Current and Potential Future Risk-Based Standards for Total Polychlorinated Biphenyls (PCBs) and Dioxin-Like PCBs

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ABSTRACT

Remediation of materials containing polychlorinated biphenyls (PCBs) is regulated in the United States by the U.S. Environmental Protection Agency (EPA). The EPA established numerical thresholds, based on the health risk to individuals that could come in contact with the materials, for management of bulk PCB remediation waste and for cleanup of spilled PCBs. The EPA recently announced its intent to revisit the PCB regulations. The EPA suggested that it might at some point propose to regulate certain PCB compounds not only as commercial products (Aroclors), but also in some instances as "dioxin-like" compounds due to their similar mode of toxicity to the class of chemicals known as dioxins (polychlorinated dibenzodioxins and dibenzofurans). The objective of this report is to evaluate potential impacts on numerical limits for PCB handling and cleanup—if the EPA were to propose risk-based standards based on dioxin-like PCBs. The report also examines possible changes to the current numerical thresholds if the toxicity bases and exposure assumptions were to be updated to be consistent with current risk assessment practice.

Keywords

Dioxins
PCBs
Polychlorinated biphenyls
Polychlorinated dibenzodioxins
Remediation
Transformer oil

EXECUTIVE SUMMARY

The distribution in commerce, use, and disposal of polychlorinated biphenyls (PCBs) is regulated by the U.S. Environmental Protection Agency (EPA) under the Toxic Substances Control Act (TSCA). Remediation of spilled PCB-containing fluids may also be regulated under the federal Comprehensive Environmental Response, Compensation, and Liability Act and/or under state regulations. Numerical thresholds for management of bulk PCB remediation waste and for cleanup of spilled PCBs may be based on human health risk or on factors such as practicality or analytical detection limits. Where the standards are risk based, the numerical limits are generally expressed in terms of total measured PCB concentration as Aroclors. *Aroclors* are commercial mixtures containing many different PCB congeners, or compounds. Current TSCA risk-based standards for activities such as spill cleanup are based on health effects research findings for specific Aroclor mixtures.

Recent statements by the EPA have suggested that it might at some point propose to regulate some PCB congeners not only as Aroclors, but also in some instances as "dioxin-like" compounds due to their similar mode of toxicity to the class of chemicals known as *dioxins* (polychlorinated dibenzodioxins and dibenzofurans). Of the 209 PCB congeners, 12 have been identified by the EPA as having dioxin-like toxicity. In a recent (2010) Advanced Notice of Proposed Rulemaking, the EPA notes concerns with the current hazard assessment of PCBs as Aroclors, noting that the Draft Dioxin Reassessment found that:

- The toxicity of PCBs calculated as dioxin-like PCBs (DLPCBs) is generally higher than the toxicity values previously used by EPA in developing TSCA PCB regulation.
- Some risks, which were found to be reasonable using older PCB toxicity information, would be unreasonable when using potentially higher toxicity information.

The objective of this report is to evaluate potential impacts on numerical limits for PCB handling and cleanup—if the EPA were to propose risk-based standards based on DLPCBs. To develop such standards, the EPA might either recalculate current standards for Aroclors to incorporate the toxicity information for the DLPCBs or propose to regulate the DLPCBS using existing risk-based limits for dioxins. In the latter case, the EPA may instead propose to regulate the non-DLPCBs separately as total PCBs, rather than raising the cleanup standards. A revised Aroclor standard might allow regulated facility owners to continue using existing analytical techniques, while comparison with a 2,3,7,8-tetrachlorodibenzodioxin toxic equivalence (TEQ) standard would probably require facilities to use highly sensitive, complex, and expensive analytical methods to determine the concentrations of DLPCB congeners present in PCB liquid, soil, or other media.

Before proposing to revise the current Aroclor standards, the EPA and other stakeholders ought to come to a consensus on how much of each DLPCB is typically present in each of the Aroclor mixtures. Aroclors vary in DLPCB content, and the available analytical studies do not agree on the DLPCB content of each mixture. Therefore, dual calculations of potential cleanup levels are provided in this report, corresponding to the two most cited Aroclor studies. Table 1 illustrates what Aroclor PCB soil cleanup standards would be if they were based on the average levels of DLPCBs in the mixtures. The projected cleanup limits differ greatly, depending on which data source is used. Additional analytical work is clearly needed to determine representative DLPCB concentrations in each common Aroclor.

As shown in Table ES-1, cleanup levels for Aroclors 1242 through 1260 would be much lower (more stringent) than at present, but cleanup levels for the other mixtures would be higher than at present. Aroclors 1242, 1254, and 1260 are the most common mixtures used in electrical equipment (ATSDR, 2000).

Table ES-1
Potential Risk-Based Aroclor Standards Calculated Using Two Sources of Aroclor Composition Data

	1 ppm Aroclor PCB standard becomes:		25 ppm Aroclor PCB standard becomes:	
Aroclor Mixture	Calculated Aroclor Standard* (EPA 2003 data)	Calculated Aroclor Standard* (Rushnek et al. 2004 data)	Calculated Aroclor Standard* (EPA 2003 data)	Calculated Aroclor Standard* (Rushnek et al. 2004 data)
Aroclor 1016	667	14.2	16,667	355
Aroclor 1221	5.1	27.2	127	681
Aroclor 1242	0.17	0.39	4.2	9.6
Aroclor 1248	0.07	0.25	1.9	6.2
Aroclor 1254	0.009	0.09	0.23	2.1
Aroclor 1260	0.005	0.13	0.13	3.3
Aroclor 1262	--	2.6	--	64.7
Aroclor 1268	--	5.1	--	127

* Calculated from the DLPCB content of each Aroclor mixture and the 2,3,7,8-TCDD toxic equivalents (TEQ) for each DLPCB congener

All values in parts per million (ppm).

If a dioxin TEQ were to be used as the risk basis for cleanup, there is considerable uncertainty as to the target PCB cleanup level that would result. The EPA recently withdrew the cancer risk-based Interim Recommended Preliminary Remediation Goals (PRGs) and has not yet released a revised cancer risk assessment for this class of compounds. However, assuming the ultimate dioxin Aroclor-based soil remediation standards are equivalent to the PRGs, PCB cleanup concentrations are calculated as shown in Table ES-2.

In the future, the EPA could potentially propose revised TSCA standards for bulk remediation waste and surface decontamination to incorporate the DLPCB toxicity information. Simply recalculating the standards using the EPA's current PCB cancer risk factor and exposure assumptions actually results in higher numerical limits. However, if the EPA proposed instead to apply toxicity factors for dioxin to the DLPCBs, this would result in far lower cleanup limits for DLPCBs when compared on an Aroclor basis. The current regulatory standards and the limits that might result from both of these approaches are shown in Table ES-3.

Table ES-2
Aroclor Equivalent Concentrations to Meet Dioxin Preliminary Remediation Goal (PRG)

Aroclor Mixture	Effective PCB Concentration (ppm)* to meet Interim Dioxin PRG**	
	Table 11-3 (EPA, 2003e) Aroclor TEQ	Rushneck et al., 2004 Aroclor TEQ
Aroclor 1016	24,667	525
Aroclor 1221	188	1,007
Aroclor 1242	6.1	14
Aroclor 1248	2.8	9.1
Aroclor 1254	0.34	3.2
Aroclor 1260	0.19	4.8
Aroclor 1262	--	96
Aroclor 1268	--	188

TEQ = 2,3,7,8-TCDD toxic equivalent quotient

* = Interim Residential PRG (37 pg/g) / [Aroclor TEQ (μg/g)* PCB high contact standard (1 μg/g)]

**The interim PRGs were withdrawn by EPA from White House OMB review on April 6, 2012.

Table ES-3
Potential Risk-Based Standards for Total and Dioxin-Like PCBs Using Updated Toxicity and Exposure Values

	Surface Cleanup (μg/100 cm^2)		Bulk Remediation Waste (ppm)	
	TSCA Standard*	Potential Recalculated Value**	TSCA Standard*	Potential Recalculated Value**
Total PCBs		50		2
DLPCBs	10	0.012	1	2.60E-05

* TSCA standard does not differentiate between PCBs and DLPCBs

** Using updated toxicity factors and exposure assumptions.

In evaluating the consequences of the development by the EPA of new risk-based PCB standards, several issues will require careful study. If extremely low cleanup standards result, it will be critical to determine whether background levels of PCBs in soil and other media will interfere with compliance and to assess the potential impact of laboratory background contamination. Other issues that may warrant additional review include the appropriate target risk level and exposure routes that the EPA selects in a revised standard, the actual congener composition of Aroclors in the environment, congener environmental degradation, how the "non-dioxin-like" effects of PCBs might be accounted for in applying the TEQ approach, and the uncertainty associated with the toxic equivalency methodology.

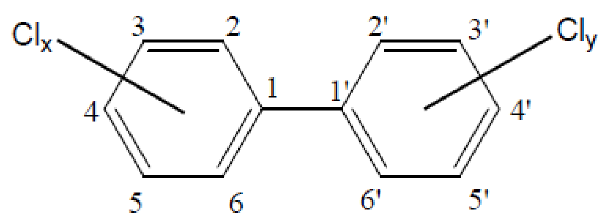
CONTENTS

LIST OF TABLES

1
INTRODUCTION

1.1 BACKGROUND

The distribution in commerce, use, and disposal of Polychlorinated Biphenyls (PCBs) is regulated by the U.S. Environmental Protection Agency (EPA) under the Toxic Substances Control Act (TSCA). TSCA sets cleanup standards for PCBs based largely on animal studies where PCB doses were administered as Aroclors, commercially produced mixtures of many individual PCB compounds (congeners). Aroclors, one of the most commonly known trade names for PCBs mixtures, were produced by Monsanto. There are 209 PCB congeners; however, not all of them occur in commercial Aroclor mixtures. The Aroclors differ in terms of the degree of chlorination (how many chlorine atoms are present on each PCB molecule), properties such as volatility and environmental persistence, and toxicity. Risk-based standards for activities such as PCB spill cleanup have historically been based on specific Aroclor mixtures rather than on concentrations of the individual PCBs. Until recently, analytical techniques for measuring individual PCB congeners were not commercially available, and these analyses remain very costly and limited to highly specialized laboratories. The basic structure of PCBs is shown below. The degree of chlorination present in Aroclor mixtures is provided in Table 1-1.



Source: ATSDR, 2000

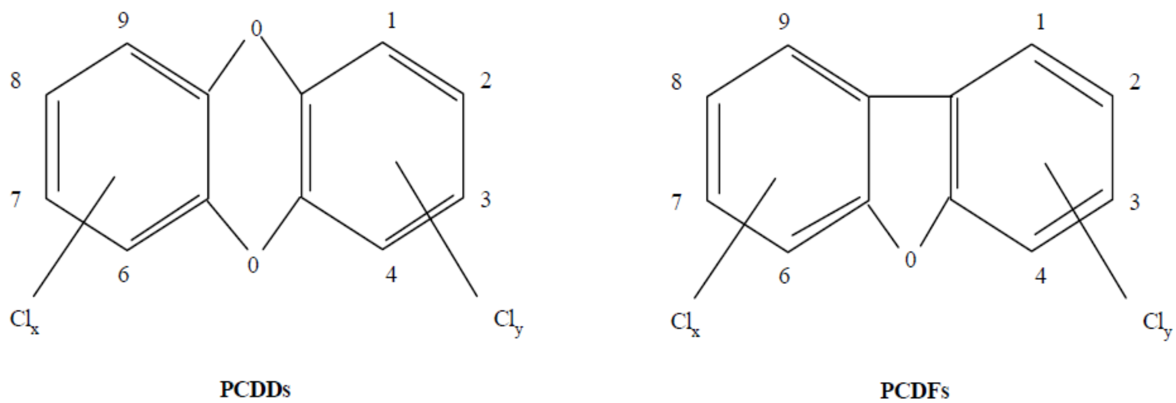
Table 1-1
Approximate Weight Percent of PCB Homologs in Some Aroclors

	Aroclor							
Homolog	**1016**	**1221**	**1232**	**1242**	**1248**	**1254**	**1260**	**1262**
$C_{12}H_9Cl$	0.7	60.06	27.55	0.75	7	ND - 0.02	0.02	0.02
$C_{12}H_8Cl_2$	17.53	33.38	26.83	15.04	1.55	0.09 - 0.24	0.08	0.27
$C_{12}H_7Cl_3$	54.67	4.22	25.64	44.91	21.27	0.39 - 1.26	0.21	0.98
$C_{12}H_6Cl_4$	22.07	1.15	10.58	20.16	32.77	4.86 - 10.25	0.35	0.49
$C_{12}H_5Cl_5$	5.07	1.23	9.39	18.85	42.92	59.12 - 71.44	8.74	3.35
$C_{12}H_4Cl_6$	ND	ND	0.21	0.31	1.64	21.97 - 26.76	43.35	26.53
$C_{12}H_3Cl_7$	ND	ND	0.03	ND	0.02	1.36 - 2.66	38.54	48.48
$C_{12}H_2Cl_8$	ND	ND	ND	ND	ND	ND - 0.04	8.27	19.69
$C_{12}H_1Cl_9$	ND	ND	ND	ND	ND	0.04	0.7	1.65

ND - not detected.

