INTERIM MEDIA PROTECTION GOALS PROPOSAL

FOR THE HOUSATONIC RIVER, REST OF RIVER

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1.0 INTRODUCTION

1.1 Background and Context

This revised Interim Media Protection Goals Proposal (IMPG Proposal) is submitted by the General Electric Company (GE) pursuant to Special Conditions II.C and II.D of the Reissued Resource Conservation and Recovery Act (RCRA) Corrective Action Permit issued by the U.S. Environmental Protection Agency (EPA) to GE on July 18, 2000 (Reissued RCRA Permit or Permit). That Permit was issued as part of the comprehensive settlement embodied in the Consent Decree (CD) for the GE-Pittsfield/Housatonic River Site, which was entered by the U.S. District Court in Massachusetts on October 27, 2000. The Reissued RCRA Permit applies to releases of polychlorinated biphenyls (PCBs) and other hazardous wastes or hazardous constituents that have migrated from the GE Facility in Pittsfield, Massachusetts, to the "Rest of River" area. The Rest of River area consists of the portion of the Housatonic River and its floodplain downstream of the confluence of the East and West Branches of the river (located approximately two miles downstream from the GE Facility) and to which releases of hazardous waste or hazardous constituents from the GE Facility are migrating or have migrated, except for the actual or potential lawn areas of current residential properties, which GE has already agreed to address under the CD through a separate Removal Action.

As provided in the CD, EPA conducted a Human Health Risk Assessment (HHRA) and an Ecological Risk Assessment (ERA) of the Rest of River area. Those draft assessments were then subject to peer review. Following the peer reviews, EPA revised the draft risk assessment reports, issuing a revised draft ERA in November 2004 (EPA, 2004a) and a revised draft HHRA in February 2005 (EPA, 2005a). After a public comment period on new information in those revised drafts, EPA issued Responsiveness Summaries for the ERA in March 2005 (EPA, 2005b) and for the HHRA in June 2005 (EPA, 2005c), concluding in both cases that no further changes to the risk assessment reports were warranted and that the November 2004 ERA and February 2005 HHRA, together with the Responsiveness Summaries, should be considered the final risk assessments for the Rest of River.[1]

[1] In January 2006, EPA issued Errata for the HHRA, consisting of revisions to the discussion of human breast milk and associated tables and figures, due to a calculation error in the February 2005 HHRA.

The Reissued RCRA Permit requires that, following completion of this process, GE must submit an IMPG Proposal presenting proposed media-specific Interim Media Protection Goals (IMPGs) for PCBs and other hazardous constituents that have migrated to the Rest of River area from the GE Facility. The IMPGs are to be used as one of the factors to be considered by GE in evaluating various potential remedial alternatives (corrective measures) in the subsequent Corrective Measures Study (CMS) to be conducted by GE under the Permit, which will be followed by EPA's selection of corrective measures for the Rest of River through a modification of the Permit.

In accordance with the schedule in the Permit, GE submitted an IMPG Proposal to EPA on September 6, 2005. On December 9, 2005, EPA issued a letter to GE in which EPA disapproved that IMPG Proposal and directed GE to submit a revised IMPG Proposal that incorporates a number of directives specified by EPA in its letter, as well as other specific revisions identified by EPA in Attachment A to its letter (EPA, 2005d). Thereafter, EPA and GE representatives met on a number of occasions to discuss EPA's comments in its letter. In the course of those discussions, EPA clarified or modified a number of the directives set out in its written comments.

Because GE does not agree with a number of EPA's comments and directives in its December 9, 2005 disapproval letter, GE submitted a notice to EPA on January 23, 2006, in which it invoked dispute resolution on that disapproval pursuant to the Permit. GE explained that, while it believes that it was not required to take that step in order to preserve its objections for a later review proceeding, it was doing so as a protective measure; and it accompanied its notice letter with a summary Statement of Position outlining GE's main objections. At the same time, GE proposed to stay that dispute resolution proceeding until either (a) the time when GE can seek administrative dispute resolution regarding EPA's notification of its intended decision on the Permit modification to select corrective measures for the Rest of River, or (b) the time of an appeal of that Permit modification pursuant to the Permit and the CD. In a letter dated January 25, 2006, EPA agreed to the stay on the terms proposed by GE.

Although GE disagrees with a number of EPA's directives for revising the IMPG Proposal, it has revised the IMPG Proposal, as required by the Reissued RCRA Permit and the CD, to incorporate the modifications directed by EPA in its December 9, 2005 comments, as modified or clarified by EPA in the subsequent discussions. In making these revisions, GE is complying

with EPA's directives to make such changes; it is not waiving its objections to EPA's directives and preserves its positions on those issues.

After EPA review and approval of this revised IMPG Proposal, as well as completion of the peer review process on validation of a PCB fate, transport, and bioaccumulation model being developed by EPA for the Rest of River, GE will submit a CMS Proposal. That Proposal will identify various potential corrective measures for the Rest of River and set forth a plan to study and evaluate those alternatives. Following EPA approval of the CMS Proposal, GE will carry out the CMS and submit a CMS Report, which will present an evaluation of the potential corrective measures and include a recommendation as to which corrective measures or combination of measures should be implemented. EPA will then review the CMS Report and, ultimately, propose and, after public comment, select Performance Standards and corrective measures for the Rest of River, through a modification of the Permit. After any appeals pursuant to the process set forth in the Permit and the CD, the corrective measures will be implemented as a Remedial Action under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and the CD.

1.2 Overview

Under the Reissued RCRA Permit, IMPGs are to consist of preliminary goals that will be used in the CMS in evaluating potential remedial alternatives for the Rest of River. They are not equivalent to cleanup standards or Performance Standards for the Rest of River remedy, which will be developed in connection with the selection of that remedy. The feasibility of attaining the IMPGs is not considered in the IMPG Proposal; rather, that factor is to be considered and balanced along with several other factors (listed in the Permit) in evaluating remedial alternatives in the CMS.

This IMPG Proposal presents preliminary numerical concentration-based goals for the protection of both human health and ecological receptors. From a human health standpoint, it addresses direct human contact with sediments and floodplain soil and human consumption of fish, waterfowl, and agricultural products from the Rest of River area. From an ecological standpoint, this IMPG Proposal addresses several groups of ecological receptors, including benthic invertebrates, amphibians, fish, and certain groups of birds and mammals. It presents concentration values for PCBs (and, in some cases, dioxin toxicity equivalents) in sediments,

floodplain soil, fish tissue, and/or other biota tissue as relevant to these human and ecological receptors.

To allow for full evaluation of an appropriate array of remedial alternatives in the CMS, this IMPG Proposal presents ranges of numerical concentration values, rather than single numbers, for most pathways and/or receptors. For the health-based values, these ranges include values based on different risk levels within EPA's acceptable cancer risk range, as well as non-cancer-based values, and they also include values based on different sets of exposure assumptions (representing individuals with reasonable maximum exposure and those with average exposure). For the ecologically based values, the ranges include the Maximum Acceptable Threshold Concentrations (MATCs) identified by EPA in the ERA, as well as other conservative threshold values derived from the ERA, or, for receptor groups for which the ERA did not specify a MATC, a PCB value based on a calculated effect level of less than 20 percent from a literature study of a sensitive surrogate species, as specified by EPA. Within the ranges, certain values at the lower end of the ranges are identified as "points of departure," as directed in EPA's December 9, 2005 comments. As also required by EPA, the numerical concentration values presented in this revised IMPG Proposal have been calculated based directly on use of the exposure assumptions, toxicity values, and data interpretations used or set forth in EPA's HHRA and ERA, despite GE's view that many of those inputs are overly conservative and not supported by the data.

Finally, this Proposal identifies, on a preliminary basis, chemical-specific applicable or relevant and appropriate requirements (ARARs), as that term is used in CERCLA, for media in the Rest of River area. The final ARARs will be specified by EPA as part of its selection of a Remedial Action. However, in accordance with the Reissued RCRA Permit, the ARARs identified herein will be used as a separate evaluative criterion in the CMS and will be subject to waiver under CERCLA if the applicable conditions for waiver are met.

1.3 Applicable Requirements

The requirements for the IMPG Proposal are set forth in Special Condition II.C of the Reissued RCRA Permit. In relevant part, those requirements are as follows:

- "The proposed IMPGs shall consist of preliminary goals that are shown to be protective of human health and the environment and that will serve as points of departure in evaluating potential corrective measures in the subsequent Corrective Measures Study . . . . Such IMPGs are not necessarily equivalent to cleanup standards or Performance Standards and may be modified or revised in the selection of Performance Standards and associated corrective measures."

- "IMPGs shall be proposed for the following media in the Rest of River area: sediments, surface water, floodplain soils, biota, and air (PCBs only)." (As discussed further below, based on surface water and ambient air data from the Rest of River and screening-level risk evaluations contained in the HHRA, there is no need to propose risk-based IMPGs for surface water and air.)

- "The constituents to be addressed by the proposed IMPGs shall be limited to those which have migrated to the Rest of River area from the GE Facility. Such constituents may be further limited to include only those constituents identified by EPA in its [HHRA] and its [ERA] as contributing to the baseline risk."

- "The proposed IMPGs for sediments, surface water, and floodplain soils shall include numerical concentration-based goals for constituents in such media, based on the assessment of direct contact of humans (i.e., incidental ingestion and/or dermal contact) with such media. They may also include narrative descriptive goals for such media based on such direct contact pathways."

- "The proposed IMPGs for biota consumed by humans shall include numerical concentration-based goals for constituents in the edible tissue of such biota, based on the assessment of human consumption of such biota. They may also include narrative descriptive goals for such biota based on such human consumption pathways. [GE] may also propose descriptive IMPGs for sediments, surface water, and/or floodplain soils based on an extrapolation from the human-consumption-based IMPGs for biota."

- "[GE] shall also propose IMPGs for relevant media based on the assessment of exposures and risks to ecological receptors. Such IMPGs shall consist of either numerical concentration-based goals or narrative descriptive goals, or a combination of these types of goals."

- "The IMPG Proposal shall include a justification demonstrating that the proposed IMPGs, if achieved, would ensure protection of human health and the environment, taking into account EPA's [HHRA] and its [ERA]."

- "The IMPG Proposal shall take into account applicable or relevant and appropriate federal and state requirements" (i.e., federal and state ARARs under CERCLA).

The Permit also specifies the role of the IMPGs in the CMS. It provides that, in the CMS Proposal, GE must identify the corrective measures it proposes to study and provide a justification for the selection of those measures, and that this justification "shall consider the ability of such corrective measures to achieve the IMPGs" (Special Condition II.E). The Permit

further requires that, in the CMS Report, GE must evaluate alternatives according to two tiers of factors (Special Condition II.G). The first tier consists of "General Standards" that all alternatives must meet. This tier does not include attainment of the IMPGs; rather, it includes overall protection of human health and the environment, control of sources of releases, and compliance with federal and state ARARs under CERCLA (or, when an ARAR would not be met, the basis for a waiver of the ARAR). The second tier consists of "Selection Decision Factors," which must be balanced against one another in evaluating alternatives. These factors include the ability of the alternatives to achieve the IMPGs, along with several other factors: long-term reliability and effectiveness; reduction of toxicity, mobility, or volume of wastes; short-term effectiveness (including impacts to nearby communities, workers, or the environment during implementation); implementability; and cost.

This IMPG Proposal does not consider the feasibility of achieving the IMPGs nor does it consider any of the other Selection Decision Factors set forth in the Permit. Those factors will be considered in the CMS phase of the process.

1.4 Scope and Basis of IMPG Proposal

As indicated in the preceding section, the Reissued RCRA Permit allows GE the option of whether to include narrative descriptive goals (in addition to numerical concentration-based goals) for the human health pathways, and the option of presenting either numerical concentrations or narrative descriptive goals (or a combination) for ecological receptors. In this revised IMPG Proposal, GE has elected to present numerical concentration-based goals for both the human health pathways and the ecological receptors, and not to present specific narrative descriptive goals at this time. Section 1.4.1 describes the constituents, media, and human exposure pathways or ecological receptors for which such numerical values have been developed. Section 1.4.2 explains that, for most pathways and receptors, GE has developed a range of values, based on assumptions, risk levels, and other inputs used in the HHRA and ERA, and has identified certain "points of departure" within those ranges as directed by EPA. Section 1.4.3 discusses the identification of ARARs.

1.4.1 Constituents, Media, and Pathways Covered

For PCBs, which are the principal contaminant of potential concern (COPC) in the Rest of River area, this Proposal sets forth numerical risk-based values for a number of media and exposure pathways. From a human health standpoint, EPA's HHRA contained three separate assessments – an assessment of direct human contact with soil or sediment, an assessment of fish and waterfowl consumption, and an assessment of agricultural products consumption. Consistent with those three assessments and with the requirements in the Reissued RCRA Permit, this Proposal presents health-based numerical values for PCBs in:

- Floodplain soil and sediment based on direct human contact with those media;
- Edible fish and waterfowl tissue based on human consumption of fish and waterfowl; and
- Edible agricultural products based on human consumption of those products.

From an ecological standpoint, EPA's ERA evaluated potential exposures and risks to a variety of ecological receptor groups, defined in the ERA in terms of "assessment endpoints." This IMPG Proposal presents numerical risk-based concentration values for PCBs based on the ERA's assessment endpoints for those ecological receptors for which the ERA found significant risks due to PCBs. Specifically, this Proposal presents such PCB values for the following media:

- Sediments based on the assessment endpoint for benthic invertebrates;
- Vernal pool and backwater sediments based on the assessment endpoint for amphibians (represented by wood frogs);
- Fish tissue based on the assessment endpoint for fish;
- Fish tissue based on the assessment endpoint for piscivorous birds (represented by osprey);
- Aquatic and terrestrial invertebrates based on the assessment endpoint for insectivorous birds (represented by wood ducks);

- Dietary items consumed by mink and otter based on the assessment endpoint for such piscivorous mammals (represented by mink);

- Floodplain soil based on the assessment endpoint for omnivorous and carnivorous mammals (represented by Northern short-tailed shrews); and

- Fish tissue based on the assessment endpoint for threatened and endangered species that consume fish (represented by bald eagles).

GE has also evaluated the need for risk-based values for PCBs in surface water based on direct human contact with the river water and for PCBs in ambient air based on inhalation of PCBs by humans. For surface water, EPA's HHRA contained a conservative screening-level evaluation of potential risks due to direct contact (HHRA, Vol. I, Sec. 5.2). In this evaluation, EPA developed very conservative screening risk-based concentrations (SRBCs), using conservative exposure assumptions for incidental ingestion of surface water, combined with stringent target risk benchmarks of a $1x10^{-6}$ cancer risk (the lower end of EPA's cancer risk range) and a non-cancer Hazard Index (HI) of 0.1 (10 times more stringent than the target HI recommended in EPA guidance). This evaluation resulted in SRBCs for PCBs of 27 micrograms per liter (µg/L) based on cancer risks and 18 µg/L based on non-cancer impacts. EPA then compared those SRBCs with the maximum detected concentration of PCBs in the surface water of the Housatonic River in the Rest of River area, which was 1.5 µg/L. Since that maximum concentration was well below the conservative SRBCs, EPA eliminated the surface water pathway from further quantitative evaluation in the direct contact risk assessment (HHRA, Vol. I, p. 5-7). In light of this conservative screening analysis, there is no need in this IMPG Proposal to develop risk-based numerical concentration values for PCBs in surface water based on direct contact.

For PCBs in ambient air, EPA's HHRA likewise presented a conservative screening-level assessment of potential risks due to inhalation (HHRA, Vol. I, Sec. 5.1). This assessment involved comparison of PCB concentrations measured in ambient air at this site with preliminary remediation goals (PRGs) developed by EPA Region IX for PCBs in ambient air, which assumed exposure to PCBs in the air 24 hours per day, 350 days per year for 30 years, and used a target cancer risk of $1x10^{-6}$. That PRG is 3.4 nanograms per cubic meter (ng/m^3). Based on this comparison, EPA found that "the average [total] PCB concentration in ambient air

[in the area] was lower than the conservative PRG, [and] therefore, the potential risks to individuals who live or recreate along the Housatonic River in the Rest of River study area was determined to be below 1E-06 and outside the EPA risk range" (HHRA, Vol. I, p. 5-3). EPA thus concluded that "the air concentrations of PCBs do not pose a human health risk for individuals living near or using the Housatonic River for recreational purposes" (HHRA, Vol. I, p. 5-4). For these reasons, there is no need in this IMPG Proposal to develop risk-based concentrations for PCBs in ambient air.

In addition, GE has evaluated the need to address constituents other than PCBs in this IMPG Proposal. The principal such constituents for which EPA's HHRA and ERA provide quantitative assessments are polychlorinated dibenzo-*p*-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs), as well as the so-called "dioxin-like" congeners of PCBs. For these constituents, under procedures used by EPA, Toxicity Equivalency Quotients (TEQs) are calculated using certain specified Toxicity Equivalency Factors (TEFs), which convert the concentrations of the various PCDD and PCDF compounds and the "dioxin-like" PCB congeners into toxic equivalents of the most potent PCDD congener – 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (2,3,7,8-TCDD) – for assessment.[2]

In assessing human health risks, EPA calculated potential cancer risks for TEQs (using a Cancer Slope Factor for 2,3,7,8-TCDD), but did not assess non-cancer impacts since there is no current non-cancer Reference Dose for 2,3,7,8-TCDD. The HHRA included TEQ cancer risks in its main quantitative assessment of fish and waterfowl consumption pathways. However, for the direct contact and agricultural products consumption risk assessments, EPA's HHRA included TEQs only in its uncertainty analyses, not in the main risk assessments. To be consistent with this EPA approach, this IMPG Proposal includes numerical risk-based values for TEQs in edible fish and waterfowl tissue, based on consumption by humans; but it does not include such values for TEQs in sediment or soil based on direct human contact or in agricultural products based on human consumption.

For ecological risks, EPA's ERA included a quantitative assessment of potential TEQ risks for some receptors but not others. Based on direction from EPA, this IMPG Proposal includes numerical risk-based TEQ values for those ecological receptors (fish, insectivorous birds, and

[2] As stated in prior comments to EPA (AMEC and BBL, 2003, 2005; GE, 2003), GE does not believe that current scientific information supports the inclusion of PCBs in the TEQ approach for assessing human health effects.

piscivorous mammals) for which EPA found significant TEQ risks that were greater or more certain than the risks due to PCBs, or for which EPA developed MATCs for TEQs.

For constituents other than PCBs and TEQs, EPA's HHRA included detailed screening evaluations for each of the three risk assessments, involving consideration of frequency of detection, frequency and magnitude of exceedances of PRGs or other risk-based concentrations, and comparison to background concentrations (HHRA, Vol. IIIA, Sec. 2.5; Vol. IV, Secs. 2.7.1 & 2.8.1; Vol. V, Sec. 2.1.1). These constituents included metals, polycyclic aromatic hydrocarbons (PAHs), and, in some cases, pesticides and herbicides. Based on these evaluations, EPA eliminated all such constituents from the quantitative assessments (except for mercury in fish, for which there is no evidence that its presence in the Rest of River is attributable to migration from the GE Facility), although it did present a qualitative evaluation of direct contact risks from some of these constituents (HHRA, Vol. IIIA, Sec. 5.4). Moreover, EPA noted that the metals in question in floodplain soil and sediments, as well as the PAHs in floodplain soil, do not appear to be related to releases from the GE facility (HHRA, Vol. IIIA, pp. 2-10, 2-11, 2-15), and that the metals and PAHs are not considered site-wide contaminants (Vol. V, p. 2-14). In the ERA, EPA did retain certain metals and PAHs for its assessments of risks to benthic invertebrates, frogs, and fish (PAHs only) (ERA, Vol. 1, pp. 3-12, 4-15, 5-9); but it found that the risks from those constituents were low (benthic invertebrates and fish – Vol. 1, pp. 3-66, 5-54) or gave them no attention (frogs). For other wildlife, EPA screened out all constituents except PCBs and TEQs (ERA, Vol. 2, p. 6-3). In these circumstances, based on review of the Permit requirements, this IMPG Proposal does not present values for these constituents.

1.4.2 Use of Ranges and Points of Departure

To allow for full evaluation of an appropriate array of potential corrective measures in the CMS, this IMPG Proposal generally does not provide single-number IMPGs. Rather, in most cases, this Proposal presents ranges of numerical risk-based concentration values (referred to herein as "Risk-based Media Concentrations" or RMCs), based on varying inputs and assumptions. In all cases, in accordance with EPA's December 9, 2005 directives, the inputs and assumptions used in this revised IMPG Proposal are taken from EPA's HHRA and ERA and reflect the varying inputs and assumptions that EPA used in those risk assessments.

The health-based RMCs are presented in Section 2 of this revised IMPG Proposal. For these RMCs, the ranges include values based both on use of EPA's Reasonable Maximum Exposure (RME) assumptions and on use of its Central Tendency Exposure (CTE) assumptions; and for each set of assumptions, the ranges include cancer-based values based on three excess lifetime cancer risk levels within EPA's acceptable cancer risk range – namely, $1x10^{-6}$, $1x10^{-5}$, and $1x10^{-4}$ – as well as non-cancer-based values using a Hazard Index (HI) of 1. This use of ranges is consistent with the National Contingency Plan (NCP) under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), which specifies that, for known or suspected carcinogens, concentration levels will be considered protective if they represent an excess lifetime cancer risk to an individual between 10^{-4} and 10^{-6} (40 CFR § 300.430(e)(2)(i)(A)(*2*)). This approach is also specified in EPA's guidance for actions under RCRA corrective action permits (EPA, 1990, p. 30826; EPA, 1996, p. 19449-50) and is consistent with EPA policy. In addition, as directed in EPA's December 9, 2005 comments, the RME-based concentration values associated with a 10^{-6} cancer risk and a non-cancer HI of 1 are identified herein as "points of departure."

The ecologically based RMCs are presented in Section 3. For the receptor groups for which EPA identified MATCs, the ranges of RMCs include the EPA MATCs, as well as certain other threshold levels which were derived from the ERA and which EPA has agreed to consider as the upper bounds of the ranges. In these cases, as directed by EPA, the values based on the MATCs are identified as "points of departure." For those receptor groups for which EPA did not calculate MATCs (namely, avian groups for which there are no site-specific effects data), the RMCs include values based on the literature. Specifically, for these groups, the RMCs for PCBs have been derived using a calculated effect level of less than 20 percent from a literature study of the most sensitive avian species identified in the ERA (chickens); and these RMCs are also identified as "points of departure" to meet EPA's requirements.[3]

The use of these ranges of RMCs allows for consideration, in the CMS, of the extent to which the potential corrective measures under evaluation will achieve various values within these ranges in addition to the identified "points of departure." To support the RMCs within these

[3] In addition, for wood ducks, a range of TEQ RMCs has been derived based on the TEQ effect threshold range determined from a literature study of wood ducks; and the lower bound of this RMC range, which is based on a 20 percent probability of exceeding the lower bound of the threshold effect range, is identified as the "point of departure." See Section 3.6 of this revised IMPG Proposal.

ranges, this Proposal includes supporting calculations showing how they were derived. These calculations demonstrate that, for the particular scenarios, receptor groups, and risk levels to which they apply, and given the assumptions used, these RMCs are protective of human health and the environment (as applicable). As such, the RMCs can provide useful benchmarks for evaluating an appropriate array of remedial alternatives in consideration of relevant site-specific factors.

As noted above, as required by EPA's directives, the RMCs presented in this revised IMPG Proposal have been based on the exposure assumptions, toxicity values, and data interpretations and analyses used in EPA's HHRA and ERA. In following this approach, this revised IMPG Proposal does not indicate GE's agreement with or acceptance of those inputs. GE preserves its position – set forth in its comments on the HHRA (AMEC and BBL, 2003, 2005; GE, 2003) and on the ERA (BBL et al., 2003, 2005; GE, 2004), as well as in its September 2005 IMPG Proposal and the Statement of Reasons accompanying its January 23, dispute resolution notice – that many of the exposure assumptions, toxicity values, and data interpretations in EPA's risk assessments are not supported by the data and substantially overestimate exposures, toxicity, and corresponding risks to humans and ecological receptors in the Rest of River area.

1.4.3 ARARs

Section 4 of this IMPG Proposal identifies chemical-specific ARARs for media in the Rest of River area. These ARARs consist of the federal water quality criteria and state water quality standards for PCBs.[4] As noted in Section 4, these ARARs do not constitute IMPGs or affect the identified IMPGs, since GE has developed site-specific RMCs that address the same receptors and pathways; and they do not constitute final ARARs, which will be specified later as part of the remedy selection. However, as required by the Reissued RCRA Permit, the ARARs identified herein will be used as a separate evaluative criterion in the CMS. These ARARs will be subject to waiver at a later stage if it is determined in the CMS Report that they cannot be achieved or that the other conditions for waiver of ARARs under CERCLA and the NCP are met (see Section 4.2 below).

[4] As discussed in Section 4, there are no such water quality criteria or standards for TEQs. While such criteria and standards exist for 2,3,7,8-TCDD, they appear to be specific to that compound, which has not been separately identified as a constituent of concern in the Rest of River.

1.5 Designated Uses

In addition to addressing IMPGs and ARARs, EPA's December 9, 2005 comments directed GE to include a statement in the revised IMPG Proposal regarding the desired outcome of the human health and ecological goals for the Rest of River in terms of designated uses for that portion of the river. As specified by EPA, the desired outcome is that, for PCBs, the Rest of River portion of the Housatonic River will attain the designated uses defined in the Massachusetts and Connecticut water quality standards. Under the Massachusetts water quality standards, the Housatonic River from Pittsfield to the Connecticut border is a Class B water (314 CMR 4.06(3), Table 3). Its designated uses are "habitat for fish, other aquatic life, and wildlife," "primary and secondary contact recreation," "irrigation and other agricultural uses," and "compatible industrial cooling and process uses" (314 CMR 4.05(3)(b)).[5] For the Connecticut portion of the river from the Massachusetts border to Lake Housatonic Dam (which is likewise a Class B water), the designated uses are "habitat for fish and other aquatic life and wildlife; recreation, navigation; and industrial and agricultural water supply" (Connecticut Water Quality Standards).

These designated uses will not be used as specific IMPGs or comparison criteria in the evaluations of potential corrective measures in the CMS. Rather, the evaluations in the CMS of the ability of the various potential corrective measures to achieve the IMPGs will be based on the numerical RMCs.

[5] This regulation also provides that "[w]here designated [Class B waters] shall be suitable as a source of public water supply with appropriate treatment." However, the Housatonic River is not so designated.

2.0 RMCs BASED ON HUMAN HEALTH EXPOSURE PATHWAYS

This section presents ranges of RMCs for the human health exposure pathways – direct contact with soil or sediment, consumption of fish or waterfowl, and consumption of agricultural products.

2.1 General Approach

For each exposure pathway, a range of numerical concentration-based RMCs has been developed using the RME and CTE assumptions set forth in the HHRA and three cancer risk levels within EPA's target risk range (10^{-6}, 10^{-5}, and 10^{-4}), as well as non-cancer hazards based on an HI of 1. All RMC values within these ranges are based on the exposure assumptions and toxicity values used in EPA's HHRA. As directed by EPA, the RMCs based on RME assumptions and a 10^{-6} cancer risk and the non-cancer HI of 1 have been identified as "points of departure."

As noted in Section 1.3, these RMCs have been developed without consideration of the feasibility or practicability of achieving those levels. That factor will be considered and balanced along with the other balancing factors listed in the Reissued RCRA Permit (e.g., long-term and short-term effectiveness, implementability, cost) in evaluating potential corrective measures in the CMS.

2.2 RMCs for PCBs in Floodplain Soil/Sediment Based on Direct Contact by Humans

In accordance with the Reissued RCRA Permit, numerical concentration-based RMCs have been developed for PCBs in floodplain soil and sediments. These are based on direct contact of humans with such media via incidental ingestion and dermal contact.

2.2.1 Methodology

Numerical RMCs have been derived through backcalculations using the exposure assumptions and toxicity values that were used in the HHRA. A range of RMCs for PCBs has been calculated for each of the exposure scenarios and receptors (i.e., age groups) evaluated in the

Direct Contact Assessment in the HHRA.[6] Specifically, RMCs have been developed for 15 direct contact scenarios. The scenarios and receptors for which RMCs have been derived are as follows:

- Residential use in portions of residential properties other than riverbanks, areas with steep slopes, and wetland areas – Adults, older children, young children;
- Residential use in portions of residential properties consisting of riverbanks, steep slopes, or wetlands – Adults, older children, young children;
- High-use general recreation – Adults, older children, young children;
- Medium-use general recreation – Adult and older children;
- Low-use general recreation – Adults and older children;
- Bank fishing – Adults and older children;
- Dirt biking/ATVing – Older children;
- Marathon canoeist – Adults;
- Recreational canoeist – Adults and older children;
- Waterfowl hunting – Adults and older children;
- Agricultural use (based on direct contact by farmer) – Adults;
- High-use commercial groundskeeper – Adults;
- Low-use commercial groundskeeper – Adults;
- Utility Worker – Adults; and
- Sediment contact - Adults and older children.

[6] As noted in Section 1.4.1, RMCs have not been calculated for TEQs in soil or sediment based on direct human contact.

As noted above, there are two residential use scenarios. The first applies to the portions of residential properties that consist of what the Consent Decree calls “Actual/Potential Lawns,” which are defined as all portions of residential properties in the Rest of River floodplain “except the riverbanks and those areas at which the wet nature or steep slope of the ground surface results in potential exposures that are inconsistent with residential use” (CD ¶ 4). The Actual/Potential Lawns areas at current residential properties downstream of the confluence of the East and West Branches are not part of the Rest of River under the Reissued RCRA Permit and the CD, but are subject to a separate Removal Action under the CD (CD ¶ 4 [definition of "Removal Actions Outside the River," subpara. 5(c)], CD ¶ 28.b). For these Actual/Potential Lawn areas, the CD establishes a Performance Standard of 2 mg/kg for PCBs in soil (CD ¶ 28.b(i); *Statement of Work for Removal Actions Outside the River* [Appendix E to CD] at p. 68), which the CD states was determined by EPA, the Massachusetts Department of Environmental Protection (MDEP), and the Connecticut Department of Environmental Protection (CDEP) to be protective of human health and the environment for such residential areas (CD, ¶ 8.b). EPA’s HHRA adopted that Performance Standard as the Screening Risk-Based Concentration for Actual/Potential Lawn areas (HHRS, Vol. I, p. 6-4); and it used the exposure and toxicity assumptions that were used in the CD to support that Performance Standard (CD, Appendix D, Attachment A) in assessing direct contact risks for areas that EPA concluded could become Actual/Potential Lawns in the future (HHRA, Vol. IIIA, pp. 4-48 to 4-51). In these circumstances, GE proposes to use the CD’s 2 mg/kg Performance Standard as the IMPG for areas where future use as a residential Actual/Potential Lawn is reasonably anticipated.

The second residential use scenario applies to the portions of residential properties that consist of riverbanks, wet areas, or steeply sloped areas. For these portions of both current and future residential properties, the HHRA used the exposure assumptions for the general recreational use scenario with the exposure frequency considered relevant for the particular area involved – which was generally, but not always, the exposure frequency for high-use general recreational areas (see HHRA, Vol. IIIA, pp. 4-48 to 4-51, 5-23, 5-45). For these portions of residential properties or reasonably anticipated future residential properties, GE proposes to use the RMCs calculated for the general recreation scenario for the use category which is most applicable to the area in question (i.e., high-use, medium-use, or low-use).

For the remaining direct contact scenarios listed above, RMCs have been derived using both EPA’s RME assumptions and its CTE assumptions. The specific exposure parameters and

assumptions used in calculating the RMCs for each scenario and receptor are detailed in Attachments 1 through 13 (contained in Appendix A). The values used for these parameters are identical to the values used to develop the potential cancer risk and non-cancer hazard estimates for the direct contact pathways in the HHRA.

The Cancer Slope Factors (CSFs) and Reference Dose (RfD) used in the RMC calculations are also the same as those used by EPA in the HHRA, which were taken from EPA's IRIS database. For the RME analysis for cancer effects, an upper bound CSF of 2 $(mg/kg\text{-}day)^{-1}$ for PCBs has been used. For the CTE analysis, the central estimate CSF of 1 $(mg/kg\text{-}day)^{-1}$ has been used, as was done in the HHRA. In the calculation of all non-cancer-based RMCs, EPA's chronic RfD of 2E-05 mg/kg-day for PCB Aroclor 1254 has been used. Finally, the relative oral and dermal absorption factors (ABS_o and ABS_d) for PCBs used in calculating the RMCs are the same as the values used by EPA in the HHRA.

Three target cancer risk levels (10^{-6}, 10^{-5} and 10^{-6}) were used to derive a range of RMCs for each receptor based on potential carcinogenic effects. These target risk levels were selected because they are consistent with EPA's target cancer risk range for the selection of remedial goals, as noted in Section 1 above. RMCs based on potential non-carcinogenic effects were derived for each scenario and receptor, using a target HI of 1. This approach, combined with the use of EPA's RME and CTE assumptions, results in a range of eight RMCs for each exposure scenario-receptor combination.

The RMCs based on potential carcinogenic effects were derived using the following general equation:

$$RMC_{cancer} = \frac{Risk}{CSF * (Exp_{ingestion} + Exp_{dermal})}$$

Where:

RMC_{cancer}	=	RMC based on the cancer endpoint (mg/kg)
Risk	=	Target risk level (unitless)
CSF	=	Cancer slope factor $(mg/kg\text{-}day)^{-1}$
$Exp_{ingestion}$	=	Exposure due to the soil ingestion pathway (day^{-1})
Exp_{dermal}	=	Exposure due to dermal contact with soil (day^{-1})

Separate RMCs based on potential non-carcinogenic effects for adults and young children were derived using the following equation:

$$RMC_{noncancer} = \frac{HI * RfD}{\left(Exp_{ingestion} + Exp_{dermal}\right)}$$

Where:

$RMC_{noncancer}$	=	RMC based on the non-cancer endpoint (mg/kg)
HI	=	Target hazard index (unitless)
RfD	=	Reference dose (mg/kg-day)
$Exp_{ingestion}$	=	Age-specific exposure due to the soil ingestion pathway (day^{-1})
Exp_{dermal}	=	Age-specific exposure due to dermal contact with soil (day^{-1})

In both of the above equations, the exposures due to soil ingestion ($Exp_{ingestion}$) and dermal contact with soil (Exp_{dermal}) were calculated using the following equations:

$$Exp_{ingestion} = \frac{IR * FI * CF * EF * ED}{AT * BW}$$

And

$$Exp_{dermal} = \frac{\left[\left(\left\{AF_1 * SA_1 * AD_1\right\} + \left\{AF_2 * SA_2 * AD_2\right\}\right) / \left(AD_1 + AD_2\right)\right] * ABS_d * CF * EF * ED}{AT * BW}$$

Where:

IR	=	Soil ingestion rate (mg/day)
FI	=	Fraction of soil ingested that is attributable to the Site (unitless)
AF_1	=	Weighted dermal adherence factor during the warmer months (mg/cm^2)
AF_2	=	Weighted dermal adherence factor during cooler months (mg/cm^2)
SA_1	=	Skin surface area exposed during the warmer months (cm^2/day)
SA_2	=	Skin surface area exposed during the cooler months (cm^2/day)
AD_1	=	Activity duration for the warmer months (months)
AD_2	=	Activity duration for the cooler months (months)
ABS_d	=	Relative dermal absorption factor (unitless)
CF	=	Unit conversion factor (1E-06 kg/mg)
EF	=	Exposure frequency (days/year)

ED	=	Exposure duration (years)
AT	=	Averaging time (days)
BW	=	Body weight (kg)

The RMCs have been derived based on the assumption that they will be applied as averages, rather than not-to-exceed values, consistent with the approach used in the Direct Contact Assessment in the HHRA. The issue of the appropriate technique to use in calculating the averages when comparing the RMCs with existing soil concentrations at particular properties or areas will be addressed in the CMS.

2.2.2 Proposed RMCs

The numerical RMCs for PCBs in floodplain soil and sediment, based on direct human contact using the assumptions in EPA's HHRA, are set forth in Table 2-1. This table presents receptor-specific RMCs for each scenario. The RMCs for residential use scenarios are discussed above. For the remaining scenarios, supporting calculations are provided in Attachments 1 through 13 (in Appendix A), which are referenced in Table 2-1. There are eight RMCs for each receptor evaluated. These include three cancer-based RMCs and one non-cancer-based RMC for the RME scenario, and three cancer-based RMCs and one non-cancer-based RMC for the CTE scenario. As directed by EPA, the RMCs calculated using the RME exposure assumptions and based on a target cancer risk of 10^{-6} and a target non-cancer HI of 1 are identified as "points of departure" by bold type and asterisks in Table 2-1.

Table 2-1. RMCs for PCBs Based on Human Direct Contact (Soil/Sediment)

Type of Area/Exposure Scenario	Receptor	RME or CTE	Assumed Frequency of Use	RMCs (in mg/kg)			
				Cancer @ 10^{-6}	Cancer @ 10^{-5}	Cancer @ 10^{-4}	Non-Cancer
Residential (reasonably anticipated Actual/Potential Lawn areas)	All	RME	150 d/yr	**2*** (per Consent Decree)			
Residential (banks, steep slopes, wet areas)	All	Both	Variable	Use RMCs for general recreation scenarios based on appropriate exposure frequencies for parcel-specific conditions			
High-use general recreation *See Att. 1*	Young child (high use)	RME	90 d/yr	**1.3***	13	134	**4.6***
		CTE	30 d/yr	18	184	1,842	32
	Young child (low use)	RME	15 d/yr	**8.0***	80	802	**27***
		CTE	15 d/yr	37	368	3,684	63
	Older child	RME	90 d/yr	**3.9***	39	388	**27***
		CTE	30 d/yr	51	514	5,143	176
	Adult	RME	90 d/yr	**1.4***	14	143	**38***
		CTE	30 d/yr	63	630	6,305	234

Table 2-1. RMCs for PCBs Based on Human Direct Contact (Soil/Sediment)

Type of Area/Exposure Scenario	Receptor	RME or CTE	Assumed Frequency of Use	RMCs (in mg/kg)			
				Cancer @ 10^{-6}	Cancer @ 10^{-5}	Cancer @ 10^{-4}	Non-Cancer
Medium-use general recreation *See Att. 2*	Young child	Not assessed		NA	NA	NA	NA
	Older child	RME	60 d/yr	**5.8***	58	582	**40***
		CTE	30 d/yr	51	514	5,143	176
	Adult	RME	60 d/yr	**2.1***	21	215	**58***
		CTE	30 d/yr	63	630	6,305	234
Low-use general recreation *See Att. 3*	Young child	Not assessed		NA	NA	NA	NA
	Older child	RME	30 d/yr	**12***	116	1,165	**80***
		CTE	15 d/yr	103	1,029	10,286	353
	Adult	RME	30 d/yr	**4.3***	43	429	**115***
		CTE	15 d/yr	126	1,261	12,610	468

Table 2-1. RMCs for PCBs Based on Human Direct Contact (Soil/Sediment)

Type of Area/Exposure Scenario	Receptor	RME or CTE	Assumed Frequency of Use	RMCs (in mg/kg)			
				Cancer @ 10^{-6}	Cancer @ 10^{-5}	Cancer @ 10^{-4}	Non-Cancer
Bank fishing *See Att. 4*	Older child	RME	30 d/yr	**6.2***	62	619	**42***
		CTE	10 d/yr	52	524	5,237	180
	Adult	RME	30 d/yr	**2.6***	26	256	**56***
		CTE	10 d/yr	70	702	7,015	220
Dirt biking/ATVing *See Att. 5*	Older child	RME	90 d/yr	**2.0***	20	205	**14***
		CTE	30 d/yr	29	290	2,901	99
Marathon canoeist *See Att. 6*	Adult	RME	150 d/yr	**0.78***	7.8	78	**13***
		CTE	90 d/yr	5.8	58	575	25
Recreational canoeist *See Att. 7*	Older child	RME	30 d/yr	**6.2***	62	619	**42***
		CTE	15 d/yr	35	349	3,491	120
	Adult	RME	60 d/yr	**1.2***	12	121	**28***
		CTE	30 d/yr	13	129	1,286	73

Table 2-1. RMCs for PCBs Based on Human Direct Contact (Soil/Sediment)

Type of Area/Exposure Scenario	Receptor	RME or CTE	Assumed Frequency of Use	RMCs (in mg/kg)			
				Cancer @ 10^{-6}	Cancer @ 10^{-5}	Cancer @ 10^{-4}	Non-Cancer
Waterfowl hunting *See Att. 8*	Older child	RME	14 d/yr	**41***	408	4080	**140***
		CTE	7 d/yr	233	2325	23,253	399
	Adult	RME	14 d/yr	**9.0***	90	904	**196***
		CTE	7 d/yr	75	752	7,518	537
Agricultural use (based on direct contact by farmer) *See Att. 9*	Adult	RME	40 d/yr	**1.2***	12	118	**43***
		CTE	10 d/yr	42	419	4,195	348
High-use commercial (groundskeeper scenario) *See Att. 10*	Adult	RME	150 d/yr	**1.8***	18	177	**25***
		CTE	150 d/yr	17	166	1,664	57
Low-use commercial (groundskeeper scenario) *See Att. 11*	Adult	RME	30 d/yr	**8.9***	89	885	**126***
		CTE	15 d/yr	166	1,664	16,642	571

Table 2-1. RMCs for PCBs Based on Human Direct Contact (Soil/Sediment)

Type of Area/Exposure Scenario	Receptor	RME or CTE	Assumed Frequency of Use	RMCs (in mg/kg)			
				Cancer @ 10^{-6}	Cancer @ 10^{-5}	Cancer @ 10^{-4}	Non-Cancer
Utility worker *See Att. 12*	Adult	RME	5 d/yr	**17***	169	1,694	**242***
		CTE	5 d/yr	209	2,093	20,933	718
Sediments *See Att. 13*	Older child	RME	36 d/yr	**4.5***	45	453	**31***
		CTE	12 d/yr	36	365	3,645	125
	Adult	RME	36 d/yr	**1.3***	13	135	**40***
		CTE	12 d/yr	28	280	2,800	152

* Points of departure, as specified by EPA.

2.3 RMCs for Fish and Waterfowl Tissue Based on Human Consumption

Numerical concentration-based RMCs have been developed for PCBs and TEQs in the edible tissue of fish and waterfowl based on human consumption of fish and waterfowl. Such RMCs have been derived using both deterministic and probabilistic approaches.

2.3.1 Methodology

RMCs have been calculated for both PCBs and TEQs that may be present in bass fillets, trout fillets, and duck breast tissue.[7] For each tissue type, separate RMCs have been developed based on the assumptions and parameters used in EPA's deterministic Fish and Waterfowl Consumption Assessment (HHRA, Vol. IV). In addition, consistent with EPA's HHRA, RMCs based on probabilistic techniques have been developed using the one-dimensional Monte Carlo (1-D Monte Carlo) model used in the HHRA.

For each type of edible tissue, RMCs have been derived for cancer risks based on combined adult and childhood exposure. This is the same approach that was used in the HHRA. As for the direct contact RMCs, three risk levels within EPA's target risk range (10^{-6}, 10^{-5}, and 10^{-4}) have been used to derive a range of RMCs for the carcinogenic endpoint for both PCBs and TEQs. In addition, non-cancer RMCs for PCBs have been separately derived for adults and children using an HI of 1. Consistent with the HHRA, non-cancer RMCs were not developed for TEQs, since TEQs were not quantitatively assessed for non-cancer impacts in the HHRA.

RMCs have been developed for six fish and waterfowl consumption scenarios (with adults and children considered in each). These scenarios are as follows:

- RMCs for PCBs based on consumption of bass;
- RMCs for PCBs based on consumption of trout;

[7] Although data are also available on the concentrations of these contaminants in duck livers, the HHRA based its risk analysis on the consumption of duck breast tissue (HHRA, Vol. I, p. 8-12); Vol. IV, p. 7-15). It also noted that while the concentrations in duck livers are slightly higher than those in duck breasts, the risks from consumption of duck livers would be considerably lower due to a lower consumption rate (HHRA, Vol. IV, pp. 7-15 - 7-17). Thus, RMCs have not been calculated for duck livers.

- RMCs for PCBs based on consumption of waterfowl;
- RMCs for TEQs based on consumption of bass;
- RMCs for TEQs based on consumption of trout; and
- RMCs for TEQs based on consumption of waterfowl.

The scenario- and age-specific point estimate and probabilistic assumptions and parameters used are detailed in Attachments 14 through 19 (contained in Appendix B). While Table 6-2 of the HHRA (HHRA, Vol. IV, p. 6-15) only provides an input distribution for adult fish consumers for use in the probabilistic analysis, the text (HHRA, Vol. IV, p. 6-25) reports that EPA assumed that children ate fish at half the rate of adults. Thus, a distribution based on one-half the adult consumption rate distribution was used in the 1-D Monte Carlo model for young children.

The CSFs and RfD used in developing the RMCs for PCBs are the same as those used in developing the direct contact RMCs, as described in Section 2.2.1, which are identical to those used by EPA in the HHRA. There is currently no CSF or RfD published in EPA's IRIS database for 2,3,7,8-TCDD, upon which the TEQ approach is based. The cancer potency of this chemical is being evaluated as part of the Dioxin Reassessment being conducted by EPA and is currently under review by the National Academy of Sciences (NAS). Thus, as was done in the HHRA, EPA's previously published CSF of 150,000 $(mg/kg\text{-}day)^{-1}$ (EPA, 1997) was used to calculate the cancer-based RMCs for TEQs in this analysis. Due to the lack of an RfD for 2,3,7,8-TCDD, non-cancer-based RMCs have not been developed for TEQs.

The deterministic and probabilistic RMCs for fish and waterfowl tissue based on potential for carcinogenic effects were derived using the following general equation:

$$RMC_{cancer} = \frac{Risk * AT_c}{EF * CSF * FI * CF * (1 - LOSS) * \left[\left(\frac{IR_c * ED_c}{BW_c} \right) + \left(\frac{IR_a * ED_a}{BW_a} \right) \right]}$$

The deterministic and probabilistic RMCs for fish and waterfowl tissue based on potential for non-cancer effects were derived separately for young children and adults using the following general equations:

Child

$$RMC_{nc-child} = \frac{HI * RfD * AT_{nc-child}}{EF * FI * CF * (1 - LOSS) * \frac{IR_c * ED_c}{BW_c}}$$

Adult

$$RMC_{nc-adult} = \frac{HI * RfD * AT_{nc-adult}}{EF * FI * CF * (1 - LOSS) * \frac{IR_a * ED_a}{BW_a}}$$

Where:

RMC_{cancer}	=	RMC for the cancer endpoint at a target risk level (mg/kg)
$RMC_{nc-child}$	=	RMC for the non-cancer endpoint in children at the target HI (mg/kg)
RMC_{nc}	=	RMC for the non-cancer endpoint in adults at the target HI (mg/kg)
Risk	=	Target risk level (unitless)
AT_c	=	Averaging time for carcinogenic effects (days)
$AT_{nc-child}$	=	Averaging time for noncarcinogenic effects for young child (days)
$AT_{nc-adult}$	=	Averaging time for noncarcinogenic effects for adult (days)
HI	=	Target hazard index (unitless)
RfD	=	Reference dose (mg/kg-day)
CSF	=	Cancer slope factor $(mg/kg\text{-}day)^{-1}$
EF	=	Exposure frequency (days/year)
FI	=	Fraction ingested from the river (unitless)
CF	=	Unit conversion factor (1E-03 kg/g)
LOSS	=	Fraction of constituent lost due to cooking (unitless)
IR_a	=	Fish/waterfowl ingestion rate for adults (g/day)
IR_c	=	Fish/waterfowl ingestion rate for children (g/day)
ED_a	=	Exposure duration for adults (years)
ED_c	=	Exposure duration for children (years)
BW_a	=	Body weight for adults (kg)
BW_c	=	Body weight for children (kg)

It should be noted that, to be consistent with EPA's HHRA, the approach used for deriving RMCs for waterfowl consumption based on the probabilistic analysis was slightly different from that used in the deterministic analysis and shown in the above equation. Instead of providing ingestion rates (IR) in units of g/day and exposure frequency (EF) in units of days/year, EPA

used an IR of grams/meal and an EF in units of meals/year (HHRA, Vol. IV, p. 6-58). Thus, while the product of these two factors still results in units of g/year (as it does in the above equation), the units of the inputs are slightly different. These inputs are summarized in Attachments 16 and 19 (in Appendix B).

In addition, it should be noted that the probabilistic RMCs calculated by GE were derived by re-arranging the risk and HI equations to backcalculate the RMCs. Although this approach is not consistent with EPA (2001) guidance, which recommends that probabilistic preliminary remediation goals be calculated using iterative forward calculations to obtain a concentration that corresponds to a risk distribution, the backcalculation approach was followed here due to its increased efficiency, after confirming that the direction of the calculation would not significantly impact the resulting RMCs. EPA, in its December 9, 2005 comments, stated that calculations conducted by EPA to verify GE's RMCs indicated that the derived RMCs for fish and waterfowl consumption corresponded to EPA's target values, when reported to one significant figure (EPA, 2005d, Att. A, p. 6). Consequently, EPA determined that GE's alternative approach had an inconsequential effect on the results, and that hence it was not necessary for GE to revise its approach.

2.3.2 Proposed RMCs

The numerical RMCs for PCBs and TEQ in edible fish and waterfowl tissue, based on consumption by humans and using the assumptions in EPA's HHRA, are set forth in Table 2-2. Supporting calculations for each scenario are provided in Attachments 14 through 19 (in Appendix B) and are referenced in Table 2-2. The RMCs presented for the probabilistic analyses represent, for the RME, the 5^{th} percentile of the output distribution (which would be exceeded by 95 percent of the calculated output values) and, for the CTE, the 50^{th} percentile of the output distribution. As directed by EPA, the RMCs calculated using the RME exposure assumptions and based on a target cancer risk of 10^{-6} and a target non-cancer HI of 1 are identified as "points of departure" by bold type and asterisks in Table 2-2.

The HHRA separately evaluated potential risks due to consumption of bass (in both the Massachusetts and Connecticut reaches of the river) and potential risks due to the consumption of trout (only in the Trout Management Area in Connecticut). The differences between these two analyses were the way in which the exposure point concentrations (EPCs) were derived

and the fish consumption rates used. For the analysis of bass consumption, the EPCs were calculated using a combination of fish tissue data for largemouth bass, brown bullhead, perch, and sunfish. EPA's analysis of trout consumption used fish tissue data for trout only. Consequently, based on EPA's methodology, the RMCs presented in Table 2-2 for bass consumption are applicable to the consumption of largemouth bass, brown bullhead, sunfish, and perch, while the RMCs presented in Table 2-2 for trout consumption are applicable only to the consumption of trout.

Table 2-2. RMCs for Fish & Waterfowl Tissue Based on Human Consumption

Tissue Type and Constituent	Assessment Type	RME or CTE	RMCs (in mg/kg for PCBs and ng/kg for TEQ)				
			Cancer @ 10^{-6}	Cancer @ 10^{-5}	Cancer @ 10^{-4}	Non-Cancer – Child	Non-Cancer – Adult
Bass fillets – PCBs *See Att. 14*	Deterministic	RME	**0.0019***	0.019	0.19	**0.026***	**0.062***
		CTE	0.049	0.49	4.9	0.19	0.43
	Probabilistic	RME (5^{th} percentile)	**0.0064***	0.064	0.64	**0.059***	**0.12***
		CTE (50^{th} percentile)	0.057	0.57	5.7	0.71	1.5
Trout fillets – PCBs *See Att. 15*	Deterministic	RME	**0.0048***	0.048	0.48	**0.069***	**0.16***
		CTE	0.11	1.1	11	0.40	0.93
	Probabilistic	RME (5^{th} percentile)	**0.014***	0.14	1.4	**0.13***	**0.27***
		CTE (50^{th} percentile)	0.12	1.2	12	1.5	3.1

Table 2-2. RMCs for Fish & Waterfowl Tissue Based on Human Consumption

Tissue Type and Constituent	Assessment Type	RME or CTE	RMCs (in mg/kg for PCBs and ng/kg for TEQ)				
			Cancer @ 10^{-6}	Cancer @ 10^{-5}	Cancer @ 10^{-4}	Non-Cancer – Child	Non-Cancer – Adult
Duck breast – PCBs *See Att. 16*	Deterministic	RME	**0.0084***	0.084	0.84	**0.12***	**0.28***
		CTE	0.066	0.66	6.6	0.25	0.58
	Probabilistic	RME (5th percentile)	**0.0075***	0.075	0.75	**0.080***	**0.17***
		CTE (50th percentile)	0.072	0.72	7.2	0.67	1.4
Bass fillets – TEQ *See Att. 17*	Deterministic	RME	**0.025***	0.25	2.5	NA	
		CTE	0.32	3.2	32	NA	
	Probabilistic	RME (5th percentile)	**0.085***	0.85	8.5	NA	
		CTE (50th percentile)	0.76	7.6	76	NA	

Table 2-2. RMCs for Fish & Waterfowl Tissue Based on Human Consumption

Tissue Type and Constituent	Assessment Type	RME or CTE	RMCs (in mg/kg for PCBs and ng/kg for TEQ)				
			Cancer @ 10^{-6}	Cancer @ 10^{-5}	Cancer @ 10^{-4}	Non-Cancer – Child	Non-Cancer – Adult
Trout fillets – TEQ *See Att. 18*	Deterministic	RME	**0.065***	0.65	6.5	NA	
		CTE	0.70	7.0	70	NA	
	Probabilistic	RME (5th percentile)	**0.18***	1.8	18	NA	
		CTE (50th percentile)	1.6	16	163	NA	
Duck breast – TEQ *See Att. 19*	Deterministic	RME	**0.11***	1.1	11	NA	
		CTE	0.44	4.4	44	NA	
	Probabilistic	RME (5th percentile)	**0.10***	1.0	10	NA	
		CTE (50th percentile)	0.96	9.6	96	NA	

* Points of departure, as specified by EPA.

