar term (noncancer)	Oral toxicity values are the main focus. Where not found online, field input was requested for the scientific study and derivation methodology underlying the toxicity value used.

The primary searches for state cleanup levels for dioxin were conducted through June 2009, to allow state agencies an opportunity to review the data compiled during the summer and provide feedback by early fall, as coordinated by EPA regional counterparts. The intent was to present information current through summer 2009. However, in finalizing this report, a number of weblinks were rechecked during October and November 2009, and several recent updates were discovered. These updates have been added to the report where identified (including one from early December 2009).

TABLE 2 Information Resources Pursued

Information Resource	Search Note
Primary	
State websites	Multiple divisions and departments.
Supporting	
U.S. EPA Region websites	Links to information for specific cleanup sites (including voluntary cleanups), as well as regional values that have been adopted by various states and cleanup sites.
Other agency websites	Includes the Agency for Toxic Substances and Disease Registry (ATSDR) website, which contains soil dioxin values (and supporting context) that have been adopted by various states and cleanup sites.
Scientific literature	Peer-reviewed journal articles that include information on state cleanup levels and supporting context, where available.
OSWER RODS database (Record of Decision System)	Database of decision documents and links to related technical reports that identify dioxin cleanup levels established for contaminated sites on the National Priorities List. (These checks were conducted to help address gaps where state policy or guideline values were not found online, and as general supporting insight.)
Other organizational websites	Summaries or extracts of soil dioxin cleanup levels from various groups.
Other online sources	Data via open google searches using selected key words and combinations (including [state], dioxin, TCDD, TEQ, soil, cleanup, remediation, site, concentration, level, limit, guideline, guidance, risk, RBC, CERCLA, RCRA, voluntary, brownfield, record of decision, five-year review, toxicity value, reference dose, slope factor, potency).

2.2 EVALUATION CRITERIA

Four criteria were considered to evaluate the state soil cleanup levels:

- Nature of peer review.
- Transparency-public availability.
- Scientific basis.
- Incorporation of most recent science.

These criteria are indicated in OSWER Directive 9285.7-53, *Human Health Toxicity Values in Superfund Risk Assessments* (U.S. EPA, 2003b), for toxicity values in Tier 3. That tier is tapped when no values are available from Tier 1 (U.S. EPA Integrated Risk Information System, IRIS) or Tier 2 (U.S. EPA provisional peer reviewed toxicity values, PPRTVs). Such is the case for dioxin.

Similar criteria have been applied across other programs, including as reflected in a joint work group of the Environmental Council of States (ECOS) and U.S. Department of Defense (DoD), which included technical input from OSWER (ECOS, 2007).

3 RESULTS

Results of the data collection and evaluation effort are organized as follows. Soil concentrations identified across states are summarized in Section 3.1, and the toxicity reference values underlying these concentrations are presented in Section 3.2. The derivation methodologies used to establish the state cleanup levels and associated toxicity values are described in Section 3.3, and the evaluation criteria are discussed in Section 3.4.

3.1 SOIL DIOXIN LEVELS BY STATE

State data relevant to dioxin cleanup levels in soil are organized in groups based on land use. The first set addresses unrestricted/residential use, and the second addresses restricted use, notably for commercial and industrial settings. Key tables and figures for each group are listed in Table 3 and described in the sections that follow.

TABLE 3 Selected Tables and Figures of State Values for Dioxin in Soil[a]

Tables and Figures per Land Use Category		Data Ordered by:			Scale	
		State *(alphabetical)*	***Concentration*** *(decreasing)*	***EPA Region***	***Basic***	***Log***
Unrestricted/Residential						
Table 4:	State cleanup levels	✓				
Figure 2a:	Representative level per state	✓			✓	
Figure 2b:	As for 2a but log scale	✓				✓
Figure 3:	As for 2b, by concentration		✓			✓
Figure 4:	As for 2b, by Region			✓		✓
Table 5:	Additional values, by state	✓				
Table 6:	States with no soil cleanup level	✓				
Figure 5:	As for 2b, plus screening values	✓				✓
Figure 6:	As for 5, by concentration		✓			✓
Figure 7:	As for 5, by Region			✓		✓
Figure 8:	Site-specific levels, by state	✓				✓
Figure 9:	As for 8, by concentration		✓			✓
Restricted Commercial/Industrial						
Table 7:	State cleanup levels	✓				
Figure 10a:	Representative level per state	✓			✓	
Figure 10b:	As for 10a but log scale	✓				✓
Figure 11:	As for 10b, by concentration		✓			✓
Figure 12:	As for 10b, by Region			✓		✓
Table 8:	Additional values, by state	✓				
Figure 13:	As for 10b, plus screening values	✓				✓
Figure 14:	As for 10b, by concentration		✓			✓
Figure 15:	As for 10b, by Region			✓		✓
Figure 16:	Site-specific levels, by state	✓				✓
Figure 17:	As for 16, by concentration		✓			✓

[a] Additional supporting tables and figures, including for toxicity values, follow this set.

3.1.1 Unrestricted/Residential Use

Soil Cleanup Levels

- About half the states have established a standard cleanup level or guideline for dioxin in soil, with some identifying multiple concentrations. Variations reflect differences in input assumptions such as extent of child exposures, target risk level, and type of carcinogen. To simplify comparisons, Figure 2a and Table 4 emphasize one cleanup level per state. (Other values identified for individual states are presented in supporting tables and figures.) These concentrations are shown by state in alphabetical order on a standard arithmetic scale. Note for Indiana, the current provisional value (45 ppt) is shown together with the draft proposed value (60 ppt) identified by the state during field review. Similarly, while no published level was found for Maine, the value identified by the state during field review is shown in the figures. Dark borders indicate a TEQ basis.

- The range of cleanup levels across states is considerable. Several concentrations at the lower end reflect the fact that some states have adopted values established for screening purposes to serve as cleanup levels. The wide distribution of cleanup levels makes it difficult to distinguish the smaller values when graphed on an arithmetic scale. To facilitate readability and comparisons across all levels, Figure 2b presents the same information as Figure 2a but on a logarithmic scale.

- Figure 3 presents these same cleanup concentrations shown in Figure 2 but in decreasing order rather than by state, for potential insights into concentration groupings.

- Figure 4 presents the same cleanup levels as Figures 2 and 3 but organized by EPA Region, for potential insights into regional patterns (similarities and differences), if any.

Supporting Context: Screening Values and Illustrative Site-Specific Cleanup Levels

- The survey of existing state limits for dioxin in soil uncovered a variety of data that extend beyond the cleanup levels shown in Figures 2 through 4. Table 5 identifies these additional values (see lower portion), and Figure 5 presents the fuller set of concentrations, which includes screening values for dioxin in soil for these scenarios. Given that certain states have adopted screening values as cleanup levels, these data are considered useful as supporting context. This complement of concentration data is presented together with the cleanup levels, alphabetized by state, to offer potential insights into similarities and differences within and across these sets.

- Figure 6 presents the same data as Figure 5 but in decreasing numerical order rather than by state, to offer potential insights into concentration groupings.

- Figure 7 presents the same data as Figure 5, organized by EPA Region.

- Many states have not established a standard concentration for dioxin (see Table 6), invoking instead a site-specific determination of soil cleanup levels. In light of this basis, Figure 8 presents illustrative cleanup levels identified in documents prepared for contaminated sites, organized by state, for practical application insights.

- Figure 9 presents the same site-specific values as Figure 8, organized by concentration.

TABLE 4 Representative Soil Cleanup Level for Dioxin by State: Unrestricted/Residential Use[a]

State	Soil Conc *(ppt)*	Date	Toxicity Value *(mg/kg-d)$^{-1}$*	Term and Scenario Context	Scientific Basis: *Exposure*	Scientific Basis: *Toxicity*	Scientific Basis: *Risk*	Peer Review and Availability	Selection Rationale
AK	38	Jun-08	150,000	Risk-based concentration for TCDD, residential use, direct contact.	General equation for direct contact, incidental ingestion and dermal exposure considered.	Slope factor source is given as HEAST.	10^{-5}	Equations are given in ADEC documents, available online.	Represents the most conservative of the three RBCs developed for three different annual exposure frequencies, taken from the state website.
AL	1,000	Apr-08	Not found; see note at right for the toxicity basis.	Preliminary screening or cleanup value for TCDD, residential use, direct contact.	(Adopted value from OSWER directive.)	Reflects the OSWER value; derivation basis is the evaluation by Kimbrough et al. (1984) of data from Kociba et al. (1978).		Cleanup value and toxicological context are available online.	Cited in document from the state website as a value that can be used for "screening or cleanup" purposes.
AS	450	Oct-08	130,000	Tier 2 action level for dioxin TEQ, residential use, direct contact. (Tier 1 is a screening level; see right-most column for Tier 2 context.)	General equation for direct contact; considers ingestion, inhalation, and dermal routes of exposure.	Slope factor reflects the value listed in the 2008 EPA RSL table (U.S. EPA, 2009b).	10^{-4}	Information is available online.	Action level adopted from Guam EPA represents the value above which residential use is not recommended absent remedial action to reduce potential exposure.
AZ	4.5	May-07 (Jul-09)	130,000	Soil remediation level for TCDD, residential use, direct contact. *(Field review input of July 2009 indicates AZ has adopted the EPA RSL and toxicity value.)*	General equation for direct contact; considers ingestion, inhalation, and dermal routes of exposure.	Slope factor is from CalEPA, as reflected in the EPA RSL table.	10^{-6}	Adopted equations and toxicity information from Regional EPA RSLs, for which documents are available online.	Current residential SRL from state website for current or intended future use of contaminated site as a child care facility or school where children <18 are reasonably expected to be in frequent, repeated contact with soil.

TABLE 4 Representative Soil Cleanup Level for Dioxin by State: Unrestricted/Residential Use[a]

State	Soil Conc *(ppt)*	Date	Toxicity Value *(mg/kg-d)$^{-1}$*	Term and Scenario Context	Scientific Basis: *Exposure*	Scientific Basis: *Toxicity*	Scientific Basis: *Risk*	Peer Review and Availability	Selection Rationale
DE	4	Dec-99	150,000	Uniform risk-based remediation standard for TCDD, unrestricted use, protection of human health.	General equation for direct contact; incidental ingestion is primary contributor.	Slope factor source is given as HEAST.	10^{-6}	Calculations and risk-based tables are available online.	Current residential URS from state document.
FL	7	Feb-05	150,000	Soil cleanup target level for TCDD TEQ, residential use, direct contact.	General equation for direct contact; considers incidental ingestion, inhalation, and dermal exposure routes.	Slope factor source is given as HEAST.	10^{-6}	Derivation basis and equations are available online. (Default and chemical-specific parameter values are in the FDEP 2005 technical report.)	Current residential SCTL from the state website.
GA	80	1992	Not found.	Notifiable concentration for TCDD, unrestricted use scenario. (This is a default starting point for the cleanup level that is determined on a site-specific basis, which in some cases may be this same concentration.)	General equation for direct contact; considers ingestion and inhalation exposure pathways	*Not found.*	10^{-5}	Soil values available online, but specific derivation basis is unclear; toxicity value and some chemical-specific parameter values are not provided.	Value identified from the state website.
GM	450	Oct-08	130,000	Tier 2 action level for dioxin TEQ, residential use, direct contact.	General equation for direct contact; considers incidental ingestion, inhalation, and dermal exposure routes.	Slope factors and toxicological information are from CalEPA, as reflected in 2008 EPA RSL table.	10^{-4}	Information is available online.	Represents value above which residential use is not recommended in absence of remedial actions to reduce potential exposure, taken from the agency website.

TABLE 4 Representative Soil Cleanup Level for Dioxin by State: Unrestricted/Residential Use[a]

State	Soil Conc *(ppt)*	Date	Toxicity Value *(mg/kg-d)*$^{-1}$	Term and Scenario Context	Scientific Basis: *Exposure*	Scientific Basis: *Toxicity*	Scientific Basis: *Risk*	Peer Review and Availability	Selection Rationale
HI	390	Sum-08	150,000	Tier 2 action level for dioxin TEQ, residential use, direct contact.	General equation for direct contact; considers incidental ingestion, inhalation, and dermal exposure routes.	Slope factor source is given as HEAST.	10^{-4}	Information is available online.	Represents value above which residential use is not recommended in absence of remedial actions to reduce potential exposure, taken from the state website.
IA	19	(Jul-09)	150,000	Cleanup level for residential land use.	Exposure equation takes into account ingestion and dermal contact.	Slope factor source is given as HEAST.	5×10^{-6}	Formula used for risk calculations is available online.	*Field review feedback identified this as the dioxin residential cleanup level, statewide soil standard, within the voluntary cleanup program, Iowa Land Recycling Program.*
IN	45	2006	150,000	TCDD, residential soil default closure level, direct contact.	Exposure equation considers ingestion, inhalation, and dermal exposure routes.	Slope factor source is given as HEAST.	10^{-5}	Current technical guide is available online.	Represents the current provisional value, available online from the state website.
	(60)	(Jun-09)	130,000	Internal draft value for TCDD, residential soil default closure level, direct contact.	Exposure equation considers ingestion, inhalation, and dermal exposure routes.	Slope factor source is given as CalEPA.	10^{-5}	Internal draft value, pending possible changes in algorithms or toxicological data.	*The soil concentration of 60 ppt was identified in field feedback as a draft internal value under consideration.*
KS	60	Jun-07	150,000	Tier 2 risk-based standard for TCDD, residential scenario. "Chemical-specific and media-specific risk-based cleanup goals …" (see Tier 2 context in right-most column).	Exposure equation considers ingestion, inhalation, and dermal exposure routes.	Slope factor source is given as HEAST.	10^{-5}	Cleanup levels and equations with soil exposure factors are available online.	From the state website, Tier 2: single contaminant and medium, standard and conservative default exposure assumptions; does not include soil to air transfer, cumulative risk from multiple contaminants or media, and risk to ecological receptors.

TABLE 4 Representative Soil Cleanup Level for Dioxin by State: Unrestricted/Residential Use[a]

State	Soil Conc *(ppt)*	Date	Toxicity Value *(mg/kg-d)*$^{-1}$	Term and Scenario Context	Scientific Basis			Peer Review and Availability	Selection Rationale
					Exposure	***Toxicity***	***Risk***		
MD	4.5	(Jul-09)	130,000	Cleanup level for TCDD, residential scenario.	Exposure equation considers ingestion, inhalation, and dermal exposure routes.	Slope factor source is given as CalEPA.	10^{-6}	EPA RSL equations are available online.	*Field review feedback indicated the EPA residential RSL is the soil cleanup level for MD.*
ME	10	Jul-09	130,000	Draft generic soil cleanup level for dioxin TEQ, residential scenario.	Value considers incidental ingestion, dermal contact, and inhalation of fugitive dust.	Slope factor source is given as CalEPA.	10^{-6}	Equations and a summary of calculations are available online. (Not known if this is pending final publication.)	*Concentration found via weblinks provided in field review feedback. This value of 10 ppt for residential use is considered representative (with its more conservative target ILCR, 10^{-6}), as it is "applicable at sites with more than one contaminant of concern."*
MI	90	Jan-06	75,000	Direct contact criterion (DCC) and risk-based screening level (RBSL) for TCDD TEQ.	Exposure equation considers ingestion and dermal routes of exposure.	Slope factor based on reanalysis of Kociba et al. (1978) data using updated (1986) NTP methodology.	10^{-5}	DCC derivation methodology is available online.	Current direct contact criterion from the state website.
MN	20	Jun-09	1,400,000	Soil reference value, residential scenario, direct contact for TCDD (or TCDD TEQs).	General equation considers incidental ingestion, dermal contact, and inhalation.	Draft upper-bound slope factor from EPA (2003), which was derived from Kociba et al. (1978) data.	10^{-5}	Methodology and updates to parameter values are available online.	Current residential SRV from the state website.

TABLE 4 Representative Soil Cleanup Level for Dioxin by State: Unrestricted/Residential Use[a]

State	Soil Conc *(ppt)*	Date	Toxicity Value *(mg/kg-d)$^{-1}$*	Term and Scenario Context	Scientific Basis: *Exposure*	Scientific Basis: *Toxicity*	Scientific Basis: *Risk*	Peer Review and Availability	Selection Rationale
MS	4.26	Feb-02	150,000	Tier 1, target remediation goal for TCDD, unrestricted land use scenario. (See right-most column for Tier 1 context.)	General equation from EPA (1996) Soil Screening Guidance; incidental ingestion is the primary contributor.	Slope factor source is given as HEAST (undated; field review feedback cited pg. 3-33 of that document).	10^{-6}	Equations from EPA are available online; the HEAST information is not.	*Field review feedback indicates target risk is default; "Tier 1 TRGs may either be used as "default" remediation goals or as screening values that will initiate a Tier 2 Evaluation or Tier 3 Evaluation."*
NE	3.9	Oct-08	150,000	Remediation goal established under the NDEQ Voluntary Cleanup Program guidance for TCDD, based on direct contact.	General equation; considers ingestion, inhalation, and dermal exposure routes.	Slope factor source given as HEAST.	10^{-6}	Cleanup levels and remediation goals are available online.	*Field review feedback indicated the VCP RGs "are both screening levels for investigation and site characterization purposes and preliminary cleanup goals for the remedial action phase."*
NH	9	May-07	150,000	Risk-based S-1 soil category for sensitive uses of property and accessible soils. (See right-most column for context.)	General equation for direct contact; considers ingestion and dermal exposure routes.	Slope factor cites RAIS (ORNL, 2005/2006); appears to reflect HEAST.	10^{-6}	Risk characterization and derivations are available online.	From the state website, relatively conservative S-1 means potential receptors of all ages may be exposed via normal everyday activities (160 d/y, 30 y).
NMI	450	Oct-08	130,000	Tier 2 action level for dioxin TEQ, residential use, direct contact. (Tier 1 is a screening level; see right-most column for Tier 2 context.)	General equation for direct contact; considers ingestion, inhalation, and dermal routes of exposure.	Slope factor reflects the value listed in the 2008 EPA RSL table.	10^{-4}	Information is available online.	Action level adopted from Guam EPA, per website; represents the value above which residential use is not recommended absent remedial action to reduce potential exposure.
OH	35.8	Oct-09	150,000	Generic cleanup numbers for TCDD TEQ, direct contact with soil.	General equation; considers ingestion, inhalation, and dermal exposure routes.	Slope factor source is given as HEAST.	10^{-5}	Derivation methodology is available online.	Current generic cleanup number from the state website.

TABLE 4 Representative Soil Cleanup Level for Dioxin by State: Unrestricted/Residential Use[a]

State	Soil Conc *(ppt)*	Date	Toxicity Value *(mg/kg-d)$^{-1}$*	Term and Scenario Context	Scientific Basis: *Exposure*	Scientific Basis: *Toxicity*	Scientific Basis: *Risk*	Peer Review and Availability	Selection Rationale
OR	4.5	Sep-09	130,000	Risk-based concentration for TCDD, residential scenario, direct contact.	General equation adopted from RSLs; considers ingestion, inhalation, and dermal routes of exposure	Slope factor underlying the RSL is from CalEPA.	10^{-6}	Values and derivation methodology are available online.	RBC from recent state update (of previous term, "acceptable risk level" above which action is to be taken to reduce exposure).
PA	120	Nov-01	150,000	Medium-specific concentration (MSC) for TCDD, residential scenario, direct contact.	General equation; considers ingestion route.	Slope factor source is given as HEAST.	10^{-5}	PADEP documents are available online.	Current residential MSC from the state website.
TX	1,000	Mar-09	Not found; see note at right for the toxicity basis.	Protective concentration level for dioxin TEQ, residential scenario.	Exposure equation accounts for ingestion, inhalation, dermal contact, and vegetable consumption.	Reflects the OSWER value, for which the derivation basis is the evaluation by Kimbrough et al. (1984) of data from Kociba et al. (1978).		Soil concentration is available online, but TX does not describe derivation basis. Toxicity values and some chemical-specific parameter values are not provided.	PCL identified on the state website; "TRRP Tier 1 protective concentration levels (PCLs) are the default cleanup standards in the TX Risk Reduction Program."
WA	11	Jun-09	150,000	Cleanup level for TCDD, unrestricted scenario, direct contact.	General equation; considers ingestion exposure route.	Slope factor source indicated as HEAST.	10^{-6}	Equations, cleanup levels, and risk calculations are available online.	Current soil cleanup level from the state website.
WY	4.5	(Jul-09)	130,000	Cleanup level for TCDD.	Exposure equation takes into account exposure from ingestion, inhalation, and dermal contact.	Slope factor source is given as CalEPA.	10^{-6}	EPA RSL equations are available online.	*Field review feedback indicated WY uses 4.5 ppt as its residential soil cleanup level.*

[a] See Notation section and report text for acronym definitions. Field input from the review phase is in italics, and the input date is in parentheses.

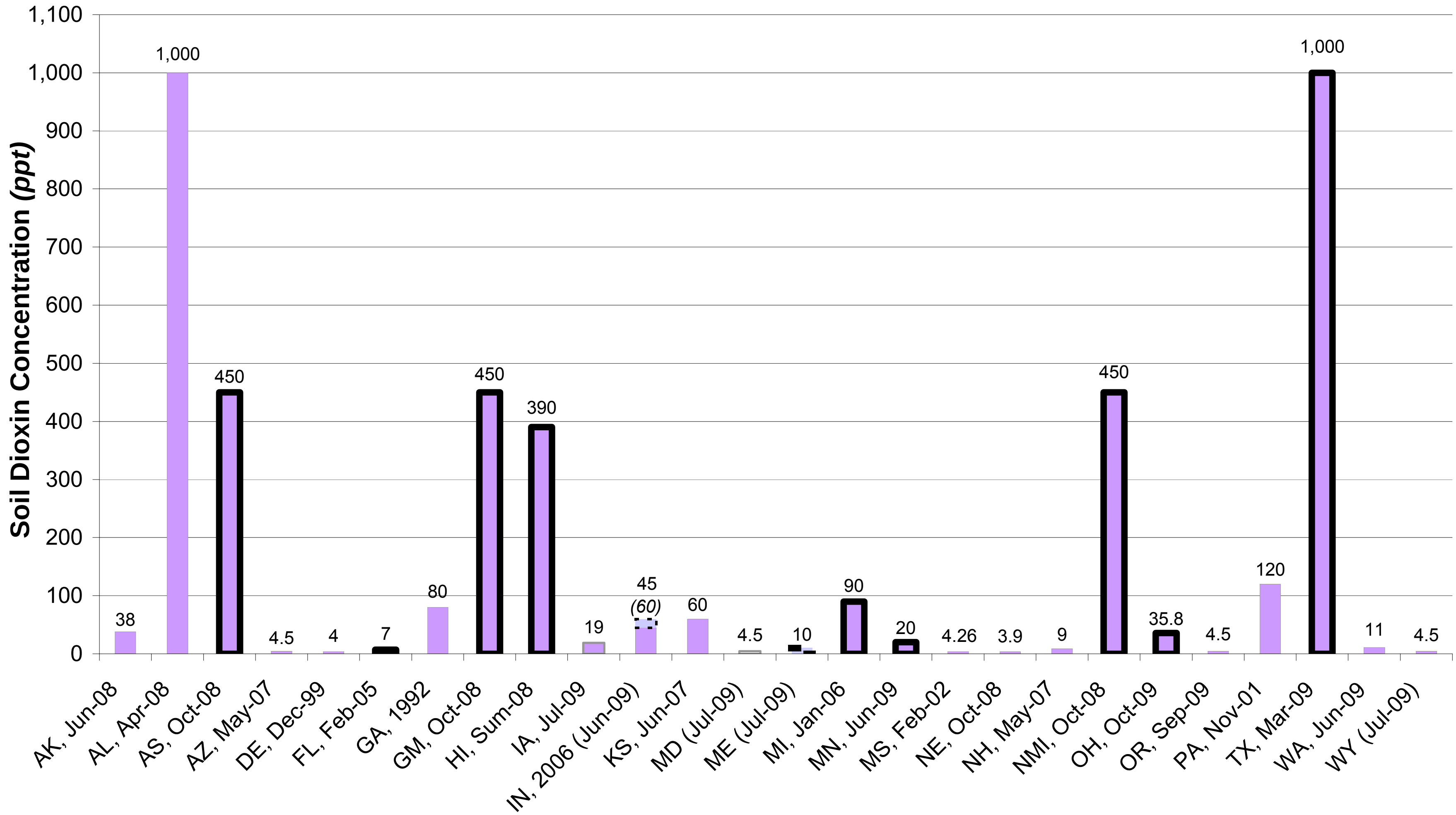

FIGURE 2a Soil Cleanup Levels: Unrestricted/Residential Use, by State

(Standard arithmetic scale; a dark border indicates the basis is TEQ vs. TCDD; a dashed border and lighter shading indicates a draft value; parenthetical dates reflect field inputs for values not yet found online.)

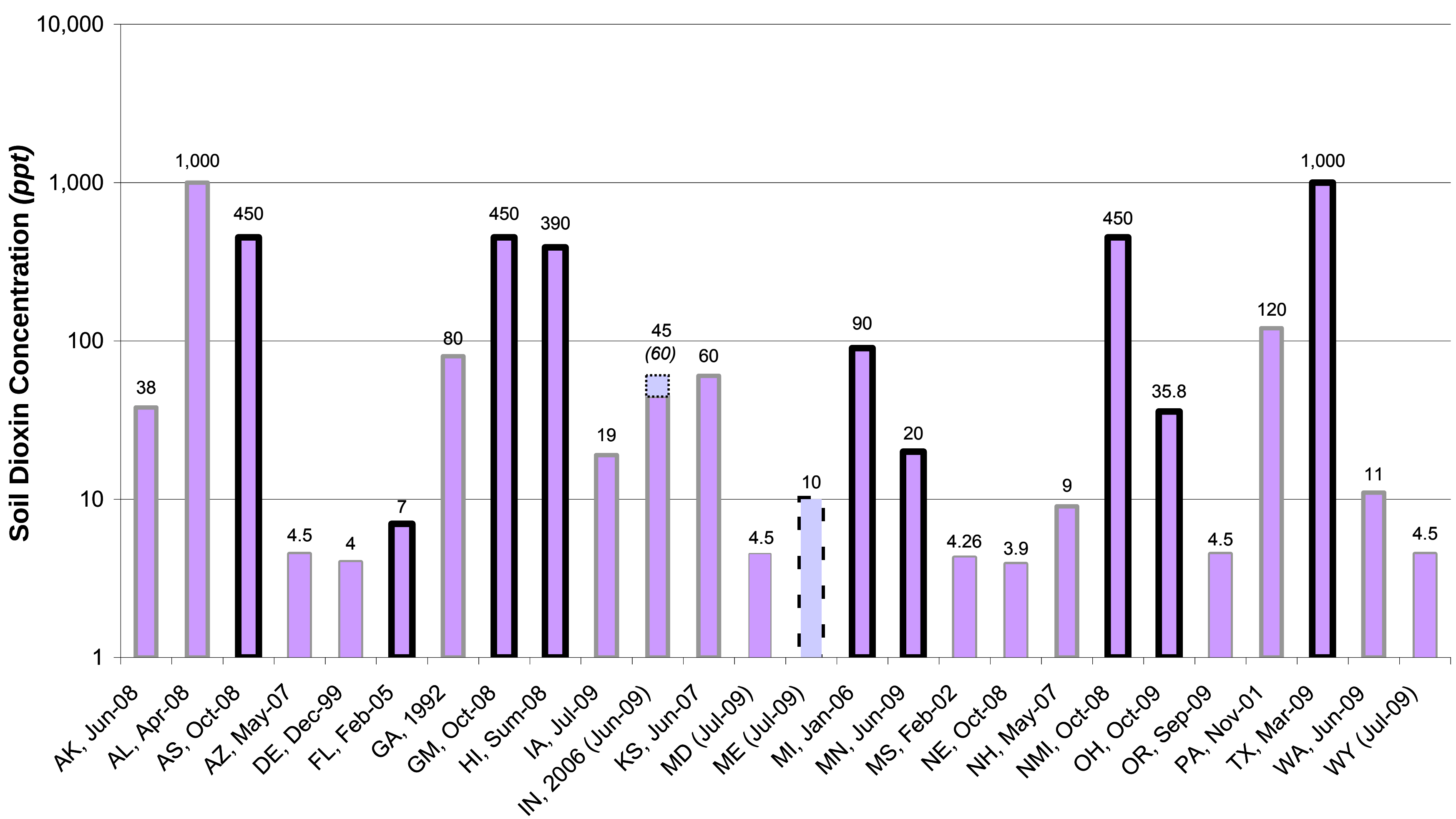

FIGURE 2b Soil Cleanup Levels: Unrestricted/Residential Use, by State

(Logarithmic scale; a dark border indicates the basis is TEQ vs. TCDD; a dashed border and lighter shading indicates a draft value; parenthetical dates reflect field inputs for values not yet found online.)

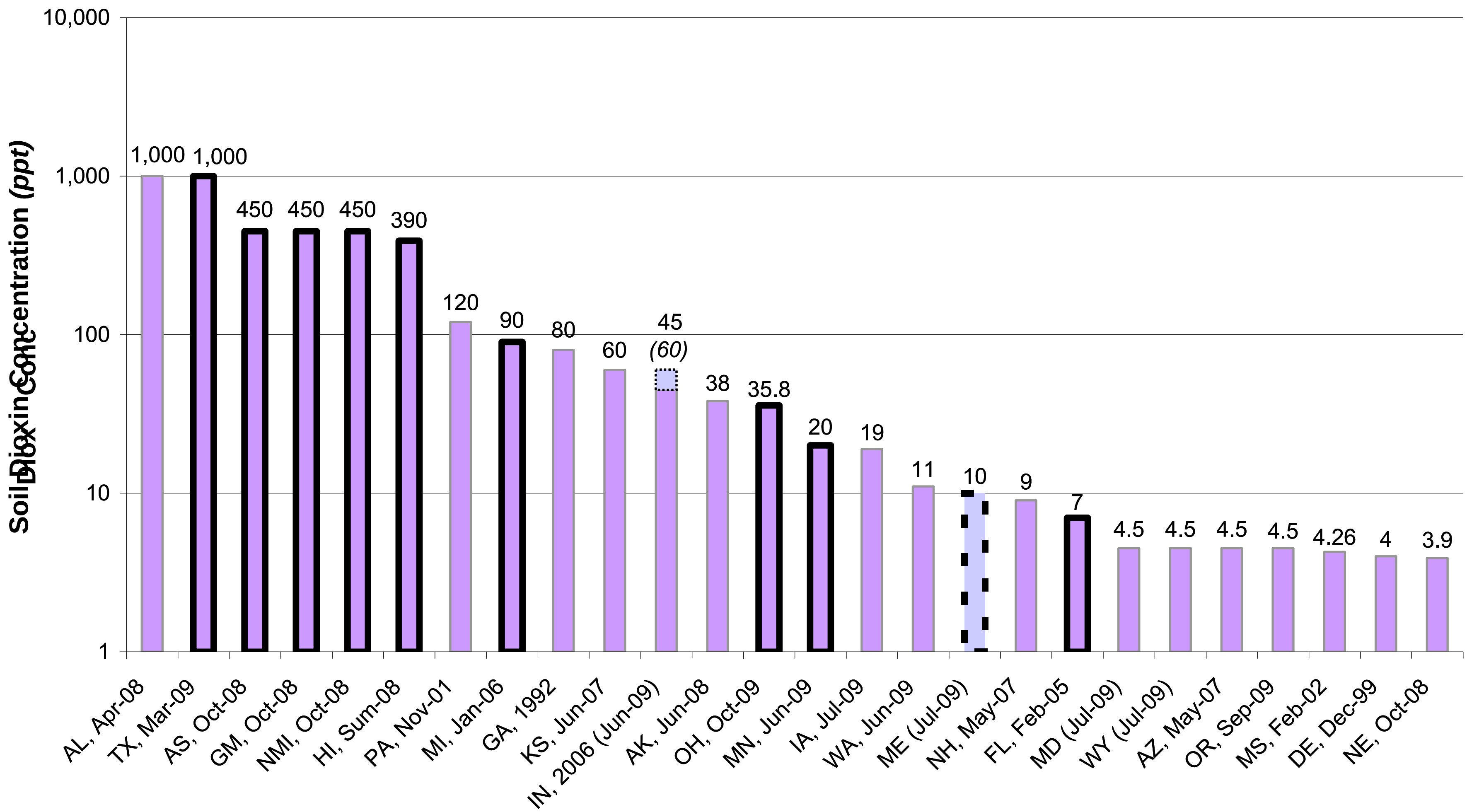

FIGURE 3 Soil Cleanup Levels: Unrestricted/Residential Use, by Concentration

(A dark border indicates the basis is TEQ vs. TCDD; a dashed border and lighter shading indicates a draft value; parenthetical dates reflect field inputs for values not yet found online.)

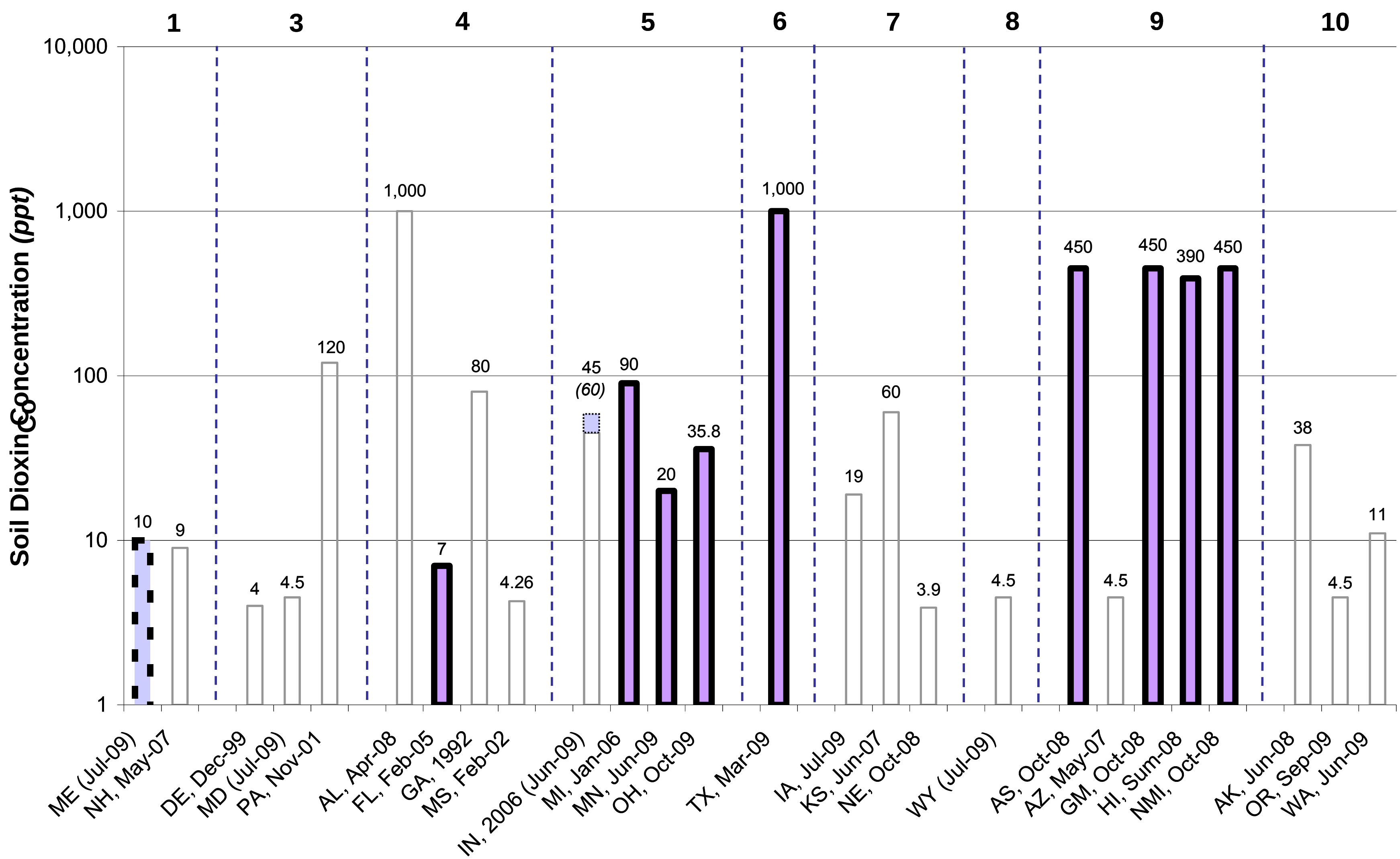

FIGURE 4 Soil Cleanup Levels: Unrestricted/Residential Use, by Region

(EPA Regions are numbered across the top; a dark border indicates the basis is TEQ vs. TCDD; a dashed border and lighter shading indicates a draft value; parenthetical dates reflect field inputs for values not yet found online.)

TABLE 5 Additional State Concentrations Potentially Relevant to Soil Cleanup[a]

State	Conc *(ppt)*	Context
AR	4.5 18	No cleanup level was found for dioxin, but ARDEQ used U.S. EPA Region 6 medium-specific screening levels (MSSLs) as a point of departure. (These values were recently harmonized as EPA RSLs.) Also, "Arkansas has not implemented a single set of soil cleanup levels for general usage. Instead, the State uses standards set in Regulation No. 23 …, usually arriving at a site-specific standard for each clean-up." (For further information including the citation, see the AR entry in Table B.6 of the appendix.)
CA	4.6 19	No cleanup levels were identified for dioxin, but CA has developed human health screening levels (HHSLs) for TCDD.
KY	4.5 18	KY regulations indicate that the state uses Region 9 PRGs for screening purposes. (These values were recently harmonized as EPA RSLs.)
MA	20 50 300	MA has developed Method 1 soil standards for dioxin TEQ for three different exposure scenarios. *Field review feedback indicated that Method 1 standards are "essentially a screening approach. If dioxin concentrations exceed this level a risk assessment can be used to evaluate the site and derive cleanup levels."* (For further information including the citation, see the MA entry in Table B.1 of the appendix.)
MT	4.5 18	State-specific risk-based screening levels (RBSLs) are listed on the MTDEQ website; none were found for dioxin or dioxin congeners. Instead, the MTDEQ flow chart directs users to screen soil dioxin concentrations based on the EPA RSLs.
NC	1,000 0.64	NC identifies two preliminary soil remediation goals (PSRGs) for TCDD TEQ: a "preliminary health-based PSRG" (1,000) and "protection of groundwater SRG" (0.64).
NV	3.9 17.7 38.1	NDEP has developed basic comparison levels for dioxin in soil for residential, commercial/industrial worker, and indoor worker (without dermal contact) scenarios. BCLs essentially represent a screening approach.
NY	600 60,000	NYDEC has developed an allowable soil concentration and a soil cleanup objective (SCO) for dioxin TEQ, both of which are to be protective of groundwater quality. The allowable concentration assumes contaminated soil is in direct contact with the water table; the SCO value assumes contaminated soil is in the unsaturated zone above the water table and is subject to attenuating processes during transport to groundwater. Neither was used to develop a "recommended" cleanup objective for the State of NY.
OK	3.9 18 38	OK indicates that EPA Region 6 MSSLs were used for screening purposes, representing residential, industrial outdoor worker, and industrial indoor worker scenarios. (The MSSLs were recently harmonized as EPA RSLs.)
SC	3.9 16	SCDHEC fact sheet suggests EPA Region 9 PRGs were used for screening purposes. (The PRGs were recently harmonized as EPA RSLs.)
TN	50	Soil screening level for dioxin TEQ, based on 10^{-6} lifetime cancer risk over a 70-year life (reflects the recent ATSDR [2008a] guideline).
VA	4.5 18	VADEQ indicates that EPA RSLs are used for screening purposes.
VT	4.5 18	VTDEC indicates that EPA RSLs are used for screening purposes.
WI	1.2 0.5	WIDNR identifies risk-based standards for human and wildlife protection, as total dioxin equivalent; values of 0.5 and 1.2 ppt are identified for agricultural land with and without grazing, respectively.
WV	4.1 370	WVDEP identifies these values for 2,3,7,8-TCDD, for the residential and industrial scenario, respectively, based on EPA Region 3 risk-based concentrations (screening values) from July 1996, except industrial value is for 10^{-5} risk rather than 10^{-6}.

[a] This table emphasizes levels developed for unrestricted/residential use; values for some other scenarios are also included; italics indicate information from the field review phase. See Appendix B for further details. See Notation and text for acronym definitions. Many states consider the EPA Regional screening values to assess dioxin-contaminated soil (U.S. EPA, 2009b).

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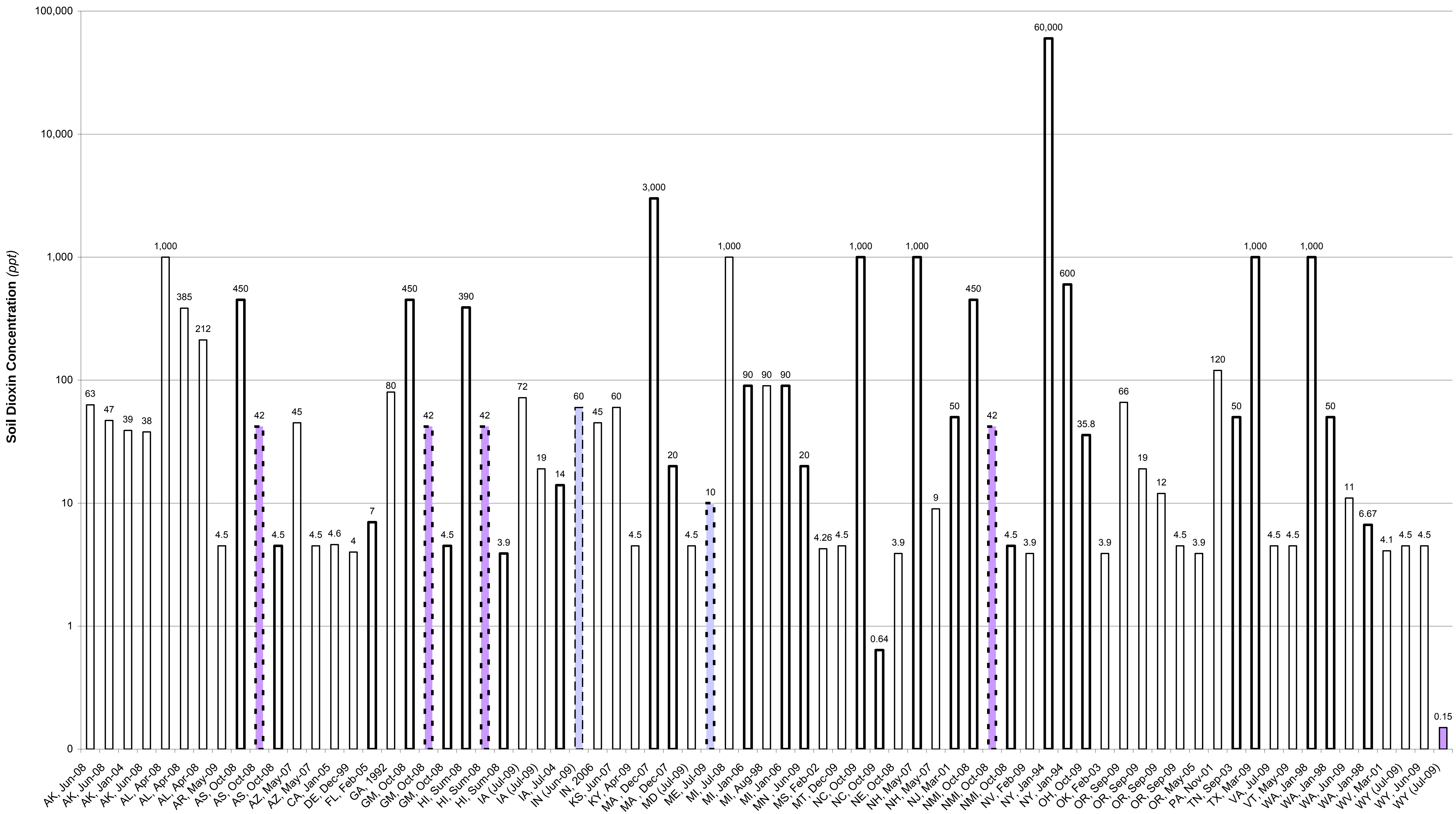

FIGURE 5 Soil Cleanup Levels and Screening Values: Unrestricted/Residential Use, by State

(Cleanup levels are solid bars, dark borders indicate the basis is TEQ not TCDD, dashed borders are for draft or supporting values; screening values are unshaded.)

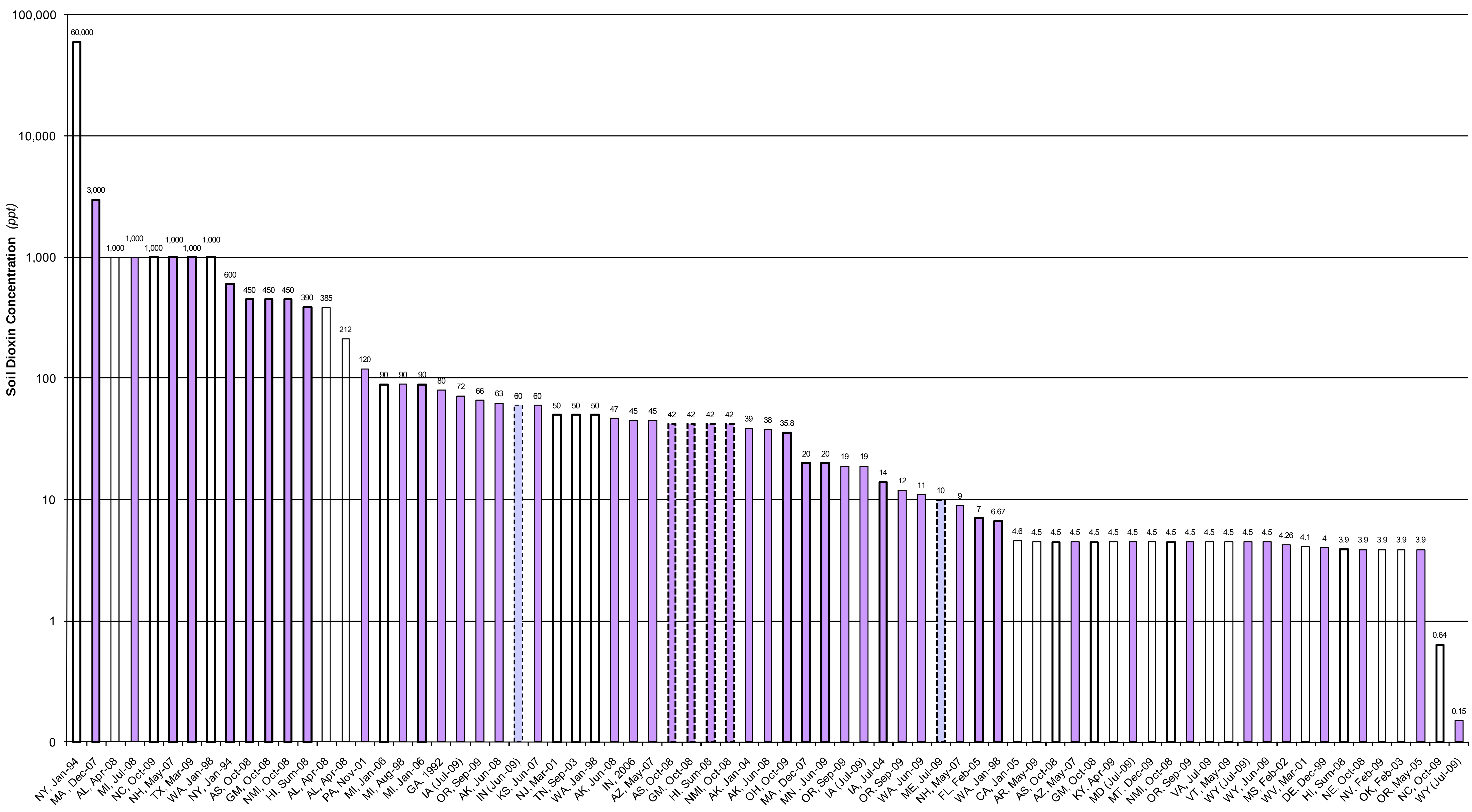

FIGURE 6 Soil Cleanup Levels and Screening Values: Unrestricted/Residential Use, by Concentration

(Cleanup levels are solid bars, dark borders indicate the basis is TEQ not TCDD, dashed borders are for draft or supporting values; screening values are unshaded.)

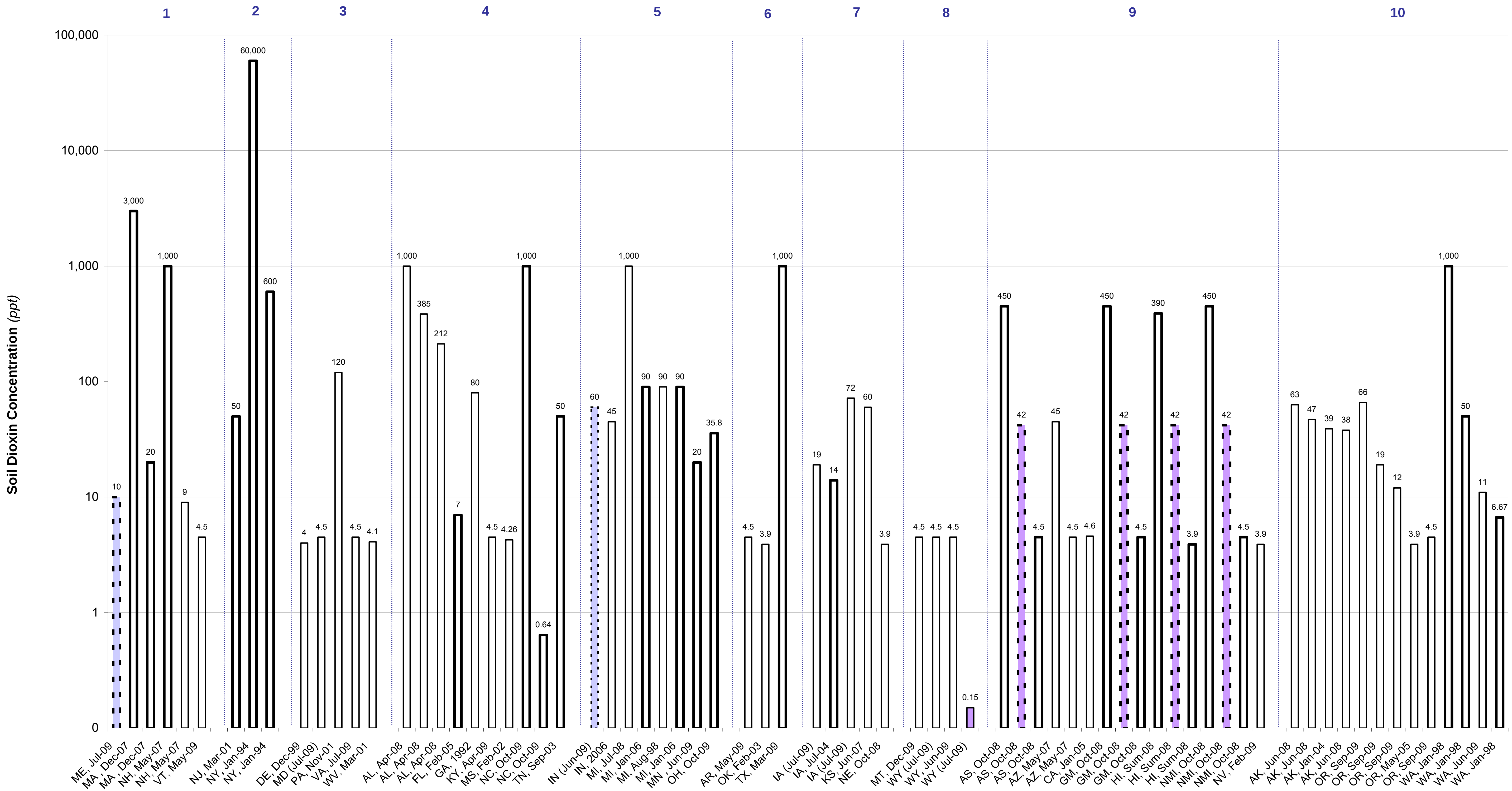

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FIGURE 7 Soil Cleanup Levels and Screening Values: Unrestricted/Residential Use, by Region

(EPA Regions are numbered across the top; cleanup levels are solid bars; a dark border indicates the basis is TEQ; a dashed border indicates a draft or supporting value; screening values are unshaded.)