Source: ATSDR, 2000

PCBs are similar in their chemical structure to two classes of toxic substances: polychlorinated dibenzodioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs). The basic structure of PCDDs and PCDFs is shown below:



X = 0 to 4, Y = 0 to 4, X + Y $\geq$ 1

Source: EPA, 2003e

The most widely studied of the PCDDs and PCDFs is 2,3,7,8-TCDD. The initial public health concern about the PCDDs/PCDFs was the result of high toxicity of 2,3,7,8-TCDD, and in particular, the concern about the human carcinogenicity of 2,3,7,8-TCDD. This compound, often called simply “dioxin,” represents the reference compound for this class of compounds. Although sometimes confusing, the term “dioxin” is often also used to refer to the complex mixtures of PCDDs and PCDFs thought to exhibit similar human health effects when emitted from sources, or found in the environment or in biological samples. “Dioxin” can also be used to refer to the total 2,3,7,8-TCDD “equivalents” found in a sample (EPA, 2003b). Between 1998 and 2003, EPA scientists developed and distributed for review and comment an evaluation of the human health effects of dioxins. This document, the "Draft Dioxin Reassessment" has been subjected to extensive review and revision and has not yet been published as a final document. In the most recent (2003) version, EPA identified 12 PCB congeners that they concluded can exhibit dioxin-like health effects. These "dioxin-like PCBs" (DLPCBs) have a chemical structure identified as "coplanar" that is thought to cause those congeners to behave like dioxins/furans in biological systems and to invoke a common battery of toxic responses.

EPA recommends that the toxic equivalency factor (TEF) methodology be used to evaluate human health risks posed by DLPCBs (2011b), as outlined in the Agency's draft Dioxin Reassessment. In that document, EPA adopted the TEF methodology developed by the World Health Organization (WHO) in 2005 for calculating risk from multiple dioxins or dioxin-like compounds whose individual toxicity may not have been specifically assessed. EPA's recommended toxic equivalency methodology could potentially result in future risk-based cleanup standards for PCBs that include DLPCBs.

There are differing interpretations of the science associated with the impact on human health and the environment from exposure to dioxins. The scientific validity of the draft EPA Dioxin Reassessment remains controversial and the inclusion of dioxin-like PCBs in the dioxin TEQ continues to be debated. In July 2006, a National Academy of Science (NAS, 2006) review of the draft Dioxin Reassessment found that EPA did not sufficiently quantify the uncertainties associated with the health risks from dioxins and did not adequately justify the assumptions used to estimate such risks. On August 29, 2011, EPA announced a plan to respond to the NAS comments in a two-volume document: Volume 1 (non-cancer health assessment) and Volume 2 (cancer health assessment and uncertainty analysis). On February 17, 2012, EPA published Volume 1 of *Reanalysis of Key Issues Related to Dioxin Toxicity and Response to NAS Comments*. This report provides hazard identification and dose-response information on 2,3,7,8-TCDD) and the most up-to-date analysis of non-cancer health effects from TCDD exposure. The report also includes an oral reference dose (RfD); there was no previous RfD for TCDD in the IRIS database. EPA also announced plans to finalize Volume 2 as expeditiously as possible (EPA, 2012).

In a recent Advance Notice of Proposed Rulemaking (ANPRM) published in the Federal Register on April 7, 2010, EPA suggested that DLPCBs might at some point be regulated differently than Aroclor PCBs in terms of use and (presumably) disposal. In the ANPRM, EPA makes the following statements regarding the current and potential future approaches to regulation of PCBs under TSCA.

- Preliminary indications from the 2003 Draft Dioxin Reassessment are that the toxicity of PCBs in general is higher than the toxicity values that EPA used in developing previous TSCA PCB regulations.
- Some PCB congeners, sometimes referred to as co-planar PCBs or DLPCBs, are considered to have toxicities similar to the most toxic of the dioxins and furans.
- It is possible that EPA would find that some risks, which were found to be reasonable using older PCB toxicity information, would be unreasonable when using potentially higher toxicity information.

- Any proposed or final PCB rulemaking which relies on the contribution of DLPCBs to the overall toxicity of PCBs will be based on the finalized Dioxin Reassessment or another EPA peer-reviewed document.

Regulation of PCBs under TSCA cannot be changed from an Aroclor basis to a congener-specific "dioxin-like" basis without a significant notice-and-comment rulemaking, which has not been proposed as of this writing. Still, many in the regulated community have expressed concern over how EPA's decision to consider DLPCBs might affect development of risk-based PCB standards under TSCA and decision-making going forward. There is also concern that the EPA could start to require congener-specific analysis. A revised Aroclor standard might allow regulated facility owners to continue using existing analytical techniques (e.g., EPA Method 8082), while comparison with a dioxin-based standard would probably require facilities to use highly sensitive, complex, and expensive analytical methods (i.e., EPA Method 1668) to determine the concentrations of DLPCB congeners present in PCB bulk remediation waste, soil, or other media.

To calculate what a potential cleanup standard for total PCBs might be if it is based on a dioxin cleanup standard requires two pieces of information: the toxicity of each DLPCB relative to 2,3,7,8-tetrachlorodibenzodioxin (TCDD), and how much of each DLPCB is present in the total PCB mixture. Toxic equivalency factors (TEFs) are unitless numerical factors that express the fractional toxicity of an individual DLPCB congener relative to the toxicity of 2,3,7,8-TCDD, the most toxic and best studied among the dioxin congeners (EPA, 2003b). The Draft Dioxin Reassessment assigns TEFs to each of the 12 DLPCBs. TEFs for DLPCBs range from 0.00001 to 0.1. The measured concentration of each DLPCB congener is multiplied by the corresponding TEF, and the products are added together for all 12 congeners. The sum, called the 2,3,7,8-TCDD toxic equivalent (TEQ) or "dioxin TEQ", can then be compared with dioxin cleanup standards or used in risk calculations. PCBs that are not "dioxin-like" would not be included, as they are not thought to have the same toxicological basis of action as the DLPCBs. A PCB measurement in units of parts per million (ppm) TEQ will always be different than a measurement in ppm of Aroclor, and a TEQ value cannot be compared to existing total PCB regulatory limits. However, if the concentration of the 12 DLPCB congeners in a sample is known, that result can be compared to a risk-based dioxin TEQ limit. Risks from the non-DLPCBs would be evaluated separately, after reducing the total PCB concentration by the amount of DLPCBs. It is anticipated that the remaining PCBs would be compared to a total PCB standard.

1.2 SCOPE OF REPORT

Because the regulation of PCBs as DLPCBs rather than Aroclors would likely result in more stringent risk-based standards, it is important to understand the relative health effects information and the quantitative impact such a change could have on risk-based decisions involving PCBs. This report analyzes and compares the cleanup standards currently in place for Aroclor PCBs with limits that could potentially apply if DLPCBs were included in a dioxin TEQ cleanup standard. This analysis will provide potentially affected companies with a better sense of the relative impact of such a change in the regulations were it to occur. The report discusses the following regulatory and scientific issues:

- Past and present information pertaining to PCBs and dioxins including:

- Regulatory bases for determining the risk-based Aroclor PCB standards, including both the TSCA and CERCLA approaches, the historical basis for the existing standards under TSCA, and the more recent Superfund-type risk equations.
- The current risk-based standards for dioxins and DLPCBs, including calculation of dioxin TEQs, CERCLA risk-based screening levels for dioxin and DLPCBs in soil, and TSCA and CERCLA based surface decontamination standards/guidelines for dioxins, PCBs, and DLPCBs.

- Hypothetical regulatory PCB standards calculated using the most recent EPA toxicity data for PCBs (cancer and non-cancer), specifically values for ingestion (mg/kg) and dermal contact (µg/100 cm^2) pathways. These calculations are similar to performing a risk assessment using Integrated Risk Information System (IRIS) toxicity data (EPA, 2011b) as part of a risk-based PCB disposal approval application.
- Hypothetical regulatory standards calculated using the most recent toxicity data for DLPCBs.
- Analysis of how DLPCB standards might be applied to Aroclors.
- Discussion of other issues to be considered concerning the implementation of the dioxin reassessment.

2
CURRENT RISK BASIS FOR REGULATING PCBS AS AROCLORS

Most EPA regulations for PCB management and cleanup specify standards that are based on total PCBs measured as an Aroclor mixture. Some of these standards are not risk-based, but are based instead on non-technical criteria such as practically achievable detection limits (i.e., a 1 ppm cleanup standard) or on an "unreasonable risk" standard (i.e., no more than 50 ppm for non-PCB status and 500 ppm requiring disposal as PCB-contaminated). Of those standards that are risk-based, some are based on a generic risk assessment, particularly standards for spill cleanup and decontamination, while others require adjustment for site-specific factors (e.g., land use).

Risk-based standards, whether generic or site-specific, are the most likely to be impacted by incorporation of DLPCB risk into the analysis. The most commonly applied risk-based standards for Aroclor PCBs are:

- Soil and surface cleanup standards contained in the TSCA PCB Spill Cleanup Policy.
- Surface and soil cleanup standards contained in the 1998 TSCA PCB Disposal Amendments (commonly known as the "Mega Rule"), particularly the self-implementing cleanup standards in 40 CFR 761.61 and the self-implementing decontamination standards contained in 40 CFR 761.79.
- EPA Regional Screening Levels (RSLs), which were developed using risk assessment guidance from the EPA Superfund (CERCLA) program for use at Superfund sites for site "screening" and as initial cleanup goals.

The following sections review the risk basis of each of these existing Aroclor PCB standards.

2.1 PCB REMEDIATION REGULATORY AND POLICY STANDARDS

The Aroclor-based PCB cleanup standards and guidelines as currently defined in the TSCA regulations are summarized in Table 2-1 and the basis for the risk determinations underlying these standards are discussed below.

Table 2-1
Regulatory Cleanup Levels for PCBs

Location	Cleanup Requirements	Definitions
1987 Spill Cleanup Policy: Cleanup Levels for PCB Spills (40 CFR 761 Subpart G)		
Spills in outdoor electrical substations: - Outdoor, fenced-off, and restricted access areas used in the transmission and/or distribution of electrical power. - Outdoor electrical substations restrict public access by being fenced or walled off. - Outdoor electrical substations located less than 0.1. km from a residential/commercial area are considered to be residential/commercial areas.	Clean solid surfaces to 100 µg/100 cm^2. Clean soil to 25 ppm or to 50 ppm (by weight) provided the area is labeled or a notice posted. Post cleanup sampling required.	
Spills in other (non-substation) restricted access areas: - Areas other than electrical substations that are at least 0.1 kilometer (km) from a residential/commercial area and limited by man-made barriers (e.g., fences and walls) to substantially limited by naturally occurring barriers such as mountains, cliffs, or rough terrain. - These areas generally include industrial facilities and extremely remote rural locations. - Areas where access is restricted but are less than 0.1 km from a residential/commercial area are considered to be residential/commercial areas.	Clean high contact solid surfaces to 10 µg/100 cm^2. Clean low contact indoor impervious solid surfaces to 10 µg/100 cm^2. Clean low contact indoor non-impervious surfaces to 10 µg/100 cm^2 or 100 µg/100 cm^2 with encapsulation. Clean low contact outdoor surfaces (impervious and non-impervious) to 10 µg/100 cm^2. Clean soil to 25 ppm PCBs by weight.	*High-contact industrial surface* means a surface in an industrial setting which is repeatedly touched, often for relatively long periods of time. Manned machinery and control panels are examples of high-contact industrial surfaces. High-contact industrial surfaces are generally of impervious solid material. Examples of low-contact industrial surfaces include ceilings, walls, floors, roofs, roadways and sidewalks in the industrial area, utility poles, unmanned machinery, concrete pads beneath electrical equipment, curbing, exterior structural building components, indoor vaults, and pipes. *Impervious solid surfaces* means solid surfaces which are nonporous and thus unlikely to absorb spilled PCBs within the short period of time required for cleanup of spills under this policy. Impervious solid surfaces include, but are not limited to, metals, glass, aluminum siding, and enameled or laminated surfaces. Nonimpervious solid surfaces means solid surfaces which are porous and are more likely to absorb spilled PCBs prior to completion of the cleanup requirements prescribed in this policy. Nonimpervious solid surfaces include, but are not limited to, wood, concrete, asphalt, and plasterboard.