2.3.3 Discussion of Impacts of Alternative Fish Consumption Practices

As directed by EPA in its December 9, 2005 comments, this section discusses the impact of certain alternative fish consumption practices on the RMCs for fish consumption. EPA's HHRA reported that certain members of the Schaghticoke Tribal Nation "have expressed a desire to return to traditional fish cooking practices, which include slow cooking whole fish (minus the head) coated with mud and then wrapped in foil" (HHRA, Vol. IV, p. 7-32). In its comments, EPA directed GE to include in the revised IMPG Proposal a discussion of the quantitative impact on the RMCs of this practice, as well as the consumption practices of "other anglers who might eat fillets with skin-off, fillets with skin-on, or whole fish" (EPA, 2005d, Att. A, p. 6).

The exposure of a fish consumer to the PCBs or TEQs present in the fish is a function of the concentrations of those constituents present, after preparation and cooking, in the portions of the fish consumed. Thus, the parts of the fish consumed, affect the EPCs of PCBs or TEQs, since concentrations are typically higher in skin-on fillets than in skin-off fillets, and even higher in whole fish.[8] However, this factor has no impact on the RMCs. This is because the RMC calculation estimates a risk-based fish tissue concentration as the output of the calculation, rather than using the fish tissue EPC as an input variable, and is thus independent of the species or parts of the fish consumed. As a result, the RMCs derived are applicable to whatever fish tissue parts are consumed by individuals. For individuals who consume fish without the skin, the risk-based RMC represents the concentration of PCBs in the consumed skin-off fillet that is associated with the target risk level. Similarly, for individuals who consume fish with the skin on or who consume whole fish, the RMC represents the concentration in the skin-on fillet or whole fish that is associated with the target risk level. Thus, the parts of the fish consumed do not affect the calculated RMC values themselves, but only the way in which they are applied.

However, to the extent that alternative fish preparation or consumption practices involve retention and consumption of the drippings from the fish that occur during cooking, they would affect the RMC values, because the RMC calculations include a factor for constituent loss due

[8] The HHRA based the EPCs for fish in the Massachusetts portion of the river on fish tissue concentrations measured in skin-off fillets and the EPCs for fish in the Connecticut portion of the river on fish tissue concentrations measured in skin-on fillets (HHRA, Vol. IV, Table 2-9, p. 2-31).

to cooking. For example, if the traditional fish consumption practices of the Schaghticoke Tribal Nation include eating those drippings, they would avoid the cooking loss factor assumed in the RMC calculations. Since the RMC calculations, consistent with the HHRA, include a cooking loss factor of 25 percent (for both the RME and CTE scenarios), consumption practices that avoid such cooking loss would result in RMCs that are 25 percent lower than the RMCs presented in Table 2-2 in order to provide the same level of protection.

2.4 RMCs for PCBs in Agricultural Products Based on Human Consumption

In accordance with the Reissued RCRA Permit, numerical concentration-based RMCs have been developed for agricultural biota consumed by humans. These RMCs are based on human consumption of such products.

2.4.1 Methodology

RMCs have been derived through backcalculations using the exposure assumptions and toxicity values in the Agricultural Products Consumption Assessment in EPA's HHRA. Consistent with that assessment, RMCs have been calculated for PCBs in cow milk, beef cow tissue, poultry meat, and poultry eggs for both commercial and backyard farms.[9] For each type of farm, RMCs have been calculated for cancer risks (for adults and children combined) and for non-cancer impacts (for adults and children separately). In addition, to be consistent with the HHRA, RMCs have been calculated for homegrown produce consumed by humans – specifically, exposed fruit, exposed vegetables, and root vegetables. For these specific farm products, based on discussions with EPA, RMCs have been calculated for children only and have been based on non-cancer health effects.

RMCs have been developed for the following agricultural products consumption scenarios:

- Consumption of cow milk at commercial dairy farm (adults and children)
- Consumption of cow milk at backyard dairy farm (adults and children)

[9] As noted in Section 1.4.1, RMCs have not been calculated for TEQs in agricultural products because EPA's Agricultural Products Consumption Assessment in the HHRA discussed TEQs only in its uncertainty analysis and did not include them in the main risk assessment.

- Consumption of beef at commercial beef farm (adults and children)
- Consumption of beef at backyard beef farm (adults and children)
- Consumption of poultry meat at commercial poultry farm (adults and children)
- Consumption of poultry meat at backyard poultry farm (adults and children)
- Consumption of poultry eggs at commercial poultry farm (adults and children)
- Consumption of poultry eggs at backyard poultry farm (adults and children); and
- Consumption of homegrown produce (exposed fruit, exposed vegetables, and root vegetables) at both commercial and backyard produce farms (children only).

The specific exposure parameters and assumptions used in calculating the RMCs for these scenarios are presented in Attachments 20 through 28 (contained in Appendix C). The values used for these parameters are the same as the values used in EPA's HHRA to develop the potential cancer risk and non-cancer hazard estimates for the agricultural products consumption pathways. For the animal products, the exposure assumptions in the HHRA differ slightly between commercial and backyard farms. For the agricultural produce (fruits and vegetables), however, the exposure assumptions for a child do not differ between commercial and backyard farms, and thus the calculated RMCs apply to both types of farms.

The CSFs and RfD used in developing these RMCs are the same as those used in developing the direct contact RMCs, as described in Section 2.2.1. These are the same as those used by EPA in the HHRA and published in EPA's IRIS database.

As with the RMCs discussed in previous sections, three target risk levels were used to derive a range of RMCs based on potential carcinogenic effects – 10^{-6}, 10^{-5}, and 10^{-4}, consistent with EPA's target risk range – and a target HI of 1 was used to calculate the RMCs based on potential non-carcinogenic effects.

The tissue-specific RMCs based on the potential for carcinogenic effects from ingesting agricultural food products were derived using the following equation:

$$RMC_{cancer} = \frac{Risk * AT_c}{CSF * IR_{adj} * F_{GI} * EF * (1 - Loss_{cook}) * (1 - Loss_{post})}$$

Where:

RMC_{cancer}	=	RMC based on the cancer endpoint (mg/kg)
Risk	=	Target risk level (unitless)
AT_c	=	Averaging time for carcinogenic exposure (days)
CSF	=	Cancer slope factor $(mg/kg\text{-}day)^{-1}$
IR_{adj}	=	Age-adjusted ingestion rate (kg-year/kg-day)[10]
F_{GI}	=	Fraction absorbed in GI tract (unitless)
EF	=	Exposure frequency (days/year)
$Loss_{cook}$	=	Cooking loss (unitless)
$Loss_{post}$	=	Post-cooking loss (from cutting, bones, fat, scraps, juices) (unitless)[11]

The tissue-specific RMCs based on potential non-carcinogenic effects from ingesting agricultural food products were derived using the following equation:

$$RMC_{noncancer} = \frac{HI * RfD * AT_{nc}}{IR * F_{GI} * EF * ED * (1 - Loss_{cook}) * (1 - Loss_{post})}$$

Where:

$RMC_{noncancer}$	=	RMC based on the non-cancer endpoint (mg/kg)
HI	=	Target hazard index (unitless)
RfD	=	Reference dose (mg/kg-day)
AT_{nc}	=	Averaging time for non-carcinogenic exposure (days)
IR	=	Ingestion rate (kg/kg-day)
F_{GI}	=	Fraction absorbed in GE tract (unitless)
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)
$Loss_{cook}$	=	Cooking loss (unitless)
$Loss_{post}$	=	Post-cooking loss (from cutting, bones, fat, scraps, juices) (unitless)[11]

[10] The age-adjusted ingestion rate was derived using the following equation: (IRa*EDa)+(IRc*EDc), where IRa is the adult ingestion rate, EDa is the adult exposure duration, IRc is the child ingestion rate, and EDc is the child exposure duration.

[11] The post-cooking loss factor is applied only to the beef and poultry ingestion pathways.

The above equations were used to calculate cancer-based and non-cancer-based RMCs based on ingestion of animal food products – i.e., cow milk, beef cow tissue, poultry meat, and poultry eggs.

As noted above, RMCs for agricultural produce have been calculated based only on non-cancer impacts to children. Hence, only the non-cancer equation shown above was used. For such produce, EPA calculated risks and HIs separately for exposed fruit, exposed vegetables, and root vegetables and then summed them to produce risks and HIs for total produce (HHRA, Vol. V, Table 4-10). In backcalculating RMCs for these products, separate RMCs have first been calculated for each type of produce, using the above non-cancer equation and a target HI of 1. Such RMCs would be applicable to situations where the child eats only one type of produce grown in the floodplain, which might occur, for example, at a commercial farm that grows only one of those produce types. By contrast, it is unlikely that a child would eat all three types of produce grown in the floodplain at the rates assumed in the HHRA for each produce type, particularly at the upper bound rates used in the RME analysis. However, to take account of the unlikely event that a child may do so, and for consistency with the HHRA, RMCs have also been calculated for total produce (i.e., all three food groups combined) using the following equation:

$$RMC(Total)_{noncancer} = \frac{HI}{((Exp_{ing\_exposedfruit} \div RfD) + (Exp_{ing\_exposedvegetable} \div RfD) + (Exp_{ing\_rootvegetable} \div RfD))}$$

Where:

$RMC(Total)_{noncancer}$ = RMC (total produce) based on non-cancer endpoint (mg/kg)

HI = Target hazard index (unitless)

RfD = Reference dose (mg/kg-day)

Exp_{ing} = Exposure due to produce consumption (kg/kg-day)

And

$$Exp_{ing} = \frac{IR * AF * F_{GI} * EF * ED * (1 - Loss_{cook})}{AT}$$

Where:

IR = Produce-specific ingestion rate (kg/kg-day)

AF = Regional consumption adjustment factor (unitless)

F_{GI} = Fraction absorbed in GI tract (unitless)

EF = Exposure frequency (days/year)

ED = Exposure duration (years)

AT = Averaging time (days)

$Loss_{cook}$ = Cooking loss (unitless)

As noted above, since the exposure assumptions for a child consuming agricultural produce do not differ between commercial and backyard farms, the calculated RMCs apply to both commercial and backyard farms.

2.4.2 Proposed RMCs

The numerical RMCs for PCBs in edible farm animal and plant tissue based on consumption by humans, using the assumptions in EPA's HHRA, are set forth in Table 2-3. For animal tissues, consideration of both cancer and non-cancer endpoints was used to derive the RMCs, resulting in three cancer-based RMCs and two non-cancer-based RMCs in children and adults for both the RME scenario and the CTE scenario. For exposures due to consumption of plant tissues (exposed fruits, exposed vegetables, and root vegetables), RMCs were calculated based only on potential non-cancer effects in children (as discussed above), and discrete RMCs are provided for each produce type and for all types of produce combined. Supporting calculations for all the RMCs are provided in Attachments 20 through 28 (in Appendix C), which are referenced in Table 2-3. As directed by EPA, the RMCs calculated using the RME exposure assumptions and based on a target cancer risk of 10^{-6} and a target non-cancer HI of 1 are identified as "points of departure" by bold type and asterisks in Table 2-3.

Table 2-3. RMCs for PCBs in Agricultural Products Based on Human Consumption

Tissue Type	Farm Type	RME or CTE	RMCs (in mg/kg-wet weight)				
			Cancer @ 10^{-6}	Cancer @ 10^{-5}	Cancer @ 10^{-4}	Non-Cancer Child	Non-Cancer Adult
Cow milk *See Atts. 20 & 21*	Commercial dairy	RME	**0.000026***	0.00026	0.0026	**0.00030***	**0.0014***
		CTE	0.00012	0.0012	0.012	0.00047	0.0017
	Backyard dairy	RME	**0.000032***	0.00032	0.0032	**0.00030***	**0.0012***
		CTE	0.00016	0.0016	0.016	0.00047	0.0010
Beef cow tissue *See Atts. 22 & 23*	Commercial beef	RME	**0.00033***	0.0033	0.033	**0.0077***	**0.014***
		CTE	0.0015	0.015	0.15	0.010	0.017
	Backyard beef	RME	**0.00047***	0.0047	0.047	**0.0077***	**0.013***
		CTE	0.0027	0.027	0.27	0.010	0.013
Poultry meat *See Atts. 24 & 25*	Commercial poultry	RME	**0.00052***	0.0052	0.052	**0.015***	**0.021***
		CTE	0.0030	0.030	0.30	0.019	0.034
	Backyard poultry	RME	**0.0009***	0.009	0.09	**0.015***	**0.026***
		CTE	0.0054	0.054	0.54	0.019	0.027

Table 2-3. RMCs for PCBs in Agricultural Products Based on Human Consumption

Tissue Type	Farm Type	RME or CTE	RMCs (in mg/kg-wet weight)				
			Cancer @ 10^{-6}	Cancer @ 10^{-5}	Cancer @ 10^{-4}	Non-Cancer Child	Non-Cancer Adult
Poultry eggs *See Atts. 26 & 27*	Commercial poultry	RME	**0.00055***	0.0055	0.055	**0.011***	**0.025***
		CTE	0.0025	0.025	0.25	0.013	0.031
	Backyard poultry	RME	**0.00082***	0.0082	0.082	**0.011***	**0.025***
		CTE	0.0044	0.044	0.44	0.013	0.026
Exposed fruit *See Att. 28*	Commercial or backyard fruit farm	RME	Not calculated (NC)			**0.11***	NC
		CTE	NC			0.15	NC
Exposed vegetables *See Att. 28*	Commercial or backyard farm with exposed vegetables	RME	NC			**0.024***	NC
		CTE	NC			0.037	NC
Root vegetables *See Att. 28*	Commercial or backyard farm with root vegetables	RME	NC			**0.030***	NC
		CTE	NC			0.049	NC

Table 2-3. RMCs for PCBs in Agricultural Products Based on Human Consumption

Tissue Type	Farm Type	RME or CTE	RMCs (in mg/kg-wet weight)				
			Cancer @ 10^{-6}	Cancer @ 10^{-5}	Cancer @ 10^{-4}	Non-Cancer Child	Non-Cancer Adult
All produce *See Att. 28*	Commercial or backyard farm with all three types of above produce	RME	NC			**0.012***	NC
		CTE	NC			0.018	NC

*Points of departure, as specified by EPA

2.5 Discussion of Breast Milk Exposure and Cumulative Exposures

EPA, in its December 9, 2005 comments, directed GE to include in the revised IMPG Proposal a qualitative discussion of the risks associated with breast milk exposure and of cumulative risk (EPA, 2005d, Att. A., p. 1). This section provides a discussion of these issues, based on the information and interpretations presented by EPA in the HHRA.

2.5.1 Breast Milk Exposure

EPA's HHRA included an evaluation of potential PCB exposure to nursing infants through the breast milk pathway (HHRA, Vol. I, Sec. 10.3, with January 2006 Errata). That evaluation focused on breast milk exposure resulting from maternal exposure through consumption of fish and waterfowl from the portion of the Rest of River upstream of Woods Pond Dam, as well as cow milk from backyard farms.[12]

In this evaluation, EPA calculated concentrations of total PCBs and PCB congeners in breast milk by estimating maternal intake of these compounds using the same equation that was used to estimate adult intake of contaminants for the evaluation of non-cancer hazards for each scenario. The only change in the parameters used was that a female body weight was selected, resulting in a slightly higher estimate of the average daily dose. Once the maternal intake was calculated, the predicted concentration in the breast milk fat was estimated using the general equation provided by EPA (1998), making assumptions about the half-life of the PCBs in adults, the fraction of PCBs ingested that were stored in the fat, and the fraction of the mother's weight that is fat. EPA then compared these predicted breast milk fat PCB concentrations with background breast milk fat PCB concentrations that have been measured in the general population. The ratio of the predicted milk fat PCB concentration for each exposure scenario to the background PCB concentration in milk fat was used by EPA to determine whether breast milk PCB concentrations were likely to be elevated above background levels. In revised Tables 10-16 through 10-21 (provided in the Errata), EPA presented the results of this analysis, showing that, for the scenarios evaluated, the predicted breast milk fat concentrations

[12] EPA noted that maternal exposures via direct contact with soil or sediment are substantially lower and not likely to contribute substantially to breast milk concentrations of PCBs (HHRA, Vol. I, p. 10-17).

of total PCBs and individual PCB congeners exceeded background levels at ratios ranging from 1.3 to 161 for RME scenarios and 0.5 to about 69 for CTE scenarios.

Since EPA's calculation of the predicted breast milk PCB concentrations follows a linear relationship, the same ratios specified by EPA can be used to estimate the PCB EPCs in the exposure media (fish tissue, waterfowl tissue, cow milk) that would be associated with background levels in breast milk. For example, in EPA's RME evaluation, the EPC for total PCBs in bass tissue resulted in a predicted breast milk concentration that was higher than background levels by a factor of 161. Thus, if the PCB EPC used by EPA in predicting the milk fat concentration is divided by this ratio, the result is a bass tissue EPC that would result in a predicted concentration in breast milk equal to background breast milk concentrations. This approach can be used to estimate the EPCs for total PCBs in each medium (fish, waterfowl, and cow milk) that would (accepting EPA's calculations) be associated with background concentrations in breast milk.[13] Results of this analysis are presented in the following table:

[13] While a similar analysis could be conducted on the individual PCB congener data, it is not possible, given the current data, to calculate EPCs for total TEQs that are associated with background concentrations in breast milk, because the HHRA does not provide data on the other components of total TEQs (i.e., additional PCB congeners, PCDDs and PCDFs) in breast milk.

Table 2-4. Estimated PCB EPCs Based on Background Levels in Breast Milk*

Scenario		PCB EPC Used in HHRA Analysis (mg/kg)	HHRA's Ratio of Predicted PCB Conc. in Breast Milk to Mean PCB Background Concentration	PCB EPC Associated with Background PCB Concentration in Breast Milk (mg/kg)
Bass Consumption	RME	15.91	161	0.099
	CTE	15.91	23.3	0.68
Waterfowl Consumption	RME	9.26	20.8	0.45
	CTE	9.26	10	0.93
Dairy Milk Consumption	RME	0.01 **	5.7	0.0018
	CTE	0.01 **	2.1	0.0048

* In this table, the PCB EPC used in the HHRA analysis (for PCBs in fish tissue, waterfowl tissue, or cow milk) is divided by EPA's calculated ratio of the predicted PCB concentration in breast milk to the mean background PCB concentration in breast milk (as also reported in the HHRA), to yield a PCB EPC in each medium (fish, waterfowl, and cow milk) that would be associated with the background PCB concentrations in breast milk.

** Calculated by multiplying the predicted PCB exposure level of 0.225 mg/kg fat given in Tables 10-20 and 10-21 of the HHRA (at 2 ppm in soil) by the milk fat percentage of 4.6 percent specified in Table 10-11 of the HHRA (Vol. I), to derive a PCB EPC in whole cow milk.

These estimated EPCs associated with background levels in breast milk can be compared with the RMCs for total PCBs that have been calculated for the original consumption scenarios (consumption of bass, duck breast, and cow milk from backyard farms), as set forth in Tables 2-2 and 2-3 above. This comparison shows that, for both RME and CTE values, the EPCs associated with background levels in breast milk (based on EPA's own calculations) are higher than the cancer-based RMCs at the 10^{-6} and 10^{-5} risk levels, as well as the non-cancer-based RMCs, and are somewhat lower than the RMCs calculated at a cancer risk level of 10^{-4}. In other words, the PCB RMCs that have been calculated for the consumption scenarios (except for those based on a 10^{-4} cancer risk) are *more stringent* than the back-calculated EPCs associated with background concentrations in breast milk. This comparison indicates that, based on EPA's calculations, maternal exposures to PCBs in fish, duck, or cow milk at the levels of those RMCs would not result in breast milk exposures exceeding background levels.[14]

[14] As with the breast milk comparisons in EPA's HHRA, these comparisons simply address the potential for breast milk PCB concentrations to exceed background levels. They do not address the risks associated with exposure above background levels.

2.5.2 Cumulative Exposures

EPA's HHRA also discussed the potential for cumulative exposures as a result of potential exposure to certain individuals through multiple pathways (HHRA, Vol. I, Sec. 10.1). Table 10-1 of the HHRA provided a summary of the potential combinations of exposure scenarios. In addition, EPA developed matrices that allow for the estimation of potential risks and hazards due to exposure from direct contract with soil/sediment via multiple recreational exposure scenarios in different exposure areas (HHRA, Vol. I, tables 10-2 through 10-7). Further, EPA presented examples showing how to calculate combined risks from direct contact plus consumption of fish, waterfowl, or agricultural products (HHRA, Vol. I, pp. 10-5 - 10-8).

There are numerous combinations of exposure scenarios that could occur within the population of interest, in addition to the individuals who only engage in a single activity. For the individuals who are involved in multiple recreational activities along the floodplain, the frequencies with which they may be involved in those activities are also likely to be highly variable. Thus, it is not realistic to attempt to estimate RMCs for every possible combination of exposure.

It should be noted, however, that if an individual is exposed through multiple exposure scenarios and all of those scenarios involve the same exposure assumptions used by EPA in the HHRA, then the RMCs for a given level of protection (e.g., 10^{-5} cancer risk) would be lower than the RMCs presented in Tables 2-1, 2-2, and 2-3 for that level of protection for each individual exposure scenario. For example, if the same individual engages in high-use recreation, bank fishing, and fish consumption, all with the same high RME frequencies and other assumptions used in the HHRA, then the RMCs associated with a 10^{-5} cancer risk for that individual would be lower than the RME RMCs presented for that cancer risk level for each of those individual scenarios. It seems unlikely, however, that the same individual would engage in all of these scenarios at the same RME frequencies and assumptions used in the HHRA.

3.0 RMCs BASED ON ECOLOGICAL RECEPTORS

3.1 General Approach

This section presents RMCs for each of the ecological assessment endpoints, based on EPA's ERA, EPA's written comments on the September 2005 version of this proposal (EPA, 2005d), and subsequent discussions with EPA regarding those comments. Several of EPA's written comments were clarified or modified during the subsequent discussions with GE. For example, although EPA's written comments appeared to direct GE to limit the RMCs to the levels identified as "points of departure" and to eliminate reference to any other endpoints, EPA agreed in subsequent discussions to consider some ranges of RMCs for some receptor groups.

Consistent with EPA's comments and those discussions, GE has developed ranges of numerical concentration-based RMCs for several receptor groups. In these cases, as directed by EPA, the values specified in the ERA as the MATCs (or, in the absence of MATCs, the lowest value in the range) are identified as "points of departure." For some receptors and/or constituents, in accordance with EPA's directions, a single RMC has been developed and is identified as the "point of departure."

As in the ERA, most of the RMCs were calculated based on the results of studies of specific species (i.e., wood frogs, ospreys, wood ducks, mink, short-tailed shrews, bald eagles) that are considered by EPA to be representative of broader receptor groups (i.e., amphibians, piscivorous birds, insectivorous birds, piscivorous mammals, omnivorous and carnivorous mammals, threatened and endangered species). Thus, the derivation of the RMCs reflects studies and life history characteristics specific to the selected receptor species, but the resultant RMCs are considered to be protective of the range of species within each of the broader groups.

As stated in EPA (1999) guidance, the overall goal for ecological receptors, with which EPA agreed in its comments (EPA, 2005d, Att. A, p. 9), is to "reduce ecological risks to levels that will result in the recovery and maintenance of healthy local populations and communities of biota"

(EPA, 1999, p. 3).[15] To be consistent with EPA's ERA, many of the RMCs are derived from organism-level studies, rather than studies at the population or community level. However, the ERA concluded that, where the endpoints from such studies relate to survival and/or reproduction, those endpoints "are expected to be strong indicators of potential local population-level effects," and that "extrapolation from organism-level to population-level effects may be logically achieved based on the predictive nature of the endpoint and/or through the use of process-based models" (ERA, Vol. 1, p. 2-68). EPA likewise indicated, in its comments on the prior IMPG Proposal, that a 20 percent effect on survivorship, growth, or fecundity in a toxicity test of a surrogate species is an appropriate endpoint for extrapolating to local subpopulation- and community-level responses (EPA, 2005d, Att. A, p. 11).[16]

3.2 RMCs Based on Benthic Invertebrate Assessment Endpoint

Numerical RMCs have been developed for PCBs in sediments based on potential risks to benthic invertebrates. The assessment endpoint that EPA specified in the ERA for benthic invertebrates is "community structure, survival, growth, and reproduction" (ERA, Vol. 1, p. 2-64). In assessing risks to benthic invertebrates in the Rest of River, EPA relied on laboratory toxicity tests using site-specific sediments (as well as sediments from reference locations), *in situ* toxicity tests, and a site-specific benthic community study, all conducted by EPA contractors, as the primary basis for developing threshold effect concentrations for PCBs in sediments (ERA, Vol. 4, pp. D-59 - D-63, D-94 - D-96). The data from these studies have been used to develop a range of RMCs for PCBs in sediments. No RMCs are proposed for TEQs because EPA did not assess TEQ risks to benthic invertebrates.

Based on the data from the toxicity tests and benthic community study, EPA's ERA identified a variety of effect thresholds for different test species and/or endpoints, including both concentrations associated with 20 percent effects (EC20s) and those associated with 50 percent effects (EC50s) – as well as, in some cases, no observed effect levels (NOELs) and lowest observed effect levels (LOELs). EPA then evaluated those thresholds to select particular

[15] For threatened and endangered species, this goal involves evaluation of effects on individual organisms because, given the already stressed nature of the populations of these species, such individual-level effects can adversely impact the local populations.

[16] For the reasons given in GE's Statement of Position accompanying its January 23, 2006 notice of dispute resolution, GE does not agree with the EPA assertions in the last two sentences of this paragraph.

threshold levels for each set of studies, and ultimately selected a MATC for sediment, as discussed below.

EPA identified a number of sediment effects thresholds from the chronic laboratory toxicity tests that evaluated growth, emergence, survival, and reproduction of *Chironomus tentans* (midge) and *Hyalella azteca* (amphipod). These thresholds were based on comparison of the results for sediments from locations within the Primary Study Area (PSA) of the Rest of River (from the confluence of the East and West Branches to Woods Pond Dam) to those from two reference areas (located on the East Branch of the River upstream of the GE facility and on the West Branch of the River, respectively). These thresholds are summarized in Table 3-1, using: (a) the "most synoptic" sediment data (closest in time), which were collected concurrently with the toxicity tests; (b) for endpoints measured multiple times, data from the longest exposure period; (c) for similar endpoints, the most sensitive; and (d) where different, the mean of comparisons to the two reference areas.

Table 3-1. Summary of Effects Thresholds from the Chronic Laboratory Benthic Invertebrate Toxicity Tests

Endpoint	Sediment tPCB Conc. (mg/kg)			
	NOEL	**LOEL**	**EC20 (by probit)**	**EC50 (by probit)**
C. tentans – 20-day ash-free dry weight	NC	NC	2.0	4.7
C. tentans – 20-day survival	< 8.7	8.7	< 8.7	< 8.7
C. tentans – 43-day emergence	< 8.7	8.7	< 8.7	< 8.7
H. azteca – 42-day dry weight	72	> 72	66.3 (NC)	> 72
H. azteca – 42-day survival	$\underline{\leq}$ 8.7	20	3.1	22.8
H. azteca – 42-day total young	$\underline{\leq}$ 8.7	20	3.9	11.1

NC = Not calculated

Summarized from ERA, Vol. 4, Tables D.3-7 and D.3-8, using: (a) the "most synoptic" sediment data; (b) endpoints from the longest exposure period when endpoints were measured multiple times, (c) the more sensitive endpoint when similar endpoints were measured; and (d) where relevant, the mean of comparisons to the two reference areas.

EPA used the lowest EC20 and EC50 values from Table 3-1 (i.e., 2 and 4.7 mg/kg, respectively, both based on impaired growth in *Chironomus tentans*) to represent the "intermediate risk" and "high risk" thresholds from the chronic laboratory toxicity tests (ERA, Vol. 1, p. 3-41; Vol. 4, p. D-62). EPA also reported that several additional lines of evidence were considered in developing these thresholds, including the chronic EC20 for *Hyallela azteca* survival and certain endpoints from the *in situ* studies (notably the 20 percent and 50 percent mortality values [LC20 and LC50] for 48-hour survival of *Daphnia magna*, identified in Table 3-2 below) (ERA Vol. 4, p. D-62).

To determine acute toxicity thresholds, EPA relied on the results of the *in situ* toxicity studies. The LC20 and LC50 values from those tests (calculated by probit or the Trimmed Spearman-Karber [TSK] method), using the "most synoptic" sediment data, are listed in Table 3-2.

Table 3-2. Summary of Effects Thresholds from the In-situ Toxicity Studies

Species	Endpoint	Compared To	Sediment tPCB Conc. (mg/kg)		
			LC20 (by probit)	LC50 (by probit)	LC50 (by TSK)
H. azteca	48-hour survival	Reference (A1)	3.0*[a]	18.6*[a]	8.3[a]
		Reference (A3)	3.2*[a]	18.1*[a]	8.2[a]
H. azteca	10-day survival	Reference (A1)	20.5*	30.8*	22.4
		Reference (A3)	15.2*	15.2*	22.9
C. tentans	48-hour survival	Reference (A1)	>521.7[b]	>521.7[b]	>521.7[b]
		Reference (A3)	>521.7[b]	>521.7[b]	>521.7[b]
C. tentans	10-day survival	Reference (A1)	20.3*	39.2*	29
		Reference (A3)	23.7*	43.2*	30.7
D. Magna	48-hour survival	Reference (A1)	1.3	5.0	6.4
		Reference (A3)	3.7	8.1	9.4
L. variegatus	48-hour survival	Reference (A1)	>521.7[b]	>521.7[b]	>521.7[b]
		Reference (A3)	>521.7[b]	>521.7[b]	>521.7[b]

Summarized from ERA, Vol. 4, Table D.3-6
* Indicates where goodness-of-fit statistic exceeded critical value
[a] Highest PCB concentration (521.7 mg/kg) excluded because of anomalous concentration-response
[b] No observed effect>20%

EPA used the geometric mean of the LC20 values for 10-day *Hyallella azteca* survival, 10-day *Chironomus tentans* survival, and 48-hour *Daphnia magna* survival, which is 10 mg/kg, to represent the “intermediate risk” threshold for acute toxicity; and it used geometric mean of the LC50 values (calculated by TSK) for the same three tests, 17.5 mg/kg, to represent the “high risk” threshold for acute toxicity (ERA, Vol. 4, p. D-62).

To evaluate the potential effects of PCBs in the benthic community study, EPA employed three types of analyses: (1) comparison of benthic community parameters measured at the study sites and reference sites; (2) analysis of the relationship between PCB concentrations in sediments and benthic community parameters to determine if there was an exposure-response relationship; and (3) application of the species sensitivity distribution (SSD) (ERA, Vol. 4, pp. D-74). Potential effects of PCBs were evaluated separately for sites with coarse- and fine-grained sediment. EPA identified a variety of effects thresholds based on comparisons between study sites and reference sites and the SSD. Three different diversity indices were used. The thresholds identified by EPA are summarized in Table 3-3:

Table 3-3. Summary of Effects Thresholds from the Site-Specific Benthic Invertebrate Community Study

Endpoint	Sediment tPCB Conc. (mg/kg)	
	EC20	EC50
Coarse Sediments		
Species sensitivity distribution	2.3	4.1
Taxa richness	13.4	141
Total abundance	5.8	37.3
Diversity indices: -- Shannon Wiener H' -- Simpson's Index -- Modified Simpson's Index	 4.7 70.3 23.5	Outside range of measured PCBs
Fine Sediments		
Species sensitivity distribution	6.4	> 14.1
Taxa richness	> 14.1	> 14.1
Total abundance	> 14.1	> 14.1
Diversity indices: -- Shannon Wiener H' -- Simpson's Index -- Modified Simpson's Index	 (58.7) (275) 22.8	Outside range of measured PCBs

Summarized from ERA, Vol. 4, pp. D-80, D-81, D-91; Attachment D-8, Table 3. EC20 values in parentheses exceed the maximum replicate PCB concentration and therefore represent extrapolations outside the range of regression.

EPA used the geometric mean of the five lowest EC20 values (2.3, 6.4, 13.4, 5.8, and 4.7 mg/kg), which is 5.6 mg/kg, as the "intermediate risk" threshold; and it used the geometric mean of the three bounded EC50 values (4.1, 141.5, and 37.3 mg/kg), which is 27.9 mg/kg, as the "high risk" threshold (ERA, Vol. 1, p. 3-57; Vol. 4, p. D-96).

To develop a MATC, EPA took the geometric mean of the "intermediate risk" threshold from the chronic laboratory toxicity tests (2 mg/kg) and the "intermediate risk" threshold from the benthic

community data (5.6 mg/kg) – which is 3.3 mg/kg – and rounded it to establish a MATC of 3 mg/kg for PCBs in sediments to protect benthic invertebrates (ERA, Vol. 1, p. 3-59; Vol. 4, p. D-99).

Based on review of the above effect thresholds and considering EPA's comments, GE has developed a range of sediment RMCs from 3 to 10 mg/kg for protection of benthic invertebrates. The lower bound of that range is the MATC specified by EPA. As directed by EPA, that value will be used as the point of departure. The upper bound of the range, 10 mg/kg, is the acute "intermediate risk" threshold identified by EPA based on the *in situ* toxicity tests. This value is lower than many of the thresholds identified in the ERA (see Tables 3-1 through 3-3 above) and is consistent with the geometric mean of 10.9 mg/kg for all the EC20s for the benthic invertebrate community parameters for which measured concentrations were available (Table 3-3), excluding values that were greater than measured or extrapolated values.

The measurement endpoints on which these RMCs are based include survival and growth of test organisms in the toxicity tests and various community-level metrics in the benthic community study. As such, the RMCs are applicable to EPA's assessment endpoint of "community structure, survival, growth, and reproduction." Moreover, the toxicity tests included species with a range of sensitivities to PCBs, and the site-specific benthic community study incorporates, and is relevant to, the range of benthic invertebrate species present in the Housatonic River. For these reasons, and because the "intermediate risk" thresholds on which the RMCs are based were derived from the lowest (or among the lowest) EC20 values in the studies, the resulting RMCs are conservatively protective of the range of species that comprise the benthic community in the Rest of River.

3.3 RMCs Based on Amphibian Assessment Endpoint

Numerical RMCs have been developed for PCBs in vernal pool and backwater sediments based on potential risks to amphibians. The assessment endpoint specified by EPA in the ERA for amphibians is "community condition, survival, reproduction, development, and maturation" (ERA, Vol. 1, p. 2-64). No RMCs are proposed for TEQs since EPA did not assess TEQ risks to amphibians.

EPA relied on data from its site-specific wood frog study (FEL, 2002) to determine effects thresholds for PCBs in sediment for protection of amphibians (ERA, Vol. 5, pp. E-142 - E-145). This study involved three phases and evaluated a wide range of endpoints related to survival, development, and maturation of wood frog egg masses, larvae, and metamorphs. In Phase 1, the investigators collected egg masses from Housatonic River vernal pools and three reference pools and exposed them in the laboratory to various treatments, covering a range of PCB exposure concentrations, that included water and sediment from their natal pools. In this phase, egg mass viability as well as larval growth, development, and metamorphosis were evaluated. In Phases II and III, the investigators collected larvae and metamorphs (respectively) from the same pools and evaluated them for growth, development, metamorphosis, malformations/ abnormalities, and (in Phase III) sex ratio.

EPA identified thresholds for those endpoints that it considered to show significant effects in the study – namely, malformations and (in Phase III) skewed sex ratio. Specifically, EPA identified thresholds for malformations in Phases I and III and sex ratio effects in Phase III, as summarized in Table 3-4. These thresholds were calculated based both on average measured PCB concentrations in the pond sediments and on spatially weighted mean exposure concentrations (calculated by EPA in an effort to take account of variability in PCB levels in the ponds). Although the ERA also reported an association between sediment PCB concentrations and an increased incidence of malformations in Phase II (i.e., a statistically significant relationship between spatially weighted PCB concentrations and the proportion of malformed Event 4 larvae) (ERA, Vol. 5, p. E-90), EPA did not calculate thresholds based on Phase II. According to EPA, “Phase III malformations were emphasized over Phase II malformations in MATC development because the [Phase III malformations] reflect site-specific PCB exposure in sediment over a longer period and through an ecologically relevant life stage (i.e., metamorphosis)” (EPA, 2005d, Att. A, p. 16).

Table 3-4. Summary of EC20 and EC50s from EPA's site-specific wood frog study

Endpoint	Sediment PCB Conc. (mg/kg)			
	EC20		EC50	
	Avg.	S.W. mean	Avg.	S.W. mean
Phase I larval malformations	> 62	> 32.3	> 62	> 32.3
Phase III metamorph malformations	3.61	3.27	59.3	38.6
Phase III skewed sex ratio	0.52	0.61	10.9	9.54

Summarized from ERA, Vol. 5, Table E.4-1 (Avg. = values calculated from averages of 2 measured PCB concentrations; S.W. mean = values calculated from spatially weighted mean PCB concentrations).

EPA concluded that the EC20 for sex ratio was not biologically relevant (ERA, Vol. 1, p. 4-53; Vol. 5, pp. E-116, E-142), and it therefore established the next lowest effect level – 3.27 mg/kg (using the spatially weighted means), which is the EC20 for Phase III malformations – as the MATC for vernal pool sediments (ERA, Vol. 1, p. 4-53; Vol. 5, p. E-144).

Based on review of the ERA and EPA's comments, GE has developed a range of sediment RMCs for protection of amphibians from 3.27 to 5.6 mg/kg, using the spatially weighted PCB concentrations. The lower end of the range is the MATC specified by EPA, which is based on the EC20 for Phase III malformations, and will serve as the point of departure in accordance with EPA's directions. The upper end of the range, 5.6 mg/kg, is the geometric mean of the EC20 for Phase III malformations (3.27 mg/kg) and the EC50 for Phase III sex ratio effects (9.54 mg/kg). The EC50 for sex ratios was used for this purpose because, as noted above, EPA indicated that small percentage changes in sex ratio are likely not of concern to local populations and that the EC50 is a more biologically meaningful endpoint than the EC20 (ERA, Vol. 4, p. E-116). The Phase I malformation thresholds were not used in developing this range of RMCs due to EPA's statement, in its December 9, 2005 comments, that the Phase I malformation data are not appropriate for RMC development because they included only external malformations, whereas the Phase III data included both external and internal

malformations, including malformations of female gonadal tissue (EPA, 2005d, Att. A, pp. 20, 22).[17]

The thresholds used to develop this range of RMCs, the EC20 for Phase III malformations and the EC50 for sex ratio effects, are based on organism-level effects. According to EPA, such effects at these levels can affect reproduction and can have potential population-level impacts (ERA, Vol. 4, pp. E-143 - E-144). Since EPA's assessment endpoint for amphibians includes "reproduction" as well as "development," the RMCs pertain to that endpoint. Moreover, since the RMCs are based on effects from sensitive early life stages and since they reflect a narrow range from the MACT to a level only slightly higher, they are conservative and should provide adequate protection for the various amphibian species inhabiting the Rest of River.

3.4 RMCs Based on Fish Assessment Endpoint

Numerical RMCs have been developed for PCBs and TEQs in fish tissue (whole body) based on risks to fish. The assessment endpoint specified by EPA in the ERA for fish is "survival, growth, and reproduction" (ERA, Vol. 1, p. 2-65). Although EPA found that PCBs and TEQs present risks to fish at the same magnitude and certainty, RMCs have been developed for both PCBs and TEQs because EPA established MATCs for both.

In developing site-specific effect thresholds for PCBs and TEQs in fish, EPA relied primarily on a two-phase site-specific study conducted by EPA contractors, which evaluated the reproductive toxicity of PCBs, TEQs, and other compounds to fish. Phase I of the study quantified PCB and TEQ concentrations in Housatonic River adult largemouth bass and evaluated effects in their offspring (i.e., survival, developmental parameters, and cytochrome P450 induction) (Tillitt et al., 2003a). Phase II of the study was designed to test whether PCBs and TEQs were causally linked to the endpoints evaluated in Phase I (Tillitt et al., 2003b). In Phase II, extracts from Housatonic River fish, as well as other chemical standards (2,3,7,8-TCDD and 3,3',4,4',5-pentachlorobiphenyl (PCB 126)) and laboratory controls, were injected into eggs from non-native largemouth bass, medaka and rainbow trout. The treated eggs and the fry that hatched

[17] In fact, the Phase I data did include some internal malformations (ERA, Vol. 5, p. E-81, Table E.3-8), but were nevertheless not used given EPA's comment noted in the text.

from them were reared in the laboratory and monitored for the same endpoints evaluated in Phase I.

For Phase I of this fish toxicity study, EPA reported a PCB effect threshold (in the range of 10 to 30 percent effects) of 45 mg/kg wet weight (ww) PCBs or 38 ng/kg ww TEQs for largemouth bass (ERA, Vol. 1, p. 5-25; Vol. 5, p. F-55). For Phase II, EPA identified a variety of egg-based effect levels (ED50 concentrations in eggs) for the three species, depending on the river location from which the extract was taken, the life stage at which the effect was seen, and the particular trial (ERA, Vol. 5, Table F.3-10). EPA used the average of these effect thresholds, 131 mg/kg ww PCB and 100 ng/kg ww TEQ, as the egg-based effect thresholds for Phase II (for warmwater species and rainbow trout combined) (ERA, Vol. 1, p. 5-34; Vol. 5, pp. F-60, F-63). EPA then converted these egg concentrations to estimated adult whole-body tissue concentrations by multiplying them by a factor of 0.5, yielding tissue-based thresholds of 66 mg/kg ww PCB and 50 ng/kg ww TEQ (ERA, Vol. 1, p. 5-34; Vol. 5, p. F-63). Finally, EPA combined the Phase I threshold of 45 mg/kg ww PCB or 38 ng/kg ww TEQ and the estimated Phase II threshold of 66 mg/kg ww PCB or 50 ng/kg ww TEQ to establish MATCs of 55 mg/kg ww PCB and 44 ng/kg ww TEQ for all species in the PSA, (ERA, Vol. 1, pp. 5-44 to 5-45; Vol. 5, pp. F-64, F-97). GE will use these MATCs as the RMCs for fish in the PSA. These values will also serve as points of departure in the CMS evaluations.

For fish downstream of the PSA, EPA established MATCs only for PCBs. For warmwater fish, EPA adopted the above PCB MATC of 55 mg/kg; and for coldwater fish, EPA established a PCB MATC of 14 mg/kg by dividing the warmwater MATC by 4 (ERA, Vol. 1, pp.5-58, 5-63; Vol. 5, pp. F-98, F-99). GE will use these MATCs as the RMCs and points of departure for fish downstream of the PSA.

The measurement endpoints on which these RMCs are based include survival and developmental effects (including abnormalities) in the offspring of exposed adult fish (Phase I) or offspring that hatched from injected eggs (Phase II). These are organism-level effects. However, they are relevant to EPA's assessment endpoint, which includes survival and reproduction of fish. These RMCs are considered protective of the fish species in the PSA and downstream of the PSA.

3.5 RMCs Based on Piscivorous Birds Assessment Endpoint

This section proposes RMCs for whole fish tissue based on consumption by piscivorous birds. The assessment endpoint that EPA specified in the ERA for piscivorous birds is the "survival, growth, and reproduction" of such birds (ERA, Vol. 1, p. 2-66). EPA selected ospreys as a representative species for piscivorous bird species that reside and breed in the Rest of River area, although ospreys that breed in Massachusetts typically nest along the coast and there is no evidence of resident or breeding osprey in the Rest of River area. Thus, the RMC calculations reflect EPA's evaluation of potential risks to osprey, but the resultant RMCs are applicable to all resident and breeding piscivorous bird species on the Housatonic River. RMCs were not developed for TEQs, because EPA predicted lower risks to the osprey from TEQs than from PCBs and characterized the TEQ risks as unclear (ERA, Vol. 2, p. 8-42; Vol. 6, pp. H-73, H-74).

EPA evaluated potential risks to ospreys based on modeled exposures and effects (ERA, Vol. 2, pp. 8-10 - 8-13, 8-17; Vol. 6, pp. H-23 - H-28, H-46 - H-47). This endpoint can be expressed as a ratio of modeled dose to a TRV – i.e., a hazard quotient (HQ). EPA did not calculate a MATC for osprey. In this situation, to generate an RMC for piscivorous birds, the equation used in the ERA to calculate the HQ was solved for the fish concentration term, holding the HQ value at a target level of 1 and using a TRV that is less than the 20 percent effect level. The equation used was as follows:

$$RMC_{fish} = THQ * TRV / (FT * FIR)$$

Where:

RMC_{fish} = Concentration of PCBs in fish that will not cause exceedance of TRV (mg/kg)
THQ = Target hazard quotient (unitless)
TRV = Toxicity reference value (mg/kg bw/d)
FT = Foraging time (unitless)
FIR = Normalized food intake rate (kg/kg bw/d)

As previously noted, the target HQ (THQ) was set at 1 to ensure that the dose does not exceed the TRV.

The TRV was based on Lillie et al.'s (1974) study of the reproductive effects of PCBs on chickens in accordance with EPA's directive to base the RMC on a study of the most sensitive avian species identified in the ERA. As acknowledged in the ERA (Vol. 2, pp. H-33, H-46; Table H.3-1; Figure H.3-1) and elsewhere (e.g., Elliott and Harris, 2001/2002; Brunstrom and Halldin, 1998; EPA, 2003; Hoffman et al., 1998; Sanderson et al., 1998), chickens have been consistently shown to be more sensitive – in some cases hundreds to thousands of times more sensitive – than other avian species to the toxicological effects of PCBs. Thus, the Lillie et al. (1974) study provides a conservative basis for avian RMCs.

Lillie et al. (1974) exposed 12 groups of 35 chickens each over a nine-week period to diets containing either 2 or 20 mg/kg (equivalent to 0.12 mg/kg BW/day or 1.2 mg/kg BW/day) of one of several different Aroclor mixtures. Hen and progeny performance were monitored during the nine-week dosing period (Period 1), as well as seven weeks after dosing had stopped (Period 2). Of the Aroclor mixtures tested by Lillie et al. (1974), Aroclor 1254 most closely resembles the PCB mixture in the Housatonic River. Therefore, effects levels – expressed as a percent change relative to controls – were examined for Lillie et al.'s (1974) findings for Aroclor 1254.

The Lillie et al. (1974) study results indicated that, for Aroclor 1254, the higher treatment level – i.e., dietary concentration of 20 mg/kg (equal to a dose of 1.2 mg/kg BW/day) – was less than the EC20. Table 3-5 summarizes the effect levels for all endpoints for which the Aroclor 1254 20 mg/kg dose group had significant differences in performance relative to controls.

Table 3-5. Significant Results for Aroclor 1254 20 mg/kg Dose Group (Lillie et al., 1974)

Endpoint	Period	Control group	Aroclor 1254 20 mg/kg group	Calculated % Effect	Lillie et al. (1974) Table
Egg Production (%)	Period 1	79.4	71.3	10	1
	Period 2	72.5	59.9	17	
	Mean [a]	76.3	66.0	13	
Food Consumption (grams per hen-day)	Period 1	125.8	119.2	5	2
	Period 2	126.7	105.4	17	
	Mean [a]	126.2	113.7	10	
Hatchability (%)	Period 1	93.7	80.7	14	3
	Period 2	91.6	79.9	13	
	Mean [a]	92.8	80.3	13	
Progeny Body Weight Gain (grams)	Period 1	163	141	13	4
	Mean [a]	151	132	13	

[a] Mean values as reported by Lillie et al. (1974).

Differences between controls and the Aroclor 1254 20 mg/kg dose group were not statistically significant for progeny mortality during either period or for progeny body weight gain during Period 2; thus, they are not shown in Table 3-5. Although the ERA refers to a slight reduction in growth rate of chicks at the lower treatment level (2 mg/kg in diet, equal to a dose of 0.12 mg/kg BW/day) (Vol. 6, p. H-46), that reduction was only 7 percent, was transitory, and does not constitute a significant reproductive effect. Thus, the dose of 1.2 mg/kg-day in this study, which is less than the EC20, has been selected as the TRV in the RMC calculation. Use of this TRV is consistent with EPA's specification, in its comments, that a 20 percent effect level is an appropriate basis for a point of departure RMC for receptor groups for which MATCs were not calculated (EPA, 2005d, p. 4).

The RMC was calculated based on the assumption that 100 percent of the osprey's foraging time (FT) is within the Rest of River (ERA, Vol. 2, p. 8-11; Vol. 6, pp. H-23, H-24). Fish were assumed to comprise 100 percent of the osprey's diet (ERA, Vol. 2, p. 8-13; Vol. 6, p. H-26).

The osprey's food intake rate (FIR) was calculated in a manner consistent with the ERA (Vol. 2, p. 8-17; Vol. 6, p. H-25), based on the following equation:

$$FIR = (FMR * CF) / (AE * G * BW)$$

Where:

FIR	=	Normalized food intake rate (kg/kg bw/d)
FMR	=	Free metabolic rate (kJ/d)
CF	=	Conversion factor (0.239 kcal/kJ)
AE	=	Assimilation efficiency (unitless)
BW	=	Body weight (kg)
G	=	Gross energy (kcal/kg)

The assimilation efficiency (AE) was assumed to be 0.79, (ERA, Vol. 2, p. 8-12; Vol. 6, p. H-25, Tables H.2-9, H.2-10), based on Karasov (1990), Stalmaster and Gessaman (1982), Castro et al. (1989), and Ricklefs (1974). Gross energy (G) was assumed to be 1,200 kcal/kg (ERA, Vol. 2, p. 8-12; Vol. 6, p. H-25, Tables H.2-9, H.2-10), based on Thayer et al. (1973).

Consistent with the ERA (Vol. 2, p. 8-11; Vol. 6, p. H-24), free metabolic rate (FMR) was calculated as follows:

$$FMR = a * BW^{b}$$

Where:

FMR	=	Free metabolic rate (kJ/d)
a	=	Slope (kJ/g-d)
BW	=	Body weight (g)
b	=	Power (unitless)

The ERA estimated FMR probabilistically, employing distributions for a and b, based on EPA's reanalysis of the data reported by Nagy et al. (1999), assuming an underlying normal distribution for each (ERA, Vol. 6, p. H-25, Tables H.2-9, H.2-10). In this deterministic analysis, average values reported in the ERA (Vol. 6, p. H-25, Tables H.2-9, H.2-10) for all three terms

were applied. Thus, a slope of 8.5, body weight of 1,696 g, and power of 0.768 were used to estimate FMR.

Based on the above equation and assumptions, the resulting RMC for osprey is a PCB concentration of 3.2 mg/kg in fish tissue. That RMC will be used as the point of departure in the CMS evaluations; no other RMCs for osprey are proposed at this time.

As noted above, the TRV used to derive this RMC is based on reproductive effects (in chickens) at the organism level. Since EPA's ERA specifies "reproduction" as an assessment endpoint for piscivorous birds, this TRV and the resulting RMC pertain to that endpoint. Moreover, because the effect level corresponding to this TRV is less than 20 percent, and because the chicken is the most sensitive surrogate species for this assessment endpoint, the RMC is conservative and fully protective of local populations of the range of resident and breeding piscivorous birds that derive their prey from the Housatonic River.

3.6 RMCs Based on Insectivorous Birds Assessment Endpoint

This section proposes RMCs for aquatic and terrestrial invertebrates based on consumption by insectivorous birds. The assessment endpoint specified by EPA in the ERA for insectivorous birds is the "survival, growth and reproduction" (ERA, Vol. 1, p. 2-65). EPA selected wood ducks as a representative species for the insectivorous bird species that reside and breed at the site. Thus, the RMC calculations reflect EPA's evaluation of potential risks to wood ducks, but the resultant RMCs are applicable to all insectivorous bird species that breed in the Rest of River area. RMCs have been developed for both total PCBs and TEQs because EPA concluded that, while the predicted risks to wood ducks from both PCBs and TEQs are similar in magnitude (intermediate to high), the certainty of the predicted TEQ risks to wood ducks is slightly higher than that for PCBs (ERA, Vol. 2, pp. 7-67, 7-68; Vol. 5, p. G-130, Tables G.4-22, G.4-23).

The general methodology used to generate the RMCs for insectivorous birds reflects EPA's evaluation of potential risks to wood ducks based on modeled exposures and effects, or HQs. (EPA did not identify a MATC for insectivorous birds.) In the ERA, the wood duck HQs for PCBs were "dose-based," in that they were calculated as the ratio of modeled doses to dose-based TRVs (ERA, Vol. 2, pp. 7-10, 7-52, 7-53; Vol. 5, pp. G-86, G-88, G-89). The HQs for

TEQs, in contrast, were “egg-based,” in that they were calculated as the ratio of modeled concentrations of TEQs in wood duck eggs to egg-based TRVs (ERA, Vol. 2, pp. 7-11, 7-53 to 7-57; Vol. 5, pp. G-86, G-89 to G-91). The calculations of RMCs for PCBs and TEQs followed these same approaches.

All exposure and toxicity assumptions employed in the derivation of RMCs were consistent with EPA’s ERA. The specific methodologies and inputs used to generate the RMCs for PCBs and TEQs are detailed in Attachment 29 (contained in Appendix D). As shown in that attachment, the RMC for PCBs (which will be used as the point of departure) is based on Lillie et al.’s (1974) study on chickens in accordance with EPA’s directive to base the RMC on a study of the most sensitive avian species identified in the ERA. As discussed in Section 3.5 and Attachment 29, that study indicated that, for Aroclor 1254, a dietary concentration of 20 mg/kg (equal to a dose of 1.2 mg/kg BW/day) was equivalent to an effects level of less than 20 percent relative to controls. Based on that TRV, the RMC for PCBs is 4.4 mg/kg in wood duck prey.