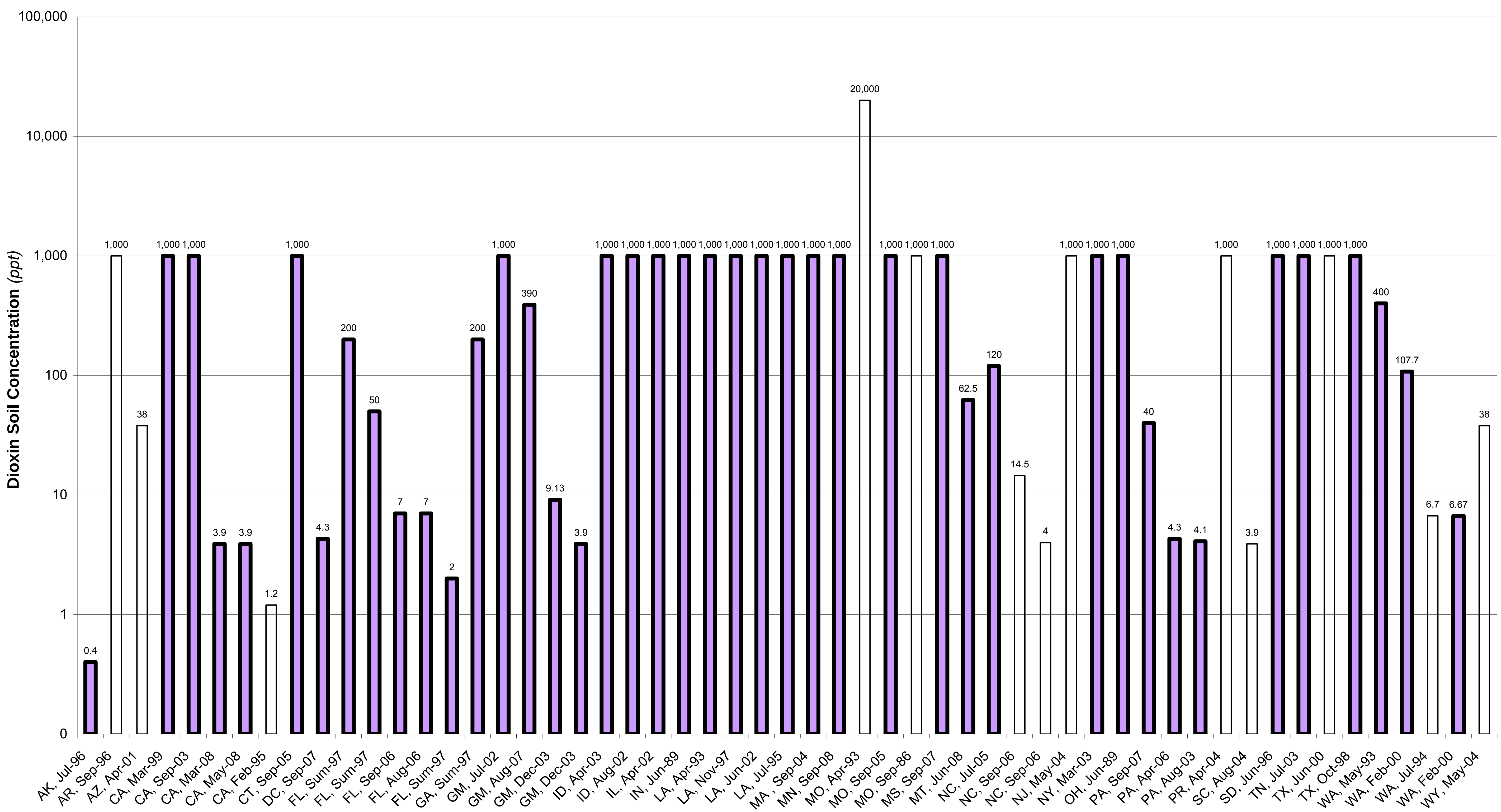

FIGURE 8 Supporting Context: Cleanup Levels Identified for Unrestricted/Residential Use from Contaminated Site Applications, by State *(Reflects site-specific cleanup decisions, so all are shaded.)*

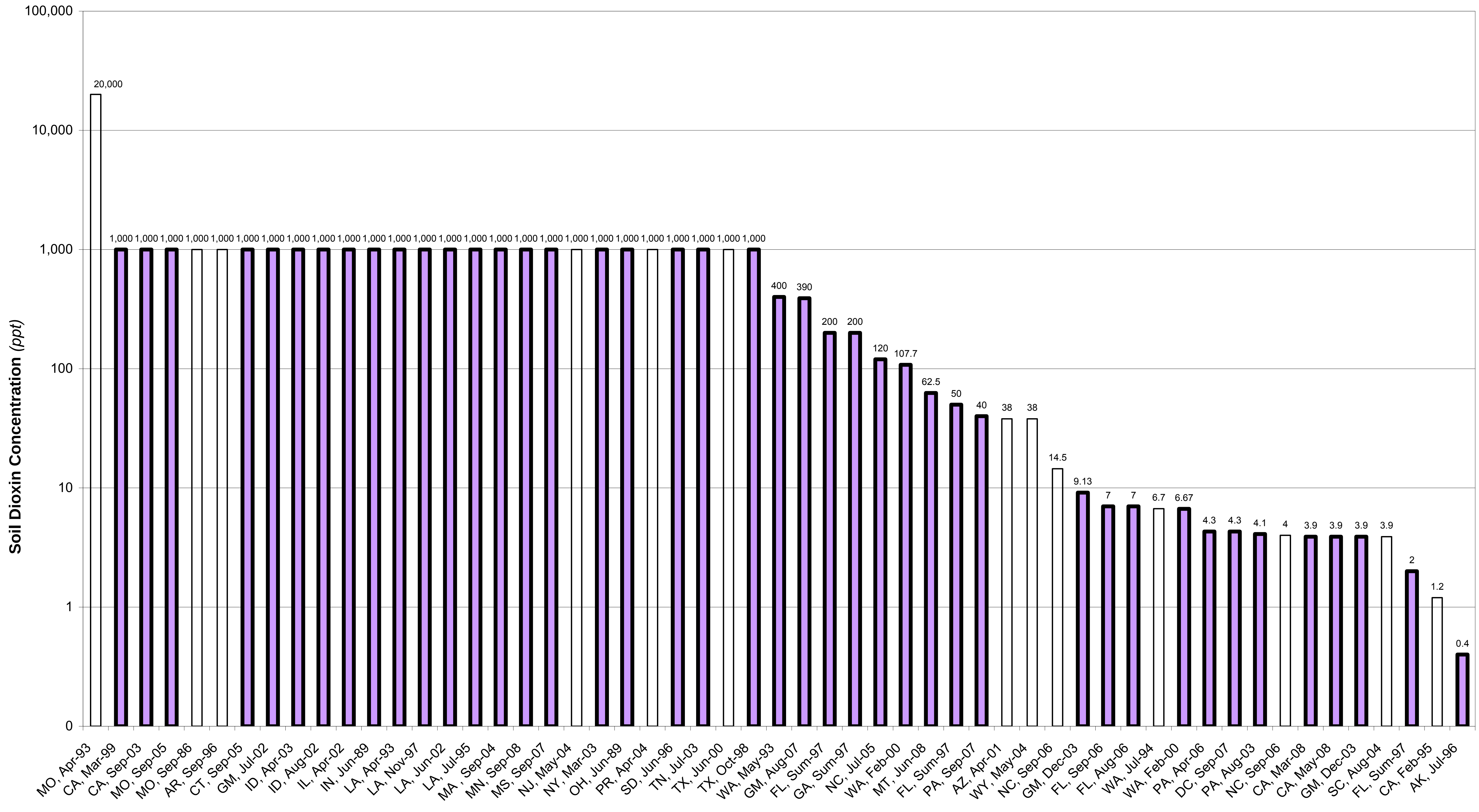

FIGURE 9 Supporting Context: Cleanup Levels Identified for Unrestricted/Residential Use from Contaminated Site Applications, by Concentration *(Reflects site-specific cleanup decisions, so all are shaded.)*

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TABLE 6 States without Formal Soil Cleanup Levels for Dioxin

State	Context
CO	CODPHE has developed and tabulated CO soil evaluation values (CSEVs), but no value for dioxin or TCDD was found in the table. *Field feedback during the review phase indicated CO uses the equations and toxicity value from the EPA Regional screening level tables to develop preliminary remediation goals for dioxin in soil.*
CT	No state-specific dioxin soil cleanup or screening levels were found.
DC	No dioxin cleanup or screening level was identified for DC. *Field review feedback indicated "DC does not have a dioxin level for site cleanups for the RCRA Corrective Action Program, since DC does not have this authority. The Voluntary Cleanup Program relies on the EPA RBCs Table for screening criteria for all chemicals but may be developing their own cleanup standards for the Voluntary Cleanup Program which may be used by other environmental programs in the District."*
ID	No state-specific dioxin soil cleanup or screening levels were identified for ID. *Field review feedback indicated that Region 10 states (which include ID) are "using (with some chemical- or exposure-specific exceptions) the Regional Screening Level tables that Superfund is sponsoring."*
IL	No state-specific dioxin soil cleanup (or screening) value was found.
LA	No state-specific dioxin soil cleanup (or screening) value was found.
MO	No state-specific dioxin soil cleanup (or screening) value was found.
ND	No state-specific dioxin soil cleanup (or screening) value was found. *Field review feedback indicated ND uses the equations and toxicity value from the EPA Regional screening level tables to develop preliminary remediation goals for dioxin in soils.*
NJ	No state-specific dioxin soil cleanup (or screening) value was found. *Field review feedback indicated NJ follows the 1998 OSWER directive in coordinating with responsible parties and uses the 2008 ATSDR value of 50 ppt as a screening level to consider the need for further evaluation of sites. Final cleanup levels are site-specific.*
NM	No state-specific dioxin soil cleanup (or screening) value was found.
PR	No state-specific dioxin soil cleanup (or screening) value was found.
RI	No state-specific dioxin soil cleanup (or screening) levels were found.
SD	No state-specific dioxin soil cleanup (or screening) value was found. *Field review feedback indicated SD uses the equations and toxicity value from the EPA Regional screening level tables to develop preliminary remediation goals for dioxin in soil.*
TT	No state-specific dioxin soil cleanup (or screening) value identified *(per field review feedback).*
UT	No state-specific dioxin soil cleanup (or screening) value was found. *Field review feedback indicated UT uses the equations and toxicity value from the EPA Regional screening level tables to develop preliminary remediation goals for dioxin in soil.*
VI	No state-specific dioxin soil cleanup (or screening) value was found.

[a] Italics indicate information from the field review phase; see tables in Appendix B for further details. See Notation and text for acronym definitions.

3.1.2 Commercial/Industrial (Restricted) Use

Soil Cleanup Levels

The figures and tables outlined below parallel those given for unrestricted use in Section 3.1.1. This information is presented to support consideration of a potential interim guideline for commercial/industrial scenarios.

- Cleanup levels identified by states for commercial/industrial (restricted) use are identified in Table 7, focusing on one representative value per state where multiple levels were identified. Figure 10a presents these soil cleanup levels on the standard arithmetic scale, alphabetized by state.

- Figure 10b illustrates the same data as Figure 10a, on a logarithmic scale to facilitate readability and comparisons.

- Figure 11 shows the same data as Figure 10b, organized by concentration in decreasing order, for possible insight into concentration groupings.

- Figure 12 gives the same information as Figure 11 but organized by EPA Region, for potential insights regarding similarities and differences, if any, across regions.

Supporting Context: Screening Values and Illustrative Site-Specific Cleanup Levels

- Additional state levels identified for commercial/industrial use are identified in Table 8. Figure 13 includes these values as the counterpart to Figure 5 (which addresses unrestricted land use), extending beyond state cleanup levels for dioxin in soil to also present screening values for these restricted land uses. As in Figure 9b, the data are alphabetized by state and shown on a logarithmic scale

- Figure 14 shows the same information as Figure 12, organized by concentration in decreasing order, for potential insights into concentration groupings. Figure 15 shows the same information organized by EPA Region to facilitate comparisons.

- Figure 16 illustrates cleanup levels identified in documents prepared for contaminated sites, organized by state. Figure 17 presents the same information as Figure 16, ordered by concentration.

- Table 9 and Figure 18 present information for subsurface cleanup levels.

3.2 TOXICITY VALUES AND TARGET RISKS

- Table 10 identifies the slope factors used by states to determine cleanup levels. The distribution of toxicity values is shown in Figure 19. Supporting information on toxicity values from other agencies is presented in Table 11.

- The target risks applied to determine state cleanup levels for dioxin in soil are identified in Table 12 (states are alphabetized within each risk level). Figure 20 presents the distribution of states by target risk for the unrestricted/residential scenarios, and Figure 21 presents this information for the commercial/industrial (restricted) scenarios.

TABLE 7 Representative Soil Cleanup Levels for Dioxin per State: Commercial/Industrial (Restricted) Use

State	Soil Conc *(ppt)*	Date	Toxicity Value *(mg/kg-d)$^{-1}$*	Term and Scenario Context	Scientific Basis: *Exposure*	Scientific Basis: *Toxicity*	Scientific Basis: *Risk*	Peer Review and Availability	Selection Rationale
AL	5,000	Apr-08	Not found; see note at right for the toxicity basis.	Preliminary screening or cleanup value for TCDD, commercial scenario, direct contact.	(Adopted value from OSWER directive.)	Reflects the OSWER value; derivation basis is the evaluation by Kimbrough et al. (1984) of data from Kociba et al. (1978).		Cleanup value and toxicological context are available online.	Cited in the state document as a value that can be used for "screening or cleanup" purposes.
AS	1,800	Oct-08	130,000	Tier 2 action level for nonresidential scenario (upper end) for dioxin TEQ. Remedial action guide varies for dioxin concentrations between 170 and 1,800 ppt.	General equation for direct contact; considers ingestion, inhalation, and dermal routes of exposure.	Slope factor reflects the value listed in the 2008 EPA Regional screening level (RSL) table.	10^{-4}	The information summarized here is available online.	Action level adopted from Guam EPA represents the value above which nonresidential use is not recommended absent remedial action to reduce potential exposure.
AZ	160	May-07 (Jul-09)	Not identified	Soil remediation level for TCDD, nonresidential scenario.	General equation; considers ingestion, inhalation, and dermal exposure. Adopted from Region 9 PRGs.	Not identified.		Remediation levels and the guidance document are available online. Specific toxicity value not provided.	Current SRL for nonresidential use, *per Field input. (Specific information regarding the toxicity value or risk target was not provided.)*
DE	40	Dec-99	150,000	Uniform risk-based remediation standard for TCDD, restricted use with protection of human health.	General equation for direct contact; incidental ingestion is primary contributor.	Slope factor from HEAST.	10^{-6}	Calculations and risk-based tables are available online.	Current restricted use URS, from state website.

TABLE 7 Representative Soil Cleanup Levels for Dioxin per State: Commercial/Industrial (Restricted) Use

State	Soil Conc *(ppt)*	Date	Toxicity Value *(mg/kg-d)$^{-1}$*	Term and Scenario Context	Scientific Basis: *Exposure*	Scientific Basis: *Toxicity*	Scientific Basis: *Risk*	Peer Review and Availability	Selection Rationale
FL	30	Feb-05	150,000	Soil cleanup target level for dioxin TEQ, commercial/industrial use based on direct contact.	General equation for direct contact; considers incidental ingestion, inhalation, and dermal exposure routes.	Slope factor from HEAST.	10^{-6}	Derivation basis and equations are available online. (Default and chemical-specific parameter values are given in the FDEP 2005 technical report.)	Current commercial/ industrial SCTL.
GM	1,800	Oct-08	130,000	Tier 2 action level for nonresidential scenario (upper end) for dioxin TEQ. Remedial action guide varies for dioxin concentrations between 170 and1,800 ppt.	General equation for direct contact; considers ingestion, inhalation, and dermal routes of exposure.	Slope factor reflects the value listed in the 2008 EPA RSL table.	10^{-4}	The information summarized here is available online.	This action level represents the value above which nonresidential use is not recommended absent remedial action to reduce potential exposure.
HI	1,600	Sum-08	150,000	Tier 2 action level for nonresidential scenario (upper end of range) for dioxin TEQ. Remedial actions vary when soil dioxin concentration is between 170-1,600 ppt.	General equation for direct contact; considers incidental ingestion, inhalation, and dermal exposure routes.	Slope factor from HEAST.	10^{-4}	The information summarized here is available online.	This action level represents the value above which nonresidential use is not recommended absent remedial action to reduce potential exposure.
IA	360	(Jul-09)	RfD: 1×10^{-9} mg/kg-d	Cleanup level for nonresidential land use based on noncancer endpoint, if dioxin is the only chemical of concern.		Specific source not identified (RfD is same as the ATSDR chronic MRL; field input indicated as an EPA source).		The formula used for the risk calculations is available online.	*Field review feedback identified as the dioxin nonresidential cleanup level, statewide soil standard, within the voluntary cleanup program, Iowa Land Recycling Program.*

TABLE 7 Representative Soil Cleanup Levels for Dioxin per State: Commercial/Industrial (Restricted) Use

State	Soil Conc *(ppt)*	Date	Toxicity Value *(mg/kg-d)$^{-1}$*	Term and Scenario Context	Scientific Basis			Peer Review and Availability	Selection Rationale
					Exposure	***Toxicity***	***Risk***		
IN	180	2006 (Jun-09)	150,000 (130,000)	Commercial/industrial provisional default closure level for TCDD in soil, based on direct contact. (The 2009 internal draft value is the same.)	General equation uses incidental ingestion as primary contributor.	Slope factor from HEAST. (More recent slope factor is being considered as part of the internal update.)	10^{-5}	The extant technical guide is available online. (2009 values have not yet been published and are pending any changes in algorithms or toxicological data.)	*The current online (published) state value is 180 ppt; this is also the value identified by IDEM as an internal draft update in development, as part of field input to this data compilation effort.*
KS	100	Jun-07	150,000	Tier 2 risk-based standard for TCDD, nonresidential scenario. "Chemical-specific and media-specific risk-based cleanup goals." (See Tier 2 context in right-most column.)	Exposure equation considers ingestion, inhalation, and dermal exposure routes.	Slope factor from HEAST.	10^{-5}	The cleanup level and equation with soil exposure factors are available online.	Tier 2 addresses a single contaminant and medium, with standard conservative default exposure assumptions; it does not include soil-to-air transfer, cumulative risk from multiple contaminants or media, or risk to ecological receptors
MD	18	(Jul-09)	130,000	Cleanup level for industrial scenario.	Exposure equation considers ingestion, inhalation, and dermal exposure routes.	Slope factor from CalEPA.	10^{-6}	EPA RSL equations are available online.	*Field review feedback identified the EPA RSL for the industrial scenario as the soil cleanup level for MD.*

TABLE 7 Representative Soil Cleanup Levels for Dioxin per State: Commercial/Industrial (Restricted) Use

State	Soil Conc *(ppt)*	Date	Toxicity Value *(mg/kg-d)$^{-1}$*	Term and Scenario Context	Scientific Basis: *Exposure*	Scientific Basis: *Toxicity*	Scientific Basis: *Risk*	Peer Review and Availability	Selection Rationale
ME	31	Jul-09	130,000	Draft generic soil cleanup level for dioxin TEQ, based on a commercial worker scenario.	Value considers incidental ingestion, dermal contact, and inhalation of fugitive dust.	Slope factor from CalEPA.	10^{-6}	Equations and a summary of calculations are available online.	*Concentration found via weblinks from field review feedback. The commercial scenario value of 31 ppt is considered representative (with a more conservative target ILCR, 10^{-6}), as it is "applicable at sites with more than one contaminant of concern."*
MN	35	Jun-09	1,400,000	Soil reference value for industrial worker, direct contact, for dioxin TEQ.	Exposure equation takes into account exposure from ingestion, inhalation, and dermal contact.	Draft slope factor from EPA (2003), which was derived from Kociba et al. (1978).	10^{-5}	Derivation methodology and updates to parameter values are available online.	Current industrial worker SRV.
MS	38.2	Feb-02	150,000	Tier 1, target remediation goal for TCDD, restricted land use scenario.	General equation uses incidental ingestion as primary contributor.	Slope factor source is given as HEAST.	10^{-6}	Equations taken from EPA sources, for EPA RAGS are available online.	State document explains, "Tier 1 TRGs may either be used as "default" remediation goals or as screening values that will initiate a Tier 2 Evaluation or Tier 3 Evaluation."
NE	160	Oct-08	150,000	Remediation goal established under the NDEQ Voluntary Cleanup Program guidance for TCDD, based on direct contact.	General equation uses incidental ingestion as primary contributor.	Slope factor source is given as HEAST.	10^{-5}	Cleanup levels and remediation goals are available online.	Current industrial VCP RG.

TABLE 7 Representative Soil Cleanup Levels for Dioxin per State: Commercial/Industrial (Restricted) Use

State	Soil Conc *(ppt)*	Date	Toxicity Value *(mg/kg-d)$^{-1}$*	Term and Scenario Context	Scientific Basis			Peer Review and Availability	Selection Rationale
					Exposure	***Toxicity***	***Risk***		
NH	300	May-07	150,000	Risk-based S-2 soil category for workers who come into contact with soil as part of their employment.	General equation for direct contact; considers ingestion and dermal exposure routes.	Slope factor taken from RAIS (ORNL, 2005/2006), appears to reflect 1997 HEAST.	10^{-6}	Risk characterization and general derivations are available online.	Derived for an adult worker exposed in a work environment or passive recreational setting, assuming soil ingestion of 100 mg/d, 146 d/y, 25 y.
NMI	1,800	Oct-08	130,000	Tier 2 action level for nonresidential scenario (upper end) for dioxin TEQ. Remedial action guide varies for dioxin concentrations between 170 and 1,800 ppt.	General equation for direct contact; considers ingestion, inhalation, and dermal routes of exposure.	Slope factor from 2008 EPA RSL table.	10^{-4}	The information summarized here is available online.	Action level adopted from Guam EPA represents the value above which nonresidential use is not recommended absent remedial action to reduce potential exposure.
OR	20	Sep-09	130,000	Risk-based concentration for TCDD, occupational scenario.	Equation is based on exposure from direct contact, ingestion, dermal, and inhalation.	Equations adopted from former EPA Region 9 PRG document.	10^{-6}	Values and derivation methodology are available online.	Risk-based concentration replaces previous acceptable risk level.
PA	530	Nov-01	150,000	Medium-specific concentration for TCDD, based on nonresidential scenario and direct contact.	General equation; considers ingestion route.	Slope factor source is given as HEAST (undated).	10^{-5}	PADEP documents are available online.	Current nonresidential MSC for surface soil.
TX	5,000	Mar-09	Not found; see note at right for the toxicity basis.	Protective concentration level for dioxin TEQ in soil, commercial/ industrial scenario.	Exposure equation takes into account ingestion, inhalation, dermal contact, and vegetable consumption.	Reflects the OSWER value; derivation basis is the evaluation by Kimbrough et al. (1984) of data from Kociba et al. (1978).		Soil values available online, but the derivation basis is ambiguous. Toxicity values and some chemical-specific parameter values are not provided.	"The TRRP Tier 1 protective concentration levels (PCLs) are the default cleanup standards in the TX Risk Reduction Program."

TABLE 7 Representative Soil Cleanup Levels for Dioxin per State: Commercial/Industrial (Restricted) Use

State	Soil Conc *(ppt)*	Date	Toxicity Value *(mg/kg-d)$^{-1}$*	Term and Scenario Context	Scientific Basis: *Exposure*	Scientific Basis: *Toxicity*	Scientific Basis: *Risk*	Peer Review and Availability	Selection Rationale
WA	1,500	Jun-09	150,000	Cleanup level for TCDD in soil, direct contact, industrial scenario.	Equation considers ingestion as primary contributor.	Slope factor source is given as HEAST.	10^{-5}	Equations, cleanup levels, and risk calculations are available online.	Current cleanup level for the industrial scenario.

Notes: Field input from the review phase is in italics, and the input date is in parentheses. More details including citations are in Appendix B.

For the AZ concentration, it is not clear from information available whether the state may still be using a cancer slope factor of 150,000 (mg/kg-d)$^{-1}$ and a target risk of 10^{-5} for the nonresidential scenario; specific values were not provided for this compilation.

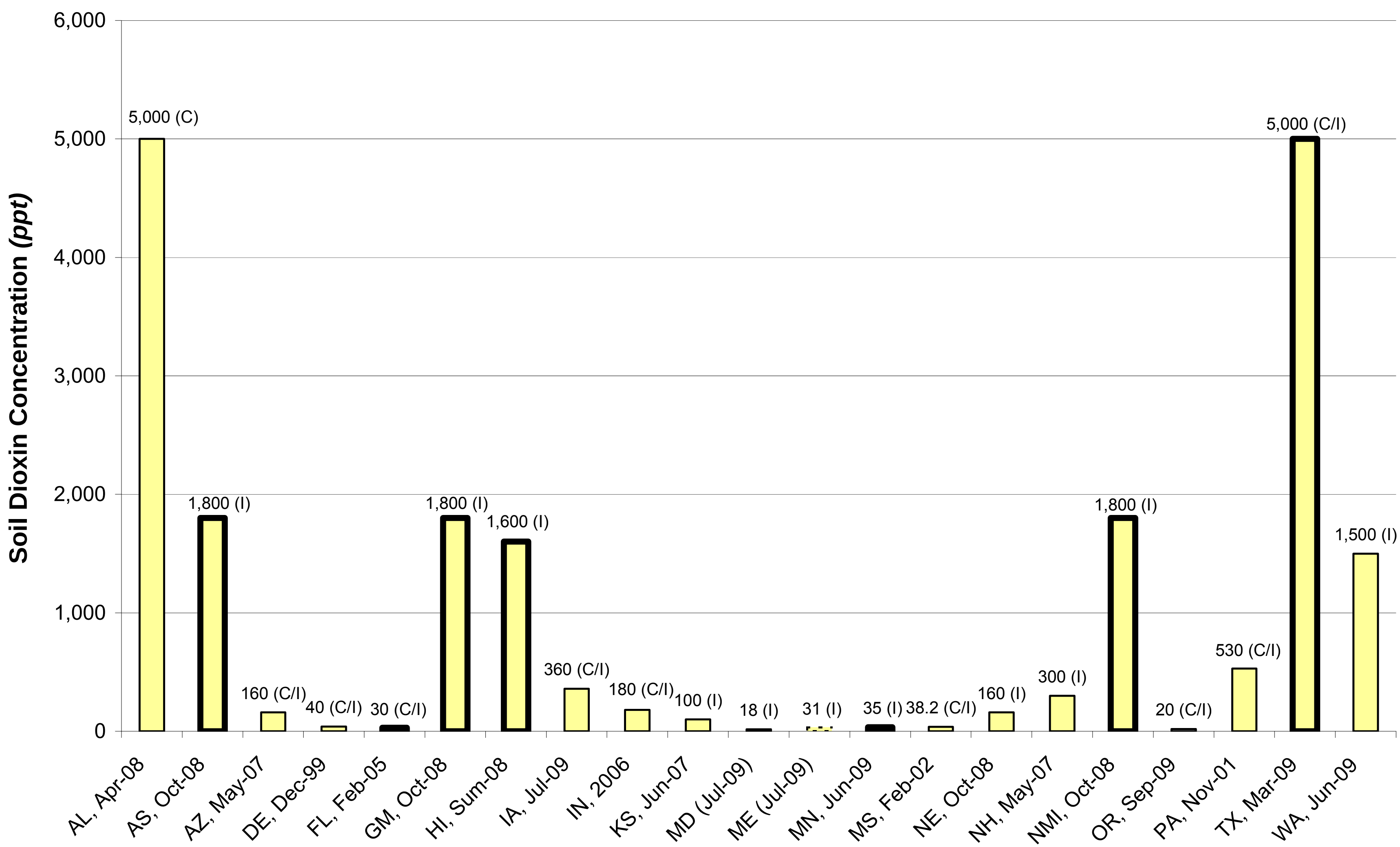

FIGURE 10a Soil Cleanup Levels: Commercial/Industrial (Restricted) Use, by State

(Standard arithmetic scale; a dark border indicates the basis is TEQ; a dashed border indicates a draft value [ME]; C = commercial; I = industrial.)

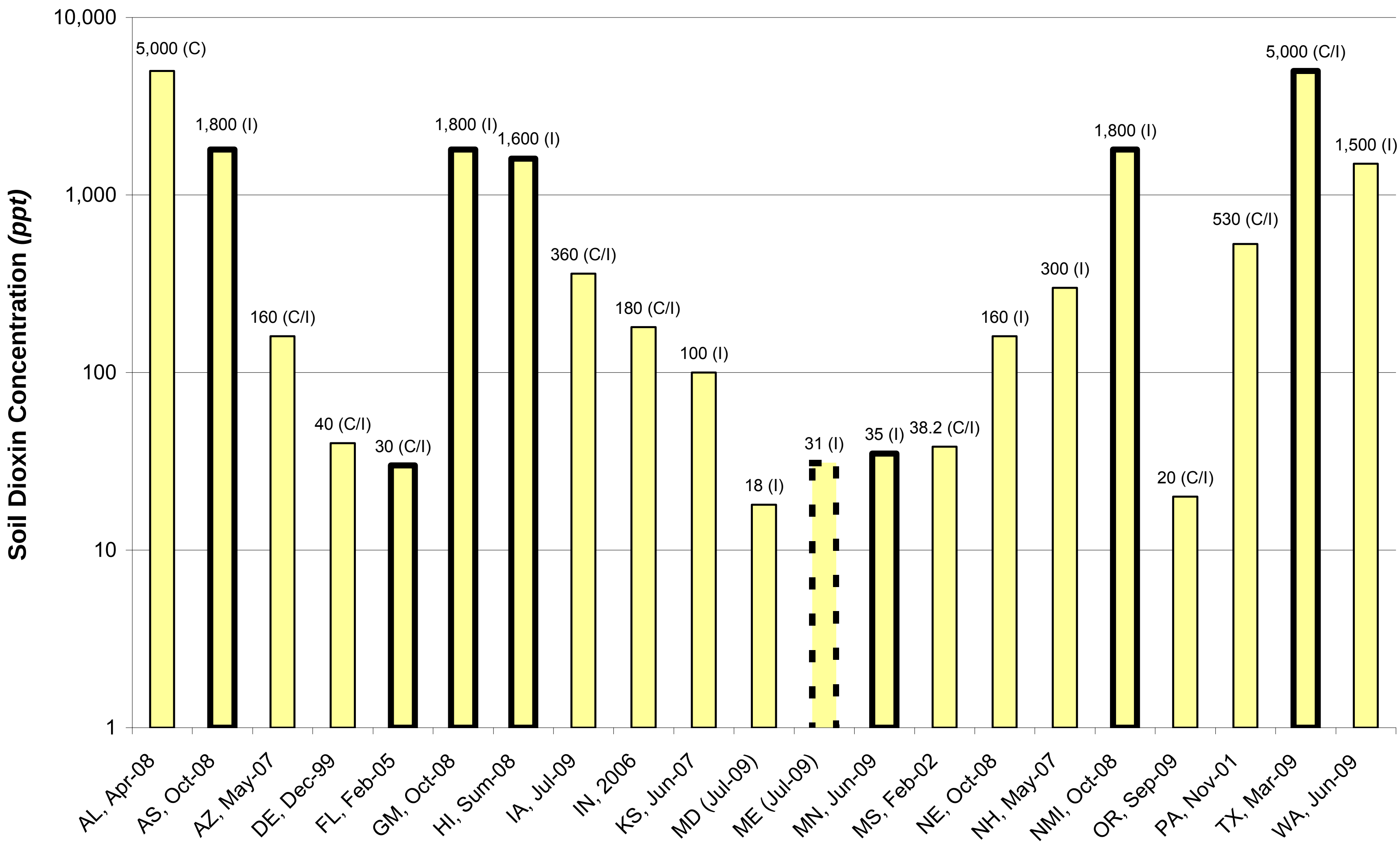

FIGURE 10b Soil Cleanup Levels: Commercial/Industrial (Restricted) Use, by State

(Logarithmic scale; dark border indicates basis is TEQ rather than TCDD; draft values have dashed borders.)

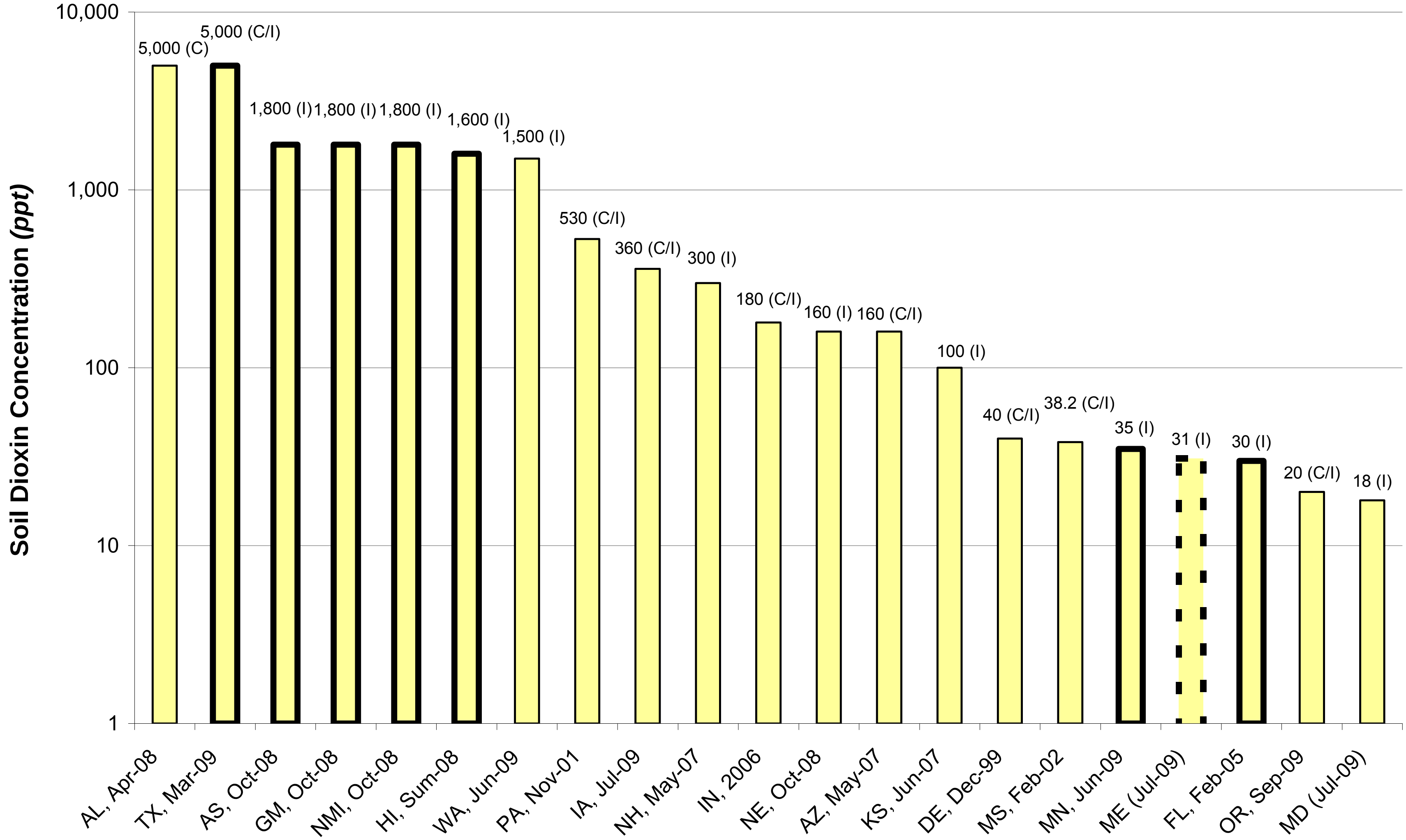

FIGURE 11 **Soil Cleanup Levels: Commercial/Industrial (Restricted) Use, by Concentration**

(A dark border indicates the basis is TEQ; a dashed border indicates draft values; parentheses indicate field input.)

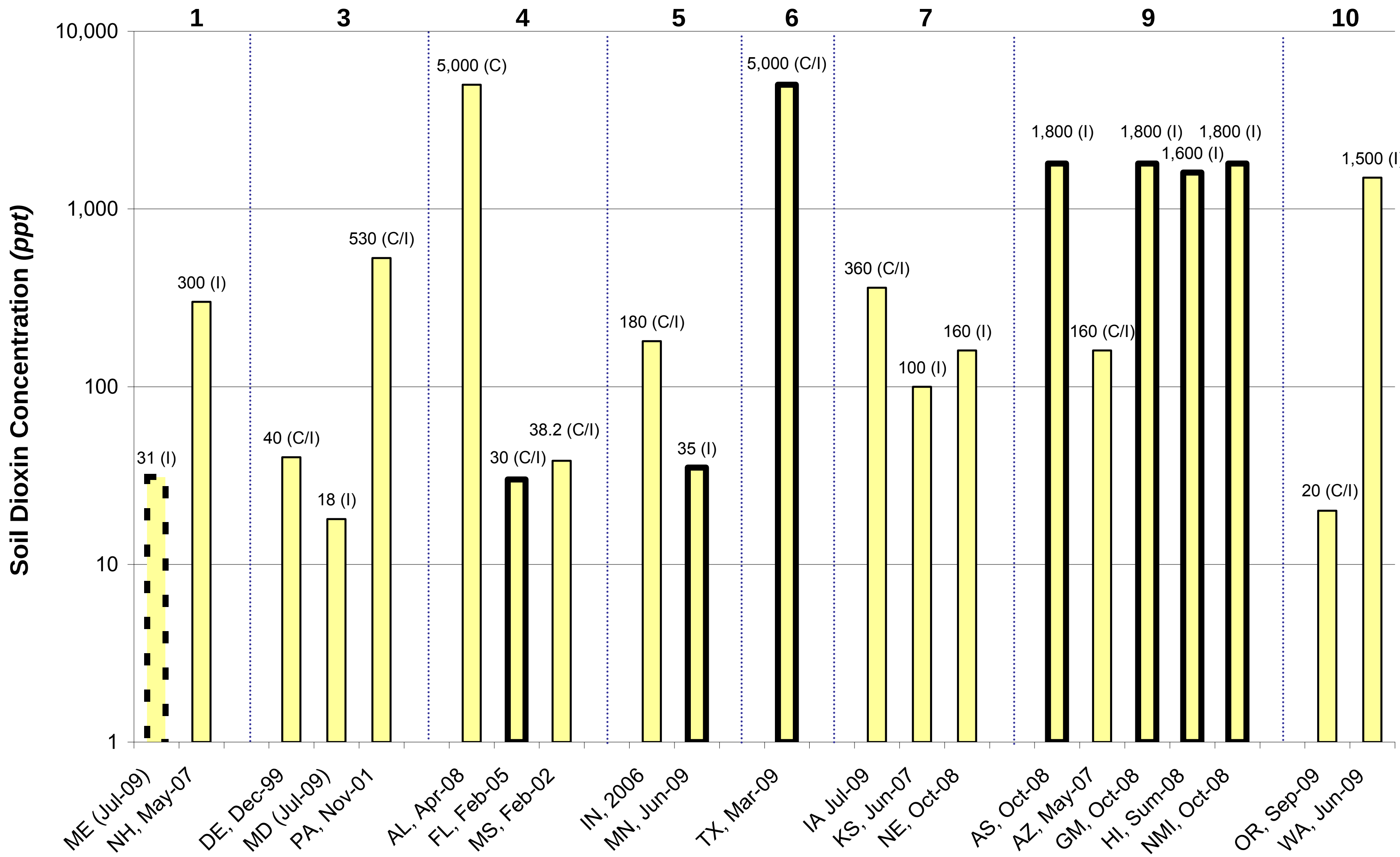

FIGURE 12 Soil Cleanup Levels: Commercial/Industrial (Restricted) Use, by Region

(EPA Regions are across top; a dark border indicates TEQ; a dashed border indicates draft values; parentheses indicate field input.)

TABLE 8 Additional State Concentrations for Dioxin: Commercial/Industrial (Restricted) Use

State	Soil Conc *(ppt)*	Date	Toxicity Value *(mg/kg-d)$^{-1}$*	Term and Scenario Context	Scientific Basis: *Exposure*	Scientific Basis: *Toxicity*	Scientific Basis: *Risk*	Peer Review and Availability	Selection Rationale
AS	170	Oct-08	1,400,000	Tier 2 action level for TCDD TEQ, lower bound for nonresidential scenario, where remedial actions vary when soil dioxin concentration is between 170 and 1,800 ppt.	General equation for direct contact, incidental ingestion as primary contributor but inhalation also considered.	From MNDOH (2003), animal bioassay upper bound derived from Kociba et al., tapped from range of values in EPA draft reassessment (2003a).	10^{-4}	Information is available online.	Value adopted from Guam EPA. Represents lower end of Tier 2 action level, below which no remedial action is required.
GM	170	Oct-08	1,400,000	Tier 2 action level for TCDD TEQ, lower bound for nonresidential scenario, where remedial actions vary when soil dioxin concentration is between 170 and 1,800 ppt.	General equation for direct contact, incidental ingestion as primary contributor but inhalation also considered.	From MNDOH (2003), animal bioassay upper bound derived from Kociba et al., tapped from range of values in EPA draft reassessment (2003a).	10^{-4}	Information is available online.	Represents lower end of Tier 2 action level, below which no remedial action is required.
HI	170	Mar-06	1,400,000	Tier 2 action level for TCDD TEQ, lower bound for nonresidential scenario, where remedial actions vary when soil dioxin concentration is between 170 and 1,800 ppt.	General equation for direct contact, incidental ingestion as primary contributor but inhalation also considered.	From MNDOH (2003), upper bound derived from Kociba et al. (1978) bioassay, from range of values in EPA reassessment (2003a).	10^{-4}	Information is available online.	Represents lower end of Tier 2 action level, below which no remedial action is required.

TABLE 8 Additional State Concentrations for Dioxin: Commercial/Industrial (Restricted) Use

State	Soil Conc *(ppt)*	Date	Toxicity Value *(mg/kg-d)$^{-1}$*	Term and Scenario Context	Scientific Basis			Peer Review and Availability	Selection Rationale
					Exposure	***Toxicity***	***Risk***		
ME	310	(Jul-09)	130,000	Generic soil cleanup level for dioxin TEQ, based on a construction/excavation worker.	Value considers incidental ingestion, dermal contact, and inhalation of fugitive dust.	Slope factor from CalEPA.	10^{-6}	Equations and a summary of calculations are available online.	*Commercial use, 31 ppt indicated in field review feedback is used as the representative value for commercial/industrial use.*
NH	5,000	May-07		Soil standard for TCDD TEQ, commercial scenario.		Reflects OSWER directive, per the Kimbrough et al. (1984) evaluation of Kociba et al. (1978) data.			Value reflects the 1998 OSWER directive. See Table 7 for the state-specific soil value identified for the commercial scenario.
OR	140	Sep-09		Risk-based concentration (RBC) for TCDD, occupational scenario protective of groundwater.	General equation for direct contact, incidental ingestion, dermal contact, and inhalation all considered.		10^{-6}		The concentration of 20 ppt identified for the occupational scenario based on direct contact was selected as the representative state-specific value for commercial/industrial use.
	150			RBC for TCDD, construction scenario, direct contact, considering ingestion, dermal, and inhalation.			10^{-6}		
	4,200			RBC for TCDD, excavation scenario, direct contact, considering ingestion, dermal, and inhalation.			10^{-6}		

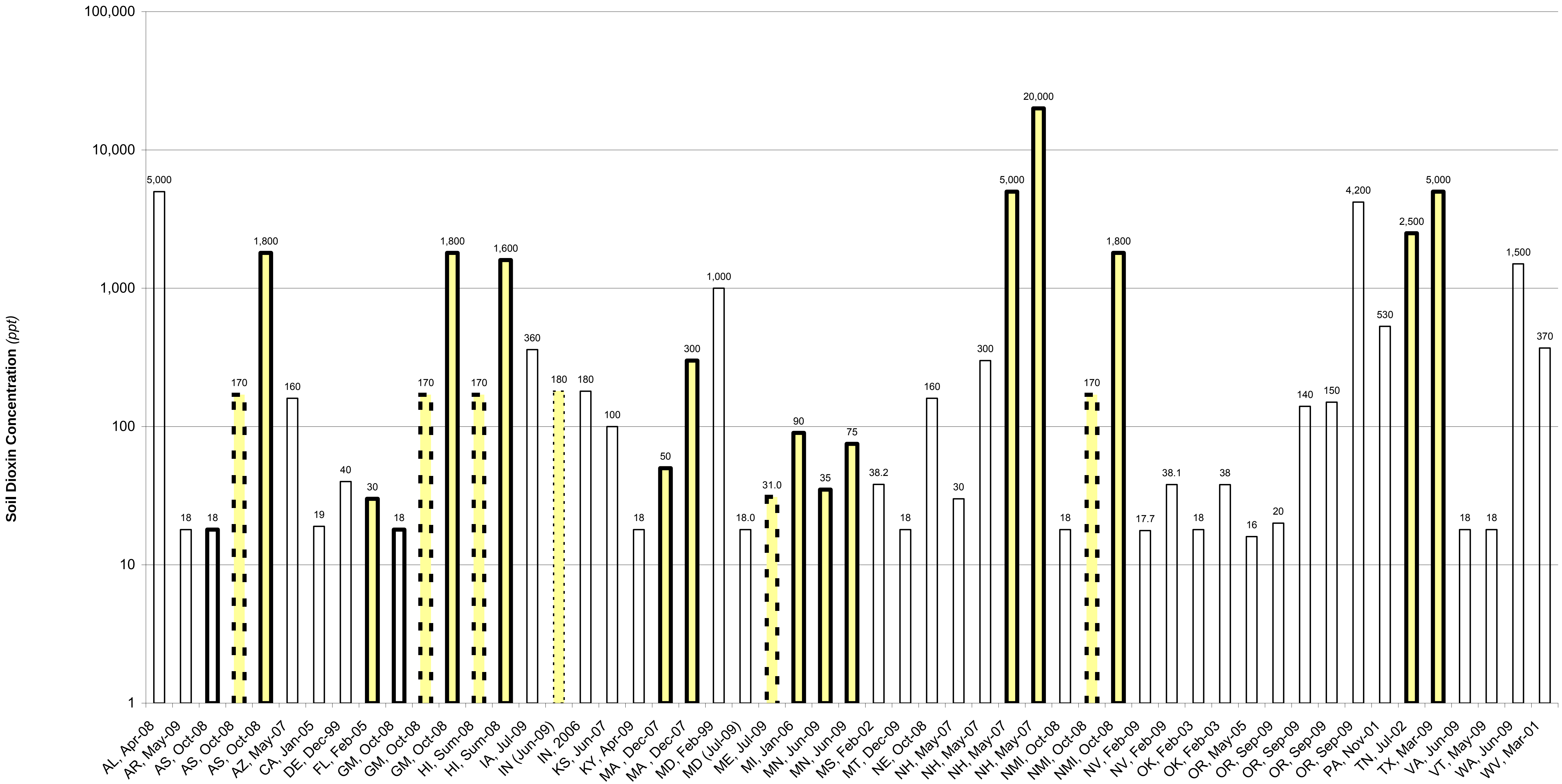

FIGURE 13 Soil Cleanup Levels and Screening Values: Commercial/Industrial (Restricted) Use, by State *(Cleanup levels are solid bars; screening values are unshaded.)*

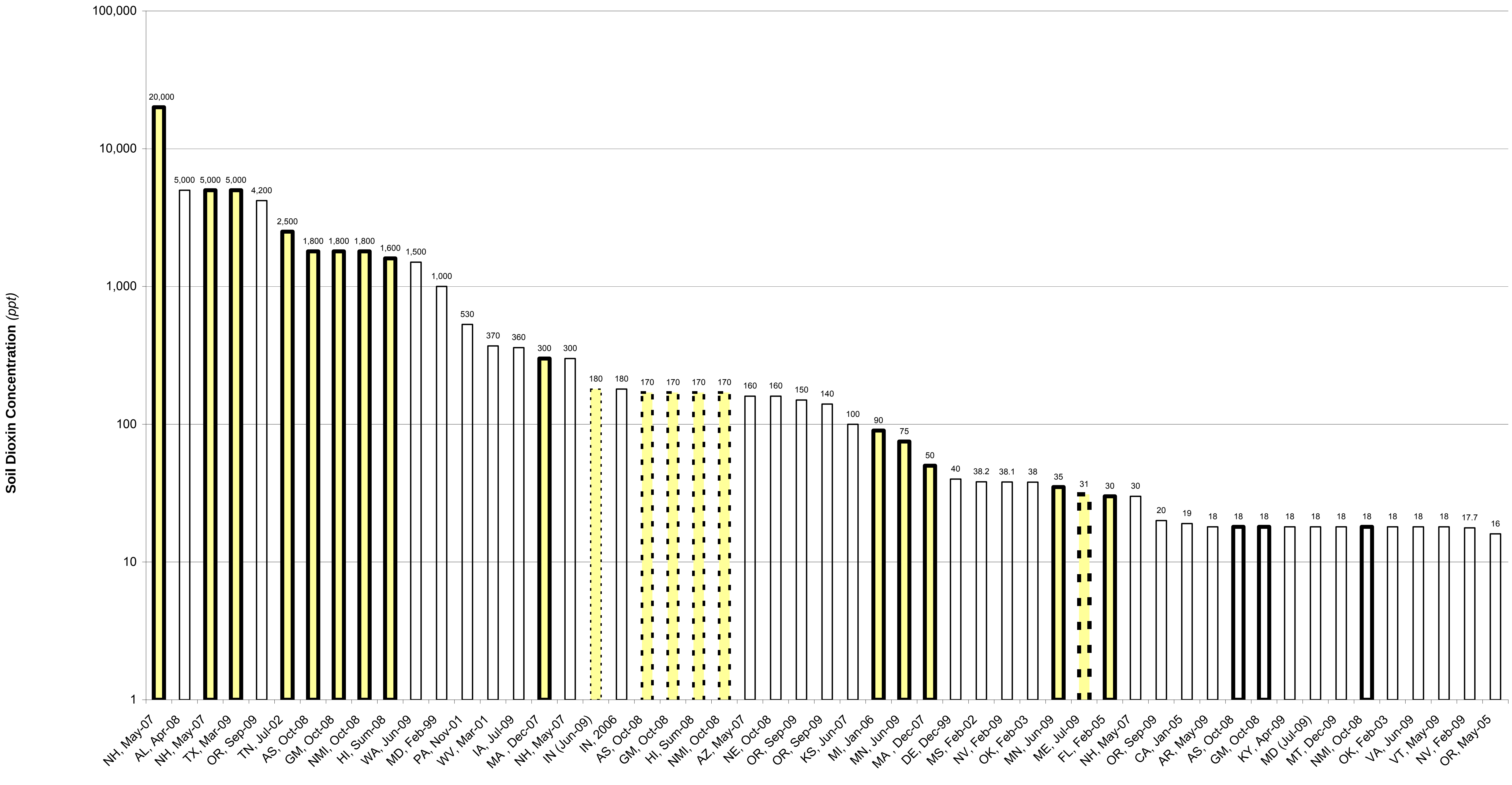

FIGURE 14 Soil Cleanup Levels and Screening Values: Commercial/Industrial (Restricted) Use, by Concentration *(Cleanup levels are solid bars; screening values are unshaded.)*

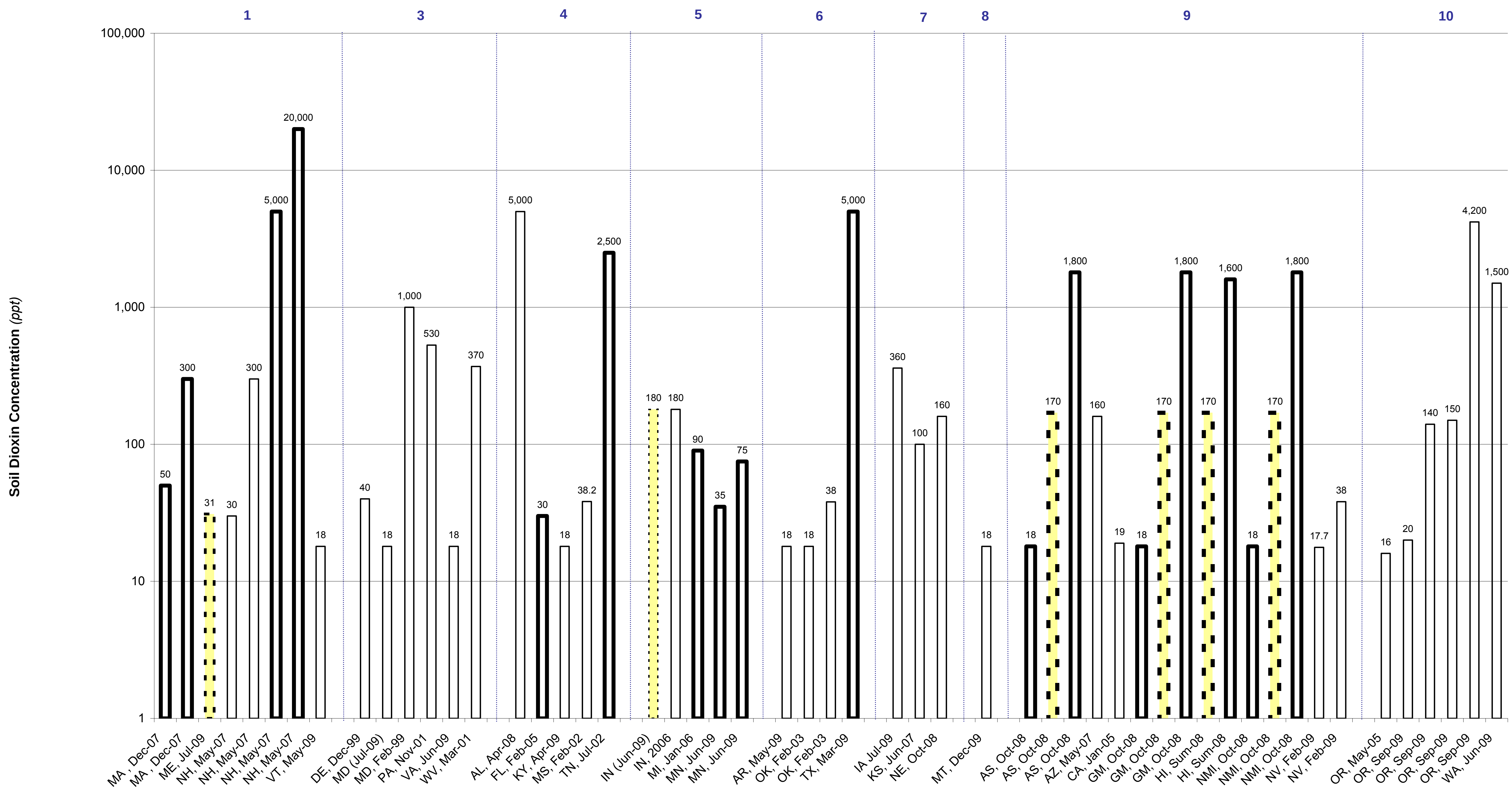

FIGURE 15 Soil Cleanup Levels and Screening Values: Commercial/Industrial (Restricted) Use, by Region

(EPA Regions are across the top; cleanup levels are solid bars; a dark border indicates the basis is TEQ; a dashed border indicates a draft or supporting value; screening values are unshaded.)

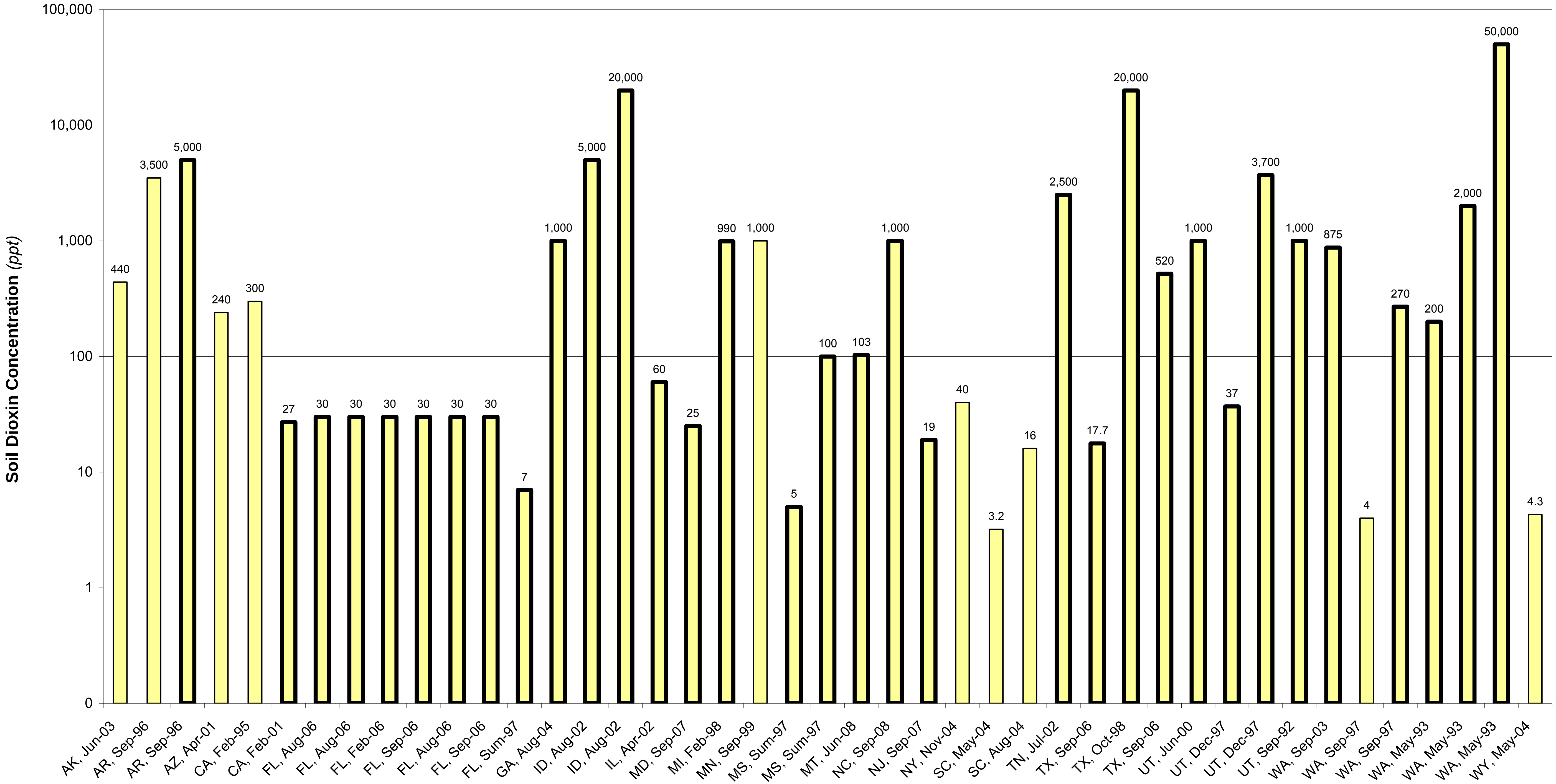

FIGURE 16 Supporting Context: Cleanup Levels Identified for Restricted Use from Contaminated Site Applications, by State *(Reflects site-specific cleanup decisions, so all are shaded.)*

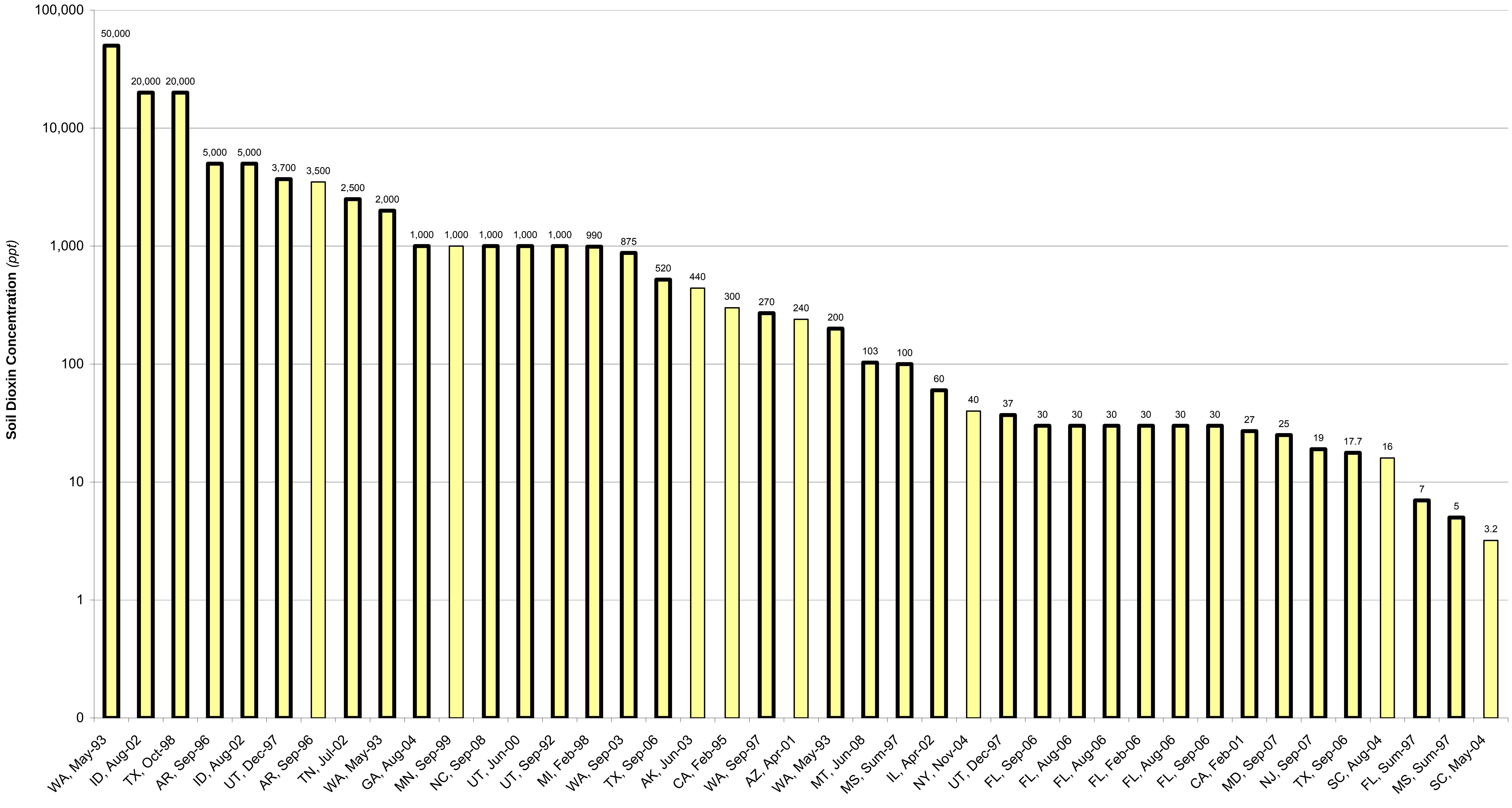

FIGURE 17 Supporting Context: Cleanup Levels Identified for Restricted Use from Contaminated Site Applications, by Concentration *(Reflects site-specific cleanup decisions, so all are shaded.)*

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TABLE 9 Supporting State Context: Subsurface Values

State	Soil Conc *(ppt)*	Date	Toxicity Value *(mg/kg-d)$^{-1}$*	Term and Scenario Context	Scientific Basis: *Exposure*	Scientific Basis: *Toxicity*	Scientific Basis: *Risk*	Peer Review and Availability
AS, GM, NMI	1,500	Oct-08	130,000	Tier 1 environmental screening level (ESL) for dioxin TEQs, deep soil (>3 m bgs) for construction/trench worker scenario.	General equation based on direct contact.	The slope factor was taken from the 2008 EPA RSL table, based on a CalEPA maximum likelihood estimate (MLE) and linearized 95% upper confidence value (UCL) citing NTP animal data from 1980 and 1982 converted to equivalent human exposures per scaling factors. (See Table B.9 for more information.)	10^{-6}	The equations and toxicity value used to derive Tier 1 environmental screening levels for different exposure scenarios are available online.
PA	1.9×10^{11}	Nov-01	150,000	Medium-specific concentration for TCDD, based on nonresidential subsurface soil (2-15 ft).	General equation uses incidental ingestion as primary contributor.	Reflects earlier EPA value indicated in HEAST.	10^{-5}	PADEP documents are available online.