Table 2-1 (continued)
Regulatory Cleanup Levels for PCBs

Location	Cleanup Requirements	Definitions
Spills in non-restricted access areas:		
Any area other than restricted access, outdoor electrical substations, and other restricted access locations, as defined in this section. In addition to residential/commercial areas, these areas include unrestricted access rural areas (areas of low density development and population where access is uncontrolled by either man-made barriers or naturally occurring barriers, such as rough terrain, mountains, or cliffs).	Dispose of toys, furnishings and other easily replaceable household items.	
Residential/commercial area s means those areas where people live or reside, or where people work in other than manufacturing or farming industries.	Decontaminate indoor solid surfaces and high contact outdoor solid surfaces (high contact residential/commercial surfaces) to 10 µg/100 cm^2.	*High-contact residential/commercial surface* means a surface in a residential/commercial area which is repeatedly touched, often for relatively long periods of time. Doors, wall areas below 6 feet in height, uncovered flooring, windowsills, fencing, bannisters, stairs, automobiles, and children's play areas such as outdoor patios and sidewalks are examples of high-contact residential/commercial surfaces.
Residential areas include housing and the property on which housing is located, as well as playgrounds, roadways, sidewalks, parks, and other similar areas within a residential community.	Clean indoor vault areas and low contact outdoor solid surfaces to 10 µg/100 cm^2. Clean low contact outdoor non-impervious solid surfaces to 10 µg/100 cm^2 or 100 µg/cm^2 with encapsulation.	*Low-contact residential/commercial surfaces* include interior ceilings, interior wall areas above 6 feet in height, roofs, asphalt roadways, concrete roadways, wooden utility poles, unmanned machinery, concrete pads beneath electrical equipment, curbing, exterior structural building components (e.g., aluminum/vinyl siding, cinder block, asphalt tiles), and pipes.
Commercial areas are typically accessible to both members of the general public and employees and include public assembly properties, institutional properties, stores, office buildings, and transportation centers.	Decontaminate soil to 10 ppm PCB by weight (excavation of soil must be to a minimum depth of 10 inches) and replace with clean soil (<1 ppm PCB). .	

Table 2-1 (continued)
Regulatory Cleanup Levels for PCBs

Location	Cleanup Requirements	Definitions
1998 PCB Disposal Amendments ("Mega Rule") - Cleanup Levels for Self-Implementing Cleanup of PCB Remediation Waste (40 CFT 761.61)		
High Occupancy Area Any area where occupancy for any individual not wearing dermal and respiratory protection for a calendar year is: 840 hours or more (an average of 16.8 hours or more per week) for non-porous surfaces and 335 hours or more (an average of 6.7 hours or more per week) for bulk PCB remediation waste. Examples include a residence, school, day care center, sleeping quarters, a single or multiple occupancy 40 hours per week work station, a control room, and a work station at an assembly line.	Clean bulk remediation waste and porous surfaces to ≤ 1 ppm with no further conditions. Clean bulk remediation waste and porous surfaces to ≤ 10 ppm with cap. Clean non-porous surfaces to ≤ 10 µg/100 cm^2.	Bulk PCB remediation waste includes soil, sediment, mud, and sewage sludge. Porous surfaces includes corroded metal, paint, porous building stone, low-density plastic, wood, concrete or cement, plaster, rubber etc. Non-porous surfaces includes smooth uncorroded metal, glass, impermeable polished marble or high density plastics that do not absorb organic solvents.
Low Occupancy Area Any area where occupancy for an individual not wearing dermal and respiratory protection for a calendar year is: less than 840 hours for non-porous surfaces and less than 335 hours for bulk PCB remediation waste. Examples include an electrical substation or a location in an industrial facility where a worker spends small amounts of time per week (such as an unoccupied area outside a building, an electrical equipment vault, or in the non-office space in a warehouse where occupation is transitory.	Clean bulk remediation waste and porous surfaces to ≤ 25 ppm. Clean bulk remediation waste and porous surfaces to ≤ 50 ppm with mark and fence. Clean bulk remediation waste and porous surfaces to ≤ 100 ppm with cap. Clean non-porous surfaces to ≤ 100 µg/100 cm^2.	Bulk PCB remediation waste includes soil, sediment, mud, and sewage sludge. Porous surfaces includes corroded metal, paint, porous building stone, low-density plastic, wood, concrete or cement, plaster, rubber etc. Non-porous surfaces includes smooth uncorroded metal, glass, impermeable polished marble or high density plastics that do not absorb organic solvents.

PCB Spill Cleanup Policy. The 1987 PCB Spill Cleanup Policy (40 CFR 761 Subpart G) established cleanup levels for recently discovered spills to solid media (e.g., building surfaces) and soil occurring after the effective date of the Policy.

The derivation of the surface cleanup standards is provided in a Draft EPA memo (known as the "Hammerstrom memo") entitled "Cleanup of Contaminated Spills Located Indoors" (EPA 1986, as cited in Environ 2010). This draft memo included risk calculations for exposure to PCBs as Aroclors in residential and occupational settings via the inhalation and dermal exposure pathways. The memo concluded that inhalation exposure from volatilized PCBs was not significant. Factors used in development of surface cleanup standards included:

- PCB cancer slope factor – 4.0 $(mg/kg\text{-}day)^{-1}$
- Body weight – 50 kg
- Transfer rate of PCBs from surface to skin – approximately 10 percent
- Skin absorption rate of PCBs – 100 percent
- Target risk level – approximately 1×10^{-6}.

In the *Development of Advisory Levels for Polychlorinated Biphenyl Cleanup*, Hwang et al. (1986) also provides background information used by EPA in developing advisory levels for PCBs as Aroclors in soil that is estimated to be permissible in protecting public health. The results of the exposure assessment and health effects studies were combined to arrive at permissible levels of PCBs in soil. The permissible levels ranged from 0.08 to 0.6 mg/kg for lifetime residential exposure to PCBs resulting from ingestion of and dermal contact with PCB-contaminated soil and inhalation of PCB-contaminated air. Both low and high intakes correspond to an upper-bound, excess lifetime cancer risk of one in one million (1×10^{-6}). For sites where there is no possibility of soil ingestion, the permissible PCBs levels in soil range from 0.1 to 2 mg/kg, at a risk of 1×10^{-6}. This scenario assumes a 10-inch soil cover and is based on inhalation only. Factors used in this analysis included:

- PCB slope factor – 4.0 $(mg/kg\text{-}day)^{-1}$
- Soil ingestion rate – 0.6 g/day and 3 g/day
- Body weight – 10 kg child; 70 kg adult
- Inhalation rate – 20 m^3/day
- Gastrointestinal (GI) absorption – 30% for ingestion; 50% for inhalation, 3% for dermal absorption
- Dermal contact rate – 1 g/day (1.5 mg/cm^2 and surface area of 1000 cm^2)

PCB Disposal Amendments. The 1998 PCB Disposal Amendments (commonly known as the "Mega Rule") established new cleanup options for addressing waste containing PCBs as a result of a spill, release, or other unauthorized disposal.. The Amendments also establish two decontamination options for various media, again based on total Aroclors. The first option is to apply predefined standards. The second option provides a means for persons to petition EPA to allow application of site-specific risk-based cleanup standards.

Under the first option, the Amendments created generic, risk-based cleanup standards based on the kind of material contaminated and the potential exposure to PCBs left after cleanup is completed. The Amendments include instructions for self-implementing cleanup and for disposal of PCB remediation waste. The cleanup standards for self-implementing actions by a facility are based on the frequency of exposure in an impacted area and are classified as high occupancy or low occupancy. A high occupancy area is one in which an individual, not wearing dermal or respiratory protection, could be present 840 hours or more per calendar year (an average of 16.8 hours or more per week for 50 weeks per year) when exposed to non-porous surfaces. The individual is assumed to be exposed not more than 335 hours or more per calendar year (an average of 6.7 hours or more per week for 50 weeks per year) when exposed to bulk remediation waste. A low occupancy area is one in which an individual would be present at less than high occupancy exposure frequency.

Under the second option, the Amendments include a risk-based cleanup, under which the EPA Regional Administrator can approve varying cleanup levels based on a site-specific risk assessment.

2.2 REGIONAL SCREENING LEVELS

The EPA Regional Screening Levels (RSLs, or SLs) are risk-based concentrations derived from standardized equations combining exposure information assumptions with EPA toxicity data, and are considered by the Agency to be protective for humans (including sensitive groups) over a lifetime. The RSL table includes risk-based SLs for soil, air, and tap water for both residential and commercial/industrial land use scenarios. The RSL table is a living document [http://www.epa.gov/region9/superfund/prg/] that reflects the current state of the science of toxicology and risk assessment, and which is anticipated to be updated approximately semiannually in the fall and spring. The RSLs are consensus based values developed jointly by EPA Region 3, Region 6, and Region 9 for use in the EPA Superfund program by all EPA regions.

As guidance for use of RSLs, the EPA (2011a) states that “they should not be used as cleanup levels without adequate consideration of the other…remedy selection criteria on CERCLA sites and without verifying numbers with a toxicologist or regional risk assessor”. The RSLs for soil contaminants are based on exposure to a chemical in soil through ingestion, inhalation, and dermal contact, and are based on a target hazard quotient of 1 for noncarcinogenic effects and 10^{-6} for carcinogenic effects.

The November 2011 RSLs for Aroclors are provided in Table 2-2. Equations used to develop residential and industrial RSLs are provided in Appendix A**.** The primary source of toxicity values used in the equations to create RSLs is the EPA’s Integrated Risk Information System (IRIS) toxicity evaluation for the PCB chemical category (CAS No. 1336-36-3), http://www.epa.gov/IRIS/. The EPA last updated the Carcinogenicity Assessment for PCBs in June, 1997 (EPA, 2011b). The EPA’s IRIS is a human health assessment program that evaluates risk information on effects that may result from exposure to environmental contaminants. Although not tied to any regulatory program, IRIS is used as the basis for risk-based rules throughout EPA.

IRIS estimates the cancer potency of total PCB mixtures using a tiered approach: for each exposure pathway; a cancer slope factor is presented for three tiers of progressively greater exposure risk and environmental persistence. For each of these tiers, IRIS calculates a central-tendency slope factor and an upper-bound slope factor. The human cancer slope factors for the three tiers range from 0.07 $(mg/kg\text{-}day)^{-1}$ for lowest risk and persistence, to 0.4 $(mg/kg\text{-}day)^{-1}$ for low risk and persistence, and to 2 $(mg/kg\text{-}day)^{-1}$ for high risk and persistence. These IRIS slope factors are lower than the slope factor of 4 $(mg/kg\text{-}day)^{-1}$ used in the Spill Cleanup Policy and the 1998 PCB Disposal Amendments. Use of a lower slope factor results in a lower calculated risk and a higher risk-based cleanup concentration.

The criteria for use of the high risk and persistence tier of factors for total PCB mixtures are:

- Food chain exposure
- Sediment or soil ingestion
- Dust or aerosol inhalation
- Dermal exposure, if an absorption factor has been applied
- Presence of dioxin-like, tumor-promoting, or persistent congeners
- Early-life exposure (all pathways and mixtures)

EPA used the tiered slope factors to develop RSLs for total PCBs as high risk, low risk, and lowest risk. The high risk and persistence slope factor is used to develop RSLs for Aroclor-1221, Aroclor-1232, Aroclor-1242, Aroclor-1248, Aroclor-1254, and Aroclor-1260 while the lowest risk and persistence slope factor is used for Aroclor-1016. EPA (2011a) developed RSLs for the 12 DLPCB congeners using toxicity values from the EPA's Environmental Criteria and Assessment Office (ECAO). Non-cancer effects are assessed separately. Non-cancer toxicity endpoints (i.e., reference dose or RfD) are available in EPA's IRIS for some commercial PCB mixtures (i.e., Aroclor-1016 and Aroclor-1254). Non-cancer toxicity endpoints used to develop non-cancer RSLs for the 12 DLPCB congeners were also obtained from ECAO. The standard approach for determining the applicable risk-based concentration for PCBs is to select the lower of the RSLs based on carcinogenic and noncarcinogenic effects.