As also shown in Attachment 29, consistent with EPA’s ERA, the RMCs for TEQs are based on White and Seginak’s (1994) field study on reproductive effects of TEQs on wood ducks at another site. That study reported an effect threshold range (i.e., the lowest range of egg TEQ concentrations judged to have adverse reproductive effects relative to the reference population) of 20 to 50 ng/kg egg ww. From those data, a range of RMCs has been calculated for TEQs in wood duck prey. In accordance with EPA’s directives, the lower bound of that range represents the dose to adults that yields a maternal body burden that in turn results in an egg concentration with a 20 percent probability of exceeding the lower end of the effect threshold range identified by White and Seginak (1994) (i.e., 20 ng/kg egg ww). That value is a dietary TEQ concentration of 14 ng/kg and will be used as the point of departure. The upper end of the range represents the dose to adults predicted to result in an egg concentration equal to the geometric mean of the lower and upper bounds of the effect threshold range identified by White and Seginak (1994), which is 32 ng/kg egg ww. The dietary concentration predicted to result in an egg concentration at that level is 22 ng/kg.

In summary, based on the methodologies and assumptions described in Attachment 29, the RMCs for wood ducks, which would apply to the aquatic and terrestrial invertebrates consumed by these ducks, are: (1) a PCB concentration of 4.4 mg/kg, which will be used as the point of

departure in the CMS; and (2) a range of TEQ concentrations of 14 ng/kg to 22 ng/kg, with the lower end of this range to be used as the point of departure in the CMS.

While the RMCs will be achieved if neither the terrestrial nor the aquatic invertebrates consumed by the wood duck have concentrations exceeding the RMC values, the RMCs can also be achieved when lower concentrations in terrestrial invertebrates co-occur with higher concentrations in aquatic invertebrates, and vice versa. To determine whether an RMC is achieved for any combination of aquatic and terrestrial invertebrate concentrations, weighted average dietary concentrations of PCBs and/or TEQs may be calculated based on the wood duck's dietary preferences and then compared to the RMC, as detailed in Attachment 29.

As noted above, the TRVs used to derive these RMC for both PCBs and TEQs are based on reproductive effects at the organism level. Since EPA's ERA specifies "reproduction" as an assessment endpoint for insectivorous birds, these TRVs and the resulting RMCs pertain to that endpoint. Moreover, because the effect level corresponding to the PCB TRV is less than a 20 percent effect in the most sensitive avian species for PCBs (chicken), the PCB RMC is conservative and fully protective of local populations of the range of resident and breeding insectivorous birds in the Rest of River area. The RMCs for TEQs should also protect local populations of insectivorous birds, because they are based on the lowest range of egg TEQ concentrations found to have adverse reproductive effects in the species selected to represent such birds. In particular, the point of departure is based on the lower bound of that range, while the range of RMCs is based on the geometric mean of the lower and upper bounds of that range.

3.7 RMCs Based on Piscivorous Mammals Assessment Endpoint

Numerical concentration-based RMCs have been developed for PCBs and TEQs in the tissue of prey items of piscivorous mammals. The assessment endpoint stated by EPA in the ERA for piscivorous mammals is "survival, growth, and reproduction" (ERA, Vol. 1, p. 2-66). The only piscivorous mammals in the Rest of River area are mink and otter. Although the MATC identified by EPA and the RMCs identified herein are based on a study of mink (as discussed below), they apply to both mink and otter.

In developing a MATC for PCBs in the diet of mink and otter, EPA utilized data from the mink feeding study conducted by EPA contractors (Bursian et al., 2003). In that study, farm-raised mink were fed a diet containing fish from the PSA at five concentrations ranging from 0.34 mg/kg to 3.7 mg/kg PCBs or 3.5 ng/kg to 68.5 ng/kg TEQ for two months prior to mating and through mating and whelping of the kits. A subset of kits was also fed that diet for six months after whelping. Endpoints evaluated included survival, reproduction, development, and growth. As recognized in the ERA (Vol. 6, p.I-61), the study reported a Lowest Observed Adverse Effect Level (LOAEL) for 6-week kit survival of 3.7 mg/kg PCBs or 68.5 ng/kg TEQ in diet and a No Observed Adverse Effect Level (NOAEL) of 1.6 mg/kg PCBs or 16.1 ng/kg TEQ. A supplemental probit analysis by EPA yielded a 20 percent effect level (LC20) for 6-week kit survival of 0.984 mg/kg PCBs or 16.2 ng/kg TEQ in diet (ERA, Vol. 2, p. 9-51; Vol. 6, pp. I-52, I-106). Based on this analysis, EPA established a MATC of 0.984 mg/kg for PCBs in the diet of mink and otter (ERA, Vol. 2, pp. 9-51, 9-54; Vol. 6, pp. I-106, I-114).[18] EPA did not specify a MATC for TEQs.

Based on the ERA and the results from EPA's mink feeding study, as well as review of EPA's comments, GE has developed a range of RMCs from 0.984 to 2.43 mg/kg for PCBs and from 16.2 to 33 ng/kg for TEQs in the diet of mink and otter. The lower bounds of these ranges consist of the EPA MATC for PCBs and the LC20 calculated by EPA for TEQs, and will serve as points of departure in the CMS, as required by EPA. The upper bounds of these ranges are the geometric means of the NOAEL and LOAEL values for 6-week kit survival determined in the mink feeding study (Bursian et al., 2003).

These RMCs are based on kit survival, an organism-level effect. Since the assessment endpoint specified by EPA for piscivorous mammals includes "survival," the RMCs relate to that endpoint. These RMCs are considered protective of both mink and otter.

While the RMCs will be achieved if all of the mink's or otter's prey items have PCB or TEQ concentrations at or below the RMC values, they can also be achieved if lower concentrations in some prey items co-occur with higher concentrations in others. To determine whether a given

[18] Although the ERA sometimes refers to this MATC as applicable to PCBs in fish (Vol. 2, p. 9-51; Vol. 6, p. I-106), that is because the only dietary item in the mink feeding study that came from the Rest of River area was fish; and the ERA makes clear in its summaries that the MATC actually applies to the overall diet of mink and otter (Vol. 2, p. 9-54; Vol. 6, p. I-114).

RMC is achieved for any combination of prey items, a weighted average dietary concentration may be calculated based on the mink's or otter's dietary preferences. The ERA assumed that the mean proportion of prey in the diet of mink was 36 percent invertebrates, 23 percent fish, 15 percent mammals, 15 percent amphibians and reptiles, and 11 percent birds (ERA, Vol. 6, pp. I-16, Table 1.2-2, Table I.2-11). For otter, the ERA assumed that fish comprise 80 percent of the diet and that crayfish constitute the remaining 20 percent of diet (ERA, Vol. 6, pp. I-35). Thus, an RMC would be achieved when measured concentrations of PCBs or TEQs in prey items, multiplied by the proportion of those items in the diet, are, in total, less than or equal to the RMC, as indicated by the following equations:

For Mink

$$[(0.36 * C_{ai}) + (0.23 * C_{fish}) + (0.15 * C_{mam}) + (0.15 * C_{amph}) + ((0.11 * C_{birds})] \leq RMC$$

Where:

C_{ai} = Concentration of PCBs or TEQs in aquatic invertebrates

C_{fish} = Concentration of PCBs or TEQs in fish

C_{mam} = Concentration of PCBs or TEQs in mammals

C_{amph} = Concentration of PCBs or TEQs in amphibians and reptiles

C_{birds} = Concentration of PCBs or TEQs in birds

For Otter

$$[(0.80 * C_{fish}) + (0.20 * C_{cray})] \leq RMC$$

Where:

C_{fish} = Concentration of PCBs or TEQs in fish

C_{cray} = Concentration of PCBs or TEQs in crayfish

3.8 RMCs Based on Omnivorous and Carnivorous Mammals Assessment Endpoint

Numerical RMCs have been developed for PCBs in floodplain soil based on potential risks to omnivorous and carnivorous mammals. The assessment endpoint specified by EPA in the ERA

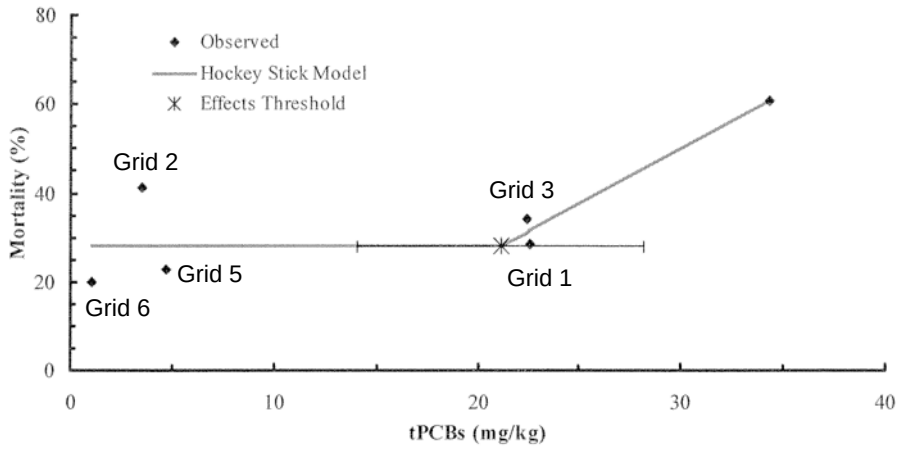
for omnivorous and carnivorous mammals is “survival, growth and reproduction” (ERA, Vol. 1, p. 2-66). EPA selected short-tailed shrews as a representative species for the omnivorous and carnivorous mammals that reside and breed at the site. Thus, the RMC calculations reflect EPA’s evaluation of potential risks to short-tailed shrews, but the resultant RMCs are applicable to all omnivorous and carnivorous mammals that reside in the Rest of River area. RMCs have not been developed for TEQs, because EPA predicted no appreciable risks to the short-tailed shrew from TEQs (ERA, Vol. 2, pp. 10-42).

EPA based its PCB MATC on survival data from the site-specific population demography study of short-tailed shrews conducted by Boonstra and Bowman (2003) (ERA, Vol. 2 p. 10-43; Vol. 6, p. J-82). These investigators reported no effects of PCBs on any endpoint measured (i.e., density, survival, sex ratio, reproduction rates, growth, and body weight) at floodplain soil PCB concentrations up to a spatially weighted average concentration of 43.5 mg/kg (Boonstra and Bowman, 2003). However, EPA conducted an independent evaluation of the data from this study, and concluded that there was a statistically significant negative relationship between PCB concentrations in the soil and shrew survival (ERA, Vol. 6, pp. J-54 to J-55). In addition, EPA presented a hockey stick regression of the arithmetic average soil data versus combined male and female survival data from the Boonstra and Bowman study (ERA, Vol. 6, Figure J.4-9, presented below as Figure 3-1). Based on that hockey stick regression, EPA established a MATC of 21.1 mg/kg for floodplain soil in short-tailed shrew habitat (ERA, Vol. 2, p. 10-43; Vol. 6, p. J-82). EPA also noted that, if the same regression analysis is conducted on the spatially weighted average soil data (rather than the arithmetic average data), the results are only borderline significant (p=0.051) (EPA, 2005b, p. 62).

Based on the ERA and these data, and considering EPA’s comments, GE has developed a range of RMCs for PCBs in floodplain soil based on potential risks to short-tailed shrews. That range is from 21.1 to 34.3 mg/kg. The lower bound of the range is the MATC identified in by EPA and will be used as the point of departure in accordance with EPA’s directions. That value represents a conservative NOAEL because, as shown on EPA’s hockey stick model (ERA, Figure J.4-9, presented below as Figure 3-1), that value lies on the zero slope phase of the curve that reflects background shrew mortality (see ERA, Vol. 6, p. J-82) and is below data for two grids that drive the zero slope phase of the regression. The upper bound of the range, 34.3 mg/kg, is the arithmetic average PCB concentration for a grid (grid 4), which represents the LOAEL and drives the dose-response phase of the hockey stick regression (see Figure 3-1

below and ERA, Vol. 6, Table J.3-5). This range is conservative in that the hockey stick inflection was observed with the arithmetic average data but not with the spatially weighted average data. Indeed, the upper bound of the range is lower than the spatially weighted average concentration of a grid (grid 3) that falls on the zero slope of the mortality curve and thus represents background mortality (see ERA, Vol. 6, Table J.3-5 and Figure 3-1).

Figure 3-1. Hockey Stick Regression Model for Survival of Male and Female Shrews Combined Versus tPCB Concentration in Soil



Source: ERA Appendix J, Figure J.4-9

This range of RMCs is based on shrew survival, an organism-level effect. Since the assessment endpoint specified by EPA for omnivorous and carnivorous mammals includes "survival," the RMCs relate to that endpoint. Given the conservative nature of the RMCs (as described above), these RMCs are considered protective of the range of omnivorous and carnivorous mammals that reside and breed in the Rest of River area.

3.9 RMC Based on Threatened and Endangered Species Assessment Endpoint

This section proposes RMCs based on the threatened and endangered (T&E) species assessment endpoint, which was defined by EPA in the ERA as "survival, growth, and reproduction" of members of those species (ERA, Vol. 1, p. 2-66). EPA selected bald eagles as a representative species for the T&E species that breed and/or winter at the site. Thus, the RMC calculations reflect EPA's evaluation of potential risks to bald eagles, but the resultant RMC is also applicable to other T&E species that breed and/or winter at the site.

A bald eagle RMC has been developed for PCBs in fish tissue (whole body) consumed by bald eagles in the Rest of River. RMCs for bald eagles have not been developed for TEQs because the weight-of-evidence analysis in the ERA did not predict greater risks to bald eagles from TEQs than from PCBs (both were considered high – see ERA, Vol. 2, p. 11-46; Vol. 6, p. K-88). Although EPA's TEQ HQ of approximately 5 (which was calculated outside of the weight-of-evidence analysis) slightly exceeded the HQ of approximately 4 for PCBs, the two HQs are negligibly different when modeling uncertainty and differences in toxicological endpoints are considered. Moreover, EPA's TRV for TEQs was based on a measured no-effect level for induction of a biomarker of exposure (CYP1A) in a reference population of bald eagles (Elliott et al., 1996), while the TRV for PCBs was based on a calculated NOAEL for reproductive effects in American kestrels (from Fernie et al. 2001). The use of a biomarker of exposure would not relate to EPA's assessment endpoint for T&E species or to its effects assessment, which focused on "effects that have an influence on the long-term maintenance of T&E species populations (i.e., mortality or impairment of reproduction or growth)" (ERA, Vol. 2, p. 11-28).

EPA evaluated potential PCB risks to bald eagles based on modeled exposures and effects – i.e., HQs. It did so in two ways: (1) by comparison of modeled total daily intake (TDI) for adult eagles to a literature-based toxicity threshold using a surrogate species, the American kestrel; and (2) by comparison of modeled eagle egg tissue concentrations to a literature-based toxicity threshold from a field study of bald eagles at another site (20 mg/kg, based on Stratus, 1999) (ERA, Vol. 6, pp. K-53 - K-54, K-68 - K-69). Since the latter was based on a study of bald eagles, rather than a surrogate species, EPA used Stratus' (1999) egg-based TRV of 20 mg/kg to derive a MATC. EPA established a MATC of 30.41 mg/kg PCBs in fish as the concentration in fish at which an adult bald eagle's TDI would result in an egg concentration that exceeds the egg-based TRV of 20 mg/kg (ERA, Vol. 2, p. 11-50; Vol. 6, p. K-69). EPA noted that the TDI

used in this derivation was calculated assuming that eagles wintering in the area would consume 83.4 percent fish and 16.1 percent waterfowl and that the waterfowl PCB concentration was zero since the waterfowl would have migrated there (ERA, Vol. 2, p. 11-50; Vol. 6, p. K-69).

GE will use EPA's MATC of 30.41 mg/kg PCBs in fish as the sole RMC and point of departure for bald eagles and other T&E species that breed and/or winter at the site and consume fish. The TRV from which that RMC was derived was based on organism-level reproductive effects. The resulting RMC thus pertains to EPA's assessment endpoint for T&E species, which includes "reproduction." Further, under EPA policy, evaluation of organism-level effects for T&E species is appropriate, both because such effects can adversely impact the already stressed populations (which may be in danger of extirpation) and due to legal requirements under the Endangered Species Act (see EPA, 2005d, Att. A, p. 29).

3.10 Summary

The RMCs for ecological receptors based on EPA's ERA are summarized in Table 3-6, with the points of departure identified by bold type and asterisks.

Table 3-6. Summary of RMCs for Ecological Receptors

Receptor Group	Medium	Constituent	RMCs
Benthic invertebrates	Sediments	PCBs	**3*** to 10 mg/kg
Amphibians	Vernal pool sediments	PCBs	**3.27*** to 5.6 mg/kg
Fish	Fish tissue in PSA (whole body)	PCBs	**55*** mg/kg
		TEQ	**44*** ng/kg
	Fish tissue downstream of PSA (whole body)	PCBs	**55*** mg/kg for warmwater fish **14*** mg/kg for coldwater fish
Piscivorous birds (represented by osprey)	Fish tissue (whole body)	PCBs	**3.2*** mg/kg
Insectivorous birds (represented by wood ducks)	Aquatic and terrestrial invertebrate prey	PCBs	**4.4*** mg/kg
		TEQ	**14*** to 22 ng/kg
Piscivorous mammals (mink and otter)	Prey items	PCBs	**0.984*** to 2.43 mg/kg
		TEQ	**16.2*** to 33 ng/kg
Omnivorous and carnivorous mammals (represented by short-tailed shrew)	Floodplain soil	PCBs	**21.1*** to 34.3 mg/kg
Threatened and endangered species (represented by bald eagle)	Fish tissue (whole body)	PCBs	**30.41*** mg/kg

* Points of departure, as specified by EPA.

4.0 CHEMICAL-SPECIFIC APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARS)

4.1 General

The Reissued RCRA Permit requires that, in addition to proposing IMPGs, the IMPG Proposal must "take into account" ARARs (as defined in CERCLA) under federal and state laws and regulations. To address this requirement, GE reviewed pertinent federal and state environmental laws and regulations to identify requirements that establish chemical-specific standards or criteria for constituents of concern in particular media present in the Rest of River area and that would meet the definition of ARARs in the CERCLA NCP (40 CFR § 300.5).

In this review, GE focused on requirements that would apply to PCBs or TEQs for the same reasons discussed in Section 1.4.1 above. Further, consistent with EPA's December 9, 2005 comments, GE limited its review to requirements that establish chemical-specific standards or criteria for particular media (i.e., sediments, surface water, floodplain soil, biota, or air). While various other federal and state laws and regulations establish substantive requirements that could be applicable or relevant and appropriate to the selection or implementation of a remedy for the Rest of River and thus may be identified in the CMS Proposal as action-specific or location-specific ARARs, they are not related to goals for constituent concentrations in particular media, which is the focus of this IMPG Proposal. Thus, GE focused its review on chemical-specific and media-specific requirements. Finally, GE limited its review to requirements that would qualify as ARARs in that they have been promulgated (after notice-and-comment rulemaking) under federal or state laws, are applicable or relevant and appropriate for the particular medium in question in the Rest of River, and, for state ARARs, are of general applicability, legally enforceable, and more stringent than federal requirements (see 40 CFR § 300.5; EPA, 1989).

Based on this review, GE has preliminarily identified certain criteria and standards that would constitute chemical-specific ARARs for the Rest of River remedy. These are described in Section 4.2. It should be noted that these do not constitute the final ARARs for the Rest of River remedy, which will be specified by EPA as part of the later remedy selection. However, the ARARs identified herein will be used in the CMS, as required by the Permit.

4.2 Identification of ARARs

Federal Water Quality Criteria and State Water Quality Standards

GE has reviewed the federal water quality criteria promulgated by EPA under Section 304(a) of the Federal Water Pollution Control Act (FWPCA) (33 USC § 1314) and the state water quality standards based on those criteria. Based on that review, GE has identified the federal water quality criteria and state water quality standards for PCBs as chemical-specific ARARs. Those criteria and standards are as follows:

- The federal water quality criteria for PCBs are: (a) 0.014 µg/L, the freshwater chronic criterion, based on protection of mink; and (b) 0.000064 µg/L, based on human consumption of water and organisms at a 10^{-6} cancer risk (EPA, 2002).

- The Massachusetts water quality standards provide that, for toxic pollutants such as PCBs, the federal water quality criteria published by EPA pursuant to Section 304 of the FWPCA will be used as standards unless a site-specific limit is established (314 CMR 4.05(5)(e)). Site-specific limits have not been adopted for PCBs in the Massachusetts portion of the Housatonic River. Thus, the above federal water quality criteria constitute the state water quality standards for PCBs in Massachusetts.

- For Connecticut, the state water quality standards for PCBs (as set forth in Connecticut Water Quality Standards, Appendix D) are: (a) 0.014 µg/L, the freshwater chronic criterion; and (b) 0.00017 µg/L, based on human consumption of organisms or of water and organisms. These values are the same as those in the prior version of the federal water quality criteria, which was in effect before EPA's adoption of revised criteria for human consumption of organisms or water and organisms in 2002.

There are no federal water quality criteria or state water quality standards for TEQs. While there are such criteria and standards for 2,3,7,8-TCDD,[19] those criteria and standards are

[19] The federal water quality criteria for 2,3,7,8-TCDD are: (a) 5.1×10^{-9} µg/L, based on human consumption of organisms at a 10^{-6} cancer risk; and (b) 5.0×10^{-9} µg/L, based on human consumption of water and organisms at a 10^{-6} cancer risk (EPA, 2002). Similar to PCBs, the Massachusetts water quality standards for 2,3,7,8-TCDD are the same as the federal criteria (314 CMR 4.05(5)(e)). The Connecticut water quality standards for 2,3,7,8-TCDD are: (a) 1.4×10^{-8} µg/L, based on human consumption of organisms; and (b) 1.3×10^{-8} µg/L, based on human consumption of water and organisms.

specific to that dioxin compound and contain no provision for applying those values to TEQs generally. Moreover, review of the water column data for PCDDs and PCDFs in the Rest of River area (from both routine and discrete sampling events) indicates that 2,3,7,8-TCDD was detected in only 2 of 133 samples analyzed for PCDDs/PCDFs (BBL and QEA, 2003, Appendix C, Table C-3). Additionally, EPA's risk assessments did not identify the specific compound 2,3,7,8-TCDD individually as a constituent of concern in any media in the Rest of River. For these reasons, GE does not believe that the federal water quality criteria and state water quality standards for 2,3,7,8-TCDD would constitute ARARs for the Rest of River remedy.

Thus, the water quality criteria and standards that constitute chemical-specific ARARs for the Rest of River remedy are those applicable to PCBs. These criteria and standards would not constitute IMPGs or affect the IMPGs identified in prior sections, because GE has developed site-specific RMCs that address the same receptors and pathways addressed by those ARARs. Specifically, as described above, GE has developed RMCs based on protection of mink (Sections 3.7) and RMCs based on human consumption of organisms from the Housatonic River (Sections 2.3).[20] Moreover, as discussed above, these criteria and standards do not constitute the final ARARs for the Rest of River remedy.

Nevertheless, GE will consider these ARARs as a separate evaluation criterion in the CMS, as required by the Permit. These ARARs will be subject to waiver under CERCLA and the NCP if achievement of them is not technically practicable or would result in greater risks to human health or the environment than other alternatives or for other reasons specified in the NCP (40 CFR § 300.430(f)(1)(ii)(C)). Under the Permit (Special Condition II.G.1.c), an evaluation of the need and basis for any such waiver will be included in the CMS Report.

Connecticut Remediation Standards for Soil

GE has also considered the Connecticut Remediation Standard regulations (RSRs), which include specific numerical criteria for soil remediation based on direct human contact with the soil, and also allow for the development of alternative soil remediation criteria based on direct contact (Conn. Agencies Regs. 22a-133k-1 through -3). These criteria apply only to soil, which

[20] The Housatonic River is not used for human consumption of water; and as discussed in Section 1.4.1, a highly conservative screening-level evaluation performed by EPA of potential risks due to direct contact with the surface water of the river demonstrated that current levels of PCBs in the river are well below any levels that could present such risks.

is defined as “unconsolidated geological material overlying bedrock, but *not including sediment*” (Conn. Agencies Regs 22a-133k-1, emphasis added). The RSRs establish separate direct exposure criteria for soil in residential areas and soil in industrial/commercial areas. The criteria for PCBs are 1 mg/kg for residential soil and 10 mg/kg for industrial/commercial soil (Appendix A to Conn. Agencies Regs. 22a-133k-1 through -3). (There are no such numerical criteria applicable to TEQs.) However, the RSRs also allow the Commissioner of the Connecticut Department of Environmental Protection (CDEP) to approve alternative direct exposure criteria for PCBs if it can be shown that such alternative criteria will protect human health and the environment from risks associated with direct exposure to PCB-containing soil and are consistent with EPA’s regulations under the Toxic Substances Control Act (40 CFR Part 761) and with EPA’s 1990 “Guide on Remedial Actions at Superfund Sites with PCB Contamination” (Conn. Agencies Regs. 22a-133k-2(d)(7)).

GE does not believe that the RSRs’ numerical direct exposure criteria for PCBs would constitute ARARs for the Rest of River in Connecticut. First, as noted above, these criteria are limited to soils and, by their terms, clearly do not apply to sediments. Second, the residential soil criterion is not an ARAR even for residential areas in the Rest of River floodplain because: (a) the RSRs allow for CDEP approval of an alternative direct exposure criterion; and (b) the Consent Decree, to which the CDEP is a party, establishes a PCB Performance Standard of 2 mg/kg, based on direct human exposure, for Actual/Potential Lawns in the Rest of River area (see Section 2.2.1 above), which the CDEP determined is protective of human health and the environment (CD, ¶ 8.b). That determination, in effect, constitutes the approval of an alternative criterion for a residential exposure scenario. Third, the RSRs’ residential direct exposure criterion is not applicable or relevant to other (e.g., recreational) exposure scenarios in the Rest of River floodplain, since it was based on residential exposure assumptions (e.g., an assumed exposure frequency of 365 days per year) that do not apply to such other scenarios. Finally, in any case, the existing floodplain soil PCB data from Connecticut show no concentrations even close to 1 mg/kg, with a maximum concentration of 0.037 mg/kg (estimated).

Summary

Apart from the regulations discussed above, no other chemical-specific ARARs have been identified. The chemical-specific ARARs that have been identified at this time for the Rest of River remedy are listed in Table 4-1. As noted above, these ARARs will be used as a separate

criterion in the CMS evaluations and will be subject to waiver if it is determined in the CMS that they cannot practicably be achieved or that the other conditions for waiver of ARARs under CERCLA and the NCP are met.

Table 4-1. Chemical-Specific ARARs for Rest of River

Medium	Regulation (Citation)	Chemical	Criterion/Standard
Surface water	Clean Water Act, Ambient Water Quality Criteria (*National Recommended Water Quality Criteria: 2002*, EPA-822-R-02-047, USEPA, Office of Water, Office of Science and Technology, Nov. 2002)	PCBs	Freshwater chronic aquatic life criterion (based on protection of mink): 0.014 µg/L Human health criterion based on human consumption of water and organisms: 0.000064 µg/L
Surface water in MA	Massachusetts water quality standards (314 CMR 4.05(5)(e))	PCBs	Same as federal water quality criteria
Surface water in CT	Connecticut surface water quality standards (*Connecticut Water Quality Standards* [effective Dec. 17, 2002], Appendix D)	PCBs	Freshwater chronic aquatic life criterion: 0.014 µg/L Human health criterion, based on human consumption of organisms only or water and organisms: 0.00017 µg/L

5.0 REFERENCES

AMEC and BBL. 2003. *Comments of the General Electric Company on the U.S. Environmental Protection Agency's Human Health Risk Assessment for the Housatonic River Site - Rest of River.* Prepared by AMEC Earth and Environmental, Inc. and BBL Sciences, Inc. July 28.

AMEC and BBL. 2005. *Comments of the General Electric Company on the Human Health Risk Assessment for the General Electric/Housatonic River Site, Rest of River (February 2005).* Prepared by AMEC Earth and Environmental, Inc. and BBL Sciences, Inc. April.

BBL (Blasland, Bouck & Lee, Inc.) and QEA (Quantitative Environmental Analysis, LLC). 2003. *Housatonic River - Rest of River, RCRA Facility Investigation Report*. Prepared for General Electric Company, Pittsfield, MA. September.

BBL Sciences, ARCADIS G&M, Branton Environmental Consulting and LWB Environmental Services. 2003. *Comments of General Electric Company on the Ecological Risk Assessment for the General Electric/Housatonic River Site, Rest of River (July 2003 Draft)*. September.

BBL Sciences, Arcadis G&M, Branton Environmental Consulting, and LWB Environmental Services. 2005. *Comments of General Electric Company on the Ecological Risk Assessment for the General Electric/Housatonic River Site. Rest of River (November 2004 Draft).* January.

Boonstra, R., and L. Bowman. 2003. Demography of short-tailed shrew populations living on polychlorinated biphenyl-contaminated sites. *Environmental Toxicology and Chemistry.* 22:1394-1403.

Bursian, S.J., R.J. Aulerich, B. Yamini, and D.E. Tillitt. 2003. *Dietary Exposure of Mink to Fish from the Housatonic River: Effects on Reproduction and Survival. Revised Final Report.* Michigan State

Brunstrom, B., and K. Halldin. 1998. EROD induction by environmental contaminants in avian embryo livers. *Comparative Biochem. and Physiol. Part C* 121:213-219.

Castro, G., N. Stoyan, and J.P. Myers. 1989. Assimilation efficiency in birds: A function of taxon or food type? *Comparative Biochemistry Physiology A. Comparative Physiology* 92:272-278.

Elliott, J.E., and M.L. Harris. 2001/2002. An ecotoxicological assessment of chlorinated hydrocarbon effects on bald eagle populations. *Reviews in Toxicology* 4:1-60.

Elliott, J.E., R.J. Norstrom, A. Lorenzen, L.E. Hart, H. Philibert, S.W. Kennedy, J.J. Stegeman, G.D. Bellward, and K.M. Cheng. 1996. Biological effects of polychlorinated dibenzo-p-dioxins, dibenzofurans, and biphenyls in bald eagle (*Haliaeetus leucocephalus*) chicks. *Environ. Toxicol. Chem.* 15:782-793.

EPA. 1989. *CERCLA Compliance with Other Laws Manual: Part II: Clean Air Act and Other Environmental Statutes and State Requirements*. U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response. EPA/540/G-89-009. OSWER Directive 9234,1-02. August.

EPA. 1990. *Corrective Action for Solid Waste Management Units (SWMUs) at Hazardous Waste Management Facilities; Proposed Rule.* Federal Register 55:30793-30884. July 27.

EPA. 1996. *Corrective Action for Releases from Solid Waste Management Units at Hazardous Waste Management Facilities; Advance Notice of Proposed Rulemaking.* Federal Register 61:19432-19464. May 1.

EPA. 1997. *Health Effects Assessment Summary Tables, FY 1997* Update. U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response. EPA-540-R-97-036. July.

EPA. 1998. *Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities, Volumes 1, 2, and 3. Peer Review Draft.*

EPA. 1999. *Issuance of Final Guidance: Ecological Risk Assessment and Risk Management Principles for Superfund.* OSWER Directive 9285.7-28 P. October 7.

EPA. 2001. *Risk Assessment Guidance for Superfund: Volume III - Part A, Process for Conducting Probabilistic Risk Assessment.* Office of Emergency and Remedial Response. Washington, DC. EPA 540-R-02-002. December.

EPA. 2002. *National Recommended Water Quality Criteria: 2002.* EPA-822-R-02-047. U.S. Environmental Protection Agency, Office of Water, Office of Science and Technology. November.

EPA. 2003. *Analyses of Laboratory and Field Studies of Reproductive Toxicity in Birds Exposed to Dioxin-like Compounds for Use in Ecological Risk Assessment.* U.S. Environmental Protection Agency, Office of Research and Development, Cincinnati, Ohio. April. EPA/600/R-03/114F.

EPA. 2004a. *Ecological Risk Assessment for General Electric (GE)/Housatonic River Site, Rest of River.* Prepared by Weston Solutions, Inc., West Chester, PA, for the U.S. Army Corps of Engineers, New England District, and the U.S. Environmental Protection Agency, New England Region. November 12.

EPA. 2005a. *Human Health Risk Assessment - GE/Housatonic River Site - Rest of River.* Prepared by Weston Solutions, Inc., West Chester, PA, for the U.S. Army Corps of Engineers, New England District, and the U.S. Environmental Protection Agency, New England Region. February 11.

EPA. 2005b. *Responsiveness Summary to Public Comments on New Information - Ecological Risk Assessment for the GE/Housatonic River Site, Rest of River.* Prepared by Weston Solutions, Inc., West Chester, PA, for the U.S. Army Corps of Engineers, New England District, and the U.S. Environmental Protection Agency, New England Region. March.

EPA. 2005c. *Responsiveness Summary to Public Comments on New Information - Human Health Risk Assessment for the GE/Housatonic River Site, Rest of River*. Prepared by Weston Solutions, Inc., West Chester, PA, for the U.S. Army Corps of Engineers, New England District, and the U.S. Environmental Protection Agency, New England Region. June.

EPA. 2005d. Letter from Susan Svirsky, EPA Region 1, to Andrew Silfer, General Electric, re: Interim Media Protection Goals Proposal. December 9.

FEL (Fort Environmental Laboratories, Inc.). 2002. *Final Report – Frog Reproduction and Development Study: 2000 Rana sylvatica Vernal Pool Study.* Prepared by Fort Environmental Laboratories, Inc., Stillwater, Oklahoma.

Fernie, K.J., J.E. Smits, G.R. Bortolotti, and D.M. Bird. 2001. Reproductive success of American kestrels exposed to dietary polychlorinated biphenyls. *Environmental Toxicology and Chemistry* 20:776-781.

GE (General Electric Co.). 2003. *Comments of the General Electric Company on EPA's Human Health Risk Assessment for the GE - Housatonic River Site - Rest of River.* Presentation to the Peer Review Panel. General Electric Company, Pittsfield, MA. November 18.

GE (General Electric Co.). 2004. *Comments of the General Electric Company on the U.S. Environmental Protection Agency's Ecological Risk Assessment for the Housatonic River Site - Rest of River.* Presentation to the Peer Review Panel. General Electric Company, Pittsfield, MA. January 13.

Hoffman, D.J., M.J. Melancon, P.N. Klein, J.D. Eisemann, and J.W. Spann. 1998. Comparative developmental toxicity of planar polychlorinated biphenyl congeners in chickens, American kestrels, and common terns. *Environmental Toxicology and Chemistry* 17:747-757.

Karasov, W.H. 1990. Digestion in birds: Chemical and physiological determinants and ecological implications. *Studies in Avian Biology* 13:391-415.

Lillie, R.J., H.C. Cecil, J. Bitman, and G.F. Fries. 1974. Differences in response of caged white leghorn layers to various polychlorinated biphenyls (PCBs) in the diet. *Poultry Science* 53:726-732.

Nagy, K.A., I.A. Girard, and T.K. Brown. 1999. Energetics of free-ranging mammals, reptiles, and birds. *Annual Review of Nutrition* 19:247-277.

Ricklefs, R.E. 1974. Energetics of reproduction in birds. In: Paynter, R.A. ed. *Avian Energetics*. Nuttall Ornithological Club, Cambridge, Massachusetts.

Sanderson, J.T., S.W. Kennedy, and J.P. Giesy. 1998. In vitro induction of ethoxyresorufin-o-deethylase and porphyrins by halogenated aromatic hydrocarbons in avian primary hepatocytes. *Environmental Toxicology and Chemistry* 17:2006-2018.

Stalmaster, M.V., and J.A. Gessaman. 1982. Food consumption and energy requirements of captive bald eagles. *Journal of Wildlife Management* 46:646-654.

Stratus (Stratus Consulting, Inc.). 1999. *Injuries to Avian Resources, Lower Fox River/Green Bay Natural Resource Damage Assessment. Final Report.* Prepared for U.S. Fish & Wildlife Service, U.S. Department of the Interior and U.S. Department of Justice. May 7.

Thayer, G.W., W.E. Schaaf, J.W. Angelovic, and M.W. LaCroix. 1973. Caloric measurements of some estuarine organisms. *Fishery Bulletin* 71:289-296.

Tillitt, D., D. Papoulias, and D. Buckler. 2003a. *Fish Reproductive Health Assessment in PCB Contaminated Regions of the Housatonic River, Massachusetts, USA: Investigations of Causal Linkages Between PCBs and Fish Health. Final Report of Phase I Studies*. Prepared for U.S. Fish and Wildlife Service, Concord, New Hampshire, and U.S. Environmental Protection Agency, Boston, Massachusetts.

Tillitt, D., D. Papoulias, and D. Buckler. 2003b. *Fish Reproductive Health Assessment in PCB Contaminated Regions of the Housatonic River, Massachusetts, USA: Investigations of Causal Linkages Between PCBs and Fish Health. Final Report of Phase II Studies.* Prepared for U.S. Fish and Wildlife Service, Concord, New Hampshire, and U.S. Environmental Protection Agency, Boston, Massachusetts.

White, D.H., and J.T. Seginak. 1994. Dioxin and furans linked to reproductive impairment in wood ducks. *Journal of Wildlife Management* 58(1):100-106.

APPENDIX A

ATTACHMENTS 1 THROUGH 13

Attachment 1
Risk-based Media Concentrations for Direct Contact with Floodplain Soil
In High-Use Recreational Areas

A range of Risk-based Media Concentrations (RMCs) has been developed for PCBs based on potential for direct contact with floodplain soil in high-use recreational areas. Consistent with the approach used in EPA's HHRA, potential soil ingestion and dermal contact exposures of young children, older children, and adults have been evaluated under reasonable maximum exposure (RME) and central tendency exposure (CTE) conditions. For each age group and set of exposure conditions, RMCs have been calculated based both on potential cancer risks and on potential non-cancer impacts, using the exposure assumptions and toxicity values used in the HHRA.

The RMCs for the cancer endpoint (RMC_{cancer}) and the non-cancer endpoint ($RMC_{noncancer}$) for this scenario have been calculated using the following equations, respectively:

$$RMC_{cancer} = \frac{Risk}{CSF * \left(Exp_{ingestion} + Exp_{dermal}\right)}$$

Where:

RMC_{cancer}	=	RMC based on the cancer endpoint (mg/kg)
Risk	=	Target risk level (unitless)
CSF	=	Cancer slope factor $(mg/kg\text{-}day)^{-1}$
$Exp_{ingestion}$	=	Exposure due to the soil ingestion pathway (day^{-1})
Exp_{dermal}	=	Exposure due to dermal contact with soil (day^{-1})

And

$$RMC_{noncancer} = \frac{HI * RfD}{\left(Exp_{ingestion} + Exp_{dermal}\right)}$$

Where:

$RMC_{noncancer}$	=	RMC based on the noncancer endpoint (mg/kg)
HI	=	Target hazard index (unitless)
RfD	=	Reference dose (mg/kg-day)
$Exp_{ingestion}$	=	Exposure due to the soil ingestion pathway (day^{-1})
Exp_{dermal}	=	Exposure due to dermal contact with soil (day^{-1})

In both of the above equations, the exposures due to soil ingestion ($Exp_{ingestion}$) and dermal contact with soil (Exp_{dermal}) have been calculated using the following equations:

$$Exp_{ingestion} = \frac{IR * FI * CF * EF * ED}{AT * BW}$$

And

$$Exp_{dermal} = \frac{(((AF_1 * SA_1 * AD_1) + (AF_2 * SA_2 * AD_2))/(AD_1 + AD_2)) * ABS_d * CF * EF * ED}{AT * BW}$$

Where:

IR	=	Soil ingestion rate (mg/day)
FI	=	Fraction of soil ingested that is attributable to the Site (unitless)
AF_1	=	Dermal adherence factor during the warmer months (mg/cm^2)
AF_2	=	Dermal adherence factor during the cooler months (mg/cm^2)
SA_1	=	Skin surface area exposed during the warmer months (cm^2/day)
SA_2	=	Skin surface area exposed during the cooler months (cm^2/day)
AD_1	=	Activity duration for the warmer months (months)
AD_2	=	Activity duration for the cooler months (months)
ABS_d	=	Dermal absorption factor (unitless)
CF	=	Unit conversion factor (1E-06 kg/mg)
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)
AT	=	Averaging time (days)
BW	=	Age-specific body weight (kg)

The specific exposure assumptions used for each age group in this analysis, and the basis of each, are summarized in Table 1a. In all cases, the assumptions and parameters used are the same as those used by EPA in its 2005 HHRA. For young children in high-use recreational areas, the HHRA evaluated some areas using the same exposure frequency as adults and older children and other areas using a lower, alternate exposure frequency. The same approach has been followed in developing the RMCs.

Standard EPA toxicity values have been used for PCBs. These include a cancer slope factor (CSF) of 2 $(mg/kg\text{-}day)^{-1}$ for the RME scenario, a CSF of 1 $(mg/kg\text{-}day)^{-1}$ for the CTE scenario, and a chronic reference dose of 2E-05 mg/kg-day for both the RME and CTE analyses. These values are published in EPA's IRIS database and were used in EPA's HHRA.

Consistent with the HHRA, separate cancer-based and non-cancer-based RMCs have been developed for each relevant age group (adults, older children, young children with high exposure frequency, and young children with lower exposure frequency). The RMCs based on potential carcinogenic effects have been developed for both the RME and CTE exposure scenarios using a range of target risks from one-in-a-million ($1x10^{-6}$) to one-in-ten-thousand ($1x10^{-4}$). This risk range is consistent with EPA's acceptable risk range. RMCs for non-cancer effects have been developed for the RME and CTE scenarios based on a target Hazard Index of 1.

Summary of Results

Estimated RMCs for cancer and non-cancer endpoints are presented in the following tables for adults (Table 1b), older children (Table 1c), young children under high frequency conditions (Table 1d), and young children under lower, alternate frequency conditions (Table 1e). For each of these receptors, the calculated RMCs are as follows.

	RME (mg/kg)				**CTE (mg/kg)**			
	Cancer Risk			**Non-cancer**	**Cancer Risk**			**Non-cancer**
	$1x10^{-6}$	**$1x10^{-5}$**	**$1x10^{-4}$**	**HI = 1**	**$1x10^{-6}$**	**$1x10^{-5}$**	**$1x10^{-4}$**	**HI = 1**
Adults	1.4	14	143	38	63	630	6,305	234
Older Child	3.9	39	388	27	51	514	5,143	176
Young Child								
High frequency	1.3	13	134	4.6	18	184	1,842	32
Alt. frequency	8.0	80	802	27	37	368	3,684	63

Table 1a. Summary of Pathway- and Age-Specific Exposure Assumptions Used in the High Use Recreational Scenario

Parameters	Units	Symbol	RME	CTE	Basis*
Common Parameters					
Unit conversion factor	kg/mg	CF	1.0E-06	1.0E-06	HHRA, Vol. IIIA. Table 4-12.
Exposure frequency	days/year	EF			
Young child (high frequency)			90	30	HHRA, Vol. IIIA; Table 4-22; EPA's professional judgment.
Older child			90	30	HHRA, Vol. IIIA; Table 4-22; EPA's professional judgment.
Adult			90	30	HHRA, Vol. IIIA; Table 4-22; EPA's professional judgment.
Young child (alternative frequency)			15	15	HHRA, Vol. IIIA; Section 4.5.3.2.1; Page 4-54; Lower usage for areas without well defined trails.
Exposure duration	years	ED			
Young child			6	6	HHRA, Vol. IIIA; Table 4-23; From age 1 to 6 years. EPA, 1991.
Older child			12	12	HHRA, Vol. IIIA; Table 4-23; Aged 7 to 18 years. Based on MDPH, 2001.
Adult			47	13	HHRA, Vol. IIIA; Table 4-23; Aged 19 to 65 years (RME); 19 to 31 years (CTE). Based on MDPH, 2001.
Body weight	kg	BW			
Young child			15	15	HHRA, Vol. IIIA; Table 4-6; based on EPA, 1989. Average age specific body weight.
Older child			45	45	HHRA, Vol. IIIA; Table 4-6; based on EPA, 1989. Average age specific body weight.
Adult			70	70	HHRA, Vol. IIIA; Table 4-6; based on EPA, 1989. Average age specific body weight.
Averaging time (cancer endpoint)	days	ATc	25,550	25,550	HHRA, Vol. IIIA; Table 4-6; based on EPA 1989. Lifetime of 70 years x 365 days/year.
Averaging time (noncancer endpoint)	days	ATnc			
Young child			2,190	2,190	HHRA, Vol. IIIA. Table 4-6; Based on EPA, 1989. Equivalent to duration in years x 365 days/year.
Older child			4,380	4,380	HHRA, Vol. IIIA. Table 4-6; Based on EPA, 1989. Equivalent to duration in years x 365 days/year.
Adult			17,155	4,745	HHRA, Vol. IIIA. Table 4-6; Based on EPA, 1989. Equivalent to duration in years x 365 days/year.
Soil Ingestion Pathway					
Soil ingestion rate	mg/day	IR			
Young child			200	100	HHRA, Vol. IIIA; Tables 4-12 and 4-24; Section 4.5.2.3. Based on EPA 1991 and 1997.
Older child			100	50	HHRA, Vol. IIIA; Tables 4-12 and 4-24; Section 4.5.2.3. Based on EPA 1991 and 1997.
Adult			100	50	HHRA, Vol. IIIA; Tables 4-12 and 4-24; Section 4.5.2.3. Based on EPA 1991 and 1997.
Fraction of ingested soil attributable to site	unitless	FI	1.0	0.5	HHRA, Vol. IIIA; Table 4-12; Section 4.5.1.3. EPA's professional judgment.
Dermal Exposure Pathway					
Dermal adherence factor (warmer months)	mg/cm^2	AF_1			
Young child			0.2	0.2	HHRA, Vol. IIIA; Table 4-26; Section 4.5.2.4.2. Children playing in wet soil weighted by exposed body area.
Older child			0.07	0.07	HHRA, Vol. IIIA; Table 4-26; Section 4.5.2.4.2. Gardeners, weighted by exposed body area.
Adult			0.07	0.07	HHRA, Vol. IIIA; Table 4-26; Section 4.5.2.4.2. Gardeners, weighted by exposed body area.
Dermal adherence factor (cooler months)	mg/cm^2	AF_2			
Young child			0.35	0.35	HHRA, Vol. IIIA; Table 4-26; Section 4.5.2.4.2. Children playing in wet soil weighted by exposed body area.
Older child			0.14	0.14	HHRA, Vol. IIIA; Table 4-26; Section 4.5.2.4.2. Gardeners, weighted by exposed body area.
Adult			0.15	0.15	HHRA, Vol. IIIA; Table 4-26; Section 4.5.2.4.2. Gardeners, weighted by exposed body area.
Skin surface area (warmer months)	cm^2/day	SA_1			
Young child			2,800	2,800	HHRA, Vol. IIIA; Tables 4-25 and 4-26; Hands, forearms, lower legs, feet and head.
Older child			4,400	4,400	HHRA, Vol. IIIA; Tables 4-25 and 4-26; Hands, forearms, lower legs, and head.
Adult			5,700	5,700	HHRA, Vol. IIIA; Tables 4-25 and 4-26; Hands, forearms, lower legs, and head.

Table 1a. Summary of Pathway- and Age-Specific Exposure Assumptions Used in the High Use Recreational Scenario

Parameters	Units	Symbol	RME	CTE	Basis*
Skin surface area (cooler months)	cm^2/day	SA_2			
Young child			684	684	HHRA, Vol. IIIA; Tables 4-25 and 4-26. Section 4.5.2.4.1. Hands and face.
Older child			1,125	1,125	HHRA, Vol. IIIA; Tables 4-25 and 4-26. Section 4.5.2.4.1. Hands and face.
Adult			1,306	1,306	HHRA, Vol. IIIA; Tables 4-25 and 4-26. Section 4.5.2.4.1. Hands and face.
Activity duration (warmer months)	months	AD_1	5	5	HHRA, Vol. IIIA; Table 4-12; EPA's professional judgment. May through September.
Activity duration (cooler months)	months	AD_2	2	2	HHRA, Vol. IIIA; Table 4-12; EPA's professional judgment. April and October.
Dermal absorption factor	unitless	ABS_d	0.14	0.14	HHRA, Vol. IIIA; Table 4-12, Page 4-38; Wester et al. 1993.

* All exposure parameters are identical to the parameters used in the HHRA (EPA, 2005). Volume and Table and/or Section numbers provided.

EPA 1989. *Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual (Part A) Interim Final.*

EPA 1991. *Risk Assessment Guidance for Superfund, Volume I; Human Health Evaluation Manual, Supplemental Guidance, Standard Default Exposure Assumptions.*

EPA 1997. *Exposure Factors Handbook, Volume I; General Factors.*

MDPH 2001. *Memo from Martha Steele, Deputy Director, Bureau of Environmental Health Assessment to Bryan Olson, EPA, Region 1 regarding Remainder of data request with respect* to information gathered from questionnaires from Housatonic River Area Exposure Assessment Study as well as questionnaires completed after the study and resulting from calls to the Bureau of Environmental Health Assessment (BEHA) hotline.

Wester, R., H. Maibach, L. Sedik, K. Melendres, and M. Wade. 1993. Percutaneous absorption of PCBs from soil. *Journal of Environmental Toxicology and Environmental Health* 39:375-382.