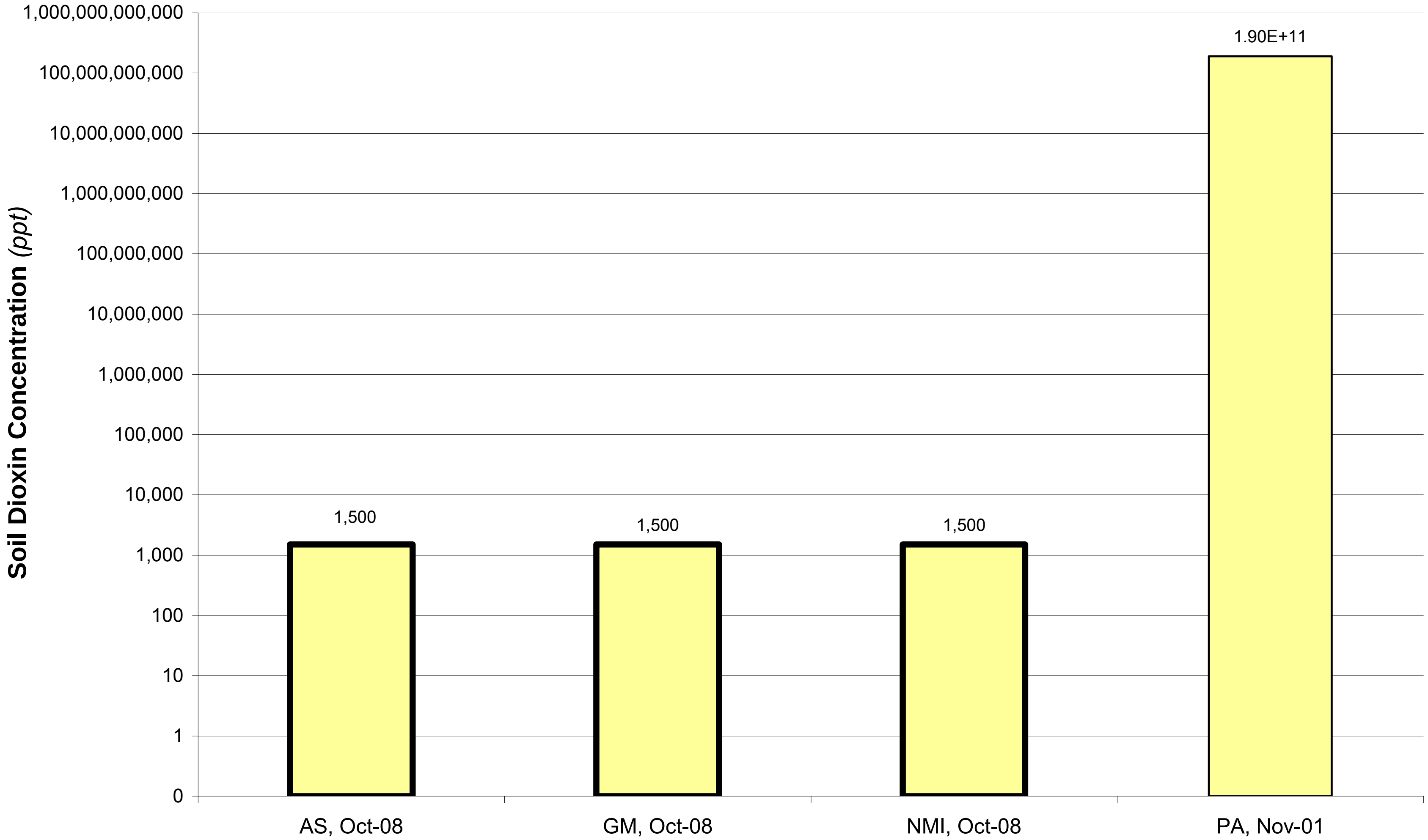

FIGURE 18 Supporting State Context: Subsurface Values, by State

TABLE 10 Dioxin Toxicity Values Underlying the State Cleanup Levels[a]

Cancer Toxicity Value *(mg/kg-d)*$^{-1}$	Number of States	Specific States	Scientific Basis	Nature of Value and Peer Review
150,000	13	AK, DE, FL, HI, IA, IN, KS, MS, NE, NH, OH, PA, WA	The source of this value is commonly given as EPA HEAST1997, which lists several citations including the *Health Assessment Document for Polychlorinated Dibenzo-p-dioxin*. (U.S. EPA, 1985). This slope factor is based on the female rat bioassay by Kociba et al. from 1978. The two-year dietary study of TCDD in female Sprague-Dawley rats indicated the highest dose (0.1 µg/kg-d, or estimated dietary amount 2,200 ppt) produced multiple toxicological effects, with lesser effects reported at 0.01 µg/kg-d (210 ppt). (This was considered to support a previous study indicating chronic ingestion of 5,000 ppt caused many toxicological effects.) No adverse effects were reported at 0.001 µg/kg-d (22 ppt), and no carcinogenic effects reported at 0.01 or 0.001 µg (210 or 22 ppt). This older toxicity value reflects earlier methodology for classifying liver tumors, which was updated by the National Toxicology Program (NTP) in 1986. Many states cite the (outdated, indirect) EPA HEAST as the source. (Note this earlier EPA value from HEAST was also listed in the previous Region 9 PRG table – which preceded the 2008 harmonization of regional screening levels, or RSLs.)	HEAST identified this as a provisional value, and qualified it as being under further evaluation. Specific peer review information was not found; however, the 1985 EPA *Health Assessment* document (listed as one of the sources) underwent external peer review. (It is not clear that the HEAST value was based solely on this document, however, since that lists a cancer slope factor of 156,000 per mg/kg-d.) The HEAST tables are now outdated. (From the HEAST introduction: "The HEAST is a comprehensive listing consisting almost entirely of provisional risk assessment information …. Although these entries in the HEAST have undergone review and have the concurrence of individual Agency Program Offices, and each is supported by an Agency reference, they have not had enough review to be recognized as high quality, Agency-wide consensus information." The HEAST document also states that when used, "the provisional nature of the value should be noted.")

TABLE 10 Dioxin Toxicity Values Underlying the State Cleanup Levels[a]

Cancer Toxicity Value *$(mg/kg\text{-}d)^{-1}$*	Number of States	Specific States	Scientific Basis	Nature of Value and Peer Review
75,000	1	MI	This value is based on a reevalution of the tumor data from the 1978 rat study by Kociba et al. (see above), using the 1986 NTP update of the liver tumor classification scheme. This reevaluation indicated lower tumor incidence rates, which resulted in a slope factor of 52,000 $(mg/kg\text{-}d)^{-1}$ based on liver tumors alone, and a slope factor of 75,000 $(mg/kg\text{-}d)^{-1}$ based on total significant tumors – which updated the factor of 150,000 $(mg/kg\text{-}d)^{-1}$ that had been based on the older methodology.	Seven independent pathologists reassessed the tumor data from the Kociba study and subsequent analyses by Squire, a pathologist consultant to the EPA Carcinogen Assessment Group.
1,400,000	1	MN	MN adopted this draft value, the upper bound slope factor based on animal data that was included in the EPA (2003) draft reassessment, which was derived from the Kociba et al. (1978) bioassay described above. (This value is 40 percent higher than the draft upper bound slope factor from the reassessment based on epidemiological data.) The MNDOH documentation notes: driving pathway-oral; endpoints-immune, repro, cancer; cancer target organ-liver; class-human carcinogen. Per the MNDOH overview, concerns about the quality of exposure estimates in human epidemiological studies preclude quantitative use of these data in developing a slope factor, but results from modeling the human studies are consistent with the cancer slope derived by modeling data from animal studies. MNDOH also notes this slope factor was derived from the same study as the previous value of 156,000 $(mg/kg\text{-}d)^{-1}$, and that its development utilized current methods of analysis, including use of body burden as the dose metric for animal-to-human dose equivalence calculations (i.e., adjustments to account for the differences in half-life of dioxins in the bodies of laboratory animals and humans), and a re-evaluation of liver tumors in the Kociba study using the latest pathology criteria.	The EPA draft reassessment underwent extensive internal and external agency peer review, and subsequent peer review by an independent NAS committee from 2004 to 2006. In noting this draft basis, MNDOH indicated it will update its guidance and recommendations if appropriate, but at this time continues to recommend using its current guidance for assessing potential carcinogenic health risks (which includes not recommending early-life adjustment for cancer potency).
	(+4, to derive a supporting lower bound for a cleanup range)	*(AS, GM, HI, NMI)*	These four entries are shown in parenthetical italics because this value only underlies supporting soil concentrations, not the basic cleanup levels for this Pacific island set. That is, this draft toxicity value was used to generate a lower bound as a companion to the standard cleanup levels based on 150,000 $(mg/kg\text{-}d)^{-1}$ for HI, and on 130,000 $(mg/kg\text{-}d)^{-1}$ for the other three islands. This toxicity value supports the lower end of the cleanup range, while the main cleanup level above which remedial action is to be considered is based on the two other slope factors applied by nearly all other states: 130,000 and 150,000 $(mg/kg\text{-}d)^{-1}$.	

TABLE 10 Dioxin Toxicity Values Underlying the State Cleanup Levels[a]

Cancer Toxicity Value *(mg/kg-d)$^{-1}$*	Number of States	Specific States	Scientific Basis	Nature of Value and Peer Review
130,000	8	AS, AZ, GM, MD, ME, NMI, OR, WY	This slope factor is listed in the current EPA Regional screening level table for residential soil, with the source given as CalEPA; its derivation is documented by California EPA (CalEPA). (As a note, the CalEPA soil screening level for 2,3,7,8-TCDD is 4.6 ppt.) The asterisk * in the RSL table for the cancer basis indicates that a screening level based on the noncancer endpoint is <1% of that based on the cancer endpoint (indicated as "[n SL < 100X c SL]"). This toxicity value is based on the NTP rat gavage studies from 1982. Summarizing from the CalEPA derivation document: a linearized multistage model was used with the NTP male mouse hepatocellular adenoma/carcinoma tumor data for TCDD, providing point estimates of extra risk for both maximum likelihood estimate (MLE) and linearized 95% upper confidence value (UCL); the UCL was calculated by maximizing the linear term, or forcing a best fit (method consistent both with expected low-dose linearity and linear nonthreshold theory). The slope of 95% UCL (q1*) was taken as the plausible upper bound cancer potency of TCDD at low doses. Rodent exposure data were converted to equivalent human exposures with scaling factors. Assumptions include: oral and inhalation routes are equivalent, air concentration is assumed to be daily oral dose, route of exposure does not affect absorption, and no difference exists in metabolism/ pharmacokinetics between animals and humans. Total weekly dose levels were averaged for a daily dose level; this assumes daily dosing in the NTP studies would give the same results as the actual twice weekly dosing schedule (as described, the TCDD half-life is relatively long so both schedules should give similar tissue concentrations). A significant increase in hepatocellular hyperplastic nodules was observed in female rats exposed to 0.1 or 0.01 µg/kg-d, while the next lower dose (0.001 µg/kg-d) showed no effect. (Note CalEPA is currently evaluating more recent toxicity data, notably the 2004 NTP study. Implications for an updated oral toxicity value are anticipated to be available later in 2009 or early 2010, following completion of the external review process.)	This value was developed by the California Department of Health Services in 1986, as documented in the derivation report developed for the California Toxic Air Contaminant program. It underwent external peer review by the California Air Resources Board (CARB) scientific review panel and was endorsed in 2002 when it was summarized and included in the 2002 CalEPA Hot Spots document. External review by the scientific panel (primarily from academia) was in accordance with a process that has been in place since 1983, per the original state air toxics legislation from the early 1980s. As described in the CalEPA overview of this value, comprehensive reviews of human studies available when the evaluation was written for the Toxic Air Contaminant (TAC) program are found in 1980s documents from the U.S. EPA and Veterans Administration.
	(+1)	*(IN)*	This entry is in parenthetical italics because 130,000 (mg/kg-d)$^{-1}$ underlies the internal draft cleanup level being considered by Indiana (60 ppt), based on field input during the review phase of this data compilation effort. The slope factor of 150,000 (mg/kg-d)$^{-1}$ underlies the current provisional level of 45 ppt.	

TABLE 11 Supporting Context from Other Agencies

Endpoint	Toxicity Value	Unit	Agency	Date	Scientific Basis	Nature of Value and Peer Review
Cancer						
Slope factor	*In final review*	$(mg/kg\text{-}d)^{-1}$	CalEPA*	*Final publication anticipated in late 2009 or early 2010*	Based on an NTP (2004) chronic gavage study of female Harlan Sprague-Dawley rats (chosen per their high incidence of hepatocarcinogenicity), dosed 5 d/wk for up to 105 wk. The study design, species, and dose range of 1 to 100 ng/kg-d were based on the dosed-feed chronic study by Kociba et al. (1978), which reflected continuous dietary exposure of Sprague-Dawley rats. Increased incidences of neoplasms were observed in the liver, lung, oral mucosa, uterus, and pancreas. "The recent chronic NTP (2004) gavage study in female Harlan Sprague-Dawley rats appears to provide a superior basis for risk assessment, due to its careful design and conduct, as well as improved survival rate, compared to Kociba et al. (1978)." Cal EPA (2007) also offers this historical context: "The non-significant risk level for TCDD calculated for California's Proposition 65 is 5 pg/day (OEHHA, 2004). This calculation uses a TCDD cancer potency factor of 1.3×10^5 $(mg/kg\text{-}day)^{-1}$ derived by the Air Toxics group in 1986 (DHS, 1986; OEHHA, 2005) … based on the incidence of liver tumors in a gavage study in male mice (NTP, 1982a). The potency factor derived [in] this PHG document, … based on the latest NTP study (NTP, 2004) in female rats … derived using updated methodology, is considered to represent a more accurate estimate of potential human cancer risk."	Has undergone independent peer review since 2007, currently in final phase.
Noncancer						
Chronic minimal risk level (oral)	1×10^{-9}	mg/kg-d	ATSDR	Current Dec-08 (established Dec-98)	Developmental endpoint from Schantz et al. (1992); point of departure (POD): 0.12 ng/kg-d, LOAEL for altered social behavior in offspring. UFs: 3 for minimal LOAEL, 3 for animal-human extrapolation, 10 for human variability.	ATSDR MRLs are independently peer-reviewed prior to being finalized (see ATSDR, 2008b).

TABLE 11 Supporting Context from Other Agencies

Endpoint	Toxicity Value	Unit	Agency	Date	Scientific Basis	Nature of Value and Peer Review
Policy guideline	(Toxicity value underlying recent soil guideline of 50 ppt is not specified, see notes below)	ATSDR		Nov-08	ATSDR (2008a) explains that this screening level "should be used as the comparison value when following the PHAGM. The comparison value is not a threshold for toxicity and should not be used to predict adverse health effects." The note accompanying dioxin health assessment values: slope factors for congeners (including 130,000 per mg/kg-d for TCDD): "Linearized multistage procedure (GLOBAL79), fitted to male mouse hepatic adenoma and carcinoma data (NTP, 1982), body weight scaling, cross-route extrapolation (CDHS, 1986)."	The external review draft of this guideline was posted for public review before being finalized, as were four earlier external peer review drafts (1991, 1992, 1994, and 1997). Note the 1998 policy was reviewed by a panel of university and Canadian health officials.

Notes:

The recent ATSDR (2008a) policy modified its 1998 policy guideline for dioxins and dioxin-like compounds in residential soil (the previous 1 ppb action level was eliminated in the 2008 update). The current policy guideline of 50 ppt for residential soil represents a screening level for dioxins, including 2,3,7,8-TCDD, and dioxin-like compounds. This level is defined to serve as an initial comparison value for site-specific health assessments evaluating exposure to dioxin directly from residential soils. As presented in ATSDR (1998/2008), this policy update replaces Appendix B of the dioxin toxicological profile and eliminates two categories of the 1998 policy guideline – namely the action level (1 ppb) and evaluation level – retaining only the 0.5 ppb screening level, to avoid confusion and maintain consistency with the ATSDR 2005 Public Health Assessment Guidance Manual (PHAGM). This value is based on the noncancer endpoint for ingestion of soil in residential settings (EPA 2008). Note that EPA (2008) also indicates: "EPA generally uses 1 ppb dioxin as a starting point for setting cleanup levels for RCRA and CERCLA sites, based on the direct contact exposure pathway for human health (does not apply to other exposure pathways, such as migration of soil contaminants to ground water or to agricultural products)."

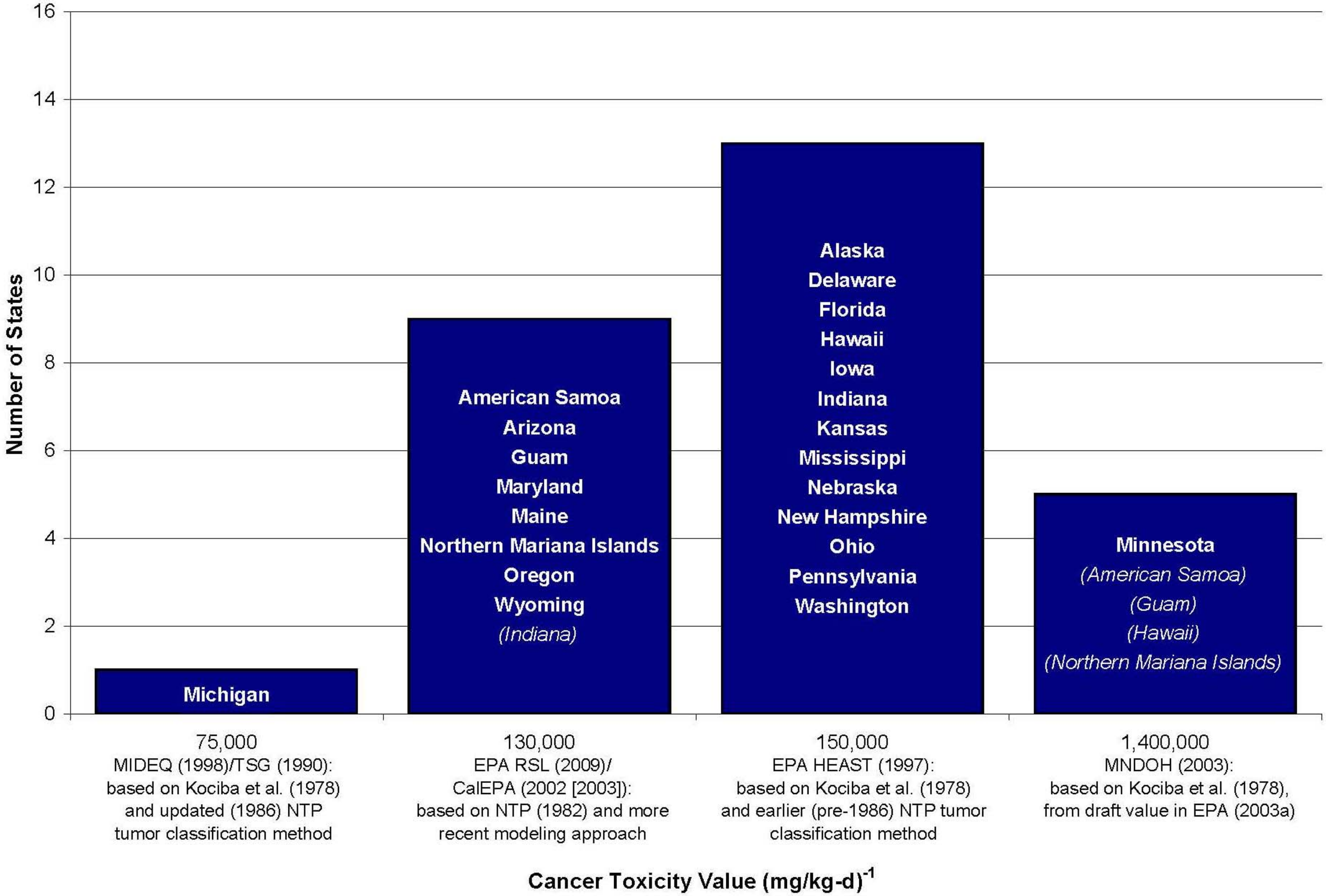

FIGURE 19 Dioxin Toxicity Values Underlying the State Cleanup Levels
(Italics indicate the toxicity value is used for a draft or supporting cleanup level.)

TABLE 12 Target Risks for the State Cleanup Levels

State per Risk Level	Soil Concentration *(ppt)* per Land Use Scenario		Terminology for Dioxin Cleanup Level *(as TCDD or Dioxin TEQ)*
	Unrestricted/Residential	***Commercial/Industrial***	
10^{-6} Incremental Lifetime Cancer Risk			
NE	3.9	(see entry under 10^{-5})	Remediation goal for TCDD
DE	4	40	Uniform risk-based remediation standard for TCDD
MS	4.26	38.2	Target remediation goal for TCDD
AZ	4.5	(see notes below)	Soil remediation level for TCDD
MD	4.5	18	Cleanup level for TCDD
OR	4.5	20	Risk-based concentration for TCDD
WY	4.5	-	Cleanup level for TCDD
FL	7	30	Soil cleanup target level for TCDD TEQ
NH	9	300	Risk-based soil standard for TCDD
ME	10	31	Generic soil cleanup level for dioxin TEQ
WA	11	(see entry under 10^{-5})	Cleanup level for TCDD
5×10^{-6} Incremental Lifetime Cancer Risk			
IA	19	(see notes below)	Cleanup level for TCDD
10^{-5} Incremental Lifetime Cancer Risk			
MN	20	35	Soil reference value for TCDD or TEQ
OH	35.8	-	Generic cleanup number for TCDD TEQ
AK	38	-	Risk-based concentration for TCDD
IN	45 *(60)*	180	Soil default closure level for TCDD
KS	60	100	Risk-based standard for TCDD
GA	80	-	Notifiable concentration for TCDD
MI	90	-	Direct contact criterion; risk-based screening level for TCDD TEQ
PA	120	530	Medium-specific concentration for TCDD
NE	(see entry under 10^{-6})	160	Remediation goal for TCDD
WA	(see entry under 10^{-6})	1,500	Cleanup level for TCDD
10^{-4} Incremental Lifetime Cancer Risk			
HI	390	1,600	Action level for dioxin TEQ
AS	450	1,800	Action level for dioxin TEQ
GM	450	1,800	Action level for dioxin TEQ
NMI	450	1,800	Action level for dioxin TEQ

Notes: Values are given for states where target risk assumptions are provided for cancer-based cleanup levels. AL has adopted residential and commercial soil cleanup levels for dioxin from the 1998 OSWER directive. TX has adopted similar values but does not explicitly state they are from OSWER. Although the AZ nonresidential soil remediation level of 160 ppt is not accompanied by an explicit target risk level, general language in the regulation indicates the cumulative excess lifetime cancer risk should not exceed 10^{-4}. The IA nonresidential cleanup level for dioxin is based on the noncancer endpoint. The current IN (2006) value is 45 ppt; 60 ppt is under consideration.

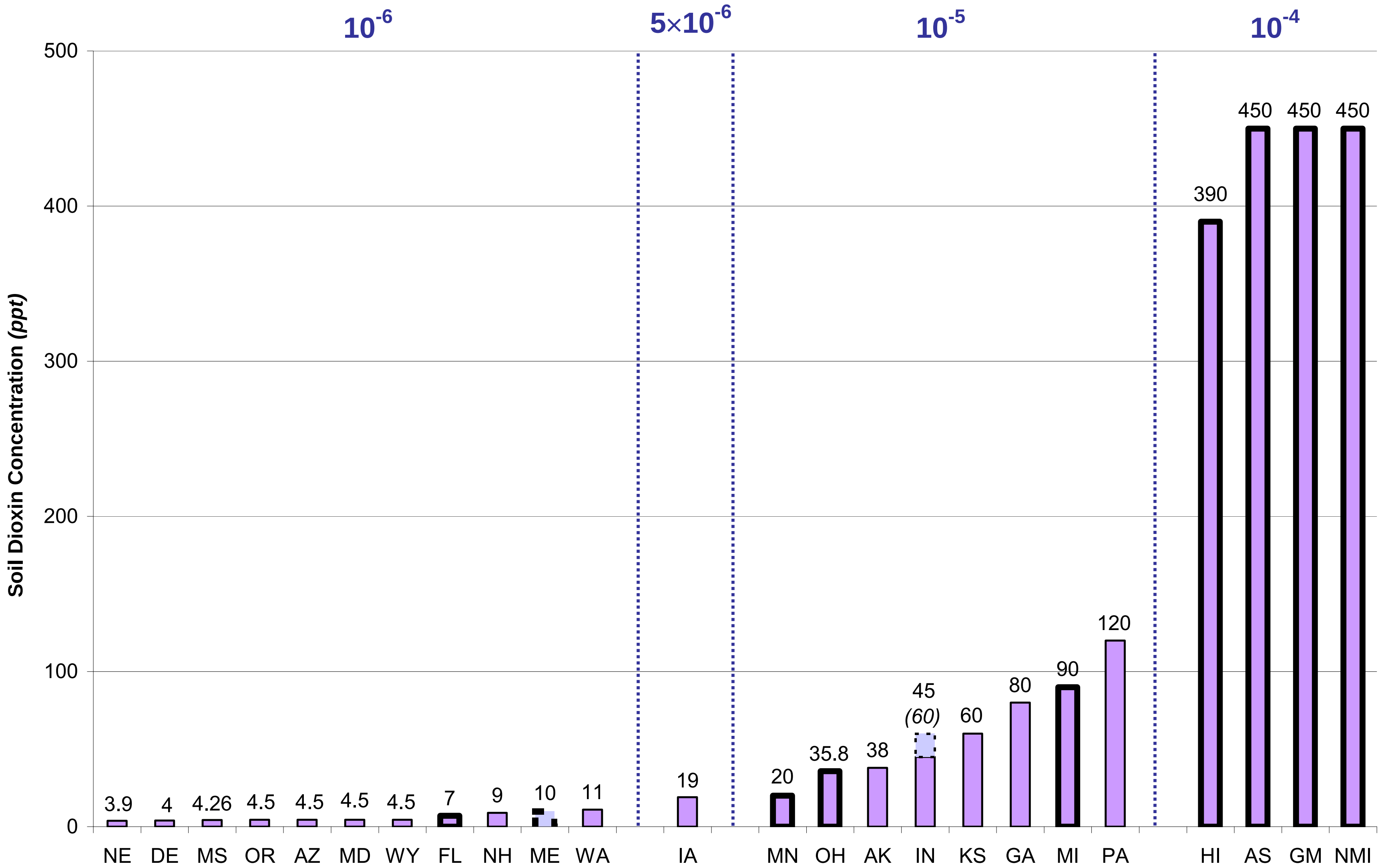

FIGURE 20 Distribution of States Listing Specific Risk Targets for Dioxin Cleanup Levels: Unrestricted/Residential Use

(A dark border indicates the basis is TEQ rather than TCDD; a dashed border and lighter shading indicate a draft value.)

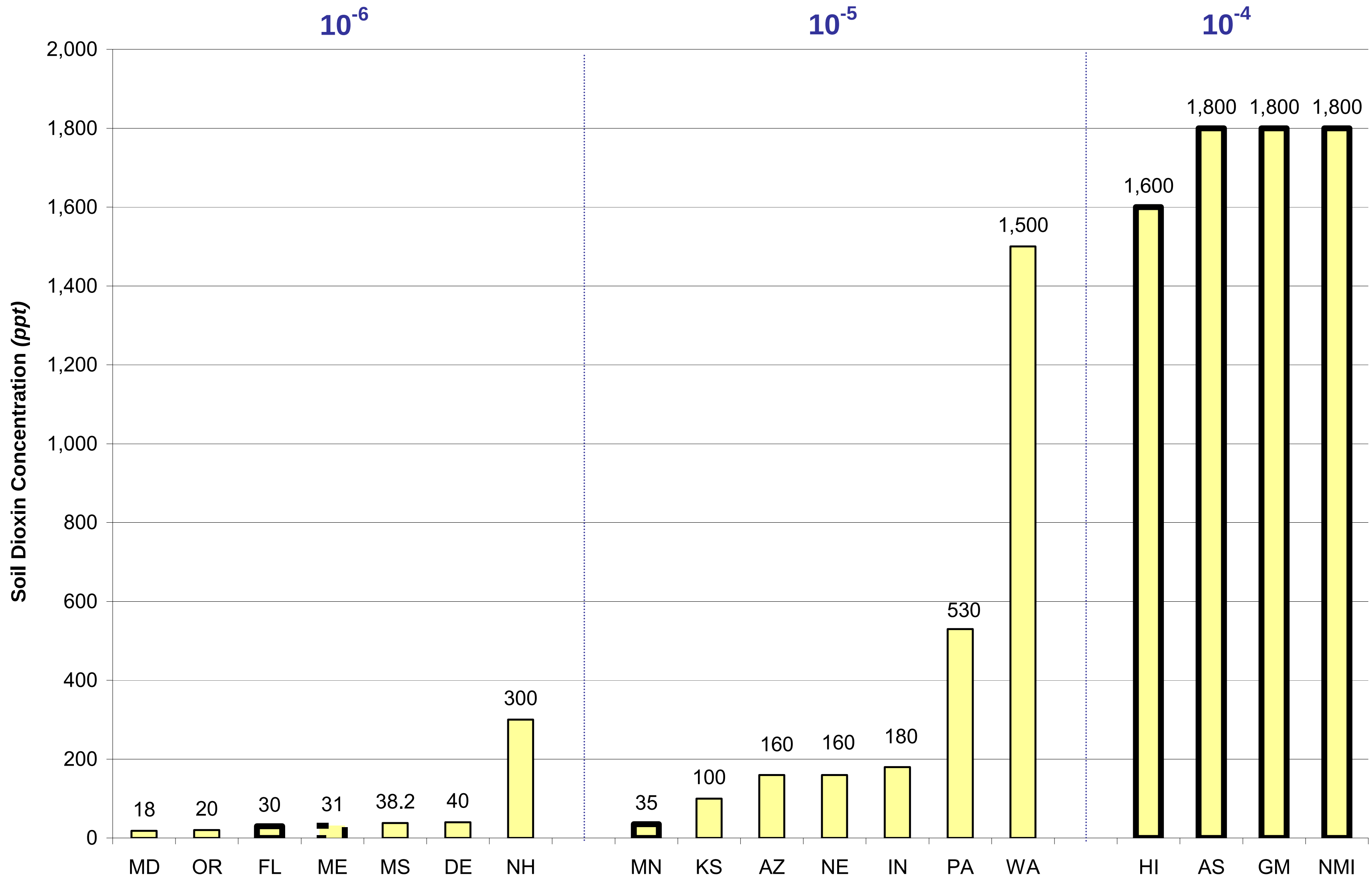

FIGURE 21 Distribution of States Listing Specific Risk Targets for Dioxin Cleanup Levels: Commercial/Industrial Use

(Dark border indicates the basis is TEQ rather than TCDD; dashed border indicates a draft value.)

3.3 DERIVATION METHODOLOGY

States have applied standard methods to determine soil cleanup levels for dioxin. The exposure and toxicity components of these methods are highlighted in Sections 3.3.1 and 3.3.2, respectively. The following discussion addresses the scientific basis of cleanup levels with an emphasis on the calculations for unrestricted/residential scenarios. However, the tables and figures also include information for commercial/industrial (restricted) cleanup levels, and the approach for those scenarios involves the same basic concepts.

3.3.1 Exposure Calculations

The review of soil cleanup levels for dioxin indicates that states follow the standard EPA approach for deriving such concentrations, commonly tapping the equation from the EPA (1989) risk assessment guidance for Superfund or EPA (1996) soil screening guidance. The same basic equation also underlies the recently harmonized EPA Regional screening levels (RSLs), which have been adopted as cleanup levels by some states.

In most cases, dioxin is one of many chemicals for which states have derived soil cleanup levels, so the agencies have identified generic exposure calculations for broad application. Although terms vary somewhat and other relatively minor differences exist in the equation structures, the basic concepts and routes considered in calculating exposures to guide cleanup levels are essentially the same.

For soil contaminated with dioxin, the exposure basis for unrestricted/residential cleanup levels is direct contact, and incidental soil ingestion is the key route. Four states base their cleanup values on this pathway alone (Delaware, Mississippi, Pennsylvania, and Washington), and for most of the remaining states with cleanup levels, incidental ingestion accounts for at least 90 percent of the total. The relative contribution is somewhat lower for six states, ranging from 50 percent (for Michigan and Minnesota) to about 75 to 85 percent (for Arkansas, Indiana, Kansas, and Ohio).

While some variations exist in the specific terms and acronyms used, the common components of the incidental ingestion equation applied across the states that provide derivation information are: intake rate (IR), exposure frequency (EF), exposure duration (ED), body weight (BW), and averaging time (AT); a units conversion factor (CF) is also often included. Extending to the health endpoint, the common components are cancer slope factor (CSF or SF) (or oral reference dose, RfD for the noncancer endpoint) and total target cancer risk (TR) (or total hazard quotient, THQ, for the noncancer endpoint).

The general equation used to calculate a soil cleanup concentration for the residential scenario based on incidental ingestion for the cancer endpoint is:

$$C_{ing}\left(\frac{mg}{kg}\right)=\frac{TR\times AT\left(365\frac{d}{y}\times 70y\right)\times BW(kg)}{SF\left(\frac{mg}{kg-d}\right)^{-1}\times EF\left(\frac{d}{y}\right)\times ED(y)\times IR\left(\frac{mg}{d}\right)\times CF\left(\frac{10^{-6}kg}{mg}\right)}$$

Most states consider different exposure factors for children and adults – including child and adult ingestion rates (IR_c and IR_a), exposure durations (ED_c and ED_a), and body weights (BW_c and BW_a). For this reason, an age-adjusted soil ingestion factor (IFS_{adj}) is commonly applied to account for these age-specific inputs under the residential scenario. Thus, a combined residential scenario (which covers the same hypothetical individual from childhood to adulthood) often reflects an IFS_{adj} calculated as follows:

$$IFS_{adj}\left(\frac{mg-y}{kg-d}\right) = \frac{ED_c(y) \times IR_c\left(\frac{mg}{d}\right)}{BW_c(kg)} + \frac{ED_a(y) \times IR_a\left(\frac{mg}{d}\right)}{BW_a(kg)}$$

The age-specific ingestion rates, exposure durations, and body weights can be lumped into a single variable, which simplifies this equation to:

$$C_{ing}\left(\frac{mg}{kg}\right) = \frac{TR \times AT\left(365\frac{d}{y} \times 70y\right)}{SF\left(\frac{mg}{kg-d}\right)^{-1} \times EF\left(\frac{d}{y}\right) \times IFS_{adj}\left(\frac{mg-y}{kg-d}\right) \times CF\left(\frac{10^{-6}kg}{mg}\right)}$$

The equations and parameter values identified by the states to derive soil cleanup levels for dioxin are summarized in Table 13; further information (including citations) is given in Appendix B. Similarities and differences in the values used for the soil ingestion pathway are highlighted in Table 14. (Shading is used to distinguish different values within related entries.)

Regarding the parameter values applied, most states use traditional EPA default assumptions so the exposure factors are generally similar. However, relatively minor differences exist, some of which reflect state-specific context. For example, the Washington averaging time and the Minnesota exposure duration are slightly longer than the EPA default values for the typical residential scenario.

The selected inputs presented in Table 14 illustrate that the combined exposure factors produce differences within a factor of ten for this key exposure pathway. Although incidental soil ingestion is the main contributor to dioxin cleanup levels for unrestricted/residential use, most states also consider inhalation and/or dermal absorption – as shown in Table 13. (These routes include modeling components unique to volatile compounds that are carried as part of the overall calculation process.) In some cases, including for certain nonresidential scenarios, these additional exposure routes can contribute more substantially to the calculated cleanup level for dioxin.

TABLE 13 Basic Components of the Derivation Methodology *(see Appendix B for further details)*

State	Conc *(ppt)*	Equation	Parameters	Exposure Routes	Notes
AK	38	$CL = \frac{TR \times AT \times 365 d/y}{EF \times [(SF_o \times IF_{soil/adj} \times CF) + (SFS \times ABS \times SF_d \times CF)]}$	CL = cleanup level, (mg/kg) TR = target cancer risk, 10^{-5} AT = averaging time, 70 y EF = 330 d/y SFo = oral slope factor, 150,000 $(mg/kg\text{-}d)^{-1}$ $IF_{soil/adj}$ = age-adjusted soil ingestion factor, 114 $(mg\text{-}y/kg\text{-}d)^{-1}$ SFS = soil dermal factor, 361 mg-y/kg-d ABS = absorption factor, 0.03 SF_d = dermal slope factor, 300,000 $(mg/kg\text{-}d)^{-1}$ CF = conversion factor, 10^{-6} kg/mg	Ingestion, dermal	
AL	1,000	Not available	Not available.	All	Adopted the residential cleanup value from the OSWER directive.
AS	450	See EPA RSL equation (last entry of this table).	AS uses the EPA RSL equation and toxicity values to derive its cleanup level, but applies a TR of 10^{-4} instead of 10^{-6}.	All	Adopted the GEPA policy for soil cleanup.
AZ	4.5	See EPA RSL equation (last entry of this table).	As given for the EPA RSL.	All	Adopted the EPA RSL as the AZ SRL for residential use.
DE	4	$RBC_{res} = \frac{TR \times AT_c}{EF_r \times IFS_{adj} \times CSF_o \times CF}$	RBC_{res} = residential risk-based concentration, (mg/kg) TR = target cancer risk, 10^{-6} ATc = averaging time carcinogens, 25,550 d EFr = exposure frequency, 350 d/y IFS_{adj} = soil ingestion factor, 114.3 mg-y/kg-d CSFo = oral cancer slope factor, 150,000 $(mg/kg\text{-}d)^{-1}$ CF = 10^{-6} kg/mg	Ingestion	DE presents the equation for residential soil ingestion from the EPA Region 3 RBC tables; other exposure routes are not identified.

TABLE 13 Basic Components of the Derivation Methodology *(see Appendix B for further details)*

State	Conc *(ppt)*	Equation	Parameters	Exposure Routes	Notes
FL	7	$SCTL = \frac{(TR \times BW \times AT \times RBA)}{EF \times ED \times FC(EXP_{oral} + EXP_{derm} + EXP_{inhal})}$ where: EXP_o = oral term = $CSF_o \times IR_o \times CF$ EXP_d = dermal term = $CSF_d \times SA \times AF \times DA \times CF$ EXP_i = inhalation term = $CSF_i \times IR_i \times (1/VF + 1/PEF)$	SCTL = soil cleanup target level (mg/kg) TR = target cancer risk, 10^{-6} BW = body weight, 51.9 kg resident AT = averaging time, 25,550 d RBA = relative bioavailability factor, 1.0 EF = exposure frequency, 350 d/y ED = exposure duration, 30 y FC = fraction from cont. source, 1.0 $CSF_{o,i}$ = oral and inhalational slope factor, 150,000 $(mg/kg\text{-}d)^{-1}$ CSF_d = dermal slope factor, 166,667 $(mg/kg\text{-}d)^{-1}$ IRo = oral ingestion rate, 120 mg/d IRi = inhalation rate, 12.2 m^3/d CF = 10^{-6} kg/mg SA = surface area of skin exposed, 4,810 cm^2/d resident AF = adherence factor, 0.1 mg/cm^2 DA = dermal absorption, 0.01 VF = volatilization factor, 4.619×10^6 m^3/kg PEF = particulate emission factor, 1.24×10^9 m^3/kg	All	

TABLE 13 Basic Components of the Derivation Methodology *(see Appendix B for further details)*

State	Conc *(ppt)*	Equation	Parameters	Exposure Routes	Notes
GA	80	$NC = \frac{(TR \times BW \times AT \times 365\ d/y)}{EF \times ED\ (EXP_{oral} + EXP_{inhal})}$ where: EXP_o = oral term = $CSF_o \times IR_{soil} \times CF$ EXP_i = inhalation term = $CSF_i \times IR_i \times (1/VF+1/PEF)$	NC = notifiable concentration (mg/kg) TR = target cancer risk, 10^{-5} BW = body weight, 70 kg AT = averaging time, 70 y EF = exposure frequency, 350 d/y resident, 250 d/y nonresident ED = exposure duration, 30 y resident,, 25 y nonresident $CSF_{o,\ i}$ = cancer slope factor, $(mg/kg\text{-}d)^{-1}$ IRsoil = soil ingestion rate, 114 mg/d resident, 50 mg/d nonresident IRi = inhalation rate, 15 m^3/d resident,,, 20 m^3/d nonresident CF = conversion factor, 10^{-6} kg/mg VF = equation given but not all chemical-specific parameters are provided PEF = particulate emission factor, 4.63×10^9 m^3/kg	Ingestion, inhalation	The GADNR website references EPA RAGS Equation 6 for carcinogen in commercial/industrial soil, but the specific derivation basis is unclear and some chemical-specific parameters are not identified.
GM	450	See EPA RSL equation (last entry of this table).	GM uses the EPA RSL equation and toxicity values to derive its cleanup level, but applies a TR of 10^{-4} instead of 10^{-6}.	All	Represents value above which residential use is not recommended in the absence of remedial actions to reduce potential exposure.
HI	390	See EPA RSL equation (last entry of this table).	HI uses the EPA RSL equation to derive its cleanup level but applies a TR of 10^{-4} instead of 10^{-6} and an oral slope factor of 150,000 $(mg/kg\text{-}d)^{-1}$ instead of 130,000 $(mg/kg\text{-}d)^{-1}$.	All	Represents value above which residential use is not recommended in the absence of remedial actions to reduce potential exposure.

TABLE 13 Basic Components of the Derivation Methodology *(see Appendix B for further details)*

State	Conc *(ppt)*	Equation	Parameters	Exposure Routes	Notes
IA	19	$CL = \frac{1}{1/C_{oral} + 1/C_{derm}}$ where: $C_{oral,derm} = \frac{RF \times AT}{Abs \times CF \times (A+B)}$ and $A = \frac{(ER_c \times EF_c \times ED_c)}{BW_c}$ $B = \frac{(ER_a \times EF_a \times ED_a)}{BW_a}$	CL = cleanup level (mg/kg) ED_a = exposure duration for adult, 24y ED_c = exposure duration for child, 6y EF_a = exposure frequency for adult, 350d/y EF_c = exposure frequency for child, 350d/y ER_a = exposure rate for adult,100 mg/d oral, 400 mg/d dermal ER_c = exposure rate for child, 200 mg/d oral, 560 mg/d dermal BW_a = body weight adult, 70 kg BW_c = body weight child, 15 kg CF = conversion factor, 10^{-6} kg/mg Abs = absorption factor, 1 oral, 0.03 dermal AT = averaging time, 25,550 d RF = TR / SF TR = target risk, 5×10^{-6} SF = slope factor, 150,000 $(mg/kg\text{-}d)^{-1}$	Ingestion, dermal	

TABLE 13 Basic Components of the Derivation Methodology *(see Appendix B for further details)*

State	Conc *(ppt)*	Equation	Parameters	Exposure Routes	Notes
IN	45	$DCL = \frac{TR \times AT_c \times 365\ d/y}{EF_r \times (A + B)}$ where: $A = \frac{SF_o \times (IngF_{adj} + [SFS_{adj} \times ABS])}{10^6\ mg/kg}$ $B = InhF_{adj} \times SF_i\ (1/VF + 1/PEF)$	DCL = default closure level (mg/kg) TR = target risk, 10^{-5} AT_c = averaging time, 70 y EF_{rs} = exposure frequency residential, 250 d/y SF_o = oral slope factor, 150,000 $(mg/kg\text{-}d)^{-1}$ $IngF_{adj}$ = ingestion factor soil, age-adjusted, 114 mg-y/kg-d SFS_{adj} = skin factor soil, age-adjusted, 1,257 mg-y/kg-d ABS = skin absorbance factor, 0.03 $InhF_{adj}$ = inhalation factor, age-adjusted, 10.9 m^3-y/kg-d SF_i = inhalation slope factor, 150,000 $(mg/kg\text{-}d)^{-1}$ VF = volatilization factor, m^3/kg PEF = particulate emission factor, 1.316×109 m^3/kg	All	State review feedback indicates the 2009 internal draft value is based on a SF_o of 130,000 $(mg/kg\text{-}d)^{-1}$ and IUR of 38 $(\mu g/m^3)^{-1}$. For these internal provisional values, calculating an inhalation cancer risk via an IUR approach would replace the inhalation slope factor and $InhF_{adj}$ in the accompanying equation.

TABLE 13 Basic Components of the Derivation Methodology *(see Appendix B for further details)*

State	Conc *(ppt)*	Equation	Parameters	Exposure Routes	Notes
KS	60	$RBC\ (mg/kg) = \frac{(TR \times BW \times AT \times 365d/y)}{EF \times ED \times [(A)+(B)+(C)]}$ where: $A = ING_s \times CF \times SF_o$ $B = INH \times SF_i \times \{1/VF_s + 1/PEF\}$ $C = SF_o \times CF \times SA \times AF \times ABS$	RBC = risk based concentration (mg/kg) TR = target cancer risk, 10^{-5} BW = body weight, 70kg AT = averaging time, 70 y EF = exposure frequency, 350 d/y ED = exposure duration, 30 y ING_s = soil ingestion rate, 100 mg/d CF = conversion factor, 10^{-6} kg/mg SF_o = oral cancer slope factor, 150,000 $(mg/kg\text{-}d)^{-1}$ INH = soil inhalation rate, 20 m^3/d SF_i = inhalation cancer slope factor, 150,000 $(mg/kg\text{-}d)^{-1}$ VF_s = soil volatilization factor, m^3/kg PEF = particulate emission factor, $1.18 \times 10^9\ m^3/kg$ SA = surface area of skin, 5000 cm^2/d AF = adherence factor, 0.2 mg/cm^2 ABS = absorption factor, 0.1	All	For carcinogens, KS uses default exposure assumptions for an adult receptor.
MD	4.5	See EPA RSL equation (last entry of this table)	See EPA RSL parameters (last entry).	All	Per state review feedback, the EPA RSL is the MD soil cleanup level.

TABLE 13 Basic Components of the Derivation Methodology *(see Appendix B for further details)*

State	Conc *(ppt)*	Equation	Parameters	Exposure Routes	Notes
ME	10	$RAG = \frac{1}{(1/EPC_{ing}) + (1/EPC_{inh}) + (1/EPC_{derm})}$ where: $EPC_{ing} = \frac{ILCR \times AT}{SF_o \times [\{ED_{yc} \times EF_{yc} \times (IR_{yc} \times CF/BW_{yc})\} + \{ED_a \times EF_a \times (IR_a \times CF/BW_a)\}]}$ Shortened versions of EPC equations with several exposure parameters lumped were available for inhalation and dermal pathways. $EPC_{inh} = \frac{0.68 \times 10^{-4}}{[IUR(\mu g/m^3)^{-1} \times (1{,}000 \mu g/mg) \times (1/PEF + 1/VF)]}$ $EPC_{derm} = \frac{0.45 \text{ (kg BW} \times \text{day/kg soil)}}{SF_o} \times \frac{1}{DAF}$	RAG = remedial action guideline (mg/kg) EPC = exposure point conc. (mg/kg) ILCR = incremental lifetime cancer risk, 10^{-6} AT = averaging time, 25,550 d SF = oral slope factor, 130,000 $(mg/kg\text{-}d)^{-1}$ ED_{yc} = exposure duration (child), 6 y ED_a = exposure duration (adult), 24 y EF_{yc} = 150 d/y EF_a = 150 d/y IR_{yc} = soil contact rate (child), 200 mg/d IR_a = soil contact rate (adult), 100 mg/d BW_{yc} = body weight (child), 14 kg BW_a = body weight (adult), 70 kg CF = conversion factor, 10^{-6} kg/mg IUR = inhalation unit risk, 38 $(\mu g/m^3)^{-1}$ PEF = 1.36×10^9 m^3/kg DAF = dermal absorbance factor, 0.03	All	Equations provided in MERAG draft technical document.
MI	90	$DCC = \frac{(TR \times AT \times CF)}{SF_o \times [(EF_i \times IF \times AE_i) + (EF_d \times DF \times AE_d)]}$	DCC = direct contact criterion, (µg/kg) TR = target risk, 10^{-5} cancer risk AT = averaging time, 25,550 d CF = correction factor, 10^9 µg/kg SFo = 75,000 $(mg/kg\text{-}d)^{-1}$ EF_i = ingestion exposure frequency, 350 d/y IF = age-adjusted soil ingestion factor, 114 mg-y/kg-d AE_i = oral absorption efficiency, 0.5 EF_d = dermal exposure frequency, 245 d/y DF = age-adjusted soil dermal factor, 2442 mg-y/kg-d AE_d = dermal absorption efficiency, chemical-specific, 0.03	Ingestion, dermal	Parameter values are given in MIDEQ (1998); more recent documentation from 2006 lists a generic DF of 353 mg-y/kg-d.

TABLE 13 Basic Components of the Derivation Methodology *(see Appendix B for further details)*

State	Conc *(ppt)*	Equation	Parameters	Exposure Routes	Notes
MN	20	$SRV = \frac{TR \times AT}{(A) + (B) + (C)}$ where: $A_{\text{(ing term)}} = \frac{IR \times SF \times CF \times FI \times EF_o \times ED \times SF \times AE}{BW}$ $B_{\text{(derm term)}} = \frac{SF \times CF \times SA \times AF \times ABS \times EF_d \times ED}{BW}$ $C_{\text{(inh term)}} = IUR \times (1{,}000\ \mu g/mg) \times EF_i \times ED \times (1/PEF + 1/VF)$ Original equations from 1999 MPCA guidance document: $ADD_{ing} = ECR_{ing}/(SF \times AE) = \frac{C_s \times IR \times CF \times FI \times EF_o \times ED}{BW \times AT}$ $ADD_{derm} = ECR_{derm}/SF = \frac{C_s \times CF \times SA \times AF \times ABS \times EF_d \times ED}{BW \times AT}$ $ADC_{inh} = ECR_{inh}/IUR = C_s \times (10^3\ \mu g/mg) \times EF_i \times ED \times (1/PEF + 1/VF)$	SRV = concentration of contaminant in soil (or C_s)), mg/kg $SF_{o,d}$ = 1,400,000 $(mg/kg\text{-}d)^{-1}$ TR = 10^{-5} cancer risk ECR = estimated cancer risk, route-specific AT = 25,550 d IR = soil intake rate, 68 mg/d (age-adjusted) CF = correction factor, 10^{-6} kg/mg FI = fraction from contaminated area, 1.0 $EF_{o,i}$ = exposure frequency oral and inhalational, 350 d/y EF_d = exposure frequency dermal, 74 d/y (adult), 97 d/y (age-adjusted) ED = exposure duration, 33 y AE = oral absorption efficiency, 0.55 SA = skin surface area, 3,609 cm^2 (age-adjusted) AF = adherence factor, 0.17 mg/cm^2 (age-adjusted) ABS = absorption factor, 0.03 IUR = inhalation unit risk, 400 $(\mu g/m^3)^{-1}$ VF = volatilization factor, 2.49×10^8 (m^3/kg) PEF = particulate emission factor, 7.7×10^8 (m^3/kg) BW = body weight, 51 kg (age-adjusted)	All	From field feedback, 20 ppt is a rounded value (appears to correspond to a target risk of 1.21×10^{-5}.) Toxicity values are taken from MPCA spreadsheet that was provided during field review, with support from MPCA 2008 excel files. Initial equations and default parameter values taken from the 1999 MPCA guidance document were updated per field input.
MS	4.26	$TRG = \frac{TR \times AT}{EF \times IFS_{adj} \times CSF_o \times CF}$	TRG = target remediation goal (mg/kg) TR = target risk, 10^{-6} CSF_o = 150,000 $(mg/kg\text{-}d)^{-1}$ BW = body weight AT = averaging time, 25,550 d EF = exposure frequency, 350 d/y ED = exposure duration, IFS_{adj} = soil ingestion factor, 114 mg-y/kg-d CF = conversion factor, 10^{-6} kg/mg	Ingestion (as indicated in field feedback and on the MSDEQ website)	Equation reflects field input during the review phase which indicated the state uses equations and parameters from the EPA (1996) Soil Screening Guidance

TABLE 13 Basic Components of the Derivation Methodology *(see Appendix B for further details)*

State	Conc *(ppt)*	Equation	Parameters	Exposure Routes	Notes
NE	3.9	$CL = \frac{1}{[(1/C_{res\ soil\ ingestion})+(1/C_{res\ soil\ dermal})+(1/C_{res\ soil\ inhalation})]}$ where: $C_{res\ soil\ ingestion} = \frac{TR_r \times AT_c}{EF_r \times IFS_{adj} \times SF_o \times 10^{-6}\ mg/kg}$ $C_{res\ soil\ dermal} = \frac{TR_r \times AT_c}{EF_r \times SFS_{adj} \times ABS_d \times (SF_o/ABS_{GI}) \times 10^{-6}\ mg/kg}$ $C_{res\ soil\ inhalation} = \frac{TR_r \times AT_c}{EF_r \times ED_a \times \frac{(URF \times 1000\ \mu g/mg)}{PEF}}$	CL = cleanup level, (mg/kg) TR = target risk, 10^{-6} SF_o = oral slope factor,150,000 $(mg/kg\text{-}d)^{-1}$ AT_c = averaging time, 25,550 d EF_r = exposure frequency, 350 d/y ED_a = exposure duration, 30 y IFS_{adj} = age-adjusted soil ingestion factor, 114 $(mg\text{-}y/kg\text{-}d)^{-1}$ SFS_{adj} = age-adjusted soil dermal factor, 361 mg-y/kg-d ABS_d = dermal absorption fraction, 0.03 ABS_{GI} = gastrointestinal absorption eff., 1.0 URF = unit risk factor, 3.3×10^{-3} $(\mu g/m^3)^{-1}$ PEF = particulate emission factor, 1.2×10^9 m^3/kg	All	
NH	9	$Conc_{soil} = \frac{(ELCR \times CF)}{\{CSF \times (\sum A + \sum B)\}}$ where: $A = \frac{(IR_i \times EF \times ED_i \times RAF_o)}{(AT \times BW_i)}$ $B = \frac{(SA_i \times EF \times ED \times AF \times RAF_d)}{(AT \times BW_i)}$	$Conc_{soil}$ = soil concentration (mg/kg) ELCR = excess lifetime cancer risk, 10^{-6} CF = conversion factor, 10^6 mg/kg CSF = slope factor,150,000 $(mg/kg\text{-}d)^{-1}$ IR_i = soil ingestion rate, 200 mg/d (2-6 y), 100 mg/d (7-31 y) EF = exposure frequency (160 d/y) ED_i = exposure duration,2-6 (5 y), 7-16(10y), 17-31 (15 y) RAF_o = relative absorption factor ingestn, 1 AT = averaging time, 25,550 d BW_i = body weight,17kg (2-6y), 40kg (7-16y), 70 kg (17-31 y) SA_i = skin surface area, 2632 cm^2 (2-6 y), 3432 cm^2(7-16 y),5044 cm^2(17-31y) AF = soil-to-skin adherence factor (adult, 0.013 mg/cm^2, child, 0.014 mg/ cm^2, 2-6 year old 0.36 mg/cm^2) RAF_d = relative absorption factor for soil dermal contact 0.03	Ingestion, dermal	

TABLE 13 Basic Components of the Derivation Methodology *(see Appendix B for further details)*

State	Conc *(ppt)*	Equation	Parameters	Exposure Routes	Notes
NMI	450	See EPA RSL equation (last entry of this table)	NMI uses the EPA RSL equation and toxicity values to derive its cleanup level for dioxin. However, they use a TR of 10^{-4} instead of 10^{-6}.	All	NMI has adopted the GEPA policy for soil cleanup.
OH	35.8	$GCN = \frac{TR \times AT}{A + B + C}$ Where: $A = SF_o \times (IFS_{adj} \times CF \times FI \times EF)$ $B = SF_o / O_{ABS} \times (SFS_{adj} \times ABS \times CF \times EF)$ $C = SF_i \times [InhF_{adj} \times EF \times (1/PEF) + (1/VF)]$	GCN = generic cleanup number, mg/kg TR = target risk, 10^{-5} AT = averaging time, carcinogens, 25,550 d $SF_{o,i}$ = oral and inhalation slope factor, 150,000 mg/kg-d IFS_{adj} = age-adjusted soil ingestion factor, 114.3 mg-y/kg-d CF = conversion factor, soil 10^{-6} FI = soil fraction ingested, 1.0 EF = exposure frequency, 350 d/y O_{ABS} = oral absorption factor, 0.5 SFS_{adj} = age-adjusted soil dermal contact factor, 360.8 mg-y/kg-d ABS = dermal absorption factor, 0.03 $InhF_{adj}$ = age-adjusted inhalation factor, 10.9 m^3-y/kg-d PEF = particulate emission factor, 1.36×10^9 m^3/kg VF = volatilization factor, none given	All	

TABLE 13 Basic Components of the Derivation Methodology *(see Appendix B for further details)*

State	Conc *(ppt)*	Equation	Parameters	Exposure Routes	Notes
OR	4.5	Conc = $\frac{TR \times AT}{EF_r\,[(IFS_{adj} \times SF_o \times CF)+(SFS_{adj} \times ABS \times SF_o \times CF)+(InhF_{adj} \times SF_i)/PEF]}$	TR = target cancer risk, 10^{-6} AT_r = averaging time, 25,550 d EF_r = exposure frequency, 350 d/y IFS_{adj} = age-adjusted soil ingestion factor, 114 $(mg\text{-}y/kg\text{-}d)^{-1}$ SF_o = oral slope factor, 130,000 $(mg/kg\text{-}d)^{-1}$ CF = 10^{-6} kg/mg SFS_{adj} = soil dermal contact factor, 361 mg-y/kg-d ABS = dermal absorption fraction, 0.03 $InhF_{adj}$ = 11 $(m^3\text{-}y/kg\text{-}d)$ SF_i = inh. slope factor, 130,000 $(mg/kg\text{-}d)^{-1}$ PEF = particulate emission factor, 1.316×10^9	All	Recent state update indicates that OR has adopted the CalEPA slope factor of 130,000 per mg/kg-d (which also underlies the current RSL), The available equation and parameter values (shown at left, with the updated slope factor information) are from 2003 documentation, which was based on the previous Region 9 PRG.
PA	120	MSC = $\frac{TR \times AT_c \times 365d/y}{CSF_o \times Abs \times EF \times IF_{adj} \times CF}$	TR = target risk, 10^{-5} AT_c = averaging time for carcinogens, 70 y CSF_o = oral cancer slope factor, 150,000 $(mg/kg\text{-}d)^{-1}$ Abs = absorption, 1.0 EF = exposure frequency, 250 d/y IF_{adj} = ingestion factor, 57.1 (mg-y/kg-d) CF = conversion	Ingestion	
TX	1,000	$^{ot}Soil_{Comb} = \frac{1}{[(1/^{Air}Soil_{Inh\text{-}VP})+(1/^{Soil}Soil_{Ing})+(1/^{Soil}Soil_{Derm})]}$	Not found		Derivation basis is not described. TX might have adopted OSWER values. Toxicity values and chemical-specific parameter values were not found online.