Table 2-2
EPA November 2011 Regional Screening Levels for PCBs as Aroclors, Congeners, and Dioxin

Analyte	Residential SL (mg/kg)		Industrial Worker SL (mg/kg)	
	Carcinogenic TR = 1E-06	Noncarcinogenic HI = 1	Carcinogenic TR = 1E-06	Noncarcinogenic HI = 1
~Polychlorinated Biphenyls (high risk)	0.22		0.74	
~Aroclor 1016	6.30	3.9	21	37
~Aroclor 1221	0.14		0.54	
~Aroclor 1232	0.14		0.54	
~Aroclor 1242	0.22		0.74	
~Aroclor 1248	0.22		0.74	
~Aroclor 1254	0.22	1.1	0.74	11
~Aroclor 1260	0.22		0.74	
~Tetrachlorobiphenyl, 3,3',4,4'- (PCB 77)	0.034	0.56	0.11	5.30
~Tetrachlorobiphenyl, 3,4,4',5- (PCB 81)	0.011	0.19	0.038	1.80
~Pentachlorobiphenyl, 2,3,3',4,4'- (PCB 105)	0.11	1.9	0.38	18
~Pentachlorobiphenyl, 2,3,4,4',5- (PCB 114)	0.11	1.9	0.38	18
~Pentachlorobiphenyl, 2,3',4,4',5- (PCB 118)	0.11	1.9	0.38	18
~Pentachlorobiphenyl, 2',3,4,4',5- (PCB 123)	0.11	1.9	0.38	18
~Pentachlorobiphenyl, 3,3',4,4',5- (PCB 126)	0.000034	0.00056	0.00011	0.0053
~Hexachlorobiphenyl, 2,3,3',4,4',5- (PCB 156)	0.11	1.9	0.38	18
~Hexachlorobiphenyl, 2,3,3',4,4',5'- (PCB 157)	0.11	1.9	0.38	18
~Hexachlorobiphenyl, 2,3',4,4',5,5'- (PCB 167)	0.11	1.9	0.38	18
~Hexachlorobiphenyl, 3,3',4,4',5,5'- (PCB 169)	0.0001	0.0019	0.00038	0.018
~Heptachlorobiphenyl, 2,3,3',4,4',5,5'- (PCB 189)	0.11	1.90	0.38	18
~TCDD, 2,3,7,8-	4.5E-06	7.2E-05	1.8E-05	8.5E-04

SL = screening level
TR = target risk level
HI = hazard index
mg/kg = milligram per kilogram

3
CURRENT BASIS FOR REGULATING DIOXINS

To simplify the comparison of dioxin findings with risk-based standards, dioxin-like compounds are collectively evaluated by adjusting congener concentrations according to their relative toxicity (multiplied by their TEFs) and calculating a dioxin toxic equivalent (TEQ). The dioxin TEQ is calculated as follows:

$$2,3,7,8\text{-TCDD TEQ} = \Sigma\ (\text{Congener}_i \times \text{TEF}_i)$$

EPA recommends the use of the TEFs developed in 2005 by the World Health Organization (WHO) (van den Berg et al. 1998, 2006) based on review of the toxicological literature (EPA, 2009a; 2011c). The recommended TEFs for DLPCBs are shown in Table 3-1. In the EPA's RSL toxicity value database described earlier, these TEFs have been applied to the toxicity values for dioxin to develop toxicity values and congener-specific RSLs for DLPCBs.

Table 3-1
Summary of WHO 2005 Toxic Equivalency Factor (TEF) values

	IUPAC No.	Structure	WHO 2005 TEF*
>Non-*ortho*	77	3,3',4,4'-TetraCB	0.0001
	81	3,4,4',5-TetraCB	0.0003
	126	3,3',4,4',5-PeCB	0.1
	169	3,3',4,4',5,5'-HxCB	0.03
>Mono-*ortho*	105	2,3,3',4,4'-PeCB	0.00003
	114	2,3,4,4',5-PeCB	0.00003
	118	2,3',4,4',5-PeCB	0.00003
	123	2',3,4,4',5-PeCB	0.00003
	156	2,3,3',4,4',5-HxCB	0.00003
	157	2,3,3',4,4',5'-HxCB	0.00003
	167	2,3',4,4',5,5'-HxCB	0.00003
	189	2,3,3',4,4',5,5'-HpCB	0.00003
>Di-*ortho***	170	2,2',3,3',4,4',5-HpCB	0.0001
	180	2,2',3,4,4',5,5'-HpCB	0.00001

* Dioxin-like toxic equivalency factors (TEF) for dioxins, furans and PCBs (Van den Berg et al. 2006), which are the World Health Organization 2005 values.
** Di-ortho values come from Ahlborg, U.G., et al. (1994), which are the WHO 1994 values from Toxic equivalency factors for dioxin-like PCBs: Report on WHO-ECEH and IPCS consultation, December 1993 Chemosphere, Volume 28, Issue 6, March 1994, Pages 1049-1067.

While use of the individual PCB congener results is not required in the TSCA PCB regulations, the generation of congener-specific PCB analyses and use of these results to calculate TEQs for comparison with dioxin standards has been suggested in EPA guidance. The IRIS (EPA, 2011b) states, "Although PCB exposures are often characterized in terms of Aroclors, this can be both imprecise and inappropriate. Total PCBs or congener or isomer analyses are recommended. When congener concentrations are available, the slope-factor approach can be supplemented by analysis of dioxin TEQs to evaluate dioxin-like toxicity. Risks from dioxin-like congeners (evaluated using dioxin TEQs) would be added to risks from the rest of the mixture (evaluated using slope factors applied to total PCBs reduced by the amount of dioxin-like congeners)."

3.1 SOURCE OF REGIONAL SCREENING LEVELS FOR DIOXINS AND INDIVIDUAL PCBS

The IRIS does not contain an assessment of dioxin or dioxin-like congeners. The dioxin toxicity data used in the RSL table for 2.3.7,8-TCDD was developed by The California Environmental Protection Agency Office of Environmental Health Hazard Assessment (OEHHA). The OEHHA toxicity values for 2,3,7,8-TCDD include an oral cancer slope factor (CSF) of 1.3 x 10^5 (mg/kg-day)$^{-1}$, an inhalation unit risk (IUR) of 3.8 x 10^1 (μg/m^3)$^{-1}$, and an inhalation reference concentration (RfC) of 4 x 10-8 mg/m^3. The oral RfD of 1 x 10-$^{-9}$ mg/kg-day for 2,3,7,8 was developed by the Agency of Toxic Substances and Disease Registry (ATSDR, 1998). EPA's ECAO used the OEHHA and ATSDR toxicity values for 2,3,7,8-TCDD to develop toxicity values for DLPCBs by applying the 2005 WHO TEFs for DLPCBs.

3.2 PRELIMINARY REMEDIATION GOALS FOR DIOXIN IN SOIL

Before issuing the Draft Dioxin Reassessment, the EPA Office of Solid Waste and Emergency Response (OSWER, 1998) recommended preliminary remediation goals (PRGs) for dioxin of 1 part per billion (ppb) TEQ [equivalent to 1,000 parts per trillion (ppt) of dioxin as TEQ] under a residential exposure scenario, and 5,000 ppt dioxin TEQ under an industrial exposure scenario. The risk to residents from oral exposure to dioxin in soil at a PRG of 1,000 ppt TEQ was estimated to be 2.5 x 10^{-4} and the risk to workers at a PRG of 5,000 ppt TEQ was estimated to be 1.3 x 10^{-4}. EPA (1998) recognized that the lifetime excess cancer risks at these concentrations were at the higher end of the range of acceptable risk of 1 x 10^{-4} to 1 x 10^{-6}. Dermal exposure was not considered for either residential or commercial/industrial land use in the development of the 1998 OSWER PRG.

EPA OSWER later developed Draft Recommended Interim PRGs for dioxin in soil in response to information in the Draft Dioxin Reassessment (EPA, 2009a). The Agency considered these PRGs to be national levels protective for both cancer [at a target cancer risk range of one in ten thousand (1 x 10^{-4}) to one in a million (1 x 10^{-6})] and non-cancer effects (at a target hazard quotient of 1) from ingestion and dermal contact with surface soils in residential and commercial/industrial exposure scenarios. The 2009 dioxin PRGs are shown in Table 3-2. The EPA (2009a) recommended that that these PRGs be considered a starting point in developing residential and commercial/industrial cleanup levels (EPA, 2009a) for dioxin (2,3,7,8-TCDD) and other dioxin-like compounds in soil, potentially including DLPCBs.

EPA (2009a) stated that Draft Recommended Interim PRGs for dioxin TEQs generally provide adequate protection against both non-cancer effects and cancer effects. The 2009 EPA recommended interim PRGs correspond to a non-cancer hazard quotient (HQ) of 1 and to an approximately 1 x 10^{-5} cancer risk level. EPA limited the upper bound cancer risk level to

1 x 10^{-5} rather than the typical upper limit of 1 x 10^{-4} to ensure protection against non-cancer effects Thus, the 2009 Draft Recommended Interim dioxin PRGs were set at a more protective cancer risk level than the 1998 dioxin PRGs, which reflect a cancer risk level of approximately 2 x 10^{-4}.

Table 3-2
Draft Recommended Interim Dioxin PRGs (EPA, 2009a)

		Potential Soil PRGs for Dioxin (as ppt TEQ)*			
		Cancer Risk Level			Non-Cancer Effect
Land Use	**Receptor**	10^{-6}	10^{-5}	10^{-4}	HQ = 1
Residential	Resident	3.7	37	370	72
Commercial/Industrial	Indoor Worker	37	370	3700	2000
	Outdoor Worker	17	170	1700	950

ppt = parts per trillion
PRG = preliminary remediation goal
HQ = hazard quotient
TEQ = 2,3,7,8-TCDD toxic equivalent
*The interim PRG was withdrawn by EPA from White House OMB review on April 6, 2012.

On April 6, 2012, EPA withdrew the Draft Recommended Interim PRGs from White House Office of Management & Budget (OMB) review. In a statement to *Inside EPA* (2012) the EPA said the interim goals are no longer necessary because EPA recently released one part of its dioxin risk assessment. The EPA split the dioxin reassessment into non-cancer and cancer effects; the portion released on February 17, 2012 addressed the non-cancer risks only. The IRIS RfD for dioxin was set at $7x10^{-10}$ mg/kg/day. Using the IRIS RfD as a basis, the interim PRGs would be reduced to 50 ppt TEQ for a resident, 660 ppt TEQ for an outdoor worker and 1400 ppt TEQ for an indoor worker.

This decision leaves considerable uncertainty as to the ultimate remediation goal for dioxins. In the absence of an IRIS cancer values, EPA evaluates other sources of toxicity values following a toxicity hierarchy approach. For dioxin, the Agency has considered EPA's Health Assessment Document cancer slope factor (CSF) for dioxin [1.56 x 10^5(mg/kg-day)$^{-1}$ from EPA (1985)] and California EPA's dioxin CSF [(1.3 x10^5 (mg/kg-day)$^{-1}$ from CalEPA (2002)]. The Interim PRGs are based on the CSF derived by EPA (1985) and a chronic oral RD of $1x10^{-9}$ mg/kg-day developed by ATSDR (1998). The dioxin RSLs discussed in Section 3.3 are based on the CSF developed by Cal EPA (2002). Using the Cal EPA (2002) CSF results in a cancer risk-based PRG of 4.5 ppt TEQ, which is slightly larger than the cancer risk-based Interim PRG of 3.7 ppt that was used in EPRI's evaluation.