Table 1b. RMCs for PCBs (mg/kg) in Soils for Target Risk Range and HI of 1
High-Use Recreational Areas
Adults

Parameter	EPA RME Analysis			EPA CTE Analysis		
Common Parameters						
Exposure duration (yrs)						
Adult	47	47	47	13	13	13
Body weight (kg)						
Adult	70	70	70	70	70	70
Averaging time - noncarcinogenic (days)						
Adult	17,155	17,155	17,155	4,745	4,745	4,745
Averaging time - carcinogenic (days)	25,550	25,550	25,550	25,550	25,550	25,550
Pathway Specific Parameters						
Incidental Ingestion of Soil						
Soil ingestion rate (mg/day)						
Adult	100	100	100	50	50	50
Fraction attributable to site	1.0	1.0	1.0	0.5	0.5	0.5
Conversion factor, soil ing (kg/mg)	1E-06	1E-06	1E-06	1E-06	1E-06	1E-06
Exposure frequency (days/year)	90	90	90	30	30	30
Exposure (soil ing)-carcinogenic $(days)^{-1}$	2.4E-07	2.4E-07	2.4E-07	5.5E-09	5.5E-09	5.5E-09
Exposure (soil ing)-noncarcinogenic $(days)^{-1}$	3.5E-07	3.5E-07	3.5E-07	2.9E-08	2.9E-08	2.9E-08
Dermal Contact with Soil						
Dermal adherence factor (mg/cm^2)						
Adult Warmer months	0.07	0.07	0.07	0.07	0.07	0.07
Cooler months	0.15	0.15	0.15	0.15	0.15	0.15
Skin surface area exposed (cm^2/day)						
Adult Warmer months	5700	5700	5700	5700	5700	5700
Cooler months	1306	1306	1306	1306	1306	1306
Activity duration for warmer months (months)	5	5	5	5	5	5
Activity duration for cooler months (months)	2	2	2	2	2	2
Dermal absorption factor (unitless)	0.14	0.14	0.14	0.14	0.14	0.14
Conversion factor, dermal con (kg/mg)	1.E-06	1.E-06	1.E-06	1.E-06	1.E-06	1.E-06
Exposure frequency (days/year)	90	90	90	30	30	30
Exposure (dermal con)-carcinogenic $(days)^{-1}$	1.1E-07	1.1E-07	1.1E-07	1.0E-08	1.0E-08	1.0E-08
Exposure (dermal con)-noncarcinogenic $(days)^{-1}$	1.7E-07	1.7E-07	1.7E-07	5.6E-08	5.6E-08	5.6E-08
CARCINOGENIC	**EPA RME Analysis**			**EPA CTE Analysis**		
Total Exposure, dermal contact $(days)^{-1}$	1.1E-07	1.1E-07	1.1E-07	1.0E-08	1.0E-08	1.0E-08
Total Exposure, soil ingestion $(days)^{-1}$	2.4E-07	2.4E-07	2.4E-07	5.5E-09	5.5E-09	5.5E-09
Cancer Slope Factor (CSF) $(mg/kg\text{-}day)^{-1}$	2	2	2	1	1	1
Target Risk Level	1.0E-04	1.0E-05	1.0E-06	1.0E-04	1.0E-05	1.0E-06
Risk-based Media Concentration (mg/kg)	**143**	**14**	**1.4**	**6305**	**630**	**63**
NONCARCINOGENIC	**Adult**			**Adult**		
Total Exposure, dermal contact $(days)^{-1}$	1.7E-07			5.6E-08		
Total Exposure, soil ingestion $(days)^{-1}$	3.5E-07			2.9E-08		
Reference Dose (RfD) (mg/kg-day)	2.00E-05			2.00E-05		
Target Hazard Index	1			1		
Risk-based Media Concentration (mg/kg)	**38**			**234**		

Table 1c. RMCs for PCBs (mg/kg) in Soils for Target Risk Range and HI of 1
High-Use Recreational Areas
Older Child

Parameter	EPA RME Analysis			EPA CTE Analysis		
Common Parameters						
Exposure duration (yrs)						
Older child	12	12	12	12	12	12
Body weight (kg)						
Older child	45	45	45	45	45	45
Averaging time - noncarcinogenic (days)						
Older child	4,380	4,380	4,380	4,380	4,380	4,380
Averaging time - carcinogenic (days)	25,550	25,550	25,550	25,550	25,550	25,550
Pathway Specific Parameters						
Incidental Ingestion of Soil						
Soil ingestion rate (mg/day)						
Older child	100	100	100	50	50	50
Fraction attributable to site	1.0	1.0	1.0	0.5	0.5	0.5
Conversion factor, soil ing (kg/mg)	1E-06	1E-06	1E-06	1E-06	1E-06	1E-06
Exposure frequency (days/year)	90	90	90	30	30	30
Exposure (soil ing)-carcinogenic $(days)^{-1}$	9.4E-08	9.4E-08	9.4E-08	7.8E-09	7.8E-09	7.8E-09
Exposure (soil ing)-noncarcinogenic $(days)^{-1}$	5.5E-07	5.5E-07	5.5E-07	4.6E-08	4.6E-08	4.6E-08
Dermal Contact with Soil						
Dermal adherence factor (mg/cm^2)						
Older child Warmer months	0.07	0.07	0.07	0.07	0.07	0.07
Cooler months	0.14	0.14	0.14	0.14	0.14	0.14
Skin surface area exposed (cm^2/day)						
Older child Warmer months	4400	4400	4400	4400	4400	4400
Cooler months	1125	1125	1125	1125	1125	1125
Activity duration for warmer months (months)	5	5	5	5	5	5
Activity duration for cooler months (months)	2	2	2	2	2	2
Dermal absorption factor (unitless)	0.14	0.14	0.14	0.14	0.14	0.14
Conversion factor, dermal con (kg/mg)	1.E-06	1.E-06	1.E-06	1.E-06	1.E-06	1.E-06
Exposure frequency (days/year)	90	90	90	30	30	30
Exposure (dermal con)-carcinogenic $(days)^{-1}$	3.5E-08	3.5E-08	3.5E-08	1.2E-08	1.2E-08	1.2E-08
Exposure (dermal con)-noncarcinogenic $(days)^{-1}$	2.0E-07	2.0E-07	2.0E-07	6.8E-08	6.8E-08	6.8E-08
CARCINOGENIC	**EPA RME Analysis**			**EPA CTE Analysis**		
Total Exposure, dermal contact $(days)^{-1}$	3.5E-08	3.5E-08	3.5E-08	1.2E-08	1.2E-08	1.2E-08
Total Exposure, soil ingestion $(days)^{-1}$	9.4E-08	9.4E-08	9.4E-08	7.8E-09	7.8E-09	7.8E-09
Cancer Slope Factor (CSF) $(mg/kg\text{-}day)^{-1}$	2	2	2	1	1	1
Target Risk Level	1.0E-04	1.0E-05	1.0E-06	1.0E-04	1.0E-05	1.0E-06
Risk-based Media Concentration (mg/kg)	**388**	**39**	**3.9**	**5143**	**514**	**51**
NONCARCINOGENIC	**Older Child**			**Older Child**		
Total Exposure, dermal contact $(days)^{-1}$	2.0E-07			6.8E-08		
Total Exposure, soil ingestion $(days)^{-1}$	5.5E-07			4.6E-08		
Reference Dose (RfD) (mg/kg-day)	2.00E-05			2.00E-05		
Target Hazard Index	1			1		
Risk-based Media Concentration (mg/kg)	**27**			**176**		

Table 1d. RMCs for PCBs (mg/kg) in Soils for Target Risk Range and HI of 1
High-Use Recreational Areas
Young Child - High Frequency

Parameter		EPA RME Analysis			EPA CTE Analysis		
Common Parameters							
Exposure duration (yrs)							
Young child		6	6	6	6	6	6
Body weight (kg)							
Young child		15	15	15	15	15	15
Averaging time - noncarcinogenic (days)							
Young child		2,190	2,190	2,190	2,190	2,190	2,190
Averaging time - carcinogenic (days)		25,550	25,550	25,550	25,550	25,550	25,550
Pathway Specific Parameters							
Incidental Ingestion of Soil							
Soil ingestion rate (mg/day)							
Young child		200	200	200	100	100	100
Fraction attributable to site		1.0	1.0	1.0	0.5	0.5	0.5
Conversion factor, soil ing (kg/mg)		1E-06	1E-06	1E-06	1E-06	1E-06	1E-06
Exposure frequency (days/year)		90	90	90	30	30	30
Exposure (soil ing)-carcinogenic $(days)^{-1}$		2.8E-07	2.8E-07	2.8E-07	2.3E-08	2.3E-08	2.3E-08
Exposure (soil ing)-noncarcinogenic $(days)^{-1}$		3.3E-06	3.3E-06	3.3E-06	2.7E-07	2.7E-07	2.7E-07
Dermal Contact with Soil							
Dermal adherence factor (mg/cm^2)							
Young child	Warmer months	0.2	0.2	0.2	0.2	0.2	0.2
	Cooler months	0.35	0.35	0.35	0.35	0.35	0.35
Skin surface area exposed (cm^2/day)							
Young child	Warmer months	2800	2800	2800	2800	2800	2800
	Cooler months	684	684	684	684	684	684
Activity duration for warmer months (months)		5	5	5	5	5	5
Activity duration for cooler months (months)		2	2	2	2	2	2
Dermal absorption factor (unitless)		0.14	0.14	0.14	0.14	0.14	0.14
Conversion factor, dermal con (kg/mg)		1.E-06	1.E-06	1.E-06	1.E-06	1.E-06	1.E-06
Exposure frequency (days/year)		90	90	90	30	30	30
Exposure (dermal con)-carcinogenic $(days)^{-1}$		9.2E-08	9.2E-08	9.2E-08	3.1E-08	3.1E-08	3.1E-08
Exposure (dermal con)-noncarcinogenic $(days)^{-1}$		1.1E-06	1.1E-06	1.1E-06	3.6E-07	3.6E-07	3.6E-07
CARCINOGENIC		**EPA RME Analysis**			**EPA CTE Analysis**		
Total Exposure, dermal contact $(days)^{-1}$		9.2E-08	9.2E-08	9.2E-08	3.1E-08	3.1E-08	3.1E-08
Total Exposure, soil ingestion $(days)^{-1}$		2.8E-07	2.8E-07	2.8E-07	2.3E-08	2.3E-08	2.3E-08
Cancer Slope Factor (CSF) $(mg/kg\text{-}day)^{-1}$		2	2	2	1	1	1
Target Risk Level		1.0E-04	1.0E-05	1.0E-06	1.0E-04	1.0E-05	1.0E-06
Risk-based Media Concentration (mg/kg)		**134**	**13**	**1.3**	**1842**	**184**	**18**
NONCARCINOGENIC		**Young Child**			**Young Child**		
Total Exposure, dermal contact $(days)^{-1}$		1.1E-06			3.6E-07		
Total Exposure, soil ingestion $(days)^{-1}$		3.3E-06			2.7E-07		
Reference Dose (RfD) (mg/kg-day)		2.00E-05			2.00E-05		
Target Hazard Index		1			1		
Risk-based Media Concentration (mg/kg)		**4.6**			**32**		

Table 1e. RMCs for PCBs (mg/kg) in Soils for Target Risk Range and HI of 1
High-Use Recreational Areas
Young Child - Alternative Frequency

Parameter		EPA RME Analysis			EPA CTE Analysis		
Common Parameters							
Exposure duration (yrs)							
Young child		6	6	6	6	6	6
Body weight (kg)							
Young child		15	15	15	15	15	15
Averaging time - noncarcinogenic (days)							
Young child		2,190	2,190	2,190	2,190	2,190	2,190
Averaging time - carcinogenic (days)		25,550	25,550	25,550	25,550	25,550	25,550
Pathway Specific Parameters							
Incidental Ingestion of Soil							
Soil ingestion rate (mg/day)							
Young child		200	200	200	100	100	100
Fraction attributable to site		1.0	1.0	1.0	0.5	0.5	0.5
Conversion factor, soil ing (kg/mg)		1E-06	1E-06	1E-06	1E-06	1E-06	1E-06
Exposure frequency (days/year)		15	15	15	15	15	15
Exposure (soil ing)-carcinogenic $(days)^{-1}$		4.7E-08	4.7E-08	4.7E-08	1.2E-08	1.2E-08	1.2E-08
Exposure (soil ing)-noncarcinogenic $(days)^{-1}$		5.5E-07	5.5E-07	5.5E-07	1.4E-07	1.4E-07	1.4E-07
Dermal Contact with Soil							
Dermal adherence factor (mg/cm^2)							
Young child	Warmer months	0.2	0.2	0.2	0.2	0.2	0.2
	Cooler months	0.35	0.35	0.35	0.35	0.35	0.35
Skin surface area exposed (cm^2/day)							
Young child	Warmer months	2800	2800	2800	2800	2800	2800
	Cooler months	684	684	684	684	684	684
Activity duration for warmer months (months)		5	5	5	5	5	5
Activity duration for cooler months (months)		2	2	2	2	2	2
Dermal absorption factor (unitless)		0.14	0.14	0.14	0.14	0.14	0.14
Conversion factor, dermal con (kg/mg)		1.E-06	1.E-06	1.E-06	1.E-06	1.E-06	1.E-06
Exposure frequency (days/year)		15	15	15	15	15	15
Exposure (dermal con)-carcinogenic $(days)^{-1}$		1.5E-08	1.5E-08	1.5E-08	1.5E-08	1.5E-08	1.5E-08
Exposure (dermal con)-noncarcinogenic $(days)^{-1}$		1.8E-07	1.8E-07	1.8E-07	1.8E-07	1.8E-07	1.8E-07
CARCINOGENIC		**EPA RME Analysis**			**EPA CTE Analysis**		
Total Exposure, dermal contact $(days)^{-1}$		1.5E-08	1.5E-08	1.5E-08	1.5E-08	1.5E-08	1.5E-08
Total Exposure, soil ingestion $(days)^{-1}$		4.7E-08	4.7E-08	4.7E-08	1.2E-08	1.2E-08	1.2E-08
Cancer Slope Factor (CSF) $(mg/kg\text{-}day)^{-1}$		2	2	2	1	1	1
Target Risk Level		1.0E-04	1.0E-05	1.0E-06	1.0E-04	1.0E-05	1.0E-06
Risk-based Media Concentration (mg/kg)		**802**	**80**	**8.0**	**3684**	**368**	**37**
NONCARCINOGENIC		**Young Child**			**Young Child**		
Total Exposure, dermal contact $(days)^{-1}$		1.8E-07			1.8E-07		
Total Exposure, soil ingestion $(days)^{-1}$		5.5E-07			1.4E-07		
Reference Dose (RfD) (mg/kg-day)		2.00E-05			2.00E-05		
Target Hazard Index		1			1		
Risk-based Media Concentration (mg/kg)		**27**			**63**		

Attachment 2
Risk-based Media Concentrations for Direct Contact with Floodplain Soil
In Medium Use Recreational Areas

A range of risk-based media concentrations (RMCs) has been developed for PCBs based on potential for direct contact with floodplain soil in medium use recreational areas. Consistent with the approach used in EPA's HHRA, potential soil ingestion and dermal contact exposures of older children and adults have been evaluated under reasonable maximum exposure (RME) and central tendency (CTE) conditions.

The RMCs for the cancer endpoint (RMC_{cancer}) and the noncancer endpoint ($RMC_{noncancer}$) for this scenario have been calculated using the following equations, respectively:

$$RMC_{cancer} = \frac{Risk}{CSF * \left(Exp_{ingestion} + Exp_{dermal}\right)}$$

Where:

RMC_{cancer}	=	RMC based on the cancer endpoint (mg/kg)
Risk	=	Target risk level (unitless)
CSF	=	Cancer slope factor $(mg/kg\text{-}day)^{-1}$
$Exp_{ingestion}$	=	Exposure due to the soil ingestion pathway (day^{-1})
Exp_{dermal}	=	Exposure due to dermal contact with soil (day^{-1})

And

$$RMC_{noncancer} = \frac{HI * RfD}{\left(Exp_{ingestion} + Exp_{dermal}\right)}$$

Where:

$RMC_{noncancer}$	=	RMC based on the noncancer endpoint (mg/kg)
HI	=	Target hazard index (unitless)
RfD	=	Reference dose (mg/kg-day)
$Exp_{ingestion}$	=	Exposure due to the soil ingestion pathway (day^{-1})
Exp_{dermal}	=	Exposure due to dermal contact with soil (day^{-1})

And

$$Exp_{ingestion} = \frac{IR * FI * CF * EF * ED}{AT * BW}$$

And

$$Exp_{dermal} = \frac{\left(\left(\left(AF_1 * SA_1 * AD_1\right) + \left(AF_2 * SA_2 * AD_2\right)\right)/\left(AD_1 + AD_2\right)\right) * ABS_d * CF * EF * ED}{AT * BW}$$

Where:

IR	=	Soil ingestion rate (mg/day)
FI	=	Fraction of soil ingested that is attributable to the Site (unitless)
AF_1	=	Dermal adherence factor during the warmer months (mg/cm^2)
AF_2	=	Dermal adherence factor during the cooler months (mg/cm^2)
SA_1	=	Skin surface area exposed during the warmer months (cm^2/day)
SA_2	=	Skin surface area exposed during the cooler months (cm^2/day)
AD_1	=	Activity duration for the warmer months (months)
AD_2	=	Activity duration for the cooler months (months)
ABS_d	=	Dermal absorption factor (unitless)
CF	=	Unit conversion factor (1E-06 kg/mg)
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)
AT	=	Averaging time (days)
BW	=	Age-specific body weight (kg)

Specific exposure assumptions used for each age group in this analysis, and the basis of each, are summarized in Table 2a. In all cases, the assumptions and parameters used are the same as those used by EPA in its 2005 HHRA.

Standard EPA toxicity values have been used for PCBs. These include a cancer slope factor (CSF) of 2 $(mg/kg\text{-}day)^{-1}$ for the RME scenario, a CSF of 1 $(mg/kg\text{-}day)^{-1}$ for the CTE scenario, and a chronic reference dose of 2E-05 mg/kg-day for both the RME and CTE analyses. These values are published in EPA's IRIS database and were used in EPA's HHRA.

RMCs based on potential carcinogenic effects have been developed for both the RME and CTE exposure scenarios using a range of target risks from one-in-a-million ($1x10^{-6}$) to one-in-ten-thousand ($1x10^{-4}$). This risk range is consistent with EPA's acceptable risk range. A single RMC for noncancer effects has been developed for each of the RME and CTE scenarios based on a target hazard index (HI) of 1.

Summary of Results

Estimated RMCs for cancer and non-cancer endpoints are presented in the following tables for adults (Table 2b) and older children (Table 2c). For each of these receptors, the calculated RMCs are as follows.

	RME				**CTE**			
	Cancer Risk			**Noncancer**	**Cancer Risk**			**Noncancer**
	$1x10^{-6}$	**$1x10^{-5}$**	**$1x10^{-4}$**	**HI = 1**	**$1x10^{-6}$**	**$1x10^{-5}$**	**$1x10^{-4}$**	**HI = 1**
Adults	2.1	21	215	58	63	630	6,305	234
Older Child	5.8	58	582	40	51	514	5,143	176

Table 2a. Summary of Pathway- and Age-Specific Exposure Assumptions Used in the Medium-Use Recreational Scenario

Parameters	Units	Symbol	RME	CTE	Basis*
Common Parameters					
Unit conversion factor	kg/mg	CF	1.0E-06	1.0E-06	HHRA, Vol. IIIA. Table 4-12.
Exposure frequency	days/year	EF			
Older child			60	30	HHRA, Vol. IIIA; Table 4-22; EPA's professional judgment.
Adult			60	30	HHRA, Vol. IIIA; Table 4-22; EPA's professional judgment.
Exposure duration	years	ED			
Older child			12	12	HHRA, Vol. IIIA; Table 4-23; Aged 7 to 18 years. Based on MDPH, 2001.
Adult			47	13	HHRA, Vol. IIIA; Table 4-23; Aged 19-65 years (RME); 19-31 years (CTE). Based on MDPH, 2001.
Body weight	kg	BW			
Older child			45	45	HHRA, Vol. IIIA; Table 4-6; based on EPA, 1989. Average age specific body weight.
Adult			70	70	HHRA, Vol. IIIA; Table 4-6; based on EPA, 1989. Average age specific body weight.
Averaging time (cancer endpoint)	days	ATc	25,550	25,550	HHRA, Vol. IIIA; Table 4-6; based on EPA 1989. Lifetime of 70 years x 365 days/year.
Averaging time (noncancer endpoint)	days	ATnc			
Older child			4,380	4,380	HHRA, Vol. IIIA. Table 4-6; Based on EPA, 1989. Equivalent to duration in years x 365 days/year.
Adult			17,155	4,745	HHRA, Vol. IIIA. Table 4-6; Based on EPA, 1989. Equivalent to duration in years x 365 days/year.
Soil Ingestion Pathway					
Soil ingestion rate	mg/day	IR			
Older child			100	50	HHRA, Vol. IIIA; Tables 4-12 and 4-24; Section 4.5.2.3. Based on EPA 1991 and 1997.
Adult			100	50	HHRA, Vol. IIIA; Tables 4-12 and 4-24; Section 4.5.2.3. Based on EPA 1991 and 1997.
Fraction of ingested soil attributable to site	unitless	FI	1.0	0.5	HHRA, Vol. IIIA; Table 4-12; Section 4.5.1.3. EPA's professional judgment.
Dermal Exposure Pathway					
Dermal adherence factor (warmer months)	mg/cm^2	AF_1			
Older child			0.07	0.07	HHRA, Vol. IIIA; Table 4-26; Section 4.5.2.4.2. Gardeners, weighted by exposed body area.
Adult			0.07	0.07	HHRA, Vol. IIIA; Table 4-26; Section 4.5.2.4.2. Gardeners, weighted by exposed body area.
Dermal adherence factor (cooler months)	mg/cm^2	AF_2			
Older child			0.14	0.14	HHRA, Vol. IIIA; Table 4-26; Section 4.5.2.4.2. Gardeners, weighted by exposed body area.
Adult			0.15	0.15	HHRA, Vol. IIIA; Table 4-26; Section 4.5.2.4.2. Gardeners, weighted by exposed body area.
Skin surface area (warmer months)	cm^2/day	SA_1			
Older child			4,400	4,400	HHRA, Vol. IIIA; Tables 4-25 and 4-26; Hands, forearms, lower legs, and head.
Adult			5,700	5,700	HHRA, Vol. IIIA; Tables 4-25 and 4-26; Hands, forearms, lower legs, and head.
Skin surface area (cooler months)	cm^2/day	SA_2			
Older child			1,125	1,125	HHRA, Vol. IIIA; Tables 4-25 and 4-26. Section 4.5.2.4.1. Hands and face.
Adult			1,306	1,306	HHRA, Vol. IIIA; Tables 4-25 and 4-26. Section 4.5.2.4.1. Hands and face.
Activity duration (warmer months)	months	AD_1	5	5	HHRA, Vol. IIIA; Table 4-12; EPA's professional judgment. May through September.
Activity duration (cooler months)	months	AD_2	2	2	HHRA, Vol. IIIA; Table 4-12; EPA's professional judgment. April and October.
Dermal absorption factor	unitless	ABS_d	0.14	0.14	HHRA, Vol. IIIA; Table 4-12, Page 4-38; Wester et al. 1993.

* All exposure parameters are identical to the parameters used in the HHRA (EPA, 2005). Volume and Table and/or Section numbers provided.

EPA 1989. *Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual (Part A) Interim Final.*

EPA 1991. *Risk Assessment Guidance for Superfund, Volume I; Human Health Evaluation Manual, Supplemental Guidance, Standard Default Exposure Assumptions.*

EPA 1997. *Exposure Factors Handbook, Volume I; General Factors.*

MDPH 2001. *Memo from Martha Steele, Deputy Director, Bureau of Environmental Health Assessment to Bryan Olson, EPA, Region 1 regarding Remainder of data request with respect* to information gathered from questionnaires from Housatonic River Area Exposure Assessment Study as well as questionnaires completed after the study and resulting from calls to the Bureau of Environmental Health Assessment (BEHA) hotline.

Wester, R., H. Maibach, L. Sedik, K. Melendres, and M. Wade. 1993. Percutaneous absorption of PCBs from soil. *Journal of Environmental Toxicology and Environmental Health* 39:375-382.

Table 2b. RMCs for PCBs (mg/kg) in Soils for Target Risk Range and HI of 1
Medium-Use Recreational Areas
Adults

Parameter		EPA RME Analysis			EPA CTE Analysis		
Common Parameters							
Exposure duration (yrs)							
Adult		47	47	47	13	13	13
Body weight (kg)							
Adult		70	70	70	70	70	70
Averaging time - noncarcinogenic (days)							
Adult		17,155	17,155	17,155	4,745	4,745	4,745
Averaging time - carcinogenic (days)		25,550	25,550	25,550	25,550	25,550	25,550
Pathway Specific Parameters							
Incidental Ingestion of Soil							
Soil ingestion rate (mg/day)							
Adult		100	100	100	50	50	50
Fraction attributable to site		1.0	1.0	1.0	0.5	0.5	0.5
Conversion factor, soil ing (kg/mg)		1E-06	1E-06	1E-06	1E-06	1E-06	1E-06
Exposure frequency (days/year)		60	60	60	30	30	30
Exposure (soil ing)-carcinogenic $(days)^{-1}$		1.6E-07	1.6E-07	1.6E-07	5.5E-09	5.5E-09	5.5E-09
Exposure (soil ing)-noncarcinogenic $(days)^{-1}$		2.3E-07	2.3E-07	2.3E-07	2.9E-08	2.9E-08	2.9E-08
Dermal Contact with Soil							
Dermal adherence factor (mg/cm^2)							
Adult	Warmer months	0.07	0.07	0.07	0.07	0.07	0.07
	Cooler months	0.15	0.15	0.15	0.15	0.15	0.15
Skin surface area exposed (cm^2/day)							
Adult	Warmer months	5700	5700	5700	5700	5700	5700
	Cooler months	1306	1306	1306	1306	1306	1306
Activity duration for warmer months (months)		5	5	5	5	5	5
Activity duration for cooler months (months)		2	2	2	2	2	2
Dermal absorption factor (unitless)		0.14	0.14	0.14	0.14	0.14	0.14
Conversion factor, dermal con (kg/mg)		1.E-06	1.E-06	1.E-06	1.E-06	1.E-06	1.E-06
Exposure frequency (days/year)		60	60	60	30	30	30
Exposure (dermal con)-carcinogenic $(days)^{-1}$		7.5E-08	7.5E-08	7.5E-08	1.0E-08	1.0E-08	1.0E-08
Exposure (dermal con)-noncarcinogenic $(days)^{-1}$		1.1E-07	1.1E-07	1.1E-07	5.6E-08	5.6E-08	5.6E-08
CARCINOGENIC		**EPA RME Analysis**			**EPA CTE Analysis**		
Total Exposure, dermal contact $(days)^{-1}$		7.5E-08	7.5E-08	7.5E-08	1.0E-08	1.0E-08	1.0E-08
Total Exposure, soil ingestion $(days)^{-1}$		1.6E-07	1.6E-07	1.6E-07	5.5E-09	5.5E-09	5.5E-09
Cancer Slope Factor (CSF) $(mg/kg\text{-}day)^{-1}$		2	2	2	1	1	1
Target Risk Level		1.0E-04	1.0E-05	1.0E-06	1.0E-04	1.0E-05	1.0E-06
Risk-based Media Concentrations (mg/kg)		**215**	**21**	**2.1**	**6305**	**630**	**63**
NONCARCINOGENIC		**Adult**			**Adult**		
Total Exposure, dermal contact $(days)^{-1}$		1.1E-07			5.6E-08		
Total Exposure, soil ingestion $(days)^{-1}$		2.3E-07			2.9E-08		
Reference Dose (RfD) (mg/kg-day)		2.00E-05			2.00E-05		
Target Hazard Index		1			1		
Risk-based Media Concentrations (mg/kg)		**58**			**234**		

Table 2c. RMCs for PCBs (mg/kg) in Soils for Target Risk Range and HI of 1
Medium-Use Recreational Areas
Older Child

Parameter		EPA RME Analysis			EPA CTE Analysis		
Common Parameters							
Exposure duration (yrs)							
Older child		12	12	12	12	12	12
Body weight (kg)							
Older child		45	45	45	45	45	45
Averaging time - noncarcinogenic (days)							
Older child		4,380	4,380	4,380	4,380	4,380	4,380
Averaging time - carcinogenic (days)		25,550	25,550	25,550	25,550	25,550	25,550
Pathway Specific Parameters							
Incidental Ingestion of Soil							
Soil ingestion rate (mg/day)							
Older child		100	100	100	50	50	50
Fraction attributable to site		1.0	1.0	1.0	0.5	0.5	0.5
Conversion factor, soil ing (kg/mg)		1E-06	1E-06	1E-06	1E-06	1E-06	1E-06
Exposure frequency (days/year)		60	60	60	30	30	30
Exposure (soil ing)-carcinogenic (days)$^{-1}$		6.3E-08	6.3E-08	6.3E-08	7.8E-09	7.8E-09	7.8E-09
Exposure (soil ing)-noncarcinogenic (days)$^{-1}$		3.7E-07	3.7E-07	3.7E-07	4.6E-08	4.6E-08	4.6E-08
Dermal Contact with Soil							
Dermal adherence factor (mg/cm^2)							
Older child	Warmer months	0.07	0.07	0.07	0.07	0.07	0.07
	Cooler months	0.14	0.14	0.14	0.14	0.14	0.14
Skin surface area exposed (cm^2/day)							
Older child	Warmer months	4400	4400	4400	4400	4400	4400
	Cooler months	1125	1125	1125	1125	1125	1125
Activity duration for warmer months (months)		5	5	5	5	5	5
Activity duration for cooler months (months)		2	2	2	2	2	2
Dermal absorption factor (unitless)		0.14	0.14	0.14	0.14	0.14	0.14
Conversion factor, dermal con (kg/mg)		1.E-06	1.E-06	1.E-06	1.E-06	1.E-06	1.E-06
Exposure frequency (days/year)		60	60	60	30	30	30
Exposure (dermal con)-carcinogenic (days)$^{-1}$		2.3E-08	2.3E-08	2.3E-08	1.2E-08	1.2E-08	1.2E-08
Exposure (dermal con)-noncarcinogenic (days)$^{-1}$		1.4E-07	1.4E-07	1.4E-07	6.8E-08	6.8E-08	6.8E-08
CARCINOGENIC		**EPA RME Analysis**			**EPA CTE Analysis**		
Total Exposure, dermal contact (days)$^{-1}$		2.3E-08	2.3E-08	2.3E-08	1.2E-08	1.2E-08	1.2E-08
Total Exposure, soil ingestion (days)$^{-1}$		6.3E-08	6.3E-08	6.3E-08	7.8E-09	7.8E-09	7.8E-09
Cancer Slope Factor (CSF) (mg/kg-day)$^{-1}$		2	2	2	1	1	1
Target Risk Level		1.0E-04	1.0E-05	1.0E-06	1.0E-04	1.0E-05	1.0E-06
Risk-based Media Concentrations (mg/kg)		**582**	**58**	**5.8**	**5143**	**514**	**51**
NONCARCINOGENIC		**EPA RME Analysis**			**EPA CTE Analysis**		
Total Exposure, dermal contact (days)$^{-1}$		1.4E-07			6.8E-08		
Total Exposure, soil ingestion (days)$^{-1}$		3.7E-07			4.6E-08		
Reference Dose (RfD) (mg/kg-day)		2.00E-05			2.00E-05		
Target Hazard Index		1			1		
Risk-based Media Concentrations (mg/kg)		**40**			**176**		

Attachment 3
Risk-based Media Concentrations for Direct Contact With Floodplain Soil
In Low-Use Recreational Areas

A range of risk-based media concentrations (RMCs) has been developed for PCBs based on potential for direct contact with floodplain soil in low-use recreational areas. Consistent with the approach used in EPA's HHRA, potential soil ingestion and dermal contact exposures of older children and adults have been evaluated under reasonable maximum exposure (RME) and central tendency exposure (CTE) conditions. For each age group and set of exposure conditions, RMCs have been calculated based both on potential cancer risks and on potential non-cancer impacts, using the exposure assumptions and toxicity values used in the HHRA.

The RMCs for the cancer endpoint (RMC_{cancer}) and the non-cancer endpoint ($RMC_{noncancer}$) for this scenario have been calculated using the following equations, respectively:

$$RMC_{cancer} = \frac{Risk}{CSF * \left(Exp_{ingestion} + Exp_{dermal}\right)}$$

Where:

RMC_{cancer}	=	RMC based on the cancer endpoint (mg/kg)
Risk	=	Target risk level (unitless)
CSF	=	Cancer slope factor $(mg/kg\text{-}day)^{-1}$
$Exp_{ingestion}$	=	Exposure due to the soil ingestion pathway (day^{-1})
Exp_{dermal}	=	Exposure due to dermal contact with soil (day^{-1})

And

$$RMC_{noncancer} = \frac{HI * RfD}{\left(Exp_{ingestion} + Exp_{dermal}\right)}$$

Where:

$RMC_{noncancer}$	=	RMC based on the non-cancer endpoint (mg/kg)
HI	=	Target hazard index (unitless)
RfD	=	Reference dose (mg/kg-day)
$Exp_{ingestion}$	=	Exposure due to the soil ingestion pathway (day^{-1})
Exp_{dermal}	=	Exposure due to dermal contact with soil (day^{-1})

In both of the above equations, the exposures due to soil ingestion ($Exp_{ingestion}$) and dermal contact with soil (Exp_{dermal}) have been calculated using the following equations:

$$Exp_{ingestion} = \frac{IR * FI * CF * EF * ED}{AT * BW}$$

And

$$Exp_{dermal} = \frac{\left(\left(\left(AF_1 * SA_1 * AD_1\right) + \left(AF_2 * SA_2 * AD_2\right)\right)/\left(AD_1 + AD_2\right)\right) * ABS_d * CF * EF * ED}{AT * BW}$$

Where:

IR	=	Soil ingestion rate (mg/day)
FI	=	Fraction of soil ingested that is attributable to the Site (unitless)
AF_1	=	Dermal adherence factor during the warmer months (mg/cm^2)
AF_2	=	Dermal adherence factor during the cooler months (mg/cm^2)
SA_1	=	Skin surface area exposed during the warmer months (cm^2/day)
SA_2	=	Skin surface area exposed during the cooler months (cm^2/day)
AD_1	=	Activity duration for the warmer months (months)
AD_2	=	Activity duration for the cooler months (months)
ABS_d	=	Dermal absorption factor (unitless)
CF	=	Unit conversion factor (1E-06 kg/mg)
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)
AT	=	Averaging time (days)
BW	=	Age-specific body weight (kg)

The specific exposure assumptions used for each age group in this analysis, and the basis of each, are summarized in Table 2a. In all cases, the assumptions and parameters used are the same as those used by EPA in its 2005 HHRA.

Standard EPA toxicity values have been used for PCBs. These include a cancer slope factor (CSF) of 2 $(mg/kg\text{-}day)^{-1}$ for the RME scenario, a CSF of 1 $(mg/kg\text{-}day)^{-1}$ for the CTE scenario, and a chronic reference dose of 2E-05 mg/kg-day for both the RME and CTE analyses. These values are published in EPA's IRIS database and were used in EPA's HHRA.

Consistent with the HHRA, separate cancer-based and non-cancer-based RMCs have been developed for each relevant age group. The RMCs based on potential carcinogenic effects have been developed for both the RME and CTE exposure scenarios using a range of target risks from one-in-a-million ($1x10^{-6}$) to one-in-ten-thousand ($1x10^{-4}$). This risk range is consistent with EPA's acceptable risk range. RMCs for non-cancer effects have been developed for each of the RME and CTE scenarios based on a target Hazard Index of 1.

Summary of Results

Estimated RMCs for cancer and non-cancer endpoints are presented in the following tables for adults (Table 3b) and older children (Table 3c). For each of these receptors, the calculated RMCs are as follows.

	RME (mg/kg)				**CTE (mg/kg)**			
	Cancer Risk			**Non-cancer**	**Cancer Risk**			**Non-cancer**
	$1x10^{-6}$	**$1x10^{-5}$**	**$1x10^{-4}$**	**HI = 1**	**$1x10^{-6}$**	**$1x10^{-5}$**	**$1x10^{-4}$**	**HI = 1**
Adults	4.3	43	429	115	126	1,261	12,610	468
Older Child	12	116	1,165	80	103	1,029	10286	353

Table 3a. Summary of Pathway- and Age-Specific Exposure Assumptions Used in the Low-Use Recreational Scenario

Parameters	Units	Symbol	RME	CTE	Basis*
Common Parameters					
Unit conversion factor	kg/mg	CF	1.0E-06	1.0E-06	HHRA, Vol. IIIA. Table 4-12.
Exposure frequency	days/year	EF			
Older child			30	15	HHRA, Vol. IIIA; Table 4-22; EPA's professional judgment
Adult			30	15	HHRA, Vol. IIIA; Table 4-22; EPA's professional judgment
Exposure duration	years	ED			
Older child			12	12	HHRA, Vol. IIIA; Table 4-23; Aged 7 to 18 years. Based on MDPH, 2001.
Adult			47	13	HHRA, Vol. IIIA; Table 4-23; Aged 19 to 65 years (RME); 19 to 31 years (CTE). Based on MDPH, 2001.
Body weight	kg	BW			
Older child			45	45	HHRA, Vol. IIIA; Table 4-6; based on EPA, 1989. Average age specific body weight.
Adult			70	70	HHRA, Vol. IIIA; Table 4-6; based on EPA, 1989. Average age specific body weight.
Averaging time (cancer endpoint)	days	ATc	25,550	25,550	HHRA, Vol. IIIA; Table 4-6; based on EPA 1989. Lifetime of 70 years x 365 days/year.
Averaging time (noncancer endpoint)	days	ATnc			
Older child			4,380	4,380	HHRA, Vol. IIIA. Table 4-6; Based on EPA, 1989. Equivalent to duration in years x 365 days/year.
Adult			17,155	4,745	HHRA, Vol. IIIA. Table 4-6; Based on EPA, 1989. Equivalent to duration in years x 365 days/year.
Soil Ingestion Pathway					
Soil ingestion rate	mg/day	IR			
Older child			100	50	HHRA, Vol. IIIA; Tables 4-12 and 4-24; Section 4.5.2.3. Based on EPA 1991 and 1997.
Adult			100	50	HHRA, Vol. IIIA; Tables 4-12 and 4-24; Section 4.5.2.3. Based on EPA 1991 and 1997.
Fraction of ingested soil attributable to site	unitless	FI	1.0	0.5	HHRA, Vol. IIIA; Table 4-12; Section 4.5.1.3. EPA's professional judgment.
Dermal Exposure Pathway					
Dermal adherence factor (warmer months)	mg/cm^2	AF_1			
Older child			0.07	0.07	HHRA, Vol. IIIA; Table 4-26; Section 4.5.2.4.2. Gardeners, weighted by exposed body area.
Adult			0.07	0.07	HHRA, Vol. IIIA; Table 4-26; Section 4.5.2.4.2. Gardeners, weighted by exposed body area.
Dermal adherence factor (cooler months)	mg/cm^2	AF_2			
Older child			0.14	0.14	HHRA, Vol. IIIA; Table 4-26; Section 4.5.2.4.2. Gardeners, weighted by exposed body area.
Adult			0.15	0.15	HHRA, Vol. IIIA; Table 4-26; Section 4.5.2.4.2. Gardeners, weighted by exposed body area.
Skin surface area (warmer months)	cm^2/day	SA_1			
Older child			4,400	4,400	HHRA, Vol. IIIA; Tables 4-25 and 4-26; Hands, forearms, lower legs, and head
Adult			5,700	5,700	HHRA, Vol. IIIA; Tables 4-25 and 4-26; Hands, forearms, lower legs, and head
Skin surface area (cooler months)	cm^2/day	SA_2			
Older child			1,125	1,125	HHRA, Vol. IIIA; Tables 4-25 and 4-26. Section 4.5.2.4.1. Hands and face.
Adult			1,306	1,306	HHRA, Vol. IIIA; Tables 4-25 and 4-26. Section 4.5.2.4.1. Hands and face.
Activity duration (warmer months)	months	AD_1	5	5	HHRA, Vol. IIIA; Table 4-12; EPA's professional judgment. May through September.
Activity duration (cooler months)	months	AD_2	2	2	HHRA, Vol. IIIA; Table 4-12; EPA's professional judgment. April and October.
Dermal absorption factor	unitless	ABS_d	0.14	0.14	HHRA, Vol. IIIA; Table 4-12, Page 4-38; Wester et al. 1993.

* All exposure parameters are identical to the parameters used in the HHRA (EPA, 2005). Volume and Table and/or Section numbers provided.

EPA 1989. *Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual (Part A) Interim Final.*

EPA 1991. *Risk Assessment Guidance for Superfund, Volume I; Human Health Evaluation Manual, Supplemental Guidance, Standard Default Exposure Assumptions.*

EPA 1997. *Exposure Factors Handbook, Volume I; General Factors.*

MDPH 2001. *Memo from Martha Steele, Deputy Director, Bureau of Environmental Health Assessment to Bryan Olson, EPA, Region 1 regarding Remainder of data request with respect* to information gathered from questionnaires from Housatonic River Area Exposure Assessment Study as well as questionnaires completed after the study and resulting from calls to the Bureau of Environmental Health Assessment (BEHA) hotline.

Wester, R., H. Maibach, L. Sedik, K. Melendres, and M. Wade. 1993. Percutaneous absorption of PCBs from soil. *Journal of Environmental Toxicology and Environmental Health* 39:375-382.

Table 3b. RMCs for PCBs (mg/kg) in Soils for Target Risk Range and HI of 1
Low-Use Recreational Areas
Adults

Parameter		EPA RME Analysis			EPA CTE Analysis		
Common Parameters							
Exposure duration (yrs)							
Adult		47	47	47	13	13	13
Body weight (kg)							
Adult		70	70	70	70	70	70
Averaging time - noncarcinogenic (days)							
Adult		17,155	17,155	17,155	4,745	4,745	4,745
Averaging time - carcinogenic (days)		25,550	25,550	25,550	25,550	25,550	25,550
Pathway Specific Parameters							
Incidental Ingestion of Soil							
Soil ingestion rate (mg/day)							
Adult		100	100	100	50	50	50
Fraction attributable to site		1.0	1.0	1.0	0.5	0.5	0.5
Conversion factor, soil ing (kg/mg)		1E-06	1E-06	1E-06	1E-06	1E-06	1E-06
Exposure frequency (days/year)		30	30	30	15	15	15
Exposure (soil ing)-carcinogenic $(days)^{-1}$		7.9E-08	7.9E-08	7.9E-08	2.7E-09	2.7E-09	2.7E-09
Exposure (soil ing)-noncarcinogenic $(days)^{-1}$		1.2E-07	1.2E-07	1.2E-07	1.5E-08	1.5E-08	1.5E-08
Dermal Contact with Soil							
Dermal adherence factor (mg/cm^2)							
Adult	Warmer months	0.07	0.07	0.07	0.07	0.07	0.07
	Cooler months	0.15	0.15	0.15	0.15	0.15	0.15
Skin surface area exposed (cm^2/day)							
Adult	Warmer months	5700	5700	5700	5700	5700	5700
	Cooler months	1306	1306	1306	1306	1306	1306
Activity duration for warmer months (months)		5	5	5	5	5	5
Activity duration for cooler months (months)		2	2	2	2	2	2
Dermal absorption factor (unitless)		0.14	0.14	0.14	0.14	0.14	0.14
Conversion factor, dermal con (kg/mg)		1.E-06	1.E-06	1.E-06	1.E-06	1.E-06	1.E-06
Exposure frequency (days/year)		30	30	30	15	15	15
Exposure (dermal con)-carcinogenic $(days)^{-1}$		3.8E-08	3.8E-08	3.8E-08	5.2E-09	5.2E-09	5.2E-09
Exposure (dermal con)-noncarcinogenic $(days)^{-1}$		5.6E-08	5.6E-08	5.6E-08	2.8E-08	2.8E-08	2.8E-08
CARCINOGENIC		**EPA RME Analysis**			**EPA CTE Analysis**		
Total Exposure, dermal contact $(days)^{-1}$		3.8E-08	3.8E-08	3.8E-08	5.2E-09	5.2E-09	5.2E-09
Total Exposure, soil ingestion $(days)^{-1}$		7.9E-08	7.9E-08	7.9E-08	2.7E-09	2.7E-09	2.7E-09
Cancer Slope Factor (CSF) $(mg/kg\text{-}day)^{-1}$		2	2	2	1	1	1
Target Risk Level		1.0E-04	1.0E-05	1.0E-06	1.0E-04	1.0E-05	1.0E-06
Risk-based Media Concentration (mg/kg)		**429**	**43**	**4.3**	**12610**	**1261**	**126**
NONCARCINOGENIC		**Adult**			**Adult**		
Total Exposure, dermal contact $(days)^{-1}$		5.6E-08			2.8E-08		
Total Exposure, soil ingestion $(days)^{-1}$		1.2E-07			1.5E-08		
Reference Dose (RfD) (mg/kg-day)		2.00E-05			2.00E-05		
Target Hazard Index		1			1		
Risk-based Media Concentration (mg/kg)		**115**			**468**		

Table 3c. RMCs for PCBs (mg/kg) in Soils for Target Risk Range and HI of 1
Low-Use Recreational Areas
Older Child

Parameter		EPA RME Analysis			EPA CTE Analysis		
Common Parameters							
Exposure duration (yrs)							
Older child		12	12	12	12	12	12
Body weight (kg)							
Older child		45	45	45	45	45	45
Averaging time - noncarcinogenic (days)							
Older child		4,380	4,380	4,380	4,380	4,380	4,380
Averaging time - carcinogenic (days)		25,550	25,550	25,550	25,550	25,550	25,550
Pathway Specific Parameters							
Incidental Ingestion of Soil							
Soil ingestion rate (mg/day)							
Older child		100	100	100	50	50	50
Fraction attributable to site		1.0	1.0	1.0	0.5	0.5	0.5
Conversion factor, soil ing (kg/mg)		1E-06	1E-06	1E-06	1E-06	1E-06	1E-06
Exposure frequency (days/year)		30	30	30	15	15	15
Exposure (soil ing)-carcinogenic (days)$^{-1}$		3.1E-08	3.1E-08	3.1E-08	3.9E-09	3.9E-09	3.9E-09
Exposure (soil ing)-noncarcinogenic (days)$^{-1}$		1.8E-07	1.8E-07	1.8E-07	2.3E-08	2.3E-08	2.3E-08
Dermal Contact with Soil							
Dermal adherence factor (mg/cm^2)							
Older child	Warmer months	0.07	0.07	0.07	0.07	0.07	0.07
	Cooler months	0.14	0.14	0.14	0.14	0.14	0.14
Skin surface area exposed (cm^2/day)							
Older child	Warmer months	4400	4400	4400	4400	4400	4400
	Cooler months	1125	1125	1125	1125	1125	1125
Activity duration for warmer months (months)		5	5	5	5	5	5
Activity duration for cooler months (months)		2	2	2	2	2	2
Dermal absorption factor (unitless)		0.14	0.14	0.14	0.14	0.14	0.14
Conversion factor, dermal con (kg/mg)		1.E-06	1.E-06	1.E-06	1.E-06	1.E-06	1.E-06
Exposure frequency (days/year)		30	30	30	15	15	15
Exposure (dermal con)-carcinogenic (days)$^{-1}$		1.2E-08	1.2E-08	1.2E-08	5.8E-09	5.8E-09	5.8E-09
Exposure (dermal con)-noncarcinogenic (days)$^{-1}$		6.8E-08	6.8E-08	6.8E-08	3.4E-08	3.4E-08	3.4E-08
CARCINOGENIC		**EPA RME Analysis**			**EPA CTE Analysis**		
Total Exposure, dermal contact (days)$^{-1}$		1.2E-08	1.2E-08	1.2E-08	5.8E-09	5.8E-09	5.8E-09
Total Exposure, soil ingestion (days)$^{-1}$		3.1E-08	3.1E-08	3.1E-08	3.9E-09	3.9E-09	3.9E-09
Cancer Slope Factor (CSF) (mg/kg-day)$^{-1}$		2	2	2	1	1	1
Target Risk Level		1.0E-04	1.0E-05	1.0E-06	1.0E-04	1.0E-05	1.0E-06
Risk-based Media Concentration (mg/kg)		**1165**	**116**	**12**	**10286**	**1029**	**103**
NONCARCINOGENIC		**Older Child**			**Older Child**		
Total Exposure, dermal contact (days)$^{-1}$		6.8E-08			3.4E-08		
Total Exposure, soil ingestion (days)$^{-1}$		1.8E-07			2.3E-08		
Reference Dose (RfD) (mg/kg-day)		2.00E-05			2.00E-05		
Target Hazard Index		1			1		
Risk-based Media Concentration (mg/kg)		**80**			**353**		

Attachment 4
Risk-based Media Concentrations for Direct Contact With Floodplain Soil
In the Bank Fishing Scenario

A range of risk-based media concentrations (RMCs) has been developed for PCBs based on potential for direct contact with floodplain soil during the bank fishing (angler) scenario. Consistent with the approach used in EPA's HHRA, potential soil ingestion and dermal contact exposures of older children and adults have been evaluated under reasonable maximum exposure (RME) and central tendency exposure (CTE) conditions. For each age group and set of exposure conditions, RMCs have been calculated based both on potential cancer risks and on potential non-cancer impacts, using the exposure assumptions and toxicity values used in the HHRA.

The RMCs for the cancer endpoint (RMC_{cancer}) and the non-cancer endpoint ($RMC_{noncancer}$) for this scenario have been calculated using the following equations, respectively:

$$RMC_{cancer} = \frac{Risk}{CSF * \left(Exp_{ingestion} + Exp_{dermal}\right)}$$

Where:

RMC_{cancer}	=	RMC based on the cancer endpoint (mg/kg)
Risk	=	Target risk level (unitless)
CSF	=	Cancer slope factor $(mg/kg\text{-}day)^{-1}$
$Exp_{ingestion}$	=	Exposure due to the soil ingestion pathway (day^{-1})
Exp_{dermal}	=	Exposure due to dermal contact with soil (day^{-1})

And

$$RMC_{noncancer} = \frac{HI * RfD}{\left(Exp_{ingestion} + Exp_{dermal}\right)}$$

Where:

$RMC_{noncancer}$	=	RMC based on the non-cancer endpoint (mg/kg)
HI	=	Target hazard index (unitless)
RfD	=	Reference dose (mg/kg-day)
$Exp_{ingestion}$	=	Exposure due to the soil ingestion pathway (day^{-1})
Exp_{dermal}	=	Exposure due to dermal contact with soil (day^{-1})

In both of the above equations, the exposures due to soil ingestion ($Exp_{ingestion}$) and dermal contact with soil (Exp_{dermal}) have been calculated using the following equations:

$$Exp_{ingestion} = \frac{IR * FI * CF * EF * ED}{AT * BW}$$

And

$$Exp_{dermal} = \frac{\left(\left(\left(AF_1 * SA_1 * AD_1\right) + \left(AF_2 * SA_2 * AD_2\right)\right)/\left(AD_1 + AD_2\right)\right) * ABS_d * CF * EF * ED}{AT * BW}$$

Where:

IR	=	Soil ingestion rate (mg/day)
FI	=	Fraction of soil ingested that is attributable to the Site (unitless)
AF_1	=	Dermal adherence factor during the warmer months (mg/cm^2)
AF_2	=	Dermal adherence factor during the cooler months (mg/cm^2)
SA_1	=	Skin surface area exposed during the warmer months (cm^2/day)
SA_2	=	Skin surface area exposed during the cooler months (cm^2/day)
AD_1	=	Activity duration for the warmer months (months)
AD_2	=	Activity duration for the cooler months (months)
ABS_d	=	Dermal absorption factor (unitless)
CF	=	Unit conversion factor (1E-06 kg/mg)
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)
AT	=	Averaging time (days)
BW	=	Age-specific body weight (kg)

The specific exposure assumptions used for each age group in this analysis, and the basis of each, are summarized in Table 4a. In all cases, the assumptions and parameters used are the same as those used by EPA in its 2005 HHRA.

Standard EPA toxicity values have been used for PCBs. These include a cancer slope factor (CSF) of 2 $(mg/kg\text{-}day)^{-1}$ for the RME scenario, a CSF of 1 $(mg/kg\text{-}day)^{-1}$ for the CTE scenario, and a chronic reference dose of 2E-05 mg/kg-day for both the RME and CTE analyses. These values are published in EPA's IRIS database and were used in EPA's HHRA.

Consistent with the HHRA, separate cancer-based and non-cancer-based RMCs have been developed for each relevant age group. The RMCs based on potential carcinogenic effects have been developed for both the RME and CTE exposure scenarios using a range of target risks from one-in-a-million ($1x10^{-6}$) to one-in-ten-thousand ($1x10^{-4}$). This risk range is consistent with EPA's acceptable risk range. RMCs for non-cancer effects have been developed for each of the RME and CTE scenarios based on a target Hazard Index of 1.

Summary of Results

Estimated RMCs for cancer and non-cancer endpoints are presented in the following tables for adults (Table 4b) and older children (Table 4c). For each of these receptors, the calculated RMCs are as follows.

	RME (mg/kg)				**CTE (mg/kg)**			
	Cancer Risk			**Non-cancer**	**Cancer Risk**			**Non-cancer**
	$1x10^{-6}$	**$1x10^{-5}$**	**$1x10^{-4}$**	**HI = 1**	**$1x10^{-6}$**	**$1x10^{-5}$**	**$1x10^{-4}$**	**HI = 1**
Adults	2.6	26	256	56	70	702	7,015	220
Older Child	6.2	62	619	42	52	524	5,237	180

Table 4a. Summary of Pathway- and Age-Specific Exposure Assumptions Used in the Bank Fishing Scenario

Parameters	Units	Symbol	RME	CTE	Basis*
Common Parameters					
Unit conversion factor	kg/mg	CF	1.0E-06	1.0E-06	Vol. IIIA. Table 4-12.
Exposure frequency	days/year	EF			
Older child			30	10	HHRA, Vol. IIIA; Table 4-22; Section 4.5.3.6.1. EPA's professional judgment based on numerous studies.
Adult			30	10	HHRA, Vol. IIIA; Table 4-22; Section 4.5.3.6.1. EPA's professional judgment based on numerous studies.
Exposure duration	years	ED			
Older child			12	12	HHRA, Vol. IIIA; Table 4-23; Aged 7 to 18 years. Based on MDPH, 2001.
Adult			38	11	HHRA, Vol. IIIA; Table 4-23; Based on MDPH, 2001.
Body weight	kg	BW			
Older child			45	45	HHRA, Vol. IIIA; Table 4-6; based on EPA, 1989. Average age specific body weight.
Adult			70	70	HHRA, Vol. IIIA; Table 4-6; based on EPA, 1989. Average age specific body weight.
Averaging time (cancer endpoint)	days	ATc	25,550	25,550	HHRA, Vol. IIIA; Table 4-6; based on EPA 1989. Lifetime of 70 years x 365 days/year.
Averaging time (noncancer endpoint)	days	ATnc			
Older child			4,380	4,380	HHRA, Vol. IIIA. Table 4-6; Based on EPA, 1989. Equivalent to duration in years x 365 days/year.
Adult			13,870	4,015	HHRA, Vol. IIIA. Table 4-6; Based on EPA, 1989. Equivalent to duration in years x 365 days/year.
Soil Ingestion Pathway					
Soil ingestion rate	mg/day	IR			
Older child			100	50	HHRA, Vol. IIIA; Tables 4-12 and 4-24; Section 4.5.2.3. Based on EPA 1991 and 1997.
Adult			100	50	HHRA, Vol. IIIA; Tables 4-12 and 4-24; Section 4.5.2.3. Based on EPA 1991 and 1997.
Fraction of ingested soil attributable to site	unitless	FI	1.0	0.5	HHRA, Vol. IIIA; Table 4-12; Section 4.5.1.3. EPA's professional judgment.
Dermal Exposure Pathway					
Dermal adherence factor (warmer months)	mg/cm^2	AF_1			
Older child			0.31	0.31	HHRA, Vol. IIIA; Table 4-26; Section 4.5.2.4.2. Reed gatherers, weighted by exposed body area.
Adult			0.3	0.3	HHRA, Vol. IIIA; Table 4-26; Section 4.5.2.4.2. Reed gatherers, weighted by exposed body area.
Dermal adherence factor (cooler months)	mg/cm^2	AF_2			
Older child			0.43	0.43	HHRA, Vol. IIIA; Table 4-26; Section 4.5.2.4.2. Reed gatherers, weighted by exposed body area.
Adult			0.47	0.47	HHRA, Vol. IIIA; Table 4-26; Section 4.5.2.4.2. Reed gatherers, weighted by exposed body area.
Skin surface area (warmer months)	cm^2/day	SA_1			
Older child			4,471	4,471	HHRA, Vol. IIIA; Tables 4-25 and 4-26; Hands, forearms, lower legs, feet and face.
Adult			6,074	6,074	HHRA, Vol. IIIA; Tables 4-25 and 4-26; Hands, forearms, lower legs, feet and face.
Skin surface area (cooler months)	cm^2/day	SA_2			
Older child			1,125	1,125	HHRA, Vol. IIIA; Tables 4-25 and 4-26. Section 4.5.2.4.1. Hands and face.
Adult			1,306	1,306	HHRA, Vol. IIIA; Tables 4-25 and 4-26. Section 4.5.2.4.1. Hands and face.
Activity duration (warmer months)	months	AD_1	5	5	HHRA, Vol. IIIA; Table 4-12; EPA's professional judgment. May through September.
Activity duration (cooler months)	months	AD_2	2	2	HHRA, Vol. IIIA; Table 4-12; EPA's professional judgment. April and October.
Dermal absorption factor for PCBs	unitless	ABS_d	0.14	0.14	HHRA, Vol. IIIA; Table 4-12, Page 4-38; Wester et al. 1993.

* All exposure parameters are identical to the parameters used in the HHRA (EPA, 2005). Volume and Table and/or Section numbers provided.

EPA 1989. *Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual (Part A) Interim Final.*

EPA 1991. *Risk Assessment Guidance for Superfund, Volume I; Human Health Evaluation Manual, Supplemental Guidance, Standard Default Exposure Assumptions.*

EPA 1997. *Exposure Factors Handbook, Volume I; General Factors.*

MDPH 2001. *Memo from Martha Steele, Deputy Director, Bureau of Environmental Health Assessment to Bryan Olson, EPA, Region 1 regarding Remainder of data request with respect* to information gathered from questionnaires from Housatonic River Area Exposure Assessment Study as well as questionnaires completed after the study and resulting from calls to the Bureau of Environmental Health Assessment (BEHA) hotline.