TABLE 13 Basic Components of the Derivation Methodology *(see Appendix B for further details)*

State	Conc *(ppt)*	Equation	Parameters	Exposure Routes	Notes
WA	11	$SCL = \frac{(RISK \times ABW \times AT \times UCF)}{(CPF \times SIR \times AB_1 \times ED \times EF)}$	SCL = soil cleanup level, mg/kg RISK = acceptable cancer risk level, 10^{-6} ABW = average body weight over the exposure duration, 16 kg AT = averaging time, 75 y UCF = unit conversion factor, 10^6 mg/kg CPF = 150,000 $(mg/kg\text{-}d)^{-1}$ SIR = soil ingestion rate, 200 mg/d AB1 = gastrointestinal absorption fraction, 0.6 ED = exposure duration, 6 y EF = exposure frequency, 1.0	Ingestion	
WY	4.5	See EPA RSL equation (last entry of this table)	See EPA RSL parameters (last entry)	All	State review feedback indicates the EPA RSL is the WY soil cleanup level.
		EPA Regional Screening Level Derivation for Residential Scenario			
EPA RSL	4.5	$RSL_{res} = \frac{1}{[(1/C_{res\ soil\ ingestion-ca})+(1/C_{res\ soil\ dermal-ca})+(1/C_{res\ soil\ inhalation-ca})]}$ where: $C_{res\ soil\ ingestion} = \frac{TR_r \times AT_r}{CSF_o \times ER_r \times IFS_{adj} \times CF}$ $C_{res\ soil\ dermal} = \frac{TR_r \times AT_r}{CSF_o \times ER_r \times DFS_{adj} \times ABS_d \times CF}$ $C_{res\ soil\ inhalation} = \frac{TR_r \times AT_r}{IUR(\mu g/m^3)^{-1} \times (1{,}000 \mu g/mg) \times ER_r \times (1/VF_s + 1/PEF) \times ED_r}$	TR = target cancer risk, 10^{-6} AT_r = averaging time, 25,550 d CSF_o = slope factor, 130,000 $(mg/kg\text{-}d)^{-1}$ ER_r = exposure frequency, 350 d/y ED_r = exposure duration, 30 y IFS_{adj} = age-adjusted soil ingestion factor, 114 (mg-y/kg-d) CF = 10^{-6} kg/mg DFS_{adj} = soil dermal contact factor, 361 mg-y/kg-d ABS_d = dermal absorption fraction, 0.03 IUR = 38 $(\mu g/m^3)^{-1}$ VF = volatilization factor PEF = particulate emission factor, 1.4×10^9 m^3/kg	All	

TABLE 14 Summary Comparison of State Derivations for Incidental Soil Ingestion *(main route for residential cleanup levels)*[a]

Generic equation for residential/unrestricted scenario,(incidental ingestion: $C_{res\_ing} = TR \times AT / SF_o \times EF \times IFS_{adj} \times 10^{-6}$ kg/mg						
State	**Conc** *(ppt)*	**Oral Cancer Slope Factor. SF_o** *(mg/kg-d)$^{-1}$*	**Target Cancer Risk, TR**	**Averaging Time** *(d)*	**Exposure Frequency, EF** *(d/y)*	**Soil Ingestion Factor, IFS_{adj} or (IR×ED)/BW** *(mg-y/kg-d)*
NE	3.9	150,000	10^{-6}	25,550	350	114
DE	4	150,000	10^{-6}	25,550	350	114
MS	4.26	150,000	10^{-6}	25,550	350	114
AZ	4.5	130,000	10^{-6}	25,550	350	114
MD	4.5	130,000	10^{-6}	25,550	350	114
OR	4.5	130,000	10^{-6}	25,550	350	114
WY	4.5	130,000	10^{-6}	25,550	350	114
FL	7	150,000	10^{-6}	25,550	350	69
NH	9	150,000	10^{-6}	25,550	160	105
ME	10	130,000	10^{-6}	25,550	150	120
WA	11	150,000	10^{-6}	27,375	365	75
IA	19	150,000	5×10^{-6}	25,550	350	114
MN	20	1,400,000	10^{-5}	25,550	350	45
OH	35.8	150,000	10^{-5}	25,550	350	114
AK	38	150,000	10^{-5}	25,550	330	114
IN	45	150,000	10^{-5}	25,550	250	114
KS	60	150,000	10^{-5}	25,550	350	42
GA	80	(not specified)	10^{-5}	25,550	350	48
MI	90	75,000	10^{-5}	25,550	350	114
PA	120	150,000	10^{-5}	25,550	250	57
HI	390	150,000	10^{-4}	25,550	350	114
AS	450	130,000	10^{-4}	25,550	350	114
GM	450	130,000	10^{-4}	25,550	350	114
NMI	450	130,000	10^{-4}	25,550	350	114

[a] Shading highlights variations within related entries. Note the internal draft provisional value of 60 ppt for Indiana uses a SF value of 130,000. AL and TX identify a cleanup level of 1,000 ppt, which is the concentration recommended in the OSWER directive for a residential scenario.

3.3.2 Toxicity Values

Most states that list soil cleanup levels for dioxin also indicate the health basis (24 of 26). Only one cleanup level is based on the noncancer endpoint: the Iowa nonresidential level, which applies only when dioxin is the only chemical of concern. This soil concentration (360 ppt) reflects a reference dose of 10^{-9} mg/kg-d, which is the same as the ATSDR (1998/2008) chronic oral MRL. (An MRL represents the estimate of daily human exposure to a hazardous substance likely to be without appreciable risk of adverse noncancer health effects for exposure extending over a year to a lifetime.)

For the rest of the cleanup levels across both land use categories, cancer is the driver. (This includes the Iowa residential level of 19 ppt, although the state also identifies a residential level of 72 ppt based on the noncancer endpoint, when dioxin is the only contaminant.) Incidental ingestion is the key exposure route, and the oral slope factor is the toxicity value of interest. *(As a note, although online information for Texas indicates that both the residential and commercial/ industrial cleanup levels are based on the noncancer endpoint ["n"], no information is given for the toxicity value, and field followup confirmed that the basis is cancer; see Table B.6.)*

Four different cancer slope factors have been applied across the 24 states that identify a toxicity value: 75,000; 130,000; 150,000; and 1,400,000 $(mg/kg\text{-}d)^{-1}$. These slope factors are based on one of two rodent bioassays published more than 25 years ago, combined with modeling derivations by CalEPA, U.S. EPA, and other scientific groups to estimate the incremental risk to humans of getting cancer over a lifetime. The data sources cited by the various states range from old HEAST tables to CalEPA, the EPA (2003a) draft dioxin reassessment, and former and current EPA Regional screening level tables.

All but two states use a slope factor of either 130,000 or 150,000 $(mg/kg\text{-}d)^{-1}$ for their soil cleanup levels. These very similar values are based on two different bioassays. The first is derived from the chronic rodent bioassay from NTP (1982). The second is based on the two-year dietary study of Sprague-Dawley rats by Kociba et al. (1978), as are the lowest and highest of the four values listed above (75,000 and 1,400,000). These two original toxicity studies were independently peer reviewed as part of the scientific publication process, as were the subsequent derivations of the slope factors.

In the Kociba et al. (1978) bioassay, female rats that were exposed to the highest study dose (0.1 µg/kg-d, or a dietary level of 2,200 ppt) exhibited a higher incidence of hepatocellular carcinoma and squamous cell carcinoma of lungs, hard palate, nasal turbinates, and tongue, yet a decreased incidence of other tumors. Lesser effects were reported at 0.01 µg/kg-d (210 ppt), while no adverse effects were reported at 0.001 µg/kg-d (22 ppt), and no carcinogenic effects were reported at either 0.01 or 0.001 µg (210 or 22 ppt). These findings were considered to support a previous study that had indicated chronic intake of 5,000 ppt TCDD could lead to many toxicological effects. The initial evaluation of these data to derive a slope factor produced a value of 150,000 $(mg/kg\text{-}d)^{-1}$, which is used by more than half the states (13 of 24). As a note, this value has also been used to determine supporting concentrations for other states, such as the Nevada basic comparison (screening) level.

Updated evaluations of the same data were used by Michigan and Minnesota, the two states with different slope factors than the rest. In 1986, the NTP revised its tumor classification scheme, and scientists (including Kociba and his colleague Squire, as well as EPA work groups) used that methodology to reevaluate the incidence of female rat liver tumors and other tumors from the 1978 data. This reevaluation identified a lower tumor incidence, which produced a lower toxicity value. A slope factor of 52,000 $(mg/kg\text{-}d)^{-1}$ was determined based on liver tumors alone, and a slope factor of 75,000 $(mg/kg\text{-}d)^{-1}$ was determined based on total significant tumors. Michigan used the latter (half the older slope factor) to determine its soil cleanup level.

In 2003, the Minnesota Department of Health (MNDOH) selected the draft slope factor of 1,400,000 $(mg/kg\text{-}d)^{-1}$ from the range of values presented in the EPA 2003 draft dioxin reassessment. This value, derived from the Kociba study, was identified as the upper bound for animal bioassays. At roughly 10 times the two most commonly applied toxicity values (and nearly 20 times the Michigan value), this slope factor was also used in a supporting role by the Pacific island group. That is, it was used to estimate a concentration that could be used as the lower bound of an operational cleanup range, as a companion to the standard cleanup levels above which remedial action should be considered. Those main cleanup levels (which are the representative concentrations shown in key figures and tables of this report) were derived using a toxicity value of either 150,000 $(mg/kg\text{-}d)^{-1}$ (for Hawaii) or 130,000 $(mg/kg\text{-}d)^{-1}$ (American Samoa, Guam, and the Northern Mariana Islands).

The slope factor of 130,000 $(mg/kg\text{-}d)^{-1}$ is used by a third of the states and is being considered by an additional state for a provisional level. This value is derived from a chronic study of Osborne-Mendel rats dosed by gavage 3 times/week, and B6C3F1 mice gavaged 2 days/week (NTP, 1982). Summarizing the toxicity basis from the ATSDR toxicological profile for chlorinated dibenzo-*p*-dioxins (ATSDR, 1998/2008): a dose of about 0.007 µg/kg-d significantly increased the incidence of thyroid follicular cell adenoma; a dose ten times higher increased the incidence of neoplastic nodules in the liver and hepatocellular carcinoma in females. At 0.1 and 0.01 µg/kg-d, females exhibited a significant increase in hepatocellular hyperplastic nodules, while those at the next lower dose (0.001 µg/kg-d) did not. Total weekly doses were averaged to estimate a daily dose level, which assumes daily dosing would give the same results. (As described in the ATSDR summary, because the TCDD half-life is relatively long, both schedules were expected to give similar tissue concentrations.) The rat data were converted to equivalent human exposures with basic scaling factors; assumptions included: oral and inhalation routes are equivalent, air concentration is assumed to be the daily oral dose, the exposure route does not affect absorption, and TCDD metabolism/pharmacokinetics do not differ between animals and humans.

CalEPA (2002/2003) documents the application of a linearized multistage model to these NTP rodent hepatocellular adenoma/carcinoma tumor data to derive the slope factor. Early development of this slope factor is documented in the 1986 California Department of Health Services derivation report prepared for the CalEPA Toxic Air Contaminant program. This value underwent external peer review by the California Air Resources Board (CARB) scientific review panel and was endorsed in 2002 when it was summarized and included in the CalEPA (2002) Air Toxics Hot Spots Program Technical Support Document for Describing Available Cancer Slope Factors. External review by the scientific panel (primarily members of academia) was in accordance with a process that has been in place since 1983, per the original state air toxics legislation from the early 1980s as documented by CalEPA (1999).

This slope factor of 130,000 $(mg/kg\text{-}d)^{-1}$ underlies the basic soil cleanup levels identified for Arizona and Oregon, as well as the three Pacific island territories (American Samoa, Guam, and the Northern Mariana Islands), as indicated above. This oral toxicity value is also reflected in the current EPA Regional screening level (RSL), which has been adopted by Maryland and Wyoming. In addition, it underlies the draft cleanup level recently developed by Maine and the internal draft being developed by Indiana – bringing the total number considering this slope factor to nine.

3.3.3 Target Risk Levels

The target risks used by states to back-calculate a soil cleanup concentration by combining exposure inputs with the toxicity value range from 10^{-4} to 10^{-6}, consistent with the EPA target incremental risk range for contaminated sites. As shown in Tables 12 and 14 and the accompanying figures, almost half the states that identify a target risk for their residential or unrestricted cleanup levels (11 of 24) apply the lower-end value of 10^{-6}. Eight use 10^{-5}, and one (Iowa) applies a value between these two (5×10^{-6}). The last four (Hawaii, American Samoa, Guam, and the Northern Mariana Islands) use the upper value of 10^{-4}. Most apply the same values for the companion commercial/industrial cleanup levels, but 2 of the 11 states that use 10^{-6} for residential cleanup (Nebraska and Washington) use 10^{-5} instead for the restricted scenarios. Spanning two orders of magnitude, this component of the derivation calculation is the key reason for differences among state cleanup levels.

3.3.4 Differences among State Cleanup Levels

The biggest reason for the fairly wide range of state-derived cleanup levels is the target risk applied, which accounts for 100-fold differences. A second reason is the slope factor, which accounts for differences of about 20-fold, with the Minnesota value about 10 times higher than the two values used by most states, and the Michigan value about half those values.

A third reason is the variation in the exposure assumptions applied, generally accounting for differences of less than 10-fold. This is illustrated by the comparison of input values used by different states for incidental soil ingestion, the primary route contributing to unrestricted/residential cleanup levels. Highlighting the values for this exposure alone offers a quick indication of similarities and differences across states, as was shown in Table 14.

Beyond that single-route comparison, it is also helpful to compare the contributions from additional routes. For this evaluation, the calculation used to derive the U.S. EPA Regional screening level (RSL) for unrestricted use was selected as the starting point. This equation and parameter values provide a useful anchor not only because the state calculations follow this same general form, but also because several states have actually adopted the RSLs as cleanup levels for residential and industrial scenarios, respectively.

The state cleanup values were normalized to their target risks to control the impact of that factor. The route-specific soil concentrations were also normalized to target risk. Table 15 presents these route-specific comparisons to the parallel RSL values. This table also identifies the contribution of each exposure route to the ultimate soil cleanup level (as a percent), to highlight the main contributors.

An additional consideration is the chemical basis, i.e., whether the value is for TCDD or TEQ. This can account for differences of at least several-fold; the factor can be higher depending on the environmental mixture. Seven states and three Pacific island territories define their cleanup levels as TEQs: Florida, Hawaii, Maine, Michigan, Minnesota, Ohio, Texas, American Samoa, Guam, and the Northern Mariana Islands. (Wyoming adopts the EPA Regional screening level for TCDD and indicates TEFs may be considered for others.) While values reported as TEQs would generally be expected to be higher than those for TCDD alone, and indeed five of the six highest residential levels are TEQ, these values are also found at the other end of the concentration range. For example, half of the ten TEQ-based cleanup levels are less than 120 ppt, and 30 percent of the state cleanup levels below 36 ppt are as TEQ.

Table 15 Main Factors Leading to Differences in Cleanup Levels for the Unrestricted/Residential Scenario[a]

Comparison basis, EPA RSL equation for cancer endpoint, unrestricted/residential scenario:

$$RSL_{res} = \frac{1}{[(1/C_{res\ soil\ ingestion})+(1/C_{res\ soil\ dermal})+(1/C_{res\ soil\ inhalation})]} = 4.5\times10^{-6}\ mg/kg$$

Where:

$$C_{res\ soil\ ingestion} = \frac{TR\times AT}{CSF_o\times EF\times IFS_{adj}\times CF} = 4.9\times10^{-6}\ mg/kg$$

$$C_{res\ soil\ dermal} = \frac{TR\times AT}{CSF_o\times EF\times DFS_{adj}\times ABS_d\times CF} = 5.2\times10^{-5}\ mg/kg$$

$$C_{res\ soil\ inhalation} = \frac{TR\times AT}{IUR(\mu g/m^3)^{-1}\times(1{,}000\mu g/mg)\times EF\times(1/VF_s+1/PEF)\times ED} = 8.7\times10^{-2}\ mg/kg$$

- TR = target cancer risk, 10^{-6}
- AT = averaging time, 25,550 d
- CSF_o = slope factor, 130,000 $(mg/kg\text{-}d)^{-1}$
- EF = exposure frequency, 350 d/y
- ED = exposure duration, 30 y
- IFS_{adj} = age-adjusted soil ingestion factor, 114 (mg-y/kg-d)
- CF = 10^{-6} kg/mg
- DFS_{adj} = soil dermal contact factor, 361 mg-y/kg-d
- ABS_d = dermal absorption fraction, 0.03
- IUR = 38 $(\mu g/m^3)^{-1}$
- VF = volatilization factor
- PEF = particulate emission factor, 1.4×10^9 m^3/kg

(Table 15)

State	Conc *(ppt)*	Target Risk *(TR)*	Ratio to RSL TR	Ingestn Subtotal *(ppt)*	Ratio to Ingestn RSL	Ingestion Contribution to Cleanup Level *(%)*	Dermal Subtotal *(ppt)*	Ratio to Dermal RSL	Dermal Contribution to Cleanup Level *(%)*	Inhaln Subtotal *(ppt)*	Ratio to Inhaln RSL	Inhalation Contribution to Cleanup Level *(%)*	Explanation of Differences between State Value and EPA RSL
						Component and Comparison to EPA RSL Values							
EPA RSL	*4.5*	*10^{-6}*	*1*	*4.9*	*1*	*91*	*5.2×10^{1}*	*1*	*9*	*8.7×10^{4}*	*1*	*<1*	-
NE	3.9	10^{-6}	1	4.3	0.9	91	4.5×10^{1}	0.9	9	8.9×10^{8}	$>10^{4}$	<1	The CSF_o of 150,000 $(mg/kg\text{-}d)^{-1}$ accounts for the difference. Although it has a negligible impact on the final cleanup value, NE cites an IUR that is 10,000 times lower than that used to calculate the RSL.
DE	4	10^{-6}	1	4.3	0.9	100							Ingestion route only. CSF_o of 150,000 $(mg/kg\text{-}d)^{-1}$.
MS	4.26	10^{-6}	1	4.3	0.9	100							Ingestion route only. CSF_o of 150,000 $(mg/kg\text{-}d)^{-1}$.
AZ	4.5	10^{-6}	1	4.9	1	91	5.2×10^{1}	1	9	8.7×10^{4}	1	<1	AZ has adopted the RSL for the unrestricted/residential scenario.

(Table 15)

State	Conc *(ppt)*	Component and Comparison to EPA RSL Values											Explanation of Differences between State Value and EPA RSL
		Target Risk *(TR)*	**Ratio to RSL TR**	**Ingestn Subtotal** *(ppt)*	**Ratio to Ingestn RSL**	**Ingestion Contribution to Cleanup Level** *(%)*	**Dermal Subtotal** *(ppt)*	**Ratio to Dermal RSL**	**Dermal Contribution to Cleanup Level** *(%)*	**Inhaln Subtotal** *(ppt)*	**Ratio to Inhaln RSL**	**Inhalation Contribution to Cleanup Level** *(%)*	
MD	4.5	10^{-6}	1	4.9	1	91	5.2×10^{1}	1	9	8.7×10^{4}	1	<1	MD has adopted the RSL for the unrestricted/residential scenario.
OR	4.5	10^{-6}	1	4.9	0.9	91	5.2×10^{1}	0.9	9	6.7×10^{4}	0.7	<1	OR 2003 document indicates use of the previous Region 9 PRG equation; 2009 update indicates adoption of the current CalEPA CSF of 130,000 $(mg/kg\text{-}d)^{-1}$, which also underlies the current RSL.
WY	4.5	10^{-6}	1	4.9	1	91	5.2×10^{1}	1	9	8.7×10^{4}	1	<1	WY has adopted the RSL for the unrestricted/residential scenario.
FL	7	10^{-6}	1	7.0	1.4	94	1.6×10^{2}	3.1	4	3.2×10^{2}	.004	2	Difference can largely be explained by FL-specific calculations for aggregate resident attributes and their impact on the ingestion calculation: BW = 51.9 kg, IR_o = 120 mg/d, SA = 4,810 cm^2/d. Using these values, the FL equivalent IFS_{adj} is only 60 percent of that used in the RSL calculations. This along with a CSF_o of 150,000 $(mg/kg\text{-}d)^{-1}$ accounts for most of the difference. The ABS_d of 0.01 makes the dermal route contribution three times higher than the RSL value. The FL use of VF accounts for the significantly lower inhalation route contribution.
NH	9	10^{-6}	1	1.0×10^{1}	2.1	92	1.2×10^{2}	2.2	8				Difference can largely be explained by the EF (160 d/y), which is less than half that used in the RSL calculation. This along with a CSF_o of 150,000 $(mg/kg\text{-}d)^{-1}$ accounts for a value twice as high as the RSL. Although less significant, NH does use different values for BW, exposed skin area (SA), and adherence factor (AF).

(Table 15)

State	Conc *(ppt)*	Target Risk *(TR)*	Ratio to RSL TR	Ingestn Subtotal *(ppt)*	Ratio to Ingestn RSL	Ingestion Contribution to Cleanup Level *(%)*	Dermal Subtotal *(ppt)*	Ratio to Dermal RSL	Dermal Contribution to Cleanup Level *(%)*	Inhaln Subtotal *(ppt)*	Ratio to Inhaln RSL	Inhalation Contribution to Cleanup Level *(%)*	Explanation of Differences between State Value and EPA RSL
		Component and Comparison to EPA RSL Values											
ME	10	10^{-6}	1	1.1×10^{1}	2.2	91	1.2×10^{2}	2.2	9	2.4×10^{6}	27.6	<1	Similar to NH, the difference in the ME level can largely be explained by an EF (150 d/y) that is less than half that used in the RSL calculation. Although it has a negligible impact, ME uses a children's BW of 14 kg instead of 15 kg.
WA	11	10^{-6}	1	1.1×10^{1}	2.2	100							WA uses a number of exposure assumptions that differ from those of most other states. The level appears to be derived based on several parameter values for a child: ED = 6 y; BW = 16 kg; IR = 200 mg/d. Also, the WA AT is 75 y.
IA	19	5×10^{-6}	5	4.3	0.9	91	4.5×10^{1}	0.9	9				The difference can be explained by a TR that is five times higher than that used for the RSL, along with a CSF_o of 150,000 $(mg/kg\text{-}d)^{-1}$.
MN	20	10^{-5}	10	2.1	0.4	77	1.5×10^{1}	0.3	11	1.3×10^{1}	0.0001	12	MN uses a TR of 10^{-5} and a CSF_o of 1,400,000 $(mg/kg\text{-}d)^{-1}$. However, these two inputs essentially cancel each other with respect to a net difference compared with the RSL (because they are both about 10 times higher than parallel RSL values and the TR is divided by the CSF_o). Other differences in exposure assumptions, particularly the IR (68 mg/d, age-adjusted), help explain the difference between the MN value and RSL. Other differences include: ED = 33 y; age-adj BW = 51 kg; age-adj dermal EF = 97 d/y. Differences in the inhalational route can be explained by a given VF value and an IUR that is 10 times higher than the parallel RSL value.

(Table 15)

State	Conc *(ppt)*	Component and Comparison to EPA RSL Values: Target Risk *(TR)*	Ratio to RSL TR	Ingestn Subtotal *(ppt)*	Ratio to Ingestn RSL	Ingestion Contribution to Cleanup Level *(%)*	Dermal Subtotal *(ppt)*	Ratio to Dermal RSL	Dermal Contribution to Cleanup Level *(%)*	Inhaln Subtotal *(ppt)*	Ratio to Inhaln RSL	Inhalation Contribution to Cleanup Level *(%)*	Explanation of Differences between State Value and EPA RSL
OH	35.8	10^{-5}	10	4.3	0.9	84	2.3×10^{1}	0.4	16	6.1×10^{4}	0.7	<1	Difference can largely be accounted for by the OH TR of 10^{-5} and CSF_o of 150,000 $(mg/kg\text{-}d)^{-1}$. Also, when calculating the dermal term, OH divides the CSF_o by an oral abs factor of 0.5, so the dermal term is half the value used for the RSL. Consequently, this term has a greater effect in terms of reducing the final cleanup level. The contribution from the inhalation route is negligible.
AK	38	10^{-5}	10	4.5	0.9	84	2.4×10^{1}	0.5	16				The AK difference can largely be explained by a TR of 10^{-5} and CSF_o of 150,000 $(mg/kg\text{-}d)^{-1}$. Like OH, AK uses a dermal CSF of 300,000 $(mg/kg\text{-}d)^{-1}$. Although its impact is negligible, AK uses an EF of 330 d instead of 350 d.
IN	45	10^{-5}	10	6.0	1.2	75	1.8×10^{1}	0.34	25	8.2×10^{4}	0.9	<1	For the ingestion route, IN uses a CSF_o of 150,000 $(mg/kg\text{-}d)^{-1}$ and an EF of 250 d/y instead of 350 d/y. For the dermal route, IN uses a DFS_{adj} (1,257 mg-y/kg-d) that is 3.5 higher than the value used in the RSL calculation. This value and the EF account for dermal route differences.

(Table 15)

State	Conc *(ppt)*	Target Risk *(TR)*	Ratio to RSL TR	Ingestn Subtotal *(ppt)*	Ratio to Ingestn RSL	Ingestion Contribution to Cleanup Level *(%)*	Dermal Subtotal *(ppt)*	Ratio to Dermal RSL	Dermal Contribution to Cleanup Level *(%)*	Inhaln Subtotal *(ppt)*	Ratio to Inhaln RSL	Inhalation Contribution to Cleanup Level *(%)*	Explanation of Differences between State Value and EPA RSL
		Component and Comparison to EPA RSL Values											
KS	60	10^{-5}	10	1.1×10^{1}	2.3	50	1.1×10^{1}	0.2	50	6.8×10^{4}	0.78	<1	In addition to a TR of 10^{-5} and CSF_o of 150,000 $(mg/kg\text{-}d)^{-1}$, differences in the KS exposure assumptions for the oral and dermal routes contribute to the difference between the RSL and KS value. In particular, KS does not use an age-adj IFS but rather assumes an IR of 100 mg/d, a BW of 70 kg, and an ED of 30 y. Consequently, the KS equivalent IFS of 42 $(mg\text{-}y/kg\text{-}d)^{-1}$ is nearly three times smaller than the age-adj IFS used for the RSL. This factor of three is reflected in the ingestion-based concentration. Similar assumptions are made for the dermal route. The KS ABS_d of 0.1 instead of 0.03 makes the dermal-based concentration smaller, which gives it a greater impact on the overall cleanup level.
GA	80	10^{-5}	10	*Not found*	*Cannot be deter-mined*	*Cannot be determined*	*Not found*	*Cannot be deter-mined*	*Cannot be determined*	*Not found*	*Cannot be deter-mined*	*Cannot be determined*	Online information indicates that GA uses a TR of 10^{-5}, and it appears that GA does not apply a grouped age-adj IFS but rather an EF = 30 y, soil IR = 114 mg/d, and BW = 70 kg resulting in an IFS-equivalent value of 49 mg-y/kg-d. This value, which is less than half the RSL IFS_{adj}, would help explain the difference in the GA value after it has been normalized per the TR.

(Table 15)

State	Conc *(ppt)*	Component and Comparison to EPA RSL Values: Target Risk *(TR)*	Ratio to RSL TR	Ingestn Subtotal *(ppt)*	Ratio to Ingestn RSL	Ingestion Contribution to Cleanup Level *(%)*	Dermal Subtotal *(ppt)*	Ratio to Dermal RSL	Dermal Contribution to Cleanup Level *(%)*	Inhaln Subtotal *(ppt)*	Ratio to Inhaln RSL	Inhalation Contribution to Cleanup Level *(%)*	Explanation of Differences between State Value and EPA RSL
MI	90	10^{-5}	10	1.7×10^{1}	3.5	53	1.9×10^{1}	0.4	47				In addition to a TR of 10^{-5}, MI uses a CSF_o of 75,000 $(mg/kg\text{-}d)^{-1}$ and an oral absorption efficiency of 0.5 for the soil ingestion calculation. These differences account for a C_{ing} that is 3.5 times higher than the RSL value after both have been normalized per TR. In addition, the MI DFS_{adj} (2442 mg-y/kg-d) is significantly higher than the value used to calculate the RSL. This in turn makes the dermal-based concentration smaller which gives it a greater impact on the overall cleanup level.
PA	120	10^{-5}	10	1.2×10^{1}	2.4	100							In addition to a TR of 10^{-5} and CSF_o of 150,000 $(mg/kg\text{-}d)^{-1}$, PA uses an IFS_{adj} (57.1 mg-y/kg-d) – which is half the value used to derive the RSL. In addition, PA uses an EF of 250 d/y instead of 350 d/y. These differences make the ingestion contribution 2.4 times higher than the equivalent RSL after both have been normalized per the TR.
HI	390	10^{-4}	100	4.3	0.9	91	4.5×10^{1}	0.9	9	8.7×10^{4}	1	<1	HI uses the same equations and parameter values as the EPA RSL except for applying a TR of 10^{-4} and a CSF_o of 150,000 $(mg/kg\text{-}d)^{-1}$.
AS	450	10^{-4}	100	4.9	1	91	5.2×10^{1}	1	9	8.7×10^{4}	1	<1	AS adopted the EPA RSL equations and parameter values except for using a TR of 10^{-4}.
GM	450	10^{-4}	100	4.9	1	91	5.2×10^{1}	1	9	8.7×10^{4}	1	<1	GM adopted the EPA RSL equations and parameter values except for using a TR of 10^{-4}.
NMI	450	10^{-4}	100	4.9	1	91	5.2×10^{1}	1	9	8.7×10^{4}	1	<1	NMI adopted the EPA RSL equations and parameter values except for using a TR of 10^{-4}.

[a] Table 15 notes:

Ingestn = incidental soil ingestion; inhaln = inhalation.

To facilitate comparisons, cleanup concentrations were calculated for each route (i.e. ingestion, dermal, inhalation) contributing to an individual state cleanup level and normalized by the total target risk applied for the state. This allowed for a more direct comparison of component values across states. The EPA RSL was used as the standard reference point. Individual route-based concentrations for each state were compared to the parallel concentrations for the RSL as a ratio. The contributions to total target risk and overall cleanup levels were also compared as ratios. Entries shaded gray indicate those routes are not included in the state cleanup level calculation.

AL and TX identify a cleanup level of 1,000 ppt, which is the concentration recommended in the OSWER directive for a residential scenario.

These normalized comparisons show that incidental ingestion accounts for nearly 75 to 85 percent of the cleanup levels for Arkansas, Indiana, Minnesota, and Ohio (which range from 20 to 45 ppt). For Kansas and Michigan, incidental ingestion accounts for half the cleanup concentrations (which are 60 and 90 ppt, respectively), while the other half comes from the dermal route. The dermal route also accounts for the rest of the Arkansas, Indiana, and Ohio values, while for Minnesota this route roughly splits the remaining portion with inhalation (jointly accounting for 23 percent of the 20 ppt cleanup level). For the rest of the states, incidental ingestion accounts for at least 90 percent of the cleanup concentration. Contributions of these other routes are also higher for selected nonresidential scenarios, such as the trench worker.

3.4 EVALUATION CRITERIA

The four criteria considered in evaluating information compiled for the state soil dioxin cleanup levels are:

- Nature of peer review.
- Transparency-public availability.
- Scientific basis.
- Incorporation of most recent science.

In many cases, only limited information was found to address these criteria during the online search. For this reason, a checklist that emphasized the type of documentation needed to effectively consider these criteria was provided to the field (Appendix A), together with site-specific clarification questions, to guide review and feedback. The feedback did little to address gaps in this area – particularly with regard to the nature of the peer review and transparency. Context for the evaluation criteria is included in the data tables of Appendix B and highlighted in overview tables of Chapter 3. Key information for the criteria is summarized in Section 4.3.

4 SUMMARY AND DISCUSSION

This chapter summarizes the range of soil concentrations identified in the search for state dioxin cleanup levels (Section 4.1), indicates key contributors to similarities and differences (Section 4.2), and considers the context provided by the evaluation criteria (Section 4.3).

4.1 STATE SOIL CLEANUP LEVELS FOR DIOXIN

Information on dioxin cleanup levels was pursued for all 50 states plus DC, Puerto Rico, the Virgin Islands, and four Pacific Rim islands. Online checks extended from state and other government agency websites to the EPA database of site cleanup decisions, and peer-reviewed scientific literature.

About 280 cleanup values were identified for dioxin in soil. Nearly half the states and territories (26), including three Pacific island territories, have established cleanup levels for unrestricted/ residential use, and 21 of these have also established levels for commercial/industrial use. These cleanup levels address scenarios ranging from intensive residential use to occupational activities such as outdoor maintenance and excavation work. Within each of these sets (unrestricted/residential and commercial/industrial), the cleanup concentrations span three orders of magnitude. A key reason for this spread is that different states have adopted different existing values as their cleanup levels. At the upper end are states that tap the recommended concentration from the OSWER directive. At the lower end are those that adopt a screening value as their cleanup level.

For those states that have derived cleanup levels, the following factors contribute to differences:

- Target risk.
- Cancer slope factor.
- Exposure assumptions.
- Reporting basis (as TCDD or dioxin TEQ).

Frequency distributions of the representative state soil cleanup values for dioxin addressing both unrestricted and restricted scenarios are presented in Figure 22.

(Although online information for the Trust Territories appears to suggest the same values as for Guam, American Samoa, and the Northern Mariana Islands, those values have not been included in the tables and figures of this report per limited field feedback, which indicated that the Trust Territories determine cleanup levels on a site-specific basis.)

Because many states identify multiple cleanup levels for dioxin in soil, to facilitate comparisons, the figures and tables focus on a representative cleanup level for each state and land use category (where available) – i.e., unrestricted/residential and commercial/industrial (restricted). Although some states indicate cleanup levels should be determined on a site-specific basis, the representative state values do not include any concentrations from site-specific decisions.

For unrestricted/residential land use:

- Cleanup levels range from about 4 to 1,000 ppt. Two states use the value of 1,000 ppt recommended in the OSWER directive as TEQ. Texas reports this value as TEQ, and Alabama reports it as TCDD. (As a note, North Carolina identified this value as a preliminary soil remediation goal in December 2009.)

- More than 75 percent of the values (20) are at or below 120 ppt, and most of these (15) are less than 40 ppt.

The seven lowest concentrations are consistent with values commonly used for preliminary screening evaluations at contaminated sites, 3.9 to 4.5 ppt. This indicates that nearly a third of the states with cleanup levels have essentially adopted a value intended for screening purposes. The screening levels are based on a target risk of 10^{-6} and relatively conservative residential exposure assumptions.

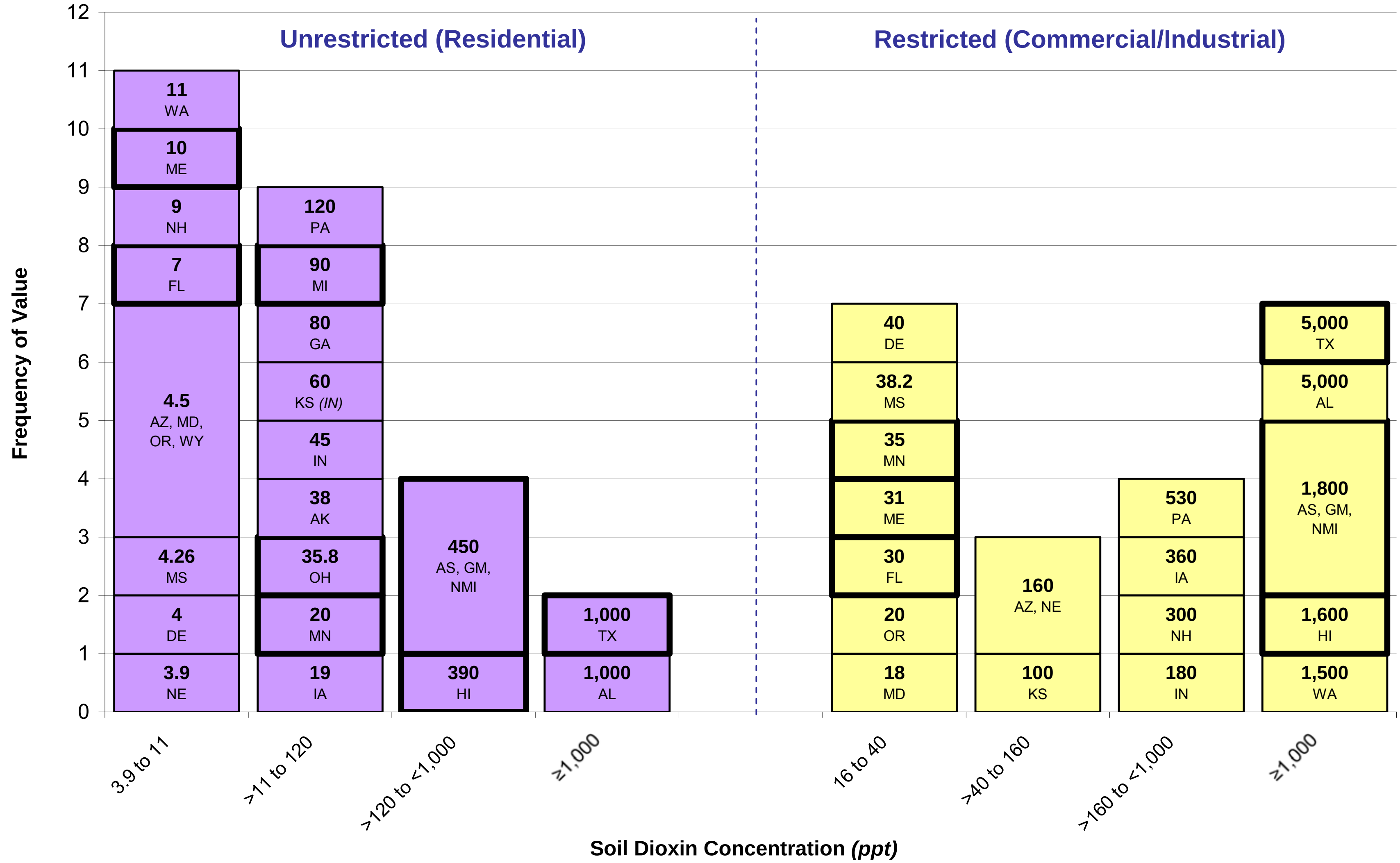

FIGURE 22 Distribution of Soil Cleanup Levels by Concentration: Unrestricted and Restricted Uses

(A dark border indicates the basis is TEQ rather than TCDD; italics in parenthesis indicate a draft value)

- The concentration group above 120 ppt contains four values that are 100 times higher than these "screening" parallels – at 390 to 450 ppt – for Hawaii and three Pacific Rim islands (documented in 2006 and 2008, respectively). These concentrations reflect the higher target risk of 10^{-4} and are as dioxin TEQ. Several other states also report cleanup levels as TEQs, notably Florida, Maine, Michigan, Minnesota, and Ohio.

- Five of the six highest concentrations are reported as TEQ, as are 30 percent of the lowest 14 values.

For restricted commercial/industrial land use:

- 21 states and territories have established restricted cleanup levels. The five states for which values were identified for residential but not restricted use are Alaska, Georgia, Ohio, Michigan, and Wyoming.

- These cleanup levels are higher than those for unrestricted use by roughly a factor of 5, as expected based on less extensive exposures and in some cases less restrictive target risks. These concentrations are also more broadly distributed – spanning a factor of 270 (compared to 250 for the residential cleanup levels).

- The lowest third of restricted use levels falls between 16 and 40 ppt, the middle third ranges from 100 to just above 500 ppt, and the top third (which includes Hawaii and three Pacific island territories) ranges from 1,500 to 5,000 ppt. Alabama and Texas identify the top soil concentration, which is the lowest end of the range identified in the OSWER directive for commercial/industrial use (5,000 to 20,000 ppt).

The plots of cleanup values organized by EPA Region indicate:

- No clear regional patterns exist for either land use category, beyond the similarities in concentrations identified for the Pacific island set in Region 9 (for which development of the guidance included the same experts).

- States in U.S. EPA Regions 2, 3, 6, and 8 have established the fewest cleanup levels for dioxin in soil, although screening levels have been established by most.

Factors affecting these totals by region include: (1) some states do not have the same issue (extent) of dioxin-contaminated sites as others, and (2) a number of states have eschewed establishing a general cleanup level, calling instead for these to be determined on a site-specific basis to incorporate consideration of local conditions. For this reason, concentrations established for cleanup decisions were also reviewed as supporting context, with an emphasis on states that had not established a cleanup level or screening value; these data are tabulated Appendix B. This review of site applications indicates:

- More cleanup levels were found for states and territories within Regions 9 and 10 (nearly 100 combined) than for the other regions.

- About half the site-specific cleanup levels reflect the concentration of 1,000 ppt, particularly in states that had not established cleanup values for dioxin in soil at the time of those decisions.

4.2 FACTORS CONTRIBUTING TO SIMILARITIES AND DIFFERENCES

Key contributors to similarities among the state cleanup levels include: the common underlying approach, the use of generally similar exposure factors, and in several cases, adoption of the same values as cleanup levels. Key contributors to differences include: the target risk levels, toxicity values, and selected exposure assumptions.

It is also noteworthy that a number of states are similar in having deferred establishing generic cleanup levels, invoking instead a risk-based determination of these levels that account for site-specific conditions. Thus, no generic cleanup levels for dioxin were identified for 15 states and one territory.

In fact, this approach is also taken by the same number of states that identify screening values but no cleanup levels. For example, while Arkansas lists concentrations of 4.5 and 18 ppt as screening levels for residential and industrial scenarios, respectively, and Massachusetts lists values of 20, 50, and 300 ppt (as TEQ) for specific residential to restricted scenario categories from essentially a screening approach, both refer to the need for site-specific determinations of actual cleanup levels.

4.2.1 Exposure Calculations

States that have identified soil cleanup levels generally follow the standard EPA approach to determine such values, including common default assumptions. Variations in cleanup levels reflect the scenarios and exposure routes considered and the parameter values applied, which in some cases account for regional context. For example, a trench worker scenario is included for the development of cleanup levels for several Pacific islands.

The summary of inputs for incidental ingestion in Table 14 illustrate that a key difference underlying the state cleanup levels is the target risk – by a factor of 100, while the slope factors differ by a factor of about 20. For this ingestion calculation, which is the key exposure route for direct contact (unrestricted use), the values for exposure frequency differ by a factor of 2.4, and those for the age-adjusted soil ingestion factor differ by less than a factor of 3. Inhalation and dermal exposures also contribute measurably to some cleanup levels, especially for certain nonresidential (restricted) scenarios. The exposure equations presented in Table 13 underlie the summary of key differences captured in Table 15, including relative route contributions. A further consideration is whether the cleanup level is for TCDD or dioxin TEQ.

4.2.2 Toxicity Values

Cancer is the driving endpoint, and the toxicity value of interest is the oral slope factor. The four values identified across the 24 states that provide this information are within a factor of 20.

The slope factor of 150,000 $(mg/kg\text{-}d)^{-1}$ underlies the cleanup level for more than half the states: Alaska, Delaware, Florida, Hawaii, Iowa, Indiana, Kansas, Mississippi, Nebraska, New Hampshire, Ohio, Pennsylvania, and Washington. This is an older value based on the data from Kociba et al. (1978) using outdated methodology.

These Kociba et al. (1978) data were reevaluated with the updated (1986) NTP tumor classification scheme, which is based on all significant tumors rather than liver tumors alone. This updated evaluation halved the slope factor to 75,000 $(mg/kg\text{-}d)^{-1}$. One state, Michigan, uses this number.

The slope factor of 1,400,000 $(mg/kg\text{-}d)^{-1}$ is a draft value that was among those discussed in the EPA draft dioxin reassessment (EPA, 2003a). This was presented as the upper bound value from animal bioassay data, and it too was based on analyses of the Kociba et al. (1978) data. This draft value (40 percent higher than the upper bound based on human epidemiological data) was used by Minnesota to calculate its soil cleanup level. At roughly ten times the values commonly used by most other states (and about 20 times higher than the Michigan value), this value was also used in a supporting role by the Pacific island set: American Samoa, Guam, Hawaii, and the Northern Mariana Islands. That is, it was used to estimate a lower-bound soil concentration to create an operational cleanup range, as a companion to the standard cleanup levels established for these islands using the more commonly applied slope factors.

The slope factor of 130,000 $(mg/kg\text{-}d)^{-1}$ is based on a slightly more recent study (NTP, 1982), and it is used by a third of the states. This toxicity value was derived by CalEPA using the updated tumor classification method and the linearized multistage model, and its derivation was extensively documented and peer reviewed. This slope factor serves as the basis of the cleanup levels identified for Arizona, Maryland, Maine, Oregon, and Wyoming, as well as the three Pacific island territories: American Samoa, Guam, and the Northern Mariana Islands. It is also being considered by Indiana in internal updates of provisional default closure levels.

In addition to its cancer-based value for the residential scenario, Iowa has identified a cleanup level for nonresidential use based on a reference dose that is the same as the ATSDR chronic oral MRL (ATSDR, 1998/2008). The MRL underwent extensive peer review prior to being finalized in 1998, under the standard process documented by ATSDR (2008b).

4.2.3 Target Risk Levels

Nearly half the states that identify a target risk for their unrestricted-use cleanup level apply the low-end value of 10^{-6}, eight use the middle value of 10^{-5}, one lists a risk between these two, and four use the upper-end value of 10^{-4}. Most states use the same risk target for the companion commercial/industrial cleanup levels, except two that use 10^{-6} to derive the unrestricted/ residential cleanup level use a target risk 10 times higher for the restricted scenarios. Thus, target risk is a major reason for differences among cleanup levels, by a combined factor of 100.

4.3 EVALUATION CONTEXT

The four evaluation criteria can be grouped into two sets: (1) scientific basis, including the recency of the studies and methodology on which the value is based; and (2) nature of the value in terms of draft or final published value, and its peer review. Even though information and field input in these areas was relatively limited, some context is available as summarized in individual tables within the body of the report and as part of the data compilations in Appendix B. This information can be used to guide interpretation of the final values presented, in terms of scientific strength and transparency of the process, including public availability and the pedigree of the scientific peer review, with an emphasis on independent review by external experts.

Toxicity values from CalEPA are considered to address the evaluation components relatively well. Values from this agency are extensively peer reviewed in accordance with a long-standing external review process. The current CalEPA slope factor of 130,000 $(mg/kg\text{-}d)^{-1}$ for dioxin, which is used by one-third of those states that identify an underlying toxicity value, is well documented in terms of scientific basis, methodology, and peer review. This value was derived from a slightly more recent bioassay (1982 NTP study) than the other toxicity values (which are based on 1978 bioassay data from Kociba and colleagues) using the linearized multi-stage model, and its derivation and review process are publicly available online.

In contrast, documentation for the slope factor of 150,000 $(mg/kg\text{-}d)^{-1}$ used by more than half the states is limited. It is based on an outdated methodology, and the general citation is an outdated EPA HEAST source. That HEAST cancer slope factor was indicated as being a provisional value, and it was qualified as being under further evaluation. HEAST tables were described in the 1997 document as containing “provisional risk assessment information” that “have not had enough review to be recognized as high quality, Agency-wide consensus information.” Specific peer review information has not been found; however, the 1985 EPA *Health Assessment Document* (which is listed as one of the sources for the HEAST value) underwent external peer review. Note it is not clear that the HEAST value was based solely on this document, since EPA (1985) lists a cancer slope factor of 156,000 $(mg/kg\text{-}d)^{-1}$, while the HEAST value is 150,000 $(mg/kg\text{-}d)^{-1}$. Thus, this value is considered not as strong overall in terms of the combined evaluation criteria.

The third slope factor, the value of 1,400,000 $(mg/kg\text{-}d)^{-1}$ used by Minnesota, is a draft taken from the draft EPA dioxin reassessment (which is still under review). The lack of a final peer-reviewed publication basis for this value limits its broader strength.

The fourth slope factor, the value of 75,000 $(mg/kg\text{-}d)^{-1}$ used by Michigan, is a final published value based on an updated and peer-reviewed evaluation of the Kociba data using the updated NTP tumor classification. Documentation of this derivation, independent peer review, and public availability of supporting information were not found to be as extensive as for the CalEPA value.

More recent scientific data (such as the 2004 NTP study) are currently being evaluated by U.S. EPA, CalEPA, and other organizations. As indicated by certain states (including California and Minnesota), information from these ongoing evaluations may offer useful insights for consideration in developing updated context for soil cleanups.

With regard to the range of cleanup levels, concentrations at the lower end (about 4 ppt) were identified by a number of states that essentially adopted values developed for screening purposes (not cleanup decisions), as reflected in the recently harmonized U.S. EPA Regional screening level table and related data sources. The scientific basis, external peer review, and transparency of these values for this application do not appear to be well documented, i.e., for purposes other than the preliminary screening for which they were designed.

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APPENDIX A: SUPPORTING DETAILS FOR THE APPROACH

APPENDIX A:
SUPPORTING INFORMATION FOR THE APPROACH

This appendix presents additional context for Phase II.

The Phase I searches produced varying levels of information. Gaps across the key entries were addressed via review and input from knowledgeable experts from the U.S. EPA Regions and individual states – which is essential to ensuring that OSWER has the best understanding of existing state cleanup levels to frame the development of an updated interim soil cleanup level.

To support field feedback on the preliminary data tables, a checklist was provided that emphasized two main themes (see Table A.2): (1) assure the data table reflects current soil cleanup levels for dioxin, and (2) provide supporting information not found online, particularly for the scientific basis and other evaluation criteria. State-specific questions were also offered to help guide field clarifications and additions.

TABLE A.1 Checklist to Support Field Review of Data Tables

Table Element	Field Input Needed	Notes
Current Entries		
Soil concentration	Please specify if the basis is wet or dry weight.	Reminder: Our scope is TCDD or dioxin TEQs (not other DLCs).
	Please confirm or revise as indicated. Note some units are converted for consistency across all entries	If you add or revise here, please also update corresponding entries (including the information source).
Endpoint basis	If missing, please identify "ca" (cancer) or "nc" (noncancer) where known.	If another agency value is adopted, please indicate which one so we can characterize this.
Toxicity reference value	Please confirm/revise as above, also noting same conversion for overall unit consistency.	Please see the evaluation criterion for scientific basis (below).
Information source	Confirm or revise as indicated; also add sources to account for any change	Please include any supporting weblinks in this table field.
Context basis	Definition-application: Please confirm or define (if missing) the nature of the concentration term and its application specific to soil cleanup. In particular: if a *screening level*, please indicate if (a) the value is defined to *not* be used as a cleanup objective or goal, and (b) the value has in fact been used as a soil *cleanup level* (in some case). Further: If a value is identified as ecological-based, please indicate if it has also been used as a health-based cleanup level.	Many state values appear to be screening levels, so this clarification is crucial – to know whether they have essentially been used as cleanup levels. If so, please provide that documentation (including weblink if available).
Context basis *(cont'd.)*	Scenario and risk target: Please confirm or identify (if missing) the land use/scenario for which the value applies – as well as the primary receptor, exposure route(s), and target risk, where specified (e.g., 10^{-6} or 10^{-5}), or the hazard index (for "nc"-based levels).	Regarding the scenario: The primary focus is levels considered acceptable for unrestricted use. (with equations and parameter values to be given in the "scientific basis" column, see below.)
	Coverage: Please confirm or identify (if missing) whether the value is for TCDD only, or TCDD equivalents or total dioxins.	Reminder: We do not need any information for DLCs (e.g., PCBs).

Table Element	Field Input Needed	Notes
Evaluation Criteria		
Nature of peer review	Please characterize the peer review of both the *soil concentration value* and its *derivation methodology,* including assumptions. For example, types of review may include: a. Internal: by same agency, same division or department responsible for the level. b. Internal-independent: by same agency but another division or department. c. External: please indicate general type/ number of peers (e.g., “international panel including 6 state university toxicologists and epidemiologists” or “remote individual review by 3 state university toxicologists”). Please provide further context as feasible (e.g., “2-year process with external review, internal revision, and reconsideration by the external reviewers”).	Please at least indicate if any external peer review was conducted.
Transparency-public availability	Transparency/clarity and public availability: Please identify whether the dioxin level and derivation approach are publicly available and clearly described – including specific calculations and scientific study(ies) on which the soil and toxicity values are based.	If this information is publicly available but the source is not yet identified in the table, please provide it in the “information source” column.
	Public comment: Please indicate if the public had an opportunity to review and comment on the dioxin cleanup and/or toxicity value.	Provide any further information for public input to the dioxin cleanup level or derivation methodology.
	Public comment: Please indicate if the public had an opportunity to review and comment, specific to the soil cleanup level for dioxin.	Feel free to give any further useful information on public input directly relevant to the soil dioxin level.
Scientific basis	Please confirm//revise or provide if missing – including: specific equation(s) used, specific input values (per scenario), the toxicity value basis, and supporting documentation – including original literature or evaluation reports underlying the toxicity value or soil concentration, particularly if these have not yet been found online (and please provide if possible, e.g., as weblink, pdf, or hard copy).	Review input is especially key, because this is a data gap for many values and the information is essential for a solid evaluation. Note some entries may have general placeholder notes for the moment, which will need to be replaced by the specific scientific basis.
Incorporation of most recent science	Please check to confirm or update, e.g., if ongoing state initiatives reflect more recent scientific studies or methodology.	Note also pursuing original documentation cited as the basis

The main intent of this phase was to obtain primary documentation underlying soil cleanup values (not found online), ranging from state derivation methodology or guidance documents to the original scientific literature studies and calculation approaches that underlie the toxicity values applied. (Similarly, many basic evaluation documents with derivation details underlying the supporting context from RODs were not found online.)