3.3 CURRENT RISK BASIS FOR SURFACE DECONTAMINATION STANDARDS FOR DIOXINS AND PCBS

Cleanup criteria for surfaces are expressed in terms of surface loading (mass of contaminant per square meter of surface), as measured by chemical analysis of surface wipes. For Aroclor PCBs, samples are collected using a standard method cited in the TSCA regulations. While there is no corresponding standard method for dioxin wipe sampling, such samples are often collected in the same manner as PCB wipe samples, only over a larger surface area (0.5-1.0 m^2) in order achieve the lower detection limits needed to meet action limits (http://www.pacelabs.com/assets/documents/dioxins-furans-bulletins/TN_Wipes.pdf).

There are no CERCLA RSLs or PRGs for surface contact with PCBs and DLPCBs (as surface wipes). Several studies reported in the literature have developed risk-based screening criteria, and EPA developed benchmark concentrations for contact with surfaces in response to the World Trade Center bombing (Table 3-3). The derivation of these values was as follows:

- In 1994, Michaud et al. developed PCB and dioxin re-entry criteria for building surfaces after fires involving PCB-containing transformer and capacitor. The criteria were based on a lifetime risk level of 1×10^{-5}, toxicological data on TCDD and PCBs, and a plausible exposure scenario of an office worker exposed via dermal contact with contaminated surfaces and incidental ingestion of dust. Their analysis suggests that 125 ng/m^2 TEQ and 750 µg/m^2 PCBs (based on Aroclor 1260) for surfaces are acceptable screening levels.
- In 2003, the EPA developed health-based, settled dust benchmark concentrations for dioxins and PCBs for the World Trade Center (WTC). The WTC risk-based benchmarks were intended to be protective of long-term habitability of residential dwellings, and were developed using established EPA risk assessment methods (EPA 2003a). The World Trade Center Indoor Air Taskforce calculated a reentry criterion of 2 ng TEQ/m^2 for residential exposure to dioxins and a 16 µg/m^2 for total PCBs (EPA, 2003a). The criteria are based on the EPA's draft CSF of 1×10^6 (mg/kg-day)$^{-1}$ for dioxin, the EPA's upper-bound CSF of 2 (mg/kg-day)$^{-1}$ for PCBs, various exposure parameters, dermal absorption values, and a target cancer risk of 1×10^{-4}. An indoor 'degradation' parameter was also included in the calculations. The health-based settled dust benchmark is set at a target risk level of 1×10^{-4} because background concentrations of dioxin in settled dust were found at concentrations similar to the health-based benchmarks set at the 1×10^{-4} risk level (EPA, 2003a).
- Green et al. (2006) calculated re-entry building surface criteria for dioxin TEQ in surface dust for four exposure scenarios: 1) adult occupational, 2) adult residential, 3) childhood "occupational" (i.e., school), and 4) childhood residential. The recommended reentry "building surface" criteria are based on a cancer risk level of 1×10^{-5}, EPA's CSF of 1.56×10^5 (mg/kg-day)$^{-1}$, and updated exposure and bioavailability parameters. The calculated reentry criteria are approximately 85, 46, 15, and 0.004 µg TEQ/m^2, for the four scenarios.
- The U.S. Army Center for Health Promotion and Preventive Medicine (USACHPPM, 2009) developed a Technical Guide (TG 312) that provides a method for evaluating potential health risks to office workers from exposure to chemical substances on indoor work surfaces. TG 312 established health-based surface wipe screening levels (SWSLs) to be compared with environmental wipe sample results. The SWSL for dioxin TEQ of 0.00354 µg/m^2 is based on a target cancer risk level of 1×10^{-6} and a target hazard index (THI) of 1. The approach includes developing exposure factors specific to the office worker scenario and applying these factors to the generic EPA equation for estimating chemical intakes from dermal, ingestion and inhalation routes of exposure.

Table 3-3
Settled Dust Screening Values and Supporting Toxicity Criteria

Substance Name	Screening Value (μg/m^2)	Screening Value (μg/100 cm^2)	Toxicity Value CSF (mg/kg/day)$^{-1}$	Toxicity Value Source
Settled Dust Screening Values and Supporting Toxicity Criteria (EPA, 2003)				
PCBs (total)	16*	0.16	2	IRIS
Dioxins	0.0017*	0.00002	1.00E+06	EPA 2000
Surface dust criteria for dioxin and dioxin-like compounds for re-entry to buildings (Greene et al,. 2004)				
Adult occupational TEQ	0.085**	0.00085	1.56E+05	EPA, 1985
Adult residential TEQ	0.046**	0.00046	1.56E+05	EPA, 1985
Childhood occupational (school) TEQ	0.015**	0.00015	1.56E+05	EPA, 1985
Childhood residential TEQ	0.004**	0.00004	1.56E+05	EPA, 1985
Surface Wipe Screening Levels (USACHPPM TG 312)				
Office Worker TEQ	0.00354**	0.0000354	--	--
PCB and dioxin re-entry criteria for building surfaces and air (Michaud et al., 1994)				
Office Worker TEQ	0.125**	0.00125	--	--
Office Worker Aroclor-1260	750**	7.5	--	--

* based on target risk of 10^{-4}

** based on target risk of 10^{-5}

*** based on target risk of 10^{-6}

CSF = cancer slope factor

IRIS = Integrated risk information system

TEQ = 2,3,7,8-TCDD toxic equivalent

PCB = polychlorinated biphenyls

4

POTENTIAL SOIL CLEANUP GOALS FOR AROCLORS BASED ON THEIR DIOXIN-LIKE PCB CONTENT

This section presents calculations illustrating what a soil cleanup goal for Aroclors might be, if EPA in the future decides to apply a dioxin TEQ approach to Aroclors based on the content of DLPCBs in each Aroclor mixture. As a practical matter, understanding the significance of using DLPCB-based remediation and decontamination goals is best accomplished by converting these goals to their Aroclor equivalent concentration and comparing them with established standards. Knowledge of the dioxin-like congener concentrations in Aroclors would, in theory, allow Aroclor concentrations to be directly related to the 2,3,7,8-TCDD TEQ threshold (Prignano et al., 2008).

An Aroclor TEQ can be calculated from the relative contribution of each dioxin-like congener to the Aroclor mixture. Each measured PCB congener concentrations in an Aroclor mixture is multiplied by its respective TEF to determine the TEQ for each congener. The 12 PCB congener TEQs are then summed to find the total Aroclor TEQ. The calculation of Aroclor TEQs is provided in Appendix B, Table B-1. Aroclor-equivalent concentrations were calculated using values from EPA (2003e and Rushneck et al. (2004, as presented in Prignano et al., 2008). The EPA (2003e) DLPCB congener concentrations in various Aroclors include mean weight percent concentrations of PCBs in Aroclors based on data from various studies using Aroclors, Clophens, and Kanechlors. Clophens and Kanechlors are trade names for PCB mixtures of from manufacturers other than Monsanto that have similar, but not the same, degrees of chlorination as Aroclors. The Rushneck DLPCB congener concentrations in common Aroclors are based solely on data for Aroclors. EPA (2003) noted that while the congeners detected for each mixture were generally similar among researchers, there is wide variability in the concentrations reported for some congeners that results in very large uncertainty associated with the mean concentrations.

In Appendix B, Table B-2, the TSCA PCB standards are multiplied by the Aroclor-TEQ to determine the equivalent dioxin TEQ concentration for each Aroclor mixture (in ppt). The equivalent TCDD concentrations for the TSCA standards are compared to the interim PRG and RSLs for dioxin. For Aroclor-1242, Aroclor-1248, and Aroclor-1254, the equivalent TCDD concentration for a 10 ppm total PCB standard exceeds the EPA 2009 draft interim residential PRG for dioxins.

To determine the Aroclor-equivalent concentration of a cleanup standard the following example calculations are provided for Aroclor 1254:

- The high-occupancy cleanup standard for Aroclor 1254 is 1 ppm. The calculated dioxin TEQ equivalent is 109 ppt TEQ, based on Table 11-3 (EPA, 2003e) values.
- The residential (presumed high occupancy) standard for dioxin as TEQ is 37 ppt.
- The Aroclor equivalent of 37 ppt is therefore 37/109, or 0.34 ppm Aroclor 1254, which would become the new Aroclor-based soil remediation standard for Aroclor-1254 if dioxin TEQ was used as the risk basis for cleanup.

The results of these calculations for Aroclor mixtures are presented below in Table 4-1.

Table 4-1
Aroclor Equivalent Concentrations to Meet Dioxin Preliminary Remediation Goal (PRG)

	Table 11-3 (EPA, 2003e) Aroclor TEQ			Rushneck et al., 2004 Aroclor TEQ		
Aroclor Mixture	**Calculated Aroclor TEQ (µg/g)**	**Equivalent 2,3,7,8-TCDD TEQ Concentration (pg/g) based on 1 ug/g PCB standard**	**Effective PCB Concentration (ppm)* to meet Interim Dioxin PRG****	**Calculated Aroclor TEQ (µg/g)**	**Equivalent 2,3,7,8-TCDD TEQ Concentration (pg/g) based on 1 µg/g PCB standard**	**Effective PCB Concentration (ppm)* to meet Interim Dioxin PRG****
Aroclor 1016	0.0015	0.0015	24667	0.07	0.07	525
Aroclor 1221	0.197	0.197	188	0.037	0.037	1007
Aroclor 1242	6.02	6.02	6.1	2.6	2.6	14
Aroclor 1248	13.4	13.4	2.8	4.1	4.1	9.1
Aroclor 1254	108.9	109	0.34	11.7	11.7	3.2
Aroclor 1260	190.7	191	0.19	7.7	7.7	4.8
Aroclor 1262	--	--	--	0.39	0.39	96
Aroclor 1268	--	--	--	0.2	0.2	188

TEQ = 2,3,7,8-toxic equivalent quotient.

* = Interim Residential PRG (37 pg/g) / [Aroclor TEQ (µg/g)* PCB high contact standard (1 µg/g)]

**The interim PRG was withdrawn by EPA from White House OMB review on April 6, 2012.

It can be seen in Appendix B, Table B-1 that the presence or absence of congener 126 in an Aroclor mixture dominates the comparative risk and therefore raises or lowers the resulting Aroclor standard proportionately. Aroclors 1242 through 1260 have elevated weight percent concentrations of congener 126, which results in a more stringent TEQ-based Aroclor standard than the current Aroclor standard. Conversely, Aroclors with very little congener 126, such as Aroclors 1016 and 1268, have a much higher TEQ-based Aroclor cleanup standard.

5
EVALUATION OF POTENTIAL RISK-BASED PCB STANDARDS FOR DLPCBS

The 2010 ANPRM implies that any proposed or final PCB rulemaking will reexamine the toxicity of PCBs, including the contribution of DLPCBs, stating that "preliminary indications from the 2003 Draft Dioxin Reassessment are that the toxicity of PCBs in general is higher than the toxicity values that EPA used in developing previous TSCA PCB regulations."

In this section, TSCA and CERCLA PCB standards are reexamined, considering both cancer and non-cancer endpoints and the contribution of DLPCBs. Existing standards are based on old toxicity data and risk assessment exposure assumptions, which EPA would likely update in a future rulemaking.

5.1 ADJUSTED BULK (SOIL) REMEDIATION GOALS

The existing TSCA soil cleanup standards were re-evaluated using the most recent toxicity data for total PCBs and dioxins. In setting risk-based PCB standards in the 1998 PCB Disposal Amendments, EPA relied on a 4.0 $(mg/kg\text{-}day)^{-1}$ CSF that does not correspond with any of the CSFs currently in IRIS. This value was used by EPA to allow for additional protection from as yet unquantified risks from dioxin-like effects, non-cancer human health effects and effects to the environment (Versar, 2000; 63 Fed. Reg. 35383, 35386 (June 29, 1998). EPA's "Response to Comments" background document). In 2000 and 2002, the Fifth Circuit Court remanded EPA's use of the 4.0 $(mg/kg\text{-}day)^{-1}$ CSF in the PCB Disposal Amendments (United States Court of Appeals, 2002; OMB, 2003).

In order to calculate the adjusted bulk (soil) standard for PCBs and DLPCBs, the current regulatory value of 1 mg/kg total PCB was adjusted using:

- The high risk and persistence total PCB slope factor of 2 $(mg/kg\text{-}day)^{-1}$ from IRIS
- The DLPCB slope factor of 1.56 x $10^5 (mg/kg\text{-}day)^{-1}$ from EPA (1985)
- The DLPCB slope factor of 1.3 x10^5 $(mg/kg\text{-}day)^{-1}$ from CalEPA (2002)

Table 5-1 compares the TSCA high-occupancy bulk standard with possible DLPCB bulk standards. The total PCB standard of 1 mg/kg is increased to 2 mg/kg using the most recent slope factor for PCBs. However, using toxicity data for dioxins, the total PCB soil cleanup standard of 1 mg/kg is reduced to $3x10^{-5}$ mg/kg (30 ppt) for DLPCBs.