Wester, R., H. Maibach, L. Sedik, K. Melendres, and M. Wade. 1993. Percutaneous absorption of PCBs from soil. *Journal of Environmental Toxicology and Environmental Health* 39:375-382.

Table 4b. RMCs for PCBs (mg/kg) in Soils for Target Risk Range and HI of 1
Bank Fishing Scenario
Adults

Parameter		EPA RME Analysis			EPA CTE Analysis		
Common Parameters							
Exposure duration (yrs)							
Adult		38	38	38	11	11	11
Body weight (kg)							
Adult		70	70	70	70	70	70
Averaging time - noncarcinogenic (days)							
Adult		13,870	13,870	13,870	4,015	4,015	4,015
Averaging time - carcinogenic (days)		25,550	25,550	25,550	25,550	25,550	25,550
Pathway Specific Parameters							
Incidental Ingestion of Soil							
Soil ingestion rate (mg/day)							
Adult		100	100	100	50	50	50
Fraction attributable to site		1.0	1.0	1.0	0.5	0.5	0.5
Conversion factor, soil ing (kg/mg)		1E-06	1E-06	1E-06	1E-06	1E-06	1E-06
Exposure frequency (days/year)		30	30	30	10	10	10
Exposure (soil ing)-carcinogenic $(days)^{-1}$		6.4E-08	6.4E-08	6.4E-08	1.5E-09	1.5E-09	1.5E-09
Exposure (soil ing)-noncarcinogenic $(days)^{-1}$		1.2E-07	1.2E-07	1.2E-07	9.8E-09	9.8E-09	9.8E-09
Dermal Contact with Soil							
Dermal adherence factor (mg/cm^2)							
Adult	Warmer months	0.3	0.3	0.3	0.3	0.3	0.3
	Cooler months	0.47	0.47	0.47	0.47	0.47	0.47
Skin surface area exposed (cm^2/day)							
Adult	Warmer months	6074	6074	6074	6074	6074	6074
	Cooler months	1306	1306	1306	1306	1306	1306
Activity duration for warmer months (months)		5	5	5	5	5	5
Activity duration for cooler months (months)		2	2	2	2	2	2
Dermal absorption factor (unitless)		0.14	0.14	0.14	0.14	0.14	0.14
Conversion factor, dermal con (kg/mg)		1.E-06	1.E-06	1.E-06	1.E-06	1.E-06	1.E-06
Exposure frequency (days/year)		30	30	30	10	10	10
Exposure (dermal con)-carcinogenic $(days)^{-1}$		1.3E-07	1.3E-07	1.3E-07	1.3E-08	1.3E-08	1.3E-08
Exposure (dermal con)-noncarcinogenic $(days)^{-1}$		2.4E-07	2.4E-07	2.4E-07	8.1E-08	8.1E-08	8.1E-08
CARCINOGENIC		**EPA RME Analysis**			**EPA CTE Analysis**		
Total Exposure, dermal contact $(days)^{-1}$		1.3E-07	1.3E-07	1.3E-07	1.3E-08	1.3E-08	1.3E-08
Total Exposure, soil ingestion $(days)^{-1}$		6.4E-08	6.4E-08	6.4E-08	1.5E-09	1.5E-09	1.5E-09
Cancer Slope Factor (CSF) $(mg/kg\text{-}day)^{-1}$		2	2	2	1	1	1
Target Risk Level		1.0E-04	1.0E-05	1.0E-06	1.0E-04	1.0E-05	1.0E-06
Risk-based Media Concentration (mg/kg)		**256**	**26**	**2.6**	**7015**	**702**	**70**
NONCARCINOGENIC		**Adult**			**Adult**		
Total Exposure, dermal contact $(days)^{-1}$		2.4E-07			8.1E-08		
Total Exposure, soil ingestion $(days)^{-1}$		1.2E-07			9.8E-09		
Reference Dose (RfD) (mg/kg-day)		2.00E-05			2.00E-05		
Target Hazard Index		1			1		
Risk-based Media Concentration (mg/kg)		**56**			**220**		

Table 4c. RMCs for PCBs (mg/kg) in Soils for Target Risk Range and HI of 1
Bank Fishing Scenario
Older Child

Parameter		EPA RME Analysis			EPA CTE Analysis		
Common Parameters							
Exposure duration (yrs)							
Older child		12	12	12	12	12	12
Body weight (kg)							
Older child		45	45	45	45	45	45
Averaging time - noncarcinogenic (days)							
Older child		4,380	4,380	4,380	4,380	4,380	4,380
Averaging time - carcinogenic (days)		25,550	25,550	25,550	25,550	25,550	25,550
Pathway Specific Parameters							
Incidental Ingestion of Soil							
Soil ingestion rate (mg/day)							
Older child		100	100	100	50	50	50
Fraction attributable to site		1.0	1.0	1.0	0.5	0.5	0.5
Conversion factor, soil ing (kg/mg)		1E-06	1E-06	1E-06	1E-06	1E-06	1E-06
Exposure frequency (days/year)		30	30	30	10	10	10
Exposure (soil ing)-carcinogenic $(days)^{-1}$		3.1E-08	3.1E-08	3.1E-08	2.6E-09	2.6E-09	2.6E-09
Exposure (soil ing)-noncarcinogenic $(days)^{-1}$		1.8E-07	1.8E-07	1.8E-07	1.5E-08	1.5E-08	1.5E-08
Dermal Contact with Soil							
Dermal adherence factor (mg/cm^2)							
Older child	Warmer months	0.31	0.31	0.31	0.31	0.31	0.31
	Cooler months	0.43	0.43	0.43	0.43	0.43	0.43
Skin surface area exposed (cm^2/day)							
Older child	Warmer months	4471	4471	4471	4471	4471	4471
	Cooler months	1125	1125	1125	1125	1125	1125
Activity duration for warmer months (months)		5	5	5	5	5	5
Activity duration for cooler months (months)		2	2	2	2	2	2
Dermal absorption factor (unitless)		0.14	0.14	0.14	0.14	0.14	0.14
Conversion factor, dermal con (kg/mg)		1.E-06	1.E-06	1.E-06	1.E-06	1.E-06	1.E-06
Exposure frequency (days/year)		30	30	30	10	10	10
Exposure (dermal con)-carcinogenic $(days)^{-1}$		4.9E-08	4.9E-08	4.9E-08	1.6E-08	1.6E-08	1.6E-08
Exposure (dermal con)-noncarcinogenic $(days)^{-1}$		2.9E-07	2.9E-07	2.9E-07	9.6E-08	9.6E-08	9.6E-08
CARCINOGENIC		**EPA RME Analysis**			**EPA CTE Analysis**		
Total Exposure, dermal contact $(days)^{-1}$		4.9E-08	4.9E-08	4.9E-08	1.6E-08	1.6E-08	1.6E-08
Total Exposure, soil ingestion $(days)^{-1}$		3.1E-08	3.1E-08	3.1E-08	2.6E-09	2.6E-09	2.6E-09
Cancer Slope Factor (CSF) $(mg/kg\text{-}day)^{-1}$		2	2	2	1	1	1
Target Risk Level		1.0E-04	1.0E-05	1.0E-06	1.0E-04	1.0E-05	1.0E-06
Risk-based Media Concentration (mg/kg)		**619**	**62**	**6.2**	**5237**	**524**	**52**
NONCARCINOGENIC		**EPA RME Analysis**			**EPA CTE Analysis**		
Total Exposure, dermal contact $(days)^{-1}$		2.9E-07			9.6E-08		
Total Exposure, soil ingestion $(days)^{-1}$		1.8E-07			1.5E-08		
Reference Dose (RfD) (mg/kg-day)		2.00E-05			2.00E-05		
Target Hazard Index		1			1		
Risk-based Media Concentration (mg/kg)		**42**			**180**		

Attachment 5
Risk-based Media Concentrations for Direct Contact With Floodplain Soil
In Dirt Biking/ATVing Scenario

A range of risk-based media concentrations (RMCs) has been developed for PCBs based on potential for direct contact with floodplain soil during the dirt biking/ATVing scenario. Consistent with the approach used in EPA's HHRA, potential soil ingestion and dermal contact exposures of older children have been evaluated under reasonable maximum exposure (RME) and central tendency exposure (CTE) conditions. The RMCs have been calculated based both on potential cancer risks and on potential non-cancer impacts, using the exposure assumptions and toxicity values used in the HHRA.

The RMCs for the cancer endpoint (RMC_{cancer}) and the non-cancer endpoint ($RMC_{noncancer}$) for this scenario have been calculated using the following equations, respectively:

$$RMC_{cancer} = \frac{Risk}{CSF * \left(Exp_{ingestion} + Exp_{dermal}\right)}$$

Where:

RMC_{cancer}	=	RMC based on the cancer endpoint (mg/kg)
Risk	=	Target risk level (unitless)
CSF	=	Cancer slope factor $(mg/kg\text{-}day)^{-1}$
$Exp_{ingestion}$	=	Exposure due to the soil ingestion pathway (day^{-1})
Exp_{dermal}	=	Exposure due to dermal contact with soil (day^{-1})

And

$$RMC_{noncancer} = \frac{HI * RfD}{\left(Exp_{ingestion} + Exp_{dermal}\right)}$$

Where:

$RMC_{noncancer}$	=	RMC based on the non-cancer endpoint (mg/kg)
HI	=	Target hazard index (unitless)
RfD	=	Reference dose (mg/kg-day)
$Exp_{ingestion}$	=	Exposure due to the soil ingestion pathway (day^{-1})
Exp_{dermal}	=	Exposure due to dermal contact with soil (day^{-1})

In both of the above equations, the exposures due to soil ingestion ($Exp_{ingestion}$) and dermal contact with soil (Exp_{dermal}) have been calculated using the following equations:

$$Exp_{ingestion} = \frac{IR * FI * CF * EF * ED}{AT * BW}$$

And

$$Exp_{dermal} = \frac{(((AF_1 * SA_1 * AD_1) + (AF_2 * SA_2 * AD_2))/(AD_1 + AD_2)) * ABS_d * CF * EF * ED}{AT * BW}$$

Where:

IR	=	Soil ingestion rate (mg/day)
FI	=	Fraction of soil ingested that is attributable to the Site (unitless)
AF_1	=	Dermal adherence factor during the warmer months (mg/cm^2)
AF_2	=	Dermal adherence factor during the cooler months (mg/cm^2)
SA_1	=	Skin surface area exposed during the warmer months (cm^2/day)
SA_2	=	Skin surface area exposed during the cooler months (cm^2/day)
AD_1	=	Activity duration for the warmer months (months)
AD_2	=	Activity duration for the cooler months (months)
ABS_d	=	Dermal absorption factor (unitless)
CF	=	Unit conversion factor (1E-06 kg/mg)
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)
AT	=	Averaging time (days)
BW	=	Age-specific body weight (kg)

The specific exposure assumptions used in this analysis and the basis of each are summarized in Table 5a. In all cases, the assumptions and parameters used are the same as those used by EPA in its 2005 HHRA.

Standard EPA toxicity values have been used for PCBs. These include a cancer slope factor (CSF) of 2 $(mg/kg\text{-}day)^{-1}$ for the RME scenario, a CSF of 1 $(mg/kg\text{-}day)^{-1}$ for the CTE scenario, and a chronic reference dose of 2E-05 mg/kg-day for both the RME and CTE analyses. These values are published in EPA's IRIS database and were used in EPA's HHRA.

Consistent with the HHRA, separate cancer-based and non-cancer-based RMCs have been developed. The RMCs based on potential carcinogenic effects have been developed for both the RME and CTE exposure scenarios using a range of target risks from one-in-a-million ($1x10^{-6}$) to one-in-ten-thousand ($1x10^{-4}$). This risk range is consistent with EPA's acceptable risk range. RMCs for non-cancer effects have been developed for each of the RME and CTE scenarios based on a target Hazard Index of 1.

Summary of Results

Estimated RMCs for cancer and non-cancer endpoints for older children who participate in dirt biking or ATVing are presented below and in Table 5b. The calculated RMCs are as follows.

	RME (mg/kg)				**CTE (mg/kg)**			
	Cancer Risk			**Non-cancer**	**Cancer Risk**			**Non-cancer**
	$1x10^{-6}$	**$1x10^{-5}$**	**$1x10^{-4}$**	**HI = 1**	**$1x10^{-6}$**	**$1x10^{-5}$**	**$1x10^{-4}$**	**HI = 1**
Older Child	2.0	20	205	14	29	290	2,901	99

Table 5a. Summary of Pathway- and Age-Specific Exposure Assumptions Used in the Dirt Biking/ATV Scenario

Parameters	Units	Symbol	RME	CTE	Basis*
Common Parameters					
Unit conversion factor	kg/mg	CF	1.0E-06	1.0E-06	HHRA, Vol. IIIA. Table 4-13.
Exposure frequency	days/year	EF	90	30	HHRA, Vol. IIIA; Table 4-22; Section 4.5.3.3.1. EPA's professional judgment.
Exposure duration	years	ED	12	12	HHRA, Vol. IIIA; Table 4-23; Aged 7 to 18 years. Calculated by EPA.
Body weight	kg	BW	45	45	HHRA, Vol. IIIA; Table 4-6; based on EPA, 1989. Average age specific body weight.
Averaging time (cancer endpoint)	days	ATc	25,550	25,550	HHRA, Vol. IIIA; Table 4-6; based on EPA 1989. Lifetime of 70 years x 365 days/year.
Averaging time (noncancer endpoint	days	ATnc	4,380	4,380	HHRA, Vol. IIIA. Table 4-6; Based on EPA, 1989. Equivalent to duration in years x 365 days/year.
Soil Ingestion Pathway					
Soil ingestion rate	mg/day	IR	200	100	HHRA, Vol. IIIA; Tables 4-13 and 4-24; Section 4.5.3.3.3. Based on EPA 1997 and Stanek et al., 1997.
Fraction of ingested soil attributable to site	unitless	FI	1.0	0.5	HHRA, Vol. IIIA; Table 4-13. EPA's professional judgment.
Dermal Exposure Pathway					
Dermal adherence factor (warmer months)	mg/cm^2	AF_1	0.14	0.14	HHRA, Vol. IIIA; Table 4-26; Section 4.5.3.3.4. Heavy equipment operators and construction workers.
Dermal adherence factor (cooler months)	mg/cm^2	AF_2	0.24	0.24	HHRA, Vol. IIIA; Table 4-26; Section 4.5.3.3.4. Heavy equipment operators and construction workers.
Skin surface area (warmer months)	cm^2/day	SA_1	3,522	3,522	HHRA, Vol. IIIA; Tables 4-25 and 4-26; Section 4.5.3.3.4. Hands, forearms, lower legs, and face.
Skin surface area (cooler months)	cm^2/day	SA_2	1,125	1,125	HHRA, Vol. IIIA; Tables 4-25 and 4-26; Section 4.5.3.3.4. Hands and face.
Activity duration (warmer months)	months	AD_1	5	5	HHRA, Vol. IIIA; Table 4-13; EPA's professional judgment. May through September.
Activity duration (cooler months)	months	AD_2	2	2	HHRA, Vol. IIIA; Table 4-13; EPA's professional judgment. April and October.
Dermal absorption factor	unitless	ABS_d	0.14	0.14	HHRA, Vol. IIIA; Table 4-13, Page 4-38; Wester et al. 1993.

* All exposure parameters are identical to the parameters used in the HHRA (EPA, 2005). Volume and Table and/or Section numbers provided.

EPA 1989. *Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual (Part A) Interim Final.*
EPA 1997. *Exposure Factors Handbook, Volume I; General Factors.*
Stanek, E.J., E.J. Calabrese, R. Barnes, P. Pekow. 1997. Soil ingestion in adults - Results of a second pilot study. *Ecotoxicology and Environmental Safety* 36:249-257
Wester, R, H. Maibach, L. Sedik, K. Melendres, and M. Wade. 1993. Percutaneous absorption of PCBs from soil. *Journal of Environmental Toxicology and Environmental Health* 39:375-382.

Table 5b. RMCs for PCBs (mg/kg) in Soils for Target Risk Range and HI of 1
Dirt Bike/ATV Scenario
Older Child

Parameter	EPA RME Analysis			EPA CTE Analysis		
Common Parameters						
Exposure duration (yrs)	12	12	12	12	12	12
Body weight (kg)	45	45	45	45	45	45
Averaging time - noncarcinogenic (days)	4,380	4,380	4,380	4,380	4,380	4,380
Averaging time - carcinogenic (days)	25,550	25,550	25,550	25,550	25,550	25,550
Pathway Specific Parameters						
Incidental Ingestion of Soil						
Soil ingestion rate (mg/day)	200	200	200	100	100	100
Fraction attributable to site	1.0	1.0	1.0	0.5	0.5	0.5
Conversion factor, soil ing (kg/mg)	1E-06	1E-06	1E-06	1E-06	1E-06	1E-06
Exposure frequency (days/year)	90	90	90	30	30	30
Exposure (soil ing)-carcinogenic $(days)^{-1}$	1.9E-07	1.9E-07	1.9E-07	1.6E-08	1.6E-08	1.6E-08
Exposure (soil ing)-noncarcinogenic $(days)^{-1}$	1.1E-06	1.1E-06	1.1E-06	9.1E-08	9.1E-08	9.1E-08
Dermal Contact with Soil						
Dermal adherence factor (mg/cm^2)						
Warmer months	0.14	0.14	0.14	0.14	0.14	0.14
Cooler months	0.24	0.24	0.24	0.24	0.24	0.24
Skin surface area exposed (cm^2/day)						
Warmer months	3522	3522	3522	3522	3522	3522
Cooler months	1125	1125	1125	1125	1125	1125
Activity duration for warmer months (months)	5	5	5	5	5	5
Activity duration for cooler months (months)	2	2	2	2	2	2
Dermal absorption factor (unitless)	0.14	0.14	0.14	0.14	0.14	0.14
Conversion factor, dermal con (kg/mg)	1.E-06	1.E-06	1.E-06	1.E-06	1.E-06	1.E-06
Exposure frequency (days/year)	90	90	90	30	30	30
Exposure (dermal con)-carcinogenic $(days)^{-1}$	5.6E-08	5.6E-08	5.6E-08	1.9E-08	1.9E-08	1.9E-08
Exposure (dermal con)-noncarcinogenic $(days)^{-1}$	3.3E-07	3.3E-07	3.3E-07	1.1E-07	1.1E-07	1.1E-07
CARCINOGENIC	**EPA RME Analysis**			**EPA CTE Analysis**		
Total Exposure, dermal contact $(days)^{-1}$	5.6E-08	5.6E-08	5.6E-08	1.9E-08	1.9E-08	1.9E-08
Total Exposure, soil ingestion $(days)^{-1}$	1.9E-07	1.9E-07	1.9E-07	1.6E-08	1.6E-08	1.6E-08
Cancer Slope Factor (CSF) $(mg/kg\text{-}day)^{-1}$	2	2	2	1	1	1
Target Risk Level	1.0E-04	1.0E-05	1.0E-06	1.0E-04	1.0E-05	1.0E-06
Risk-based Media Concentration (mg/kg)	**205**	**20**	**2.0**	**2901**	**290**	**29**
NONCARCINOGENIC	**EPA RME Analysis**			**EPA CTE Analysis**		
Total Exposure, dermal contact $(days)^{-1}$	3.3E-07			1.1E-07		
Total Exposure, soil ingestion $(days)^{-1}$	1.1E-06			9.1E-08		
Reference Dose (RfD) (mg/kg-day)	2.00E-05			2.00E-05		
Target Hazard Index	1			1		
Risk-based Media Concentration (mg/kg)	**14**			**99**		

Attachment 6
Risk-based Media Concentrations for Direct Contact With Floodplain Soil
In Marathon Canoeing Scenario

A range of risk-based media concentrations (RMCs) has been developed for PCBs based on potential for direct contact with floodplain soil during the marathon canoeing scenario. Consistent with the approach used in EPA's HHRA, potential soil ingestion and dermal contact exposures of adults have been evaluated under reasonable maximum exposure (RME) and central tendency exposure (CTE) conditions. RMCs have been calculated based both on potential cancer risks and on potential non-cancer impacts, using the exposure assumptions and toxicity values used in the HHRA.

The RMCs for the cancer endpoint (RMC_{cancer}) and the non-cancer endpoint ($RMC_{noncancer}$) for this scenario have been calculated using the following equations, respectively:

$$RMC_{cancer} = \frac{Risk}{CSF * \left(Exp_{ingestion} + Exp_{dermal}\right)}$$

Where:

RMC_{cancer}	=	RMC based on the cancer endpoint (mg/kg)
Risk	=	Target risk level (unitless)
CSF	=	Cancer slope factor $(mg/kg\text{-}day)^{-1}$
$Exp_{ingestion}$	=	Exposure due to the soil ingestion pathway (day^{-1})
Exp_{dermal}	=	Exposure due to dermal contact with soil (day^{-1})

And

$$RMC_{noncancer} = \frac{HI * RfD}{\left(Exp_{ingestion} + Exp_{dermal}\right)}$$

Where:

$RMC_{noncancer}$	=	RMC based on the non-cancer endpoint (mg/kg)
HI	=	Target hazard index (unitless)
RfD	=	Reference dose (mg/kg-day)
$Exp_{ingestion}$	=	Exposure due to the soil ingestion pathway (day^{-1})
Exp_{dermal}	=	Exposure due to dermal contact with soil (day^{-1})

In both of the above equations, the exposures due to soil ingestion ($Exp_{ingestion}$) and dermal contact with soil (Exp_{dermal}) have been calculated using the following equations:

$$Exp_{ingestion} = \frac{IR * FI * CF * EF * ED}{AT * BW}$$

And

$$Exp_{dermal} = \frac{(((AF_1 * SA_1 * AD_1) + (AF_2 * SA_2 * AD_2))/(AD_1 + AD_2)) * ABS_d * CF * EF * ED}{AT * BW}$$

Where:

IR	=	Soil ingestion rate (mg/day)
FI	=	Fraction of soil ingested that is attributable to the Site (unitless)
AF_1	=	Dermal adherence factor during the warmer months (mg/cm^2)
AF_2	=	Dermal adherence factor during the cooler months (mg/cm^2)
SA_1	=	Skin surface area exposed during the warmer months (cm^2/day)
SA_2	=	Skin surface area exposed during the cooler months (cm^2/day)
AD_1	=	Activity duration for the warmer months (months)
AD_2	=	Activity duration for the cooler months (months)
ABS_d	=	Dermal absorption factor (unitless)
CF	=	Unit conversion factor (1E-06 kg/mg)
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)
AT	=	Averaging time (days)
BW	=	Age-specific body weight (kg)

The specific exposure assumptions used in this analysis and the basis of each are summarized in Table 6a. In all cases, the assumptions and parameters used are the same as those used by EPA in its 2005 HHRA.

Standard EPA toxicity values have been used for PCBs. These include a cancer slope factor (CSF) of 2 $(mg/kg\text{-}day)^{-1}$ for the RME scenario, a CSF of 1 $(mg/kg\text{-}day)^{-1}$ for the CTE scenario, and a chronic reference dose of 2E-05 mg/kg-day for both the RME and CTE analyses. These values are published in EPA's IRIS database and were used in EPA's HHRA.

Consistent with the HHRA, separate cancer-based and non-cancer-based RMCs have been developed. The RMCs based on potential carcinogenic effects have been developed for both the RME and CTE exposure scenarios using a range of target risks from one-in-a-million ($1x10^{-6}$) to one-in-ten-thousand ($1x10^{-4}$). This risk range is consistent with EPA's acceptable risk range. RMCs for noncancer effects have been developed for each of the RME and CTE scenarios based on a target Hazard Index of 1.

Summary of Results

Estimated RMCs for cancer and non-cancer endpoints for adults who participate in marathon canoeing are presented below and in Table 6b. The calculated RMCs are as follows.

	RME (mg/kg)				**CTE (mg/kg)**			
	Cancer Risk			**Non-cancer**	**Cancer Risk**			**Non-cancer**
	$1x10^{-6}$	**$1x10^{-5}$**	**$1x10^{-4}$**	**HI = 1**	**$1x10^{-6}$**	**$1x10^{-5}$**	**$1x10^{-4}$**	**HI = 1**
Adult	0.78	7.8	78	13	5.8	58	575	25

Table 6a. Summary of Pathway- and Age-Specific Exposure Assumptions Used in the Marathon Canoeist Scenario

Parameters	Units	Symbol	RME	CTE	Basis*
Common Parameters					
Unit conversion factor	kg/mg	CF	1.0E-06	1.0E-06	HHRA, Vol. IIIA. Table 4-14.
Exposure frequency	days/year	EF	150	90	HHRA, Vol. IIIA; Table 4-22; Weston 2001.
Exposure duration	years	ED	30	15	HHRA, Vol. IIIA; Table 4-23; RME based on Weston 2001. CTE based on EPA's professional judgment.
Body weight	kg	BW	70	70	HHRA, Vol. IIIA; Table 4-6; based on EPA, 1989. Average age specific body weight.
Averaging time (cancer endpoint)	days	ATc	25,550	25,550	HHRA, Vol. IIIA; Table 4-6; based on EPA 1989. Lifetime of 70 years x 365 days/year.
Averaging time (noncancer endpoint)	days	ATnc	10,950	5,475	HHRA, Vol. IIIA. Table 4-14; Based on EPA, 1989. Equivalent to duration in years x 365 days/year.
Soil Ingestion Pathway					
Soil ingestion rate	mg/day	IR	50	50	HHRA, Vol. IIIA; Tables 4-14 and 4-24; Section 4.5.3.4.5. Based on EPA 1997.
Fraction of ingested soil attributable to site	unitless	FI	1.0	0.5	HHRA, Vol. IIIA; Table 4-14; EPA's professional judgment.
Dermal Exposure Pathway					
Dermal adherence factor (warmer months)	mg/cm^2	AF_1	0.32	0.32	HHRA, Vol. IIIA; Table 4-26; Section 4.5.3.4.4. Reed gatherers.
Dermal adherence factor (cooler months)	mg/cm^2	AF_2	0.658	0.658	HHRA, Vol. IIIA; Table 4-26; Section 4.5.3.4.4. Reed gatherers.
Skin surface area (warmer months)	cm^2/day	SA_1	5,672	5,672	HHRA, Vol. IIIA; Tables 4-25 and 4-26; Section 4.5.3.4.4. Hands, forearms, lower legs, and feet.
Skin surface area (cooler months)	cm^2/day	SA_2	904	904	HHRA, Vol. IIIA; Tables 4-25 and 4-26. Section 4.5.3.4.4. Hands.
Activity duration (warmer months)	months	AD_1	5	5	HHRA, Vol. IIIA; Table 4-14; Professional judgment. May through September.
Activity duration (cooler months)	months	AD_2	2	2	HHRA, Vol. IIIA; Table 4-14; Professional judgment. April and October.
Dermal absorption factor	unitless	ABS_d	0.14	0.14	HHRA, Vol. IIIA; Table 4-14, Page 4-38; Wester et al. 1993.

* All exposure parameters are identical to the parameters used in the HHRA (EPA, 2005). Volume and Table and/or Section numbers provided.

EPA 1989. *Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual (Part A) Interim Final.*
EPA 1997. *Exposure Factors Handbook, Volume I; General Factors.*
Wester, R, H. Maibach, L. Sedik, K. Melendres, and M. Wade. 1993. Percutaneous absorption of PCBs from soil. *Journal of Environ. Toxicology and Environ. Health* 39:375-382.
Weston 2001. Email memorandum from M. Isabel Zapisek (Weston Pittsfield, MA Office) to Robert Warwick (West Chester, PA office). October 9.

Table 6b. RMCs for PCBs (mg/kg) in Soils for Target Risk Range and HI of 1
Marathon Canoeist Scenario
Adults

Parameter	EPA RME Analysis			EPA CTE Analysis		
Common Parameters						
Exposure duration (yrs)	30	30	30	15	15	15
Body weight (kg)	70	70	70	70	70	70
Averaging time - noncarcinogenic (days)	10,950	10,950	10,950	5,475	5,475	5,475
Averaging time - carcinogenic (days)	25,550	25,550	25,550	25,550	25,550	25,550
Pathway Specific Parameters						
Incidental Ingestion of Soil						
Soil ingestion rate (mg/day)	50	50	50	50	50	50
Fraction attributable to site	1.0	1.0	1.0	0.5	0.5	0.5
Conversion factor, soil ing (kg/mg)	1E-06	1E-06	1E-06	1E-06	1E-06	1E-06
Exposure frequency (days/year)	150	150	150	90	90	90
Exposure (soil ing)-carcinogenic $(days)^{-1}$	1.3E-07	1.3E-07	1.3E-07	1.9E-08	1.9E-08	1.9E-08
Exposure (soil ing)-noncarcinogenic $(days)^{-1}$	2.9E-07	2.9E-07	2.9E-07	8.8E-08	8.8E-08	8.8E-08
Dermal Contact with Soil						
Dermal adherence factor (mg/cm^2)						
Warmer months	0.32	0.32	0.32	0.32	0.32	0.32
Cooler months	0.658	0.658	0.658	0.658	0.658	0.658
Skin surface area exposed (cm^2/day)						
Warmer months	5672	5672	5672	5672	5672	5672
Cooler months	904	904	904	904	904	904
Activity duration for warmer months (months)	5	5	5	5	5	5
Activity duration for cooler months (months)	2	2	2	2	2	2
Dermal absorption factor (unitless)	0.14	0.14	0.14	0.14	0.14	0.14
Conversion factor, dermal con (kg/mg)	1.E-06	1.E-06	1.E-06	1.E-06	1.E-06	1.E-06
Exposure frequency (days/year)	150	150	150	90	90	90
Exposure (dermal con)-carcinogenic $(days)^{-1}$	5.2E-07	5.2E-07	5.2E-07	1.5E-07	1.5E-07	1.5E-07
Exposure (dermal con)-noncarcinogenic $(days)^{-1}$	1.2E-06	1.2E-06	1.2E-06	7.2E-07	7.2E-07	7.2E-07
CARCINOGENIC	**EPA RME Analysis**			**EPA CTE Analysis**		
Total Exposure, dermal contact $(days)^{-1}$	5.2E-07	5.2E-07	5.2E-07	1.5E-07	1.5E-07	1.5E-07
Total Exposure, soil ingestion $(days)^{-1}$	1.3E-07	1.3E-07	1.3E-07	1.9E-08	1.9E-08	1.9E-08
Cancer Slope Factor (CSF) $(mg/kg\text{-}day)^{-1}$	2	2	2	1	1	1
Target Risk Level	1.0E-04	1.0E-05	1.0E-06	1.0E-04	1.0E-05	1.0E-06
Risk-based Media Concentration (mg/kg)	**78**	**7.8**	**0.78**	**575**	**58**	**5.8**
NONCARCINOGENIC	**Adult**			**Adult**		
Total Exposure, dermal contact $(days)^{-1}$	1.2E-06			7.2E-07		
Total Exposure, soil ingestion $(days)^{-1}$	2.9E-07			8.8E-08		
Reference Dose (RfD) (mg/kg-day)	2.00E-05			2.00E-05		
Target Hazard Index	1			1		
Risk-based Media Concentration (mg/kg)	**13**			**25**		

Attachment 7
Risk-based Media Concentrations for Direct Contact with Floodplain Soil
Recreational Canoeing Scenario

A range of risk-based media concentrations (RMCs) has been developed for PCBs based on potential for direct contact with floodplain soil during the recreational canoeing scenario. Consistent with the approach used in EPA's HHRA, potential soil ingestion and dermal contact exposures of older children and adults have been evaluated under reasonable maximum exposure (RME) and central tendency exposure (CTE) conditions. For each age group and set of exposure conditions, RMCs have been calculated based both on potential cancer risks and on potential non-cancer impacts, using the exposure assumptions and toxicity values used in the HHRA.

The RMCs for the cancer endpoint (RMC_{cancer}) and the non-cancer endpoint ($RMC_{noncancer}$) for this scenario have been calculated using the following equations, respectively:

$$RMC_{cancer} = \frac{Risk}{CSF * \left(Exp_{ingestion} + Exp_{dermal}\right)}$$

Where:

RMC_{cancer}	=	RMC based on the cancer endpoint (mg/kg)
Risk	=	Target risk level (unitless)
CSF	=	Cancer slope factor $(mg/kg\text{-}day)^{-1}$
$Exp_{ingestion}$	=	Exposure due to the soil ingestion pathway (day^{-1})
Exp_{dermal}	=	Exposure due to dermal contact with soil (day^{-1})

And

$$RMC_{noncancer} = \frac{HI * RfD}{\left(Exp_{ingestion} + Exp_{dermal}\right)}$$

Where:

$RMC_{noncancer}$	=	RMC based on the non-cancer endpoint (mg/kg)
HI	=	Target hazard index (unitless)
RfD	=	Reference dose (mg/kg-day)
$Exp_{ingestion}$	=	Exposure due to the soil ingestion pathway (day^{-1})
Exp_{dermal}	=	Exposure due to dermal contact with soil (day^{-1})

In both of the above equations, the exposures due to soil ingestion ($Exp_{ingestion}$) and dermal contact with soil (Exp_{dermal}) have been calculated using the following equations:

$$Exp_{ingestion} = \frac{IR * FI * CF * EF * ED}{AT * BW}$$

And

$$Exp_{dermal} = \frac{\left(\left(\left(AF_1 * SA_1 * AD_1\right) + \left(AF_2 * SA_2 * AD_2\right)\right)/\left(AD_1 + AD_2\right)\right) * ABS_d * CF * EF * ED}{AT * BW}$$

Where:

IR	=	Soil ingestion rate (mg/day)
FI	=	Fraction of soil ingested that is attributable to the Site (unitless)
AF_1	=	Dermal adherence factor during the warmer months (mg/cm^2)
AF_2	=	Dermal adherence factor during the cooler months (mg/cm^2)
SA_1	=	Skin surface area exposed during the warmer months (cm^2/day)
SA_2	=	Skin surface area exposed during the cooler months (cm^2/day)
AD_1	=	Activity duration for the warmer months (months)
AD_2	=	Activity duration for the cooler months (months)
ABS_d	=	Dermal absorption factor (unitless)
CF	=	Unit conversion factor (1E-06 kg/mg)
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)
AT	=	Averaging time (days)
BW	=	Age-specific body weight (kg)

Specific exposure assumptions used in this analysis and the basis of each are summarized in Table 7a. In all cases, the assumptions and parameters used are the same as those used by EPA in its 2005 HHRA.

Standard EPA toxicity values have been used for PCBs. These include a cancer slope factor (CSF) of 2 $(mg/kg\text{-}day)^{-1}$ for the RME scenario, a CSF of 1 $(mg/kg\text{-}day)^{-1}$ for the CTE scenario, and a chronic reference dose of 2E-05 mg/kg-day for both the RME and CTE analyses. These values are published in EPA's IRIS database and were used in EPA's HHRA.

Consistent with the HHRA, separate cancer-based and non-cancer-based RMCs have been developed for each relevant age group. The RMCs based on potential carcinogenic effects have been developed for both the RME and CTE exposure scenarios using a range of target risks from one-in-a-million ($1x10^{-6}$) to one-in-ten-thousand ($1x10^{-4}$). This risk range is consistent with EPA's acceptable risk range. RMCs for non-cancer effects have been developed for each of the RME and CTE scenarios based on a target Hazard Index of 1.

Summary of Results

Estimated RMCs for cancer and non-cancer endpoints for adults and older children who participate in recreational canoeing are presented below and in Tables 7b and 7c, respectively. The calculated RMCs are as follows.

	RME (mg/kg)				**CTE (mg/kg)**			
	Cancer Risk			**Non-cancer**	**Cancer Risk**			**Non-cancer**
	$1x10^{-6}$	**$1x10^{-5}$**	**$1x10^{-4}$**	**HI = 1**	**$1x10^{-6}$**	**$1x10^{-5}$**	**$1x10^{-4}$**	**HI = 1**
Adult	1.2	12	121	28	13	129	1,286	73
Older child	6.2	62	619	42	35	349	3,491	120

Table 7a. Summary of Pathway- and Age-Specific Exposure Assumptions Used in the Recreational Canoeing Scenario

Parameters	Units	Symbol	RME	CTE	Basis*
Common Parameters					
Unit conversion factor	kg/mg	CF	1.0E-06	1.0E-06	HHRA, Vol. IIIA. Table 4-15.
Exposure frequency	days/year	EF			
Older child			30	15	HHRA, Vol. IIIA; Table 4-22; EPA's professional judgment.
Adult			60	30	HHRA, Vol. IIIA; Table 4-22; Weston 2001.
Exposure duration	years	ED			
Older child			12	12	HHRA, Vol. IIIA; Table 4-23; Aged 7 to 18 years. Calculated by EPA.
Adult			40	20	HHRA, Vol. IIIA; Table 4-23; RME based on Weston 2001; CTE based on EPA's professional judgment.
Body weight	kg	BW			
Older child			45	45	HHRA, Vol. IIIA; Table 4-6; based on EPA 1989. Average age specific body weight.
Adult			70	70	HHRA, Vol. IIIA; Table 4-6; based on EPA 1989. Average age specific body weight.
Averaging time (cancer endpoint)	days	ATc	25,550	25,550	HHRA, Vol. IIIA; Table 4-6; based on EPA 1989. Lifetime of 70 years x 365 days/year.
Averaging time (noncancer endpoint)	days	ATnc			
Older child			4,380	4,380	HHRA, Vol. IIIA. Table 4-6; Based on EPA, 1989. Equivalent to duration in years x 365 days/year.
Adult			14,600	7,300	HHRA, Vol. IIIA. Table 4-6; Based on EPA, 1989. Equivalent to duration in years x 365 days/year.
Soil Ingestion Pathway					
Soil ingestion rate	mg/day	IR			
Older child			100	50	HHRA, Vol. IIIA; Tables 4-15 and 4-24; Section 4.5.3.5.3. Based on EPA 1991 and 1997.
Adult			100	50	HHRA, Vol. IIIA; Tables 4-15 and 4-24; Section 4.5.3.5.3. Based on EPA 1991 and 1997.
Fraction of ingested soil attributable to site	unitless	FI	1.0	0.5	HHRA, Vol. IIIA; Table 4-15; EPA's professional judgment.
Dermal Exposure Pathway					
Dermal adherence factor (warmer months)	mg/cm^2	AF_1			
Older child			0.31	0.31	HHRA, Vol. IIIA; Table 4-26; Section 4.5.3.5.4. Reed gatherers, weighted by exposed body area.
Adult			0.3	0.3	HHRA, Vol. IIIA; Table 4-26; Section 4.5.3.5.4. Reed gatherers, weighted by exposed body area.
Dermal adherence factor (cooler months)	mg/cm^2	AF_2			
Older child			0.43	0.43	HHRA, Vol. IIIA; Table 4-26; Section 4.5.3.5.4. Reed gatherers, weighted by exposed body area.
Adult			0.47	0.47	HHRA, Vol. IIIA; Table 4-26; Section 4.5.3.5.4. Reed gatherers, weighted by exposed body area.
Skin surface area (warmer months)	cm^2/day	SA_1			
Older child			4,471	4,471	HHRA, Vol. IIIA; Tables 4-25 and 4-26; Hands, forearms, lower legs, feet and face.
Adult			6,074	6,074	HHRA, Vol. IIIA; Tables 4-25 and 4-26; Hands, forearms, lower legs, feet and face.
Skin surface area (cooler months)	cm^2/day	SA_2			
Older child			1,125	1,125	HHRA, Vol. IIIA; Tables 4-25 and 4-26. Hands and face.
Adult			1,306	1,306	HHRA, Vol. IIIA; Tables 4-25 and 4-26. Hands and face.
Activity duration (warmer months)	months	AD_1	5	5	HHRA, Vol. IIIA; Table 4-15; EPA's professional judgment. May through September.
Activity duration (cooler months)	months	AD_2	2	2	HHRA, Vol. IIIA; Table 4-15; EPA's professional judgment. April and October.
Dermal absorption factor	unitless	ABS_d	0.14	0.14	HHRA, Vol. IIIA; Table 4-15, Page 4-38; Wester et al. 1993.

* All exposure parameters are identical to the parameters used in the HHRA (EPA, 2005). Volume and Table and/or Section numbers provided.

EPA 1989. *Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual (Part A) Interim Final.*
EPA 1991. *Risk Assessment Guidance for Superfund, Volume I; Human Health Evaluation Manual, Supplemental Guidance, Standard Default Exposure Assumptions.*
EPA 1997. *Exposure Factors Handbook, Volume I; General Factors.*
Wester, R, H. Maibach, L. Sedik, K. Melendres, and M. Wade. 1993. Percutaneous absorption of PCBs from soil. *Journal of Environmental Toxicology and Environmental Health* 39:375-382.
Weston 2001. Email memorandum from M. Isabel Zapisek (Weston Pittsfield, MA Office) to Robert Warwick (West Chester, PA office). October 9.

Table 7b. RMCs for PCBs (mg/kg) in Soils for Target Risk Range and HI of 1
Recreational Canoeing
Adults

Parameter	EPA RME Analysis			EPA CTE Analysis		
Common Parameters						
Exposure duration (yrs)						
Adult	40	40	40	20	20	20
Body weight (kg)						
Adult	70	70	70	70	70	70
Averaging time - noncarcinogenic (days)						
Adult	14,600	14,600	14,600	7,300	7,300	7,300
Averaging time - carcinogenic (days)	25,550	25,550	25,550	25,550	25,550	25,550
Pathway Specific Parameters						
Incidental Ingestion of Soil						
Soil ingestion rate (mg/day)						
Adult	100	100	100	50	50	50
Fraction attributable to site	1.0	1.0	1.0	0.5	0.5	0.5
Conversion factor, soil ing (kg/mg)	1E-06	1E-06	1E-06	1E-06	1E-06	1E-06
Exposure frequency (days/year)	60	60	60	30	30	30
Exposure (soil ing)-carcinogenic (days)$^{-1}$	1.3E-07	1.3E-07	1.3E-07	8.4E-09	8.4E-09	8.4E-09
Exposure (soil ing)-noncarcinogenic (days)$^{-1}$	2.3E-07	2.3E-07	2.3E-07	2.9E-08	2.9E-08	2.9E-08
Dermal Contact with Soil						
Dermal adherence factor (mg/cm^2)						
Adult Warmer months	0.3	0.3	0.3	0.3	0.3	0.3
Cooler months	0.47	0.47	0.47	0.47	0.47	0.47
Skin surface area exposed (cm^2/day)						
Adult Warmer months	6074	6074	6074	6074	6074	6074
Cooler months	1306	1306	1306	1306	1306	1306
Activity duration for warmer months (months)	5	5	5	5	5	5
Activity duration for cooler months (months)	2	2	2	2	2	2
Dermal absorption factor (unitless)	0.14	0.14	0.14	0.14	0.14	0.14
Conversion factor, dermal con (kg/mg)	1.E-06	1.E-06	1.E-06	1.E-06	1.E-06	1.E-06
Exposure frequency (days/year)	60	60	60	30	30	30
Exposure (dermal con)-carcinogenic (days)$^{-1}$	2.8E-07	2.8E-07	2.8E-07	6.9E-08	6.9E-08	6.9E-08
Exposure (dermal con)-noncarcinogenic (days)$^{-1}$	4.9E-07	4.9E-07	4.9E-07	2.4E-07	2.4E-07	2.4E-07
CARCINOGENIC	**EPA RME Analysis**			**EPA CTE Analysis**		
Total Exposure, dermal contact (days)$^{-1}$	2.8E-07	2.8E-07	2.8E-07	6.9E-08	6.9E-08	6.9E-08
Total Exposure, soil ingestion (days)$^{-1}$	1.3E-07	1.3E-07	1.3E-07	8.4E-09	8.4E-09	8.4E-09
Cancer Slope Factor (CSF) (mg/kg-day)$^{-1}$	2	2	2	1	1	1
Target Risk Level	1.0E-04	1.0E-05	1.0E-06	1.0E-04	1.0E-05	1.0E-06
Risk-based Media Concentrations (mg/kg)	**121**	**12**	**1.2**	**1286**	**129**	**13**
NONCARCINOGENIC	**Adult**			**Adult**		
Total Exposure, dermal contact (days)$^{-1}$	4.9E-07			2.4E-07		
Total Exposure, soil ingestion (days)$^{-1}$	2.3E-07			2.9E-08		
Reference Dose (RfD) (mg/kg-day)	2.00E-05			2.00E-05		
Target Hazard Index	1			1		
Risk-based Media Concentrations (mg/kg)	**28**			**73**		

Table 7c. RMCs for PCBs (mg/kg) in Soils for Target Risk Range and HI of 1
Recreational Canoeing Scenario
Older Child

Parameter	EPA RME Analysis			EPA CTE Analysis		
Common Parameters						
Exposure duration (yrs)						
Older child	12	12	12	12	12	12
Body weight (kg)						
Older child	45	45	45	45	45	45
Averaging time - noncarcinogenic (days)						
Older child	4,380	4,380	4,380	4,380	4,380	4,380
Averaging time - carcinogenic (days)	25,550	25,550	25,550	25,550	25,550	25,550
Pathway Specific Parameters						
Incidental Ingestion of Soil						
Soil ingestion rate (mg/day)						
Older child	100	100	100	50	50	50
Fraction attributable to site	1.0	1.0	1.0	0.5	0.5	0.5
Conversion factor, soil ing (kg/mg)	1E-06	1E-06	1E-06	1E-06	1E-06	1E-06
Exposure frequency (days/year)	30	30	30	15	15	15
Exposure (soil ing)-carcinogenic (days)$^{-1}$	3.1E-08	3.1E-08	3.1E-08	3.9E-09	3.9E-09	3.9E-09
Exposure (soil ing)-noncarcinogenic (days)$^{-1}$	1.8E-07	1.8E-07	1.8E-07	2.3E-08	2.3E-08	2.3E-08
Dermal Contact with Soil						
Dermal adherence factor (mg/cm^2)						
Older child Warmer months	0.31	0.31	0.31	0.31	0.31	0.31
Cooler months	0.43	0.43	0.43	0.43	0.43	0.43
Skin surface area exposed (cm^2/day)						
Older child Warmer months	4471	4471	4471	4471	4471	4471
Cooler months	1125	1125	1125	1125	1125	1125
Activity duration for warmer months (months)	5	5	5	5	5	5
Activity duration for cooler months (months)	2	2	2	2	2	2
Dermal absorption factor (unitless)	0.14	0.14	0.14	0.14	0.14	0.14
Conversion factor, dermal con (kg/mg)	1.E-06	1.E-06	1.E-06	1.E-06	1.E-06	1.E-06
Exposure frequency (days/year)	30	30	30	15	15	15
Exposure (dermal con)-carcinogenic (days)$^{-1}$	4.9E-08	4.9E-08	4.9E-08	2.5E-08	2.5E-08	2.5E-08
Exposure (dermal con)-noncarcinogenic (days)$^{-1}$	2.9E-07	2.9E-07	2.9E-07	1.4E-07	1.4E-07	1.4E-07
CARCINOGENIC	**EPA RME Analysis**			**EPA CTE Analysis**		
Total Exposure, dermal contact (days)$^{-1}$	4.9E-08	4.9E-08	4.9E-08	2.5E-08	2.5E-08	2.5E-08
Total Exposure, soil ingestion (days)$^{-1}$	3.1E-08	3.1E-08	3.1E-08	3.9E-09	3.9E-09	3.9E-09
Cancer Slope Factor (CSF) (mg/kg-day)$^{-1}$	2	2	2	1	1	1
Target Risk Level	1.0E-04	1.0E-05	1.0E-06	1.0E-04	1.0E-05	1.0E-06
Risk-based Media Concentrations (mg/kg)	**619**	**62**	**6.2**	**3491**	**349**	**35**
NONCARCINOGENIC	**Older Child**			**Older Child**		
Total Exposure, dermal contact (days)$^{-1}$	2.9E-07			1.4E-07		
Total Exposure, soil ingestion (days)$^{-1}$	1.8E-07			2.3E-08		
Reference Dose (RfD) (mg/kg-day)	2.00E-05			2.00E-05		
Target Hazard Index	1			1		
Risk-based Media Concentrations (mg/kg)	**42**			**120**		

Attachment 8
Risk-based Media Concentrations for Direct Contact with Floodplain Soil
Waterfowl Hunting Scenario

A range of risk-based media concentrations (RMCs) has been developed for PCBs based on potential for direct contact with floodplain soil during the waterfowl hunting scenario. Consistent with the approach used in EPA's HHRA, potential soil ingestion and dermal contact exposures of adults and older children have been evaluated under reasonable maximum exposure (RME) and central tendency exposure (CTE) conditions. For each age group and set of exposure conditions, RMCs have been calculated based both on potential cancer risks and on potential non-cancer impacts, using the exposure assumptions and toxicity values used in the HHRA.

The RMCs for the cancer endpoint (RMC_{cancer}) and the non-cancer endpoint ($RMC_{noncancer}$) for this scenario have been calculated using the following equations, respectively:

$$RMC_{cancer} = \frac{Risk}{CSF * \left(Exp_{ingestion} + Exp_{dermal}\right)}$$

Where:

RMC_{cancer}	=	RMC based on the cancer endpoint (mg/kg)
Risk	=	Target risk level (unitless)
CSF	=	Cancer slope factor $(mg/kg\text{-}day)^{-1}$
$Exp_{ingestion}$	=	Exposure due to the soil ingestion pathway (day^{-1})
Exp_{dermal}	=	Exposure due to dermal contact with soil (day^{-1})

And

$$RMC_{noncancer} = \frac{HI * RfD}{\left(Exp_{ingestion} + Exp_{dermal}\right)}$$

Where:

$RMC_{noncancer}$	=	RMC based on the non-cancer endpoint (mg/kg)
HI	=	Target hazard index (unitless)
RfD	=	Reference dose (mg/kg-day)
$Exp_{ingestion}$	=	Exposure due to the soil ingestion pathway (day^{-1})
Exp_{dermal}	=	Exposure due to dermal contact with soil (day^{-1})

In both of the above equations, the exposures due to soil ingestion ($Exp_{ingestion}$) and dermal contact with soil (Exp_{dermal}) have been calculated using the following equations:

$$Exp_{ingestion} = \frac{IR * FI * CF * EF * ED}{AT * BW}$$

And

$$Exp_{dermal} = \frac{AF * SA * ABS_d * CF * EF * ED}{AT * BW}$$

Where:

IR	=	Soil ingestion rate (mg/day)
FI	=	Fraction of soil ingested that is attributable to the Site (unitless)
AF	=	Dermal adherence factor (mg/cm^2)
SA	=	Skin surface area exposed (cm^2/day)
ABS_d	=	Dermal absorption factor (unitless)
CF	=	Unit conversion factor (1E-06 kg/mg)
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)
AT	=	Averaging time (days)
BW	=	Age-specific body weight (kg)

The specific exposure assumptions used in this analysis and the basis of each are summarized in Table 8a. In all cases, the assumptions and parameters used are the same as those used by EPA in its 2005 HHRA.

Standard EPA toxicity values have been used for PCBs. These include a cancer slope factor (CSF) of 2 $(mg/kg\text{-}day)^{-1}$ for the RME scenario, a CSF of 1 $(mg/kg\text{-}day)^{-1}$ for the CTE scenario, and a chronic reference dose of 2E-05 mg/kg-day for both the RME and CTE analyses. These values are published in EPA's IRIS database and were used in EPA's HHRA.

Consistent with the HHRA, separate cancer-based and non-cancer-based RMCs have been developed for each relevant age group. RMCs based on potential carcinogenic effects have been developed for both the RME and CTE exposure scenarios using a range of target risks from one-in-a-million ($1x10^{-6}$) to one-in-ten-thousand ($1x10^{-4}$). This risk range is consistent with EPA's acceptable risk range. RMCs for non-cancer effects have been developed for each of the RME and CTE scenarios based on a target Hazard Index of 1.

Summary of Results

Estimated RMCs for cancer and non-cancer endpoints for adults and older children who engage in waterfowl hunting are presented below and in Tables 8b and 8c, respectively. The calculated RMCs are as follows.

	RME (mg/kg)				**CTE (mg/kg)**			
	Cancer Risk			**Non-cancer**	**Cancer Risk**			**Non-cancer**
	$1x10^{-6}$	**$1x10^{-5}$**	**$1x10^{-4}$**	**HI = 1**	**$1x10^{-6}$**	**$1x10^{-5}$**	**$1x10^{-4}$**	**HI = 1**
Adult	9	90	904	196	75	752	7,518	537
Older child	41	408	4080	140	233	2,325	23,253	399

Table 8a. Summary of Pathway- and Age-Specific Exposure Assumptions Used in the Waterfowl Hunting Scenario

Parameters	Units	Symbol	RME	CTE	Basis*
Common Parameters					
Unit conversion factor	kg/mg	CF	1.0E-06	1.0E-06	HHRA, Vol. IIIA. Table 4-17.
Exposure frequency	days/year	EF			
Older child			14	7	HHRA, Vol. IIIA; Table 4-22; Based on USFWS 2001 and EOEA 2000.
Adult			14	7	HHRA, Vol. IIIA; Table 4-22; Based on USFWS 2001 and EOEA 2000.
Exposure duration	years	ED			
Older child			6	6	HHRA, Vol. IIIA; Table 4-23; Age 12 -18 years. Section 4.5.3.7.2. Based on MassWildlife 2001.
Adult			38	25	HHRA, Vol. IIIA; Table 4-23; Section 4.5.3.7.2. Based on MDPH 2001.
Body weight	kg	BW			
Older child			45	45	HHRA, Vol. IIIA; Table 4-6; based on EPA 1989. Average age specific body weight.
Adult			70	70	HHRA, Vol. IIIA; Table 4-6; based on EPA 1989. Average age specific body weight.
Averaging time (cancer endpoint)	days	ATc	25,550	25,550	HHRA, Vol. IIIA; Table 4-6; based on EPA 1989. Lifetime of 70 years x 365 days/year.
Averaging time (noncancer endpoint)	days	ATnc			
Older child			2,190	2,190	HHRA, Vol. IIIA. Table 4-6; Based on EPA, 1989. Equivalent to duration in years x 365 days/year.
Adult			13,870	9,125	HHRA, Vol. IIIA. Table 4-6; Based on EPA, 1989. Equivalent to duration in years x 365 days/year.
Soil Ingestion Pathway					
Soil ingestion rate	mg/day	IR			
Older child			100	100	HHRA, Vol. IIIA; Tables 4-17 and 4-24; Section 4.5.3.7.3. Based on EPA 1991 and 1997.
Adult			100	100	HHRA, Vol. IIIA; Tables 4-17 and 4-24; Section 4.5.3.7.3. Based on EPA 1991 and 1997.
Fraction of ingested soil attributable to site	unitless	FI	1.0	0.5	HHRA, Vol. IIIA; Table 4-17; EPA's professional judgment.
Dermal Exposure Pathway					
Dermal adherence factor	mg/cm^2	AF			
Older child			0.43	0.43	HHRA, Vol. IIIA; Table 4-26; Section 4.5.3.7.4. Reed gatherers (hands), gardeners (face).
Adult			0.47	0.47	HHRA, Vol. IIIA; Table 4-26; Section 4.5.3.7.4. Reed gatherers (hands), gardeners (face).
Skin surface area	cm^2/day	SA			
Older child			1,125	1,125	HHRA, Vol. IIIA; Tables 4-25 and 4-26; Hands and face.
Adult			1,306	1,306	HHRA, Vol. IIIA; Tables 4-25 and 4-26; Hands and face.
Dermal absorption factor	unitless	ABS_d	0.14	0.14	HHRA, Vol. IIIA; Table 4-17, Page 4-38; Wester et al. 1993.