APPENDIX B: DETAILED DATA TABLES

APPENDIX B:
DETAILED DATA TABLES

B.1 DATA ORGANIZED BY U.S. EPA REGION

To facilitate field review and input, data from the Phase I online searches were compiled in tables organized alphabetically by state within U.S. EPA Regions 1 through 10. The Regional distribution of states is illustrated in Figure B.1.

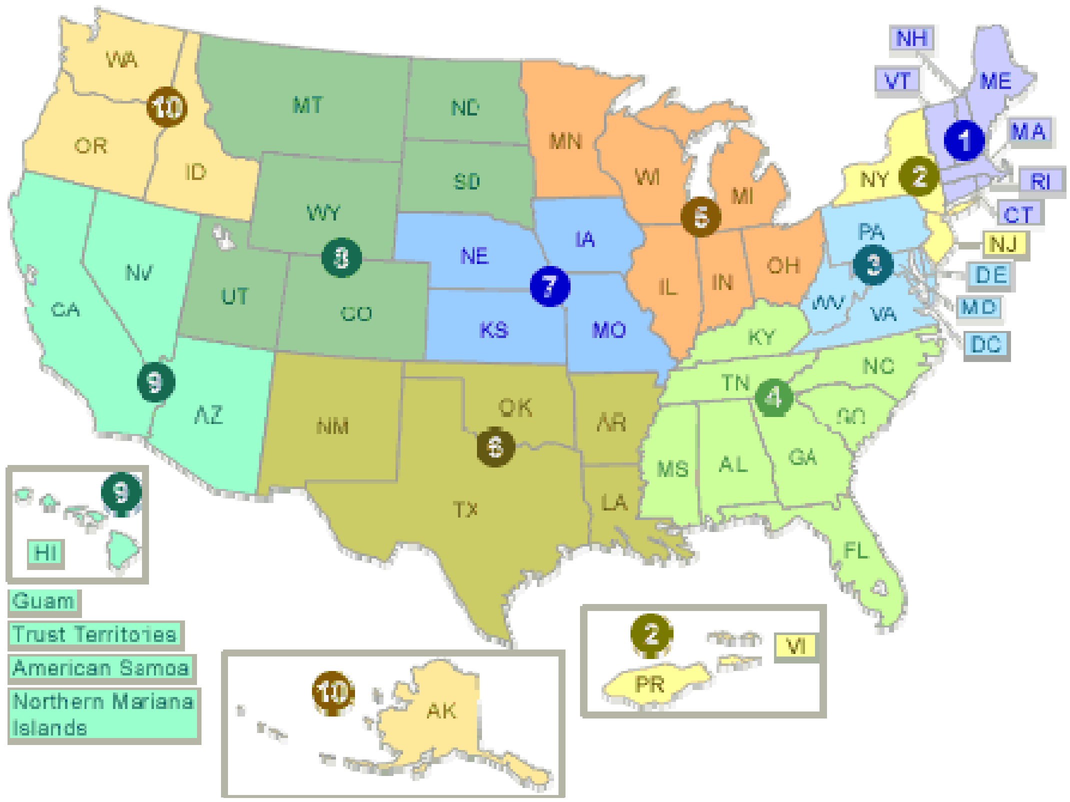

FIGURE B.1 States in U.S. EPA Regions (Source: EPA, 2008x, *Regional Map*, Office of Solid Waste and Emergency Response, http://www.epa.gov/oswer/regionalmap.htm; last updated Dec. 26, 2008; accessed Aug. 2009.)

These Regional tables presented on the following pages include:

- State: using the standard abbreviations.
- Soil concentration: as ppt to facilitate comparisons (several were converted to this unit).
- Date: as month-year where available (to help indicate timing per the extant OSWER directive, as well as recent scientific studies and harmonization efforts).
- Endpoint basis: cancer (c) or noncancer (n).
- Type of toxicity reference value: such as SF (slope factor) or RfD (reference dose);

- Toxicity value units: as consistent unit: $(mg/kg/d)^{-1}$ (or mg/kg-d for noncancer endpoint), to facilitate comparisons.

- Information source: streamlined reference (for quick indication of the nature of this source, e.g., state agency or other), with weblink to facilitate direct checks.

- Context notes: to indicate, where available:

  - contaminant addressed – TCDD or toxic equivalents (TEQ);

  - land use scenario – e.g., unrestricted or commercial/industrial;

  - name of the value – e.g., cleanup level, or screening or comparison level; and

  - application context.

- Evaluation criteria: To highlight information relevant to the four criteria, as available.

Formatting to facilitate quick-glance checks Includes:

1. Concentration column

   - No state cleanup level: this entry is blank if the state has not developed a soil cleanup level for dioxin. (Note in some cases states have developed cleanup levels for other chemicals and conditions but those documents did not include dioxin).

   - Same concentration as OSWER directive values: the shading is more intense for values that are the same as those identified in the 1998 directive – i.e., 1,000 ppt for the residential scenario, and 5,000 to 20,000 ppt for commercial/industrial scenarios.

2. Sources other than state agencies

   - Lighter font and italics are used to distinguish entries that summarize site-specific applications or articles from journals or others sources beyond the primary focus, which is direct state agency information. (Site-specific levels are included in supporting context figures within the report, but those entries that provide no context of basis for corroboration are not.)

As a further note, in a few cases, dioxin values were found for joint human-ecological protection or in conjunction with concentrations for ecological protection as part of the search for health-based levels; these limited entries have been retained (in green font) simply for related insights they may offer.

TABLE B.1 State Cleanup Levels for Dioxin in Soil: Region 1

State	Soil Conc *(ppt)*	Date	End-point Basis	Toxicity Reference Value		Information Source	Context Notes	Evaluation Criteria			
								Nature of Peer Review	Transparency-Public Availability	Scientific Basis	Incorporation of Most Recent Science
CT	*1,000*	*Sep-05*	*c*	*150,000 (CSF)*	*(mg/kg-d)$^{-1}$*	*EPA (2005d), ROD Summary, Solvents Recovery Service of New England, Inc (SRSNE) Site, Southington (http://www.epa.gov/superfund/sites/rods/fulltext/r0105008.pdf).*	*For TCDD toxicity equivalents (TEQ), based on EPA 1998 OSWER directive; as the lower value of that 1 ppb level or background 2,3,7,8-TCDD TEQ. (ROD indicates there are no residential direct exposure criteria or pollutant mobility criteria for dioxin in the CT Remediation Standard Regulations.)*		*ROD is available online (via RODS database).*	*The Kimbrough et al. (1984) evaluation of Kociba et al. (1978) underlies the OSWER value. The site-specific risk assessment used reasonable maximum exposure and the cancer slope factor (CSF) of 150,000 per mg/kg-d from the 1999 Health Effects Assessment Summary Table (HEAST).*	
	300		*eco*				*Ecological toxicity benchmark of 0.3 µg/kgTCDD TEQ identified as the concentration "not to be exceeded in soil according to MDNR (1988) (primary citation not provided).*				
MA	20	Dec-07	c	150,000 (CSF)	(mg/kg-d)$^{-1}$	MADEP (2007), The Massachusetts Contingency Plan, 310, CMR 40 (http://www.mass.gov/dep/service/regulations/310cmr40.pdf); Standard from MADEP [undated A], Documentation for S1 Standards (http://www.mass.gov/dep/cleanup/laws/prop_s1.htm).	For 2,3,7,8-TCDD equivalents, dry weight basis residential scenario, unrestricted use, accessible soil (<3 ft below surface, not completely paved), direct contact (ingestion, dermal contact) also considering leaching; high frequency or intensity for child use, or high frequency and intensity for adult use , or high frequency and intensity for child use but soil potentially accessible (3 to15 ft below surface) (category S-1); e.g., residential areas, school yards, playgrounds, gardens.		MADEP (2007 & undated A, B, C, D) documents are available online.	Example equation used to derive soil category S-1 standards MADEP (undated A), for residential exposure for an adult (15-31y): (Note: This equation is based on the summation of three age groups, however, due to space, only the factors for the 15-31 age group appear. See MADEP (undated A) for all relevant data) $OHM_{ca\text{-}dc} = \frac{(ELCR)}{(LADSIR \times RAF_{inh}) \times (A \times RAF_{dermal}) \times CSF_{oral}}$ $LADSIR = \frac{IR_{soil} \times EF_1 \times EF_2 \times EP}{BW \times AP \times C_1 \times C_2}$ $A = LADSDCR = \frac{SSA \times SAF \times EF_1 \times EF_2 \times EP}{BW \times AP \times C_1 \times C_2}$ where $OHM_{ca\text{-}dc}$ = target risk-based soil concentration direct contact (ingestion), mg/kg ELCR = target lifetime excess cancer risk, 10^{-6} LADSIR = lifetime average daily soil ingestion rate, (d)$^{-1}$ $RAF_{ca\text{-}ing}$ = relative absorption factor for cancer, oral exposure (1, per RAGS Part E) CSF_{oral} = oral cancer slope factor, 150,000 (mg/kg-d)$^{-1}$ IR_{soil} = soil ingestion rate, 50 mg/d EF_1 = exposure frequency, 5 d/wk EF_2 = exposure frequency, 30 wk/y EP = exposure period, 30 y BW = body weight, 54.2 kg AP = averaging period, 70 y C_1 = conversion factor, 365 d/y C_2 = conversion factor, 10^6 mg/kg LADSDCR = lifetime average daily soil dermal contact rate, (d)$^{-1}$ SSA = average daily skin surface area exposed, 5,653 cm^2 SAF = soil adherence factor, 0.13 mg/cm^2	
	50					MADEP (undated B), Documentation for S2 Standards (http://www.mass.gov/dep/cleanup/laws/prop_s2.htm).	For 2,3,7,8-TCDD equivalents, dry weight basis, considering moderate direct exposure (ingestion, dermal contact) also considering leaching; accessible soil with no child use, or high frequency or intensity of adult use, or potentially accessible soil with high frequency or intensity of child use or high frequency and intensity of adult use (category S-2), e.g., retail space, landscaping.				
	300					MADEP (undated C), Documentation for S3 Standards (http://www.mass.gov/dep/cleanup/laws/prop_s3.htm).	For 2,3,7,8-TCDD equivalents, dry weight basis, direct contact (ingestion, dermal contact), and inhalation of airborne particulates; potentially accessible soil with low child use, or low adult frequency or intensity of use, or isolated soil (deeper than 15 ft, or 3 ft beneath the floor of a structure) (category S-3); addresses short but intense construction/ excavation exposure scenarios.				
	3,000					MADEP (undated D), Upper Concentration Limits (http://www.mass.gov/dep/cleanup/laws/ucls.htm).	For 2,3,7,8-TCDD equivalents, upper concentration limit in soil applicable as public welfare and environmental resource standards.			"The UCLs [upper concentration limits] are simply 10-fold multiples of the highest Method 1 exposure-related (S-1, S-2 or S-3 in soil) standard, capped at a maximum concentration. For soil, the UCL is capped at 1%" (MADEP, D).	

TABLE B.1 State Cleanup Levels for Dioxin in Soil: Region 1

State	Soil Conc *(ppt)*	Date	End-point Basis	Toxicity Reference Value		Information Source	Context Notes	Evaluation Criteria: Nature of Peer Review	Evaluation Criteria: Transparency-Public Availability	Evaluation Criteria: Scientific Basis	Evaluation Criteria: Incorporation of Most Recent Science
MA *(cont'd.)*	*4*	*2006 (2004)*				*Easthope (2006), ATSDR 1,000 ppt dioxin soil standard: Letter from concerned citizens, environmental groups (http://www.trwnews.net/Documents/TRW/Request%20to%20atsdr%20to%20clarify%201000ppt.pdf); Lists same values identified in: EC (2004), Dioxin Soil Cleanup Levels in Other States, cited in table available via Tittabawassee River Watch (TRW) News (http://www.trwnews.net/images/StateCleanup2006.PDF).*	*Basis not provided.*		*Limited information is available via the weblinks at left, with neither the derivation methodology or basis of underlying toxicity values.*	*Basis not provided.*	
	1,000	*Sep-04*	*c*			***EPA (2004f), EPA Region 1, Shpack Landfill Superfund Site Record of Decision Summary,** Norton/Attleboro (http://www.epa.gov/superfund/sites/rods/fulltext/r0104694.pdf).*	*For dioxin TEQ, based on 1998 OSWER directive: "one ppb is to be generally used as a starting point for setting cleanup levels for setting cleanup levels for CERCLA removal sites and as a cleanup level for remedial sites for dioxin in surface soil involving a residential exposure. The "adjacent resident, w/o groundwater exposure" scenario on which the remedy is based assumes approximately 150 days of exposure to site soils, which is essentially equivalent to an on-site exposure. Therefore, the cleanup goal for dioxin protective of human health is being set at 1 ppb TEQ."*		*ROD is available online (via RODS database).*	*The Kimbrough et al. (1984) evaluation of Kociba et al. (1978) underlies the OSWER value.*	
ME	10	Jul-09	c	130,000 (SF_o)	$(mg/kg\text{-}d)^{-1}$	MEDEP (2009a), Maine Remedial Action Guidelines for all Scenarios http://www.maine.gov/dep/rwm/publications/guidance/rags/MERAGS%20APPENDIX%201_2_3%20Numbers_Public_Rev_Draft_7-17-09.xls); based on calculations in MEDEP (2009b), Technical Basis and Background for the Maine Remedial Action Guidelines (http://www.maine.gov/dep/rwm/publications/guidance/rags/MERAG_Basis_Draft_For_Public_Comment_2009_july_14_V2-rhd.DOC)' from Wright (2009) (personal communication).	For dioxin TEQ, residential scenario, based on sites with more than one contaminant of concern		MEDEP (2009a,b) are available online, the values are draft and are currently open for public comment.	An ILCR of10^{-6} was "Applicable at sites with more than one contaminant of concern." TEQ toxicity is based on WHO 2005 guidelines. ME is in the final stages of revising generic draft soil cleanup levels for dioxin TEQ. These guidelines are based on MEDEP (2009b). Equation is provided in MERAG technical document, highlighted in Table 15 of the report.	
	17						For dioxin TEQ, park user scenario, based on sites with more than one contaminant of concern				
	31						For dioxin TEQ, commercial worker scenario, based on sites with more than one contaminant of concern				
	310						For dioxin TEQ, excavation/construction worker scenario, based on sites with more than one contaminant of concern				
NH	9	May-07	c	150,000 (CSF)	$(mg/kg\text{-}d)^{-1}$	NHDES (2007), Risk Characterization and Management Policy, Groundwater Quality Table 2, Appendix A-E with soil values (http://des.nh.gov/organization/divisions/waste/hwrb/documents/rcmp.pdf); the higher values are estimated using EPA (1998a), Approach for Addressing Dioxin in Soil at CERCLA and RCRA Sites, OSWER Directive 9200.4-26 (http://www.epa.gov/superfund/resources/remedy/pdf/92-00426-s.pdf).	For 2,3,7,8-TCDD, risk-based S-1 soil category, for sensitive uses of property and accessible soils, either currently or in the foreseeable future. For these soil concentration entries, TCDD is marked as "negative contaminant migration" so groundwater was considered for each of the NH soil concentrations listed here and determined to not be a contributing factor.	The May 2007 NHDES document is referred to as being under review; intra-agency.	Both the NH risk characterization document and EPA OSWER directive are available online.	Assumes the upper-bound lifetime excess cancer risk from residential exposure to a concentration of 1 ppb dioxin is 0.00025. The estimate for commercial/industrial exposure to 5 ppb is 0.00013. Slope factor of 150,000 per mg/kg-d (citing indirect resource RAIS 2/2006) used to develop the direct contact risk-based concentrations.	
	30						For 2,3,7,8-TCDD, risk-based S-2 category, for moderate exposure to accessible soil, currently or foreseeable future (e.g., maintenance worker)				
	300						For 2,3,7,8-TCDD, risk-based S-3 soil category, for restricted access property with limited potential for exposure, currently or foreseeable future (e.g., excavation worker).				
	1,000						For 2,3,7,8-TCDD TEQs, based on OSWER directive approach using TEQs, S-1 category.				
	5,000						For 2,3,7,8-TCDD TEQs, based on OSWER directive approach using TEQs, S-2 category.				
	20,000						For 2,3,7,8-TCDD TEQs, based on OSWER directive approach using TEQs, S-3 category.				

TABLE B.1 State Cleanup Levels for Dioxin in Soil: Region 1

State	Soil Conc *(ppt)*	Date	End-point Basis	Toxicity Reference Value		Information Source	Context Notes	Evaluation Criteria			
								Nature of Peer Review	Transparency-Public Availability	Scientific Basis	Incorporation of Most Recent Science
RI		Feb-04				RIDEM (2004), Rules and Regulations for the Investigation and Remediation of Hazardous Material Releases (http://www.dem.ri.gov/pubs/regs/regs/waste/remreg04.pdf).	These RIDEM Remediation Regulations (updated February 2004) contain tables listing direct exposure criteria for residential and commercial/industrial soils for a number of contaminants. They were checked for dioxin entries but none were found (nor was other input provided during the field review phase).		The RIDEM (2004) document is available online.	Basis not pursued because dioxin is not included in this suite of state values.	
	40	*Sep-97*				*DoN (1997), Final Record of Decision: Site 09 – Allen Harbor Landfill, Naval Construction Battalion, OU 01, Davisville (http://www.epa.gov/superfund/sites/rods/fulltext/r0197157.pdf).*	*For 2,3,7,8-TCDD equivalents, determined using toxic equivalency factors from EPA (1994), specific citation not provided; represents risk-based concentration for soils up to a depth of 10 ft. (As a note, the entry for TCDD soil screening level is ND, no data.) This risk-based concentration was developed for a recreational scenario.*		*ROD is available online (via RODS database).Public comments included support for no action, limited action, two of the proposed plans (one of which was implemented), and landfill excavation.*		
VT	4.5	May-09	c	130,000 (SF_O)	$(mg/kg\text{-}d)^{-1}$	VTDEC, Brownfields Reuse Initiative (http://www.anr.state.vt.us/dec/wastediv/SMS/RCPP/Cleanup-Stand-Guid.htm); for soil and air, links to EPA (2009), Regional Screening Levels (RSL) for Chemical Contaminants at Superfund Sites, RSL Table Update (http://www.epa.gov/region09/superfund/prg/).	For 2,3,7,8-TCDD in residential soils, total risk. The VT website introduces the link to the Regional EPA screening values (and VT links for other environmental media) with: "The following links are provided to standards and guidance utilized by the Department in the management of brownfield projects."		The VT context and the EPA RSL table and User's Guide (EPA 2009e,f), including equations, are available online.	See Table 13 of the report for the derivation methodology and values underlying the EPA regional screening levels.	
	18						For 2,3,7,8-TCDD in industrial soils, total risk; with further note as above. Note the supporting documentation includes an RfD_0 of 1.0×10^{-9} mg/kg-d; however, cancer was the limiting endpoint for the residential and industrial screening levels. (Note this RfD is the same as the ATSDR chronic MRL finalized in 1998.)				

TABLE B.2 State Cleanup Levels for Dioxin in Soil: Region 2

State	Soil Conc *(ppt)*	Date	End-point Basis	Toxicity Reference Value	Information Source	Context Notes	Evaluation Criteria			
							Nature of Peer Review	**Transparency-Public Availability**	**Scientific Basis**	**Incorporation of Most Recent Science**
NJ	*50*	*Mar-01*	*c*		*NJDHSS (2001), Public Health Assessment: Franklin Burn Site (http://www.state.nj.us/health/eoh/assess/fb_pc.pdf).*	*For 2,3,7,8-TCDD TEQs, adopted from the ATSDR screening value used as a "comparison value" for public health assessment at that time. (See related information in the ATSDR entry in Table 11 of the report.)*	*See information for the ATSDR entry in Table 11.*	*See ATSDR entry in Table 11; toxicity value not found in the NJ documentation.*	*See ATSDR entry in Table 11.*	
	19	*Sep-07*	*c*		*DoA (2007b), ROD, Site 180 (PICA 093) Waste Burial Area, Final, Picatinny (http://www.epa.gov/superfund/sites/rods/fulltext/r2007020002538.pdf).*	*For 2,3,7,8-TCDD toxic equivalency concentration (TEC) for surface and subsurface soil, based on the EPA Region 3 risk-based concentration for the industrial scenario; IRBCs were used when NJ had not established a nonresidential direct contact soil cleanup criterion.*		*ROD available online (RODS database) Toxicity value not found.*	*Based on a target risk level of 10^{-6}; see Table 13 of the report for other values and the derivation methodology (first entry); note the Region 3 RBCs have since been harmonized with the screening values from Regions 6 and 9.*	
	1,000	*May-04*	*c*		*EPA (2004d), ROD, Franklin Burn, OU 01, Franklin Township (http://www.epa.gov/superfund/sites/rods/fulltext/r2004020001417.pdf).*	*For dioxin, the surface soil risk-based preliminary remedial goal is described in the text as a policy-driven value, the 1 ppb cleanup level for dioxins/furans is consistent with OSWER Directive 9200.4-26."*		*ROD available online (RODS database) Toxicity value not found.*	*The Kimbrough et al. (1984) evaluation of Kociba et al. (1978) underlies the OSWER value.*	
NY		Sep-06			NYDEC (2006), New York State Brownfield Cleanup Program, Development of Soil Cleanup Objectives, Technical Support Document (http://www.dec.ny.gov/docs/remediation_hudson_pdf/techsuppdoc.pdf); link provided in feedback during field review, from Olsen (2009) (personal communication).	This document states that 2,3,7,8-TCDD was deleted from the list of priority contaminants requiring a soil cleanup objective because dioxin is rarely found at sites. If dioxins are listed as a contaminant of concern at Brownfield sites by the EPA, then NYSDEC would consider dioxin in its remedial programs.		NYSDEC (2006) document available online.		
	600	Jan-94			NYDEC (2009), TAGM 4046, Table 3 (http://www.dec.ny.gov/regulations/30582.html); the document that established these levels is dated 1994, but the specific tables from this document are shown by themselves on a webpage that was updated in 2009.	For 2,3,7,8-TCDD TEQs, identified as the "allowable soil concentration" protective of groundwater, which assumes the contaminated soil is in direct contact with the water table. That is, the value assumes leachate from contaminated soil does not violate groundwater/drinking water standards.		Alternative and recommended cleanup objectives are available online, as is part of the derivation methodology and context (notably for the soil water concentration). Specific toxicity values and bases underlying the cleanup objectives have not been found online.	Allowable soil concentration calculated using the water-soil equilibrium partition theory: $C_s = f \times C_w \times K_{oc}$ where: C_s = soil concentration f = fraction of organic carbon of the natural soil medium, 1% or 0.01 C_w = appropriate water quality value from NY Division of Water Technical and Operational Guidance Series (TOGS) 1.1.1, given as 0.000035 µg/L for TCDD in TAGM 4046, Table 3 K_{oc} = partition coefficient between water and soil media, 1,709,800	

TABLE B.2 State Cleanup Levels for Dioxin in Soil: Region 2

State	Soil Conc *(ppt)*	Date	End-point Basis	Toxicity Reference Value		Information Source	Context Notes	Evaluation Criteria			
								Nature of Peer Review	Transparency-Public Availability	Scientific Basis	Incorporation of Most Recent Science
NY (cont'd)	60,000	Jan-94				NYDEC (2009), TAGM 4046, Table 3 (as above).	For 2,3,7,8-TCDD TEQs, "Soil cleanup objective" that is protective of groundwater quality. This value assumes that contaminated soil in the unsaturated zone above the water table is subject to attenuating processes during transport to groundwater. (NY DEC TAGM 4046 states that alternative cleanup objectives are derived considering a number of criteria including HEAST and RfD values, concentrations protective of groundwater, detection limits, and background concentrations. "Recommended" cleanup objectives are based on the criterion that produces the most stringent value. No such "recommended" cleanup objective value is provided for TCDD.)			Soil cleanup objective protective of groundwater is derived by applying a correction factor to the allowable soil concentration. This factor assumes that various properties and processes including volatility, transformation, and degradation prevent transfer of the full contaminant from soil to groundwater. Soil Cleanup Objective = $C_s \times CF$ where: C_s = soil concentration CF = 100 (consistent with the EPA dilution attenuation factor [DAF] approach)	
	40	*Nov-04*				*U.S. AF (2004a), Final ROD for the Electrical Power Substation, Area of Concern (SS-44) at the Former Griffiss Air Force Base, Rome (http://www.epa.gov/superfund/sites/rods/fulltext/r0205015.pdf).*	*For 2,3,7,8-TCDD, soil guidance value. This value is reported within the comments section of the ROD, which cites a report that has not been found online (Law Engineering and Environmental Services, Inc., December 1996, Draft-Final Primary Report, Volume 7, Remedial Investigation, Griffiss Air Force Base, New York, Contract No. DACA41-92-D-8001, Kennesaw, GA). Residential, recreational, and commercial/industrial future land use scenarios were evaluated.*		*ROD available online (via RODS database), but not the report referenced for the indicated guidance value. Toxicity context not found.*		
	1,000	*Mar-03*	*c*			*U.S. AF (2003a), SiteSS-026 Explosive Ordinance Disposal Range: ROD, Plattsburgh Air Force Base, Installation Restoration Program, Plattsburgh (http://www.epa.gov/superfund/sites/rods/fulltext/r0203022.pdf).*	*As dioxin toxicity equivalence. The ROD states that the regulatory criteria used in the assessment for soil include the NY TAGM 4046 Soil Cleanup Guidelines (1994, see earlier entry in this table) and EPA dioxin toxic equivalency guidelines (EPA, 1989), and refers to the EPA recommended action level of 1 µg/kg TEQ.*		*ROD available online (via RODS database) Toxicity value not found.*	*The Kimbrough et al. (1984) evaluation of Kociba et al. (1978) underlies the OSWER value.*	
PR	*1,000*	*Apr-04*	*c*			*EPA (2004c), ROD, Vega Baja Solid Waste Disposal, OU 01, Rio Abajo Ward (http://www.epa.gov/superfund/sites/rods/fulltext/r2004020001421.pdf).*	*For dioxin; the ROD mentions the EPA recommended action level of 1 ppb (which suggests the basis was the OSWER directive). Dioxin was not considered a chemical of concern at the site because soil concentrations did not exceed 1 ppb.*		*ROD available online (via RODS database); toxicity value not found.*	*The Kimbrough et al. (1984) evaluation of Kociba et al. (1978) underlies the OSWER value.*	

TABLE B.3 State Cleanup Levels for Dioxin in Soil: Region 3

State	Soil Conc *(ppt)*	Date	End-point Basis	Toxicity Reference Value		Information Source	Context Notes	Evaluation Criteria			
								Nature of Peer Review	Transparency-Public Availability	Scientific Basis	Incorporation of Most Recent Science
DE	4	Dec-99	c	150,000 (CSF_o)	$(mg/kg\text{-}d)^{-1}$	DEDNREC (1999), Remediation Standards Guidance under the Delaware Hazardous Substance Cleanup Act (http://www.dnrec.state.de.us/dnrec2000/divisions/awm/sirb/docs/pdfs/misc/remstnd.pdf).	For 2,3,7,8-TCDD, dry weight basis, unrestricted use scenario. ["Where current or future use will not be restricted in any way to ensure the protection of human health" (DEDNREC 1999)]. Based on both critical and non-critical water resource area in both surface and subsurface soil, from DE Uniform Risk-Based Remediation Standards (URS) for protection of human health.	Intra-agency	Calculations and risk-based tables can be found in both the DEDNREC Remediation Standards, Attachment 4, and the PA Bulletin (1997), both of which are available online.	Cancer slope factor values obtained from EPA Health Effects Assessment Summary Table (HEAST) document (1997). The PA document also provides calculations. Some of the risk-assessment equations are based on EPA (1989) suggestions and the Inhalation Numeric Values are based on EPA (1995b) Risk-Based Concentration Tables (RBC). DEDNREC (1999) document provides RBC equations for soil ingestion. $RBC_{res} = \frac{TR \times AT_c}{EF_r \times IFS_{adj} \times CSF_o \times CF}$ where: RBC_{res} = residential risk-based concentration TR = target cancer risk, 10^{-6} AT_c = averaging time carcinogens, 25,550 d EF_r = residential exposure frequency, 350 d/y IFS_{adj} = soil ingestion factor, 114.29 mg-y/kg-d CSF_o = oral carcinogenic slope factor, 150,000 $(mg/kg\text{-}d)^{-1}$ CF = 10^{-6} kg/mg	The document uses equations and values from the EPA (1995b) Regional RBCs; note these regional screening levels were recently harmonized (in 2008, with 2009 update).
	40						For 2,3,7,8-TCDD, based on restricted use, ["Where current or future use will be restricted in some way (either through deed restriction, risk management or engineering control measures) to ensure the protection of human health" (DEDNREC 1999)]. Based on both critical and non-critical water resource area in both surface and subsurface soil, from DE URS for protection of human health.				
	3		eco				URS for protection of the environment for surface soil from ORNL May 1998 screening benchmark levels for ecological risk assessment		Original ORNL document not found.		
	4	*2006 (2004)*				*Easthope (2006), ATSDR 1,000 ppt dioxin soil standard: Letter from concerned citizens, environmental groups (http://www.trwnews.net/Documents/TRW/Request%20to%20atsdr%20to%20clarify%201000ppt.pdf); lists same values identified in: EC (2004), Dioxin Soil Cleanup Levels in Other States, cited in table available via Tittabawassee River Watch News (http://www.trwnews.net/images/StateCleanup2006.PDF).*	*Basis not provided.*		*Limited information is available via the weblinks at left, with neither the derivation methodology or basis of underlying toxicity values.*	*Basis not provided.*	

TABLE B.3 State Cleanup Levels for Dioxin in Soil: Region 3

State	Soil Conc (ppt)	Date	End-point Basis	Toxicity Reference Value		Information Source	Context Notes	Evaluation Criteria: Nature of Peer Review	Evaluation Criteria: Transparency-Public Availability	Evaluation Criteria: Scientific Basis	Evaluation Criteria: Incorporation of Most Recent Science
DC		Jul-09				Rios Jafolla (2009) (personal communication).	Feedback during the field review phase indicated DC has not identified a soil dioxin level for site cleanups because it does not have the authority. The DC Voluntary Cleanup Program relies on the EPA RBC Table for screening levels, but DC may be developing its own cleanup standards. Those standards may also be used by other environmental programs in DC.				
	4	*2006 (2004)*				*Easthope (2006), ATSDR 1,000 ppt dioxin soil standard: Letter from concerned citizens, environmental groups (http://www.trwnews.net/Documents/TRW/Request%20to%20atsdr%20to%20clarify%201000ppt.pdf); lists same values identified in: EC (2004), Dioxin Soil Cleanup Levels in Other States, cited in table available via Tittabawassee River Watch News (http://www.trwnews.net/images/StateCleanup2006.PDF).*	*Basis not provided.*		*Limited information is available via the weblinks at left, with neither the derivation methodology or basis of underlying toxicity values.*	*Basis not provided.*	
	4.3	*Sep-07*	*c*			*NAVFAC (2007b), FFA Final ROD for Sites 1, 2, 3, 7, 9, 11, and 13, Washington Navy Yard (http://www.epa.gov/superfund/sites/rods/fulltext/r2008030002103.pdf).*	*For total dioxin TEQ, screening toxicity value reflects toxicity equivalency factors (TEFs) for dioxins/furans from EPA (2000); the full citation was not found in the ROD.*		*Available online (via RODS database).*		Supplemental exposure point concentrations calculated with older TEFs from Van den Berg (1997), to compare with the screening toxicity value. (Full source citation was not found in the ROD.)
MD	4.5 18	Jul-09	c	130,000	$(mg/kg\text{-}d)^{-1}$	Rios Jafolla (2009) (personal communication).	Feedback during the field review phase identified the EPA residential RSL as the MD cleanup level . Feedback indicated MD generally uses screening levels as cleanup levels, however site-specific factors are considered, including what other contaminants may be present.				
	4	*2006 (2004)*				*Easthope (2006), ATSDR 1,000 ppt dioxin soil standard: Letter from concerned citizens, environmental groups (http://www.trwnews.net/Documents/TRW/Request%20to%20atsdr%20to%20clarify%201000ppt.pdf); lists same values identified in: EC (2004), Dioxin Soil Cleanup Levels in Other States, cited in table available via Tittabawassee River Watch News (http://www.trwnews.net/images/StateCleanup2006.PDF).*	*Basis not provided.*		*Limited information is available via the weblinks at left, with neither the derivation methodology or basis of underlying toxicity values.*	*Basis not provided.*	
	25	*Sep-07*	*c*	*150,000 (CSF)*	$(mg/kg\text{-}d)^{-1}$	*DoA (2007a), Canal Creek Study Area, ROD for Remedial Action – G-Street Salvage Yard, Final, Aberdeen Proving Ground (http://www.epa.gov/superfund/sites/rods/fulltext/r2007030001944.pdf).*	*Based on total dioxin TEQ; this final cleanup level is the risk-based goal for a site worker based on a 10^{-6} risk target. From the 2005 feasibility study by Shaw Group (that document has not been found online).*		*Available online (via RODS database).*	*Cancer slope factor from 1997 HEAST. Derivation of risk-based remedial goals indicated as being in the 2005 feasibility study, which has not been found online.*	
	1,000	*Feb-99*	*c*			*EPA (Region 3) (1999a), Documentation of Environmental Indicator Determination (http://www.epa.gov/reg3wcmd/ca/md/hhpdf/hh_mdd981041601.pdf).*	*Indicates the MD Department of Transportation (DOT) discovered soil contaminated with dioxin and pursued remediation at the site to a level of 1,000 ppt, based on the EPA OSWER directive.*			*The Kimbrough et al. (1984) evaluation of Kociba et al. (1978) underlies the OSWER value.*	

TABLE B.3 State Cleanup Levels for Dioxin in Soil: Region 3

State	Soil Conc (ppt)	Date	End-point Basis	Toxicity Reference Value		Information Source	Context Notes	Evaluation Criteria: Nature of Peer Review	Evaluation Criteria: Transparency-Public Availability	Evaluation Criteria: Scientific Basis	Evaluation Criteria: Incorporation of Most Recent Science
PA	120 530 1.9×10^{11}	Nov-01	c	150,000 (CSF)	$(mg/kg\text{-}d)^{-1}$	PADEP (2001), Medium-Specific Concentrations (MSCs) for Organic Regulated Substances in Soil (http://www.depweb.state.pa.us/landrecwaste/lib/landrecwaste/land_recycling/table_3a.pdf); developed as part of the PADEP (2002) Land Recycling Program Technical Guidance Manual (http://www.depweb.state.pa.us/ocrlgs/cwp/view.asp?a=1459&q=518850); equations based on PA (1997), Pennsylvania Bulletin, Environmental Quality Board Administration of the Land Recycling Program (Act 2), Ingestion Numeric Values (http://www.pacode.com/secure/data/025/chapter250/s250.306.html).	For 2,3,7,8-TCDD, residential scenario, soil (0-15 ft), direct contact, based on ingestion. Based on cancer risk; noncancer toxicity value also identified. For 2,3,7,8-TCDD, nonresidential scenario, surface soil (0-2 ft), direct contact, based on ingestion. Based on cancer risk; noncancer toxicity value also identified. For 2,3,7,8-TCDD, direct contact, cap (maximum) concentration for nonresidential subsurface soil (2-15 ft), 190,000 mg/kg. Based on cancer risk; noncancer toxicity value also identified.		The PADEP documentation is available online.	Criteria address state legislation (PA 1997). Equation used for ingestion of dioxin in residential soil: $MSC = \frac{TR\times AT_c\times 365d/y}{CSF_o\times Abs\times EF\times IF_{adj}\times CF}$ where: TR = target risk, 10^{-5} AT_c = verage time for carcinogens, 70 y CSF_o = oral cancer slope factor, 150,000 $(mg/kg\text{-}d)^{-1}$ Abs = absorption, 1 EF = exposure frequency, 250 d IF_{adj} = ingestion factor, 57.1 (mg-y/kg-d) CF = conversion factor, 10^{-6} kg/mg	
	120	*2006 (2004)*				*Easthope (2006), ATSDR 1,000 ppt dioxin soil standard: Letter from concerned citizens, environmental groups (http://www.trwnews.net/Documents/TRW/Request%20to%20atsdr%20to%20clarify%201000ppt.pdf); lists same values identified in: EC (2004), Dioxin Soil Cleanup Levels in Other States, cited in table available via Tittabawassee River Watch News (http://www.trwnews.net/images/StateCleanup2006.PDF).*	*Basis not provided.*		*Limited information is available via the weblinks at left, with neither the derivation methodology or basis of underlying toxicity values.*	*Basis not provided.*	
	40	*Sep-07*	*c*			*NAVFAC Mid-Atlantic (2007a), ROD, Site 5 Soil, OU 4, Naval Air Station, Joint Reserve Base, Willow Grove (http://www.epa.gov/superfund/sites/rods/fulltext/r2007030001999.pdf).*	*For 2,3,7,8-TCDD equivalents, preliminary remediation goal (PRG) for resident, based on 10^{-5} cancer risk; described as agreed upon by EPA, PADEP, and Navy, "developed by EPA Region III and the Navy using EPA Region III RBCs and based on site-specific risk for lifetime resident exposure scenarios."*		*Available online (via RODS database).*		
	4.3	*Apr-06*	*c*	*150,000 (CSF)*	$(mg/kg\text{-}d)^{-1}$	*U.S. ACE (2006), ROD for the Phase IV BRAC Parcels, Groundwater Southeastern (SE) Area Operable Unit 3B and Part of Soil Operable Unit SE OU 8, AEDBR Sites LEAD-016, -114, -115, Letterkenny Army Depot, Chambersburg (http://www.epa.gov/superfund/sites/rods/fulltext/r2006030001362.pdf).*	*For 2,3,7,8-TCDD TEQ. Soil concentration calculated from the RBC equation. The ROD identifies the calculations and parameter values for developing age-adjusted RBCs.*		*Available online (via RODS database).*	*Slope factor taken from 2002 HEAST; equation for calculating age-adjusted residential RBCs for soil ingestion based on cancer risk:* $RBC = \frac{TR\times AT}{EF\times CSF_o\times IFS_{adj}\times CF}$; *where:* *RBC = risk-based concentration, mg/kg* *TR = target cancer risk, 10^{-6}* *AT = averaging time, 25,550 d* *EF = exposure frequency, 350d/y* *CSF_o = oral slope factor, 150,000 $(mg/kg\text{-}d)^{-1}$* *IFS_{adj} = age-adjusted soil ingestion factor, 114 $(mg\text{-}y/kg\text{-}d)^{-1}$* *CF = conversion factor, 10^{-6} kg/mg*	

TABLE B.3 State Cleanup Levels for Dioxin in Soil: Region 3

State	Soil Conc *(ppt)*	Date	End-point Basis	Toxicity Reference Value		Information Source	Context Notes	Evaluation Criteria: Nature of Peer Review	Evaluation Criteria: Transparency-Public Availability	Evaluation Criteria: Scientific Basis	Evaluation Criteria: Incorporation of Most Recent Science
PA *(cont'd.)*	*4.1*	*Aug-03*	*c*	*150,000 (CSF)*	*(mg/kg-d)$^{-1}$*	*U.S. ACE (2003), ROD for Phase III Parcels, Letterkenny Army Depot, Chambersburg (http://www.epa.gov/superfund/sites/rods/fulltext/r0303065.pdf).*	*2,3,7,8-TCDD TEQ soil risk-based health screening concentration (RBSC) for future child or adult resident.*		*Available online (via RODS database).*	*Slope factor taken from 2002 HEAST. Equation for calculating age-adjusted residential RBSC for soil ingestion based on cancer risk:* $RBSC_o = \frac{TR \times AT}{EF \times CSF_o \times IFS_{adj} \times CF}$ *wher:e* *$RBSC_o$ = risk-based screening concentration, mg/kg* *TR = target cancer risk, 10^{-6}* *AT = averaging time, 25,550 d* *EF = exposure frequency, 350d/y* *CSF_o = oral slope factor, 150,000 (mg/kg-d)$^{-1}$* *IFS_{adj} = age-adjusted ingestion factor, 114 (mg-y/kg-d)$^{-1}$* *CF = conversion factor, 10^{-6} kg/mg*	
	48						*For 2,3,7,8-TCDD equivalents, subsurface soil, represents the soil screening level for groundwater protection, basis indicated as carcinogen; considered a total hazard quotient of 0.1; dilution attenuation factor of 20. The ROD refers to the remedial investigation/risk assessment for the methodology explanation.*				
	10,000		*eco*				*2,3,7,8-TCDD TEQ ecological benchmark, EPA Region III BTAG screening level for fauna; from EPA (Region 3) (1995a).*				
	0.32		*(eco)*				*For 2,3,7,8-TCDD TEQ, identified as NOAEL-based benchmark for humans/mammals, from ORNL (1997); ROD indicates PRGs were adjusted to NOAEL-based criteria using a factor of 10.*				
	1.6		*eco*				*For 2,3,7,8-TCDD TEQ, NOAEL-based benchmark for birds, from ORNL (1997); ROD indicates PRGs were adjusted to NOAEL-based criteria using a factor of 10.*				
VA	4.5	Jul-09	c	130,000 (SF_o)	(mg/kg-d)$^{-1}$	VADEQ (2009b), Contaminants of Concern Soil: Unrestricted (http://www.deq.virginia.gov/export/sites/default/vrprisk/files/screen/vrp25.xls); SF_o from VADEQ (2009c) Table 4.2, (http://www.deq.virginia.gov/export/sites/default/vrprisk/files/toxicity/vrp42.xls);	For 2,3,7,8-TCDD, residential scenario, EPA regional screening level and VA Voluntary Remediation Program (VRP) Tier II screening level.	Intra-agency	VADEQ (2008c) provides toxicity tables, risk calculations and route-specific (dermal, ingestion, inhalation) equations for remediation levels; this document is available online.	The VADEQ VRP adopts the lower value of the EPA Region III RBCs for the residential scenario or EPA Soil Screening guidance for transfer from soil to groundwater or air as its Tier II, unrestricted (residential) screening levels. See Table 13 of the report regarding the Regional EPA RBCs.	VADEQ cites the most recent EPA (2005) guidelines for carcinogen risk assessment.
	18	Jun-09				VADEQ (2009a), Contaminants of Concern Soil: Restricted (http://www.deq.virginia.gov/export/sites/default/vrprisk/files/screen/vrp29.xls).	For 2,3,7,8-TCDD, commercial/industrial scenario, EPA regional screening level and VRP Tier III screening level.			Same as above, except RBCs for industrial scenario and Tier III, restricted (commercial/industrial) screening levels.	
	4	*2006 (2004)*				*Easthope (2006), ATSDR 1,000 ppt dioxin soil standard: Letter from concerned citizens, environmental groups (http://www.trwnews.net/Documents/TRW/Request%20to%20atsdr%20to%20clarify%201000ppt.pdf); lists same values identified in: EC (2004), Dioxin Soil Cleanup Levels in Other States, cited in table available via Tittabawassee River Watch News (http://www.trwnews.net/images/StateCleanup2006.PDF).*	*Basis not provided.*		*Limited information is available via the weblinks at left, with neither the derivation methodology or basis of underlying toxicity values.*	*Basis not provided.*	
		May-05	*c*			*DoA (2005), Decision Document, EBS-13 Parcel, OU 6, Blackstone, (http://www.epa.gov/superfund/sites/rods/fulltext/r0305061.pdf).*	*For dioxin toxicity equivalents; the document indicates the TEQ risk falls within the target range (10^{-4} to 10^{-6}) and indicates PRGs were developed based on the EPA Region III RBCs, but does not provide the concentrations used; cites the site evaluation document by Tetra Tech (2004), which has not yet been found online.*		*Decision document is available online (via RODS database).*		

TABLE B.3 State Cleanup Levels for Dioxin in Soil: Region 3

State	Soil Conc *(ppt)*	Date	End-point Basis	Toxicity Reference Value		Information Source	Context Notes	Evaluation Criteria: Nature of Peer Review	Evaluation Criteria: Transparency-Public Availability	Evaluation Criteria: Scientific Basis	Evaluation Criteria: Incorporation of Most Recent Science
WV	4.1	Mar-01	c	156,000 (CPS_o)	$(mg/kg\text{-}d)^{-1}$	WVDEP (2001), Voluntary Remediation and Redevelopment Act: Guidance Manual, Version 2.1 (http://www.wvdep.org/Docs/3200_RemediationGuidanceVersion2-1.pdf).	For 2,3,7,8-TCDD, residential scenario, based on soil ingestion; slope factor from HEAST (specific citation not provided); value reflects EPA Region III risk-based concentrations from July 1996.	Expert peer review coordinated by the National Institute for Chemical Studies	The equations are given in WVDEP (2001) which is available online. The WVDEP document cites EPA (1989, 1996a, 1996b).	Uniform risk-based equation for residential soil ingestion: $C = \frac{TR \times AT_c}{[(EF_r \times (IFS_{adj} \times CSF_o)] \times 10^{-6} kg/mg}$ where: C = soil concentration, (mg/kg); TR = target cancer risk, 10^{-6}; AT_c = averaging time, carcinogens, 25,550 d; EF_r = exposure frequency, 350 d/y; IFS_{adj} = ingestion factor, 114 $(mg\ y/kg\text{-}d)^{-1}$; CSF_o = cancer slope factor oral, 156,000 $(mg/kg\text{-}d)^{-1}$ (Equation for industrial soil ingestion is also available in the WVDEP [2001] document.)	Cited documents range from 1951-1998; most are from the late 1980s and early 1990s.
	370						For 2,3,7,8-TCDD, industrial scenario, based on soil ingestion; slope factor from HEAST (citation not provided); concentration reflects EPA Region III risk-based concentration from July 1996, multiplied by 10 to yield a value based on 10^{-5} risk.				
	4	*2006 (2004)*				*Easthope (2006), ATSDR 1,000 ppt dioxin soil standard: Letter from concerned citizens, environmental groups (http://www.trwnews.net/Documents/TRW/Request%20to%20atsdr%20to%20clarify%201000ppt.pdf); lists same values identified in: EC (2004), Dioxin Soil Cleanup Levels in Other States, cited in table available via Tittabawassee River Watch News (http://www.trwnews.net/images/StateCleanup2006.PDF).*	*Basis not provided.*		*Limited information is available via the weblinks at left, with neither the derivation methodology nor basis of underlying toxicity values.*	*Basis not provided.*	

TABLE B.4 State Cleanup Levels for Dioxin in Soil: Region 4

State	Soil Conc *(ppt)*	Date	End-point Basis	Toxicity Reference Value		Information Source	Context Notes	Evaluation Criteria			
								Nature of Peer Review	Transparency-Public Availability	Scientific Basis	Incorporation of Most Recent Science
AL	1,000	Apr-08	c			ADEM (2008), AL Risk Based Corrective Action Guidance Manual (http://www.adem.state.al.us/LandDivision/Guidance/ARBCAApril2008final.pdf).	For 2,3,7,8-TCDD, residential scenario. Preliminary screening level adopted as a cleanup level for "Direct Contact Exposure Pathway" from 1998 OSWER directive.		The ADEM screening value and basis (OSWER directive) are available online.	The Kimbrough et al. (1984) evaluation of Kociba et al. (1978) underlies the OSWER value. General equations for deriving (other) cleanup are available in ADEM (2008).	Values for equations are from EPA (1989, 2000).
	5,000						For 2,3,7,8-TCDD, commercial scenario. Preliminary screening level adopted as a cleanup level for "Direct Contact Exposure Pathway" from 1998 OSWER directive.				
	212		c	150,000 (SF_o)	$(mg/kg\text{-}d)^{-1}$		For 2,3,7,8-TCDD, large soil source ($4047.5 m^2$), soil screening level protective of groundwater resource protectionRM-1 levels per ADEM AL Risk Based Corrective Action Guidance Manual (ARBCA).				
	385						For 2,3,7,8-TCDD, small soil source ($225 m^2$), soil screening level protective of groundwater resource protection, Risk Management-1 (RM-1) Levels per ADEM ARBCA.				
FL	7	Feb-05	c	150,000 (CSF_o)	$(mg/kg\text{-}d)^{-1}$	FDEP (2005), Technical Report: Development of Cleanup Target Levels (CTLs) for Chapter 62-77, F.A.C., Table 2 ([http://www.dep.state.fl.us/waste/quick_topics/rules/documents/62-777/TableIISoilCTLs4-17-05.pdf,](http://www.dep.state.fl.us/waste/quick_topics/rules/documents/62-777/TableIISoilCTLs4-17-05.pdf) from http://toxicology.ufl.edu/documents/TechnicalFeb05.pdf.	For 2,3,7,8-TCDD TEQ, residential direct contact soil cleanup target level (SCTL). Derivation provided in FDEP (2005). The value reported in the CTL table (7 mg/kg-d), is also cited by Paustenbach et al. (2006) as the cleanup target level for FL (as 7 ng TEQ/kg, risk-based calculation).	Paustenbach et al. (2006) was peer reviewed as part of the journal publication process.	Derivation basis and equations values clear for residential and commercial/ industrial SCTLs. Default and chemical-specific values for equation variables provided in FDEP (2005), Technical Report. EPA (1997a) Health Effects Assessment Summary Tables (HEAST) values for nonradionuclides have not been found via open access online.	Slope factors and other toxicological information cite EPA 1997 HEAST. Model equation for developing acceptable risk based concentrations in soils for carcinogens: $SCTL = \frac{TR \times BW \times AT \times RBA}{EF \times ED \times FC(EXP_{oral}+EXP_{derm}+EXP_{inhal})}$ where: EXP_o = oral term = $CSF_o \times IR_o \times CF$ EXP_d = dermal term = $CSF_d \times SA \times AF \times DA \times CF$ EXP_i = inhalation term = $CSF_i \times IR_i \times (1/VF+1/PEF)$ TR = target cancer risk, 10^{-6} BW = body weight, 51.9 kg, resident AT = averaging time, 25,550 d RBA = relative bioavailability factor, 1.0 EF = exposure frequency, 350 d/y resident ED = exposure duration, 30 y, resident FC = fraction from contaminated source, 1.0 CSF = cancer slope factor, $(mg/kg\text{-}d)^{-1}$ IR_o = oral ingestion rate, 120 mg/d, resident IR_i = inhalation rate, 12.2 m^3/d, resident CF = conversion factor, 10^{-6} kg/mg SA = surface area skin exposed, 4810 cm^2/d, resident AF = adherence factor, 0.1 mg/cm^2, resident DA = dermal absorption, 0.01 VF = volatilization factor, 4.619×10^6 m^3/kg, resident PEF = particulate emission factor, 1.24×10^9 m^3/kg	FDEP report was prepared in 2005. Toxicity value and context was taken from the outdated EPA HEAST (1997) source.
	30						For 2,3,7,8-TCDD TEQ, commercial/industrial direct contact SCTL.				