Table 5-1
Updated Bulk Cleanup Level for PCBs using Current Slope Factor for PCBS and Dioxin

	Slope Factor (mg/kg-day)$^{-1}$			Cleanup Level for Bulk PCB Remediation Waste (mg/kg)	
Analyte	**Regulatory Value**	**Updated Value**	**Basis**	**Regulatory Value**	**Updated Value**
Total PCBs	4	2	IRIS; high risk and persistence	1	2
Dioxin-Like PCBs	4	1.56E+05	EPA, 1985		2.6E-05
Dioxin-Like PCBs	4	1.30E+05	Cal EPA, 1986, 2002		3.1E-05

PCB = polychlorinated biphenyl

5.2 ADJUSTED SURFACE DECONTAMINATION GOALS

The existing TSCA surface cleanup standards were re-evaluated using the most recent toxicity data for total PCBs and dioxins. In addition, several exposure parameters were also re-evaluated including body weight, transfer rate from non-impervious or porous surface to skin, and the absorption factor for PCBs on skin. These adjustments were made to bring the past EPA risk-based cleanup goals in line with current EPA risk assessment practice. The following discussion presents the basis for reevaluation for each exposure parameter, and the resulting impacts on existing PCB decontamination regulatory standards.

Body Weight

Exposure is defined as the contact of an organism with a chemical or physical agent. Intake of a contaminant is normalized for body weight by dividing the total exposure by body weight. Risk assessment guidance (EPA 1989) specifies the use of an adult body weight of 70 kilograms. In the development of the TSCA PCB surface decontamination standards (40 CFR 761.79), EPA (1986) used a body weight of 50 kg; no basis was provided for this value. Currently, an adult body weight of 70 kg is commonly used to assess human health risks, although data show body weight of the U.S. population has increased steadily over the years (EPA, 2011d). A mean adult body weight of 80 kg is listed in the 2011 Exposure Factors Handbook. Although the EPA recommends using data most representative of the exposed population, the agency also cautions that updating the weight assumption would result in inconsistencies with the agency-derived toxicity data where a body weight of 70 kg is still used (EPA, 2011d). The net effect of the change in body weight would be a slight increase in the cleanup level.

Transfer Rate

Surface-to-skin transfer efficiency is the fraction of material that is transferred from a surface to the skin (EPA 2009b). The transfer efficiency of a chemical from a contaminated surface to the skin may be highly variable due to the nature and extent of the contact and the chemical composition and its affinity for skin relative to the surface (EPA, 2007a).

In development of the TSCA PCB surface decontamination standards, EPA used a transfer rate of about 10% (ENVIRON, 2010). For dermal contact, much less transfer will occur to body parts with less intensive surface contact than hands such as the arms, legs, and face. For the development of surface benchmarks for the World Trade Center (WTC) cleanup (EPA, 2003a), values of 5% from soft surfaces and 25% from hard surfaces were applied, which were assumed to represent an area-weighted transfer to all exposed skin and transfer of sooty material to the skin. For pesticides, EPA (2009b and 2009c), the 50th percentile generic fraction of active ingredient that is available to transfer from hard surfaces is 0.03 and the 95th percentile is 0.11 (EPA 2009b; 2009c). The 10% transfer factor was retained in this re-examination of the TSCA PCB surface decontamination standards.

Absorption Factor

Absorption refers to the ability of the chemical to penetrate and pass through intact skin. The rate of absorption (ABS) is chemical-specific and varies depending on the receptor, the amount applied to the skin, and the medium in which the PCBs are applied. While there is a paucity of information on absorption from dermal contact with hard surfaces, absorption factors for dermal contact with PCBs and dioxins in soil and solvent vehicles are available. EPA (1992, 2001b, as cited in EPA 2003a) proposed a dermal absorption fraction of 0.06 for PCBs from soil. Michaud et al. (1994, as cited in EPA 2003a) used 0.03 for PCBs and 0.02 for dioxins uptake from a sooty surface, based on the ranges of estimated ABS values for soil. Hwang et al. (1986) applies a GI absorption rate of 3% for dermal absorption of PCBs in soil.

In EPA guidance for conducting dermal exposure assessments (EPA 2004), a dermal absorption fraction was estimated at 14% for Aroclor 1254 and 1242 (and other PCBs) from soil. Reported ranges for dermal uptake for PCBs in solvent vehicles are reported to range from 15 to 56%. In a study by Wester (1983), dermal absorption in Guinea pigs was 33% of the applied 14C-labeled 42% PCB dose and 56% of the 14C-labeled 54% PCB dose. In Rhesus monkeys, 15-34% of the labeled 42% PCB was dermally absorbed. Reported ranges for 2,3,7,8-TCDD in solvent vehicles are reported to range from 1 to 40% (ATSDR, 1998).

Even if absorption might be enhanced by residual solvent, the maximum possible absorption of 100% that was used in the development of the TSCA PCB standards (Environ, 2010) would be unrealistic even for worst-case exposure. An absorption fraction of 56% for PCBs and DLPCBs (conservatively based on transfer of 54% PCB from solvents) was used in our re-examination.

Adjusted Surface Decontamination Goals

Table 5-2 summarizes the adjustments to the low-contact TSCA surface cleanup standard for PCBs, which include use of the IRIS high risk and persistence cancer slope factor of 2 (mg/kg-day)$^{-1}$, average adult body weight of 70 kg (EPA, 2011a), an absorption factor of 56 percent, and transfer factor of 10 percent. After making these adjustments, a surface standard for DLPCBs was derived by applying the EPA (1985) and CalEPA (1986; 2002) slope factor for dioxins.

Table 5-2
Updates to Baseline Conditions for Current Low-Contact Surface Cleanup Level for PCBs

Analyte and Baseline Conditions	Regulatory Value	Updated Value	Ratio of Input Parameter Differences[a]
Total PCBs			
Low Contact Surface Cleanup Level (µg/100 cm^2)	10	50	--
Cancer Slope Factor (CSF), $(mg/kg\text{-}day)^{-1}$	4	2[b]	2
Body Weight (kg)	50	70	1.4
Absorption Rate (unitless)	100	56	1.79
Transfer Rate (unitless)	10	10	1
Dioxin-Like PCBs			
Low Contact Surface Cleanup Level (µg/100 cm^2)	10	0.012	--
Cancer Slope Factor (CSF), $(mg/kg\text{-}day)^{-1}$	4	156000[c]	2.56E-05
Body Weight (kg)	50	70	1.4
Absorption Rate (unitless)	100	3	33
Transfer Rate (unitless)	10	10	1
Dioxin-Like PCBs			
Low Contact Surface Cleanup Level (µg/100 cm^2)	10	0.014	--
Cancer Slope Factor (CSF), $(mg/kg\text{-}day)^{-1}$	4	130000[d]	3.08E-05
Body Weight (kg)	50	70	1.4
Absorption Rate (unitless)	100	3	33
Transfer Rate (unitless)	10	10	1

PCB = polychlorinated biphenyl

1 cm^2 = 0.0001 m^2

100 cm^2 = 0.01 m^2

[a] Ratio of regulatory value to updated value. Inverse ratio used for body weight because intake is normalized to body weight.

[b] IRIS; high risk and persistence

[c] EPA, 1985

[d] Cal EPA, 1986, 2002

Using the IRIS PCB slope factor, the TSCA high-occupancy decontamination standard of 100 µg/100 cm^2 would decrease to 50 µg/100 cm^2. However, using a cancer slope factor for dioxins, the total PCB standard of 10 µg/100 cm^2 would decrease to a DLPCB cleanup standard of 0.012 µg/100 cm^2 if based on the EPA (1985) slope factor, and to 0.014 µg/100 cm^2 if based on the Cal EPA (1986; 2002) slope factor. Either value represents a more than 10,000-fold lower cleanup standard than the current regulatory limit.

6

OTHER ISSUES TO BE CONSIDERED

When evaluating the potential impact of using DLPCBs as the basis for risk-based regulatory standards, other issues should be considered.

6.1 INTERPRETATION OF AROCLOR CONGENER CONTENT

Research to date has focused on congener content in pure Aroclors (based on information from manufacturers). Additional information is needed to determine individual congener content of degraded Aroclors found in the environment (USWAG, 2004). Individual congeners weather, volatilize, degrade, and bioaccumulate at different rates (Bernhardt and Petron, 2001). Better data on typical congener content will have an effect on the interpreted toxicity of Aroclors using DLPCBs as the basis for regulatory standards, since the toxicity of PCBs is congener-specific. As EPA could regulate DLPCBs based on TEQ rather than individual congener concentrations, additional environmental measurements would help industry to predict what a TEQ standard would mean for remediation goals. Knowledge of congener content is also important for separating risks from dioxin-like congeners (evaluated using dioxin TEQs) from the rest of the PCB mixture (evaluated using slope factors applied to total PCBs reduced by the amount of dioxin-like congeners (EPA, 2011b).

6.2 BACKGROUND LEVELS OF PCBS/DIOXINS IN SOIL

Background levels of dioxin TEQ in soil for urban and rural conditions are presented in EPA (2003c). EPA (2003c) calculated mean $TEQ_{DF\text{-}WHO98}$ levels based on the available data to represent "typical" background conditions in the North America. The mean rural background $TEQ_{DF\text{-}WHO98}$ level was estimated to be 2.8 pg/g (ppt), and the "typical" urban background $TEQ_{DF\text{-}WHO98}$ level was estimated to be 9.4 ppt, assuming that non-detects equal zero. In comparison, the EPA (2011a) RSL for dioxins in a residential setting (4.5 ppt) is lower than urban background. Data on DLPCB congener soil concentrations were not found in the literature; the PCB soil concentration data found in the literature were reported as either total PCB concentrations or concentrations of Aroclor PCB mixtures. However, Henningsen et al. (2000 as cited in EPA 2003c) reported an average $TEQ_{DFP\text{-}WHO98}$ of 1 ppt for this data set. Background $TEQ_{DF\text{-}WHO98}$ levels for soils were estimated by setting non-detects to zero instead of one-half the detection limit, because congener-specific detection limits were not available for most studies. If one-half the detection limits had been used to represent non-detected congeners, the estimated background $TEQ_{DF\text{-}WHO98}$ levels may have been slightly higher.

EPA (2007b) conducted a national-scale pilot survey of levels of CDDs, CDFs, PCBs and mercury in rural/remote soils of the United States. These results provide a preliminary characterization of soils in rural/remote areas. Total CDDs averaged 1,585 ppt; total CDFs averaged 47 ppt. Levels of the TCDD homologues were the lowest, with an average concentration of 0.2 pg/g. Levels of the OCDD homologue were the highest, with an average concentration of 1,482 ppt. Total PCBs averaged 3,089 ppt. Levels of the deca-chlorinated biphenyl homologues were the lowest, with an average concentration of 29 ppt. Levels of the penta-chlorinated biphenyl homologues were the highest, with an average concentration of

1,013 ppt. Total TEQs averaged 1.76 ppt, which is lower than the 30 ppt dioxin-TEQ based soil cleanup level calculated in Section 5 of this report. The PCBs generally were a small fraction of the total TEQ in soil.

Another problematic issue that can arise when cleanup levels are extremely low is that background contamination of environmental samples may occur during field sampling and laboratory analysis. An EPRI (2010) report found detectable levels of DLPCBs in essentially all laboratory blanks analyzed using Draft EPA Method 1668, the proposed EPA method for PCB congener-specific analysis.

In short, calculated background concentrations of dioxin TEQ in soils could be problematic for a risk-based PCB cleanup standard if background dioxin, furans and PCB contributions are not considered. For example, the EPA RSL of 4.5 ppt for dioxins in a residential setting is lower than urban background of 9.4 ppt (EPA, 2007b). Anthropogenic background and laboratory contamination may interfere with reported results, and may not actually be associated with a PCB release.