* All exposure parameters are identical to the parameters used in the HHRA (EPA, 2005). Volume and Table and/or Section numbers provided.

EOEA 2000. Masschusetts Executive Office of Environmental Affairs. Massachusetts Outdoors 2000! Statewide Comprehensive Outdoor Recreational Plan (SCORP).
EPA 1989. *Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual (Part A) Interim Final.*
EPA 1991. *Risk Assessment Guidance for Superfund, Volume I; Human Health Evaluation Manual, Supplemental Guidance, Standard Default Exposure Assumptions*
EPA 1997. *Exposure Factors Handbook, Volume I; General Factors.*
MDPH 2001. *Memo from Martha Steele, Deputy Director, Bureau of Environmental Health Assessment to Bryan Olson, EPA, Region 1 regarding Remainder of data request with respect* to information gathered from questionnaires from Housatonic River Area Exposure Assessment Study as well as questionnaires completed after the study and resulting from calls to the Bureau of Environmental Health Assessment (BEHA) hotline.
USFWS 2001. U.S. Fish and Wildlife Service. 2001 National *Survey of Fishing, Hunting, and Wildlife-Associated Recreation - Massachusetts.* FHW/01-MA-Rev.
Wester, R, H. Maibach, L. Sedik, K. Melendres, and M. Wade. 1993. Percutaneous absorption of PCBs from soil. *Journal of Environmental Toxicology and Environmental Health* 39:375-382.

Table 8b. RMCs for PCBs (mg/kg) in Soils for Target Risk Range and HI of 1
Waterfowl Hunting
Adults

Parameter	EPA RME Analysis			EPA CTE Analysis		
Common Parameters						
Exposure duration (yrs)						
Adult	38	38	38	25	25	25
Body weight (kg)						
Adult	70	70	70	70	70	70
Averaging time - noncarcinogenic (days)						
Adult	13,870	13,870	13,870	9,125	9,125	9,125
Averaging time - carcinogenic (days)	25,550	25,550	25,550	25,550	25,550	25,550
Pathway Specific Parameters						
Incidental Ingestion of Soil						
Soil ingestion rate (mg/day)						
Adult	100	100	100	100	100	100
Fraction attributable to site	1.0	1.0	1.0	0.5	0.5	0.5
Conversion factor, soil ing (kg/mg)	1E-06	1E-06	1E-06	1E-06	1E-06	1E-06
Exposure frequency (days/year)	14	14	14	7	7	7
Exposure (soil ing)-carcinogenic $(days)^{-1}$	3.0E-08	3.0E-08	3.0E-08	4.9E-09	4.9E-09	4.9E-09
Exposure (soil ing)-noncarcinogenic $(days)^{-1}$	5.5E-08	5.5E-08	5.5E-08	1.4E-08	1.4E-08	1.4E-08
Dermal Contact with Soil						
Dermal adherence factor (mg/cm^2)						
Adult	0.47	0.47	0.47	0.47	0.47	0.47
Skin surface area exposed (cm^2/day)						
Adult	1306	1306	1306	1306	1306	1306
Dermal absorption factor (unitless)	0.14	0.14	0.14	0.14	0.14	0.14
Conversion factor, dermal con (kg/mg)	1.E-06	1.E-06	1.E-06	1.E-06	1.E-06	1.E-06
Exposure frequency (days/year)	14	14	14	7	7	7
Exposure (dermal con)-carcinogenic $(days)^{-1}$	2.6E-08	2.6E-08	2.6E-08	8.4E-09	8.4E-09	8.4E-09
Exposure (dermal con)-noncarcinogenic $(days)^{-1}$	4.7E-08	4.7E-08	4.7E-08	2.4E-08	2.4E-08	2.4E-08
CARCINOGENIC	**EPA RME Analysis**			**EPA CTE Analysis**		
Total Exposure, dermal contact $(days)^{-1}$	2.6E-08	2.6E-08	2.6E-08	8.4E-09	8.4E-09	8.4E-09
Total Exposure, soil ingestion $(days)^{-1}$	3.0E-08	3.0E-08	3.0E-08	4.9E-09	4.9E-09	4.9E-09
Cancer Slope Factor (CSF) $(mg/kg\text{-}day)^{-1}$	2	2	2	1	1	1
Target Risk Level	1.0E-04	1.0E-05	1.0E-06	1.0E-04	1.0E-05	1.0E-06
Risk-based Media Concentrations (mg/kg)	**904**	**90**	**9.0**	**7518**	**752**	**75**
NONCARCINOGENIC	**Adult**			**Adult**		
Total Exposure, dermal contact $(days)^{-1}$	4.7E-08			2.4E-08		
Total Exposure, soil ingestion $(days)^{-1}$	5.5E-08			1.4E-08		
Reference Dose (RfD) (mg/kg-day)	2.00E-05			2.00E-05		
Target Hazard Index	1			1		
Risk-based Media Concentrations (mg/kg)	**196**			**537**		

Table 8c. RMCs for PCBs (mg/kg) in Soils for Target Risk Range and HI of 1
Waterfowl Hunting
Older Child

Parameter	EPA RME Analysis			EPA CTE Analysis		
Common Parameters						
Exposure duration (yrs)						
Older child	6	6	6	6	6	6
Body weight (kg)						
Older child	45	45	45	45	45	45
Averaging time - noncarcinogenic (days)						
Older child	2,190	2,190	2,190	2,190	2,190	2,190
Averaging time - carcinogenic (days)	25,550	25,550	25,550	25,550	25,550	25,550
Pathway Specific Parameters						
Incidental Ingestion of Soil						
Soil ingestion rate (mg/day)						
Older child	100	100	100	100	100	100
Fraction attributable to site	1.0	1.0	1.0	0.5	0.5	0.5
Conversion factor, soil ing (kg/mg)	1E-06	1E-06	1E-06	1E-06	1E-06	1E-06
Exposure frequency (days/year)	14	14	14	7	7	7
Exposure (soil ing)-carcinogenic $(days)^{-1}$	7.3E-09	7.3E-09	7.3E-09	1.8E-09	1.8E-09	1.8E-09
Exposure (soil ing)-noncarcinogenic $(days)^{-1}$	8.5E-08	8.5E-08	8.5E-08	2.1E-08	2.1E-08	2.1E-08
Dermal Contact with Soil						
Dermal adherence factor (mg/cm^2)						
Older child	0.43	0.43	0.43	0.43	0.43	0.43
Skin surface area exposed (cm^2/day)						
Older child	1125	1125	1125	1125	1125	1125
Dermal absorption factor (unitless)	0.14	0.14	0.14	0.14	0.14	0.14
Conversion factor, dermal con (kg/mg)	1.E-06	1.E-06	1.E-06	1.E-06	1.E-06	1.E-06
Exposure frequency (days/year)	14	14	14	7	7	7
Exposure (dermal con)-carcinogenic $(days)^{-1}$	4.9E-09	4.9E-09	4.9E-09	2.5E-09	2.5E-09	2.5E-09
Exposure (dermal con)-noncarcinogenic $(days)^{-1}$	5.8E-08	5.8E-08	5.8E-08	2.9E-08	2.9E-08	2.9E-08
CARCINOGENIC	**EPA RME Analysis**			**EPA CTE Analysis**		
Total Exposure, dermal contact $(days)^{-1}$	4.9E-09	4.9E-09	4.9E-09	2.5E-09	2.5E-09	2.5E-09
Total Exposure, soil ingestion $(days)^{-1}$	7.3E-09	7.3E-09	7.3E-09	1.8E-09	1.8E-09	1.8E-09
Cancer Slope Factor (CSF) $(mg/kg\text{-}day)^{-1}$	2	2	2	1	1	1
Target Risk Level	1.0E-04	1.0E-05	1.0E-06	1.0E-04	1.0E-05	1.0E-06
Risk-based Media Concentrations (mg/kg)	**4080**	**408**	**41**	**23253**	**2325**	**233**
NONCARCINOGENIC	**Older Child**			**Older Child**		
Total Exposure, dermal contact $(days)^{-1}$	5.8E-08			2.9E-08		
Total Exposure, soil ingestion $(days)^{-1}$	8.5E-08			2.1E-08		
Reference Dose (RfD) (mg/kg-day)	2.00E-05			2.00E-05		
Target Hazard Index	1			1		
Risk-based Media Concentrations (mg/kg)	**140**			**399**		

Attachment 9
Risk-based Media Concentrations for Direct Contact with Floodplain Soil
Farmer Scenario

A range of risk-based media concentrations (RMCs) has been developed for PCBs based on potential for direct contact with floodplain soil during the farmer scenario. Consistent with the approach used in EPA's HHRA, potential soil ingestion and dermal contact exposures of adults have been evaluated under reasonable maximum exposure (RME) and central tendency exposure (CTE) conditions. RMCs have been calculated based both on potential cancer risks and on potential non-cancer impacts, using the exposure assumptions and toxicity values used in the HHRA.

The RMCs for the cancer endpoint (RMC_{cancer}) and the non-cancer endpoint ($RMC_{noncancer}$) for this scenario have been calculated using the following equations, respectively:

$$RMC_{cancer} = \frac{Risk}{CSF * \left(Exp_{ingestion} + Exp_{dermal}\right)}$$

Where:

RMC_{cancer}	=	RMC based on the cancer endpoint (mg/kg)
Risk	=	Target risk level (unitless)
CSF	=	Cancer slope factor $(mg/kg\text{-}day)^{-1}$
$Exp_{ingestion}$	=	Exposure due to the soil ingestion pathway (day^{-1})
Exp_{dermal}	=	Exposure due to dermal contact with soil (day^{-1})

And

$$RMC_{noncancer} = \frac{HI * RfD}{\left(Exp_{ingestion} + Exp_{dermal}\right)}$$

Where:

$RMC_{noncancer}$	=	RMC based on the non-cancer endpoint (mg/kg)
HI	=	Target hazard index (unitless)
RfD	=	Reference dose (mg/kg-day)
$Exp_{ingestion}$	=	Exposure due to the soil ingestion pathway (day^{-1})
Exp_{dermal}	=	Exposure due to dermal contact with soil (day^{-1})

In both of the above equations, the exposures due to soil ingestion ($Exp_{ingestion}$) and dermal contact with soil (Exp_{dermal}) have been calculated using the following equations:

$$Exp_{ingestion} = \frac{IR * FI * CF * EF * ED}{AT * BW}$$

And

$$Exp_{dermal} = \frac{AF * SA * ABS_d * CF * EF * ED}{AT * BW}$$

Where:

IR	=	Soil ingestion rate (mg/day)
FI	=	Fraction of soil ingested that is attributable to the Site (unitless)
AF	=	Dermal adherence factor (mg/cm^2)
SA	=	Skin surface area exposed (cm^2/day)
ABS_d	=	Dermal absorption factor (unitless)
CF	=	Unit conversion factor (1E-06 kg/mg)
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)
AT	=	Averaging time (days)
BW	=	Age-specific body weight (kg)

The specific exposure assumptions used in this analysis and the basis of each are summarized in Table 9a. In all cases, the assumptions and parameters used are the same as those used by EPA in its 2005 HHRA.

Standard EPA toxicity values have been used for PCBs. These include a cancer slope factor (CSF) of 2 $(mg/kg\text{-}day)^{-1}$ for the RME scenario, a CSF of 1 $(mg/kg\text{-}day)^{-1}$ for the CTE scenario, and a chronic reference dose of 2E-05 mg/kg-day for both the RME and CTE analyses. These values are published in EPA's IRIS database and were used in EPA's HHRA.

Consistent with the HHRA, separate cancer-based and non-cancer-based RMCs have been developed. The RMCs based on potential carcinogenic effects have been developed for both the RME and CTE exposure scenarios using a range of target risks from one-in-a-million ($1x10^{-6}$) to one-in-ten-thousand ($1x10^{-4}$). This risk range is consistent with EPA's acceptable risk range. RMCs for non-cancer effects have been developed for each of the RME and CTE scenarios based on a target Hazard Index of 1.

Summary of Results

Estimated RMCs for cancer and non-cancer endpoints for adult farmers are presented below and in Table 9b. The calculated RMCs are as follows.

	RME (mg/kg)				**CTE (mg/kg)**			
	Cancer Risk			**Non-cancer**	**Cancer Risk**			**Non-cancer**
	$1x10^{-6}$	**$1x10^{-5}$**	**$1x10^{-4}$**	**HI = 1**	**$1x10^{-6}$**	**$1x10^{-5}$**	**$1x10^{-4}$**	**HI = 1**
Adult	1.2	12	118	43	42	419	4,195	348

Table 9a. Summary of Pathway- and Age-Specific Exposure Assumptions Used in the Farmer Scenario

Parameters	Units	Symbol	RME	CTE	Basis*
Common Parameters					
Unit conversion factor	kg/mg	CF	1.0E-06	1.0E-06	HHRA, Vol. IIIA. Table 4-19.
Exposure frequency	days/year	EF	40	10	HHRA, Vol. IIIA; Table 4-22; Based on Fries 2002.
Exposure duration	years	ED	64	29	HHRA, Vol. IIIA; Table 4-23; Section 4.5.3.9.2. Based on MDPH 2001.
Body weight	kg	BW	70	70	HHRA, Vol. IIIA; Table 4-6; based on EPA 1989. Average age specific body weight.
Averaging time (cancer endpoint)	days	ATc	25,550	25,550	HHRA, Vol. IIIA; Table 4-6; based on EPA 1989. Lifetime of 70 years x 365 days/year.
Averaging time (noncancer endpoint)	days	ATnc	23,360	10,585	HHRA, Vol. IIIA. Table 4-6; Based on EPA, 1989. Equivalent to duration in years x 365 days/year.
Soil Ingestion Pathway					
Soil ingestion rate	mg/day	IR	200	100	HHRA, Vol. IIIA; Tables 4-19 and 4-24; Section 4.5.3.9.3. Based on EPA 1997 and Stanek et al. 1997.
Fraction of ingested soil attributable to site	unitless	FI	1.0	0.5	HHRA, Vol. IIIA; Table 4-19; EPA's professional judgment.
Dermal Exposure Pathway					
Dermal adherence factor	mg/cm^2	AF	0.21	0.21	HHRA, Vol. IIIA; Table 4-26; Section 4.5.3.9.4. Based on farmers.
Skin surface area	cm^2/day	SA	3,300	3,300	HHRA, Vol. IIIA; Tables 4-25 and 4-26; Hands, forearms and head.
Dermal absorption factor	unitless	ABS_d	0.14	0.14	HHRA, Vol. IIIA; Table 4-19, Page 4-38; Wester et al. 1993.

* All exposure parameters are identical to the parameters used in the HHRA (EPA, 2005). Volume and Table and/or Section numbers provided.

EPA 1989. *Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual (Part A) Interim Final.*

EPA 1997. *Exposure Factors Handbook, Volume I; General Factors.*

Fries 2002. USDA (retired). Personal communication.

MDPH 2001. *Memo from Martha Steele, Deputy Director, Bureau of Environmental Health Assessment to Bryan Olson, EPA, Region 1 regarding Remainder of data request with respect* to information gathered from questionnaires from Housatonic River Area Exposure Assessment Study as well as questionnaires completed after the study and resulting from calls to the Bureau of Environmental Health Assessment (BEHA) hotline.

Stanek, E. J., C. Calabrese, R. Barnes, P. Pekow. 1997. Soil ingestion adults - results of a second pilot study. *Ecotoxicology and Environmental Safety 36:249:257.*

Wester, R, H. Maibach, L. Sedik, K. Melendres, and M. Wade. 1993. Percutaneous absorption of PCBs from soil. *Journal of Environmental Toxicology and Environmental Health* 39:375-382.

Table 9b. RMCs for PCBs (mg/kg) in Soils for Target Risk Range and HI of 1
Farmer Scenario
Adult

Parameter	EPA RME Analysis			EPA CTE Analysis		
Common Parameters						
Exposure duration (yrs)	64	64	64	29	29	29
Body weight (kg)	70	70	70	70	70	70
Averaging time - noncarcinogenic (days)	23,360	23,360	23,360	10,585	10,585	10,585
Averaging time - carcinogenic (days)	25,550	25,550	25,550	25,550	25,550	25,550
Pathway Specific Parameters						
Incidental Ingestion of Soil						
Soil ingestion rate (mg/day)	200	200	200	100	100	100
Fraction attributable to site	1.0	1.0	1.0	0.5	0.5	0.5
Conversion factor, soil ing (kg/mg)	1E-06	1E-06	1E-06	1E-06	1E-06	1E-06
Exposure frequency (days/year)	40	40	40	10	10	10
Exposure (soil ing)-carcinogenic $(days)^{-1}$	2.9E-07	2.9E-07	2.9E-07	8.1E-09	8.1E-09	8.1E-09
Exposure (soil ing)-noncarcinogenic $(days)^{-1}$	3.1E-07	3.1E-07	3.1E-07	2.0E-08	2.0E-08	2.0E-08
Dermal Contact with Soil						
Dermal adherence factor (mg/cm^2)	0.21	0.21	0.21	0.21	0.21	0.21
Skin surface area exposed (cm^2/day)	3300	3300	3300	3300	3300	3300
Dermal absorption factor (unitless)	0.14	0.14	0.14	0.14	0.14	0.14
Conversion factor, dermal con (kg/mg)	1.E-06	1.E-06	1.E-06	1.E-06	1.E-06	1.E-06
Exposure frequency (days/year)	40	40	40	10	10	10
Exposure (dermal con)-carcinogenic $(days)^{-1}$	1.4E-07	1.4E-07	1.4E-07	1.6E-08	1.6E-08	1.6E-08
Exposure (dermal con)-noncarcinogenic $(days)^{-1}$	1.5E-07	1.5E-07	1.5E-07	3.8E-08	3.8E-08	3.8E-08
CARCINOGENIC	**EPA RME Analysis**			**EPA CTE Analysis**		
Total Exposure, dermal contact $(days)^{-1}$	1.4E-07	1.4E-07	1.4E-07	1.6E-08	1.6E-08	1.6E-08
Total Exposure, soil ingestion $(days)^{-1}$	2.9E-07	2.9E-07	2.9E-07	8.1E-09	8.1E-09	8.1E-09
Cancer Slope Factor (CSF) $(mg/kg\text{-}day)^{-1}$	2	2	2	1	1	1
Target Risk Level	1.0E-04	1.0E-05	1.0E-06	1.0E-04	1.0E-05	1.0E-06
Risk-based Media Concentrations (mg/kg)	**118**	**12**	**1.2**	**4195**	**419**	**42**
NONCARCINOGENIC	**Adult**			**Adult**		
Total Exposure, dermal contact $(days)^{-1}$	1.5E-07			3.8E-08		
Total Exposure, soil ingestion $(days)^{-1}$	3.1E-07			2.0E-08		
Reference Dose (RfD) (mg/kg-day)	2.00E-05			2.00E-05		
Target Hazard Index	1			1		
Risk-based Media Concentrations (mg/kg)	**43**			**348**		

Attachment 10
Risk-based Media Concentrations for Direct Contact with Floodplain Soil
High Use Commercial Groundskeeper Scenario

A range of risk-based media concentrations (RMCs) has been developed for PCBs based on potential for direct contact with floodplain soil during the high-use commercial groundskeeper scenario. Consistent with the approach used in EPA's HHRA, potential soil ingestion and dermal contact exposures of adults have been evaluated under reasonable maximum exposure (RME) and central tendency exposure (CTE) conditions. RMCs have been calculated based both on potential cancer risks and on potential non-cancer impacts, using the exposure assumptions and toxicity values used in the HHRA.

The RMCs for the cancer endpoint (RMC_{cancer}) and the non-cancer endpoint ($RMC_{noncancer}$) for this scenario have been calculated using the following equations, respectively:

$$RMC_{cancer} = \frac{Risk}{CSF * \left(Exp_{ingestion} + Exp_{dermal}\right)}$$

Where:

RMC_{cancer}	=	RMC based on the cancer endpoint (mg/kg)
Risk	=	Target risk level (unitless)
CSF	=	Cancer slope factor $(mg/kg\text{-}day)^{-1}$
$Exp_{ingestion}$	=	Exposure due to the soil ingestion pathway (day^{-1})
Exp_{dermal}	=	Exposure due to dermal contact with soil (day^{-1})

And

$$RMC_{noncancer} = \frac{HI * RfD}{\left(Exp_{ingestion} + Exp_{dermal}\right)}$$

Where:

$RMC_{noncancer}$	=	RMC based on the non-cancer endpoint (mg/kg)
HI	=	Target hazard index (unitless)
RfD	=	Reference dose (mg/kg-day)
$Exp_{ingestion}$	=	Exposure due to the soil ingestion pathway (day^{-1})
Exp_{dermal}	=	Exposure due to dermal contact with soil (day^{-1})

In both of the above equations, the exposures due to soil ingestion ($Exp_{ingestion}$) and dermal contact with soil (Exp_{dermal}) have been calculated using the following equations:

$$Exp_{ingestion} = \frac{IR * FI * CF * EF * ED}{AT * BW}$$

And

$$Exp_{dermal} = \frac{AF * SA * ABS_d * CF * EF * ED}{AT * BW}$$

Where:

IR	=	Soil ingestion rate (mg/day)
FI	=	Fraction of soil ingested that is attributable to the Site (unitless)
AF	=	Dermal adherence factor (mg/cm^2)
SA	=	Skin surface area exposed (cm^2/day)
ABS_d	=	Dermal absorption factor (unitless)
CF	=	Unit conversion factor (1E-06 kg/mg)
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)
AT	=	Averaging time (days)
BW	=	Age-specific body weight (kg)

The specific exposure assumptions used in this analysis and the basis of each are summarized in Table 10a. In all cases, the assumptions and parameters used are the same as those used by EPA in its 2005 HHRA.

Standard EPA toxicity values have been used for PCBs. These include a cancer slope factor (CSF) of 2 (mg/kg-day)$^{-1}$ for the RME scenario, a CSF of 1 (mg/kg-day)$^{-1}$ for the CTE scenario, and a chronic reference dose of 2E-05 mg/kg-day for both the RME and CTE analyses. These values are published in EPA's IRIS database and were used in EPA's HHRA.

Consistent with the HHRA, separate cancer-based and non-cancer-based RMCs have been developed. The RMCs based on potential carcinogenic effects have been developed for both the RME and CTE exposure scenarios using a range of target risks from one-in-a-million (1x10^{-6}) to one-in-ten-thousand (1x10^{-4}). This risk range is consistent with EPA's acceptable risk range. RMCs for non-cancer effects have been developed for each of the RME and CTE scenarios based on a target Hazard Index of 1.

Summary of Results

Estimated RMCs for cancer and non-cancer endpoints for adult groundskeepers in high-use commercial areas are presented below and in Table 10b. The calculated RMCs are as follows.

	RME (mg/kg)				**CTE (mg/kg)**			
	Cancer Risk			**Non-cancer**	**Cancer Risk**			**Non-cancer**
	1x10^{-6}	**1x10^{-5}**	**1x10^{-4}**	**HI = 1**	**1x10^{-6}**	**1x10^{-5}**	**1x10^{-4}**	**HI = 1**
Adult	1.8	18	177	25	17	166	1,664	57

Table 10a. Summary of Pathway- and Age-Specific Exposure Assumptions Used in the High-use Commercial Groundskeeper Scenario

Parameters	Units	Symbol	RME	CTE	Basis*
Common Parameters					
Unit conversion factor	kg/mg	CF	1.0E-06	1.0E-06	HHRA, Vol. IIIA. Table 4-20.
Exposure frequency	days/year	EF	150	150	HHRA, Vol. IIIA; Table 4-22; Section 4.5.3.10.1. Based on EPA's professional judgment.
Exposure duration	years	ED	25	12	HHRA, Vol. IIIA; Table 4-23; Section 4.5.3.10.2. EPA 1991 (RME) and EPA's professional judgment (CTE).
Body weight	kg	BW	70	70	HHRA, Vol. IIIA; Table 4-6; based on EPA 1989. Average age specific body weight.
Averaging time (cancer endpoint)	days	ATc	25,550	25,550	HHRA, Vol. IIIA; Table 4-6; based on EPA 1989. Lifetime of 70 years x 365 days/year.
Averaging time (noncancer endpoint)	days	ATnc	9,125	4,380	HHRA, Vol. IIIA. Table 4-6; Based on EPA, 1989. Equivalent to duration in years x 365 days/year.
Soil Ingestion Pathway					
Soil ingestion rate	mg/day	IR	100	50	HHRA, Vol. IIIA; Tables 4-20 and 4-24; Section 4.5.3.10.3. Based on EPA 1991 and 1997.
Fraction of ingested soil attributable to site	unitless	FI	1.0	0.5	HHRA, Vol. IIIA; Table 4-20; EPA's professional judgment.
Dermal Exposure Pathway					
Dermal adherence factor	mg/cm^2	AF	0.1	0.1	HHRA, Vol. IIIA; Table 4-26; Section 4.5.3.10.4. Based on gardeners.
Skin surface area	cm^2/day	SA	2,479	2,479	HHRA, Vol. IIIA; Tables 4-25 and 4-26; Hands, forearms and face.
Dermal absorption factor	unitless	ABS_d	0.14	0.14	HHRA, Vol. IIIA; Table 4-20, Page 4-38; Wester et al. 1993.

* All exposure parameters are identical to the parameters used in the HHRA (EPA, 2005). Volume and Table and/or Section numbers provided.

EPA 1989. *Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual (Part A) Interim Final.*
EPA 1991. Risk Assessment Guidance for Superfund, Volume I; Human Health Evaluation Manual, Supplemental Guidance, Standard Default Exposure Assumptions.
EPA 1997. *Exposure Factors Handbook, Volume I; General Factors.*
Wester, R, H. Maibach, L. Sedik, K. Melendres, and M. Wade. 1993. Percutaneous absorption of PCBs from soil. *Journal of Environmental Toxicology and Environmental Health* 39:375-382.

Table 10b. RMCs for PCBs (mg/kg) in Soils for Target Risk Range and HI of 1
High-Use Commercial Groundskeeper Scenario
Adults

Parameter	EPA RME Analysis			EPA CTE Analysis		
Common Parameters						
Exposure duration (yrs)	25	25	25	12	12	12
Body weight (kg)	70	70	70	70	70	70
Averaging time - noncarcinogenic (days)	9,125	9,125	9,125	4,380	4,380	4,380
Averaging time - carcinogenic (days)	25,550	25,550	25,550	25,550	25,550	25,550
Pathway Specific Parameters						
Incidental Ingestion of Soil						
Soil ingestion rate (mg/day)	100	100	100	50	50	50
Fraction attributable to site	1.0	1.0	1.0	0.5	0.5	0.5
Conversion factor, soil ing (kg/mg)	1E-06	1E-06	1E-06	1E-06	1E-06	1E-06
Exposure frequency (days/year)	150	150	150	150	150	150
Exposure (soil ing)-carcinogenic $(days)^{-1}$	2.1E-07	2.1E-07	2.1E-07	2.5E-08	2.5E-08	2.5E-08
Exposure (soil ing)-noncarcinogenic $(days)^{-1}$	5.9E-07	5.9E-07	5.9E-07	1.5E-07	1.5E-07	1.5E-07
Dermal Contact with Soil						
Dermal adherence factor (mg/cm^2)	0.1	0.1	0.1	0.1	0.1	0.1
Skin surface area exposed (cm^2/day)	2479	2479	2479	2479	2479	2479
Dermal absorption factor (unitless)	0.14	0.14	0.14	0.14	0.14	0.14
Conversion factor, dermal con (kg/mg)	1.E-06	1.E-06	1.E-06	1.E-06	1.E-06	1.E-06
Exposure frequency (days/year)	150	150	150	150	150	150
Exposure (dermal con)-carcinogenic $(days)^{-1}$	7.3E-08	7.3E-08	7.3E-08	3.5E-08	3.5E-08	3.5E-08
Exposure (dermal con)-noncarcinogenic $(days)^{-1}$	2.0E-07	2.0E-07	2.0E-07	2.0E-07	2.0E-07	2.0E-07
CARCINOGENIC	**EPA RME Analysis**			**EPA CTE Analysis**		
Total Exposure, dermal contact $(days)^{-1}$	7.3E-08	7.3E-08	7.3E-08	3.5E-08	3.5E-08	3.5E-08
Total Exposure, soil ingestion $(days)^{-1}$	2.1E-07	2.1E-07	2.1E-07	2.5E-08	2.5E-08	2.5E-08
Cancer Slope Factor (CSF) $(mg/kg\text{-}day)^{-1}$	2	2	2	1	1	1
Target Risk Level	1.0E-04	1.0E-05	1.0E-06	1.0E-04	1.0E-05	1.0E-06
Risk-based Media Concentrations (mg/kg)	**177**	**18**	**1.8**	**1664**	**166**	**17**
NONCARCINOGENIC	**Adult**			**Adult**		
Total Exposure, dermal contact $(days)^{-1}$	2.0E-07			2.0E-07		
Total Exposure, soil ingestion $(days)^{-1}$	5.9E-07			1.5E-07		
Reference Dose (RfD) (mg/kg-day)	2.00E-05			2.00E-05		
Target Hazard Index	1			1		
Risk-based Media Concentrations (mg/kg)	**25**			**57**		

Attachment 11
Risk-based Media Concentrations for Direct Contact with Floodplain Soil
Low-Use Commercial Groundskeeper Scenario

A range of risk-based media concentrations (RMCs) has been developed for PCBs based on potential for direct contact with floodplain soil during the low-use commercial groundskeeper scenario. Consistent with the approach used in EPA's HHRA, potential soil ingestion and dermal contact exposures of adults have been evaluated under reasonable maximum exposure (RME) and central tendency exposure (CTE) conditions. RMCs have been calculated based both on potential cancer risks and on potential non-cancer impacts, using the exposure assumptions and toxicity values used in the HHRA.

The RMCs for the cancer endpoint (RMC_{cancer}) and the non-cancer endpoint ($RMC_{noncancer}$) for this scenario have been calculated using the following equations, respectively:

$$RMC_{cancer} = \frac{Risk}{CSF * \left(Exp_{ingestion} + Exp_{dermal}\right)}$$

Where:

RMC_{cancer}	=	RMC based on the cancer endpoint (mg/kg)
Risk	=	Target risk level (unitless)
CSF	=	Cancer slope factor $(mg/kg\text{-}day)^{-1}$
$Exp_{ingestion}$	=	Exposure due to the soil ingestion pathway (day^{-1})
Exp_{dermal}	=	Exposure due to dermal contact with soil (day^{-1})

And

$$RMC_{noncancer} = \frac{HI * RfD}{\left(Exp_{ingestion} + Exp_{dermal}\right)}$$

Where:

$RMC_{noncancer}$	=	RMC based on the non-cancer endpoint (mg/kg)
HI	=	Target hazard index (unitless)
RfD	=	Reference dose (mg/kg-day)
$Exp_{ingestion}$	=	Exposure due to the soil ingestion pathway (day^{-1})
Exp_{dermal}	=	Exposure due to dermal contact with soil (day^{-1})

In both of the above equations, the exposures due to soil ingestion ($Exp_{ingestion}$) and dermal contact with soil (Exp_{dermal}) have been calculated using the following equations:

$$Exp_{ingestion} = \frac{IR * FI * CF * EF * ED}{AT * BW}$$

And

$$Exp_{dermal} = \frac{AF * SA * ABS_d * CF * EF * ED}{AT * BW}$$

Where:

IR	=	Soil ingestion rate (mg/day)
FI	=	Fraction of soil ingested that is attributable to the Site (unitless)
AF	=	Dermal adherence factor (mg/cm^2)
SA	=	Skin surface area exposed (cm^2/day)
ABS_d	=	Dermal absorption factor (unitless)
CF	=	Unit conversion factor (1E-06 kg/mg)
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)
AT	=	Averaging time (days)
BW	=	Age-specific body weight (kg)

The specific exposure assumptions used in this analysis and the basis of each are summarized in Table 11a. In all cases, the assumptions and parameters used are the same as those used by EPA in its 2005 HHRA.

Standard EPA toxicity values have been used for PCBs. These include a cancer slope factor (CSF) of 2 $(mg/kg\text{-}day)^{-1}$ for the RME scenario, a CSF of 1 $(mg/kg\text{-}day)^{-1}$ for the CTE scenario, and a chronic reference dose of 2E-05 mg/kg-day for both the RME and CTE analyses. These values are published in EPA's IRIS database and were used in EPA's HHRA.

Consistent with the HHRA, separate cancer-based and non-cancer-based RMCs have been developed. The RMCs based on potential carcinogenic effects have been developed for both the RME and CTE exposure scenarios using a range of target risks from one-in-a-million ($1x10^{-6}$) to one-in-ten-thousand ($1x10^{-4}$). This risk range is consistent with EPA's acceptable risk range. RMCs for non-cancer effects have been developed for each of the RME and CTE scenarios based on a target Hazard Index of 1.

Summary of Results

Estimated RMCs for cancer and non-cancer endpoints for adult groundskeepers in high-use commercial areas are presented below and in Table 11b. The calculated RMCs are as follows.

	RME (mg/kg)				**CTE (mg/kg)**			
	Cancer Risk			**Non-cancer**	**Cancer Risk**			**Non-cancer**
	$1x10^{-6}$	**$1x10^{-5}$**	**$1x10^{-4}$**	**HI = 1**	**$1x10^{-6}$**	**$1x10^{-5}$**	**$1x10^{-4}$**	**HI = 1**
Adult	8.9	89	885	126	166	1,664	16,642	571

Table 11a. Summary of Pathway- and Age-Specific Exposure Assumptions Used in the Low-Use Commercial Groundskeeper Scenario

Parameters	Units	Symbol	RME	CTE	Basis*
Common Parameters					
Unit conversion factor	kg/mg	CF	1.0E-06	1.0E-06	HHRA, Vol. IIIA. Table 4-20.
Exposure frequency	days/year	EF	30	15	HHRA, Vol. IIIA; Table 4-22; Section 4.5.3.10.1. Based on EPA's professional judgment.
Exposure duration	years	ED	25	12	HHRA, Vol. IIIA; Table 4-23; Section 4.5.3.10.2. EPA 1991 (RME) and EPA's professional judgment (CTE).
Body weight	kg	BW	70	70	HHRA, Vol. IIIA; Table 4-6; based on EPA 1989. Average age specific body weight.
Averaging time (cancer endpoint)	days	ATc	25,550	25,550	HHRA, Vol. IIIA; Table 4-6; based on EPA 1989. Lifetime of 70 years x 365 days/year.
Averaging time (noncancer endpoint)	days	ATnc	9,125	4,380	HHRA, Vol. IIIA. Table 4-6; Based on EPA, 1989. Equivalent to duration in years x 365 days/year.
Soil Ingestion Pathway					
Soil ingestion rate	mg/day	IR	100	50	HHRA, Vol. IIIA; Tables 4-20 and 4-24; Section 4.5.3.10.3. Based on EPA 1991 and 1997.
Fraction of ingested soil attributable to site	unitless	FI	1.0	0.5	HHRA, Vol. IIIA; Table 4-20; EPA's professional judgment.
Dermal Exposure Pathway					
Dermal adherence factor	mg/cm^2	AF	0.1	0.1	HHRA, Vol. IIIA; Table 4-26; Section 4.5.3.10.4. Based on gardeners.
Skin surface area	cm^2/day	SA	2,479	2,479	HHRA, Vol. IIIA; Tables 4-25 and 4-26; Hands, forearms and face.
Dermal absorption factor	unitless	ABS_d	0.14	0.14	HHRA, Vol. IIIA; Table 4-20, Page 4-38; Wester et al. 1993.

* All exposure parameters are identical to the parameters used in the HHRA (EPA, 2005). Volume and Table and/or Section numbers provided.

EPA 1989. *Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual (Part A) Interim Final.*
EPA 1991. Risk Assessment Guidance for Superfund, Volume I; Human Health Evaluation Manual, Supplemental Guidance, Standard Default Exposure Assumptions.
EPA 1997. *Exposure Factors Handbook, Volume I; General Factors.*
Wester, R, H. Maibach, L. Sedik, K. Melendres, and M. Wade. 1993. Percutaneous absorption of PCBs from soil. *Journal of Environmental Toxicology and Environmental Health* 39:375-382.

Table 11b. RMCs for PCBs (mg/kg) in Soils for Target Risk Range and HI of 1
Low-Use Commercial Groundskeeper Scenario
Adults

Parameter	EPA RME Analysis			EPA CTE Analysis		
Common Parameters						
Exposure duration (yrs)	25	25	25	12	12	12
Body weight (kg)	70	70	70	70	70	70
Averaging time - noncarcinogenic (days)	9,125	9,125	9,125	4,380	4,380	4,380
Averaging time - carcinogenic (days)	25,550	25,550	25,550	25,550	25,550	25,550
Pathway Specific Parameters						
Incidental Ingestion of Soil						
Soil ingestion rate (mg/day)	100	100	100	50	50	50
Fraction attributable to site	1.0	1.0	1.0	0.5	0.5	0.5
Conversion factor, soil ing (kg/mg)	1E-06	1E-06	1E-06	1E-06	1E-06	1E-06
Exposure frequency (days/year)	30	30	30	15	15	15
Exposure (soil ing)-carcinogenic $(days)^{-1}$	4.2E-08	4.2E-08	4.2E-08	2.5E-09	2.5E-09	2.5E-09
Exposure (soil ing)-noncarcinogenic $(days)^{-1}$	1.2E-07	1.2E-07	1.2E-07	1.5E-08	1.5E-08	1.5E-08
Dermal Contact with Soil						
Dermal adherence factor (mg/cm^2)	0.1	0.1	0.1	0.1	0.1	0.1
Skin surface area exposed (cm^2/day)	2479	2479	2479	2479	2479	2479
Dermal absorption factor (unitless)	0.14	0.14	0.14	0.14	0.14	0.14
Conversion factor, dermal con (kg/mg)	1.E-06	1.E-06	1.E-06	1.E-06	1.E-06	1.E-06
Exposure frequency (days/year)	30	30	30	15	15	15
Exposure (dermal con)-carcinogenic $(days)^{-1}$	1.5E-08	1.5E-08	1.5E-08	3.5E-09	3.5E-09	3.5E-09
Exposure (dermal con)-noncarcinogenic $(days)^{-1}$	4.1E-08	4.1E-08	4.1E-08	2.0E-08	2.0E-08	2.0E-08
CARCINOGENIC	**EPA RME Analysis**			**EPA CTE Analysis**		
Total Exposure, dermal contact $(days)^{-1}$	1.5E-08	1.5E-08	1.5E-08	3.5E-09	3.5E-09	3.5E-09
Total Exposure, soil ingestion $(days)^{-1}$	4.2E-08	4.2E-08	4.2E-08	2.5E-09	2.5E-09	2.5E-09
Cancer Slope Factor (CSF) $(mg/kg\text{-}day)^{-1}$	2	2	2	1	1	1
Target Risk Level	1.0E-04	1.0E-05	1.0E-06	1.0E-04	1.0E-05	1.0E-06
Risk-based Media Concentrations (mg/kg)	**885**	**89**	**8.9**	**16642**	**1664**	**166**
NONCARCINOGENIC	**Adult**			**Adult**		
Total Exposure, dermal contact $(days)^{-1}$	4.1E-08			2.0E-08		
Total Exposure, soil ingestion $(days)^{-1}$	1.2E-07			1.5E-08		
Reference Dose (RfD) (mg/kg-day)	2.00E-05			2.00E-05		
Target Hazard Index	1			1		
Risk-based Media Concentrations (mg/kg)	**126**			**571**		

Attachment 12
Risk-based Media Concentrations for Direct Contact with Floodplain Soil
Utility Worker Scenario

A range of risk-based media concentrations (RMCs) has been developed for PCBs based on potential for direct contact with floodplain soil during the utility worker scenario. Consistent with the approach used in EPA's HHRA, potential soil ingestion and dermal contact exposures of adults have been evaluated under reasonable maximum exposure (RME) and central tendency exposure (CTE) conditions. RMCs have been calculated based both on potential cancer risks and on potential non-cancer impacts, using the exposure assumptions and toxicity values used in the HHRA.

The RMCs for the cancer endpoint (RMC_{cancer}) and the non-cancer endpoint ($RMC_{noncancer}$) for this scenario have been calculated using the following equations, respectively:

$$RMC_{cancer} = \frac{Risk}{CSF * \left(Exp_{ingestion} + Exp_{dermal}\right)}$$

Where:

RMC_{cancer}	=	RMC based on the cancer endpoint (mg/kg)
Risk	=	Target risk level (unitless)
CSF	=	Cancer slope factor $(mg/kg\text{-}day)^{-1}$
$Exp_{ingestion}$	=	Exposure due to the soil ingestion pathway (day^{-1})
Exp_{dermal}	=	Exposure due to dermal contact with soil (day^{-1})

And

$$RMC_{noncancer} = \frac{HI * RfD}{\left(Exp_{ingestion} + Exp_{dermal}\right)}$$

Where:

$RMC_{noncancer}$	=	RMC based on the non-cancer endpoint (mg/kg)
HI	=	Target hazard index (unitless)
RfD	=	Reference dose (mg/kg-day)
$Exp_{ingestion}$	=	Exposure due to the soil ingestion pathway (day^{-1})
Exp_{dermal}	=	Exposure due to dermal contact with soil (day^{-1})

In both of the above equations, the exposures due to soil ingestion ($Exp_{ingestion}$) and dermal contact with soil (Exp_{dermal}) have been calculated using the following equations:

$$Exp_{ingestion} = \frac{IR * FI * CF * EF * ED}{AT * BW}$$

And

$$Exp_{dermal} = \frac{AF * SA * ABS_d * CF * EF * ED}{AT * BW}$$

Where:

IR	=	Soil ingestion rate (mg/day)
FI	=	Fraction of soil ingested that is attributable to the Site (unitless)
AF	=	Dermal adherence factor (mg/cm^2)
SA	=	Skin surface area exposed (cm^2/day)
ABS_d	=	Dermal absorption factor (unitless)
CF	=	Unit conversion factor (1E-06 kg/mg)
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)
AT	=	Averaging time (days)
BW	=	Age-specific body weight (kg)

The specific exposure assumptions used in this analysis and the basis of each are summarized in Table 12a. In all cases, the assumptions and parameters used are the same as those used by EPA in its 2005 HHRA.

Standard EPA toxicity values have been used for PCBs. These include a cancer slope factor (CSF) of 2 (mg/kg-day)$^{-1}$ for the RME scenario, a CSF of 1 (mg/kg-day)$^{-1}$ for the CTE scenario, and a chronic reference dose of 2E-05 mg/kg-day for both the RME and CTE analyses. These values are published in EPA's IRIS database and were used in EPA's HHRA.

Consistent with the HHRA, separate cancer-based and non-cancer-based RMCs have been developed. The RMCs based on potential carcinogenic effects have been developed for both the RME and CTE exposure scenarios using a range of target risks from one-in-a-million ($1x10^{-6}$) to one-in-ten-thousand ($1x10^{-4}$). This risk range is consistent with EPA's acceptable risk range. RMCs for non-cancer effects have been developed for each of the RME and CTE scenarios based on a target Hazard Index of 1.

Summary of Results

Estimated RMCs for cancer and non-cancer endpoints for adult utility workers are presented below and in Table 12b. The calculated RMCs are as follows.

	RME (mg/kg)				**CTE (mg/kg)**			
	Cancer Risk			**Non-cancer**	**Cancer Risk**			**Non-cancer**
	$1x10^{-6}$	**$1x10^{-5}$**	**$1x10^{-4}$**	**HI = 1**	**$1x10^{-6}$**	**$1x10^{-5}$**	**$1x10^{-4}$**	**HI = 1**
Adult	17	169	1,694	242	209	2,093	20,933	718

Table 12a. Summary of Pathway- and Age-Specific Exposure Assumptions Used in the Utility Worker Scenario

Parameters	Units	Symbol	RME	CTE	Basis*
Common Parameters					
Unit conversion factor	kg/mg	CF	1.0E-06	1.0E-06	HHRA, Vol. IIIA. Table 4-21.
Exposure frequency	days/year	EF	5	5	HHRA, Vol. IIIA; Table 4-22; Section 4.5.3.11.1. Based on EPA's professional judgment.
Exposure duration	years	ED	25	12	HHRA, Vol. IIIA; Table 4-23; Section 4.5.3.11.2. EPA 1991 (RME) and EPA's professional judgment (CTE).
Body weight	kg	BW	70	70	HHRA, Vol. IIIA; Table 4-6; based on EPA 1989. Average age specific body weight.
Averaging time (cancer endpoint)	days	ATc	25,550	25,550	HHRA, Vol. IIIA; Table 4-6; based on EPA 1989. Lifetime of 70 years x 365 days/year.
Averaging time (noncancer endpoint)	days	ATnc	9,125	4,380	HHRA, Vol. IIIA. Table 4-6; Based on EPA, 1989. Equivalent to duration in years x 365 days/year.
Soil Ingestion Pathway					
Soil ingestion rate	mg/day	IR	330	100	HHRA, Vol. IIIA; Tables 4-21 and 4-24; Section 4.5.3.11.3. Based on EPA 1997 and Stanek et al. 1997.
Fraction of ingested soil attributable to site	unitless	FI	1.0	0.5	HHRA, Vol. IIIA; Table 4-21; EPA's professional judgment.
Dermal Exposure Pathway					
Dermal adherence factor	mg/cm^2	AF	0.2	0.2	HHRA, Vol. IIIA; Table 4-26; Section 4.5.3.11.4. Based on utility workers.
Skin surface area	cm^2/day	SA	3,300	3,300	HHRA, Vol. IIIA; Tables 4-25 and 4-26; Hands, forearms and head.
Dermal absorption factor	unitless	ABS_d	0.14	0.14	HHRA, Vol. IIIA; Table 4-21, Page 4-38; Wester et al. 1993.

* All exposure parameters are identical to the parameters used in the HHRA (EPA, 2005). Volume and Table and/or Section numbers provided.

EPA 1989. *Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual (Part A) Interim Final.*
EPA 1991. Risk Assessment Guidance for Superfund, Volume I; Human Health Evaluation Manual, Supplemental Guidance, Standard Default Exposure Assumptions.
EPA 1997. *Exposure Factors Handbook, Volume I; General Factors.*
Stanek, E., E. Calabrese, R. Barnes, P. Pekow. 1997. Soil ingestion adults - results of a second pilot study. *Ecotoxicology and Environmental Safety* 36:249:257.
Wester, R, H. Maibach, L. Sedik, K. Melendres, and M. Wade. 1993. Percutaneous absorption of PCBs from soil. *Journal of Environmental Toxicology and Environmental Health* 39:375-382.

Table 12b. RMCs for PCBs (mg/kg) in Soils for Target Risk Range and HI of 1
Utility Worker Scenario
Adults

Parameter	EPA RME Analysis			EPA CTE Analysis		
Common Parameters						
Exposure duration (yrs)	25	25	25	12	12	12
Body weight (kg)	70	70	70	70	70	70
Averaging time - noncarcinogenic (days)	9,125	9,125	9,125	4,380	4,380	4,380
Averaging time - carcinogenic (days)	25,550	25,550	25,550	25,550	25,550	25,550
Pathway Specific Parameters						
Incidental Ingestion of Soil						
Soil ingestion rate (mg/day)	330	330	330	100	100	100
Fraction attributable to site	1.0	1.0	1.0	0.5	0.5	0.5
Conversion factor, soil ing (kg/mg)	1E-06	1E-06	1E-06	1E-06	1E-06	1E-06
Exposure frequency (days/year)	5	5	5	5	5	5
Exposure (soil ing)-carcinogenic $(days)^{-1}$	2.3E-08	2.3E-08	2.3E-08	1.7E-09	1.7E-09	1.7E-09
Exposure (soil ing)-noncarcinogenic $(days)^{-1}$	6.5E-08	6.5E-08	6.5E-08	9.8E-09	9.8E-09	9.8E-09
Dermal Contact with Soil						
Dermal adherence factor (mg/cm^2)	0.2	0.2	0.2	0.2	0.2	0.2
Skin surface area exposed (cm^2/day)	3300	3300	3300	3300	3300	3300
Dermal absorption factor (unitless)	0.14	0.14	0.14	0.14	0.14	0.14
Conversion factor, dermal con (kg/mg)	1.E-06	1.E-06	1.E-06	1.E-06	1.E-06	1.E-06
Exposure frequency (days/year)	5	5	5	5	5	5
Exposure (dermal con)-carcinogenic $(days)^{-1}$	6.5E-09	6.5E-09	6.5E-09	3.1E-09	3.1E-09	3.1E-09
Exposure (dermal con)-noncarcinogenic $(days)^{-1}$	1.8E-08	1.8E-08	1.8E-08	1.8E-08	1.8E-08	1.8E-08
CARCINOGENIC	**EPA RME Analysis**			**EPA CTE Analysis**		
Total Exposure, dermal contact $(days)^{-1}$	6.5E-09	6.5E-09	6.5E-09	3.1E-09	3.1E-09	3.1E-09
Total Exposure, soil ingestion $(days)^{-1}$	2.3E-08	2.3E-08	2.3E-08	1.7E-09	1.7E-09	1.7E-09
Cancer Slope Factor (CSF) $(mg/kg\text{-}day)^{-1}$	2	2	2	1	1	1
Target Risk Level	1.0E-04	1.0E-05	1.0E-06	1.0E-04	1.0E-05	1.0E-06
Risk-based Media Concentrations (mg/kg)	**1694**	**169**	**17**	**20933**	**2093**	**209**
NONCARCINOGENIC	**Adult**			**Adult**		
Total Exposure, dermal contact $(days)^{-1}$	1.8E-08			1.8E-08		
Total Exposure, soil ingestion $(days)^{-1}$	6.5E-08			9.8E-09		
Reference Dose (RfD) (mg/kg-day)	2.00E-05			2.00E-05		
Target Hazard Index	1			1		
Risk-based Media Concentrations (mg/kg)	**242**			**718**		

Attachment 13
Risk-based Media Concentrations for Direct Contact with Sediment
Sediment Exposure Scenario

A range of risk-based media concentrations (RMCs) has been developed for PCBs based on potential for direct contact with sediments under the sediment exposure scenario. Consistent with the approach used in EPA's HHRA, potential sediment ingestion and dermal contact exposures of adults and older children have been evaluated under reasonable maximum exposure (RME) and central tendency exposure (CTE) conditions. For each age group and set of exposure conditions, RMCs have been calculated based both on potential cancer risks and on potential non-cancer impacts, using the exposure assumptions and toxicity values used in the HHRA.

The RMCs for the cancer endpoint (RMC_{cancer}) and the non-cancer endpoint ($RMC_{noncancer}$) for this scenario have been calculated using the following equations, respectively:

$$RMC_{cancer} = \frac{Risk}{CSF * \left(Exp_{ingestion} + Exp_{dermal}\right)}$$

Where:

RMC_{cancer}	=	RMC based on the cancer endpoint (mg/kg)
Risk	=	Target risk level (unitless)
CSF	=	Cancer slope factor $(mg/kg\text{-}day)^{-1}$
$Exp_{ingestion}$	=	Exposure due to the sediment ingestion pathway (day^{-1})
Exp_{dermal}	=	Exposure due to dermal contact with sediment (day^{-1})

And

$$RMC_{noncancer} = \frac{HI * RfD}{\left(Exp_{ingestion} + Exp_{dermal}\right)}$$

Where:

$RMC_{noncancer}$	=	RMC based on the non-cancer endpoint (mg/kg)
HI	=	Target hazard index (unitless)
RfD	=	Reference dose (mg/kg-day)
$Exp_{ingestion}$	=	Exposure due to the sediment ingestion pathway (day^{-1})
Exp_{dermal}	=	Exposure due to dermal contact with sediment (day^{-1})

In both of the above equations, the exposures due to sediment ingestion ($Exp_{ingestion}$) and dermal contact with sediment (Exp_{dermal}) have been calculated using the following equations:

$$Exp_{ingestion} = \frac{IR * FI * CF * EF * ED}{AT * BW}$$

And

$$Exp_{dermal} = \frac{AF * SA * ABS_d * CF * EF * ED}{AT * BW}$$

Where:

IR	=	Sediment ingestion rate (mg/day)
FI	=	Fraction of sediment ingested that is attributable to the Site (unitless)
AF	=	Dermal adherence factor (mg/cm^2)
SA	=	Skin surface area exposed (cm^2/day)
ABS_d	=	Dermal absorption factor (unitless)
CF	=	Unit conversion factor (1E-06 kg/mg)
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)
AT	=	Averaging time (days)
BW	=	Age-specific body weight (kg)

The specific exposure assumptions used in this analysis and the basis of each are summarized in Table 13a. In all cases, the assumptions and parameters used are the same as those used by EPA in its 2005 HHRA.