TABLE B.4 State Cleanup Levels for Dioxin in Soil: Region 4

State	Soil Conc *(ppt)*	Date	End-point Basis	Toxicity Reference Value		Information Source	Context Notes	Evaluation Criteria: Nature of Peer Review	Evaluation Criteria: Transparency-Public Availability	Evaluation Criteria: Scientific Basis	Evaluation Criteria: Incorporation of Most Recent Science
FL *(cont'd.)*	7	2006 (2004)				*Easthope (2006), ATSDR 1,000 ppt dioxin soil standard: Letter from concerned citizens, environmental groups (http://www.trwnews.net/Documents/TRW/Request%20to%20atsdr%20to%20clarify%201000ppt.pdf); lists same values identified in: EC (2004), Dioxin Soil Cleanup Levels in Other States, cited in table available via Tittabawassee River Watch News (http://www.trwnews.net/images/StateCleanup2006.PDF).*	*Basis not provided.*		*Limited information is available via the weblinks at left, with neither the derivation methodology nor basis of underlying toxicity values.*	*Basis not provided.*	
	2	1997	c			*Hirschhorn (1997a), Cleanup Levels for Dioxin Contaminated Soils; Hirschhorn (1997b), Two Superfund Environmental Justice Case Studies (http://www.trwnews.net/Documents/Cleanup/two_superfund_environmental_just.htm)*	*Indicated as TCDD TEQ in soil. Escambia Treating Company Superfund site, Pensacola, FL, for residential scenario (reflecting ingestion, inhalation, and dermal exposure), 10^{-6} risk.*	*Article peer reviewed as part of journal publication process.*			
	7						*Coleman-Evans Wood Preserving Superfund site cleanup level; 10^{-6} risk.*				
	200						*Escambia Treating Company Superfund Site, Pensacola (1996) cleanup level for off-site residential areas (from EPA Region 4); corresponds to 10^{-4} cancer risk level (ignoring noncancer health effects).*				
	50	1997	n			*Hirschhorn (1997a), Cleanup Levels for Dioxin Contaminated Soils; Hirschhorn (1997b), Two Superfund Environmental Justice Case Studies (http://www.trwnews.net/Documents/Cleanup/two_superfund_environmental_just.htm).*	*Indicated as TCDD TEQ in soil; 1995 "ATSDR Public Health Assessment for Escambia Superfund site cited 50 ppt level for noncancer effects." (Note: not found in the ROD for this site, from the RODS database.)*	*Article peer reviewed as part of journal publication process.*		*See information for the ATSDR entry in Table 11 of the main report.*	
	7	Sep-06				*EPA (2006g), ROD Summary of Remedial Alternative Selection: Coleman-Evans Wood Preserving Company: Superfund Site, OU 02 (Residual Dioxin in Soil), Whitehouse (http://www.epa.gov/superfund/sites/rods/fulltext/r2006040001242.pdf).*	*Based on FL Department of Environmental Protection Dioxin (FDEP) Toxic Equivalent (TEQ) Soil Cleanup Target Levels (SCTLs) for residential and commercial/industrial scenario; 7 ppt for attributable off-facility property, 30 ppt for on facility property.*		*Available online (via RODS database).*		
	30										
	30	Aug-06				*EPA (2006d), ROD Summary of Remedial Alternative Selection: Jacksonville Ash Site, Jacksonville (http://www.epa.gov/superfund/sites/rods/fulltext/r2006040001162.pdf).*	*Based on FDEP Dioxin TEQ SCTLs for commercial/industrial scenario.*		*Available online (via RODS database).*		
	7	Aug-06				*EPA (2006c), ROD Summary of Remedial Alternative Selection: Brown's Dump Site, Jacksonville (http://www.epa.gov/superfund/sites/rods/fulltext/r2006040001161.pdf); equations given in (http://toxicology.ufl.edu/documents/TechnicalFeb05.pdf).*	*Remediation goals as TEQ were adopted from FDEP SCTLs: 7 ppt for residential scenario, 30 ppt for commercial/industrial scenario; calculated for 10^{-6} risk level.*		*Available online (via RODS database). See information for FDEP (2005) above.*	*See information for FDEP (2005) above.*	*See information regarding FDEP (2005) above.*
	30										
	30	Feb-06				*EPA (2006a), ROD Summary of Remedial Alternative Selection: Escambia Wood Treating Company: Superfund Site, Operable Unit 01 (Soil), Pensacola (http://www.epa.gov/superfund/sites/rods/fulltext/r2006040001445.pdf).*	*For 2,3,7,8 TCDD TEQ, based on FDEP SCTL for commercial scenario, lifetime cancer risk of 10^{-6}. (ROD notes the Department shall not require site rehabilitation to achieve a cleanup target level for an individual contaminant that is more stringent than the site-specific, naturally occurring background concentration for that contaminant. Florida Statute 376.30701.)*		*Available online (via RODS database).*		

TABLE B.4 State Cleanup Levels for Dioxin in Soil: Region 4

State	Soil Conc *(ppt)*	Date	End-point Basis	Toxicity Reference Value	Information Source	Context Notes	Evaluation Criteria Nature of Peer Review	Transparency-Public Availability	Scientific Basis	Incorporation of Most Recent Science
GA	80	1992	c		GADNR (1992), Chapter 391-3-19 - Appendix 1: Regulated Substances and Soil Concentrations that Trigger Notification (http://rules.sos.state.ga.us/docs/391/3/19/AP.pdf) Part of GA Hazardous Site Response Act (HSRA). Lund (2009) (personal communication).	For 2,3,7,8-TCDD, notifiable concentration for the unrestricted use scenario. "These rules are promulgated to protect and enhance the quality of Georgia's environment and to protect the public health, safety, and well-being of its citizens." From feedback during field review, when this level is found in soil, it is a requirement to notify the state. Not an official soil cleanup level, this concentration is a default starting point for the cleanup level that is determined on a site-specific basis, which in some cases may be this same concentration.		Soil values are readily available on GADNR website, but derivation basis is ambiguous. Some chem. specific values (e.g. diffusivity) used in the derivation of VF are not provided. Slope factors used in derivation are not provided in the Appendix, calling instead for using current values from the EPA Integrated Risk Information System (IRIS) or if not listed in IRIS, from HEAST.	Basis of equation is from EPA (2000) Chapter 3. Although not stated explicitly in HSRA Appendix, Equation 6 of the EPA document was likely used to calculate GA soil value. However, HSRA Appendix provided different default parameter values than the EPA document. $C = \frac{TR \times BW \times AT \times 365\ d/y}{EF \times ED\ (EXP_{oral}+EXP_{inhal})}$ where: EXP_o = oral term = $CSF_o \times IR_{soil} \times CF$ EXP_i = inhalation term = $CSF_i \times IR_i \times (1/VF+1/PEF)$ TR = target cancer risk, 10^{-5} BW = body weight, 70 kg AT = averaging time, 70 y EF = exposure frequency, 350 d/y resident ED = exposure duration, 30 y resident CSF = cancer slope factor, $(mg/kg\text{-}d)^{-1}$ IR_{soil} = soil ingestion rate, 114 mg/d resident IR_i = inhalation rate, 15 m^3/d resident CF = conversion factor, 10^{-6} kg/mg VF = equation given but not all chemical-specific parameter values PEF = particulate emission factor, $4.63 \times 10^9\ m^3/kg$	GA HSRA is from 1992. The basis (and date) of the slope factor was not specified.
	5	*2006 (2004)*			*Easthope (2006), ATSDR 1,000 ppt dioxin soil standard: Letter from concerned citizens, environmental groups (http://www.trwnews.net/Documents/TRW/Request%20to%20atsdr%20to%20clarify%201000ppt.pdf); lists same values identified in: EC (2004), Dioxin Soil Cleanup Levels in Other States, cited in table available via Tittabawassee River Watch News (http://www.trwnews.net/images/StateCleanup2006.PDF).*	*Basis not provided.*		*Limited information is available via the weblinks at left, with neither the derivation methodology nor basis of underlying toxicity values.*	*Basis not provided.*	
	4.8	*1997*			*Hirschhorn (1997a), Cleanup Levels for Dioxin Contaminated Soils.*	*"The state of Georgia publishes a cleanup value corresponding to 4.8 ppt and North Carolina uses 4.1 ppt, both presumably following EPA risk methods, but probably with some minor change in one or more exposure parameters." No basis provided, no further information given.*	*Article peer reviewed as part of journal publication process.*			
	200	*1997*			*Hirschhorn (1997b), Two Superfund Environmental Justice Case Studies (http://www.trwnews.net/Documents/Cleanup/two_superfund_environmental_just.htm).*	*Marzone Inc./Chevron Chemical Company Superfund Site, Tifton (1996), indicated as cleanup level for residential scenarios (from EPA Region 4); corresponds to 10^{-4} cancer risk level, even though risk-based cleanup levels for pesticides at the site were based on 10^{-6} cancer risk for residential exposure.*				
	1,000	*Aug-04*			*EPA (2004e), Woolfolk Chemical Works Site, OU #3: Amended Record of Decision (http://www.epa.gov/superfund/sites/rods/fulltext/a0404664.pdf).*	*For 2,3,7,8 TCDD TEQ, commercial/industrial scenario. Value is given as SCTL.*		*Available online (RODS database).*		

TABLE B.4 State Cleanup Levels for Dioxin in Soil: Region 4

State	Soil Conc *(ppt)*	Date	End-point Basis	Toxicity Reference Value		Information Source	Context Notes	Evaluation Criteria: Nature of Peer Review	Evaluation Criteria: Transparency-Public Availability	Evaluation Criteria: Scientific Basis	Evaluation Criteria: Incorporation of Most Recent Science
KY		Aug-09				Martin (2009) (personal communication).	Feedback from field review phase indicates that although KY is required by statue to screen against 2002 PRGs, they also recommend considering updated 2009 RSLs. They do accept site-specific parameters that may allow a soil concentration higher than that in the PRGs or RSLs, however this generally requires an Environmental Covenant to ensure that the parameters remain valid.				
	4.5	Apr-09	c	130,000 (SFO)	$(mg/kg\text{-}d)^{-1}$	KY Legislature (2009), Kentucky Administrative Regulations (http://www.lrc.state.ky.us/kar/401/100/030.htm); based on EPA (2009a) Preliminary Remediation Goals (http://www.epa.gov/region09/superfund/prg/pdf/ressoil_sl_table_run_APRIL2009.pdf) & (http://www.epa.gov/region09/superfund/prg/pdf/indsoil_sl_table_run_APRIL2009.pdf).	For 2,3,7,8-TCDD, residential scenario. KY regulation dictates that the state use EPA Region 9 Preliminary Remediation Goals (PRGs) (see Table13 of the report for recently harmonized regional levels).		The PRG documentation is available online.	See Tables 11 and 13 for the basis of EPA regional levels, including the toxicity value.	CalEPA report from late 2002 reflects the 1982 NTP study (slightly more recent than the Kociba study, using updated tumor classification methodology). See Tables 11 and 13 of the report for information underlying the recently harmonized regional screening levels (last updated in fall 2009, with intent to assess for update every 6 months).
	18						For 2,3,7,8-TCDD, industrial scenario. KY regulation dictates that the state use EPA Region 9 PRGs (see Table 13 of the report for recently harmonized regional levels).				
MS	38.2	Feb-02	c	150,000 (CSF_o)	$(mg/kg\text{-}d)^{-1}$	MSDEQ (2002), Final Regulations Governing Brownfield Voluntary Cleanup and Redevelopment in MS (http://www.deq.state.ms.us/MDEQ.nsf/pdf/Main_HW-2/$File/HW-2.pdf?OpenElement); based on EPA (2000) Supplemental Guidance to RAGS (http://www.epa.gov/Region4/waste/ots/healthbul.htm). Hess (2009) (personal communication), verified that EPA (1996), Soil Screening Guidance: User's Guide (http://www.epa.gov/superfund/health/conmedia/soil/pdfs/ssg496.pdf) was used to derive MS target remediation goal (TRGs).	For 2,3,7,8-TCDD, restricted scenario, based on ingestion. Calculated using equations in EPA RAGS (2000). Slope factors (hierarchy) from EPA IRIS, HEAST, ATSDR or peer-reviewed literature.		Target remediation goals are available online. Toxicological basis from HEAST (outdated) is not publicly available.	Residential TRGs are calculated using Equation 2 from USEPA (1996) Soil Screening Guidance $TRG = \frac{TR \times AT}{EF \times IFS_{adj} \times CSF_o \times CF}$ where : TRG = target remediation goal, (mg/kg) TR = target risk, 10^{-6} CSF_o = 150,000 $(mg/kg\text{-}d)^{-1}$ AT = averaging time, 25,550 d EF = exposure frequency, 350 d IFS_{adj} = soil ingestion factor, 114 mg-y/kg-d CF = conversion factor, 10	The Region 4 guide is from 2000. The basis of the outdated HEAST values was not reported.
	4.26						For 2,3,7,8-TCDD, unrestricted land-use scenario, based on ingestion. Calculated using equations in EPA RAGS (2000). Slope factors are to be taken from EPA IRIS, HEAST, ATSDR or peer-reviewed literature.				
	5	*2006 (2004)*				*Easthope (2006), ATSDR 1,000 ppt dioxin soil standard: Letter from concerned citizens, environmental groups (http://www.trwnews.net/Documents/TRW/Request%20to%20atsdr%20to%20clarify%201000ppt.pdf); lists same values identified in: EC (2004), Dioxin Soil Cleanup Levels in Other States, cited in table available via Tittabawassee River Watch News (http://www.trwnews.net/images/StateCleanup2006.PDF).*	*Basis not provided.*		*Limited information is available via the weblinks at left, with neither the derivation methodology nor basis of underlying toxicity values.*	*Basis not provided.*	
	5	*1997*	*c*			*Hirschhorn (1997a), Cleanup Levels for Dioxin Contaminated Soils.*	*Indicated for Naval Seabees Center, Gulfpoint, MS; to remove contaminated soil with about 100 ppt dioxins.*	*Article peer reviewed as part of journal publication process.*			
	100						*Commercial scenario in Gulfport, MS in 1987; "first commercial dioxin cleanup in the United States … goal of the Air Force project is to reduce dioxin levels in the soil to less than 0.1 ppb and then to delist the soil as safe."*				
	1,000	*Sep-07*				*EPA (2007), ROD Summary of Remedial Alternative Selection: Picayune Wood Treating Site, Picayune (http://www.epa.gov/superfund/sites/rods/fulltext/r2007040001948.pdf).*	*Based on EPA 1998 OSWER directive.*		*Available online (via RODS database).*	*The Kimbrough et al. (1984) evaluation of Kociba et al. (1978) underlies the OSWER value.*	

TABLE B.4 State Cleanup Levels for Dioxin in Soil: Region 4

State	Soil Conc *(ppt)*	Date	End-point Basis	Toxicity Reference Value		Information Source	Context Notes	Evaluation Criteria			
								Nature of Peer Review	Transparency-Public Availability	Scientific Basis	Incorporation of Most Recent Science
NC	1,000	Oct-09	c			NCDENR (2009), Inactive Hazardous Sites Branch Soil Remediation Goals (http://www.wastenotnc.org/soiltable.pdf) (link updated in October 2009); Inactive Hazardous Sites Program Guidelines for Assessment and Cleanup (http://www.wastenotnc.org/sfhome/stateleadguidance.pdf)	For TCDD TEQ, preliminary health-based preliminary soil remediation goal (PSRG) for unrestricted land use; NCDENR indicates a target risk of 10^{-6} is used preliminary health-based PSRGs based on cancer. (1,000 ppt is the OSWER value for residential soil, which is not based on that risk level.) NCDENR also indicates the PSRGs are adapted from the April 2009 EPA RSL tables. (Note the current 1,000 ppt replaces the October 2008 residential value of 4.5 ppt, which is the EPA RSL for TCDD; an industrial level no longer appears in the 2009 documentation (18 ppt in 2008).		The PSRGs are available online.	Not clear; NCDENR indicates adoption of the EPA RSL, and also indicates a target risk of 10^{-6} is applied for , but the RSL value for dioxin is not reflected here (the 1,000 ppt appears to reflect the OSWER directive). The toxicity value was not found.	NCDENR provides the current WHO TEF values for determining TEQ although the source of these values is not cited, e.g., Van den Berg et al. (2006) or WHO (2005).
	0.64						For TCDD TEQ, protection of groundwater SRG. (For comparison, the EPA RSL risk-based soil screening level for protection of groundwater is 0.15 ppt.)			Refers to EPA 1996 soil screening guidance, and soil leachate model with default values "appropriate for NC. " Specific input values for dioxin were not found, nor was the toxicity value.	
	4	*2006 (2004)*				*Easthope (2006), ATSDR 1,000 ppt dioxin soil standard: Letter from concerned citizens, environmental groups (http://www.trwnews.net/Documents/TRW/Request%20to%20atsdr%20to%20clarify%201000ppt.pdf);lists same values identified in: EC (2004), Dioxin Soil Cleanup Levels in Other States, cited in table available via Tittabawassee River Watch News (http://www.trwnews.net/images/StateCleanup2006.PDF).*	*Basis not provided.*		*Limited information is available via the weblinks at left, with neither the derivation methodology nor basis of underlying toxicity values.*	*Basis not provided.*	
	4.1	*1997*				*Hirschhorn (1997a), Cleanup Levels for Dioxin Contaminated Soils.*	*"The state of Georgia publishes a cleanup value corresponding to 4.8 ppt and North Carolina uses 4.1 ppt, both presumably following EPA risk methods, but probably with some minor change in one or more exposure parameters." No basis provided, no further information given.*	*Article peer reviewed as part of journal publication process.*			
	1,000	*Sep-08*				*EPA (2008e),* ***Lower Roanoke River, Weyerhaeuser Operable Unit 2, Martin County, NC, Part 2: The Decision Summary*** *(http://www.epa.gov/superfund/sites/rods/fulltext/r2008040002458.pdf).*	*Mentions EPA cleanup level of 1 ppb from 1998 OSWER directive and states soil levels are below this level. The ROD calls for "monitored natural recovery" given that soil dioxin is <1 ppb.*		*Available online (via RODS database).*		
	4	*Sep-06*				*EPA (2006e), Record of Decision Summary of Remedial Alternative Selection, Sigmon's Septic Tank Site, Statesville (http://www.epa.gov/superfund/sites/rods/fulltext/r2006040001281.pdf).*	*Indicated as NC soil remediation goal for dioxins.*		*Available online (via RODS database).*		
	14.5	*Sep-06*				*DoD (2006), Final ROD, Operable Unite 6, Site 12, Marine Corps Air Station Cherry Point, Havelock (http://www.epa.gov/superfund/sites/rods/fulltext/r2006040001306.pdf); Calculation given in Appendix 2, NC DENR (2005) (http://wastenot.enr.state.nc.us/hwhome/guidance/pdf/HWScleanup5-05draft.pdf).*	*Indicates the NC soil screening level for TCDD of 14.5 ppt is back-calculated from the concentration protective of groundwater. NC Hazardous Waste Section (HWS) soil screening process sets the unrestricted use level as the lowest of the background concentration, a SSL protective of GW, or the EPA Region 9 residential PRG. In this case, the regional PRG of 3.9 was used as a final remediation goal.*		*Available online (via RODS database).*		
	120	*Jul-05*		*150,000 (SF_o)*	*$(mg/kg\text{-}d)^{-1}$*	*EPA (2005b), Amendment to the ROD, Carolina Transformer Site, Fayetteville (http://www.epa.gov/superfund/sites/rods/fulltext/a0405038.pdf).*	*For 2,3,7,8 TCDD TEQ, based on cancer risk. Derivation of the remediation goal was not found in this document. Action selected to "protect the local community and the environment".*		*Available online (via RODS database).*		

TABLE B.4 State Cleanup Levels for Dioxin in Soil: Region 4

State	Soil Conc *(ppt)*	Date	End-point Basis	Toxicity Reference Value		Information Source	Context Notes	Evaluation Criteria: Nature of Peer Review	Evaluation Criteria: Transparency-Public Availability	Evaluation Criteria: Scientific Basis	Evaluation Criteria: Incorporation of Most Recent Science
SC		Aug-09				Byrd (2009) (personal communication).	Feedback from field review indicates no state cleanup value exists for dioxin. SC uses EPA screening values, toxicity values, and guidance for risk-based cleanup levels.				
	3.9	*Aug-04*				*SCDHEC (2004), Evaluation of the Koppers Inc. Site under the RCRIS Corrective Action Environmental Indicator Event Code CA723 (Human Exposures), with attachment (1999), Documentation of Environmental Indicator Determination (http://www.scdhec.gov/environment/lwm/pubs/eipdfs/Koppers%20CA725,%20dated%20August%2019,%202004.pdf).*	*PRG for residential scenario. Memo with attachment does not provide derivation basis.*		*Memo with attachment in which values are cited is available online.*	*Scientific basis not found.*	*Memo is from 2004, with the attachment dated February 1999.*
	16						*PRG for industrial scenario. Memo does not provide derivation basis.*				
	3.2	*May-04*	*c*	*150,000 (SF_o)*	*$(mg/kg\text{-}d)^{-1}$*	*DOE (2004), ROD, Remedial Alternative Selection for the R-Area Burning/Rubble Pits (131-R and 131-1R) and Rubble Pile (631-25G) Operable Unit (U), Aiken (http://www.epa.gov/superfund/sites/rods/fulltext/r0404088.pdf).*	*Remedial goal (RG) for TCDD isomers identified, selected as the lower of the most restrictive human health RG objectives (RGOs) for expected future land use and lowest LOAEL-based RGO. (RGOs calculated in WSRC 2003, RFI/RI/WPA with Baseline Risk Assessment for the R -Area Burning Rubble Pits (131-R and 131-1R) and Rubble Pile (631-25G) Operable Unit (U), WSRC-RP-2002-4183, Rev.1, June.)*		*Available online (via RODS database).*	*References the 2002 EPA Integrated Risk Information System (IRIS)as source of toxicity data (with B2 as the carcinogen descriptor).*	
TN	50	Sep-03	c			DHHS (2003), Residential Dioxin Contamination (http://health.state.tn.us/Environmental/PDFs/hc-e-easygoer.pdf); based on ATSDR (1998), Toxicological Profile for Chlorinated Dibenzo-p-Dioxins (http://www.atsdr.cdc.gov/toxprofiles/tp104.pdf).	For 2,3,7,8 TCDD TEQ. Soil screening level for dioxins based on 10^{-6} lifetime cancer risk over a 70-year life span. Reflects recent ATSDR guideline.	ATSDR follows an external review process (e.g., the 1998 policy with the screening value was reviewed by a panel of university and Canadian health officials).	Available online.	See ASTDR entry in Table 11 of the report.	The updated ATSDR dioxin policy was not based on new scientific data or a reanalysis of the existing data. "The update does not change the assessment of health hazards associated with dioxin exposure, as summarized in the 1998 ATSDR Toxicological Profile and in the derivation of the Minimal Risk Level (MRL). The policy update impacts site-specific health assessments evaluating exposure to dioxin directly from residential soils."
	2,500	*Jul-02*	*c*			*Bates et al. (2002), American Creosote Site Case Study: Solidification/Stabilization of Dioxins, PCP and Creosote for $64 per Cubic Yard.*	*For 2,3,7,8 TCDD TEQ. Soil action level based on 10^{-4} lifetime cancer risk for future adult worker.*	*Article peer reviewed as part of journal publication process.*	*Available online.*	*Scientific basis not found.*	This contaminated site was remediated in 1996.
	1,000	*Jul-03*	*c*			*EPA (2003e), ROD, Summary of Remedial Alternative Selection for the Soil and Groundwater at the Wrigley Charcoal Site, Wrigley (http://www.epa.gov/superfund/sites/rods/fulltext/r0403576.pdf).*	*For 2,3,7,8 TCDD TEQ. The ROD indicates that soil was tested for dioxin on two separate occasions and found to be below the EPA cleanup level of 1 ppb.*		*Available online (RODS database)*		

TABLE B.5 State Cleanup Levels for Dioxin in Soil: Region 5

State	Soil Conc *(ppt)*	Date	End-point Basis	Toxicity Reference Value		Information Source	Context Notes	Evaluation Criteria: Nature of Peer Review	Evaluation Criteria: Transparency-Public Availability	Evaluation Criteria: Scientific Basis	Evaluation Criteria: Incorporation of Most Recent Science
IL	14	Jun-05	n (eco)	1.4×10^{-5} (NOAEL)	mg/kg-d	CWLP (2005), Springfield, IL, City Water, Light & Power, Supplement to Part 7 of PSD Permit Application, Additional Impact Analysis for Metals (http://yosemite.epa.gov/r5/r5ard.nsf/c408a2009710018f8625716f004d9038/df97027430f55b6d862571a3005a188e/$FILE/CWLP%20Metals%20Analysis_3_14_06.pdf); based on wildlife benchmark in Sample et al. (1996) (http://www.esd.ornl.gov/programs/ecorisk/documents/tm86r3.pdf).	Screening level of 1.4×10^{-5} (or 14×10^{-6}) mg/kg soil is based on the no observed adverse effect level (NOAEL) for a ring-necked pheasant – which was "used to represent closest available species and was the worst-case screening level for dioxins" – taken from ORNL technical report for DOE, "Toxicology Benchmarks for Wildlife: 1996 Revision."	(1996 ORNL report underwent technical review; nature of peer review for the screening level derivation not found.)	Full derivation approach not found. Summary information from the toxicological study is available online in ORNL (1996). (The original Nosek et al. [1992] article is not publicly available online.)	Methodology is not provided; soil *concentration* appears to be the same value as the *daily dose* summarized in ORNL (1996) from Nosek et al. (1992): intraperitoneal, 10-wk study during critical life stage for the reproductive endpoint; chronic NOAEL of 14 ng/kg-d; chronic of lowest observed adverse effect level (LOAEL) 140 ng/kg-d. ORNL (1996) also summarized similar dose information from a second study, Murray et al. (1979): rat dietary 3-generation study; chronic NOAEL of 1 ng/kg-d; chronic LOAEL of 10 ng/kg-d.	The ecological benchmark from Nosek et al. (1992) is cited in the ORNL (1996) technical report on toxicological benchmarks for wildlife.
	1,000	*Apr-02*	*c*			*ROD; OU 04, Sangamo Electric Dump/ Crab Orchard National Wildlife Refuge, Carterville (http://www.epa.gov/superfund/sites/rods/fulltext/r0502044.pdf).*	*For Site 36, 2,3,7,8 TCDD TEQ levels exceeded Region 9 PRGs (screening values); no cleanup action was taken because concentrations were below the 1,000 ppt cleanup level from EPA 1998 OSWER directive; that level TEQ translates is indicated to translate to 2.5×10^{-4} risk for residential use. Site use is not residential so applying this value is conservative; all concentrations were less than 1 ppb. A baseline human health potential remediation goal (BHRG) of 1,000 ppt was identified for recreational use.*		*Methodology and assumptions for deriving BHRGs are provided in the 1996 human health baseline risk assessment and ecological risk assessment, for the site, not yet found via open access online.*	*The Kimbrough et al. (1984) evaluation of Kociba et al. (1978) underlies the OSWER value.*	
	60						*For Site 22A, For 2,3,7,8 TCDD TEQ, a BHRG of 60 ppt was established for site workers.*				
	45		*n (eco)*				*For 2,3,7,8 TCDD TEQ, ecological risk-based concentration (RBC) identified as interim cleanup level, based on the LOAEL per assumptions given in the feasibility study (FS) ecological risk model.*		*The FS that provides basis information has not been found online.*	*The ROD indicates the RBC basis is the LOAEL for each receptor group (cites the FS, which was not found online).*	
IN	45	2006	c	150,000 (SF_o)	$(mg/kg\text{-}d)^{-1}$	IDEM (2006), Risk Integrated System of Closure (RISC), Provisional 2006 Default Closure Levels (data sheet); personal communication from Anderson (2009); algorithms and data, including hierarchies, are stated as being from IDEM (2001), RISC Technical Guide (http://www.in.gov/idem/files/risctechguidance.pdf); also note IDEM (2009), RISC Technical Guide, Appendix 1, Default Closure Tables (http://www.in.gov/idem/files/risctech_appendix1_2006_r1.pdf), this technical guide reflects revisions since IDEM (2001) and IDEM (2006) (note the internal 2009 tables are not yet available online).	Current provisional default closure level for TCDD in residential soil, is 4.5×10^{-5} mg/kg (direct contact); it is based on the cancer endpoint, with HEAST (undated) identified as the source of the SF, 150,000 per mg/kg-d. (From field feedback during the review phase, the draft internal proposed value for the residential scenario is 60 ppt, based on the slope factor of 130,000 per mg/kg-d from CalEPA.)	Not identified.	The RISC technical guide (2006/2009, which does not yet contain any dioxin values) is available online. The provisional and proposed values and their complete derivation including parameter values and citations/ context for the toxicity values are not yet found online.	Basic calculation from IDEM (2006): $DCL = \dfrac{TR\times AT_c\times 365\ d/y}{EF_r\times(A+[InhF_{adj}\times SF_i\times B])}$ $A = \dfrac{SF_o\times(IngF_{adj}+[SFS_{adj}\times ABS])}{10^6\ mg/kg}$ $B = \dfrac{1}{VF} + \dfrac{1}{PEF}$ where: TR = target risk, 10^{-5} AT_c = averaging time, 70 y EF_{rs} = exposure frequency residential soil, 250 d/y SF_o = oral slope factor, 150,000 $(mg/kg\text{-}d)^{-1}$ (130,000 for 2009 internal draft level) $IngF_{adj}$ = ingestion factor soil age adjusted, 114 mg-y/kg-d SFS_{adj} = skin factor soil age adjusted, 1,257 mg-y/kg-d ABS = skin absorbance factor, 0.03 $InhF_{adj}$ = inhalation factor age adjusted, 10.9 m^3-y/kg-d SF_i = inhalation SF, same as for SF_o above VF = volatilization factor, m^3/kg PEF = particulate emission factor, 1.316×10^9 m^3/kg	The internal 2009 update of the IDEM Technical Guide refined selected values used in the calculations, but the methodology and citations for the toxicity values were not provided; thus, it is not known how recently the scientific basis underlying those values was considered.
	180						Current provisional closure level for TCDD for the commercial/industrial scenarios is 1.8×0^{-4} mg/kg, the basis is the same as for the residential level. This concentration is also the default level for residential soil based on migration to ground water. (It is also the draft internal proposed value from July 2009, based on feedback during the field review phase.) Note the supporting documentation includes an RfD_0 of 1.0×10^{-9} mg/kg-d; however, cancer was the limiting endpoint for the residential and industrial screening levels. (Note this RfD is the same as the ATSDR chronic MRL finalized in 1998.)				

TABLE B.5 State Cleanup Levels for Dioxin in Soil: Region 5

State	Soil Conc (ppt)	Date	End-point Basis	Toxicity Reference Value		Information Source	Context Notes	Evaluation Criteria: Nature of Peer Review	Evaluation Criteria: Transparency-Public Availability	Evaluation Criteria: Scientific Basis	Evaluation Criteria: Incorporation of Most Recent Science
IN *(cont'd)*	60	Jun-09	c	130,000 (SF_o)	$(mg/kg\text{-}d)^{-1}$	IDEM (2009), Risk Integrated System of Closure (RISC), Proposed 2009 Default Closure Levels (data sheet); personal communication from Anderson (2009); updated levels reflect proposed changes in default algorithms and hierarchies in IDEM (2009) (same information source identified above); per feedback during field review, proposed levels may be released in late 2009 or 2010.	From feedback during field review, represents the Internal draft proposed residential soil default closure level for TCDD, given as 6.0 $\times 10^{-5}$ mg/kg (this is also the default closure level for residential soil, direct contact); it is based on the cancer endpoint; CALEPA (undated) is given as the basis of the oral slope factor of 130,000 per mg/kg-d (and inhalation unit risk of 38 per µg/m^3). The proposed commercial/industrial default level for soil direct contact, and the proposed residential and commercial/ industrial level for migration to groundwater, are the same as the 2006 provisional level (180 ppt).	Not identified.	As above.	Basic equation is as above. However, the internal draft proposed values incorporate the CalEPA oral cancer slope factor and IUR (rather than using the oral SF for the inhalation SF).	As above.
	180						Proposed commercial/industrial soil default closure level for TCDD, given as 1.8 $\times 10^{-4}$ mg/kg; with the same basis as the preceding entry. (This value is also the default closure level for industrial soil, as well as the default level for residential soil based on migration to ground water.) The supporting documentation also considers the noncancer endpoint, noting the chronic ATSDR MRL of 1×10^{-9} mg/kg-d, (and intermediate MRL of 2×10^{-8} mg/kg-d), as well as the CalEPA reference concentration of 4×10^{-7} mg/m^3. However, cancer is the driving endpoint for the closure levels.				
	1,000	*Jun-89*	*c*			*EPA (1989c), ROD; OU 01, Wedzeb Enterprises, Inc., Lebanon (http://www.epa.gov/superfund/sites/rods/fulltext/r0589097.pdf).*	*For 2,3,7,8 TCDD TEQ. Dioxin found at very low levels; no cleanup action taken because the concentration was less than the cleanup level of 1,000 ppt.*		*ROD indicates community involvement was not significant; concerns expressed by citizens and local officials on remedy implementation were addressed at the 6/1/89 public meeting so no formal comments were received by Wedzeb on the remedy.*		

TABLE B.5 State Cleanup Levels for Dioxin in Soil: Region 5

State	Soil Conc *(ppt)*	Date	End-point Basis	Toxicity Reference Value		Information Source	Context Notes	Evaluation Criteria			
								Nature of Peer Review	Transparency-Public Availability	Scientific Basis	Incorporation of Most Recent Science
MI	90	Jan-06	c	75,000 (SF)	$(mg/kg\text{-}d)^{-1}$	MIDEQ (2006), Attachment 1, Table 2, Soil: Residential and Commercial, (http://www.michigan.gov/documents/deq/deq-rrd-OpMemo_1-Attachment1Table2SoilResidential_283553_7.pdf); from Technical Support Document, Part 201 Generic Cleanup Criteria and Screening Levels, Part 213 Tier 1 Risk-Based Screening Levels (http://www.michigan.gov/deq/0,1607,7-135-3311_4109_9846_30022-101581--,00.html); basis and equations from MIDEQ (2005), Attachment 6 (from same main document as above) (http://www.michigan.gov/documents/deq/deq-rrd-OpMemo_1-Attachment6_285488_7.pdf).	For 2,3,7,8 TCDD TEQ. Direct contact criteria (DCC) and risk-based screening level (RBSL), protective against adverse health effects from long-term ingestion and dermal contact with soil. MIDEQ notes "of all polychlorinated and polybrominated dibenzodioxin and dibenzofuran isomers present at a facility, expressed as an equivalent concentration of 2,3,7,-tetrachlorodibenzo-p-dioxin based upon their relative potency, shall be added together and compared to the criteria for 2,3,7,8-tetrachlorodibenzo-p-dioxin. The generic cleanup criteria for 2,3,7,8-tetrachlorodibenzo-p-dioxin are not calculated according to the algorithms presented in R 299.5714 to R 299.5726. The generic cleanup criteria are being held at the values that the DEQ has used since August 1998, in recognition of the fact that national efforts to reassess risks posed by dioxin are not yet complete. Until these studies are complete, it is premature to select a revised slope factor and/or reference dose for calculation of generic cleanup criteria."		The DCC derivation methodology is available online.	Generic residential and commercial algorithm: $DCC = \frac{TR \times AT \times CF}{SF \times [(EF_i \times IF \times AE_i)+(EF_d \times DF \times AE_d)]}$ where: DCC = direct contact criterion, µg/kg (ppb); TR = target risk, 10^{-5} cancer risk; AT = averaging time, 25,550 d; CF = correction factor, 10^{9} µg/kg; EF_i = ingestion exposure frequency, 350d/y; IF = age-adj soil ingestion factor, 114 mg-y/kg-d; AE_i = oral absorption efficiency, 0.5; EF_d = dermal exposure frequency, 245 d/y; DF = age-adjusted soil dermal factor, 2,442 mg-y/kg-d; AE_d = dermal absorption efficiency, 0.3	The value for age-adjusted soil dermal factor was obtained from MIDEQ (1998). This parameter appears to have been updated in MIDEQ (2005) document to a value of 353 mg-y/kg-d. However, the DCC for dioxin has remained unchanged.
	90	Aug-98	c	75,000 (SF)	$(mg/kg\text{-}d)^{-1}$	MIDEQ (1998), More Details on Dioxin 90 ppt value, Excerpt from Part 201, Generic Soil Direct Contact Criteria, Technical Support Document; developed under MIDEQ 1994 Natural Resources and Environmental Protection Act 451, Part 201 (http://www.michigan.gov/documents/deq/deq-whm-hwp-dow-excerpt_of_dcc_tsd_251913_7.pdf); SF context given in TSG (1990), Carcinogenicity Slope Factor for 2,3,7,8-TCDD: Overview and Recent Developments, Toxic Steering Group Meeting (http://www.michigan.gov/documents/deq/deq-whm-hwp-dow-slope_factor_251918_7.pdf). (Also see CalEPA [2007] for further context and citations, in Table 11 of the report.)	Concentration is based on a risk target of 10^{-5} (note the hazard quotient of 1 for noncancer endpoint was not used for the 90 ppt level). The slope factor (SF) is for total significant tumors per the 1986 NTP classification scheme, context is given in TSG (1990); the earlier SF from the initial Kociba et al. (1978) analysis was higher. (Note that study served as a key basis for the earlier 1 ppb value from ATSDR, and the EPA 1998 OSWER value.) TSG (1990) includes historical context from the 1980s, including the EPA Carcinogen Assessment Group (CAG) SF of 156,000 $(mg/kg\text{-}d)^{-1}$ based on significant female tumors (liver, lung, nasal turbinates/hard palate), as the geometric mean of the Kociba analysis (151,000) and Squire analysis (161,000), adjusted for early mortality (deaths in year 1). Reanalysis per the NTP 1986 liver classification scheme produced an SF of 52,000 $(mg/kg\text{-}d)^{-1}$ per liver tumors only. TSG (1990) cites EPA regarding FDA, CDC, and CA using SFs of 151,000 or 161,000 per mg/kg-d based on liver tumors only, from the Kociba or Squire analysis, respectively.	(Underlying studies are from peer-reviewed literature.)	The DCC derivation methodology is available online, as is summary context for the slope factor.	Tumors from 2-y dietary rat study, Kociba et al. (1978), with subsequent reanalysis per 1986 NTP methodology producing a SF of 75,000 $(mg/kg\text{-}d)^{-1}$ based on total significant tumors. Equation is same as identified above for MIDEQ (2006).	MIDEQ methodology (1998) cites EPA guidance from 1992 or earlier; some default values have changed since then, e.g., for dermal and other exposure factors (e.g., the "IF" would have been lower per the EPA 2008 child-specific EFH and the EPA 1997 EFH; note that document was itself recently updated and released in October 2009 as an external review draft . The toxicity value is based on analyses of the 1978 Kociba et al. (1978) data using updated tumor classification methodology.
	1,000	*Jul-08*	*c*			*Heltman (2008), EPA Requires Limited Dioxin Cleanup at Dow Site Absent Final Risk Levels (http://www.trwnews.net/Documents/EPA/epa072908.htm).*	*Indicates MI waived its standard in consenting to 1 ppb for cleanup of the Riverside Blvd. site near Dow Chemical Co., and notes State regulations allow for a different cleanup level based on site-specific and other information; the amount of contaminated soil was considered too large for interim remediation; article indicates (per state officials) that this level was selected as matter of practicality.*			*Concentration appears to reflect OSWER directive. (The Kimbrough et al. (1984) evaluation of Kociba et al. (1978) underlies the OSWER value.)*	
	90	*2006*	*c*			*Paustenbach (2006), Identifying Soil Cleanup Criteria for Dioxins In Urban Residential Soils: How Have 20 Years of Research and Risk Assessment Experience Affected the Analysis? (http://ndep.nv.gov/bmi/docs/060406_dioxin%20paper.pdf).*	*For 2,3,7,8 TCDD-TEQ; risk-based calculation reported for soil ingestion pathway, which indicates this is the driving pathway.*	*Article peer reviewed as part of journal publication process.*			

TABLE B.5 State Cleanup Levels for Dioxin in Soil: Region 5

State	Soil Conc *(ppt)*	Date	End-point Basis	Toxicity Reference Value		Information Source	Context Notes	Evaluation Criteria			
								Nature of Peer Review	Transparency-Public Availability	Scientific Basis	Incorporation of Most Recent Science
MI *(cont'd.)*	*990*	*Feb-98*	*c*			*EPA (1998c), AMD, OU 03, Ott/Story/Cordova Chemical Co., Dalton Township (http://www.epa.gov/superfund/sites/rods/fulltext/a0598101.pdf).*	*For 2,3,7,8 TCDD TEQ concentrations do not exceed any State or Federal requirement for industrial land use, and the MI direct contact value (DCV) of 0.99 ppb applies (rather than the default standard of 1 ppt for residential use). "If anyone were to perform any future excavation, soils 1 to 3 feet below grade may present a 1 in 100,000 chance of an individual developing cancer if that individual performs industrial work on the site for 70 years." (Note this ROD preceded the OSWER directive and refers to the RCRA Land Disposal Restriction Universal Treatment Standard, with excavated soil greater than 1 ppb requiring off-site incineration.) Target method detection limit (TMDL) is the lowest value accepted by MI that lab can measure.*			*Target method detection limit, TMDL, is lowest value accepted by MI that laboratory equipment can measure; if 20 x DW is <what the laboratory can detect, the TMDL becomes the cleanup standard, where 20 x DW = 20x the MI Part 201 industrial drinking water standard, which represent the soil concentration above which leaching to groundwater may exceed acceptable drinking water standards.) Area F&G exceeded the TMDL of 1 ppt but that standard was determined not to apply because the contaminant was not shown to leach at unacceptable levels so the DCV of 0.99 ppb applies.)*	
MN	20	Jun-09	c	1,400,000 (SF_o)	$(mg/kg\text{-}d)^{-1}$	MPCA (2009), Risk-Based Guidance for the Soil - Human Health Pathway, Tier 1 and Tier 2 SRV Spreadsheets (http://www.pca.state.mn.us/cleanup/riskbasedoc.html#pathway); These soil reference values (SRVs) update the Jan 1999 working draft values that were based on an SF_o of 1,400,000 $(mg/kg\text{-}d)^{-1}$, from MPCA (1999), Draft Guidelines: Risk-Based Guidance for the Soil - Human Health Pathway, Volume 2, Technical Support Document (http://www.pca.state.mn.us/cleanup/pubs/srv3_99.pdf). Hansen (2009) (personal communication).	For 2,3,7,8 TCDD TEQ. The Tier 1 and 2 soil reference values (SRVs) are as dry weight, for direct exposure via incidental ingestion, dermal contact, and inhalation (e.g., soil, dust), with excess lifetime cancer risk (ELCR) not to exceed 10^{-5}. The ELCR for chronic scenarios is 10^{-5}; that for subchronic scenarios (e.g., short-term worker) is 10^{-6}. Tier 1 (screening) is for residential scenarios, typically using maximum concentrations with default exposure factors (to determine if further investigation and/or remediation may be indicated). Tier 2 (simple site-specific) uses representative concentrations and site-specific conditions; standard residential, recreational and industrial use scenarios reflect reasonable maximum exposures. The SRV for Tier 1 and Tier 2 residential scenario (ELCR 10^{-5}) is 20 per mg/kg-d. (Note the 1999 value was 200 per mg/kg-d and applied to chronic residential and recreational scenarios and subchronic child scenarios based on an ELCR of 10^{-5} – except for the Tier 2 child subchronic scenario, which was based on 10^{-6} risk; that scenario is no longer included in the 2008 update.) The feedback from field review (Hansen, 2009) indicates that the Tier 1 SRV is based on an assumption of age-adjusted soil ingestion, rounded to 20 ppt.	(The preceding 1999 working draft was provided for public review, with the comment period ending July 31; the 1999 working draft has remained available online.)	The derivation methodology is described in MPCA (1999), and updates of specific parameter values are given in the individual spreadsheets. MNDOH (2003) that is cited as the basis for the SF_o is not provided. (Note the 1999 working draft document is available online.)	Driving pathway-oral; endpoints-immune, repro, cancer; cancer target organ-liver; class-human carcinogen; SF_o 1.4×10^{-6} per mg/kg-d; basis-rat dietary study (not provided); source-MNDOH (2003) (not provided). [Note previous SF_o 150,000 from MPCA (1999) also indicated rat dietary study (not provided); target organ-liver; cancer classification-B2 (probable human carcinogen-inadequate evidence in humans); source HEAST (1995).] $ADD_{ing} = ECR/(SF\times AE) = \frac{C_s\times IR\times CF\times FI\times EF_o\times ED}{BW\times AT}$ $ADD_{derm}=ECR/SF=\frac{C_s\times CF\times SA\times AF\times ABS\times EF_d\times ED}{BW\times AT}$ $ADC_{inh} =ECR/IUR= \frac{C_s\times(10^3\ \mu g/mg)\times EF_i\times ED}{(PEF + VF)}$ C_S = soil concentration (SRV), mg/kg $SF_{o,d}$ = 1,400,000 $(mg/kg\text{-}d)^{-1}$ TR = 10^{-5} cancer risk ECR = estimated cancer risk, route-specific AT = 25,550 d IR = soil intake rate, 68 mg/d (age-adj) CF = correction factor, 10^{-6} kg/mg FI = fraction from contaminated area, 1.0 $EF_{o,i}$ = oral and inh exp frequency, 350 d/y EF_d = derm exp frequency, 97 d/y (age- adj) ED = exposure duration, 33 y AE = oral absorption efficiency, 0.55 SA = skin surface area, 3,609 cm^2 (age-adj) AF = adherence factor, 0.17 mg/cm^2 (age-adj) ABS = absorption factor, 0.03 IUR = inhalation unit risk, 400 $(\mu g/m^3)^{-1}$ VF = volatilization factor, 2.49×10^6 (m^3/kg) PEF = part. emission factor, 7.7×10^8 (m^3/kg) BW = body weight, 51 kg (age-adj)	Reflects MPCA (1999) draft guidelines; working draft guidance remains in place for the derivation methodology; updates reflected in 2008 documentation include the following. New SRVs were calculated in 2005; the 1998 WHO TEF values were replaced with 2005 values in 2006; and the subchronic child scenario was removed in 2007. Note the EPA 2005 cancer classification categories are reflected in the footnotes but various 2008 table entries still contain older categories (e.g., B2); TCDD is listed as "human carcinogen."

TABLE B.5 State Cleanup Levels for Dioxin in Soil: Region 5

State	Soil Conc *(ppt)*	Date	End-point Basis	Toxicity Reference Value		Information Source	Context Notes	Evaluation Criteria: Nature of Peer Review	Evaluation Criteria: Transparency-Public Availability	Evaluation Criteria: Scientific Basis	Evaluation Criteria: Incorporation of Most Recent Science
MN *(cont'd.)*	25	Jun-09	c	1,400,000 (SF_o)	$(mg/kg\text{-}d)^{-1}$	MPCA (2009), Risk-Based Guidance for the Soil - Human Health Pathway, Tier 1 and Tier 2 SRV Spreadsheets (http://www.pca.state.mn.us/cleanup/riskbasedoc.html#pathway); These soil reference values (SRVs) update the Jan 1999 working draft values that were based on an SF_o of 1,400,000 $(mg/kg\text{-}d)^{-1}$, from MPCA (1999), Risk-Based Guidance for the Soil - Human Health Pathway, Volume 2 (http://www.pca.state.mn.us/cleanup/pubs/srv3_99.pdf). Hansen (2009) (personal communication).	For 2,3,7,8 TCDD TEQ. Tier 2 recreational scenario; ELCR of 10^{-5} (updated from the 1999 value of 200 per mg/kg-d).			Same as above. For recreational, chronic incidental soil ingestion, age-adjusted: IR = 155 mg/d, EF = 92 d/y, ED = 33 y, BW = 51 kg.	
	35						For 2,3,7,8 TCDD TEQ. Tier 2 industrial worker; ELCR of 10^{-5} (updated from the 1999 value of 350 per mg/kg-d for the chronic industrial scenario).			Same as above. For industrial, chronic incidental soil ingestion: IR = 80 mg/d, EF = 250 d/y, ED = 25 y, BW = 70 kg.	
	75						For 2,3,7,8 TCDD TEQ. Tier 2 short-term worker scenario; ELCR of 10^{-6} (updated from the 1999 value of 800 per mg/kg-d).			Same as above. For short-term worker: IR = 330 mg/d, EF = 45 d (5 d/wk, 9-wk construction period within 1 y), BW = 70 kg; ELCR = 10^{-6} (IR changed from 1999 value of 480 per EPA [2002]).	
	1,000	*Sep-08*	*n*			*MPCA (2008), Second Five-Year Review Report for Ritari Post and Pole Superfund Site, Sebeka, Wadena County, September 2008 (http://www.epa.gov/superfund/sites/fiveyear/f2008050002503.pdf).*	*For 2,3,7,8 TCDD TEQ. Action level identified in 1994 ROD, sustained through 1999 and 2008 explanation of significant difference (ESD) documents, and five-year review reports in 2003 and 2008. "Based on calculations by the Agency for Toxic Substance and Disease Registry (ASTDR) and the Centers for Disease Control (CDC), a residential cleanup criterion of 1 ppb or microgram/kilogram (μg/kg) was established for TCDDeq." (See context for value in Tables 11 and 13 of the report.) As of the September 2008 5-year review, the site is zoned "Mixed (Agricultural/ Residential/Forestry District)" and is assessed as "Agricultural - Non-homestead."*	*Adopted the ATSDR residential soil value available in 1994.*	*Basis for using this ATSDR value as the soil cleanup level for the site was available to the public. (See subsequent information in the ATSDR entry in Table 11 of the report.)*	*See information for the ATSDR entry in Table 11 of the report.*	*The 2008 5-year review considered the recent WHO 2005 TEFs and determined it would not change the protectiveness of the site remedy. This September 2008 review preceded the ATSDR update of Oct.-Nov. 2008 (which retained 0.04 ppb as a screening level and eliminated 1 ppb as an action level); see information for the ATSDR entry in Table 11 of the report. Also note the historical content provided in the earlier documents regarding ATSDR value of 1 ppb for residential cleanup that preceded its 1998 documentation of the policy guideline, excerpted under "context notes" at left.*
	1,000	*Sep-99*	*c*			*EPA (1999d), ROD AMD; OU 01, 03, MacGillis & Gibbs Co./ Bell Lumber & Pole Co., New Brighton (http://www.epa.gov/superfund/sites/rods/fulltext/a0599147.pdf).*	*Amendment did not alter cleanup level from the 1994 ROD, with total risk meeting the 10^{-4} limit for commercial and industrial use; the surrounding area is commercial and residential. From the 1994 ROD: MN generally establishes its cleanup goals at the 10^{-5} level ... for PCDDs/PCDFs, the cleanup level is 1 μg/kg. This cleanup level was developed by ATSDR and has been established as EPA policy. This concentration was also the practical detection limit for laboratory analysis of PCDDs/PCDFs in soil. The 1 μg/kg cleanup level does exceed the 10^{-5} risk level that MPCA uses as a goal. However, the remaining cleanup levels for other site contaminants have been calculated so that total risk from all contaminants at the site will not exceed 10^{-4} which is within U.S. EPA's acceptable risk range."*				

TABLE B.5 State Cleanup Levels for Dioxin in Soil: Region 5

State	Soil Conc *(ppt)*	Date	End-point Basis	Toxicity Reference Value		Information Source	Context Notes	Evaluation Criteria: Nature of Peer Review	Evaluation Criteria: Transparency-Public Availability	Evaluation Criteria: Scientific Basis	Evaluation Criteria: Incorporation of Most Recent Science
OH	35.8	Oct-09	c	150,000 (SF_o)	$(mg/kg\text{-}d)^{-1}$	OHEPA (2009), Closure Plan Review Guidance for RCRA Facilities (http://epa.ohio.gov/portals/32/pdf/2008CPRG.pdf);	For 2,3,7,8 TCDD TEQ. Values are for single chemicals, direct contact with soil. Considers ingestion, dermal contact, and inhalation, with ingestion as the primary pathway.		OHEPA document and tables available online. Cites EPA (1996) Soil Screening Guidance and EPA (2002) supplemental guidance (available online).	Slope factor from HEAST database. Calculation of direct contact cancer GCN for a constituent that has an SF_o and a SF_i. $GCN = \frac{TR \times AT}{A + B + C}$ Where: $A = SF_o \times (IFS_{adj} \times CF \times FI \times EF)$ $B = SF_o / O_{ABS} \times (SFS_{adj} \times ABS \times CF \times EF)$ $C = SF_i \times [InhF_{adj} \times EF \times (1/PEF) + (1/VF)]$ GCN = generic cleanup number, mg/kg TR = target risk, 10^{-5} AT = averaging time, carcinogens, 25550 d $SF_{o,i}$ = oral and inhalational cancer slope factor,150,000 mg/kg-d IFS_{adj} = age-adjusted soil ingestion factor, 114.3 mg-y/kg-d CF = conversion factor, soil 10^{-6} FI = soil fraction ingested, 1.0 EF = exposure frequency residential, 350 d/y O_{ABS} = oral absorption factor, 0.5 SFS_{adj} = age-adjusted soil dermal contact factor, 360.8 mg-y/kg-d ABS = dermal absorption factor, 0.03 $InhF_{adj}$ = age-adjusted inhalation factor, 10.9 m^3-y/kg-d PEF = particulate emission factor, 1.36×10^9 m^3/kg VF = volatilization factor, no value provided	
	1,000	*Jun-89*	*c*	*156,000*	*$(mg/kg\text{-}d)^{-1}$*	*EPA (1989b), ROD; OU 01, Laskin/Poplar Oil Co., Jefferson Township (http://www.epa.gov/superfund/sites/rods/fulltext/r0589091.pdf).*	*No cleanup action was taken because soil concentrations were below the 1,000 ppt TCDD equivalent cleanup level from the EPA 1998 OSWER directive.*		*ROD displays cancer slope factor from Superfund Public Health Evaluation Manual (SPHEM) (US EPA, 1986), but SF is not used to derive any site-specific dioxin cleanup level.*	*The Kimbrough et al. (1984) evaluation of Kociba et al. (1978) underlies the OSWER value.* *(Although the ROD also identifies a cancer slope factor of 156,000 per mg/kg-d from the 1986 EPA SPHEM, that value was not used to derive a site-specific dioxin cleanup level because the site adopted the extant EPA 1,000 ppt level.)*	
WI	0.5	May-00	n (eco)	0.0001 (NOAEL)	mg/kg-d	Wheat (2000), [USCC] Dioxins and Furans (http://mailman.cloudnet.com/pipermail/compost/2000-May/006755.html); WDNR, cites WI Dept. of Health memo (May 4, 1994, from Goldring, Bureau of Public Health, subject: "Revision of DOH Guidelines for Dioxin in Landspread Sludge"). Toxicity value is from Thiel et al. (1995).	Identified as risk-based standards for human and wildlife protection, as total dioxin equivalent (TDE); indicates wildlife emphasis [hence "(eco)" in endpoint column]: Using this methodology, WI DNR "has derived ... wildlife dioxin criterion for surface spreading (i.e., no incorporation) ..." these are meant to be applied "in situations where contaminated material is spread in a thin layer on the surface and not incorporated" (Thiel et al. 1995). Standard for agricultural land with grazing.	Underlying study is from peer-reviewed literature.	Memo from WI Dept. of Health not found online; Thiel et al. (1995) available via Journal of Environmental Toxicology and Chemistry.	From Thiel et al. (1995): NOAEL of 0.1 µg/kg-d for embryo hatchability. Methodology not identified in this information source. Thiel et al. publication is not publicly available.	Thiel et al. (1995) reflects research from 1977 through 1994.
	1.2						TDE, standard for agricultural land without grazing.				

TABLE B.6 State Cleanup Levels for Dioxin in Soil: Region 6

State	Soil Conc *(ppt)*	Date	End-point Basis	Toxicity Reference Value		Information Source	Context Notes	Evaluation Criteria: Nature of Peer Review	Evaluation Criteria: Transparency-Public Availability	Evaluation Criteria: Scientific Basis	Evaluation Criteria: Incorporation of Most Recent Science
AR	4.5	May-09	c	130,000 (SF_o)	$(mg/k\text{-}d)^{-1}$	ARDEQ (2009a,b) AR Corrective Action Strategy (http://www.adeq.state.ar.us/hazwaste/branch_tech/risk_assessment.htm), (http://www.adeq.state.ar.us/hazwaste/branch_tech/cas.htm#CAS); ARDEQ website links to the EPA (Region 6) Corrective Action Strategy (http://www.epa.gov/earth1r6/6pd/rcra_c/pd-o/riskman.htm).	For 2,3,7,8-TCDD, the RSL for residential soil; AR Dept. of Environmental Quality (ARDEQ) uses EPA Region 6 medium-specific screening levels (MSSLs) as a point of departure (these are now harmonized with Regions 3 and 9 as regional screening levels, see Table 13 of the report). These generic screening levels are used early in the process, before the development of actual cleanup levels based on site-specific risk evaluations. "Arkansas has not implemented a single set of soil clean-up levels for general usage. Instead, the State uses standards set in Regulation No. 23 …, usually arriving at a site-specific standard for each clean-up."		Regional screening levels are available online from EPA Region 6 (and Regions 3 and 9).	For cleanup levels (which are distinct from screening levels): "Site-specific clean-up standards established through site specific, risk-based minimized threat variances should be within the range of values that ARDEQ and EPA generally find acceptable for risk-based cleanup levels … total excess risk to an individual exposed over a lifetime generally falling within a range from 10^{-4} to 10^{-6}, using 10^{-6} as a point of departure … For non-carcinogenic effects, ensure constituent concentrations that an individual could be exposed to on a daily basis without appreciable risk of deleterious effect during a lifetime; in general, the hazard index should not exceed one (1). Constituent concentrations that achieve these levels should be calculated based on a reasonable maximum exposure scenario -- that is, based on an analysis of both the current and reasonable expected future land uses, with exposure parameters chosen based on a reasonable assessment of the maximum exposure that might occur."	
	18						For 2,3,7,8-TCDD, RSL for industrial scenario.				
	(1,000)	Apr-08				APEC (2008), Regulation No. 23, Hazardous Waste Management (http://www.adeq.state.ar.us/regs/files/reg23_final_080526.pdf);	Regulation No. 23 identifies a treatment standard of 1,000 ppt for TCDD TEQ in nonwastewater hazardous waste.				
	1,000	*Sep-96*	*c*			*EPA (1996e), ROD, OU 02, Vertac, Inc., Jacksonville (http://www.epa.gov/superfund/sites/rods/fulltext/r0696102.pdf); EPA (1998b), ESD, OU 02, Vertac, Inc., Jacksonville (http://www.epa.gov/superfund/sites/rods/fulltext/e0698160.pdf); CH2MHILL (2003), Second Five-Year Review for the Vertac Incorporated Superfund Site, Jacksonville (prepared for EPA Region 6) (http://www.epa.gov/superfund/sites/fiveyear/f04-06002.pdf).*	*For TCDD, the remedial objective for offsite areas OU, residential and agricultural soil, 1 ppb (also identified as the residential action level); prevent direct public contact to soil above this level, and assure risks meet 10^{-4} to 10^{-6} range. The ESD sustains this cleanup level and indicates further excavation was warranted (to 12 inches) where new samples exceeded 1 ppb. The five-year review stated no reassessment was needed as 1 ppb was still accepted; 2,3,7,8-TCDD was still present.*			*The ROD includes supporting equations and parameter values.*	
	3,500						*For TCDD, the cleanup goal for onsite soils, based on a site-specific determination that TCDD accounted for 70% of the TCDD TEQ (thus scaled from 5 ppb remedial objective for industrial use).*				
	5,000						*For TCDD TEQs, remedial objective for OU 2 (soils, foundations, curbs, and underground utilities, onsite), 5 ppb based on industrial use.*				
LA						LDEQ (2003a), Recap Table 1 Screening Option: Screening Standards for Soil and Groundwater (http://www.deq.louisiana.gov/portal/LinkClick.aspx?fileticket=bIPYm4ICf9g%3d&tabid=2930).	The list was checked for TCDD and dioxin, and no standards were found.				