6.3 SELECTION OF A TARGET RISK LEVEL

Under CERCLA, when the cumulative carcinogenic site risk is less than 1 x 10^{-4} and the non-carcinogenic hazard quotient is less than 1, action generally is not warranted. The upper boundary of the risk range is not a discrete line at 1 X 10^{-4} and site-specific risk estimates around 1 x 10^{-4} may be considered acceptable if justified based on site-specific conditions (EPA, 1991). EPA developed the RSLs for total PCBs and DLPCBs in Table 2-2 using the most current risk-based methodology and a target risk level of 1 x 10^{-6}. The TSCA standards for total PCBs are based on a target risk level of approximately 1 x 10^{-6}, as discussed in Section 2.1. For total PCBs and DLPCBs, a target cancer risk level of 1 x 10^{-5} may be a more appropriate target risk level. The EPA's (2009a) recommended interim PRGs for dioxins limited the upper bound cancer risk level to 1 x 10^{-5} rather than the typical upper limit of 1 x 10^{-4} to ensure protection against non-cancer effects. At the 1 x 10^{-5} risk level, the total PCB residential RSL for cancer effects would be 2.2 mg/kg, and the non-cancer residential RSL would be 1.1 mg/kg for Aroclor 1254 and 3.9 mg/kg for Aroclor 1016. Thus, the target risk level of 10^{-5} would also provide adequate protection against non-cancer effects of total PCBs. As EPA re-evaluates regulatory standards for total PCBs and DLPCBs, use of a 10^{-5} target risk level would result in a higher standard that provides adequate protection against both cancer and non-cancer effects.

6.4 PCB EXPOSURE ROUTES FOR FUTURE CLEANUP STANDARDS

Using methods developed for the WTC, the total PCB surface wipe benchmarks based on 10^{-4} target cancer risk level is 0.16 µg/100cm^2, which is lower than the existing total PCB high occupancy standard of 10 µg/100 cm^2. The dioxin benchmark is 0.00002 µg/100 cm^2. The intake equation used to develop the WTC settled dust benchmark includes incidental ingestion through hand-to-mouth activities and dermal contact. A similar framework has been used by the EPA Office of Pesticides Program to address residential post-application exposure to pesticides and to evaluate the safety of CCA-treated wood for residential application. The current TSCA surface standard is based on dermal contact only. EPA could potentially include incidental ingestion exposure in revised PCB surface standards, which would likely result in more conservative (lower) cleanup values. However, EPA does not have standardized procedures for estimating incidental ingestion through hand-to-mouth activities. A number of assumptions are used to estimate a hand-to-mouth dose rate, for example, the fraction of residues that can be transferred to the skin, daily skin loads, mouthing behaviors for different age groups, and dissipation of surface loading over time (EPA, 2003a). Should EPA include incidental ingestion in their reevaluation of regulatory standards for PCBs and DLPCBs, the uncertainty associated with quantifying ingestion exposure needs to be considered.

6.5 UNCERTAINTY IN APPLYING TEFS FOR DIETARY INTAKE TO ABIOTIC MEDIA

There is uncertainty associated with the application of TEFs to abiotic media (soil and dust) that should be considered if DLPCBs are used as the basis for risk-based regulatory standards, Van Der Berg et al. (2006) states, "Concern is expressed about the application of the TEF/TEQ approach to abiotic environmental matrices, such as soil, sediment, etc. The present TEF scheme and TEQ methodology are primarily meant for estimating exposure via dietary intake situations because present TEFs are based largely on oral uptake studies, often through diet. Application of these ''intake or ingestion'' TEFs for calculating the TEQ in abiotic environmental matrices has limited toxicological relevance and use for risk assessment, unless the aspect of reduced bioavailability and environmental fate and transport of the various dioxin-like compounds are taken into account. If human risk assessment is done for abiotic matrices, it is recommended that congener-specific equations be used throughout the whole model, instead of using a total TEQ basis, because fate and transport properties differ widely between congeners."

6.6 EPA PROPOSAL OF CONSERVATIVE TOTAL TOXICITY FACTOR

In the 1998 Mega Rule and in the PCB Risk Assessment Review Guidance Document (Versar, 2000), EPA proposed that a total toxicity factor of 4.0 $(mg/kg/day)^{-1}$ may be used in PCB risk assessments submitted in response to the PCB disposal rule to calculate the risk from both cancer and non-cancer endpoints (Versar, 2000). EPA proposed that this value should be used in conjunction with exposure values, and is based on total PCBs (i.e., the sum of Aroclor-based concentrations). The document states that evaluation of PCB congeners is not required when using the conservative total toxicity factor of 4.0 mg/kg/day, because it is assumed to account for dioxin-like effects, as well as non-carcinogenic effects of PCBs.

"Industry petitioners challenged the Mega Rule, arguing that the 4.0 $(mg/kg\text{-}day)^{-1}$ CSF could not be defended based on the record or science. Industry pointed out that it is well-known—and accepted by EPA and all other entities to assess risk from chemical exposure—that cancer and non-cancer risks are not summed in the course of risk assessment. Rather, cancer and non-cancer risks should be estimated separately and the more stringent of the risk estimates should drive the regulatory standard" (OMB, 2003). EPA agreed to a remand of the 4.0 $(mg/kg/day)^{-1}$ CSF. The Court then remanded the matter to EPA (Central & Southwest Services, Inc. v. EPA, 220 F.3d 683 (5th Cir. 2000) as cited in OMB, 2003). General Electric Co. petitioned for review of the "PCB Risk Assessment Review Guidance Document". This document was vacated by the United States Court of Appeals, District of Columbia Circuit (Argued December 3, 2001; Decided May 17, 2002). The Fifth Circuit said: "EPA is in the process of conducting a comprehensive assessment of the non-cancer toxic effects of PCBs.

According to EPA, it promulgated the Final Rule before the assessment was completed, in order to comply with the desires of the regulated community to finalize the rulemaking as soon as possible. However, EPA states that it has already committed to reexamine the toxicity of PCBs and has no objection to a remand so that it can consider the results of the assessment. Therefore, we remand §§ 761.61(a) and 761.79(b) to give EPA an opportunity to complete its assessment and reconsider the Final Rule in light of its study." To date, EPA has not proposed corrected Mega Rule standards for PCBs; the ANPRM indicates that the toxicity of PCBs will be re-evaluated.

7
CONCLUSIONS

There are differing interpretations of the science associated with the impact on human health and the environment from exposure to dioxins. The scientific validity and relevance of the Draft EPA Dioxin Reassessment and the inclusion of DLPCBs remains controversial and continues to be debated, but the recent ANPRM suggests that EPA might at some point propose to regulate DLPCBS differently than Aroclor PCBs in terms of use and (presumably) disposal. Many utilities have wondered what that would mean in practice. This document analyzes and compares the projected requirements for DLPCBs with regulatory criteria currently in place for Aroclor PCBs. The approximate congener concentrations for different standard Aroclors are known, so it is possible to determine the TEQs for each Aroclor and the comparative concentrations. Various use and disposal/cleanup standards were re-evaluated so that utilities could better understand the potential impact of standards based on TEQ instead of Aroclor concentrations.

There is large uncertainty associated with the DLPCB concentrations in Aroclor mixtures. A change in interpretation of the congener content in particular Aroclors will have an effect on the interpreted toxicity of the Aroclor using DLPCBs as the basis for regulatory standards. The presence or absence of congener 126 in an Aroclor mixture dominates the comparative risk and therefore raises or lowers the resulting Aroclor standard proportionately. Aroclors 1242 through 1260 all have significant congener 126 levels, resulting in a potential future TEQ-based Aroclor standard would likely be lower than the current Aroclor standard. Conversely, Aroclors with very little congener 126, such as Aroclors 1016 and 1268, would have a much higher TEQ-based Aroclor cleanup standard.

The ANPRM noted that human health risks at current cleanup levels would be considered “unreasonable” if EPA applies dioxin TEQ toxicity factors rather than those that were used in assessing the hazards of PCBs as Aroclors. However, our recalculation of surface decontamination and bulk remediation standards using EPA’s own (current) risk assumptions and current total PCB toxicity factors found that this actually would result in higher surface cleanup standards for total PCBs. However, recalculating surface decontamination standards using dioxin TEQ toxicity factors would result in much more stringent cleanup criteria. When applying the dioxin reassessment to regulatory standards for PCBs, other information such as anthropogenic background, the appropriate target risk level and exposure routes, the actual congener content of Aroclors in the environment, the ability of laboratory to accurately quantify DLPCBs, and the uncertainty associated with TEQ methodology, should be considered to ensure that the regulatory standard is both reasonable and protective.

8
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A

DERIVATION OF RESIDENTIAL SOIL REGIONAL SCREENING LEVELS

Source: http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/usersguide.htm

Noncancer Screening Level

Incidental ingestion of soil:

$$SL_{res\text{-}sol\text{-}nc\text{-}ing}\left(mg/kg\right)=\frac{THQ\times AT_r\left(\frac{365\text{ days}}{\text{year}}\times ED_c\left(6\text{ years}\right)\right)\times BW_c\left(15\text{ Kg}\right)}{EF_r\left(\frac{350\text{ days}}{\text{year}}\right)\times ED_c\left(6\text{ year}\right)\times\frac{1}{RfD_o\left(\frac{mg}{Kg\text{-}day}\right)}\times IRS_c\left(\frac{200\text{ mg}}{\text{day}}\right)\times\frac{10^{-6}Kg}{1\text{mg}}}$$

Inhalation of particulates:

$$SL_{res\text{-}sol\text{-}nc\text{-}inh}\left(mg/kg\right)=\frac{THQ\times AT_r\left(\frac{365\text{ days}}{\text{year}}\times ED_c\left(6\text{ years}\right)\right)}{EF_r\left(\frac{350\text{ days}}{\text{year}}\right)\times ED_c\left(6\text{ year}\right)\times ET_{rs}\left(\frac{24\text{ hours}}{\text{day}}\right)\times\left(\frac{1\text{ day}}{24\text{ hours}}\right)\times\frac{1}{RfC\left(mg/m^3\right)}\times\left(\frac{1}{VF_s\left(\frac{m^3}{Kg}\right)}+\frac{1}{PEF_w\left(\frac{m^3}{Kg}\right)}\right)}$$

Dermal contact with soil:

$$SL_{res\text{-}sol\text{-}nc\text{-}der}\left(mg/kg\right)=\frac{THQ\times AT_r\left(\frac{365\text{ days}}{\text{year}}\times ED_c\left(6\text{ years}\right)\right)\times BW_c\left(15\text{ Kg}\right)}{EF_r\left(\frac{350\text{ days}}{\text{year}}\right)\times ED_c\left(6\text{ year}\right)\times\frac{1}{\left(RfD_o\left(\frac{mg}{Kg\text{-}day}\right)\times GIABS\right)}\times SA_c\left(\frac{2800\text{ cm}^2}{\text{day}}\right)\times AF_c\left(\frac{0.2\text{ mg}}{\text{cm}^2}\right)\times ABS_d\times\frac{10^{-6}Kg}{1\text{mg}}}$$

Total:

$$SL_{res\text{-}sol\text{-}nc\text{-}tot}\left(mg/kg\right)=\frac{1}{\frac{1}{SL_{res\text{-}sol\text{-}nc\text{-}ing}}+\frac{1}{SL_{res\text{-}sol\text{-}nc\text{-}der}}+\frac{1}{SL_{res\text{-}sol\text{-}nc\text{-}inh}}}$$

Carcinogenic Screening Level:

Incidental ingestion of soil:

$$SL_{res\text{-}sol\text{-}ca\text{-}ing}\left(mg/kg\right)=\frac{TR\times AT_r\left(\frac{365\text{ days}}{\text{year}}\times LT\left(70\text{ years}\right)\right)}{CSF_o\left(\frac{mg}{Kg\text{-}day}\right)^{-1}\times EF_r\left(\frac{350\text{ days}}{\text{year}}\right)\times IFS_{adj}\left(\frac{114\text{ mg-Year}}{Kg\text{-}day}\right)\times\left(\frac{10^{-6}Kg}{mg}\right)}$$

where:

$$IFS_{adj}\left(\frac{114\text{ mg-Year}}{Kg\text{-}day}\right)=\frac{ED_c\left(6\text{ years}\right)\times IRS_c\left(\frac{200\text{ mg}}{day}\right)}{BW_c\left(15\text{ Kg}\right)}+\frac{ED_r\text{-}ED_c\left(24\text{ years}\right)\times IRS_a\left(\frac{100\text{ mg}}{day}\right)}{BW_a\left(70\text{ Kg}\right)}$$