Standard EPA toxicity values have been used for PCBs. These include a cancer slope factor (CSF) of 2 (mg/kg-day)$^{-1}$ for the RME scenario, a CSF of 1 (mg/kg-day)$^{-1}$ for the CTE scenario, and a chronic reference dose of 2E-05 mg/kg-day for both the RME and CTE analyses. These values are published in EPA's IRIS database and were used in EPA's HHRA.

Consistent with the HHRA, separate cancer-based and non-cancer-based RMCs have been developed for each relevant age group. The RMCs based on potential carcinogenic effects have been developed for both the RME and CTE exposure scenarios using a range of target risks from one-in-a-million (1x10^{-6}) to one-in-ten-thousand (1x10^{-4}). This risk range is consistent with EPA's acceptable risk range. RMCs for non-cancer effects have been developed for each of the RME and CTE scenarios based on a target Hazard Index of 1.

Summary of Results

Estimated RMCs for cancer and non-cancer endpoints for adults and older children who engage in sediment contact activities are presented below and in Tables 13b and 13c, respectively. The calculated RMCs are as follows.

	RME (mg/kg)				**CTE (mg/kg)**			
	Cancer Risk			**Non-cancer**	**Cancer Risk**			**Non-cancer**
	1x10^{-6}	**1x10^{-5}**	**1x10^{-4}**	**HI = 1**	**1x10^{-6}**	**1x10^{-5}**	**1x10^{-4}**	**HI = 1**
Adult	1.3	13	135	40	28	280	2,800	152
Older child	4.5	45	453	31	36	365	3,645	125

Table 13a. Summary of Pathway- and Age-Specific Exposure Assumptions Used in the Sediment Exposure Scenario

Parameters	Units	Symbol	RME	CTE	Basis*
Common Parameters					
Unit conversion factor	kg/mg	CF	1.0E-06	1.0E-06	HHRA, Vol. IIIA. Table 4-18.
Exposure frequency	days/year	EF			
Older child			36	12	HHRA, Vol. IIIA; Table 4-22; Based on EPA's professional judgment.
Adult			36	12	HHRA, Vol. IIIA; Table 4-22; Based on EPA's professional judgment.
Exposure duration	years	ED			
Older child			12	12	HHRA, Vol. IIIA; Table 4-23; Age 7 -18 years. Section 4.5.3.8.2. Calculated by EPA.
Adult			52	19	HHRA, Vol. IIIA; Table 4-23; Section 4.5.3.8.2. Based on MDPH 2001.
Body weight	kg	BW			
Older child			45	45	HHRA, Vol. IIIA; Table 4-6; based on EPA 1989. Average age specific body weight.
Adult			70	70	HHRA, Vol. IIIA; Table 4-6; based on EPA 1989. Average age specific body weight.
Averaging time (cancer endpoint)	days	ATc	25,550	25,550	HHRA, Vol. IIIA; Table 4-6; based on EPA 1989. Lifetime of 70 years x 365 days/year.
Averaging time (noncancer endpoint)	days	ATnc			
Older child			4,380	4,380	HHRA, Vol. IIIA. Table 4-6; Based on EPA, 1989. Equivalent to duration in years x 365 days/year.
Adult			18,980	6,935	HHRA, Vol. IIIA. Table 4-6; Based on EPA, 1989. Equivalent to duration in years x 365 days/year.
Soil Ingestion Pathway					
Soil ingestion rate	mg/day	IR			
Older child			100	50	HHRA, Vol. IIIA; Tables 4-18 and 4-24; Section 4.5.3.8.3. Based on EPA 1991 and 1997.
Adult			100	50	HHRA, Vol. IIIA; Tables 4-18 and 4-24; Section 4.5.3.8.3. Based on EPA 1991 and 1997.
Fraction of ingested soil attributable to site	unitless	FI	1.0	0.5	HHRA, Vol. IIIA; Table 4-18; EPA's professional judgment.
Dermal Exposure Pathway					
Dermal adherence factor	mg/cm^2	AF			
Older child			0.31	0.31	HHRA, Vol. IIIA; Table 4-26; Section 4.5.3.8.4. Gardeners (face) and Reed gatherers (other body parts).
Adult			0.3	0.3	HHRA, Vol. IIIA; Table 4-26; Section 4.5.3.8.4. Gardeners (face) and Reed gatherers (other body parts).
Skin surface area	cm^2/day	SA			
Older child			4,471	4,471	HHRA, Vol. IIIA; Tables 4-25 and 4-26; Hands, forearms, lower legs, feet and face.
Adult			6,074	6,074	HHRA, Vol. IIIA; Tables 4-25 and 4-26; Hands, forearms, lower legs, feet and face.
Dermal absorption factor	unitless	ABS_d	0.14	0.14	HHRA, Vol. IIIA; Table 4-18, Page 4-38; Wester et al. 1993.

* All exposure parameters are identical to the parameters used in the HHRA (EPA, 2005). Volume and Table and/or Section numbers provided.

EPA 1989. *Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual (Part A) Interim Final.*
EPA 1991. *Risk Assessment Guidance for Superfund, Volume I; Human Health Evaluation Manual, Supplemental Guidance, Standard Default Exposure Assumptions.*
EPA 1997. *Exposure Factors Handbook, Volume I; General Factors.*
MDPH 2001. *Memo from Martha Steele, Deputy Director, Bureau of Environmental Health Assessment to Bryan Olson, EPA, Region 1 regarding Remainder of data request with respect* to information gathered from questionnaires from Housatonic River Area Exposure Assessment Study as well as questionnaires completed after the study and resulting from calls to the Bureau of Environmental Health Assessment (BEHA) hotline.
Wester, R., H. Maibach, L. Sedik, K. Melendres, and M. Wade. 1993. Percutaneous absorption of PCBs from soil. *Journal of Environmental Toxicology and Environmental Health* 39:375-382.

Table 13b. RMCs for PCBs (mg/kg) in Soils for Target Risk Range and HI of 1
Sediment Exposure Scenario
Adults

Parameter	EPA RME Analysis			EPA CTE Analysis		
Common Parameters						
Exposure duration (yrs)						
Adult	52	52	52	19	19	19
Body weight (kg)						
Adult	70	70	70	70	70	70
Averaging time - noncarcinogenic (days)						
Adult	18,980	18,980	18,980	6,935	6,935	6,935
Averaging time - carcinogenic (days)	25,550	25,550	25,550	25,550	25,550	25,550
Pathway Specific Parameters						
Incidental Ingestion of Soil						
Soil ingestion rate (mg/day)						
Adult	100	100	100	50	50	50
Fraction attributable to site	1.0	1.0	1.0	0.5	0.5	0.5
Conversion factor, soil ing (kg/mg)	1E-06	1E-06	1E-06	1E-06	1E-06	1E-06
Exposure frequency (days/year)	36	36	36	12	12	12
Exposure (soil ing)-carcinogenic $(days)^{-1}$	1.0E-07	1.0E-07	1.0E-07	3.2E-09	3.2E-09	3.2E-09
Exposure (soil ing)-noncarcinogenic $(days)^{-1}$	1.4E-07	1.4E-07	1.4E-07	1.2E-08	1.2E-08	1.2E-08
Dermal Contact with Soil						
Dermal adherence factor (mg/cm^2)						
Adult	0.3	0.3	0.3	0.3	0.3	0.3
Skin surface area exposed (cm^2/day)						
Adult	6074	6074	6074	6074	6074	6074
Dermal absorption factor (unitless)	0.14	0.14	0.14	0.14	0.14	0.14
Conversion factor, dermal con (kg/mg)	1.E-06	1.E-06	1.E-06	1.E-06	1.E-06	1.E-06
Exposure frequency (days/year)	36	36	36	12	12	12
Exposure (dermal con)-carcinogenic $(days)^{-1}$	2.7E-07	2.7E-07	2.7E-07	3.3E-08	3.3E-08	3.3E-08
Exposure (dermal con)-noncarcinogenic $(days)^{-1}$	3.6E-07	3.6E-07	3.6E-07	1.2E-07	1.2E-07	1.2E-07
CARCINOGENIC	**EPA RME Analysis**			**EPA CTE Analysis**		
Total Exposure, dermal contact $(days)^{-1}$	2.7E-07	2.7E-07	2.7E-07	3.3E-08	3.3E-08	3.3E-08
Total Exposure, soil ingestion $(days)^{-1}$	1.0E-07	1.0E-07	1.0E-07	3.2E-09	3.2E-09	3.2E-09
Cancer Slope Factor (CSF) $(mg/kg\text{-}day)^{-1}$	2	2	2	1	1	1
Target Risk Level	1.0E-04	1.0E-05	1.0E-06	1.0E-04	1.0E-05	1.0E-06
Risk-based Media Concentrations (mg/kg)	**135**	**13**	**1.3**	**2800**	**280**	**28**
NONCARCINOGENIC	**Adult**			**Adult**		
Total Exposure, dermal contact $(days)^{-1}$	3.6E-07			1.2E-07		
Total Exposure, soil ingestion $(days)^{-1}$	1.4E-07			1.2E-08		
Reference Dose (RfD) (mg/kg-day)	2.00E-05			2.00E-05		
Target Hazard Index	1			1		
Risk-based Media Concentrations (mg/kg)	**40**			**152**		

Table 13c. RMCs for PCBs (mg/kg) in Soils for Target Risk Range and HI of 1
Sediment Exposure Scenario
Older Child

Parameter	EPA RME Analysis			EPA CTE Analysis		
Common Parameters						
Exposure duration (yrs)						
Older child	12	12	12	12	12	12
Body weight (kg)						
Older child	45	45	45	45	45	45
Averaging time - noncarcinogenic (days)						
Older child	4,380	4,380	4,380	4,380	4,380	4,380
Averaging time - carcinogenic (days)	25,550	25,550	25,550	25,550	25,550	25,550
Pathway Specific Parameters						
Incidental Ingestion of Soil						
Soil ingestion rate (mg/day)						
Older child	100	100	100	50	50	50
Fraction attributable to site	1.0	1.0	1.0	0.5	0.5	0.5
Conversion factor, soil ing (kg/mg)	1E-06	1E-06	1E-06	1E-06	1E-06	1E-06
Exposure frequency (days/year)	36	36	36	12	12	12
Exposure (soil ing)-carcinogenic $(days)^{-1}$	3.8E-08	3.8E-08	3.8E-08	3.1E-09	3.1E-09	3.1E-09
Exposure (soil ing)-noncarcinogenic $(days)^{-1}$	2.2E-07	2.2E-07	2.2E-07	1.8E-08	1.8E-08	1.8E-08
Dermal Contact with Soil						
Dermal adherence factor (mg/cm^2)						
Older child	0.31	0.31	0.31	0.31	0.31	0.31
Skin surface area exposed (cm^2/day)						
Older child	4471	4471	4471	4471	4471	4471
Dermal absorption factor (unitless)	0.14	0.14	0.14	0.14	0.14	0.14
Conversion factor, dermal con (kg/mg)	1.E-06	1.E-06	1.E-06	1.E-06	1.E-06	1.E-06
Exposure frequency (days/year)	36	36	36	12	12	12
Exposure (dermal con)-carcinogenic $(days)^{-1}$	7.3E-08	7.3E-08	7.3E-08	2.4E-08	2.4E-08	2.4E-08
Exposure (dermal con)-noncarcinogenic $(days)^{-1}$	4.3E-07	4.3E-07	4.3E-07	1.4E-07	1.4E-07	1.4E-07
CARCINOGENIC	**EPA RME Analysis**			**EPA CTE Analysis**		
Total Exposure, dermal contact $(days)^{-1}$	7.3E-08	7.3E-08	7.3E-08	2.4E-08	2.4E-08	2.4E-08
Total Exposure, soil ingestion $(days)^{-1}$	3.8E-08	3.8E-08	3.8E-08	3.1E-09	3.1E-09	3.1E-09
Cancer Slope Factor (CSF) $(mg/kg\text{-}day)^{-1}$	2	2	2	1	1	1
Target Risk Level	1.0E-04	1.0E-05	1.0E-06	1.0E-04	1.0E-05	1.0E-06
Risk-based Media Concentrations (mg/kg)	**453**	**45**	**4.5**	**3645**	**365**	**36**
NONCARCINOGENIC	**Older Child**			**EPA CTE Analysis**		
Total Exposure, dermal contact $(days)^{-1}$	4.3E-07			1.4E-07		
Total Exposure, soil ingestion $(days)^{-1}$	2.2E-07			1.8E-08		
Reference Dose (RfD) (mg/kg-day)	2.00E-05			2.00E-05		
Target Hazard Index	1			1		
Risk-based Media Concentrations (mg/kg)	**31**			**125**		

APPENDIX B

ATTACHMENTS 14 THROUGH 19

Attachment 14
Risk-based Media Concentrations for PCBs in Massachusetts and Connecticut Bass Tissue Fish Consumption Scenario

A range of Risk-based Media Concentrations (RMCs) has been developed for PCBs based on potential for exposure, via human consumption, to PCBs in the edible tissue of bass obtained from the Massachusetts and Connecticut portions of the river. Consistent with the approach used in EPA's HHRA, potential fish consumption exposures of young children and adults have been evaluated under reasonable maximum exposure (RME) and central tendency exposure (CTE) conditions. RMCs have been developed using both a deterministic approach and a probabilistic 1-dimensional Monte Carlo approach (1-D Monte Carlo). For each set of exposure conditions and each type of assessment (deterministic and probabilistic), RMCs have been calculated based on potential cancer risks (for children and adults combined) and potential non-cancer impacts (for children and adults separately), using the exposure assumptions and toxicity values used in the HHRA.

The RMCs for the cancer endpoint (RMC_{cancer}) for this scenario have been calculated using the following equation that combines exposures to young children and adults.

$$RMC_{cancer} = \frac{Risk * AT_c}{EF * CSF * FI * (1 - LOSS) * CF * \left(\left(\frac{IR_c * ED_c}{BW_c} \right) + \left(\frac{IR_a * ED_a}{BW_a} \right) \right)}$$

The RMCs for the non-cancer endpoint (RMC_{nc}) for this scenario have been calculated using the following equation. Non-cancer RMCs have been calculated separately for young children and adults.

Young Child

$$RMC_{nc} = \frac{HI * RfD * AT_{nc}}{EF * FI * (1 - LOSS) * CF * \frac{IR_c * ED_c}{BW_c}}$$

Adult

$$RMC_{hc} = \frac{HI * RfD * AT_{nc}}{EF * FI * (1 - LOSS) * CF * \frac{IR_a * ED_a}{BW_a}}$$

In the above equations:

RMC_{cancer}	=	RMC based on the cancer endpoint (mg/kg)
RMC_{nc}	=	RMC based on the non-cancer endpoint (mg/kg)
Risk	=	Target risk level (unitless)
HI	=	Target hazard index (unitless)
AT_c	=	Averaging time for carcinogenic exposure (days)
AT_{nc}	=	Averaging time for non-carcinogenic exposure (days)
EF	=	Exposure frequency (days/year)
CSF	=	Cancer slope factor $(mg/kg\text{-}day)^{-1}$
FI	=	Fraction ingested from the site (unitless)

LOSS	=	Cooking loss (unitless)
CF	=	Unit conversion factor (1E-03 kg/g)
IR_c	=	Bass ingestion rate for children aged 1-6 years (g/day)
IR_a	=	Bass ingestion rate for adults (g/day)
ED_c	=	Exposure duration for children aged 1-6 years (years)
ED_a	=	Exposure duration for adults (years)
BW_c	=	Body weight for children aged 1-6 years (kg)
BW_a	=	Body weight for adults (kg)
RfD	=	Reference dose (mg/kg-day)

The specific exposure assumptions used for each age group in the deterministic analysis, and the basis of each, are summarized in Table 14a. In all cases, the assumptions and parameters used are the same as those used by EPA in its deterministic assessment in the 2005 HHRA.

For the probabilistic analysis, the input distributions were developed from the information provided in Table 6-2 of Vol. IV of the HHRA (p. 6-15). Descriptions of these distributions are provided in Table 14b. Fifty thousand iterations of the model were run, using @Risk, for each of the target risk levels (combining adult and childhood exposure) and for the non-cancer hazard index of 1 (evaluating adults and children separately).

Standard EPA toxicity values have been used for PCBs. These include a cancer slope factor (CSF) of 2 $(mg/kg\text{-}day)^{-1}$ for the RME scenario, a CSF of 1 $(mg/kg\text{-}day)^{-1}$ for the CTE scenario, and a chronic reference dose of 2E-05 mg/kg-day for both the RME and CTE analyses. These values are published in EPA's IRIS database and were used in EPA's HHRA. For the probabilistic analysis, a point estimate CSF of 2 $(mg/kg\text{-}day)^{-1}$ was used for both the RME and CTE scenarios.

Deterministic RMCs based on potential carcinogenic effects (for children and adults combined) have been developed for both the RME and CTE exposure scenarios using a range of target risks from one-in-a-million ($1x10^{-6}$) to one-in-ten-thousand ($1x10^{-4}$). This risk range is consistent with EPA's acceptable risk range. RMCs for non-cancer effects have been developed for the RME and CTE scenarios for adults and young children separately, based on a target Hazard Index of 1.

For the probabilistic analysis, the same risk range and Hazard Index have been used. Once the analysis was completed, the 5th percentile (95% of the calculated RMC output distribution values exceed the 5th percentile) and the 50th percentile values from the output distributions of potential RMCs at each target risk level were selected as the RME and CTE RMCs, respectively.

Summary of Results

Estimated RMCs for cancer and non-cancer endpoints based on the deterministic analysis are presented in Table 14c. A summary of the distribution of RMCs calculated using the 1-D Monte Carlo is provided in Table 14d. The RMCs resulting from both the deterministic analysis and the probabilistic analysis (using the 5th and 50th percentile values for the RME and CTE, respectively) are summarized in the following table.

	RME (mg/kg)				CTE (mg/kg)			
	Cancer Risk			Non-cancer	Cancer Risk			Non-cancer
Deterministic	**$1x10^{-6}$**	**$1x10^{-5}$**	**$1x10^{-4}$**	**HI = 1**	**$1x10^{-6}$**	**$1x10^{-5}$**	**$1x10^{-4}$**	**HI = 1**
Young child/Adult	0.0019	0.019	0.19	NC	0.049	0.49	4.9	NC
Adult	NC	NC	NC	0.062	NC	NC	NC	0.43
Young child	NC	NC	NC	0.026	NC	NC	NC	0.19
1-D Monte Carlo								
Young child/Adult	0.0064	0.064	0.64	NC	0.057	0.57	5.7	NC
Adult	NC	NC	NC	0.12	NC	NC	NC	1.5
Young child	NC	NC	NC	0.059	NC	NC	NC	0.71

NC = Not calculated

Table 14a. Summary of Pathway- and Age-Specific Exposure Assumptions Used in the Deterministic Fish Consumption Scenario for Bass

Parameters	Units	Symbol	RME	CTE	Basis*
Unit conversion factor	kg/g	CF	1.0E-03	1.0E-03	HHRA, Vol IV; Tables 4-8 and 4-10.
Ingestion rate	g/day	IR			
Young child			16	4.3	HHRA, Vol IV; Tables 4-9 and 4-10. Section 4.5.2.2.6. EPA's calculation based on EPA 2002.
Adult			31	8.7	HHRA, Vol IV; Tables 4-9 and 4-10. Section 4.5.2.2.4. Based on EPA's evaluation of the Ebert et al. 1993 data.
Fraction ingested from site	unitless	FI	0.97	0.5	HHRA, Vol IV; Tables 4-8 and 4-10. Section 4.5.2.4. EPA's professional judgment.
Exposure frequency	days/year	EF	365	365	HHRA, Vol IV; Tables 4-8 and 4-10. Fish consumption rates are average daily rates over 365 days.
Fraction PCBs lost during cooking	unitless	LOSS	0.25	0.25	HHRA, Vol IV; Tables 4-8 and 4-10. Section 4.5.2.3. EPA's evaluation based on multiple studies.
Exposure duration	years	ED			
Young child			6	6	HHRA, Vol IV; Tables 4-9 and 4-10. Ages 1 to 6 years. Calculated by EPA, Section 4.5.2.6.
Adult			44	17	HHRA, Vol IV; Tables 4-9 and 4-10. Section 4.5.2.6. Based on MDPH 2001.
Body weight	kg	BW			
Young child			15	15	HHRA, Vol. IV; Table 4-9; based on EPA 1989. Average age specific body weight.
Adult			70	70	HHRA, Vol. IV; Table 4-9; based on EPA 1989. Average age specific body weight.
Averaging time (cancer endpoint)	days	ATc	25,550	25,550	HHRA, Vol. IV; Table 4-8; based on EPA 1989. Lifetime of 70 years x 365 days/year.
Averaging time (noncancer endpoint)	days	ATnc			
Young child			2,190	2,190	HHRA, Vol. IV. Table 4-10; Based on EPA, 1989. Equivalent to duration in years x 365 days/year.
Adult			16,060	6,205	HHRA, Vol. IV. Table 4-10; Based on EPA, 1989. Equivalent to duration in years x 365 days/year.

* All exposure parameters are identical to the parameters used in the HHRA (EPA, 2005). Volume and Table and/or Section numbers provided.

Ebert, E., N. Harrington, K. Boyle, J. Knight, and R. Keenan. 1993. Estimating consumption of freshwater fish among Maine anglers.*North American Journal of Fisheries Management* 13:737-745.
EPA 1989. *Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual (Part A) Interim Final.*
EPA 2002. *Estimated Per Capita Fish Consumption in the United States.*
MDPH 2001. *Memo from Martha Steele, Deputy Director, Bureau of Environmental Health Assessment to Bryan Olson, EPA, Region 1 regarding Remainder of data request with respect* to information gathered from questionnaires from Housatonic River Area Exposure Assessment Study as well as questionnaires completed after the study and resulting from calls to

the Bureau of Environmental Health Assessment (BEHA) hotline.

Table 14b. Summary of Exposure Assumptions and Distributions Used in the 1-D Monte Carlo Analysis for the Bass Consumption Scenario[1]

Parameters	Units	Symbol	Min	Max	Central Estimate	Standard Deviation	Distribution Type
Unit conversion factor	kg/g	CF	-	-	1.0E-03	-	Point Estimate
Ingestion rate	g/day	IR					
Adult			0.27	80.22	8.5	13.6	Empirical Distribution Function
Young child			0.135	40.11	4.25	6.5	Empirical Distribution Function[2]
Fraction ingested from site	unitless	FI	0.1	1	0.50	0.28	Empirical Distribution Function[3]
Fraction PCBs lost during cooking	unitless	LOSS	0.016	1	0.26	0.18	Stochastic mixture of distributions[4]
Exposure frequency	days/yr	EF	-	-	365	-	Point Estimate
Exposure duration (cancer endpoint)	years	ED					
Young child			1	6	3.5	1.4	Uniform
Adult			0	64	29	20	T-lognormal
Body weight	kg	BW					
Young child			12	23	17	2.3	Lognormal
Adult			39	119	72	15	Lognormal
Averaging time (cancer endpoint)	days	ATc			25,550		Point Estimate

[1]All distribution statistics are presented in Table 6-2, page 6-15, of the HHRA Volume IV.

[2]Based on one-half the adult distribution of rates.

[3]Empirical distribution function derived from Figure 6-17 of HHRA Volume IV yielded slightly different values than those reported in Table 6-2 of HHRA.

[4]Table 6-2 of HHRA Volume IV reports that minimum value as 0.16. However, Figure 6-6 and minimum values for the individual methods reported in Table 6-2 indicate that the minimum value is actually 0.016.

Table 14c. Deterministic RMCs for PCBs (mg/kg) in Bass Tissue for Target Risk Range and Hazard Index of 1
Fish Consumption - Massachusetts and Connecticut Bass

Parameter	EPA RME Analysis			EPA CTE Analysis		
Pathway Specific Parameters						
Exposure duration (yrs)						
Child	6	6	6	6	6	6
Adult	44	44	44	17	17	17
Body weight (kg)						
Child	15	15	15	15	15	15
Adult	70	70	70	70	70	70
Averaging time - noncarcinogenic (days)						
Child	2,190	2,190	2,190	2,190	2,190	2,190
Adult	16,060	16,060	16,060	6,205	6,205	6,205
Averaging time - carcinogenic (days)	25,550	25,550	25,550	25,550	25,550	25,550
Bass ingestion rate (g/day)						
Child	16	16	16	4.3	4.3	4.3
Adult	31	31	31	8.7	8.7	8.7
Fraction attributable to site	0.97	0.97	0.97	0.5	0.5	0.5
Cooking loss (unitless)	0.25	0.25	0.25	0.25	0.25	0.25
Conversion factor, fish ing (kg/g)	1E-03	1E-03	1E-03	1E-03	1E-03	1E-03
Exposure frequency (days/year)	365	365	365	365	365	365
Exposure - carcinogenic $(days)^{-1}$	2.7E-04	2.7E-04	2.7E-04	2.1E-05	2.1E-05	2.1E-05
Exposure - noncarcinogenic $(days)^{-1}$ - Child	7.8E-04	7.8E-04	7.8E-04	1.1E-04	1.1E-04	1.1E-04
Exposure - noncarcinogenic $(days)^{-1}$ - Adult	3.2E-04	3.2E-04	3.2E-04	4.7E-05	4.7E-05	4.7E-05
CARCINOGENIC	**EPA RME Analysis**			**EPA CTE Analysis**		
Total Exposure, fish ingestion $(days)^{-1}$	2.7E-04	2.7E-04	2.7E-04	2.1E-05	2.1E-05	2.1E-05
Cancer Slope Factor (CSF) $(mg/kg\text{-}day)^{-1}$	2	2	2	1	1	1
Target Risk Level	1.0E-04	1.0E-05	1.0E-06	1.0E-04	1.0E-05	1.0E-06
Risk-based Media Concentration (mg/kg)	**0.19**	**0.019**	**0.0019**	**4.9**	**0.49**	**0.049**
NONCARCINOGENIC	**Child 1-6 years**			**Child 1-6 years**		
Total Exposure, fish ingestion $(days)^{-1}$	7.8E-04			1.1E-04		
Reference Dose (RfD) (mg/kg-day)	2.00E-05			2.00E-05		
Target Hazard Index	1			1		
Risk-based Media Concentration (mg/kg)	**0.026**			**0.19**		
NONCARCINOGENIC	**Adult**			**Adult**		
Total Exposure, fish ingestion $(days)^{-1}$	3.2E-04			4.7E-05		
Reference Dose (RfD) (mg/kg-day)	2.00E-05			2.00E-05		
Target Hazard Index	1			1		
Risk-based Media Concentration (mg/kg)	**0.062**			**0.43**		

Table 14d. Summary of PCB RMC (mg/kg) Output of 1-D Monte Carlo for Consumption of Bass

	RMC (mg/kg)				
	Cancer			Non-cancer	
Percentile	10^{-6} Risk	10^{-5} Risk	10^{-4} Risk	Adult	Child
Minimum	0.00066	0.0066	0.066	0.014	0.0076
5	0.0064	0.064	0.64	0.119	0.059
10	0.010	0.10	1.0	0.205	0.098
15	0.014	0.14	1.4	0.29	0.14
20	0.019	0.19	1.9	0.39	0.18
25	0.023	0.23	2.3	0.50	0.23
30	0.028	0.28	2.8	0.62	0.29
35	0.034	0.34	3.4	0.77	0.36
40	0.040	0.40	4.0	0.96	0.45
45	0.048	0.48	4.8	1.2	0.56
50	0.057	0.57	5.7	1.5	0.71
55	0.067	0.67	6.7	1.9	0.90
60	0.081	0.81	8.1	2.4	1.1
65	0.098	0.98	9.8	3.0	1.4
70	0.12	1.2	12	3.9	1.8
75	0.15	1.5	15	5.2	2.4
80	0.19	1.9	19	6.8	3.2
85	0.25	2.5	25	9.2	4.3
90	0.35	3.5	35	13	6.1
95	0.59	5.9	59	22	10
Maximum	735	7349	73492	7963	4754

Attachment 15
Risk-based Media Concentrations for PCBs in Connecticut Trout Tissue
Fish Consumption Scenario

A range of Risk-based Media Concentrations (RMCs) has been developed for PCBs based on potential for exposure, via human consumption, to PCBs in the edible tissue of trout obtained from the Connecticut portions of the river. Consistent with the approach used in EPA's HHRA, potential fish consumption exposures of young children and adults have been evaluated under reasonable maximum exposure (RME) and central tendency exposure (CTE) conditions. RMCs have been developed using both a deterministic and a probabilistic 1-dimensional Monte Carlo approach (1-D MC). For each set of exposure conditions and each type of assessment (deterministic and probabilistic), RMCs have been calculated based on potential cancer risks (for children and adults combined) and potential non-cancer impacts (for children and adults separately), using the exposure assumptions and toxicity values used in the HHRA.

The RMCs for the cancer endpoint (RMC_{cancer}) for this scenario have been calculated using the following equation that combines exposures to young children and adults.

$$RMC_{cancer} = \frac{Risk * AT_c}{EF * CSF * FI * (1 - LOSS) * CF * \left(\left(\frac{IR_c * ED_c}{BW_c} \right) + \left(\frac{IR_a * ED_a}{BW_a} \right) \right)}$$

The RMCs for the non-cancer endpoint (RMC_{nc}) for this scenario have been calculated using the following equation. Non-cancer RMCs have been calculated separately for young children and adults.

Young Child

$$RMC_{nc} = \frac{HI * RfD * AT_{nc}}{EF * FI * (1 - LOSS) * CF * \frac{IR_c * ED_c}{BW_c}}$$

Adult

$$RMC_{nc} = \frac{HI * RfD * AT_{nc}}{EF * FI * (1 - LOSS) * CF * \frac{IR_a * ED_a}{BW_a}}$$

In the above equations:

RMC_{cancer}	=	RMC based on the cancer endpoint (mg/kg)
RMC_{nc}	=	RMC based on the non-cancer endpoint (mg/kg)
Risk	=	Target risk level (unitless)
HI	=	Target hazard index (unitless)
AT_c	=	Averaging time for carcinogenic exposure (days)
AT_{nc}	=	Averaging time for non-carcinogenic exposure (days)
EF	=	Exposure frequency (days/year)
CSF	=	Cancer slope factor $(mg/kg\text{-}day)^{-1}$
FI	=	Fraction ingested from the site (unitless)
LOSS	=	Cooking loss (unitless)
CF	=	Unit conversion factor (1E-03 kg/g)

IR_c	=	Trout ingestion rate for children aged 1-6 years (g/day)
IR_a	=	Trout ingestion rate for adults (g/day)
ED_c	=	Exposure duration for children aged 1-6 years (years)
ED_a	=	Exposure duration for adults (years)
BW_c	=	Body weight for children aged 1-6 years (kg)
BW_a	=	Body weight for adults (kg)
RfD	=	Reference dose (mg/kg-day)

The specific exposure assumptions used for each age group in the deterministic analysis, and the basis of each, are summarized in Table 15a. In all cases, the assumptions and parameters used are the same as those used by EPA in its deterministic assessment in the 2005 HHRA.

For the probabilistic analysis, the input distributions were developed from the information provided in Table 6-2 of Vol. IV of the HHRA (p. 6-15). Descriptions of these distributions are provided in Table 15b. Fifty thousand iterations of the model were run, using @Risk, for each of the target risk levels (combining adult and childhood exposure) and for the non-cancer hazard index of 1 (evaluating adults and children separately).

Standard EPA toxicity values have been used for PCBs. These include a cancer slope factor (CSF) of 2 $(mg/kg\text{-}day)^{-1}$ for the RME scenario, a CSF of 1 $(mg/kg\text{-}day)^{-1}$ for the CTE scenario, and a chronic reference dose of 2E-05 mg/kg-day for both the RME and CTE analyses. These values are published in EPA's IRIS database and were used in EPA's HHRA. For the probabilistic analysis, a point estimate CSF of 2 $(mg/kg\text{-}day)^{-1}$ was used for both the RME and CTE scenarios.

Deterministic RMCs based on potential carcinogenic effects (for children and adults combined) have been developed for both the RME and CTE exposure scenarios using a range of target risks from one-in-a-million ($1x10^{-6}$) to one-in-ten-thousand ($1x10^{-4}$). This risk range is consistent with EPA's acceptable risk range. RMCs for noncancer effects have been developed for the RME and CTE scenarios for adults and young children separately, based on a target Hazard Index of 1.

For the 1-D MC analysis, the same risk range and target Hazard Index have been used. Once the analysis was completed, the 5^{th} percentile (95% of the calculated RMC output distribution values exceed the 5^{th} percentile) and the 50^{th} percentile values from the output distribution of potential RMCs at each target risk level were selected as the RME and CTE RMCs, respectively.

Summary of Results

Estimated RMCs for cancer and non-cancer endpoints based on the deterministic analysis are presented in Table 15c. A summary of the distribution of RMCs calculated using the 1-D MC is provided in Table 15d. The RMCs resulting from both the deterministic analysis and the probabilistic analysis (using the 5^{th} and 50^{th} percentile values for the RME and CTE, respectively) are summarized in the following table.

	RME (mg/kg)				CTE (mg/kg)			
	Cancer Risk			Non-cancer	Cancer Risk			Non-cancer
Deterministic	**$1x10^{-6}$**	**$1x10^{-5}$**	**$1x10^{-4}$**	**HI = 1**	**$1x10^{-6}$**	**$1x10^{-5}$**	**$1x10^{-4}$**	**HI = 1**
Young child/Adult	0.0048	0.048	0.48	NC	0.11	1.1	11	NC
Adult	NC	NC	NC	0.16	NC	NC	NC	0.93
Young child	NC	NC	NC	0.069	NC	NC	NC	0.40
1-D MC								
Young child/Adult	0.014	0.14	1.4	NC	0.12	1.2	12	NC
Adult	NC	NC	NC	0.27	NC	NC	NC	3.1
Young child	NC	NC	NC	0.13	NC	NC	NC	1.5

NC = Not calculated

Table 15a. Summary of Pathway- and Age-Specific Exposure Assumptions Used in the Deterministic Fish Consumption Scenario for Trout

Parameters	Units	Symbol	RME	CTE	Basis*
Unit conversion factor	kg/g	CF	1.0E-03	1.0E-03	HHRA, Vol IV; Tables 4-8 and 4-10.
Ingestion rate	g/day	IR			
Young child			6	2	HHRA, Vol IV; Tables 4-9 and 4-10. Section 4.5.2.2.6. EPA's calculation based on EPA 2002.
Adult			12	4	HHRA, Vol IV; Tables 4-9 and 4-10. Section 4.5.2.2.4. Based on EPA's evaluation of the Ebert et al. 1993 data.
Fraction ingested from site	unitless	FI	0.97	0.5	HHRA, Vol IV; Tables 4-8 and 4-10. Section 4.5.2.4. EPA's professional judgment.
Exposure frequency	days/year	EF	365	365	HHRA, Vol IV; Tables 4-8 and 4-10. Fish consumption rates are average daily rates over 365 days.
Fraction PCBs lost during cooking	unitless	LOSS	0.25	0.25	HHRA, Vol IV; Tables 4-8 and 4-10. Section 4.5.2.3. EPA's evaluation based on multiple studies.
Exposure duration	years	ED			
Young child			6	6	HHRA, Vol IV; Tables 4-9 and 4-10. Ages 1 to 6 years. Calculated by EPA, Section 4.5.2.6.
Adult			44	17	HHRA, Vol IV; Tables 4-9 and 4-10. Section 4.5.2.6. Based on MDPH 2001.
Body weight	kg	BW			
Young child			15	15	HHRA, Vol. IV; Table 4-9; based on EPA 1989. Average age specific body weight.
Adult			70	70	HHRA, Vol. IV; Table 4-9; based on EPA 1989. Average age specific body weight.
Averaging time (cancer endpoint)	days	ATc	25,550	25,550	HHRA, Vol. IV; Table 4-8; based on EPA 1989. Lifetime of 70 years x 365 days/year.
Averaging time (noncancer endpoint)	days	ATnc			
Young child			2,190	2,190	HHRA, Vol. IV. Table 4-10; Based on EPA, 1989. Equivalent to duration in years x 365 days/year.
Adult			16,060	6,205	HHRA, Vol. IV. Table 4-10; Based on EPA, 1989. Equivalent to duration in years x 365 days/year.

* All exposure parameters are identical to the parameters used in the HHRA (EPA, 2005). Volume and Table and/or Section numbers provided.

Ebert, E., N. Harrington, K. Boyle, J. Knight, and R. Keenan. 1993. Estimating consumption of freshwater fish among Maine anglers.*North American Journal of Fisheries Management* 13:737-745.
EPA 1989. *Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual (Part A) Interim Final.*
EPA 2002. *Estimated Per Capita Fish Consumption in the United States.*
MDPH 2001. *Memo from Martha Steele, Deputy Director, Bureau of Environmental Health Assessment to Bryan Olson, EPA, Region 1 regarding Remainder of data request with respect* to information gathered from questionnaires from Housatonic River Area Exposure Assessment Study as well as questionnaires completed after the study and resulting from calls to

the Bureau of Environmental Health Assessment (BEHA) hotline.

Table 15b. Summary of Exposure Assumptions and Distributions Used in the 1-D Monte Carlo Analysis for the Trout Consumption Scenario[1]

Parameters	Units	Symbol	Min	Max	Central Estimate	Standard Deviation	Distribution Type
Unit conversion factor	kg/g	CF	-	-	1.0E-03	-	Point Estimate
Fraction ingested from site	unitless	FI	0.1	1	0.50	0.28	Empirical Distribution Function[2]
Fraction PCBs lost during cooking	unitless	LOSS	0.016	1	0.26	0.18	Stochastic Mixture of Distributions[3]
Ingestion rate	g/day	IR					
Young child			0.14	23.3	2.0	3.4	Empirical Distribution Function[4]
Adult			0.27	46.6	4.2	7.3	Empirical Distribution Function
Exposure frequency	days/year	EF	-	-	365	-	Point Estimate
Exposure duration (cancer endpoint)	years	ED					
Young child			1	6	3.5	1.4	Uniform
Adult			1	64	29	20	T-lognormal
Body weight	kg	BW					
Young child			12	23	17	2.3	Lognormal
Adult			39	119	72	15	Lognormal
Averaging time (cancer endpoint)	days	ATc			25,550		Point Estimate

[1]All distribution statistics are presented in Table 6-2, page 6-15, of the HHRA Volume IV.

[2]Empirical distribution function derived from Figure 6-17 of HHRA Volume IV yielded slightly different values than those reported in Table 6-2 of HHRA.

[3]Table 6-2 of HHRA Volume IV reports that minimum value as 0.16. However, Figure 6-6 and minimum values for the individual methods reported in Table 6-2 indicate that the minimum value is actually 0.016.

[4]Developed by using half the adult rate distribution.

Table 15c. Deterministic RMCs for PCBs (mg/kg) in Trout Tissue for Target Risk Range and Hazard Index of 1
Fish Consumption - Connecticut Trout

Parameter	EPA RME Analysis			EPA CTE Analysis		
Pathway Specific Parameters						
Exposure duration (yrs)						
Child	6	6	6	6	6	6
Adult	44	44	44	17	17	17
Body weight (kg)						
Child	15	15	15	15	15	15
Adult	70	70	70	70	70	70
Averaging time - noncarcinogenic (days)						
Child	2,190	2,190	2,190	2,190	2,190	2,190
Adult	16,060	16,060	16,060	6,205	6,205	6,205
Averaging time - carcinogenic (days)	25,550	25,550	25,550	25,550	25,550	25,550
Ingestion rate (g/day)						
Child	6	6	6	2	2	2
Adult	12	12	12	4	4	4
Fraction attributable to site	0.97	0.97	0.97	0.5	0.5	0.5
Cooking loss (unitless)	0.25	0.25	0.25	0.25	0.25	0.25
Conversion factor, fish ing (kg/g)	1E-03	1E-03	1E-03	1E-03	1E-03	1E-03
Exposure frequency (days/year)	365	365	365	365	365	365
Exposure -carcinogenic $(days)^{-1}$	1.0E-04	1.0E-04	1.0E-04	9.5E-06	9.5E-06	9.5E-06
Exposure - noncarcinogenic $(days)^{-1}$ - Child	2.9E-04	2.9E-04	2.9E-04	5.0E-05	5.0E-05	5.0E-05
Exposure - noncarcinogenic $(days)^{-1}$ - Adult	1.25E-04	1.25E-04	1.25E-04	2.14E-05	2.14E-05	2.14E-05
CARCINOGENIC	**EPA RME Analysis**			**EPA CTE Analysis**		
Total Exposure, fish ingestion $(days)^{-1}$	1.0E-04	1.0E-04	1.0E-04	9.5E-06	9.5E-06	9.5E-06
Cancer Slope Factor (CSF) $(mg/kg\text{-}day)^{-1}$	2	2	2	1	1	1
Target Risk Level	1.0E-04	1.0E-05	1.0E-06	1.0E-04	1.0E-05	1.0E-06
Risk-based Media Concentration (mg/kg)	**0.48**	**0.048**	**0.0048**	**11**	**1.1**	**0.11**

NONCARCINOGENIC	**Child 1-6 years**	**Child 1-6 years**
Total Exposure, fish ingestion $(days)^{-1}$	2.9E-04	5.0E-05
Reference Dose (RfD) (mg/kg-day)	2.00E-05	2.00E-05
Target Hazard Index	1	1
Risk-based Media Concentration (mg/kg)	**0.069**	**0.40**

NONCARCINOGENIC	**Adult**	**Adult**
Total Exposure, fish ingestion $(days)^{-1}$	1.2E-04	2.1E-05
Reference Dose (RfD) (mg/kg-day)	2.00E-05	2.00E-05
Target Hazard Index	1	1
Risk-based Media Concentration (mg/kg)	**0.16**	**0.93**

Table 15d. Summary of PCB RMC (mg/kg) Output of 1-D Monte Carlo for Consumption of Trout

	RMC (mg/kg)				
	Cancer			Non-cancer	
Percentile	10^{-6} Risk	10^{-5} Risk	10^{-4} Risk	Adult	Child
Minimum	0.00090	0.0090	0.093	0.024	0.014
5	0.014	0.14	1.4	0.27	0.13
10	0.022	0.22	2.2	0.46	0.22
15	0.031	0.31	3.1	0.64	0.31
20	0.040	0.40	4.0	0.84	0.40
25	0.050	0.50	5.0	1.1	0.51
30	0.061	0.61	6.1	1.4	0.64
35	0.073	0.73	7.3	1.7	0.79
40	0.087	0.87	8.7	2.1	0.99
45	0.10	1.0	10	2.5	1.2
50	0.12	1.2	12	3.1	1.5
55	0.14	1.4	14	3.8	1.8
60	0.17	1.7	17	4.7	2.2
65	0.20	2.0	20	5.7	2.7
70	0.24	2.4	24	7.0	3.4
75	0.29	2.9	29	8.8	4.2
80	0.37	3.7	37	11	5.2
85	0.47	4.7	47	14	6.7
90	0.63	6.4	63	20	9.2
95	1.0	10	100	31	15
Maximum	607	6065	60645	13672	1131

Attachment 16
Risk-based Media Concentrations for PCBs in Waterfowl Tissue
Waterfowl Consumption Scenario

A range of Risk-based Media Concentrations (RMCs) has been developed for PCBs based on potential for exposure, via human consumption, to PCBs in waterfowl tissues obtained in the edible tissue of waterfowl from the river. Consistent with the approach used in EPA's HHRA, potential waterfowl consumption exposures of young children and adults have been evaluated under reasonable maximum exposure (RME) and central tendency exposure (CTE) conditions. RMCs have been developed using both a deterministic and a probabilistic 1-dimensional Monte Carlo approach (1-D MC). For each set of exposure conditions and each type of assessment (deterministic and probabilistic), RMCs have been calculated based on potential cancer risks (for children and adults combined) and potential non-cancer impacts (for children and adults separately), using the exposure assumptions and toxicity values used in the HHRA.

The RMCs for the cancer endpoint (RMC_{cancer}) for this scenario have been calculated using the following equation that combines exposures to young children and adults.

$$RMC_{cancer} = \frac{Risk * AT_c}{EF * CSF * FI * (1 - LOSS) * CF * \left(\left(\frac{IR_c * ED_c}{BW_c} \right) + \left(\frac{IR_a * ED_a}{BW_a} \right) \right)}$$

The RMCs for the non-cancer endpoint (RMC_{nc}) for this scenario have been calculated using the following equation. Non-cancer RMCs have been calculated separately for young children and adults.

Young Child

$$RMC_{nc} = \frac{HI * RfD * AT_{nc}}{EF * FI * (1 - LOSS) * CF * \frac{IR_c * ED_c}{BW_c}}$$

Adult

$$RMC_{nc} = \frac{HI * RfD * AT_{nc}}{EF * FI * (1 - LOSS) * CF * \frac{IR_a * ED_a}{BW_a}}$$

In the above equations:

RMC_{cancer}	=	RMC based on the cancer endpoint (mg/kg)
RMC_{nc}	=	RMC based on the non-cancer endpoint (mg/kg)
Risk	=	Target risk level (unitless)
HI	=	Target hazard index (unitless)
AT_c	=	Averaging time for carcinogenic exposure (days)
AT_{nc}	=	Averaging time for non-carcinogenic exposure (days)
EF	=	Exposure frequency (days/year for deterministic; meals/year for 1-D MC)
CSF	=	Cancer slope factor $(mg/kg\text{-}day)^{-1}$
FI	=	Fraction ingested from the site (unitless)
LOSS	=	Cooking loss (unitless)
CF	=	Unit conversion factor (1E-03 kg/g)

IR_c	=	Waterfowl ingestion rate for children aged 1-6 years (g/day for deterministic; g/meal for 1-D MC)
IR_a	=	Waterfowl ingestion rate for adults (g/day for deterministic; g/meal for 1-D MC)
ED_c	=	Exposure duration for children aged 1-6 years (years)
ED_a	=	Exposure duration for adults (years)
BW_c	=	Body weight for children aged 1-6 years (kg)
BW_a	=	Body weight for adults (kg)
RfD	=	Reference dose (mg/kg-day)

The specific exposure assumptions used for each age group in this analysis, and the basis of each, are summarized in Table 16a. In all cases, the assumptions and parameters used are the same as those used by EPA in its deterministic assessment in the 2005 HHRA. (It should be noted that the approach used in the deterministic analysis differs slightly from that used in the 1-D Monte Carlo. For the deterministic analysis, the IRWF is reported in g/day and is multiplied by an EF of 365 days/year to derive the g/year estimate. In the 1-D MC analysis, the g/year estimate is derived by multiplying the IRWF in units of g/meal by an EF of meals/year.)

For the 1-D MC analysis, the input distributions were developed from the information provided in Table 6-4 of Vol. IV of the HHRA (p. 6-58). Descriptions of these distributions are provided in Table 16b. Fifty thousand iterations of the model were run, using @Risk, for each of the target risk levels (combining adult and childhood exposure) and for the non-cancer Hazard Index of 1 (evaluating adults and children separately).

Standard EPA toxicity values have been used for PCBs. These include a cancer slope factor (CSF) of 2 $(mg/kg\text{-}day)^{-1}$ for the RME scenario, a CSF of 1 $(mg/kg\text{-}day)^{-1}$ for the CTE scenario, and a chronic reference dose of 2E-05 mg/kg-day for both the RME and CTE analyses. These values are published in EPA's IRIS database and were used in EPA's HHRA. For the probabilistic analysis, a point estimate CSF of 2 $(mg/kg\text{-}day)^{-1}$ was used for both the RME and CTE scenarios.

Deterministic RMCs based on potential carcinogenic effects (for children and adults combined) have been developed for both the RME and CTE exposure scenarios using a range of target risks from one-in-a-million ($1x10^{-6}$) to one-in-ten-thousand ($1x10^{-4}$). This risk range is consistent with EPA's acceptable risk range. RMCs for noncancer effects have been developed for the RME and CTE scenarios for adults and young children separately, based on a target Hazard Index of 1.

For the 1-D MC analysis, the same risk range and target Hazard Index have been used. Once the analysis was completed, the 5^{th} percentile (95% of the calculated RMC output distribution values exceed the 5^{th} percentile) and the 50^{th} percentile values from the output distribution of potential RMCs at each target risk level were selected as the RME and CTE RMCs, respectively.

Summary of Results

Estimated RMCs for cancer and non-cancer endpoints based on the deterministic analysis are presented in Table 16c. A summary of the distribution of RMCs calculated using the 1-D Monte

Carlo is provided in Table 16d. The RMCs resulting from both the deterministic analysis and the probabilistic analysis (using the 5th and 50th percentile values for the RME and CTE, respectively) are summarized in the following table.

	RME (mg/kg)				CTE (mg/kg)			
	Cancer Risk			Non-cancer	Cancer Risk			Non-cancer
Deterministic	**$1x10^{-6}$**	**$1x10^{-5}$**	**$1x10^{-4}$**	**HI = 1**	**$1x10^{-6}$**	**$1x10^{-5}$**	**$1x10^{-4}$**	**HI = 1**
Young child/Adult	0.0084	0.084	0.84	NC	0.066	0.66	6.6	NC
Adult	NC	NC	NC	0.28	NC	NC	NC	0.58
Young child	NC	NC	NC	0.12	NC	NC	NC	0.25
1-D MC								
Young child/adult	0.0075	0.075	0.75	NC	0.072	0.72	7.2	NC
Adult	NC	NC	NC	0.17	NC	NC	NC	1.4
Young child	NC	NC	NC	0.080	NC	NC	NC	0.67

NC = Not calculated

Table 16a. Summary of Pathway- and Age-Specific Exposure Assumptions Used in the Deterministic Waterfowl Consumption Scenario

Parameters	Units	Symbol	RME	CTE	Basis*
Unit conversion factor	kg/g	CF	1.0E-03	1.0E-03	HHRA, Vol IV; Tables 4-38 and 4-40.
Ingestion rate	g/day	IR			
Young child			2.5	1.2	HHRA, Vol IV; Tables 4-39 and 4-40. Section 4.6.2.1. Calculated by EPA based on one-half adult rate.
Adult			5	2.4	HHRA, Vol IV; Tables 4-39 and 4-40. Section 4.6.2.1. Meal size based on poultry meal sizes from Pao et al. 1982; meal frequency based on 90th percentile from MDPH 2001 survey.
Fraction ingested from site	unitless	FI	1	1	HHRA, Vol IV; Tables 4-38 and 4-40. Section 4.6.2.3. EPA's professional judgment.
Exposure frequency	days/year	EF	365	365	HHRA, Vol IV; Tables 4-38 and 4-40. Waterfowl consumption rates are average daily rates over 365 days.
Fraction PCBs lost during cooking	unitless	LOSS	0	0	HHRA, Vol IV; Tables 4-38 and 4-40. Section 4.6.2.2. EPA's professional judgment.
Exposure duration	years	ED			
Young child			6	6	HHRA, Vol IV; Tables 4-39 and 4-40. Ages 1 to 6 years. Calculated by EPA based on EPA 1989.
Adult			44	17	HHRA, Vol IV; Tables 4-39 and 4-40. Section 4.6.2.5. Based on MDPH 2001.
Body weight	kg	BW			
Young child			15	15	HHRA, Vol. IV; Tables 4-39 and 4-40; based on EPA 1989. Average age specific body weight.
Adult			70	70	HHRA, Vol. IV; Tables 4-39 and 4-40; based on EPA 1989. Average age specific body weight.
Averaging time (cancer endpoint)	days	ATc	25,550	25,550	HHRA, Vol. IV; Table 4-38; based on EPA 1989. Lifetime of 70 years x 365 days/year.
Averaging time (noncancer endpoint)	days	ATnc			
Young child			2,190	2,190	HHRA, Vol. IV. Table 4-40; Based on EPA, 1989. Equivalent to duration in years x 365 days/year.
Adult			16,060	6,205	HHRA, Vol. IV. Table 4-40; Based on EPA, 1989. Equivalent to duration in years x 365 days/year.

* All exposure parameters are identical to the parameters used in the HHRA (EPA, 2005). Volume and Table and/or Section numbers provided.

EPA 1989. *Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual (Part A) Interim Final.*

MDPH 2001. *Memo from Martha Steele, Deputy Director, Bureau of Environmental Health Assessment to Bryan Olson, EPA, Region 1 regarding Remainder of data request with respect* to information gathered from questionnaires from Housatonic River Area Exposure Assessment Study as well as questionnaires completed after the study and resulting from calls to the Bureau of Environmental Health Assessment (BEHA) hotline.

Pao E., K. Fleming, P. Guenther, S. Mickle. 1982. *Foods Commonly Esten by Individuals: Amount Per Day and Per Eating Occasion.* Consumer Nutrition Center, Human Nutrition Information Service, U.S. Department of Agriculture. Hyattsville, MD. Home Economics Reserach Report Number 44.

Table 16b. Summary of Exposure Assumptions and Distributions Used in the 1-D Monte Carlo Analysis for the Waterfowl Consumption Scenario[1]

Parameters	Units	Symbol	Min	Max	Central Estimate	Standard Deviation	Distribution Type
Unit conversion factor	kg/g	CF	-	-	1.0E-03	-	Point Estimate
Ingestion rate	g/meal	IR					
Young child			19	338	94	57	Lognormal
Adult			38	675	188	113	Lognormal
Exposure frequency	meals/year	EF	1	52	5.4	10.6	Empirical Distribution Function
Fraction PCBs lost during cooking	unitless	LOSS	-	-	0	-	Point Estimate
Exposure duration (cancer endpoint)	years	ED					
Young child			1	6	3.5	1.4	Uniform
Adult			1	64	29	20	T-lognormal
Body weight	kg	BW					
Young child			12	23	17	2.3	Lognormal
Adult			39	119	72	15	Lognormal
Averaging time (cancer endpoint)	days	ATc			25,550		Point Estimate

[1]All distribution statistics are presented in Table 6-4, page 6-58, of the HHRA Volume IV.