TABLE B.6 State Cleanup Levels for Dioxin in Soil: Region 6

State	Soil Conc *(ppt)*	Date	End-point Basis	Toxicity Reference Value		Information Source	Context Notes	Evaluation Criteria: Nature of Peer Review	Evaluation Criteria: Transparency-Public Availability	Evaluation Criteria: Scientific Basis	Evaluation Criteria: Incorporation of Most Recent Science
LA *(cont'd.)*	1,000	Mar-03				LDEQ (2003b), Title 33 Part V. Hazardous Waste and Hazardous Materials, Subpart 1. Table 2 Treatment Standards for Hazardous Wastes (Final Rule) (http://www.deq.louisiana.gov/portal/portals/0/planning/regs/pdf/HW083fin.pdf).	For all TCDDs (as TEQ.) the *treatment standard* (acceptable level) for "non-waste waters" is 0.001 mg/kg.				
	1,000	*Jun-02*	*c*	*150,000 (SF)*	*$(mg/kg\text{-}d)^{-1}$*	*EPA (2002), ROD, OU 01, Marion Pressure Treating (http://www.epa.gov/superfund/sites/rods/fulltext/r0602009.pdf);* *ATSDR (2006), Health Consultation: A Review of Soil Data, Marion Pressure Treating Co., Marion, Union Parish, LA (http://www.atsdr.cdc.gov/HAC/PHA/Marion%20Pressure%20Treating%20Company/MarionPressureTreatingCoHC013106.pdf).*	*For 2,3,7,8-TCDD total TEQ (note 2,3,7,8-TCDD had not been detected). Dioxin screening value is "based on the OSWER residential preliminary remediation goal of 0.001 mg/kg, and therefore is not directly based on a 10^{-6} cancer risk."* *From the health consultation, the health-based assessment comparison value (environmental medium evaluation guide) is 5×10^{-5} mg/kg (50 ppt), also indicated as the ATSDR screening value.* *For recreational and industrial scenario; the dioxin screening value reflects the EPA PRG for the residential scenario, 1 ppb.*			*Health consultation indicates risk from ingestion is calculated by:* $ID_s = \frac{(C \times IR \times EF \times CF)}{BW} \times SF$ *where:* *ID_s = soil ingestion cancer risk, mg/kg-d* *C = contaminate concentration, mg/kg* *IR = soil ingestion rate, 100 mg/d* *EF = exposure factor, unitless* *(EF = exposure frequency × exposure duration) time* *(ED = exposure duration, 15 y)* *(EF = 2 d/wk, 26 wk/y; time: 365 d/y for 15 y)* *BW = body weight, 43kg and 70kg* *CF = conversion factor, 10^{-6} kg/mg* *SF = cancer slope factor, 1.5×10^{5} $(mg/kg\text{-}d)^{-1}$* *(risk = 10^{-4})*	
	1,000	*Nov-97*	*c*	*150,000 (SF_o)*	*$(mg/kg\text{-}d)^{-1}$*	*EPA (1997c), ROD, OU 01, Lincoln Creosote, Bossier City (http://www.epa.gov/superfund/sites/rods/fulltext/r0698047.pdf).*	*For TCDD TEQ, residential scenario; ingestion of soil with dioxins/ furans meets the target risk range (10^{-4} to 10^{-6}.) for the adult resident (RME) and child 5-13 (CTE) for current and assumed future conditions. "All detections of dioxins/ furans in soil and sediment were less than the 1 µg/kg (ppb) cleanup level used by EPA in some Records of Decision for residential sites."*			*Little information is given in the ROD; source of oral cancer slope factor is identified as EPA (1994) but the citation was not provided. The dermal cancer slope factor is identified as the same (150,000 per mg/kg-d), obtained by dividing the oral SF by the GI absorption factor of 1.0 (as the default for organics).*	
	1,000	*Jul-95*	*c*			*EPA (1995e), ROD, OU 01, Southern Shipbuilding, Slidell (http://www.epa.gov/superfund/sites/rods/fulltext/r0695093.pdf).*	*For 2,3,7,8-TCDD TEQ residential scenario; remedial goal for treatment alternatives, per EPA and ATSDR. (No 2,3,7,8-TCDD was found at the site; neither TCDD nor dioxin was mentioned in either the first or second five-year review.)*			*Specific scientific basis of cleanup level or toxicity value was not found in these documents. The document states: it has been determined by EPA and ATSDR that 2,3,7,8 TCDD between 1 to 10 µg/kg does not represent a significant residential risk provided they are covered with at least 12 inches of clean soil. Furthermore, the document indicates that ATSDR and EPA have established that a level of 1 µg/kg or less of 2,3,7,8 TCDD is an acceptable level in surface soils)*	
	10,000						*For 2,3,7,8-TCDD TEQ, extending to subsurface soil: up to 10 ppb of 2,3,7,8-TCDD allowed if the contaminated soil is covered with at least 12 inches of clean soil, per EPA and ATSDR.*				

TABLE B.6 State Cleanup Levels for Dioxin in Soil: Region 6

State	Soil Conc *(ppt)*	Date	End-point Basis	Toxicity Reference Value		Information Source	Context Notes	Evaluation Criteria: Nature of Peer Review	Evaluation Criteria: Transparency-Public Availability	Evaluation Criteria: Scientific Basis	Evaluation Criteria: Incorporation of Most Recent Science
LA *(cont'd.)*	*1,000*	*Apr-93*	*c*			*EPA (1993a), ROD, OU 01, American Creosote Works, Inc., Winnfield (http://www.epa.gov/superfund/sites/rods/fulltext/r0693086.pdf);* *CH2M HILL (2005a), Second Five-Year Review for American Creosote Works, Inc., Winnfield (http://www.epa.gov/superfund/sites/fiveyear/f05-06003.pdf).*	*For 2,3,7,8-TCDD equivalents, residential scenario, remedial goal for alternatives with dioxin treatment. The five-year review did not indicate any change (2005 is most recent). No 2,3,7,8-TCDD had actually been found.*			*As indicated for the previous entry (EPA, 1995e).*	
	10,000						*For 2,3,7,8-TCDD TEQ, extending to subsurface soil: up to 10 ppb of 2,3,7,8-TCDD allowed if the contaminated soil is covered with at least 12 inches of clean soil, per EPA and ATSDR. ("It has been determined by EPA and the Agency for Toxic Substances and Disease Registry (ATSDR) as presented in the RI/FS that levels of 2,3,7,8 TCDD between 1 to 10 µg/kg do not represent a significant residential risk provided they are covered with at least 12 inches of clean soil.")*				
NM		Jun-06				NMED (2006), Technical Background Document For Development of Soil Screening Levels, Revision 4.0 Vol. 1 Tier 1: Soil Screening Guidance Technical Background Document, Table A-1 (ftp://ftp.nmenv.state.nm.us/hwbdocs/HWB/guidance_docs/NMED_June_2006_SSG.pdf).	This table was checked for 2,3,7,8-TCDD and dioxin, and no entries were found (nor was other input provided during the field review phase).				
OK	3.9	Feb-03	c	150,000 (SF_o)	$(mg/kg\text{-}d)^{-1}$	OKDEQ (2004), Site Cleanup Using Risk-Based Decision Making (http://www.deq.state.ok.us/lpdnew/FactSheets/RiskbasedDecisionGuidanceFinal.pdf); EPA (Region 6) (2003), Medium-Specific Screening Levels (http://www.deq.state.ok.us/LPDnew/HW/02screentable.pdf);	For 2,3,7,8-TCDD, screening level, residential scenario; this OK website links to the earlier table of Region 6 medium-specific screening levels (now represented by joint regional screening levels, see Table 13 of the report). OKDEQ represents the target risk level of 10^{-5} as a policy; calculations also follow EPA (1989).			$Intk = \frac{CS \times IR \times CF \times FI \times EF \times ED}{BW \times AT}$ where: Intk = Intake, mg/kg-d (multiplied by slope factor, 150,000 $(mg/kg\text{-}d)^{-1}$) CS = chemical concentration in soil, mg/kg IR = ingestion rate, 200 mg_{soil}/d for child (1-6 y), 100 mg_{soil}/d for over 6 y old CF = conversion factor, 10^{-6} kg/mg FI = fraction ingested from contaminated source EF = exposure frequency, 365d/y ED = exposure duration, 70 y by convention, 9 y is national median time at one residence BW = body weight, 70 kg adult, 16 kg child AT = averaging time = ED×365 d/y	Source of slope factor from the earlier Region 6 table is indicated as HEAST (which is not a current resource). (Note the 2008/2009 harmonized screening level table identifies CalEPA as the source of the value reflected there).
	18						For 2,3,7,8-TCDD, screening level, industrial scenario, outdoor worker.				
	38						For 2,3,7,8-TCDD, screening level, industrial scenario, indoor worker.				

TABLE B.6 State Cleanup Levels for Dioxin in Soil: Region 6

State	Soil Conc *(ppt)*	Date	End-point Basis	Toxicity Reference Value	Information Source	Context Notes	Evaluation Criteria: Nature of Peer Review	Transparency-Public Availability	Scientific Basis	Incorporation of Most Recent Science
TX	1,000	Mar-09	c		TRRP (2009), TRRP Protective Concentration Levels, Tables 1-5 (http://www.tceq.state.tx.us/remediation/trrp/trrppcls.html); TXCEQ (2005), TXCEQ Regulatory Guidance RG-366/TRRP-22: Tiered Development of Human Health PCLs (http://www.tceq.state.tx.us/comm_exec/forms_pubs/pubs/rg/rg-366_trrp_22.html); Haney (2009) (personal communication).	Tier 1 residential soil PCL for 2,3,7,8-TCDD TEQ for both a 0.5-acre and 30-acre source area, total and combined; includes ingestion, dermal, inhalation, and vegetable consumption. "The TRRP Tier 1 protective concentration levels (PCLs) are the default cleanup standards in the TX Risk Reduction Program." A level of 1 ng TEQ/kg was cited by Paustenbach et al. (2006) as the promulgated TX value. Note the 2005 guidance indicates 2,3,7,8-TCDD TEQs, but the TX 2009 tables reflect TCDD alone; Haney (2009) clarified the basis as TEQs.	Paustenbach et al. (2006) was peer reviewed as part of the journal publication process.	TCEQ documents are available online.	Toxicity value not found in toxicity tables provided. TCEQ documentation indicates the PCL is based on the noncancer endpoint.	
	5,000					Tier 1 commercial/industrial scenario for 2,3,7,8-TCDD TEQ for both a 0.5-acre and 30-acre source area, total and combined, as above.				
	520	*Sep-06*	*c*		*EPA (2006f), ROD, OU 1, Jasper Creosoting Company, Inc. (http://www.epa.gov/superfund/sites/rods/fulltext/r2006060001482.pdf).*	*Industrial scenario for 2,3,7,8-TCDD TEQ, worker. The lower values of the soil direct contact PRGs for protection of both human health and the ecological receptors were selected as the final soil direct contact PRGs; 10^{-5} risk level. (No 2,3,7,8-TCDD was detected.)*			*ROD indicates: Value developed by taking the ratio of the toxicological reference value (TRV) known to cause adverse effects to the total dose from the site-specific risk estimates (HQs) and factoring out the site-specific soil exposure concentrations used in those estimates. The resulting value is the soil concentration that would represent an excessive risk. A lower range PRG was established by using a no-effect level TR. An upper-range PRG was established by using a lowest-effect level TRV. The final PRG was the average of the no-effect and lowest-effect level PRGs as allowed in EPA guidance and recommended in TCEQ guidance document.*	
	17.7					*For 2,3,7,8-TCDD toxicity equivalents, represents the Region 6 medium-specific screening level (note these are now harmonized as joint regional screening levels, see Table 11 of the report).*				
	1,000	*Jun-00*			*TXNRCC (2000), Proposed Remedial Action Document: Toups State Superfund Site: Sour Lake, Hardin County (http://www.tceq.state.tx.us/assets/public/remediation/superfund/register/pdf0100.pdf).*	*Residential scenario for 2,3,7,8-TCDD; cleanup goal based on soil-to-groundwater pathway or soil ingestion/inhalation/dermal contact, whichever is lower.*				
	1,000	*Oct-98*	*c*		*EPA (1998d), ROD AMD, OU 02, United Creosoting Co., Conroe (http://www.epa.gov/superfund/sites/rods/fulltext/a0699032.pdf);* *CH2M HILL (2005b), Second Five-Year Review for the United Creosoting Company Superfund Site (http://www.epa.gov/superfund/sites/fiveyear/f05-06008.pdf);* *TDH under cooperative agreement with ATSDR (2003) Health Consultation: Sediments in Stewarts Creek, Conroe Creosoting Co. (http://www.dshs.state.tx.us/epitox/consults/cccsed_hc_fnl.pdf).*	*Residential soil target action level for 2,3,7,8-TCDD equivalents. Based on the EPA OSWER directive. Cleanup values for sediment were the same as those for soil. (2,3,7,8-TCDD itself was not detected). The AMD states no changes were necessary from the 1989 ROD. Both five-year reviews found the same, no changes needed to the cleanup level.*			*Cancer risk comparisons based on EPA values:* *Cancer risk = 10^{-6}* *Exposure period = 70 y* *TX Department of Health (TDH) also identifies these values:*	
	20,000					*Industrial soil target action level for 2,3,7,8-TCDD equivalents.*			*Body weight = 15 kg for child, 70 kg for adult* *Soil incidental ingestion rate = 200 mg/d for a child, 100 mg/day for an adult*	

TABLE B.7 State Cleanup Levels for Dioxin in Soil: Region 7

State	Soil Conc *(ppt)*	Date	End-point Basis	Toxicity Reference Value		Information Source	Context Notes	Evaluation Criteria: Nature of Peer Review	Evaluation Criteria: Transparency-Public Availability	Evaluation Criteria: Scientific Basis	Evaluation Criteria: Incorporation of Most Recent Science
IA	19	Jul-09	c	150,000 (SF_o)	$(mg/kg\text{-}d)^{-1}$	IADNR (undated), Statewide Soil Standards, IA Land Recycling Program (LRP); personal communication from Drustrup (2009); based on risk calculation in: IA General Assembly (1998), Environmental Protection [567], Chapter 137, Iowa Land Recycling Program and Response Action Standards (http://www.iowadnr.gov/land/consites/documents/chap137.pdf)	Residential cleanup level for TCDD based on cancer risk.		Residential cleanup value based on cancer risk found online, noncancer values provided from the field via personal communication during the field review phase.	SFo is from 1997 HEAST; RfD is from an earlier value (field feedback during review phase indicated it was from EPA IRIS (this basis is unclear); note the value is the same as the 1998 ATSDR chronic MRL, which is the source of the same value indicated in the EPA RSL table, and also noted by selected other states). Standards are based on a cancer TR of 5×10^{-6}. $CL = \dfrac{1}{1/C_{oral}+1/C_{derm}}$ where: $C_{oral,derm} = \dfrac{RF\times AT}{Abs\times CF\times(A+B)}$ and $A = \underline{(ER_c\times EF_c\times ED_c)}/\ BW_c$ $B = \underline{(ER_a\times EF_a\times ED_a)}/\ BW_a$ CL = cleanup level (mg/kg) ED_a = exposure duration for adult, 24 y ED_c = exposure duration for child, 6 y EF_a = exposure frequency for adult, 350 d/y EF_c = exposure frequency for child, 350 d/y ER_a = exposure rate for adult, 100 mg/d oral, 400 mg/d dermal ER_c = exposure rate for child, 200 mg/d oral, 560 mg/d dermal BW_a = body weight adult, 70 kg BW_c = body weight child, 15 kg CF = conversion factor, 10^{-6} kg/mg Abs = absorption factor, 1 oral, 0.03 dermal AT = averaging time, 25,550 d RF = TR / SF TR = target risk, 5×10^{-6} SF = slope factor, 150,000 $(mg/kg\text{-}d)^{-1}$	
	72		n	10^{-9} (RfD)	mg/kg-d		Residential cleanup level for TCDD where it is the only contaminant of concern; field review feedback indicated basis is noncancer endpoint				
	360		n				Nonresidential cleanup level for TCDD; field review feedback indicated basis is noncancer endpoint.				
	14	*2006 (2004)*	*c*			*Easthope (2006), ATSDR 1,000 ppt dioxin soil standard: Letter from concerned citizens, environmental groups (http://www.trwnews.net/Documents/TRW/Request%20to%20atsdr%20to%20clarify%201000ppt.pdf); lists same values identified in: EC(2004), Dioxin Soil Cleanup Levels in Other States, cited in table available via TRW News (http://www.trwnews.net/images/StateCleanup2006.PDF).*	*Basis not provided.*		*Limited information is available via the weblinks at left, with neither the derivation methodology nor basis of underlying toxicity values.*	*Basis not provided.*	
	14	Jul-04	c			MIDEQ (2004), Dioxin Contamination in the Midland Area (http://www.michigan.gov/documents/deq/deq-whm-hwp-Dow-FactsFinal_251769_7.pdf).	For dioxin TEQ, residential scenario. No cleanup level found from searches of IA websites or RODS database, but the MI document notes: "Of the other states that have derived safe levels for dioxin in soil, seven are lower than Michigan … Iowa [is] at 14 ppt." No specific reference for IA was cited or located, thus no other information was found (including for toxicity value and basis).				

TABLE B.7 State Cleanup Levels for Dioxin in Soil: Region 7

State	Soil Conc *(ppt)*	Date	End-point Basis	Toxicity Reference Value		Information Source	Context Notes	Evaluation Criteria: Nature of Peer Review	Evaluation Criteria: Transparency-Public Availability	Evaluation Criteria: Scientific Basis	Evaluation Criteria: Incorporation of Most Recent Science
KS	60	Jun-07	c	150,000 (SF_o = SF_i = SF_d)	$(mg/kg\text{-}d)^{-1}$	KDHE (2007), Risk-Based Standards for KS RSK Manual - 4th Version (http://www.kdheks.gov/remedial/download/RSK_Manual_07.pdf); Nightingale (2009) (personal communication).	For 2,3,7,8 TCDD, residential scenario. "Chemical-specific and media-specific risk-based cleanup goals were calculated using guidance and directives from the United States Environmental Protection Agency and various other technical resources."		Cleanup levels and RBC equations with soil exposure factors are available online; 1997 Health Effects Assessment. Summary Tables (HEAST), are no longer maintained.	Source of slope factors and other toxicological information is given as EPA 1997 HEAST. "The soil exposure pathways evaluated in the human health risk-based calculations include incidental ingestion of soil, inhalation of airborne particulates (dusts), inhalation of chemicals volatilizing from the soil (volatile compounds only), and dermal contact with soil (organic compounds only)." RBC calculation for residential scenario: $RBC = \frac{TR \times BW \times AT \times 365\ d/y}{EF \times ED \times [(ING_s \times CF \times SF_o)+(INH \times SF_i \times \{1/VF_s + 1/PEF\})+(SF_o \times CF \times SA \times AF \times ABS)]}$ where: RBC = risk based concentration (mg/kg) TR = target cancer risk, 10^{-5} BW = body weight, 70 kg AT = averaging time, 70 y EF = exposure frequency, 350 d/y ED = exposure duration, 30 y ING_s = soil ingestion rate, 100 mg/d CF = conversion factor, 10^{-6} kg/mg SF_o = oral cancer slope factor, 150,000 $(mg/kg\text{-}d)^{-1}$ INH = soil inhalation rate, 20 m^3/d SF_i = inhalation cancer slope factor, 150,000 $(mg/kg\text{-}d)^{-1}$ VF_s = soil volatilization factor, m^3/kg PEF = particulate emission factor, $1.18 \times 10^9\ m^3/kg$ SA = surface area of skin, 5000 cm^2/d AF = adherence factor, 0.2 mg/cm^2	References are from 1979-1998, including the 1996 EPA Region 9 PRGs
	100						For 2,3,7,8 TCDD, industrial (non-resident) scenario.				
MO	(1,000)	Jul-09				Garoutte (2009) (personal communication).	Feedback during field review indicated MO has not established or adopted any specific cleanup level for dioxin in soil, while also stating that the MO Department of Health and Senior Services (MDHSS) had been involved with the EPA and MDNR in establishing 1 ppb as a surface soil cleanup level for contaminated sites in MO.				
		Apr-06				MDNR (2006), MRBCA Technical Guidance (Appendices) (http://www.dnr.mo.gov/env/hwp/mrbca/docs/mrbca-append6-06.pdf).	MDNR MRBCA Technical Guidance document (updated June 2008) contains guidelines for surface soil. This *document* was searched for TCDD and dioxin, but no information was found.		MDNR document is available online.		
	1,000	*1997*				*Hirschhorn (1997a), Cleanup Levels for Dioxin-Contaminated Soil.*	*Indicated for 2,3,7,8 TCDD, residential scenario; 1 ppb for residential land use from EPA 1988 decision for Superfund cleanup at Times Beach, MO, set the stage for the policy-based level.*		*Article peer reviewed as part of journal publication process.*		
	1,000	*Sep-05*	*c*			*EPA (2005c), Missouri Electric Works Sites, OU 02, Cape Girardeau (http://www.epa.gov/superfund/sites/rods/fulltext/r0705052.pdf).*	*For 2,3,7,8-TCDD TEQ, residential scenario. TCDD was a combustion byproduct of concern during thermal treatment of PCB-contaminated soil. TCDD soil concentrations were monitored to ensure levels below 1 ppb.*		*Available online (RODS database).*	*Concentration appears to reflect the OSWER directive. The Kimbrough et al. (1984) evaluation of Kociba et al. (1978) underlies the OSWER value.*	

TABLE B.7 State Cleanup Levels for Dioxin in Soil: Region 7

State	Soil Conc (ppt)	Date	End-point Basis	Toxicity Reference Value		Information Source	Context Notes	Evaluation Criteria: Nature of Peer Review	Evaluation Criteria: Transparency-Public Availability	Evaluation Criteria: Scientific Basis	Evaluation Criteria: Incorporation of Most Recent Science
MO *(cont'd.)*	*20,000*	*Apr-93*	*c*			*EPA (1993b), Ground Water OU 02, Syntex Agribusiness, Inc., Verona (http://www.epa.gov/superfund/sites/rods/fulltext/r0793071.pdf).*	*For 2,3,7,8-TCDD, residential scenario. Toxicity value not found. Action level provided for excavation and treatment of surface soils (with maintenance of a vegetative cover over soils containing between 1 and 20 ppb dioxin).*		*Available online (RODS database).*	*Concentration appears to reflect the OSWER directive. The Kimbrough et al. (1984) evaluation of Kociba et al. (1978) underlies the OSWER value.*	
	1,000	*Sep-86*	*c*			*EPA (1986) Ellisville Site, OU 02, Ellisville (http://www.epa.gov/superfund/sites/rods/fulltext/r0786006.pdf).*	*For 2,3,7,8-TCDD, residential scenario. Toxicity value not found. (Document updates the 1985 ROD and 1991 ROD Amendment.) Toxicity value not found.*		*Available online (RODS database).*	*Concentration appears to reflect the OSWER directive. The Kimbrough et al. (1984) evaluation of Kociba et al. (1978) underlies the OSWER value.*	
NE		Jul-09				Borovich (2009) (personal communication).	Feedback during field review indicates that the remediation goals here are both screening levels and preliminary cleanup goals. The NDEQ Voluntary Cleanup Program (VCP) does allow a site to develop different risk-based cleanup levels based on site characterization and NDEQ approval. For sites not under VCP regulations, the NDEQ may use EPA RGs or medium-specific screening levels as cleanup levels, given proper documentation.			Slope factor from the EPA1997 HEAST. The NDEQ documentation indicates a slope factor other than HEAST would be used if (a) the source was considered "higher" in the EPA's toxicity hierarchy and (b) the science behind the level was well-documented and available for review.	NDEQ indicates a plan to update the VCP Remediation Goals Lookup Table based on the most recent review of toxicological data.
	3.9	Oct-08	c	150,000 (SF_o)	$(mg/kg\text{-}d)^{-1}$	NDEQ (2008), NE Voluntary Cleanup Guidance (http://www.deq.state.ne.us/Publica.nsf/23e5e39594c064ee852564ae004fa010/d243c2b56e34ea8486256f2700698997/$FILE/VCP%20Guidance%20Oct%202008.pdf). NDEQ (2006), Protocol for VCP Remediation Goals Lookup Tables (http://www.deq.state.ne.us/Publica.nsf/23e5e39594c064ee852564ae004fa010/d243c2b56e34ea8486256f2700698997/$FILE/ATTEBI5L/RG%20Protocol%20August%202006.pdf).	For 2,3,7,8-TCDD, residential soil; based on direct contact.		Cleanup levels and RG equations with soil exposure factors available to public; EPA (1997a) Health Effects Assessment Summary Tables (HEAST) values for nonradionuclides have not been found via open access online.	Slope factors and other toxicological information are taken from EPA 1997 HEAST. Equation for calculating the residential soil concentration for incidental ingestion of carcinogenic compounds is: $CL = \frac{1}{[(1/C_{ing})+(1/C_{derm})+(1/C_{inh})]}$ where: $C_{res\ soil\ ingestion-ca} = \frac{TR_r \times AT_c}{EF_r \times IFS_{adj} \times SF_o \times 10^{-6}\ mg/kg}$ $C_{res\ soil\ dermal-ca} = \frac{TR_r \times AT_c}{EF_r \times SFS_{adj} \times ABS_d \times (SF_o/ABS_{GI}) \times 10^{-6}\ mg/kg}$ $C_{res\ soil\ inhalation-ca} = \frac{TR_r \times AT_c}{EF_r \times ED_a \times [(URF \times 1000\ \mu g/mg)]}$ CL = cleanup level, (mg/kg) TR = target risk, 10^{-6} SF_o = oral slope factor,150,000 $(mg/kg\text{-}d)^{-1}$ AT_c = averaging time, 25,550 d EF_r = exposure frequency, 350 d/y ED_a = exposure duration, 30 y IFS_{adj} = age-adjusted soil ingestion factor, 114 $(mg\text{-}y/kg\text{-}d)^{-1}$ SFS_{adj} = age-adjusted soil dermal factor, 361 mg-y/kg-d ABS_d = dermal absorption fraction, 0.03 ABS_{GI} = gastrointestinal absorption eff., 1.0 URF = unit risk factor, 3.3×10^{-3} $(\mu g/m^3)^{-1}$ PEF = particulate emission factor, 1.2×10^9 m^3/kg	
	160						For 2,3,7,8-TCDD, industrial soil; based on direct contact.				

TABLE B.8 State Cleanup Levels for Dioxin in Soil: Region 8

State	Soil Conc *(ppt)*	Date	End-point Basis	Toxicity Reference Value		Information Source	Context Notes	Evaluation Criteria: Nature of Peer Review	Evaluation Criteria: Transparency-Public Availability	Evaluation Criteria: Scientific Basis	Evaluation Criteria: Incorporation of Most Recent Science
CO		Dec-07				CODPHE (2007), CO Soil Evaluation Values (CSEV) (http://www.cdphe.state.co.us/hm/csev.pdf).	The CODPHE has developed CO soil evaluation values (CSEVs), but no dioxin value was found in the table.		CODPHE (2007) document is available online.		
MT	4.5 18	Dec-09	c	130,000 (SF_o)	$(mg/kg\text{-}d)^{-1}$	MTDEQ (2009), Soil Screening Process (Attachment C) (http://www.deq.state.mt.us/StateSuperfund/vcraguide.asp).	Some state-specific risk-based screening levels (RBSLs) are provided on website but no specific value was found for dioxin. Newly updated guidance (Attachment C) shows 2-part process, to address both direct contact and leaching to groundwater. For Part 1, flow chart directs users to screen soil dioxin concentrations based on 2009 EPA Regional Screening Levels (RSLs), which are as TCDD. (Regional EPA values were recently harmonized, see Table 13 of this report.) Values at left are for residential and industrial use, respectively. For Part 2, site contaminants are compared to the risk-based soil screening level using a dilution attenuation factor of 10. Beyond this value for TCDD (e.g., for other dioxins) "The DEQ uses the most current toxicity data, including toxicity equivalency factors (TEFs), as much as possible. Because of this, the DEQ requires dioxin/furan calculations for soil and water samples to use the World Health Organization (WHO) 2005 TEFs." (These TEFs are presented in Van den Berg et al. [2006].)	Intra-agency review.	MTDEQ document and the EPA RSL Table and User's Guide (EPA 2009e,f) with equations are available online.	See Tables 11 and 13 of the report for information underlying the regional screening levels, including the toxicity value.	Reflects current WHO TEFs, Attachment C (December 2009) updates the basic guidance from August 2002.
	62.5	*Jun-08*				*MTDEQ (2008), Final Feasibility Study Report, KRY Site (http://www.deq.state.mt.us/StateSuperfund/KPT/FinalFSJuly2008/FinalFSreportComplied.pdf).*	*For 2,3,7,8-TCDD TEQ, residential scenario.*		*MTDEQ (2008a) is available online, but not the appendix with the key data.*	*MTDEQ used the earlier World Health Organization (WHO) (1998) Toxicity Equivalence Factors (TEFs) for TCDD and dioxin-like compounds (DLCs) to determine cleanup levels.*	*WHO TEFs were recently updated, as captured in 2005 and 2006 publications (see* Van den Berg et al. [2006]*).*
	103						*For 2,3,7,8-TCDD TEQ, industrial scenario. Limited information; the document states that the cleanup levels are based on risk analysis and soil modeling in Appendix C, which cannot be found online.*				
	736						*For 2,3,7,8-TCDD TEQ, residential subsurface scenario.*				
	736						*For 2,3,7,8-TCDD TEQ, industrial subsurface scenario.*				
ND							No state-specific guidelines for dioxin soil cleanup levels were identified from the ND Department of Health, Division of Waste Management website.				
SD		Nov-09				SDDENR (2009), Lookup Table For Surface Soil (0-3.2 feet) (http://denr.sd.gov/des/gw/LookUpTables/Lookup_Tables.aspx).	No soil screening or cleanup values for dioxin were identified on the SDDENR website. The SDDENR has developed look-up tables with Tier 1 action levels calculated for some soil contaminants leaching to ground water based on 10^{-5} cancer risk, but no value was identified for dioxin.		SDDENR (2009) website and lookup tables are available online (website last updated November 24).		
	1,000	*Jun-96*	*c*			*U.S. AF (1996), ROD, Ellsworth Air Force Base, OU 08, Ellsworth AFB (http://www.epa.gov/superfund/sites/rods/fulltext/r0896124.pdf).*	*For dioxin TEQ, international toxic equivalents corresponding to dioxin concentrations were below the 1,000 ppt level of concern for residential soil; risk associated with dioxins in surface soil is in the 10^{-5} range.*		*Available online.*	*Site-specific risk assessment results for exposure to surface soil are within EPA target range for incremental risk, and TCDD TEQ are below 1,000 ppt; the specific source of this value was not provided (but could be the 1998 OSWER directive, which is based on an evaluation by Kimbrough et al. [1984] of Kociba et al. [1978] data).*	

TABLE B.8 State Cleanup Levels for Dioxin in Soil: Region 8

State	Soil Conc *(ppt)*	Date	End-point Basis	Toxicity Reference Value		Information Source	Context Notes	Evaluation Criteria: Nature of Peer Review	Transparency-Public Availability	Scientific Basis	Incorporation of Most Recent Science
UT		May-06				UT (2006), UT LUST Program Screening Levels for Soil and Groundwater (http://www.undergroundtanks.utah.gov/docs/tank_news_sum06.pdf).	UTDEQ has developed initial screening levels (ISLs), for leaking underground storage tanks (LUSTs). No screening level was found for dioxin.		LUST table (2006) is available online at the UTDEQ website.		
	1,000	*Jun-00*				*U.S. ACE (2000), Final OU 4 Hotspot, ROD Amendment for OU 4, Ogden Hill (http://www.epa.gov/superfund/sites/rods/fulltext/a0800533.pdf).*	*For 2,3,7,8-TCDD TEQ, remedial action goals for site soils where future land use is commercial/industrial.*		*Available online (RODS database).*		
	37	*Dec-97*	*c*	*150,000 (SF_O)*	*$(mg/kg\text{-}d)^{-1}$*	*EPA (1997d), Explanation of Significant Difference, Petrochem Recycling Corp./Ekotek Plant, Salt Lake City, OU 01 (http://www.epa.gov/superfund/sites/rods/fulltext/e0898175.pdf).*	*For 2,3,7,8-TCDD TEF, derived from the soil performance standard, based on a combination of soil preliminary remediation goals (PRGs) and applicable or relevant and appropriate requirements (ARARs). Value is for a cancer risk of 10^{-6} (site wide) for the commercial worker for exposure to soil via ingestion and dermal absorption. These performance standards "represent the levels of protection that must be achieved through containment of the low-level contaminated soils".*		*Available online (RODS database).*	*Values were calculated based on the same equations and assumptions as in the August 2, 1994 Baseline Human Health Risk Assessment for the Petrochem Site. The equation for the soil performance standard (SPS) is not available, but the parameter values are given as: TR = target risk, 10^{-6} BW = body weight, 70 kg AT = averaging time, 70 y EF = exposure frequency 250 d/y ED = exposure duration, 25 y SF_o = slope factor oral, 150,000 $(mg/kg\text{-}d)^{-1}$ CF = conversion factor, 10^{-6} kg/mg IR = ingestion rate for soil, 50 mg/d*	
	3,700						*For 2,3,7,8-TCDD TEF, derived from the soil hot spot performance standard based on a combination of soil PRGs and applicable or relevant and appropriate requirements (ARARs). Value is for localized areas with elevated cancer risk above 10^{-4} (hot spots) for the industrial worker for exposure to soil via ingestion and dermal absorption. These performance standards "establish the levels of soils that must be excavated and shipped for offsite disposal".*				
	1,000	*Sep-92*				*EPA (1992b), ROD, Ogden Defense Depot (DLA), OU 04, Ogden (http://www.epa.gov/superfund/sites/rods/fulltext/r0892061.pdf).*	*For 2,3,7,8-TCDD TEQ. Value derived from the Dioxin Disposal Advisory Group as the recommended total equivalency value of less than 1 ppb of dioxin in contaminated soil. (Note this document preceded the 1998 OSWER directive.)*		*Available online (RODS database).*		
	1,000					*RMCOEH-UT DFPM (undated), A Comparison of Dioxin Levels Found in Residential Soils of Davis County Utah with Those Found in Residential Soils in the Denver Front Range (http://www.wasatchintegrated.org/PDF/Davis%20Dioxin%20Study.pdf).*	*For 2,3,7,8-TCDD TEQ. Davis County study sampled soil for dioxin, using the ATSDR screening and action levels as a point of reference, based on De Rosa et. al. (1997). (Note the date of this document is at least 2001, per its most recent internal citation.)*		*Available online.*		

TABLE B.8 State Cleanup Levels for Dioxin in Soil: Region 8

State	Soil Conc *(ppt)*	Date	End-point Basis	Toxicity Reference Value		Information Source	Context Notes	Evaluation Criteria: Nature of Peer Review	Transparency-Public Availability	Scientific Basis	Incorporation of Most Recent Science
WY	4.5	(Jul-09)	c	130,000	(mg/kg-d)$^{-1}$	Griffin (2009) (personal communication).	Field feedback indicated this was the cleanup level for dioxin (unrestricted/residential scenario).				
	0.15						Field feedback indicated this was the value for the residential scenario based on migration to groundwater.				
	4.5	Jun-09	c	130,000 (SF_o)	(mg/kg-d)$^{-1}$	WYDEQ (2009), Fact Sheet #12: Soil Cleanup Level Lookup Table (http://deq.state.wy.us/volremedi/downloads/Current%20Fact%20Sheets/FS_12.pdf),	For 2,3,7,8-TCDD, residential scenario, based on direct contact; the fact sheet links to the Region 9 PRG table. Prior to the WYDEQ June update, the residential value was 3.9 ppt. Regional EPA values were recently harmonized, see related entry in Table 13 of the report. The fact sheet indicates: "Note that prior to evaluation, concentrations of dioxins and furans may be adjusted using appropriate toxicity equivalency factors (TEF) [see EPA (1989) for further information]." Nevertheless, the fact sheet links to the Regional screening value, which is based on TCDD. (Thus, in this report, the latter is indicated as the general basis for the WY value.)		The WYDEQ document is available online.		Screening levels from Regions 3, 6, and 9 were harmonized in 2008 (see related entry in Table 13), and updated in fall 2009; these include an updated SF of 130,000 per mg/kg-d. Note that WYDEQ indicates an intent to update its table whenever the Region 9 PRGs are updated. As a further note, WHO (2005) has updated the TEFs (also see Van den Berg et al. [2006]).
							For 2,3,7,8-TCDD, industrial scenario, based on direct contact. Prior to the WYDEQ June update, the Regional screening value of 16 ppt was identified for the industrial value. No industrial cleanup levels were identified in the June update of the WY fact sheet, leaving this instead to a site-specific determination. (Regional EPA values were recently harmonized, see related entry in Table 13 of the report.)				
	4.3 *38*	*May-04*		*150,000* (*SF_o*)	*(mg/kg-d)$^{-1}$*	*U.S. AF (2004b), ROD, OU 10, Landfill 7 and Fire Protection Area 1, F.E. Warren Air Force Base (http://www.epa.gov/superfund/sites/rods/fulltext/r0804104.pdf).*	*For 2,3,7,8-TCDD; used 2001 EPA Region 3 industrial and residential RBCs for dioxin as initial screening levels. Levels of 2,3,7,8- TCDD did not exceed RBCs. One dioxin and one furan did exceed RBC levels and further evaluation is provided in the baseline risk assessment (BRA) (Landfill 7/FPTA 1 RI [U.S. AF 2002d]) (which could not be found online)). The ROD indicates the SF_o is from IRIS.*			*Note that the EPA 2001 Region 3 tables were updated May 2009 to EPA RSLs; see Table 13 of the report for RSL values and derivation.*	

TABLE B.9 State Cleanup Levels for Dioxin in Soil: Region 9

State	Soil Conc *(ppt)*	Date	End-point Basis	Toxicity Reference Value		Information Source	Context Notes	Evaluation Criteria: Nature of Peer Review	Evaluation Criteria: Transparency-Public Availability	Evaluation Criteria: Scientific Basis	Evaluation Criteria: Incorporation of Most Recent Science
AS (Amer. Samoa)	4.5	Oct-08	c	130,000 (SF_o)	$(mg/kg\text{-}d)^{-1}$	GEPA (2008)/HDOH (2008a), Evaluation of Environmental Hazards at Sites with Contaminated Soil and Groundwater – Pacific Basin Edition (http://hawaii.gov/health/environmental/hazard/pdf/pbvolume1mar2009.pdf); Volume 2, Appendix 1 (http://hawaii.gov/health/environmental/hazard/pdf/pbvolume2app1mar2009.pdf); Volume 2, Appendices 2-9 (http://hawaii.gov/health/environmental/hazard/pdf/pbvolume2app2to9mar2009.pdf). Approach is based on Guam EPA procedures; calculations are supported by the spreadsheet at HDOH (2008b), Evaluation of Environmental Hazards at Sites with Contaminated Soil and Groundwater - Hawai'i Edition (http://www.hawaiidoh.org/references/HDOH%202008.pdf).	For dioxin TEQs, environmental screening levels (ESLs), based on direct soil contact, 10^{-6} risk (except for construction/trench worker: 10^{-5} risk per lower exposure frequency and duration). "Although prepared specifically for Guam EPA, the use of well-accepted, US Environmental Agency (USEPA) standards, models and protocols should permit flexible use of the guidance throughout tropical and subtropical areas of the Pacific Basin region with little or no modification." "The screening levels are based on slight modifications to the USEPA Region IX Preliminary Remediation Goals and more recent Regional Screening Levels (USEPA 2004, 2008). The modifications as used in Hawai'i have been discussed in detail with USEPA Region IX. No adjustment of the HDOH Tier 2 screening levels is necessary for use in Guam and other areas of the Pacific Basin." 4.5 ppt is the Tier 1 environmental screening level for unrestricted use, shallow soil: ≤3 m, below ground surface (bgs).		The equations and toxicity value used to derive Tier 1 environmental screening levels for different exposure scenarios are available online. Equations provided in Appendix 2, adopted from 2008 EPA RSL documentation. ["The Tier 1 environmental screening levels were updated in October 2008 to incorporate updates to the USEPA Region Screening Levels (USEPA 2008)."] This information is available online.	Equations for calculating Tier 1 ESLs and the toxicity value were taken from 2008 EPA RSLs. See Guam entry for specific environmental screening level equations. Regarding direct exposure: text indicates dioxins are not considered significantly mobile in soil due to their strong sorption to organic carbon and clay particles, so consideration of soil leaching hazards was not needed. Also notes: "The 2008 U.S. Environmental Protection Agency (USEPA) *Regional Screening Levels* (RSLs; USEPA 2008a) replace *Preliminary Remediation Goals* (PRGs) previously published by individual regions. This includes PRGs published by USEPA Region IX (USEPA 2004) and referenced in pre-2008 editions of the CNMI and HDOH guidance documents." The slope factor of 130,000 $(mg/kg\text{-}d)^{-1}$ was taken from the 2008 EPA RSL table, which is based on a CalEPA maximum likelihood estimate (MLE) and linearized 95% upper confidence value (UCL); using animal data (NTP 1980a, 1982a) converted to equivalent human exposures per scaling factors. Assumptions include: oral and inhalation routes are equivalent, air concentration assumed to be daily oral dose, route of exposure does not affect absorption, and no difference in metabolism/ pharmacokinetics between animals and humans. Total weekly dose levels were averaged over the week to get a daily dose level; this assumes daily dosing in NTP studies would have given the same results as the actual twice weekly dosing schedule (because the TCDD half-life is relatively long, both schedules should give similar tissue concentrations).	Values derived in a manner similar to the 2008 EPA RSLs. Toxicity value was adopted from the 2008 EPA RSL (which is more recent than others, but does not reflect more recent scientific data such as the 2004 NTP study); see notes for parallel entries for GM, NMI, TT. Document cites the recent 2005 WHO TEFs documented in Van den Berg et al. (2006). Note however that Table L of Volume 2, Appendix 1 reflects the old (pre-2005) cancer classification scheme, indicating "B1?" for TCDD. The cancer slope factor was revised in October 2007 from previous guidance (this affected the action levels).
	18						Tier 1 environmental screening level for commercial/industrial land use scenario, shallow soil (≤3 m bgs).				
	1,500						Tier 1 environmental screening level, deep soil (>3 m bgs) for: unrestricted (residential) use, commercial/industrial use, and construction/trench worker.				
	42			1,400,000 (SF_o)	$(mg/kg\text{-}d)^{-1}$		For dioxin TEQs, Tier 2 action levels, direct contact, 10^{-4} risk; especially intended for redevelopment of former agricultural fields but apply to any site. Guidelines rather than strict, regulatory, cleanup requirements; alternate values can be proposed in site-specific assessments. Unrestricted (residential) land use: <42 ppt: No action required. 42-450 ppt: "Within USEPA range of acceptable health risk." Removal and offsite disposal of small, easily identifiable hot spots is recommended. Consider other measures to reduce daily soil exposure. For large areas, notify future homeowners of elevated levels.			42 ppt was derived using the basic calculation in the HDOH (2008b) spreadsheet, with the target risk level updated from 10^{-6} to 10^{-4}. The SF of 1,400,000 $(mg/kg\text{-}d)^{-1}$, tapped the SF from MNDOH (2003), which is the upper bound from animal bioassay data given in the EPA reassessment; this value was derived from Kociba et al. (1978) and is higher than the value recommended in the draft reassessment, which is based on human data; this higher SF was used to generate a lower bound. See Guam entry in this table for equations used to calculate action levels.	
	450			130,000 (SF_o)	$(mg/kg\text{-}d)^{-1}$		>450 ppt: Unrestricted (residential) land use is not recommended in the absence of remedial action to reduce exposure.			As above, using the SF_o from the recently harmonized 2008 EPA RSL, updates the previous Tier 2 action level of 390 ppt, which had used the previous RSL SF_o of 150,000 $(mg/kg\text{-}d)^{-1}$.	
	170			1,400,000 (SF_o)	$(mg/kg\text{-}d)^{-1}$		<170 ppt: Commercial/industrial use, no action. 170-1,800 ppt: Within USEPA range of acceptable health risk. Remedial actions vary depending on site-specific factors, including current and planned use, available options for onsite isolation or offsite disposal, and technical/economical constraints.			Same approach as described above for the action level of 42 ppt; the upper-bound animal-based SF of 1,400,000 $(mg/kg\text{-}d)^{-1}$ was used to generate a lower bound for cleanup consideration.	
	1,800			130,000 (SF_o)	$(mg/kg\text{-}d)^{-1}$		>1,800 ppt: Commercial/industrial use not recommended in absence of remedial actions to reduce potential exposure.			As above, using SF_o of 130,000 $(mg/kg\text{-}d)^{-1}$ from the recently harmonized 2008 EPA RSL; updates the previous Tier 2 level of 1,600 ppt, which reflected the previous SF_o,150,000 $(mg/kg\text{-}d)^{-1}$.	

TABLE B.9 State Cleanup Levels for Dioxin in Soil: Region 9

State	Soil Conc *(ppt)*	Date	End-point Basis	Toxicity Reference Value		Information Source	Context Notes	Evaluation Criteria			
								Nature of Peer Review	Transparency-Public Availability	Scientific Basis	Incorporation of Most Recent Science
AZ	4.5	May-07	c	130,000	$(mg/kg\text{-}d)^{-1}$	AZDEQ (2007), Title 18. Environmental Quality Chapter 7. Remedial Action (http://www.azsos.gov/public_services/Title_18/18-07.htm); ADHS (1999), Deterministic Risk Assessment Guidance (http://www.azdhs.gov/phs/oeh/pdf/guidance.pdf).	For 2,3,7,8-TCDD, residential use, 10^{-6} risk level. The 2007 soil remediation levels (SRLs) update the 1997 values and apply unless the site was characterized before May 5, 2007 and remediated or a risk assessment completed before May 5, 2010 (in which case the 1997 values apply). The target risk of 10^{-6} must be used if current or intended future use of a contaminated site is a child care facility or school where children <18 are reasonably expected to be in frequent, repeated contact with soil. Per field feedback (Stralka, 2009), AZDEQ has adopted the recently harmonized RSL (see Table 13 in this report).		The AZDEQ documentation and ADHS guidance document are available online. However, specific toxicity values used to derive the SRLs are not provided in either document.	Equations and default parameter values for SRL derivation are indicated in ADHS (1999), although the link appears to be damaged as the equations were not visible. Equations were adopted from the 1996 Region 9 PRG document. The toxicity value was not found in the AZDEQ or ADHS document. (Note that ADHS [1999] mentions slope factors were taken from IRIS, HEAST, or NCEA.) Field input indicated the adoption of the EPA RSL and underlying toxicity value (see residential value).	The toxicity value is the slope factor used in the EPA regional screening level table from that time, which does reflect the more recent scientific literature, such as the 2004 NTP study).
	45						For 2,3,7,8-TCDD, residential use, 10^{-5} risk level. This value updates the 1997 residential SRL of 38 ppt (provided here as context for entries below). As stated: a risk level of 10^{-5} may be used for any carcinogen other than a known human carcinogen.				
	160		c				For 2,3,7,8-TCDD, nonresidential use, based on cancer risk; this updates the 1997 SRL of 240 ppt (provided here as context for the entry below).			Specific information was not provided for the nonresidential SRL, including for toxicity value or risk level (e.g., to determine if 10^{-5}) is assumed, per the 1997 SRL indication of TCDD as a B2 (probable) rather than A (known) human carcinogen.	
	38	*2006 (2004)*	*c*			*Easthope (2006), ATSDR 1,000 ppt dioxin soil standard: Letter from concerned citizens, environmental groups (http://www.trwnews.net/Documents/TRW/Request%20to%20atsdr%20to%20clarify%201000ppt.pdf); lists same values identified in: EC (2004), Dioxin Soil Cleanup Levels in Other States, cited in table available via Tittabawassee River Watch News (http://www.trwnews.net/images/StateCleanup2006.PDF).*	*Basis not provided, but appears to reflect the AZDEQ 1997 residential SRL (which was updated to 45 ppt in 2007, see entry above).*		*Limited information is available via the weblinks at left, with neither the derivation methodology nor basis of underlying toxicity values.*	*Basis not provided, but see entry for AZDEQ (2007) above.*	
	38	*Apr-01*	*c*			*EPA (2001), ESD, Tucson International Airport Area, OU 02 (http://www.epa.gov/superfund/sites/rods/fulltext/e0901612.pdf).*	*For 2,3,7,8-TCDD, residential scenario; shown in table excerpted from AZ Administrative Code Title 18, Chapter 7, Article 2, Appendix A, Soil Remediation Levels (listed as current through December 31, 1999).*		*Available online (via RODS database).*	*See entry for AZDEQ (2007) above. Excerpted table identifies TCDD as: Group B2 carcinogen. (Probable human carcinogen, with inadequate or no evidence of carcinogenicity in humans. Sufficient evidence for carcinogenicity in laboratory animals.)*	*Reflects the older EPA cancer classification scheme (updated by EPA in 2005).*
	240						*For 2,3,7,8-TCDD, nonresidential scenario.*				

TABLE B.9 State Cleanup Levels for Dioxin in Soil: Region 9

State	Soil Conc *(ppt)*	Date	End-point Basis	Toxicity Reference Value		Information Source	Context Notes	Evaluation Criteria: Nature of Peer Review	Evaluation Criteria: Transparency-Public Availability	Evaluation Criteria: Scientific Basis	Evaluation Criteria: Incorporation of Most Recent Science
CA	4.6	Jan-05	c	130,000 (SF_o)	$(mg/kg\text{-}d)^{-1}$	CalEPA (2005a), Human-Exposure-Based Screening Numbers Developed to Aid Estimation of Clean-Up Costs for Contaminated Soil (http://www.oehha.ca.gov/risk/pdf/screenreport010405.pdf). CalEPA (2005b), Use of CA Human Health Screening Levels (HHSLs) in Evaluation of Contaminated Properties (http://www.calepa.ca.gov/Brownfields/documents/2005/CHHSLsGuide.pdf); CalEPA (2009d), Human Health Risk Assessment (HHRA) Note 2, Interim, Remedial Goals for Dioxins and Dioxin-Like Compounds for Consideration at California Hazardous Waste Sites; (http://www.dtsc.ca.gov/AssessingRisk/upload/HHRA_Note2_dioxin-2.pdf).	For 2,3,7,8-TCDD, residential land use, HHSL. Note that a value of 50 ppt as dioxin TEQ was recently suggested an interim remedial goal developed for consideration at sites in California. This value is for a target risk of 10^{-6} and is based on the HHSL, with an adjustment that reflects multiplying by 10 "to account for the minimal contribution of soil and dust to the dioxin human body burden, as shown in the University of Michigan dioxin exposure study." (Note the study has recently undergone independent technical review.) The CalEPA document is suggested residential remedial goal should only be considered if a farming scenario is not relevant. Note that the remedial goal based on noncancer effects is 78 ppt, so the cancer-based goal is protective. The noncancer-based value is calculated for the residential child, with 1 pg/kg-d considered the minimum risk level for the neurological endpoint (based on data for monkeys, described in ATSDR (1998/2008).		Information on the HHSLs and their derivation basis is available online, including the source of the cancer slope factor, via the CalEPA OEHHA website.	Indicates the slope factor was computed from the OEHHA REL. HHSL equations for both residential and industrial-occupational scenarios consider ingestion, dermal, and inhalation exposures. To simplify this presentation, only the ingestion component is included below because this pathway dominates (over dermal and inhalation contributions to the total). $HHSL_{res} = \dfrac{TR \times AT_r}{EF_r \times (CSF_o \times IFS_{adj} \times 10^{-6}\ kg/mg)}$ where: TR = target risk, 10^{-6} AT_r = averaging time, 25,550 d CSF_o = 130,000 per mg/kg-d EF_r = exposure frequency, 350 d IFS_{adj} = residential soil ingestion rate, 114 mg-y/kg-d	
	19						For 2,3,7,8-TCDD, commercial/industrial land use, HHSL.			$HHSL_{ind} = \dfrac{TR \times AT_r \times BW_a}{EF_o \times ED_o \times (IRS_o \times CSF_o \times 10^{-6}\ kg/mg)}$ where: TR = target risk, 10^{-6} AT_r = averaging time, 25,550 d BW_a = adult body weight, 70 kg EF_o = occupational exposure frequency, 250 d/y ED_o = occupational exposure duration, 25 y CSF_o = 130,000 per mg/kg-d IRS_o = occupational soil ingestion rate, 100 mg/d	
	4	*2006* *(2004)*				*Easthope (2006), ATSDR 1,000 ppt dioxin soil standard: Letter from concerned citizens, environmental groups (http://www.trwnews.net/Documents/TRW/Request%20to%20atsdr%20to%20clarify%201000ppt.pdf); lists same values identified in: EC (2004), Dioxin Soil Cleanup Levels in Other States, cited in table available via Tittabawassee River Watch News (http://www.trwnews.net/images/StateCleanup2006.PDF).*	*Basis not provided.*		*Limited information is available via the weblinks at left, with neither the derivation methodology nor basis of underlying toxicity values.*	*Basis not provided.*	

TABLE B.9 State Cleanup Levels for Dioxin in Soil: Region 9

State	Soil Conc *(ppt)*	Date	End-point Basis	Toxicity Reference Value		Information Source	Context Notes	Evaluation Criteria: Nature of Peer Review	Evaluation Criteria: Transparency-Public Availability	Evaluation Criteria: Scientific Basis	Evaluation Criteria: Incorporation of Most Recent Science
CA *(cont'd.)*	3.9	Mar-08	c	130,000 (SF_o)	$(mg/kg\text{-}d)^{-1}$	NAVFAC (2008), ESD for OU 3 ROD, Camp Pendleton (http://www.epa.gov/superfund/sites/rods/fulltext/e2008090002747.pdf).	For 2,3,7,8-TCDD TEQ. Original remediation goal of 4.1 ng/kg (from 2/21/08 ROD for OU 5) was revised to 3.9 ng/kg, based on the 2004 EPA Region 9 PRG-residential for 2,3,7,8-TCDD. The basis of the original 4.1 ng/kg was identified as the EPA-derived mean rural soil TCDD TEQ concentration (EPA 2000).		Available online (via RODS database).	Derivation of NOAEL-based toxicity reference value for mammals in Sample et al., (1996), which summarizes several toxicity studies, including the study by Murray et al. (1979). Three-generation dietary study in rats, NOAEL of 0.000001 mg/kg-d for the reproductive endpoint. Total uncertainty factor (UF) of 1 produced a toxicity reference value (TRV) of 0.000001 mg/kg-d. Tier-1 average daily dose was estimated as follows: Tier-1 ADD = $(C_{soil} \times T1\text{-}IR_F)+(C_{soil} \times IR_S \times T1\text{-}IR_F)$ where: C_{soil} = soil EPC (mg COPC/kg soil dry weight) $T1\text{-}IR_F$ = Tier-1 food ingestion rate (kg food dry weight/kg body weight-d) IR_S = incidental soil ingestion rate (% of food ingestion rate) COPC = chemical of potential concern	
	44		eco				Site-specific ecological PRG; ESD, original ROD was written in 1996; a remediation goal was developed for 2,3,7,8 TCDD at Site 1A, burn ash site. "The value for both Tier 1 and Tier 2 exposure estimates for mammalian receptors was 0.000044. The upper-bound limit for an acceptable exposure-point concentration for the dioxins (the eco PRG) is approximately 4.4×10^{-5} mg/kg (44 pg/g) or less."				
	3.9	May-08	c	130,000 (SF_o)	$(mg/kg\text{-}d)^{-1}$	AFRL (2008), ROD AFRL Soil and Debris Sites OUs 4 and 9, Edwards AFB (http://www.epa.gov/superfund/sites/rods/fulltext/r2008090002438.pdf).	For 2,3,7,8-TCDD TEQ, adopted the EPA Region 9 PRG-residential value of 3.9 ng/kg as the remediation goal for dioxin, but indicated that detected levels were not of concern.		Available online (via RODS database).		
	1.2	Feb-95	c			DoA (1995), Fort Ord, OU 05, Marina (http://www.epa.gov/superfund/sites/rods/fulltext/r0995138.pdf).	For 2,3,7,8-TCDD, adult residential scenario; PRG taken from the Draft Final Technical Memorandum, Preliminary Remediation Goals, Fort Ord, CA (June 24, 1994). PRGs were developed per procedures in the EPA Risk Assessment Guidance for Superfund, Vols. 1-2.		Available online (via RODS database). However, the technical memorandum was not found online.	Refers to PRGs derived in the Draft Final Technical Memorandum, Preliminary Remediation Goals, Fort Ord, California (dated June 24, 1994), and Indicates they were developed according to procedures in the EPA Risk Assessment. Guidelines for Superfund, Vols. 1 and 2. The specific equations and toxicity value were not found in the ROD.	
	300						For 2,3,7,8-TCDD, PRG for construction worker scenario.				
	27	Feb-01	c			DOE (2001), Interim Site-Wide ROD for LLNL, Site 300 (http://www.epa.gov/superfund/sites/rods/fulltext/r0901606.pdf).	For 2,3,7,8-TCDD TEQ, cleanup standard at building 850 Firing Table area. The Region 9 industrial PRG was adopted as the cleanup standard.		Available online (via RODS database). (Note Region 9 PRGs have since been harmonized with Regions 3 and 6 screening levels.)	See toxicity value basis information in the body of this report.	
	1,000	Mar-99	c			EPA (1999b), ROD, McCormick & Baxter Creosoting Co., OU 01 and 03, Stockton (http://www.epa.gov/superfund/sites/rods/fulltext/r0999044.pdf).	For 2,3,7,8-TCDD TEQ. EPA 1998 OSWER directive (Approach for Addressing Dioxin in Soil at CERCLA and RCRA Sites) taken into account in deriving the cleanup standard.		Available online (via RODS database).	Concentration reflects OSWER directive (which is based on an evaluation by Kimbrough et al. [1984] of a study by Kociba et al. [1978]).	
	1,000	Sep-03	c			EPA (2003g) ROD AMD, Selma Treating Co. OU 1, Selma (http://www.epa.gov/superfund/sites/rods/fulltext/a0903016.pdf).	For 2,3,7,8-TCDD TEQ, the actual concentration is unclear because of a units/symbol issue. The 2003 ROD amendment identifies a value for dioxins/furans TEQ from the original (1988) ROD as "1 microgram per kilogram (pg/kg)" -- and then adjacent to this entry identifies the value from the 2003 ESD as "1 pg/kg." It is not clear if the more recent value is intended to also be 1 microgram/kg, or 1,000 ppt (which seems more likely than 0.001 ppt). (Note the 2003 update did change concentrations for two other contaminants.)		Available online (via RODS database).	Concentration appears to reflect OSWER directive (which is based on an evaluation by Kimbrough et al. [1984] of a study by Kociba et al. [1978]).	