Inhalation of particulates emitted from soil:

$$SL_{res\text{-}soi\text{-}ca\text{-}vc\text{-}inh}\left(mg/kg\right)=\frac{TR}{\left(\frac{IUR\left(\mu g/m^3\right)^{-1}\times EF_r\left(\frac{350\text{ days}}{\text{year}}\right)\times ED\left(30\text{ years}\right)\times ET_{rs}\left(\frac{24\text{ hours}}{day}\right)\times\left(\frac{1\text{ day}}{24\text{ hours}}\right)\times\left(\frac{1000\text{ }\mu g}{mg}\right)}{AT_r\left(\frac{365\text{ days}}{\text{year}}\times LT\left(70\text{ years}\right)\right)\times VF_s\left(\frac{m^3}{kg}\right)}\right)+\left(\frac{IUR\left(\mu g/m^3\right)^{-1}}{VF_s\left(\frac{m^3}{kg}\right)}\times\left(\frac{1000\text{ }\mu g}{mg}\right)\right)}$$

Dermal contact with soil:

$$SL_{res\text{-}sol\text{-}ca\text{-}vc\text{-}der}\left(mg/kg\right)=\frac{TR}{\left(\frac{\frac{CSF_o\left(\frac{mg}{Kg\text{-}day}\right)^{-1}}{GIABS}\times EF_r\left(\frac{350\text{ days}}{\text{year}}\right)\times DFS_{adj}\left(\frac{361\text{ mg-yr}}{kg\text{-}day}\right)\times ABS_d\times\frac{10^{-6}Kg}{1\text{ mg}}}{AT_r\left(\frac{365\text{ days}}{\text{year}}\times LT\left(70\text{ years}\right)\right)}\right)+\left(\frac{\frac{CSF_o\left(\frac{mg}{Kg\text{-}day}\right)^{-1}}{GIABS}\times SA_c\left(\frac{2800\text{ cm}^2}{day}\right)\times AF_c\left(\frac{0.2\text{ mg}}{cm^2}\right)\times ABS\times\frac{10^{-6}Kg}{1\text{ mg}}}{BW_c\left(15\text{ kg}\right)}\right)}$$

Total:

$$SL_{res\text{-}sol\text{-}ca\text{-}vc\text{-}tot}\,(mg/kg) = \frac{1}{\frac{1}{SL_{res\text{-}sol\text{-}ca\text{-}vc\text{-}ing}} + \frac{1}{SL_{res\text{-}sol\text{-}ca\text{-}vc\text{-}der}} + \frac{1}{SL_{res\text{-}sol\text{-}ca\text{-}vc\text{-}inh}}}$$

Inhalation of contaminants adsorbed to respirable particles (PM10) was assessed using a default PEF equal to 1.36 x 10^9 m^3/kg
Aroclor 1016 is considered “lowest risk” and assigned appropriate toxicity values. All other Aroclors are assigned the high risk toxicity values.

Dermal absorption factor for PCBs (as Aroclors and congeners) is 0.14.

B
CALCULATIONS SUPPORTING DERIVATION OF POTENTIAL CLEANUP VALUES

Table B-1
Weight Percent Concentrations of Dioxin-Like PCBs in Aroclors (EPA 2003e values)

	Mean concentration, ND = 0 (g/kg)							TEQ-WHO$_{2005}$ Concentration (mg/kg)					
Congener	**Aroclor 1016**	**Aroclor 1221**	**Aroclor 1242**	**Aroclor 1248**	**Aroclor 1254**	**Aroclor 1260**	**WHO 2005 TEF**	**Aroclor 1016**	**Aroclor 1221**	**Aroclor 1242**	**Aroclor 1248**	**Aroclor 1254**	**Aroclor 1260**
77		1.075	3.3	4.36	0.8	0.13	0.0001	0	0.1075	0.33	0.436	0.08	0.013
81		0.0875	1.09	1.76	7.85	0.08	0.0003	0	0.02625	0.327	0.528	2.355	0.024
105	0.0375	0.3875	4.02	10.12	35.83	1.59	0.00003	0.001125	0.011625	0.1206	0.3036	1.0749	0.0477
114			1.13	0.39	12.17	0.71	0.00003	0	0	0.0339	0.0117	0.3651	0.0213
118	0.0125	1.725	8.04	20.98	81.65	9.51	0.00003	0.000375	0.05175	0.2412	0.6294	2.4495	0.2853
123			1.12	1.48	4.59	0.0005	0.00003	0	0	0.0336	0.0444	0.1377	0.000015
126			0.049	0.11	0.99	1.81	0.1	0	0	4.9	11	99	181
156			0.39	1.13	11.08	6.89	0.00003	0	0	0.0117	0.0339	0.3324	0.2067
157			0.021	0.19	1.91	1.59	0.00003	0	0	0.00063	0.0057	0.0573	0.0477
167			0.021	0.16	2.74	2.87	0.00003	0	0	0.00063	0.0048	0.0822	0.0861
169			0.00013	0.01	0.08	0.16	0.03	0	0	0.0039	0.3	2.4	4.8
170			0.19	0.96	5.06	32.94	0.0001	0	0	0.019	0.096	0.506	3.294
180			0.16	1.24	5.79	82.61	0.00001	0	0	0.0016	0.0124	0.0579	0.8261
189				0.0018	0.045	1.74	0.00003	0	0	0	0.000054	0.00135	0.0522
Total Weight	0.050	3.275	19.53	42.89	170.59	142.63	**Total Aroclor TEQ (mg/kg)**	0.0015	0.197	6.02	13.41	108.90	190.70
							Potential Aroclor TEQ Standard*						
							1 ppm PCB regulatory standard	667	5	0.17	0.075	0.009	0.005
							25 ppm PCB regulatory standard	16667	127	4.2	1.9	0.23	0.13

Source: EPA, 2003e, Table 11-3 adapted to use WHO 2005 toxic equivalency factor (TEF) values

mg/kg = milligram per kilogram
g/kg = gram per kilogram

ND = non-detect

* Calculated from the DLPCB content of each Aroclor mixture and the dioxin toxic equivalents (TEQ) for each DLPCB congener; equivalent to the PCB regulatory standard/ Arcolor TEQ.

Table B-2
Dioxin-like PCB Congener Concentrations in Commercial Aroclors and Calculated Aroclor TEQs (values from Rushneck et al., 2004, as cited in Prignano et al., 2008)

	Dioxin-like PCB Congener Concentrations in Commercial Aroclors (µg/g or ppm)										Calculated Aroclor TEQ using Dioxin-Like Congener Concentrations and WHO_{2005} TEFs (µg/g or ppm)								
Congener	**Aroclor 1016**	**Aroclor 1221**	**Aroclor 1232**	**Aroclor 1242**	**Aroclor 1248**	**Aroclor 1254**	**Aroclor 1260**	**Aroclor 1262**	**Aroclor 1268**	**WHO 2005 TEF**	**Aroclor 1016**	**Aroclor 1221**	**Aroclor 1232**	**Aroclor 1242**	**Aroclor 1248**	**Aroclor 1254**	**Aroclor 1260**	**Aroclor 1262**	**Aroclor 1268**
77	40.9	12.6	2150	2590	4440	174	33.8	84.6	36.1	0.0001	0.00409	0.00126	0.215	0.259	0.444	0.0174	0.00338	0.00846	0.00361
81	1.96	0.51	111	156	221	16.4	3.33	4.63	1.35	0.0003	0.000588	0.000153	0.0333	0.0468	0.0663	0.00492	0.000999	0.001389	0.000405
105	69.5	55.9	3030	4840	17300	33800	434	764	107	0.00003	0.002085	0.001677	0.0909	0.1452	0.519	1.014	0.01302	0.02292	0.00321
114	6.03	4.04	248	443	1320	1930	17	46	5.86	0.00003	0.0001809	0.0001212	0.00744	0.01329	0.0396	0.0579	0.00051	0.00138	0.0001758
118	110	88.1	4460	6980	24200	78900	5610	1980	101	0.00003	0.0033	0.002643	0.1338	0.2094	0.726	2.367	0.1683	0.0594	0.00303
123	4.72	3.33	164	277	806	1150	5.02	27.8	3.24	0.00003	0.0001416	0.0000999	0.00492	0.00831	0.02418	0.0345	0.0001506	0.000834	0.0000972
126	0.56	0.28	21	33.6	98	37.3	2.13	2.28	1.76	0.1	0.056	0.028	2.1	3.36	9.8	3.73	0.213	0.228	0.176
156	3.72	7.49	90.7	255	654	8440	4860	946	17.6	0.00003	0.0001116	0.0002247	0.002721	0.00765	0.01962	0.2532	0.1458	0.02838	0.000528
157	1.03	1.46	22	70.9	171	1870	252	63.8	7.92	0.00003	0.0000309	0.0000438	0.00066	0.002127	0.00513	0.0561	0.00756	0.001914	0.0002376
167	1.1	2.52	32.4	80.7	207	3100	1990	278	4.96	0.00003	0.000033	0.0000756	0.000972	0.002421	0.00621	0.093	0.0597	0.00834	0.0001488
169	0.13	0.08	0.17	0.11	0.21	0.81	0.82	0.4	0.32	0.03	0.0039	0.0024	0.0051	0.0033	0.0063	0.0243	0.0246	0.012	0.0096
189	0.12	1.17	4.36	4.53	11	246	1290	451	4.4	0.00003	0.0000036	0.0000351	0.0001308	0.0001359	0.00033	0.00738	0.0387	0.01353	0.000132
Total concentration	239.770	177.48	10333.63	15730.84	49428.21	129664.51	14498.10	4648.51	291.51	**Aroclor TEQ (µg/g)**	0.070	0.037	2.6	4.06	11.7	7.7	0.68	0.39	0.20

	Aroclor 1016	Aroclor 1221	Aroclor 1232	Aroclor 1242	Aroclor 1248	Aroclor 1254	Aroclor 1260	Aroclor 1262	Aroclor 1268
High Contact PCB standard (µg/g)	1	1	1	1	1	1	1	1	1
Equivalent 2,3,7,8-TCDD Concentration (pg/g)	*0.07*	*0.04*	*2.6*	*4.1*	*11.7*	*8*	*1*	*0.39*	*0.20*
Low Contact PCB standard (µg/g)	10	10	10	10	10	10	10	10	10
Equivalent 2,3,7,8-TCDD Concentration (pg/g)	*0.70*	*0.37*	*26*	*41*	*117*	*77*	*6.8*	*3.9*	*2.0*
Low Contact PCB standard (µg/g)	25	25	25	25	25	25	25	25	25
Equivalent 2,3,7,8-TCDD Concentration (pg/g)	*1.8*	*0.92*	*65*	*101*	*291*	*191*	*17*	*10*	*4.9*
Residential EPA proposed Dioxin Criterion (pg/g)	**37**	**37**	**37**	**37**	**37**	**37**	**37**	**37**	**37**
Indoor Worker EPA proposed Dioxin Criterion (pg/g)	**370**	**370**	**370**	**370**	**370**	**370**	**370**	**370**	**370**
Outdoor Worker EPA proposed Dioxin Criterion (pg/g)	**170**	**170**	**170**	**170**	**170**	**170**	**170**	**170**	**170**
Resident RSL - Equivalent 2,3,7,8-TCDD Concentration (pg/g)	**45**	**45**	**45**	**45**	**45**	**45**	**45**	**45**	**45**
Industrial Worker RSL - Equivalent 2,3,7,8-TCDD Concentration (pg/g)	**180**	**180**	**180**	**180**	**180**	**180**	**180**	**180**	**180**
Potential Aroclor TEQ Standard*									
1 ppm PCB regulatory standard	14	27	0.39	0.25	0.09	0.13	1.5	2.6	5.1
25 ppm PCB regulatory standard	355	681	10	6.2	2.1	3.3	37	65	127

ppm = parts per million = mg/kg = µg/g
mg/kg = milligram per kilogram
µg/g = microgram per gram
0.001 ppm = 1 ppb = 1000 ppt
pg/g = part per trillion
37 ppt = =.037 ppb = 0.000037 ppm

* Calculated from the DLPCB content of each Aroclor mixture and the dioxin toxic equivalents (TEQ) for each DLPCB congener; equivalent to the PCB regulatory standard/ Aroclor TEQ.

Export Control Restrictions

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