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GM (Guam)	4.5	Oct-08	c	130,000 (SF_o)	$(mg/kg\text{-}d)^{-1}$	GEPA (2008)/HDOH (2008a), Evaluation of Environmental Hazards at Sites with Contaminated Soil and Groundwater – Pacific Basin Edition (http://hawaii.gov/health/environmental/hazard/pdf/pbvolume1mar2009.pdf); Volume 2, Appendix 1 (http://hawaii.gov/health/environmental/hazard/pdf/pbvolume2app1mar2009.pdf); Volume 2, Appendices 2-9 (http://hawaii.gov/health/environmental/hazard/pdf/pbvolume2app2to9mar2009.pdf). Calculations supported by spreadsheet at HDOH (2008b), Evaluation of Environmental Hazards at Sites with Contaminated Soil and Groundwater - Hawai'i Edition (http://www.hawaiidoh.org/references/HDOH%202008.pdf).	For 2,3,7,8-TCDD TEQ, environmental screening levels based on direct soil contact, 10^{-6} risk (except construction/ trench worker: 10^{-5} risk per lower exposure frequency and duration). "Although prepared specifically for Guam EPA, the use of well-accepted, US Environmental Agency (USEPA) standards, models and protocols should permit flexible use of the guidance throughout tropical and subtropical areas of the Pacific Basin region with little or no modification." "The screening levels are based on slight modifications to the USEPA Region IX Preliminary Remediation Goals and more recent Regional Screening Levels (USEPA 2004, 2008). The modifications as used in Hawai'i have been discussed in detail with USEPA Region IX. No adjustment of the HDOH Tier 2 screening levels is necessary for use in Guam and other areas of the Pacific Basin." (This updated earlier guidance prepared for the Commonwealth of the Mariana Islands DEQ. (See the AS entry where these values are first discussed for further details, across all columns.) Unrestricted land use: 4.5 is the Tier 1 environmental screening level for shallow soil (≤3 m bgs).		Equations are provided in HDOH (2008) Appendix 2, adopted from the 2008 EPA RSL documentation. The slope factor was taken from the EPA RSL table. This information is available online.	Equations for calculating Tier 1 environmental screening levels were taken from 2008 EPA RSL documentation, as was the toxicity value. (For the basis, see the AS entry and discussion in the body of this report.) Environmental screening level/RSL equations for the residential, industrial, and trench worker scenarios consider ingestion, dermal, and inhalation routes of exposure. To simplify this presentation, only the ingestion component is reflected below because this pathway is the dominant contributor to the total. Unrestricted land use: $C_{res} = \frac{TR \times AT_r}{EF_r \times (CSF_o \times IFS_{adj} \times 10^{-6}\ kg/mg)}$ where: TR = target risk, 10^{-6} AT_r = averaging time, 25,550 d CSF_o = 130,000 $(mg/kg\text{-}d)^{-1}$ EF_r = exposure frequency, 350 d IFS_{adj} = residential soil ingestion rate, 114 mg-y/kg-d	Reflects the slope factor from the recently harmonized EPA RSL table; as a note, this value does not reflect more recent scientific literature (e.g., the 2004 NTP study). See notes for parallel entries for AS, NMI, and TT.
	18						For 2,3,7,8-TCDD TEQ. Commercial/industrial land use, Tier 1 environmental screening level, for shallow soil (≤3 m bgs). (See the AS entry where these values are first discussed for further details.)			Commercial/industrial land use: $C_{ind} = \frac{TR \times AT_r \times BW_a}{EF_o \times ED_o \times (IRS_o \times CSF_o \times 10^{-6}\ kg/mg)}$ where: TR = target risk, 10^{-6} AT_r = averaging time, 25,550 d BW_a = adult body weight, 70 kg EF_o = occupational exposure frequency, 250 d/y ED_o = occupational exposure duration, 25 y CSF_o = 130,000 $(mg/kg\text{-}d)^{-1}$ IRS_o = occupational soil ingestion rate, 100 mg/d	
	1,500						For 2,3,7,8-TCDD TEQ. Construction/trench worker scenario, Tier 1 environmental screening level for deep soil (>3 m bgs). (See the AS entry where these values are first discussed for further details.)			Construction/trench worker: $C_{ind} = \frac{TR \times AT_r \times BW_a}{EF_{ctw} \times ED_{ctw} \times (IRS_{ctw} \times CSF_o \times 10^{-6}\ kg/mg)}$ where: TR = target risk, 10^{-5} AT_r = averaging time, 25,550 d BW_a = adult body weight, 70 kg EF_o = occupational exposure frequency, 35 d/y ED_o = occupational exposure duration, 7 y CSF_o = 130,000 $(mg/kg\text{-}d)^{-1}$ IRS_o = worker soil ingestion rate, 330 mg/d	

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State	Soil Conc *(ppt)*	Date	End-point Basis	Toxicity Reference Value		Information Source	Context Notes	Evaluation Criteria: Nature of Peer Review	Evaluation Criteria: Transparency-Public Availability	Evaluation Criteria: Scientific Basis	Evaluation Criteria: Incorporation of Most Recent Science
GM *(cont'd.)*	42	Oct-08	c	1,400,000 (SF_o)	$(mg/kg\text{-}d)^{-1}$	GEPA (2008)/HDOH (2008a) *(cont'd.)*	For 2,3,7,8-TCDD TEQ, Tier 2 action levels, direct contact, 10^{-4} risk; especially intended for redevelopment of former agricultural fields but apply to any site. These are guidelines rather than strict, regulatory, cleanup requirements, and alternate values can be proposed in site-specific assessments. (See the AS entry where these values are first discussed for further details, across all columns.) Unrestricted (residential) use: <42 ppt: No action required. (See parallel AS entry for lower bound context.) 42-450 ppt: "Within USEPA range of acceptable health risk. Consider removal and offsite disposal of localized spill areas when possible in order to reduce potential exposure (not required for large, former field areas)."		Equations are provided in HDOH (2008) Appendix 2, adopted from the 2008 EPA RSL documentation. Slope factors were taken from EPA RSL tables and MNDOH (2003). This information is available online.	The SF of 1,400,000 $(mg/kg\text{-}d)^{-1}$ was used to generate a lower bound, as described for AS. The SF factor of 130,000 $(mg/kg\text{-}d)^{-1}$ was taken from the 2008 EPA RSL table, to derive the standard cleanup level. As for Tier 1, Tier 2 equations for residential and industrial scenarios consider ingestion, dermal, and inhalation routes of exposure. To simplify this presentation, only the ingestion component is reflected below because this pathway is the dominant contributor. Unrestricted (residential) land use: $C_{res} = \frac{TR \times AT_r}{EF_r \times (CSF_o \times IFS_{adj} \times 10^{-6}\ kg/mg)}$ where: TR = target risk, 10^{-6} AT_r = averaging time, 25,550 d CSF_o = 130,000 or 1,400,000 $(mg/kg\text{-}d)^{-1}$ EF_r = exposure frequency, 350 d IFS_{adj} = residential soil ingestion rate, 114 mg-y/kg-d	The standard cleanup level reflects the slope factor from the recently harmonized EPA RSL table (2008, updated in 2009).
	450			130,000 (SF_o)	$(mg/kg\text{-}d)^{-1}$		>450 ppt: Residential use not recommended in the absence of remedial actions to reduce potential exposure. (See parallel AS entry for SF/update context.)				
	170			1,400,000 (SF_o)	$(mg/kg\text{-}d)^{-1}$		For 2,3,7,8-TCDD TEQ, Tier 2 action levels for commercial/industrial scenario: <170 ppt: No action required. (See parallel AS entry for lower bound context.)			Commercial/industrial land use: $C_{ind} = \frac{TR \times AT_r \times BW_a}{EF_o \times ED_o \times (IRS_o \times CSF_o \times 10^{-6}\ kg/mg)}$ where: TR = target risk, 10^{-6} AT_r = averaging time, 25,550 d BW_a = adult body weight, 70 kg EF_o = occupational exposure frequency, 250 d/y ED_o = occupational exposure duration, 25 y CSF_o = 130,000 or 1,400,000 $(mg/kg\text{-}d)^{-1}$ IRS_o = occupational soil ingestion rate, 100 mg/d	
	170- 1,800						170-1,800 ppt: "Within USEPA range of acceptable health risk. Remedial actions vary depending on site-specific factors, including current and planned use, available options for onsite isolation or offsite disposal, and technical and economical constraints."				
	1,800			130,000 (SF_o)	$(mg/kg\text{-}d)^{-1}$		>1,800 ppt: Commercial/industrial use not recommended in the absence of remedial actions to reduce potential exposure. (See parallel AS entry for SF/update context.)				
	390	*Aug-07*	*c*			*U.S. AF (2007a), ROD for Sites 7, 16, 17, 31, and 36, Northwest Field, Andersen AFB* *(http://www.epa.gov/superfund/sites/rods/fulltext/r2008090002420.pdf).*	*For 2,3,7,8-TCDD TEQ, cleanup level, unrestricted use. Cleanup level for removal action at Site 36; Value reflects PRG for industrial use.* *Document states "The cleanup level for dioxins in surface soil was equivalent to 10^{-4} resident child cancer risk … Although the cleanup level for TCDD-TEQ was initially established to be equivalent to 10^{-4} cancer risk, confirmation sample results were below the residential PRG and were therefore protective of 10^{-6} cancer risk. Risks to human receptors (future resident adults and children – the most conservative receptor population) were reduced to acceptable risk levels, allowing for unlimited use and unrestricted access to the land."*		*Available online (via RODS database).*	*Document refers to the 2007 risk assessment update to reflect more recent values, including for the exposure calculation and slope factor, but specific information was not found. The ROD discussion includes some more specific context (e.g., the child soil ingestion rate, which was considered to overestimate intake, was based on studies by Binder et al. [1986] and Clausing et al. [1987]) but the specific calculations with values were not included.*	

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State	Soil Conc *(ppt)*	Date	End-point Basis	Toxicity Reference Value		Information Source	Context Notes	Evaluation Criteria: Nature of Peer Review	Transparency-Public Availability	Scientific Basis	Incorporation of Most Recent Science
GM *(cont'd.)*	*9.13*	*Dec-03*	*c*	*150,000*	*(mg/kg-d)$^{-1}$*	*U.S. AF (2003b), ROD for Urunao Dumpsites 1 and 2, Urunao OU, Andersen AFB (http://www.epa.gov/superfund/sites/rods/fulltext/r0904002.pdf).*	*For 2,3,7,8-TCDD TEQ. For resident child, surface soil, remedial goal objective (RGO) corresponding to 10^{-6} risk level.*			*Indicates cancer slope factor of 150,000 per mg/kg-d: weight of evidence cancer guideline description: B2/respiratory and liver; from HEAST (5/1/95). (Reflects earlier carcinogen classification.)*	
	9.43						*For 2,3,7,8-TCDD TEQ. For resident child, subsurface soil, RGO corresponding to 10^{-6} risk level.*			*Ingestion intake = $\frac{Conc \times CR \times EF \times ED \times CF}{BW \times AT}$*	
	3.9						*For 2,3,7,8-TCDD TEQ. The evaluation used this screening toxicity value "taken from USEPA Region IX Preliminary Remediation Goals (PRGs) Table, USEPA, November 2000" as a comparison value in screening site soil concentrations.*			*where: Intake = mg/kg-d Conc = chemical concentration, mg/kg EF = exposure frequency, 350 d/y ED = exposure duration, 30 y CR = ingestion rate, 100 mg/d CF = conversion factor, 10^{-6} kg/mg BW = body weight, 70 kg AT = averaging time, 25,550 d*	
	1,000	*July-02*	*c*	*150,000 (SF_o)*	*(mg/kg-d)$^{-1}$*	*U.S. AF (2002), Final ROD for Harmon Annex OU, Andersen AFB (http://yosemite.epa.gov/r9/sfund/r9sfdocw.nsf/3dc283e6c5d6056f88257426007417a2/1dca993480c9ecd788257205002bf81e/$FILE/andersen%20ROD%20harmon%20annex.pdf).*	*For 2,3,7,8-TCDD TEQ, Considered for soil at IRP Site 39/Harmon Substation, 1,000 ppt reflects OSWER directive; Region 9 PRGs were also considered; "Subsurface soil exceeded the Region 9 residential PRG (0.0038 µg/kg), but was less than the industrial PRG (0.03 µg/kg). This TEQ concentration is considerably lower than the subsurface dioxin cleanup standard of 1.0 µg/kg established by the U.S. AF, GEPA, and the Office of Solid Waste and Emergency Response (OSWER) directive (IT/OHM, 1999c), and no further action is required. Therefore, the area on the southwest corner of Parcel A was not recommended for remediation."*			*The sources cited for the specific information that would inform this entry (e.g., IT/OHM reports) have not been found online.*	

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								Nature of Peer Review	Transparency-Public Availability	Scientific Basis	Incorporation of Most Recent Science
HI	3.9	Sum-08	c	150,000 (SF_o)	$(mg/kg\text{-}d)^{-1}$	HDOH (2008b), Evaluation of Environmental Hazards at Sites with Contaminated Soil and Groundwater - Hawaiʻi Edition (http://www.hawaiidoh.org/references/HDOH%202008.pdf); calculations supported by spreadsheet (gepatier2.deoct2008.xls) are available via this weblink. Also reflects information from: EPA (1996), Soil Screening Guidance: User's Guide (http://www.epa.gov/superfund/health/conmedia/soil/pdfs/ssg496.pdf).	For 2,3,7,8-TCDD TEQ. From the EPA Soil Screening Guidance, for Environmental Action Levels (EAL), Volume 1: "this document incorporates and significantly expands upon the USEPA Preliminary Remediation Goals and more recent Regional Screening Levels." Report is similar to the GEPA report of same name developed for the Pacific Basin (see Guam), much is the same, although some scenarios and terminology differ. (Note the June 2008 Brewer memo in Appendix 8 of the GEPA (2008)/HDOH (2008a) report indicates that ambient levels (as dioxin TEQ) in undisturbed areas in former sugar can fields (in HI) appear to be <50 ppt. Tier 1 environmental action level (EAL) for unrestricted use scenario, includes potential use for residential housing, schools, day care, and health care.	Toxicity values considered OSWER 2003 hierarchy (IRIS, PPRTVs); EPA Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites, Peer Review Draft.	The EPA RSL table and User's Guide with equations are available online; the PPRTVs are not publicly available online.	Reflects equations for noncancer and cancer endpoints from EPA (1996); suite of equations addresses exposures via ingestion, inhalation, and dermal contact. To simplify this presentation, the following screening-level equation focuses on incidental ingestion of carcinogenic contaminants in residential soil, as this is the dominant pathway: $SL = \dfrac{TR \times AT \times 365\ d/y}{SF_o \times EF \times IF_{soil/adj} \times 10^{-6} kg/mg}$ where: SL = screening level, (mg/kg) TR = target cancer risk, 10^{-6} AT = averaging time, 70 y EF = exposure frequency, 350 SF_o = oral slope factor, $(mg\text{-}kg\text{-}d)^{-1}$ $IF_{soil/adj}$ = age-adjusted soil ingestion factor, 114 mg-y/kg-d	EPA User's Guide published in 2008; the document does not reflect changes in TCDD screening levels presented in the 2008 EPA RSL tables. Note that the document cites an SF_o of 150,000 rather then 130,000 per mg/kg-d, which is reflected in the RSL tables.
	42	Sum-08	c	1,400,000 (SF_o)	$(mg/kg\text{-}d)^{-1}$	HDOH (2008b), Evaluation of Environmental Hazards at Sites with Contaminated Soil and Groundwater - Hawaiʻi Edition (http://www.hawaiidoh.org/references/HDOH%202008.pdf); HDOH (2006), Proposed dioxin action levels for East Kapolei Brownfield Site (http://hawaii.gov/health/environmental/hazard/pdf/dioxinactionlevelsmarch2005.pdf); MNDOH (2003), Cancer Risk Assessment for Dioxins (www.canceractionny.org/cancerriskassessment.htm).	For 2,3,7,8-TCDD TEQ. HDOH established Tier 2 action levels primarily to guide remedial actions for former agricultural fields. They do not serve as strict regulatory cleanup requirements. Tier 2 action levels were initially proposed in 2006 document but updated in 2008. GEPA updated values further to reflect toxicity value updates in 2008 RSLs (see GM). Residential/recreational, low risk, 42 ppt: no further action required; memo from Environmental Risk Assessment HEER Office to Brownfields Coordinator HEER Office. "This memo presents an approach for assessing dioxin contamination at the East Kapolei Brownfield site" … "The dioxin action levels are not recommended for use in Hawaiʻi."		Equations are provided in HDOH (2008) Appendix 2, adopted from the 2008 EPA RSL documentation. Slope factors were taken from EPA RSL tables and MNDOH (2003). This information is available online.	The SF factor of 150,000 $(mg/kg\text{-}d)^{-1}$ was taken from the previous Region 9 PRGs (subsequently updated). The SF of 1,400,000 $(mg/kg\text{-}d)^{-1}$, was used to generate a lower bound, as described for AS. As for the Tier 1 equations, Tier 2 equations for residential and industrial scenarios consider ingestion, dermal, and inhalation routes of exposure. To simplify this presentation, the equation for the dominant route, ingestion of carcinogenic contaminants in residential soil, is provided below. $C_{res} = \dfrac{TR \times AT_r}{[EF_r \times (CSF_o \times IFS_{adj} \times 10^{-6}\ kg/mg)]}$ where: TR = target risk, 10^{-6} AT_r = averaging time, 25,550 d CSF_o = 150,000 or 1,400,000 (mg/kg-d)-1 EF_r = exposure frequency, 350 d IFS_{adj} = res. soil ingestion rate, 114 mg-y/kg-d	Reflects slope factor underlying previous PRG.
	390			150,000 (SF_o)	$(mg/kg\text{-}d)^{-1}$		For 2,3,7,8-TCDD TEQ, residential/recreational scenarios, intermediate risk; >42- 390 ppt. Residential/recreational, high risk, >390 ppt: residential use not recommended absent remedial actions to reduce potential exposure. Process: determine area-wide background total dioxins (e.g., across the 400-acre site as a whole). If background is <42 ng/kg, identify "hot spots" as areas that exceed 42 ng/kg TEQ dioxins. Evaluate the feasibility of removing or capping soil to reduce long-term exposure (see below). If background is >42 but <390, identify "hot spots" as areas that exceed background and similarly evaluate the feasibility of remove or capping soil. For areas that exceed 42 ng/kg dioxins (2,3,7,8-TCDD TEQ) but are within background, recommended (but not required) are exposure minimization measures and notice to future homeowners of potential health risks (e.g., include in CC&Rs, notice to deeds).				

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State	Soil Conc *(ppt)*	Date	End-point Basis	Toxicity Reference Value		Information Source	Context Notes	Evaluation Criteria			
								Nature of Peer Review	Transparency-Public Availability	Scientific Basis	Incorporation of Most Recent Science
HI *(cont'd.)*	170	Sum-08	c	1,400,000 (SF_o)	$(mg/kg\text{-}d)^{-1}$		For 2,3,7,8-TCDD TEQ, industrial/commercial, low risk, <170 ppt; see residential/recreational, low risk.			Equation for ingestion of carcinogenic contaminants in industrial scenario: $C_{ind} = \frac{TR \times AT_r \times BW_a}{[EF_o \times ED_o \times (IRS_o \times CSF_o \times 10^{-6}\ kg/mg)]}$ where: TR = target risk, 10^{-6} AT_r = averaging time, 25,550 d BW_a = adult body weight, 70 kg EF_o = occupational exposure frequency, 250 d/y ED_o = occupational exposure duration, 25 y CSF_o = 150,000 or 1,400,000 (mg/kg-d)-1 IRS_o = occupational soil ingestion rate, 100 mg/d	
							For 2,3,7,8-TCDD TEQ, industrial/commercial, intermediate risk, 170-1,600 ppt; see residential/recreational, intermediate risk.				
	1,600			150,000 (SF_o)	$(mg/kg\text{-}d)^{-1}$		For 2,3,7,8-TCDD TEQ , industrial/commercial, high risk, >1,600 ppt; see residential/recreational, high risk.				
	4	*2006* *(2004)*				*Easthope (2006), ATSDR 1,000 ppt dioxin soil standard: Letter from concerned citizens, environmental groups (http://www.trwnews.net/Documents/TRW/Request%20to%20atsdr%20to%20clarify%201000ppt.pdf); lists same values identified in: EC (2004), Dioxin Soil Cleanup Levels in Other States, cited in table available via Tittabawassee River Watch News (http://www.trwnews.net/images/StateCleanup2006.PDF).*	*Basis not provided.*		*Limited information is available via the weblinks at left, with neither the derivation methodology nor basis of underlying toxicity values.*	*Basis not provided.*	
NMI (North'n Mariana Islands)	4.5	Oct-08	c	130,000 (SF_o)	$(mg/kg\text{-}d)^{-1}$	GEPA (2008)/HDOH (2008a), Evaluation of Environmental Hazards at Sites with Contaminated Soil and Groundwater – Pacific Basin Edition (http://hawaii.gov/health/environmental/hazard/pdf/pbvolume1mar2009.pdf); Volume 2, Appendix 1 and Appendices 2-9 (http://hawaii.gov/health/environmental/hazard/pdf/pbvolume2app1mar2009.pdf; http://hawaii.gov/health/environmental/hazard/pdf/pbvolume2app2to9mar2009.pdf); calculations supported by spreadsheet at HDOH (2008b), Evaluation of Environmental Hazards at Sites with Contaminated Soil and Groundwater - Hawai'i Edition (http://www.hawaiidoh.org/references/HDOH%202008.pdf); GEPA 2008 updates information from HDOH (2005), Screening for Environmental Concerns at Sites with Contaminated Soil and Groundwater, Volume 1: Summary Tier 1 Lookup Tables (http://www.deq.gov.mp/artdoc/Sec8art133ID453.pdf); Stralka (2009) (personal communication).	For 2,3,7,8-TCDD TEQ, environmental screening levels (ESLs), based on direct soil contact, 10^{-6} risk (except construction/ trench worker: 10^{-5} risk per lower exposure frequency and duration). "Although prepared specifically for Guam EPA, the use of well-accepted, US Environmental Agency (USEPA) standards, models and protocols should permit flexible use of the guidance throughout tropical and subtropical areas of the Pacific Basin region with little or no modification." "The screening levels are based on slight modifications to the USEPA Region IX Preliminary Remediation Goals and more recent Regional Screening Levels (USEPA 2004, 2008). The modifications as used in Hawai'i have been discussed in detail with USEPA Region IX. No adjustment of the HDOH Tier 2 screening levels is necessary for use in Guam and other areas of the Pacific Basin." (This updated the earlier guidance prepared for the Commonwealth of the Mariana Islands DEQ. See the AS entry where these values are first discussed for further details, across all columns.) Unrestricted land use: 4.5 is Tier 1 ESL for shallow soil (≤3 m bgs). (Field input indicated NMI follows current Guam guidance, which updated HDOH [2005], which previous indicated a value of 3.9 ppt).		Equations are provided in HDOH (2008) Appendix 2, adopted from the 2008 EPA RSL documentation. The slope factor was taken from the EPA RSL table. This information is available online.	Based on recent Guam EPA guidance; as described for AS, Equations for calculating Tier 1 ESLs and the toxicity value were taken from 2008 EPA RSL documentation. See GM entry for specific environmental screening level equations. Regarding direct exposure: text indicates dioxins are not considered significantly mobile in soil due to their strong sorption to organic carbon and clay particles, so consideration of soil leaching hazards was not needed. Also notes: "The 2008 U.S. Environmental Protection Agency (USEPA) *Regional Screening Levels* (RSLs; USEPA 2008a) replace *Preliminary Remediation Goals* (PRGs) previously published by individual regions. This includes PRGs published by USEPA Region IX (USEPA 2004) and referenced in pre-2008 editions of the CNMI and HDOH guidance documents." The slope factor of 130,000 $(mg/kg\text{-}d)^{-1}$ was taken from the 2008 EPA RSL table, based on the CalEPA value, maximum likelihood estimate (MLE) and linearized 95% upper confidence value (UCL) using animal data (NTP 1980a, 1982a) converted to equivalent human exposures per scaling factors. Assumptions from CalEPA include: oral and inhalation routes are equivalent, air concentration assumed to be daily oral dose, route of exposure does not affect absorption, and no difference in metabolism/ pharmacokinetics between animals and humans. Total weekly dose levels were averaged over the week to get a daily dose level; this assumes daily dosing in NTP studies would have given the same results as the actual twice weekly dosing schedule (because the TCDD half-life is relatively long, both schedules should give similar tissue concentrations).	See notes for parallel entries for AS, GM, and TT.

TABLE B.9 State Cleanup Levels for Dioxin in Soil: Region 9

State	Soil Conc *(ppt)*	Date	End-point Basis	Toxicity Reference Value		Information Source	Context Notes	Evaluation Criteria: Nature of Peer Review	Evaluation Criteria: Transparency-Public Availability	Evaluation Criteria: Scientific Basis	Evaluation Criteria: Incorporation of Most Recent Science
NMI *(cont'd.)*	18	Oct-08	c	130,000 (SF_o)	$(mg/kg\text{-}d)^{-1}$		For 2,3,7,8-TCDD TEQ. Commercial/industrial land use, Tier 1 ESL for shallow soil (≤3 m bgs). (See AS where these values are first discussed for further details.) (Field input indicated this update from the previous value of 16 ppt from HDOH [2005].)				
	1,500						For 2,3,7,8-TCDD TEQ. Construction/trench worker scenario, Tier 1 environmental screening level for deep soil (>3 m bgs). (See AS where these values are first discussed for further details.) (Field input indicated this update from the previous value of 2,000 ppt identified from HDOH [2005].)				
	42	Oct-08	c	1,400,000 (SF_o)	$(mg/kg\text{-}d)^{-1}$	GEPA (2008)/HDOH (2008a) *(cont'd.)*	For 2,3,7,8-TCDD TEQ, Tier 2 action levels, direct contact, 10^{-4} risk; especially intended for redevelopment of former agricultural fields but apply to any site. These are guidelines rather than strict, regulatory, cleanup requirements, and alternate values can be proposed in site-specific assessments. (See AS where these values are first discussed for further details.) Unrestricted (residential) use: <42 ppt: No action required. (See parallel AS entry for lower bound context.) 42-450 ppt: "Within USEPA range of acceptable health risk. Consider removal and offsite disposal of localized spill areas when possible in order to reduce potential exposure (not required for large, former field areas)."			The action level of 42 ppt was derived using the basic calculation in the HDOH (2008b) spreadsheet, with the target risk level updated from 10^{-6} to 10^{-4}. The SF of 1,400,000 $(mg/kg\text{-}d)^{-1}$ was used to generate a lower bound, as described for AS (and GM). See Guam entry in this table for the equations used to calculate action levels.	
	450			130,000 (SF_o)	$(mg/kg\text{-}d)^{-1}$		>450 ppt: Residential use not recommended in the absence of remedial actions to reduce potential exposure. (See AS for SF context.)			As above, using the SF_o from the recently harmonized 2008 EPA RSL; updates the previous Tier 2 action level of 390 ppt, per the previous RSL SF_o, 150,000 $(mg/kg\text{-}d)^{-1}$.	
	170			1,400,000 (SF_o)	$(mg/kg\text{-}d)^{-1}$		For 2,3,7,8-TCDD TEQ, Tier 2 action levels, commercial/industrial scenario: <170 ppt: No action required. (See parallel AS entry for lower bound context.)			Same approach as for the 42 ppt action level above; the SF of 1,400,000 $(mg/kg\text{-}d)^{-1}$ was used to generate a lower bound.	
	170-1,800						170-1,800 ppt: "Within USEPA range of acceptable health risk. Remedial actions vary depending on site-specific factors, including current and planned use, available options for onsite isolation or offsite disposal, and technical and economical constraints."				
	1,800			130,000 (SF_o)	$(mg/kg\text{-}d)^{-1}$		>1,800 ppt: Commercial/industrial use not recommended in absence of remedial actions to reduce potential exposure. (See parallel AS entry for SF/update context.)			As above, using SF_o of 130,000 $(mg/kg\text{-}d)^{-1}$ from the recently harmonized 2008 EPA RSL; updates the previous Tier 2 level of 1,600 ppt, which reflected the previous SF_o,150,000 $(mg/kg\text{-}d)^{-1}$.	

TABLE B.9 State Cleanup Levels for Dioxin in Soil: Region 9

State	Soil Conc *(ppt)*	Date	End-point Basis	Toxicity Reference Value		Information Source	Context Notes	Evaluation Criteria: Nature of Peer Review	Evaluation Criteria: Transparency-Public Availability	Evaluation Criteria: Scientific Basis	Evaluation Criteria: Incorporation of Most Recent Science
NV	3.9	Feb-09	c	150,000 (SF_o)	$(mg/kg\text{-}d)^{-1}$	NDEP (2009), Basic Comparison Levels (http://ndep.nv.gov/bmi/docs/bcl_calculations_table09.pdf); NDEP (2009), User's Guide and Background Technical Document for NDEP Basic Comparison Levels (BCLs) for Human Health for the BMI Complex and Common Areas (http://ndep.nv.gov/bmi/docs/bcl_guidance09.pdf).	2,3,7,8-TCDD, residential soil. (Values designed for use at the BMI Complex and Common Areas in Henderson, NV.) Identifies HEAST as the source of the toxicity value. (Note that the table title indicates Basic Comparison Levels 2008, but the footer of this document identifies the date of February 12, 2009, as supported by the weblink.)		Former HEAST tables not available; equations used to identify comparison levels for residential and industrial scenarios are available online.	Toxicity value cites (former) EPA HEAST, no date indicated. Residential scenario: ingestion of carcinogenic contaminants in soil (driving pathway): $CL = \frac{TR \times AT}{CSF_o \times 10^{-6} \times EF \times IFS_{adj}}$ where: CL = comparison level, mg/kg TR = target risk, 10^{-6} AT = averaging time, 25,550 d CSF_o = 150,000 $(mg/kg\text{-}d)^{-1}$ EF = exposure frequency, 350 d IFS_{adj} = adjusted soil ingestion, 114 mg-y/kg-d	
	17.7						2,3,7,8-TCDD, for industrial/commercial worker (outdoor).			Industrial/commercial scenario, outdoor worker: ingestion of carcinogenic contaminants in soil: $CL = \frac{TR \times AT \times BW_a}{EF_o \times ED_o \times (IRS_o \times CSF_o \times 10^{-6}\ kg/mg)}$ where: TR = target risk, 10^{-6} AT = averaging time, 25,550 d BW_a = adult body weight, 70 kg EF_o = occupational exposure frequency, 250 d/y ED_o = occupational exposure duration, 25 y CSF_o = 150,000 $(mg/kg\text{-}d)^{-1}$ IRS_o = industrial outdoor worker soil ingestion rate, 100 mg/d	
	38.1						2,3,7,8-TCDD, for industrial indoor worker without dermal exposure.			Industrial scenario, indoor worker: ingestion of carcinogenic contaminants: $CL = \frac{TR \times AT \times BW_a}{EF_o \times ED_o \times (IRS_o \times CSF_o \times 10^{-6}\ kg/mg)}$ where: TR = target risk, 10^{-6} AT = averaging time, 25,550 d BW_a = adult body weight, 70 kg EF_o = occupational exposure frequency, 250 d/y ED_o = occupational exposure duration, 25 y CSF_o = 150,000 $(mg/kg\text{-}d)^{-1}$ IRS_o = indoor worker soil ingestion rate, 50 mg/d	

TABLE B.9 State Cleanup Levels for Dioxin in Soil: Region 9

State	Soil Conc *(ppt)*	Date	End-point Basis	Toxicity Reference Value		Information Source	Context Notes	Evaluation Criteria: Nature of Peer Review	Evaluation Criteria: Transparency-Public Availability	Evaluation Criteria: Scientific Basis	Evaluation Criteria: Incorporation of Most Recent Science
NV *(cont'd.)*	*4*	*2006 (2004)*				*Easthope (2006), ATSDR 1,000 ppt dioxin soil standard: Letter from concerned citizens, environmental groups (http://www.trwnews.net/Documents/TRW/Request%20to%20atsdr%20to%20clarify%201000ppt.pdf); lists same values identified in: EC (2004), Dioxin Soil Cleanup Levels in Other States, cited in table available via Tittabawassee River Watch News (http://www.trwnews.net/images/StateCleanup2006.PDF).*	*Basis not provided.*		*Limited information is available via the weblinks at left, with neither the derivation methodology nor basis of underlying toxicity values.*	*Basis not provided.*	
TT (Trust Terri-tories)	4.5	Oct-08	c	130,000 (SF_o)	$(mg/kg\text{-}d)^{-1}$	GEPA (2008)/HDOH (2008a), Evaluation of Environmental Hazards at Sites with Contaminated Soil and Groundwater – Pacific Basin Edition (http://hawaii.gov/health/environmental/hazard/pdf/pbvolume1mar2009.pdf); (http://hawaii.gov/health/environmental/hazard/pdf/pbvolume2app1mar2009.pdf); (http://hawaii.gov/health/environmental/hazard/pdf/pbvolume2app2to9mar2009.pdf); Stralka (2009) (personal communication).	Field feedback for TT during the review phase indicated soil cleanup levels are determined on a site-specific basis (Stralka, 2009). Other online information suggests the context summarized for AS may be considered, so that information is offered here for context.) The environmental screening levels (ESLs) are based on slight modifications to the USEPA Region IX Preliminary Remediation Goals and more recent Regional Screening Levels (USEPA 2004, 2008). The modifications as used in Hawai'i have been discussed in detail with USEPA Region IX. No adjustment of the HDOH Tier 2 screening levels is necessary for use in Guam and other areas of the Pacific Basin." Guam EPA (2008) updated the earlier guidance prepared for the Commonwealth of the Mariana Islands, DEQ. Although not specifically prepared for TT, the document states, "Although prepared specifically for Guam EPA, the use of well-accepted, US Environmental Agency (USEPA) standards, models and protocols should permit flexible use of the guidance throughout tropical and subtropical areas of the Pacific Basin region with little or no modification." For 2,3,7,8-TCDD, Tier 1 ESL, residential scenario for shallow soil (≤3 m, below ground surface, bgs) is 4.5 ppt.		Toxicity values, and equations used to derive Tier 1 environmental screening levels for different exposure scenarios are available online in the HDOH document.	Equations for calculating Tier 1 ESLs were taken from 2008 EPA RSLs, as was the toxicity value. See parallel entries for AS and GM for further details.	As a note, the AS, GM, HI, NMI, and TT values appear to reflect a similar approach as that for the EPA 2008 RSLs. As for many relatively recent values, the toxicity value reflected is more current than others; it is adopted from the 2008 EPA RSLs, which reflects more recent data than Kociba et al. (1978) but not even more recent scientific data (such as the 2004 NTP study): Tier 2 levels incorporate the draft slope factor from MNDOH (2003), which reflects the upper bound from bioassay data based on the earlier study by Kociba et al. (1978) (taken from the range of values given in the EPA 2003 reassessment, rather than the recommended value (upper bound from epidemiological data).
	18						For 2,3,7,8-TCDD, Tier 1 ESL, industrial scenario, shallow soil (≤3 m bgs).				
	1,500						For 2,3,7,8-TCDD, Tier 1 ESL, construction/trench worker scenarios, deep soil (>3 m bgs).				

TABLE B.9 State Cleanup Levels for Dioxin in Soil: Region 9

State	Soil Conc *(ppt)*	Date	End-point Basis	Toxicity Reference Value		Information Source	Context Notes	Evaluation Criteria			
								Nature of Peer Review	Transparency-Public Availability	Scientific Basis	Incorporation of Most Recent Science
TT *(cont'd.)*	42	Oct-08	c	1,400,000 (SF$_o$)	(mg/kg-d)$^{-1}$	GEPA (2008)/HDOH (2008a), Evaluation of Environmental Hazards at Sites with Contaminated Soil and Groundwater – Pacific Basin Edition (http://hawaii.gov/health/environmental/hazard/pdf/pbvolume1mar2009.pdf); (http://hawaii.gov/health/environmental/hazard/pdf/pbvolume2app2to9mar2009.pdf) see Appendix 8; HDOH (2006), Proposed dioxin action levels for East Kapolei Brownfield Site (http://hawaii.gov/health/environmental/hazard/pdf/dioxinactionlevelsmarch2005.pdf).	(See the AS entry where these values are first discussed for further details, across all columns.) In addition to the Tier 1 ESL values, HDOH established Tier 2 action levels primarily to guide remedial actions for former agricultural fields. They do not serve as strict regulatory cleanup requirements. Values were initially proposed in 2006 document but updated in 2008 to reflect most recent toxicological data from EPA RSLs. Tier 2 action levels for TCDD (TEQs), residential scenario: <42 ppt: No action required. 42-450 ppt: Removal and offsite disposal of small, easily identifiable hot spots recommended. Consider other measures to reduce daily exposure to soil. For new developments, notify future homeowners of elevated levels of dioxin on the property. (See parallel AS entry for lower bound context.)		Equations are provided in Appendix 2 of the 2008 document, adopted from the 2008 Regional EPA RSLs. Slope factors were taken from the EPA RSL tables (current value) and MNDOH (2003) proposed value. This information is available online.	The SF of 1,400,000 (mg/kg-d)$^{-1}$, which was proposed several years ago by MNDOH (2003) (derived from Kociba et al. [1978]), was used to generate a lower bound. The slope factor of 130,000 (mg/kg-d)$^{-1}$ is from the current EPA RSL table. See the Guam entry for the equations used to calculate intake/dose.	As described above, does not reflect more recent scientific data (such as the 2004 NTP study).
	450			130,000 (SF$_o$)	(mg/kg-d)$^{-1}$		>450 ppt: Residential use not recommended in absence of remedial actions to reduce potential exposure. (See parallel AS entry for SF/update context.)				
	170			1,400,000 (SF$_o$)	(mg/kg-d)$^{-1}$		For TCDD (TEQs), Tier 2 action levels, industrial scenario: <170 ppt: No action required. (See parallel AS entry for lower bound context.)			For additional details, see the AS entry where these values are first discussed.	
	170-1,800						170-1,800 ppt: "Within USEPA range of acceptable health risk. Remedial actions vary depending on site-specific factors, including current and planned use, available options for onsite isolation or offsite disposal, and technical and economical constraints."				
	1,800			130,000 (SF$_o$)	(mg/kg-d)$^{-1}$		>1,800 ppt: Commercial/industrial use not recommended in absence of remedial actions to reduce potential exposure. (See parallel AS entry for SF/update context.)				

TABLE B.10 State Cleanup Levels for Dioxin in Soil: Region 10

State	Soil Conc *(ppt)*	Date	End-point Basis	Toxicity Reference Value		Information Source	Context Notes	Evaluation Criteria			
								Nature of Peer Review	**Transparency-Public Availability**	**Scientific Basis**	**Incorporation of Most Recent Science**
AK	38	Jun-08	c	150,000 (SF_o)	$(mg/kg\text{-}d)^{-1}$	ADEC Division of Spill Prevention and Response, Contaminated Sites Program (2008a), Cleanup Levels Guidance (http://www.dec.state.ak.us/spar/csp/guidance/cleanuplevels.pdf); ADEC Division of Spill Prevention and Response, Contaminated Sites Program (2008b), Cumulative Risk Guidance (http://ddoe.dc.gov/ddoe/lib/ddoe/Riggs_Remedy_94.pdf).	For 2,3,7,8-TCDD based on direct contact with soil, exposure frequency 330 d/y.	Document does not mention any intra-agency or external review.	Equations/tables for each element of the cleanup level equation are given in the ADEC documentation, which is available online.	Used EPA standards for exposure frequency and developed AK-specific soil parameters for equations. Equation used for dioxin in residential soil: $CL = \frac{TR \times AT \times 365 d/y}{EF \times SF_o \times IF_{soil/adj} \times 10^{-6} kg/mg}$ where: CL = cleanup level, mg/kg; TR = target cancer risk, 10^{-5}; AT = averaging time, 70 y; EF = exposure frequency, Arctic zone 200 d/y, under 40-inch zone 270 d/y, and over 40-inch zone 330 d/y; SF_o = oral slope factor, 150,000 $(mg/kg\text{-}d)^{-1}$; $IF_{soil/adj}$ = age-adjusted soil ingestion factor, 114 $(mg\text{-}y/kg\text{-}d)^{-1}$	EPA documents referred to range from 1996-2004.
	47						For 2,3,7,8-TCDD based on direct contact with soil, exposure frequency 270 d/y.				
	63						For 2,3,7,8-TCDD based on direct contact with soil, exposure frequency 200 d/y.				
	39	Jan-04	c	150,000	$(mg/kg\text{-}d)^{-1}$	ADEC Division of Spill Prevention and Response (2004), Dioxin and the Haines-Alaska Pipeline (http://www.dec.state.ak.us/spar/csp/docs/hfp/hfpdioxin_factsh_1_04.pdf).	Residential scenario, for dioxins; ADEC adopted the Region 9 PRG for TCDD but calculated value based on TR of 10^{-5} instead of 10^{-6}		Equation basis for Region 9 PRG and ADEC document are available online	Used EPA Region 9 PRG equation to derive value for TCDD. Slope factors and other toxicological information are taken from EPA 1997 HEAST ADEC based value on TR of 10^{-5}.	
	440	*Jun-03*	*c*			*EPA (2003d), ESD, OU 01, Arctic Surplus, Fairbanks (http://www.epa.gov/superfund/sites/rods/fulltext/e1003009.pdf); EPA (2008d), First Five Year Review Report for Arctic Surplus Salvage Yard Superfund Site, Fairbanks (http://yosemite.epa.gov/r10/CLEANUP.NSF/sites/fiveyr/$FILE/Arctic%20Surplus%20First%20121808.pdf).*	*Industrial scenario for dioxins. Did not alter original 1995 ROD; value reflects risk-based concentration (RBC) for 10^{-5} risk level.*		*Available online (RODS database).*		
	0.4	*Jul-96*	*c*			*EPA (1996d), ROD, OU 01, Standard Steel and Metal Salvage Yard (USDOT), Anchorage (http://www.epa.gov/superfund/sites/rods/fulltext/r1096141.pdf); U.S. ACE, (2008) Second Five-Year Review Report for Standard Steel and Metal Salvage Yard (USDOT), Anchorage (http://www.epa.gov/superfund/sites/fiveyear/f2008100002158.pdf).*	*For 2,3,7,8 TCDD TEQ. Residential scenario screening value for 10^{-6} risk level. Five-year reviews have not indicated any change to the cleanup level.*		*Available online (RODS database).*		

TABLE B.10 State Cleanup Levels for Dioxin in Soil: Region 10

State	Soil Conc *(ppt)*	Date	End-point Basis	Toxicity Reference Value		Information Source	Context Notes	Evaluation Criteria			
								Nature of Peer Review	Transparency-Public Availability	Scientific Basis	Incorporation of Most Recent Science
ID	*1,000*	*Apr-03*	*c*			*EPA (2003c), ESD, OU 03, Idaho National Engineering Laboratory (USDOE), Idaho Falls (http://www.epa.gov/superfund/sites/rods/fulltext/e1003133.pdf); USDOE (2007), Five Year Review of CERCLA Response Actions at the INL (http://yosemite.epa.gov/r10/CLEANUP.NSF/sites/INEEL/$FILE/DOE-NE-ID-11201-R3.pdf).*	*For 2,3,7,8-TCDD TEQ, based on EPA 1998 OSWER directive.*		*Available online (RODS database).*	*The Kimbrough et al. (1984) evaluation of Kociba et al. (1978) underlies the OSWER value.*	
	1,000	*Aug-02*	*c*			*EPA (2006b), Poles, Incorporated Integrated Assessment (http://yosemite.epa.gov/R10/CLEANUP.NSF/9f3c21896330b4898825687b007a0f33/434a255cbae5217d88256b560065cb04?OpenDocument); EPA (2002), Poles Incorporated Dioxin/Furan Sampling, Surface Soil Samples Analytical Results Summary, Oldtown (http://yosemite.epa.gov/R10/CLEANUP.NSF/9f3c21896330b4898825687b007a0f33/434a255cbae5217d88256b560065cb04/$FILE/Soil%20Results.PDF).*	*For 2,3,7,8-TCDD TEQ , residential scenario; EPA OSWER PRGs; based on dioxin screening of surface soil samples from a residential area nearby Poles Inc. and Idaho Hill Elementary School in Oldtown.*		*Available online (RODS database)*	*The Kimbrough et al. (1984) evaluation of Kociba et al. (1978) underlies the OSWER value.*	
	5,000-20,000						*For 2,3,7,8-TCDD TEQ , industrial scenario; per EPA OSWER PRGs based on dioxin screening of surface soil samples taken from Poles Inc. in Oldtown.*				
OR	4.5	Sep-09	c	130,000	$(mg/kg\text{-}d)^{-1}$	ORDEQ (2009), Risk-Based Concentrations (http://www.deq.state.or.us/lq/pubs/docs/RBDMTable.pdf); ORDEQ (2003), Risk-Based Decision Making for the Remediation of Petroleum-Contaminated Sites (http://www.deq.state.or.us/lq/pubs/docs/RBDMGuidance.pdf); Bailey (2009) (personal communication).	RBC for 2,3,7,8-TCDD; residential; direct contact via ingestion, dermal, or inhalation.	Substantial revisions made in 2003 with input from TPH Generic Remedy Work Group along with DEQ employees; updated in 2009.	Equations used for the derivation can be found online in the ORDEQ (2003) document for the remediation of petroleum-contaminated sites (Appendix B).	The basic equations are from 1995-2000; revisions were made in 2003. Calculations are based on cancer risk of 10^{-6}. Although a toxicity value was not explicitly identified in the updated table, a value of 130,000 per mg/kg-d can be inferred because of the use of the RSLs as the basis, per Bailey (2009); this can be confirmed by check calculations.	2003 document cites (DEQ, 2000); (EPA, 1996a); (ASTM 1995); Mott (1995); Mariner et al. (1997); and Park and San Juan (2000) as the basis for the equations provided.
	12						RBC for 2,3,7,8-TCDD; urban residential; direct contact via ingestion, dermal, or inhalation.				
	20						RBC for 2,3,7,8-TCDD; occupational; direct contact via ingestion, dermal, or inhalation.				
	150						RBC for 2,3,7,8-TCDD; construction; direct contact via ingestion, dermal, or inhalation.				
	4,200						RBC for 2,3,7,8-TCDD; excavation; direct contact via ingestion, dermal, or inhalation.				
	19						RBC for 2,3,7,8-TCDD; residential; leaching to groundwater.				
	66						RBC for 2,3,7,8-TCDD; urban residential; leaching to groundwater.				
	140						RBC for 2,3,7,8-TCDD; occupational; leaching to groundwater.				

TABLE B.10 State Cleanup Levels for Dioxin in Soil: Region 10

State	Soil Conc *(ppt)*	Date	End-point Basis	Toxicity Reference Value		Information Source	Context Notes	Evaluation Criteria: Nature of Peer Review	Evaluation Criteria: Transparency-Public Availability	Evaluation Criteria: Scientific Basis	Evaluation Criteria: Incorporation of Most Recent Science
OR *(cont'd.)*	3.9	May-05	c	150,000	$(mg/kg\text{-}d)^{-1}$	ORDEQ (2005), Pre-Calculated Hot Spot Look-Up Tables (http://www.deq.state.or.us/lq/pubs/docs/cu/PreCalculatedHotSpotLookupTables.pdf).	RBC for 2,3,7,8-TCDD, residential scenario for exposure by ingestion, inhalation of vapors/particulates, and dermal contact.			Acceptable risk level calculated using EPA Region 9 PRG equation of that time: $PRG = \frac{TR \times AT}{EF[(IFS_{aj} \times SF_o \times CF) + (SFS_{aj} \times ABS \times SF_o \times CF) + (InhF_{aj} \times SF_i)/PEF]}$ TR = target cancer risk, 10^{-6} AT_r = averaging time, 25,550 d EF_r = exposure frequency, 350 d/y IFS_{adj} = age-adjusted soil ingestion factor, 114 $(mg\text{-}y/kg\text{-}d)^{-1}$ $SF_{o,i}$ = oral and inhalation slope factor, 150,000 $(mg/kg\text{-}d)^{-1}$ CF = 10^{-6} kg/mg SFS_{adj} = soil dermal contact factor, 361 mg-y/kg-d ABS = dermal absorption fraction, 0.03 $InhF_{adj}$ = 11 $(m^3\text{-}y/kg\text{-}d)$ PEF = particulate emission factor, 1.316×10^9	
	16						RBC for 2,3,7,8-TCDD; industrial scenario for exposure by ingestion, inhalation of vapors/particulates, and dermal contact.				
	3.9	*2006 (2004)*				*Easthope (2006), ATSDR 1,000 ppt dioxin soil standard: Letter from concerned citizens, environmental groups (http://www.trwnews.net/Documents/TRW/Request%20to%20atsdr%20to%20clarify%201000ppt.pdf); lists same values identified in: EC (2004), Dioxin Soil Cleanup Levels in Other States, cited in table available via Tittabawassee River Watch (TRW) News, (http://www.trwnews.net/images/StateCleanup2006.PDF).*	*Basis not provided.*		*Limited information is available via the weblinks at left, with neither the derivation methodology nor basis of underlying toxicity values.*	*Basis not provided.*	

TABLE B.10 State Cleanup Levels for Dioxin in Soil: Region 10

State	Soil Conc *(ppt)*	Date	End-point Basis	Toxicity Reference Value	Information Source	Context Notes	Evaluation Criteria: Nature of Peer Review	Evaluation Criteria: Transparency-Public Availability	Evaluation Criteria: Scientific Basis	Evaluation Criteria: Incorporation of Most Recent Science
WA	11	Jun-09	c	150,000 (SF_o) $(mg/kg\text{-}d)^{-1}$	WADEC (2009), Cleanup Levels and Risk Calculations (https://fortress.wa.gov/ecy/clarc/Reporting/CLARCReporting.aspx).	For 2,3,7,8-TCDD. Unrestricted scenario; Method B, Carcinogen, Standard Formula Value, Direct Contact (ingestion only); Cleanup Levels and Risk Calculation (CLARC) tool, a searchable database developed and maintained by the WA Department of Ecology.	"Although CLARC has undergone review to ensure the quality of the information provided, there is no assurance that CLARC is free from errors."	"CLARC includes technical information related to the establishment of cleanup levels under the Model Toxics Control Act Cleanup Regulation, chapter 173-340 WAC."	SCL = $\frac{(RISK \times ABW \times AT \times UCF)}{(CPF \times SIR \times AB_1 \times ED \times EF)}$ where: SCL = soil cleanup level, mg/kg RISK = acceptable cancer risk level, 1 in 1,000,000 ABW = average body weight over the exposure duration, 16kg AT = averaging time, 75 y UCF = unit conversion factor, 1,000,000 mg/kg CPF = carcinogenic potency factor as defined in WAC 173-340-708(8) SIR = soil ingestion rate, 200mg/d AB_1 = gastrointestinal absorption fraction, 1.0 ED = exposure duration, 6 y EF = exposure frequency, 1.0	
	1,500					For 2,3,7,8-TCDD. Industrial scenario; Method C, Carcinogen, Standard Formula Value, Direct Contact (ingestion only); CLARC tool, a searchable database developed and maintained by the WA Department of Ecology.				
	6.67	Jan-98			WADEC (1998), Fact Sheet: Controlling Metals and Dioxins in Fertilizers (http://www.ecy.wa.gov/news/1998news/fert.html).	For 2,3,7,8-TCDD TEQ. Used as a final cleanup level for dioxins but it is possible that a higher cleanup level could be used if there are no exposure pathways or the existing pathways have been mitigated. This level was established by Model Toxics Control Act (MTCA) Method B Residential Soil Standard from the MTCA.				
	50 to 1,000					For 2,3,7,8-TCDD TEQ. Residential scenario for direct exposure via ingestion of dioxins; screening level, adopted per ATSDR (these levels are used as screens to trigger a more comprehensive, site-specific evaluation of potential human exposure).				
	8.7	*2006 (2004)*			*Easthope (2006), ATSDR 1,000 ppt dioxin soil standard: Letter from concerned citizens, environmental groups (http://www.trwnews.net/Documents/TRW/Request%20to%20atsdr%20to%20clarify%201000ppt.pdf); lists same values identified in: EC (2004), Dioxin Soil Cleanup Levels in Other States, cited in table available via Tittabawassee River Watch (TRW) News, (http://www.trwnews.net/images/StateCleanup2006.PDF).*	*Basis not provided.*		*Limited information is available via the weblinks at left, with neither the derivation methodology nor basis of underlying toxicity values.*	*Basis not provided.*	
	875	*Sep-03*			*EPA (2003f), Final ROD, OU 10, Oeser Company Superfund Site Remedial Action, Bellingham, (http://www.epa.gov/superfund/sites/rods/fulltext/r1003135.pdf).*	*For 2,3,7,8-TCDD TEQ, site-specific cleanup level derived from WA Dept. of Ecology, MTCA Method C for industrial scenario, 10^{-5} risk level.*		*Available online (RODS database).*		
	107.7	*Feb-00*	*c*		*EPA (2000), Wyckoff Co./Eagle Harbor Superfund Site, Soil and Groundwater Operable Units, Bainbridge Island, OU 02,04 (http://www.epa.gov/superfund/sites/rods/fulltext/r1000047.pdf);* *U.S. ACE (2007), Second Five-Year Review Report for the Wyckoff./Eagle Harbor Superfund Site, Bainbridge Island, Kitasp County(http://www.epa.gov/superfund/sites/fiveyear/f2007100001727.pdf).*	*Residential scenario for 2,3,7,8-TCDD toxicity equivalency factor (TEF), reasonable maximum exposure (RME) concentration, 2.52 x 10^{-5} cancer risk from EPA (1994b).* *Soil cleanup levels in the ROD were based on MTCA method B TEQ calculations. The second five-year report concludes that the minor changes in the basis for TEQ calculations would not significantly change the level of protectiveness. The only changes made were for other dioxin compounds (not 2,3,7,8-TCDD).*		*Available online (RODS database).*	*Equation for ingestion for RME exposure, based on data from EPA (1987) and Van den Berg et al. (1998, 2006):* IF_{soil}/adj *(mg-y/kg-d) =* $\frac{I_{soil}/age\ 1\text{-}6 \times D_{age}1\text{-}6}{W_{age}1\text{-}6} + \frac{I_{soil}\ 7\text{-}31 \times D_{age}7\text{-}31}{W_{age}7\text{-}31}$ *where:* IF_{soil}/adj *= age-adjusted soil ingestion factor (114 mg-y/ kg-d)* $W_{age}1\text{-}6$ *= average body weight from ages from 1-6 (15 kg)* $W_{age}7\text{-}31$ *= average body weight from ages from 7-31 (70 kg)* $D_{age}1\text{-}6$ *= exposure duration during ages 1-6 (6 y)* $D_{age}7\text{-}31$ *= exposure duration during ages 7-31 (24 y)* $I_{soil}/age\ 1\text{-}6$ *= ingestion rate of soil ages 1-6 (200 mg/d)* $I_{soil}\ 7\text{-}31$ *= ingestion rate of soil all other ages (100 mg/d)*	
	6.67					*Soil cleanup level for 2,3,7,8-TCDD TEQ.*				

TABLE B.10 State Cleanup Levels for Dioxin in Soil: Region 10

State	Soil Conc (ppt)	Date	End-point Basis	Toxicity Reference Value		Information Source	Context Notes	Evaluation Criteria: Nature of Peer Review	Evaluation Criteria: Transparency-Public Availability	Evaluation Criteria: Scientific Basis	Evaluation Criteria: Incorporation of Most Recent Science
WA (cont'd)	4	Sep-97	c			EPA (1997b), ROD, OU 01, Old Navy Dump/Manchester Laboratory (USEPA/NOAA), Manchester (http://www.epa.gov/superfund/sites/rods/fulltext/r1097201.pdf); U.S. ACE (2004), First Five-Year Review Report for Manchester Annex Superfund Site, Kitsap County (http://www.epa.gov/superfund/sites/fiveyear/f04-10009.pdf).	Landfill screening level, for 2,3,7,8-TCDD, 10^{-6} cancer risk; MTCA Method C for industrial scenario.		Available online (RODS database).	Industrial equation for carcinogenic effects of hazardous substances due to ingestion: Soil cleanup level = $\frac{RISK \times ABW \times AT \times UCF}{CPF \times SIR \times ABI \times ED \times EF}$ where: RISK = acceptable cancer risk level, 1 in 100,000; ABW = average body weight over exposure duration, 70 kg; AT = averaging time, 75 y; UCF = unit conversion factor, 10^6 mg/kg; CPF = carcinogenic potency factor; SIR = soil ingestion rate, 50 mg/d; ABI = gastrointestinal absorption fraction, 0.1; ED = exposure duration, 20 y; EF = exposure frequency, 0.4	
	270						For 2,3,7,8-TCDD TEQ, cleanup level.				
	6.7	Jul-94				EPA (1994c), ROD, OU 02, Naval Air Station, Whidbey Island (Ault Field) (http://www.epa.gov/superfund/sites/rods/fulltext/r1094077.pdf); DoN (2004), Final Five-Year Review Operable Units 1 through 5 Naval Air Station, Whidbey Island, Oak Harbor (http://www.epa.gov/superfund/sites/fiveyear/f04-10003.pdf).	Residential scenario for dioxin; 10^{-6} risk level. Neither five-year review mention any changes in dioxin levels.		Available online (RODS database).		
	400	May-93				EPA (1993c), ROD, OU 01, EPA Superfund Record of Decision: American Crossarm & Conduit Co., Chehalis (http://www.epa.gov/superfund/sites/rods/fulltext/r1093060.pdf); EPA (2004g), Second Five-Year Review Report for American Crossarm & Conduit Co. Superfund Site, Chehalis (http://www.epa.gov/superfund/sites/fiveyear/f04-10004.pdf).	For 2,3,7,8 TCDD TEQ. Residential scenario for incidental soil ingestion for dioxin, RME, calculated over a lifetime (75 y), upper-bound 95th percentile, Region 10 assumptions. Neither five-year review mention any changes in dioxin-contaminated soil.		Available online (RODS database).		
	200						For 2,3,7,8 TCDD TEQ. Industrial scenario for dioxin; RME for landfill.				
	2,000						For 2,3,7,8 TCDD TEQ. Industrial scenario for dioxin; RME for mill.				
	50,000						For 2,3,7,8 TCDD TEQ. Industrial scenario for dioxin; RME for treatment areas.				

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