Table 16c. Deterministic RMCs for PCBs (mg/kg) in Waterfowl Tissue at Target Risk Range and Hazard Index of 1
Waterfowl Consumption Scenario

Parameter	EPA RME Analysis			EPA CTE Analysis		
Pathway Specific Parameters						
Exposure duration (yrs)						
Child	6	6	6	6	6	6
Adult	44	44	44	17	17	17
Body weight (kg)						
Child	15	15	15	15	15	15
Adult	70	70	70	70	70	70
Averaging time - noncarcinogenic (days)						
Child	2,190	2,190	2,190	2,190	2,190	2,190
Adult	16,060	16,060	16,060	6,205	6,205	6,205
Averaging time - carcinogenic (days)	25,550	25,550	25,550	25,550	25,550	25,550
Ingestion rate (g/day)						
Child	2.5	2.5	2.5	1.2	1.2	1.2
Adult	5	5	5	2.4	2.4	2.4
Fraction attributable to site	1.0	1.0	1.0	1.0	1.0	1.0
Cooking loss (unitless)	0	0	0	0	0	0
Conversion factor, waterfowl ing (kg/g)	1E-03	1E-03	1E-03	1E-03	1E-03	1E-03
Exposure frequency (days/year)	365	365	365	365	365	365
Exposure -carcinogenic (days)$^{-1}$	5.9E-05	5.9E-05	5.9E-05	1.5E-05	1.5E-05	1.5E-05
Exposure - noncarcinogenic (days)$^{-1}$ - Child	1.7E-04	1.7E-04	1.7E-04	8.0E-05	8.0E-05	8.0E-05
Exposure - noncarcinogenic (days)$^{-1}$ - Adult	7.1E-05	7.1E-05	7.1E-05	3.4E-05	3.4E-05	3.4E-05
CARCINOGENIC	**EPA RME Analysis**			**EPA CTE Analysis**		
Total Exposure, waterfowl ingestion (days)$^{-1}$	5.9E-05	5.9E-05	5.9E-05	1.5E-05	1.5E-05	1.5E-05
Cancer Slope Factor (CSF) (mg/kg-day)$^{-1}$	2	2	2	1	1	1
Target Risk Level	1.0E-04	1.0E-05	1.0E-06	1.0E-04	1.0E-05	1.0E-06
Risk-based Media Concentration (mg/kg)	**0.84**	**0.084**	**0.0084**	**6.6**	**0.66**	**0.066**
NONCARCINOGENIC	**Child 1-6 years**			**Child 1-6 years**		
Total Exposure, waterfowl ingestion (days)$^{-1}$	1.7E-04			8.0E-05		
Reference Dose (RfD) (mg/kg-day)	2.00E-05			2.00E-05		
Target Hazard Index	1			1		
Risk-based Media Concentration (mg/kg)	**0.12**			**0.25**		
NONCARCINOGENIC	**Adult**			**Adult**		
Total Exposure, waterfowl ingestion (days)$^{-1}$	7.1E-05			3.4E-05		
Reference Dose (RfD) (mg/kg-day)	2.00E-05			2.00E-05		
Target Hazard Index	1			1		
Risk-based Media Concentration (mg/kg)	**0.28**			**0.58**		

Table 16d. Summary of PCB RMC (mg/kg) Output of 1-D Monte Carlo for Consumption of Waterfowl

	RMC (mg/kg)				
	Cancer			Non-cancer	
Percentile	10^{-6} Risk	10^{-5} Risk	10^{-4} Risk	Adult	Child
Minimum	0.00057	0.0057	0.057	0.014	0.0074
5	0.0075	0.075	0.75	0.17	0.080
10	0.012	0.12	1.2	0.28	0.14
15	0.017	0.17	1.7	0.39	0.19
20	0.022	0.22	2.2	0.49	0.23
25	0.028	0.28	2.8	0.60	0.29
30	0.035	0.35	3.5	0.72	0.35
35	0.042	0.42	4.2	0.86	0.42
40	0.050	0.50	5.0	1.0	0.49
45	0.060	0.60	6.0	1.2	0.57
50	0.072	0.72	7.2	1.4	0.67
55	0.085	0.85	8.5	1.6	0.77
60	0.10	1.0	10	1.9	0.89
65	0.12	1.2	12	2.2	1.0
70	0.15	1.5	15	2.5	1.2
75	0.18	1.8	18	2.9	1.3
80	0.23	2.3	23	3.3	1.5
85	0.30	3.0	30	3.9	1.8
90	0.42	4.2	42	4.7	2.2
95	0.68	6.8	68	6.1	2.9
Maximum	9.1	91	906	20	7.7

Attachment 17
Risk-based Media Concentrations for TEQ in Massachusetts and Connecticut Bass Tissue Fish Consumption Scenario

A range of Risk-based Media Concentrations (RMCs) has been developed for dioxin toxicity equivalency quotients (TEQs) based on the potential for humans to be exposed, via consumption, to dioxins, furans, and dioxin-like PCBs in the edible tissue of bass obtained from the Massachusetts and Connecticut portions of the river. Consistent with the approach used in EPA's HHRA, potential fish consumption exposures of young children and adults have been evaluated under reasonable maximum exposure (RME) and central tendency exposure (CTE) conditions. RMCs have been developed using both a deterministic and a probabilistic 1-dimensional Monte Carlo approach (1-D MC). For each set of exposure conditions and each type of assessment (deterministic and probabilistic), RMCs have been calculated for TEQs based on potential cancer risks for children and adults combined, using the exposure assumptions and TEQ toxicity value used in the HHRA. Consistent with the HHRA, since EPA has not developed a non-cancer reference dose for dioxin TEQs, RMCs based on non-cancer impacts have not been developed for TEQs.

The RMCs for the cancer endpoint (RMC_{cancer}) for this scenario have been calculated using the following equation that combines exposures to young children and adults.

$$RMC_{cancer} = \frac{Risk * AT_c * CF_1}{EF * CSF * FI * (1 - LOSS) * CF_2 * \left(\left(\frac{IR_c * ED_c}{BW_c} \right) + \left(\frac{IR_a * ED_a}{BW_a} \right) \right)}$$

Where:

RMC_{cancer}	=	RMC based on the cancer endpoint (ng/kg)
Risk	=	Target risk level (unitless)
AT_c	=	Averaging time for carcinogenic exposure (days)
CF_1	=	Unit conversion factor (1,000,000 ng/mg)
EF	=	Exposure frequency (days/year)
CSF	=	Cancer slope factor $(mg/kg\text{-}day)^{-1}$
FI	=	Fraction ingested from the site (unitless)
LOSS	=	Cooking loss (unitless)
CF_2	=	Unit conversion factor (1E-03 kg/g)
IR_c	=	Bass ingestion rate for children aged 1-6 years (g/day)
IR_a	=	Bass ingestion rate for adults (g/day)
ED_c	=	Exposure duration for children aged 1-6 years (years)
ED_a	=	Exposure duration for adults (years)
BW_c	=	Body weight for children aged 1-6 years (kg)
BW_a	=	Body weight for adults (kg)

The specific exposure assumptions used for each age group in the deterministic analysis, and the basis of each, are summarized in Table 17a. In all cases, the assumptions and parameters used are the same as those used by EPA in its deterministic assessment in the 2005 HHRA.

For the 1-D MC analysis, the input distributions were developed from the information provided in Table 6-2 of Vol. IV of the HHRA (p. 6-15). Descriptions of these distributions are provided in Table 17b. Fifty thousand iterations of the model were run, using @Risk, for each of the target risk levels (combining adult and childhood exposure).

Currently EPA's IRIS database does not publish a cancer slope factor (CSF) for dioxin. Consistent with the approach used in the HHRA, a CSF for 2,3,7,8-tetrachlorodibenzo-*p*-dioxin of 150,000 $(mg/kg\text{-}day)^{-1}$, which was the CSF published in EPA's 1997 *Health Effects Assessment Summary Tables*, has been used to calculate the RMCs for dioxin TEQs.

Deterministic RMCs based on potential carcinogenic effects (for children and adults combined) have been developed for both the RME and CTE exposure scenarios using a range of target risks from one-in-a-million ($1x10^{-6}$) to one-in-ten-thousand ($1x10^{-4}$). This risk range is consistent with EPA's acceptable risk range.

For the 1-D MC analysis, the same risk range and Hazard Index have been used. Once the analysis was completed, the 5th percentile (95% of the calculated RMC output distribution exceeds the 5th percentile) and the 50th percentile values from the output distributions of potential RMCs at each target risk level were selected as the RME and CTE RMCs, respectively.

Summary of Results

Estimated RMCs (in ng/kg or ppt) for the cancer endpoint based on the deterministic analysis are presented in Table 17c. A summary of the distribution of RMCs calculated using the 1-D MC is provided in Table 17d. The RMCs resulting from both the deterministic analysis and the probabilistic analysis (using the 5th and 50th percentile values for the RME and CTE, respectively) are summarized in the following table.

	RME (ng/kg)			**CTE (ng/kg)**		
	Cancer Risk			**Cancer Risk**		
Deterministic	**$1x10^{-6}$**	**$1x10^{-5}$**	**$1x10^{-4}$**	**$1x10^{-6}$**	**$1x10^{-5}$**	**$1x10^{-4}$**
Young child/Adult	0.025	0.25	2.5	0.32	3.2	32
1-D MC						
Young child/Adult	0.085	0.85	8.5	0.76	7.6	76

Table 17a. Summary of Pathway- and Age-Specific Exposure Assumptions Used in the Deterministic Fish Consumption Scenario for Bass

Parameters	Units	Symbol	RME	CTE	Basis*
Unit conversion factor	ng/mg	CF_1	1.E+06	1.E+06	Necessary to derive RMC units of ng/kg
Unit conversion factor	kg/g	CF_2	1.0E-03	1.0E-03	HHRA, Vol IV; Tables 4-8 and 4-10.
Ingestion rate	g/day	IR			
Young child			16	4.3	HHRA, Vol IV; Tables 4-9 and 4-10. Section 4.5.2.2.6. EPA's calculation based on EPA 2002.
Adult			31	8.7	HHRA, Vol IV; Tables 4-9 and 4-10. Section 4.5.2.2.4. Based on EPA's evaluation of the Ebert et al. 1993.
Fraction ingested from site	unitless	FI	0.97	0.5	HHRA, Vol IV; Tables 4-8 and 4-10. Section 4.5.2.4. EPA's professional judgment.
Exposure frequency	days/year	EF	365	365	HHRA, Vol IV; Tables 4-8 and 4-10. Fish consumption rates are average daily rates over 365 days.
Fraction PCBs lost during cooking	unitless	LOSS	0.25	0.25	HHRA, Vol IV; Tables 4-8 and 4-10. Section 4.5.2.3. EPA's evaluation based on multiple studies.
Exposure duration	years	ED			
Young child			6	6	HHRA, Vol IV; Tables 4-9 and 4-10. Ages 1 to 6 years. Calculated by EPA, Section 4.5.2.6.
Adult			44	17	HHRA, Vol IV; Tables 4-9 and 4-10. Section 4.5.2.6. Based on MDPH 2001.
Body weight	kg	BW			
Young child			15	15	HHRA, Vol. IV; Table 4-9; based on EPA 1989. Average age specific body weight.
Adult			70	70	HHRA, Vol. IV; Table 4-9; based on EPA 1989. Average age specific body weight.
Averaging time (cancer endpoint)	days	ATc	25,550	25,550	HHRA, Vol. IV; Table 4-8; based on EPA 1989. Lifetime of 70 years x 365 days/year.

* All exposure parameters are identical to the parameters used in the HHRA (EPA, 2005). Volume and Table and/or Section numbers provided.

Ebert, E., N. Harrington, K. Boyle, J. Knight, and R. Keenan. 1993. Estimating consumption of freshwater fish among Maine anglers. *North American Journal of Fisheries Management* 13:737-745.

EPA 1989. *Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual (Part A) Interim Final.*

EPA 2002. *Estimated Per Capita Fish Consumption in the United States.*

MDPH 2001. *Memo from Martha Steele, Deputy Director, Bureau of Environmental Health Assessment to Bryan Olson, EPA, Region 1 regarding Remainder of data request with respect* to information gathered from questionnaires from Housatonic River Area Exposure Assessment Study as well as questionnaires completed after the study and resulting from calls to the Bureau of Environmental Health Assessment (BEHA) hotline.

Table 17b. Summary of Exposure Assumptions and Distributions Used in the 1-D Monte Carlo Analysis for the Bass Consumption Scenario[1]

Parameters	Units	Symbol	Min	Max	Central Estimate	Standard Deviation	Distribution Type
Unit conversion factor	ng/mg	CF1	-	-	1.0E+06	-	Point Estimate
Unit conversion factor	kg/g	CF	-	-	1.0E-03	-	Point Estimate
Ingestion rate	g/day	IR					
Adult			0.27	80.22	8.5	13.6	Empirical Distribution Function
Young child			0.135	40.11	4.25	6.8	Empirical Distribution Function[2]
Fraction ingested from site	unitless	FI	0.1	1	0.5	0.28	Empirical Distribution Function[3]
Fraction PCBs lost during cooking	unitless	LOSS	0.016	1	0.26	0.18	Stochastic Mixture of Distributions[4]
Exposure frequency	days/year	EF	-	-	365	-	Point Estimate
Exposure duration (cancer endpoint)	years	ED					
Young child			1	6	3.5	1.4	Uniform
Adult			1	64	29	20	T-lognormal
Body weight	kg	BW					
Young child			12	23	17	2.3	Lognormal
Adult			39	119	72	15	Lognormal
Averaging time (cancer endpoint)	days	ATc			25,550		Point Estimate

[1]All distribution statistics are presented in Table 6-2, page 6-15, of the HHRA Volume IV.

[2]Distribution is half of the adult empirical distribution.

[3]Empirical distribution function derived from Figure 6-17 of HHRA Volume IV yielded slightly different values than those reported in Table 6-2 of HHRA.

[4]Table 6-2 of HHRA Volume IV reports that minimum value as 0.16. However, Figure 6-6 and minimum values for the individual methods reported in Table 6-2 indicate that the minimum value is actually 0.016.

Table 17c. Deterministic RMCs for TEQ (ng/kg) in Bass Tissue at Target Risk Range and Hazard Index of 1
Fish Consumption - Massachusetts and Connecticut Bass

Parameter	EPA RME Analysis			EPA CTE Analysis		
Pathway Specific Parameters						
Exposure duration (yrs)						
Young child	6	6	6	6	6	6
Adult	44	44	44	17	17	17
Body weight (kg)						
Young child	15	15	15	15	15	15
Adult	70	70	70	70	70	70
Averaging time - carcinogenic (days)	25,550	25,550	25,550	25,550	25,550	25,550
Ingestion rate (g/day)						
Young child	16	16	16	4.3	4.3	4.3
Adult	31	31	31	8.7	8.7	8.7
Fraction attributable to site	0.97	0.97	0.97	0.5	0.5	0.5
Cooking loss (unitless)	0.25	0.25	0.25	0.25	0.25	0.25
Conversion factor, fish ing (kg/g)	1E-03	1E-03	1E-03	1E-03	1E-03	1E-03
Exposure frequency (days/year)	365	365	365	365	365	365
Exposure -carcinogenic (days)$^{-1}$	2.7E-04	2.7E-04	2.7E-04	2.1E-05	2.1E-05	2.1E-05
CARCINOGENIC	**EPA RME Analysis**			**EPA CTE Analysis**		
Total Exposure, fish ingestion (days)$^{-1}$	2.7E-04	2.7E-04	2.7E-04	2.1E-05	2.1E-05	2.1E-05
Cancer Slope Factor (CSF) (mg/kg-day)$^{-1}$	150,000	150,000	150,000	150,000	150,000	150,000
Target Risk Level	1.0E-04	1.0E-05	1.0E-06	1.0E-04	1.0E-05	1.0E-06
Unit conversion factor (ng/mg)	1.0E+06	1.0E+06	1.0E+06	1.0E+06	1.0E+06	1.0E+06
Risk-based Media Concentration (ng/kg)	**2.5**	**0.25**	**0.025**	**32**	**3.2**	**0.32**

Table 17d. Summary of TEQ RMC (ng/kg) Output of 1-D Monte Carlo for Consumption of Bass

	RMC (ng/kg)		
	Cancer		
Percentile	10^{-6} Risk	10^{-5} Risk	10^{-4} Risk
Minimum	0.0088	0.088	0.88
5	0.085	0.85	8.5
10	0.14	1.4	14
15	0.19	1.9	19
20	0.25	2.5	25
25	0.31	3.1	31
30	0.37	3.7	37
35	0.45	4.5	45
40	0.53	5.3	53
45	0.64	6.4	64
50	0.76	7.6	76
55	0.89	8.9	89
60	1.1	11	110
65	1.3	13	130
70	1.6	16	160
75	2.0	20	200
80	2.5	25	250
85	3.3	33	330
90	4.7	47	470
95	7.9	79	790
Maximum	9799	97987	979867

Attachment 18
Risk-based Media Concentrations for TEQ in Connecticut Trout Tissue
Fish Consumption Scenario

A range of Risk-based Media Concentrations (RMCs) has been developed for dioxin toxicity equivalency quotients (TEQs) based on the potential for humans to be exposed, via consumption, to dioxins, furans, and dioxin-like PCBs in the edible tissue of trout obtained from the Connecticut portion of the river. Consistent with the approach used in EPA's HHRA, potential fish consumption exposures of young children and adults have been evaluated under reasonable maximum exposure (RME) and central tendency exposure (CTE) conditions. RMCs have been developed using both a deterministic approach and a probabilistic 1-dimensional Monte Carlo approach (1-D MC). For each set of exposure conditions and each type of assessment (deterministic and probabilistic), RMCs have been calculated for TEQs based on potential cancer risks for children and adults combined, using the exposure assumptions and TEQ toxicity value used in the HHRA. Consistent with the HHRA, since EPA has not developed a non-cancer reference dose for dioxin TEQs, RMCs based on non-cancer impacts have not been developed for TEQs.

The RMCs for the cancer endpoint (RMC_{cancer}) for this scenario have been calculated using the following equation that combines exposures to young children and adults.

$$RMC_{cancer} = \frac{Risk * AT_c * CF_1}{EF * CSF * FI * (1 - LOSS) * CF_2 * \left(\left(\frac{IR_c * ED_c}{BW_c} \right) + \left(\frac{IR_a * ED_a}{BW_a} \right) \right)}$$

Where:

RMC_{cancer}	=	RMC based on the cancer endpoint (ng/kg)
Risk	=	Target risk level (unitless)
AT_c	=	Averaging time for carcinogenic exposure (days)
CF_1	=	Unit conversion factor (1,000,000 ng/mg)
EF	=	Exposure frequency (days/year)
CSF	=	Cancer slope factor $(mg/kg\text{-}day)^{-1}$
FI	=	Fraction ingested from the site (unitless)
LOSS	=	Cooking loss (unitless)
CF_2	=	Unit conversion factor (1E-03 kg/g)
IR_c	=	Trout ingestion rate for children aged 1-6 years (g/day)
IR_a	=	Trout ingestion rate for adults (g/day)
ED_c	=	Exposure duration for children aged 1-6 years (years)
ED_a	=	Exposure duration for adults (years)
BW_c	=	Body weight for children aged 1-6 years (kg)
BW_a	=	Body weight for adults (kg)

The specific exposure assumptions used for each age group in the deterministic analysis, and the basis of each, are summarized in Table 18a. In all cases, the assumptions and parameters used are the same as those used by EPA in its deterministic assessment in the 2005 HHRA.

For the 1-D MC analysis, the input distributions were developed from information provided in Table 6-2 of Vol. IV of the HHRA (p. 6-15). Descriptions of these distributions are provided in Table 18b. Fifty thousand iterations of the model were run, using @Risk, for each of the target risk levels (combining adult and childhood exposure).

Currently EPA's IRIS database does not publish a cancer slope factor (CSF) for dioxin. Consistent with the approach used in the HHRA, a CSF for 2,3,7,8-tetrachlorodibenzo-*p*-dioxin of 150,000 $(mg/kg\text{-}day)^{-1}$, which was the CSF published in EPA's 1997 *Health Effects Assessment Summary Tables*, has been used to calculate the RMCs for dioxin TEQs.

Deterministic RMCs based on potential carcinogenic effects (for children and adults combined) have been developed for both the RME and CTE exposure scenarios using a range of target risks from one-in-a-million ($1x10^{-6}$) to one-in-ten-thousand ($1x10^{-4}$). This risk range is consistent with EPA's acceptable risk range.

For the 1-D MC analysis, the same risk range and Hazard Index have been used. Once the analysis was completed, the 5th percentile (95% of the calculated RMC output distribution values exceed the 5th percentile) and the 50th percentile values from the output distributions of potential RMCs at each target risk level were selected as the RME and CTE RMCs, respectively.

Summary of Results

Estimated RMCs (in ng/kg or ppt) for the cancer endpoint based on the deterministic analysis are presented in Table 18c. A summary of the distribution of RMCs calculated using the 1-D MC is provided in Table 18d. The RMCs resulting from both the deterministic analysis and the probabilistic analysis (using the 5th and 50th percentile values for the RME and CTE, respectively) are summarized in the following table.

	RME (ng/kg)			**CTE (ng/kg)**		
	Cancer Risk			**Cancer Risk**		
Deterministic	**$1x10^{-6}$**	**$1x10^{-5}$**	**$1x10^{-4}$**	**$1x10^{-6}$**	**$1x10^{-5}$**	**$1x10^{-4}$**
Young child/Adult	0.065	0.65	6.5	0.70	7.0	70
1-D MC						
Young child/Adult	0.18	1.8	18	1.6	16	163

Table 18a. Summary of Pathway- and Age-Specific Exposure Assumptions Used in the Deterministic Fish Consumption Scenario for Trout

Parameters	Units	Symbol	RME	CTE	Basis*
Unit conversion factor	ng/mg	CF_1	1.0E+06	1.0E+06	Necessary to derive RMC units of ng/kg
Unit conversion factor	kg/g	CF_2	1.0E-03	1.0E-03	HHRA, Vol IV; Tables 4-8 and 4-10.
Ingestion rate	g/day	IR			
Young child			6	2	HHRA, Vol IV; Tables 4-9 and 4-10. Section 4.5.2.2.6. EPA's calculation based on EPA 2002.
Adult			12	4	HHRA, Vol IV; Tables 4-9 and 4-10. Section 4.5.2.2.4. Based on EPA's evaluation of the Ebert et al. 1993.
Fraction ingested from site	unitless	FI	0.97	0.5	HHRA, Vol IV; Tables 4-8 and 4-10. Section 4.5.2.4. EPA's professional judgment.
Exposure frequency	days/year	EF	365	365	HHRA, Vol IV; Tables 4-8 and 4-10. Fish consumption rates are average daily rates over 365 days.
Fraction PCBs lost during cooking	unitless	LOSS	0.25	0.25	HHRA, Vol IV; Tables 4-8 and 4-10. Section 4.5.2.3. EPA's evaluation based on multiple studies.
Exposure duration	years	ED			
Young child			6	6	HHRA, Vol IV; Tables 4-9 and 4-10. Ages 1 to 6 years. Calculated by EPA, Section 4.5.2.6.
Adult			44	17	HHRA, Vol IV; Tables 4-9 and 4-10. Section 4.5.2.6. Based on MDPH 2001.
Body weight	kg	BW			
Young child			15	15	HHRA, Vol. IV; Table 4-9; based on EPA 1989. Average age specific body weight.
Adult			70	70	HHRA, Vol. IV; Table 4-9; based on EPA 1989. Average age specific body weight.
Averaging time	days	ATc	25,550	25,550	HHRA, Vol. IV; Table 4-8; based on EPA 1989. Lifetime of 70 years x 365 days/year.

* All exposure parameters are identical to the parameters used in the HHRA (EPA, 2005). Volume and Table and/or Section numbers provided.

Ebert, E., N. Harrington, K. Boyle, J. Knight, and R. Keenan. 1993. Estimating consumption of freshwater fish among Maine anglers. *North American Journal of Fisheries Management* 13:737-745.

EPA 1989. *Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual (Part A) Interim Final.*

EPA 2002. *Estimated Per Capita Fish Consumption in the United States.*

MDPH 2001. *Memo from Martha Steele, Deputy Director, Bureau of Environmental Health Assessment to Bryan Olson, EPA, Region 1 regarding Remainder of data request with respect* to information gathered from questionnaires from Housatonic River Area Exposure Assessment Study as well as questionnaires completed after the study and resulting from calls to

the Bureau of Environmental Health Assessment (BEHA) hotline.

Table 18b. Summary of Exposure Assumptions and Distributions Used in the 1-D Monte Carlo Analysis for the Trout Consumption Scenario[1]

Parameters	Units	Symbol	Min	Max	Central Estimate	Standard Deviation	Distribution Type
Unit conversion factor	ng/mg	CF_1	-	-	1.0E+06	-	Point Estimate
Unit conversion factor	kg/g	CF_2	-	-	1.0E-03	-	Point Estimate
Ingestion rate	g/day	IR					
Adult			0.27	46.62	4.2	7.3	Empirical Distribution Function
Young child			0.135	23.31	2.1	3.65	Empirical Distribution Function[2]
Fraction ingested from site	unitless	FI	0.1	1	0.5	0.28	Empirical Distribution Function[3]
Fraction PCBs lost during cooking	unitless	LOSS	0.016	1	0.26	0.18	Stochastic Mixture of Distributions[4]
Exposure frequency	days/yr		-	-	365	-	Point Estimate
Exposure duration	years	ED					
Young child			1	6	3.5	1.4	Uniform
Adult			1	64	29	20	T-lognormal
Body weight	kg	BW					
Young child			12	23	17	2.3	Lognormal
Adult			39	119	72	15	Lognormal
Averaging time	days	ATc			25,550		Point Estimate

[1]All distribution statistics are presented in Table 6-2, page 6-15, of the HHRA Volume IV.

[2]Distribution is half the adult distribution.

[3]Empirical distribution function derived from Figure 6-17 of HHRA Volume IV yielded slightly different values than those reported in Table 6-2 of HHRA.

[4]Table 6-2 of HHRA Volume IV reports that minimum value as 0.16. However, Figure 6-6 and minimum values for the individual methods reported in Table 6-2 indicate that the minimum value is actually 0.016.

Table 18c. Deterministic RMCs for TEQ (ng/kg) in Trout Tissue at Target Risk Range and Hazard Index of 1
Fish Consumption - Connecticut Trout

Parameter	EPA RME Analysis			EPA CTE Analysis		
Pathway Specific Parameters						
Exposure duration (yrs)						
Young child	6	6	6	6	6	6
Adult	44	44	44	17	17	17
Body weight (kg)						
Young child	15	15	15	15	15	15
Adult	70	70	70	70	70	70
Averaging time - carcinogenic (days)	25,550	25,550	25,550	25,550	25,550	25,550
Ingestion rate (g/day)						
Young child	6	6	6	2	2	2
Adult	12	12	12	4	4	4
Fraction attributable to site	0.97	0.97	0.97	0.5	0.5	0.5
Cooking loss (unitless)	0.25	0.25	0.25	0.25	0.25	0.25
Conversion factor, fish ing (kg/g)	1E-03	1E-03	1E-03	1E-03	1E-03	1E-03
Exposure frequency (days/year)	365	365	365	365	365	365
Exposure -carcinogenic (days)$^{-1}$	1.0E-04	1.0E-04	1.0E-04	9.5E-06	9.5E-06	9.5E-06
CARCINOGENIC	**EPA RME Analysis**			**EPA CTE Analysis**		
Total Exposure, fish ingestion (days)$^{-1}$	1.0E-04	1.0E-04	1.0E-04	9.5E-06	9.5E-06	9.5E-06
Cancer Slope Factor (CSF) (mg/kg-day)$^{-1}$	150,000	150,000	150,000	150,000	150,000	150,000
Target Risk Level	1.0E-04	1.0E-05	1.0E-06	1.0E-04	1.0E-05	1.0E-06
Unit conversion factor (ng/mg)	1.0E+06	1.0E+06	1.0E+06	1.0E+06	1.0E+06	1.0E+06
Risk-based Media Concentration (ng/kg)	**6.5**	**0.65**	**0.065**	**70**	**7.0**	**0.70**

Table 18d. Summary of TEQ RMC (ng/kg) Output of 1-D Monte Carlo for Consumption of Trout

	RMC (ng/kg)		
	Cancer		
Percentile	10^{-6} Risk	10^{-5} Risk	10^{-4} Risk
Minimum	0.012	0.12	1.2
5	0.18	1.8	18
10	0.29	2.9	29
15	0.41	4.1	41
20	0.53	5.3	53
25	0.67	6.7	67
30	0.81	8.1	81
35	0.97	9.7	97
40	1.2	12	116
45	1.4	14	137
50	1.6	16	163
55	1.9	19	192
60	2.3	23	227
65	2.7	27	267
70	3.2	32	320
75	3.9	39	387
80	4.9	49	493
85	6.3	63	627
90	8.4	84	840
95	13	133	1333
Maximum	8087	80867	808667

Attachment 19
Risk-based Media Concentrations for TEQ in Waterfowl Tissue
Waterfowl Consumption Scenario

A range of Risk-based Media Concentrations (RMCs) has been developed for dioxin toxicity equivalency quotients (TEQ) based on the potential for humans to be exposed, via consumption, to dioxins, furans, and dioxin-like PCBs in the edible tissue of waterfowl obtained from the study area. Consistent with the approach used in EPA's HHRA, potential waterfowl consumption exposures of young children and adults have been evaluated under reasonable maximum exposure (RME) and central tendency exposure (CTE) conditions. RMCs have been developed using both a deterministic and a probabilistic 1-dimensional Monte Carlo approach (1-D MC). For each set of exposure conditions and each type of assessment (deterministic and probabilistic), RMCs have been calculated for TEQs based on potential cancer risks for children and adults combined, using the exposure assumptions and TEQ toxicity value used in the HHRA. Consistent with the HHRA, since EPA has not developed a non-cancer reference dose for dioxin TEQs, RMCs based on non-cancer impacts have not been developed for TEQs.

The RMCs for the cancer endpoint (RMC_{cancer}) for this scenario have been calculated using the following equation that combines exposures to young children and adults.

$$RMC_{cancer} = \frac{Risk * AT_c * CF_1}{EF * CSF * FI * (1 - LOSS) * CF_2 * \left(\left(\frac{IR_c * ED_c}{BW_c} \right) + \left(\frac{IR_a * ED_a}{BW_a} \right) \right)}$$

Where:

RMC_{cancer}	=	RMC based on the cancer endpoint (ng/kg)
Risk	=	Target risk level (unitless)
AT_c	=	Averaging time for carcinogenic exposure (days)
CF_1	=	Unit conversion factor (1,000,000 ng/mg)
EF	=	Exposure frequency (days/year for deterministic; meals/year for 1-D MC)
CSF	=	Cancer slope factor $(mg/kg\text{-}day)^{-1}$
FI	=	Fraction ingested from the site (unitless)
LOSS	=	Cooking loss (unitless)
CF_2	=	Unit conversion factor (1E-03 kg/g)
IR_c	=	Waterfowl ingestion rate for children aged 1-6 years (g/day for deterministic; g/meal for 1-D MC)
IR_a	=	Waterfowl ingestion rate for adults (g/day for deterministic; g/meal for 1-D MC)
ED_c	=	Exposure duration for children aged 1-6 years (years)
ED_a	=	Exposure duration for adults (years)
BW_c	=	Body weight for children aged 1-6 years (kg)
BW_a	=	Body weight for adults (kg)

The specific exposure assumptions used for each age group in the deterministic analysis, and the basis of each, are summarized in Table 19a. In all cases, the assumptions and parameters used are the same as those used by EPA in its deterministic assessment in the 2005 HHRA.

For the 1-D MC analysis, the input distributions were developed from the information provided in Table 6-4 of Vol. IV of the HHRA (p. 6-58). Descriptions of these distributions are provided in Table 16b. Fifty thousand iterations of the model were run, using @Risk, for each of the target risk levels (combining adult and childhood exposure).

Currently EPA's IRIS database does not publish a cancer slope factor (CSF) for dioxin. Consistent with the approach used in the HHRA, a CSF for 2,3,7,8-tetrachlorodibenzo-*p*-dioxin of 150,000 $(mg/kg\text{-}day)^{-1}$, which was the CSF published in EPA's 1997 *Health Effects Assessment Summary Tables*, has been used to calculate the RMCs for dioxin TEQs.

Deterministic RMCs based on potential carcinogenic effects (for children and adults combined) have been developed for both the RME and CTE exposure scenarios using a range of target risks from one-in-a-million ($1x10^{-6}$) to one-in-ten-thousand ($1x10^{-4}$). This risk range is consistent with EPA's acceptable risk range.

For the 1-D MC analysis, the same risk range and target Hazard Index have been used. Once the analysis was completed, the 5th percentile (95% of the calculated RMC output distribution values exceed the 5th percentile) and 50th percentile values from the output distribution of potential RMCs at each target risk level were selected as the RME and CTE RMCs, respectively.

Summary of Results

Estimated RMCs (in ng/kg or ppt) for the cancer endpoint based on the deterministic analysis are presented in Table 19b. A summary of the distribution of RMCs calculated using the 1-D MC is provided in Table 19d. The RMCs resulting from both the deterministic analysis and the probabilistic analysis (using the 5th and 50th percentile values for the RME and CTE, respectively) are summarized in the following table.

	RME (ng/kg)			**CTE (ng/kg)**		
	Cancer Risk			**Cancer Risk**		
Deterministic	**$1x10^{-6}$**	**$1x10^{-5}$**	**$1x10^{-4}$**	**$1x10^{-6}$**	**$1x10^{-5}$**	**$1x10^{-4}$**
Young child/Adult	0.11	1.1	11	0.44	4.4	44
1-D MC						
Young child/Adult	0.10	1.0	10	0.96	9.6	96

Table 19a. Summary of Pathway- and Age-Specific Exposure Assumptions Used in the Waterfowl Consumption Scenario

Parameters	Units	Symbol	RME	CTE	Basis*
Unit conversion factor	ng/g	CF_1	1.E+06	1.E+06	Necessary to derive RMC units of ng/kg
Unit conversion factor	kg/g	CF_2	1.0E-03	1.0E-03	HHRA, Vol IV; Tables 4-38 and 4-40.
Ingestion rate	g/day	IR			
Young child			2.5	1.2	HHRA, Vol IV; Tables 4-39 and 4-40. Section 4.6.2.1. Calculated by EPA based on one-half adult rate.
Adult			5	2.4	HHRA, Vol IV; Tables 4-39 and 4-40. Section 4.6.2.1. Meal size based on poultry meal sizes from Pao et al. 1982; meal frequency based on 90th percentile from MDPH 2001 survey.
Fraction ingested from site	unitless	FI	1	1	HHRA, Vol IV; Tables 4-38 and 4-40. Section 4.6.2.3. EPA's professional judgment.
Exposure frequency	days/year	EF	365	365	HHRA, Vol IV; Tables 4-38 and 4-40. Waterfowl consumption rates are average daily rates over 365 days.
Fraction PCBs lost during cooking	unitless	LOSS	0	0	HHRA, Vol IV; Tables 4-38 and 4-40. Section 4.6.2.2. EPA's professional judgment.
Exposure duration	years	ED			
Young child			6	6	HHRA, Vol IV; Tables 4-39 and 4-40. Ages 1 to 6 years. Calculated by EPA based on EPA 1989.
Adult			44	17	HHRA, Vol IV; Tables 4-39 and 4-40. Section 4.6.2.5. Based on MDPH 2001.
Body weight	kg	BW			
Young child			15	15	HHRA, Vol. IV; Tables 4-39 and 4-40; based on EPA 1989. Average age specific body weight.
Adult			70	70	HHRA, Vol. IV; Tables 4-39 and 4-40; based on EPA 1989. Average age specific body weight.
Averaging time	days	ATc	25,550	25,550	HHRA, Vol. IV; Table 4-38; based on EPA 1989. Lifetime of 70 years x 365 days/year.

* All exposure parameters are identical to the parameters used in the HHRA (EPA, 2005). Volume and Table and/or Section numbers provided.

EPA 1989. *Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual (Part A) Interim Final.*

MDPH 2001. *Memo from Martha Steele, Deputy Director, Bureau of Environmental Health Assessment to Bryan Olson, EPA, Region 1 regarding Remainder of data request with respect* to information gathered from questionnaires from Housatonic River Area Exposure Assessment Study as well as questionnaires completed after the study and resulting from calls to the Bureau of Environmental Health Assessment (BEHA) hotline.

Pao E., K. Fleming, P. Guenther, S. Mickle. 1982. *Foods Commonly Esten by Individuals: Amount Per Day and Per Eating Occasion.* Consumer Nutrition Center, Human Nutrition Information Service, U.S. Department of Agriculture. Hyattsville, MD. Home Economics Reserach Report Number 44.

Table 19b. Summary of Exposure Assumptions and Distributions Used in the 1-D Monte Carlo Analysis for the Waterfowl Consumption Scenario[1]

Parameters	Units	Symbol	Min	Max	Central Estimate	Standard Deviation	Distribution Type
Unit conversion factor	ng/mg	CF_1	-	-	1.0E+06	-	Point Estimate
Unit conversion factor	kg/g	CF_2	-	-	1.0E-03	-	Point Estimate
Ingestion rate	g/meal	IR					
Young child			19	338	94	57	Lognormal
Adult			38	675	188	113	Lognormal
Exposure frequency	meals/year	EF	1	52	5.4	10.6	Empirical Distribution Function
Fraction ingested from site	unitless	FI	-	-	1	-	Point Estimate[2]
Fraction PCBs lost during cooking	unitless	LOSS	-	-	0	-	Point Estimate
Exposure duration	years	ED					
Young child			1	6	3.5	1.4	Uniform
Adult			1	64	29	20	T-lognormal
Body weight	kg	BW					
Young child			12	23	17	2.3	Lognormal
Adult			39	119	72	15	Lognormal
Averaging time	days	ATc			25,550		Point Estimate

[1]All distribution statistics are presented in Table 6-4, page 6-58, of the HHRA Volume IV.

[2]Table 6-4 does not include a value for fraction ingested from the site but the text indicates that it is assumed to be 100 percent for waterfowl.

Table 19c. Deterministic RMCs for TEQ (ng/kg) in Waterfowl Tissue at Target Risk Range and Hazard Index of 1
Waterfowl Consumption Scenario

Parameter	EPA RME Analysis			EPA CTE Analysis		
Pathway Specific Parameters						
Exposure duration (yrs)						
Young child	6	6	6	6	6	6
Adult	44	44	44	17	17	17
Body weight (kg)						
Young child	15	15	15	15	15	15
Adult	70	70	70	70	70	70
Averaging time - carcinogenic (days)	25,550	25,550	25,550	25,550	25,550	25,550
Ingestion rate (g/day)						
Young child	2.5	2.5	2.5	1.2	1.2	1.2
Adult	5	5	5	2.4	2.4	2.4
Fraction attributable to site	1.0	1.0	1.0	1.0	1.0	1.0
Cooking loss (unitless)	0	0	0	0	0	0
Conversion factor, waterfowl ing (kg/g)	1E-03	1E-03	1E-03	1E-03	1E-03	1E-03
Exposure frequency (days/year)	365	365	365	365	365	365
Exposure-carcinogenic (days)$^{-1}$	5.9E-05	5.9E-05	5.9E-05	1.5E-05	1.5E-05	1.5E-05
CARCINOGENIC	**EPA RME Analysis**			**EPA CTE Analysis**		
Total Exposure, waterfowl ingestion (days)$^{-1}$	5.9E-05	5.9E-05	5.9E-05	1.5E-05	1.5E-05	1.5E-05
Cancer Slope Factor (CSF) (mg/kg-day)$^{-1}$	150,000	150,000	150,000	150,000	150,000	150,000
Target Risk Level	1.0E-04	1.0E-05	1.0E-06	1.0E-04	1.0E-05	1.0E-06
Unit conversion factor (ng/mg)	1.0E+06	1.0E+06	1.0E+06	1.0E+06	1.0E+06	1.0E+06
Risk-based Media Concentration (ng/kg)	**11**	**1.1**	**0.11**	**44**	**4.4**	**0.44**

Table 19d. Summary of TEQ RMC (ng/kg) Output of 1-D Monte Carlo for Consumption of Waterfowl

	RMC (ng/kg)		
	Cancer		
Percentile	10^{-6} Risk	10^{-5} Risk	10^{-4} Risk
Minimum	0.0076	0.076	0.76
5	0.10	1.0	10
10	0.16	1.6	16
15	0.23	2.3	23
20	0.29	2.9	29
25	0.37	3.7	37
30	0.46	4.6	46
35	0.56	5.6	56
40	0.67	6.7	67
45	0.81	8.1	81
50	0.96	9.6	96
55	1.1	11	114
60	1.4	14	135
65	1.6	16	163
70	2.0	20	199
75	2.4	24	244
80	3.1	31	306
85	4.0	40	399
90	5.6	56	559
95	9.1	91	907
Maximum	121	1208	12083

APPENDIX C

ATTACHMENTS 20 THROUGH 28

Attachment 20
Risk-based Media Concentrations for Ingestion of Dairy Products (Cow Milk) from Commercial Farms

A range of Risk-based Media Concentrations (RMCs) has been developed for PCBs based on potential consumption of dairy products from commercial farms by adult farmers and children. Consistent with the approach used in EPA's HHRA, potential ingestion of dairy products by adult farmers and children have been evaluated under reasonable maximum exposure (RME) and central tendency exposure (CTE) conditions. For each set of exposure conditions, RMCs have been calculated based on potential cancer risks (for children and adults combined) and potential non-cancer impacts (for children and adults separately), using the exposure assumptions and toxicity values used in the HHRA.

The tissue-specific RMCs based on the potential for carcinogenic effects from ingesting cow milk from commercial farms were derived using the following general equation:

$$RMC_{cancer} = \frac{Risk * AT_c}{CSF * IR_{adj} * F_{GI} * EF * (1 - Loss_{cook})}$$

Where:

RMC_{cancer}	=	RMC based on the cancer endpoint (mg/kg)
Risk	=	Target risk level (unitless)
AT_c	=	Averaging time for carcinogenic exposure (days)
CSF	=	Cancer slope factor $(mg/kg\text{-}day)^{-1}$
IR_{adj}[1]	=	Age-adjusted ingestion rate (kg-year/kg-day)
F_{GI}	=	Fraction absorbed in GI tract (unitless)
EF	=	Exposure frequency (days/year)
$Loss_{cook}$	=	Cooking loss (Milk loss factor) (unitless)

The tissue-specific RMCs based on potential non-carcinogenic effects from ingesting cow milk from commercial farms were derived using the following equation:

$$RMC_{noncancer} = \frac{HI * RfD * AT_{nc}}{IR * F_{GI} * EF * ED * (1 - Loss_{cook})}$$

Where:

$RMC_{noncancer}$	=	RMC based on the non-cancer endpoint (mg/kg)
HI	=	Target hazard index (unitless)
RfD	=	Reference dose (mg/kg-day)
AT_{nc}	=	Averaging time for non-carcinogenic exposure (days)

[1] The age-adjusted ingestion rate was derived using the following equation: (IRa*EDa)+(IRc*EDc), where IRa is the adult ingestion rate, EDa is the adult exposure duration, IRc is the child ingestion rate, and EDc is the child exposure duration.

IR	=	Ingestion rate (kg/kg-day)
F_{GI}	=	Fraction absorbed in the GI tract (unitless)
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)
$Loss_{cook}$	=	Cooking loss (Milk loss factor) (unitless)

The specific exposure assumptions used for each age group in this analysis, and the basis of each, are summarized in Table 20a. In all cases, the assumptions and parameters used are the same as those used by EPA in its 2005 HHRA.

Standard upper-bound EPA toxicity values have been used for PCBs. These include a cancer slope factor (CSF) of 2 $(mg/kg\text{-}day)^{-1}$ for the RME scenarios and a CSF of 1 $(mg/kg\text{-}day)^{-1}$, for the CTE scenarios, and a chronic reference dose of 2E-05 for both the RME and CTE scenario. These values are published in EPA's IRIS database and were used in EPA's HHRA.

RMCs based on potential carcinogenic effects (for children and adults combined) have been developed for both the RME and CTE exposure scenarios using a range of target risks from one-in-a-million (1×10^{-6}) to one-in-ten thousand (1×10^{-4}). This risk range is consistent with EPA's acceptable risk range. RMCs for non-cancer effects have been developed for the RME and CTE scenarios for adults and young children separately, based on a target Hazard Index of 1.

Summary of Results

Estimated RMCs for cancer and non-cancer endpoints are presented in Table 20b and are summarized as follows.

	RME (mg/kg)				**CTE (mg/kg)**			
	Cancer Risk			**Non-cancer**	**Cancer Risk**			**Non-cancer**
	$1x10^{-6}$	**$1x10^{-5}$**	**$1x10^{-4}$**	**HI = 1**	**$1x10^{-6}$**	**$1x10^{-5}$**	**$1x10^{-4}$**	**HI = 1**
Child/Adult	0.000026	0.00026	0.0026	NC	0.00012	0.0012	0.012	NC
Child	NC	NC	NC	0.00030	NC	NC	NC	0.00047
Adult	NC	NC	NC	0.0014	NC	NC	NC	0.0017

Table 20a. Summary of Pathway- and Age-Specific Exposure Assumptions Used in the Commercial Farm Dairy Consumption Scenario

Parameters	Units	Symbol	RME	CTE	Basis
Common Parameters					
Exposure frequency	days/year	EF			
Adult Farmer			350	350	HHRA, Vol. V; Appendix D; Table 4-10. EPA Assumed.
Child			350	350	HHRA, Vol. V; Appendix D; Table 4-10. EPA Assumed.
Exposure duration	years	ED			
Adult Farmer			64	29	HHRA, Vol. V; Appendix D; Table 4-10. EPA Assumed.
Child			6	6	HHRA, Vol. V; Appendix D; Table 4-10. EPA Assumed (1-7 year old).
Averaging time (cancer endpoint)	days	ATc	25,550	25,550	HHRA, Vol. V; Appendix D; Table 4-10. Based on 70 years * 365 days/year
Averaging time (noncancer endpoint)	days	ATnc			
Adult Farmer			23,360	10,585	HHRA, Vol. V; Appendix D; Table 4-10. Based on ED * 365 days/year
Child			2,190	2,190	HHRA, Vol. V; Appendix D; Table 4-10. Based on ED * 365 days/year
Tissue Ingestion Pathway					
Dairy Ingestion Rate	kg/kg-day	IR			
Adult Farmer			0.01511	0.0124	HHRA, Vol. V; Appendix D; Table 4-10. Based on EPA, 1997; Table 13-28 & Table 11-2
Child			0.0703	0.0441	HHRA, Vol. V; Appendix D; Table 4-10. Based on EPA, 1997; Table 13-28 & Table 11-2
Age-Adjusted	(kg-year/kg-day)	IR_{adj}	1.3882	0.6242	GE-derived value for aggregate risk RMC. Based on EPA ED and IR.
Milk Loss Factor	unitless	$Loss_{cook}$	0	0	HHRA, Vol V; Appendix D; Table 4-10. EPA Assumed.
Fraction absorbed in GI tract	unitless	F_{GI}	1.0	1.0	HHRA, Vol. V; Appendix D; Table 4-10. EPA Assumed.

EPA 1997. *Exposure Factors Handbook, Volume I; General Factors.*
EPA 2005. *Human Health Risk Assessment GE/Housatonic River Site Rest of River Volume V; Appendix D Agricultural Product Consumption Risk Assessment.*

Table 20b. RMCs for PCBs (mg/kg) in Dairy Products for Target Risk Range and HI of 1

Commmercial Farm

Parameter	EPA RME Analysis			EPA CTE Analysis		
Common Parameters						
Exposure duration (yrs)						
Child	6	6	6	6	6	6
Adult	64	64	64	29	29	29
Averaging time - noncarcinogenic (days)						
Child	2,190	2,190	2,190	2,190	2,190	2,190
Adult	23,360	23,360	23,360	10,585	10,585	10,585
Averaging time - carcinogenic (days)	25,550	25,550	25,550	25,550	25,550	25,550
Pathway Specific Parameters						
Dairy Consumption						
Ingestion rate (kg/kg-day)						
Child	0.0703	0.0703	0.0703	0.0441	0.0441	0.0041
Adult	0.0151	0.0151	0.0151	0.0124	0.0124	0.0124
Age-Adjusted (kg-year/kg-day)	1.3882	1.3882	1.3882	0.6242	0.6242	0.6242
Milk Loss Factor (unitless)	0	0	0	0	0	0
Fraction absorbed in GI tract (unitless)	1.0	1.0	1.0	1.0	1.0	1.0
Exposure frequency (days/year)	350	350	350	350	350	350
Exposure (dairy ing)-carcinogenic (kg/kg-day)	0.01902	0.01902	0.01902	0.00855	0.00855	0.00855
Exposure (dairy ing)-noncarcinogenic (kg/kg-day) - child	0.06741	0.06741	0.06741	0.04229	0.04229	0.00393
Exposure (dairy ing)-noncarcinogenic (kg/kg-day) - adult	0.01448	0.01448	0.01448	0.01189	0.01189	0.01189
CARCINOGENIC	**EPA RME Analysis**			**EPA CTE Analysis**		
Total Exposure, dairy ingestion (kg/kg-day)	1.9E-02	1.9E-02	1.9E-02	8.6E-03	8.6E-03	8.6E-03
Cancer Slope Factor (CSF) $(mg/kg\text{-}day)^{-1}$	2	2	2	1	1	1
Target Risk Level	1.0E-04	1.0E-05	1.0E-06	1.0E-04	1.0E-05	1.0E-06
Risk-based Media Concentration (mg/kg-wet weight)	**0.0026**	**0.00026**	**0.000026**	**0.012**	**0.0012**	**0.00012**
NONCARCINOGENIC	**Child**			**Child**		
Total Exposure, dairy ingestion (kg/kg-day)	6.7E-02			4.2E-02		
Reference Dose (RfD) (mg/kg-day)	2.00E-05			2.00E-05		
Target Hazard Index	1			1		
Risk-based Media Concentration (mg/kg-wet weight)	**0.00030**			**0.00047**		
NONCARCINOGENIC	**Adult**			**Adult**		
Total Exposure, dairy ingestion (kg/kg-day)	1.4E-02			1.2E-02		
Reference Dose (RfD) (mg/kg-day)	2.00E-05			2.00E-05		
Target Hazard Index	1			1		
Risk-based Media Concentration (mg/kg-wet weight)	**0.0014**			**0.0017**		

Attachment 21
Risk-based Media Concentrations for Ingestion of Dairy Products (Cow Milk) from Backyard Farms

A range of Risk-based Media Concentrations (RMCs) has been developed for PCBs based on potential consumption of dairy products from backyard farms by adult residents and children. Consistent with the approach used in EPA's HHRA, potential ingestion of dairy products by adult residents and children have been evaluated under reasonable maximum exposure (RME) and central tendency exposure (CTE) conditions. For each set of exposure conditions, RMCs have been calculated based on potential cancer risks (for children and adults combined) and potential non-cancer impacts (for children and adults separately), using the exposure assumptions and toxicity values used in the HHRA.

The tissue-specific RMCs based on the potential for carcinogenic effects from ingesting cow milk from backyard farms were derived using the following general equation:

$$RMC_{cancer} = \frac{Risk * AT_c}{CSF * IR_{adj} * F_{GI} * EF * (1 - Loss_{cook})}$$

Where:

RMC_{cancer}	=	RMC based on the cancer endpoint (mg/kg)
Risk	=	Target risk level (unitless)
AT_c	=	Averaging time for carcinogenic exposure (days)
CSF	=	Cancer slope factor $(mg/kg\text{-}day)^{-1}$
IR_{adj}[1]	=	Age-adjusted ingestion rate (kg-year/kg-day)
F_{GI}	=	Fraction absorbed in the GI tract (unitless)
EF	=	Exposure frequency (days/year)
$Loss_{cook}$	=	Cooking loss (Milk loss factor) (unitless)

The tissue-specific RMCs based on potential non-carcinogenic effects from ingesting cow milk from backyard farms were derived using the following equation:

$$RMC_{noncancer} = \frac{HI * RfD * AT_{nc}}{IR * F_{GI} * EF * ED * (1 - Loss_{cook})}$$

Where:

$RMC_{noncancer}$	=	RMC based on the non-cancer endpoint (mg/kg)
HI	=	Target hazard index (unitless)
RfD	=	Reference dose (mg/kg-day)
AT_{nc}	=	Averaging time for non-carcinogenic exposure (days)
IR	=	Ingestion rate (kg/kg-day)

[1] The age-adjusted ingestion rate was derived using the following equation: (IRa*EDa)+(IRc*EDc), where IRa is the adult ingestion rate, EDa is the adult exposure duration, IRc is the child ingestion rate, and EDc is the child exposure duration.

F_{GI} = Fraction absorbed in the GI tract (unitless)
EF = Exposure frequency (days/year)
ED = Exposure duration (years)
$Loss_{cook}$ = Cooking loss (Milk loss factor) (unitless)

The specific exposure assumptions used for each age group in this analysis, and the basis of each, are summarized in Table 21a. In all cases, the assumptions and parameters used are the same as those used by EPA in its 2005 HHRA.

Standard upper-bound EPA toxicity values have been used for PCBs. These include a cancer slope factor (CSF) of 2 $(mg/kg\text{-}day)^{-1}$ for the RME scenarios and a CSF of 1 $(mg/kg\text{-}day)^{-1}$for the CTE scenarios, and a chronic reference dose of 2E-05 for both the RME and CTE scenario. These values are published in EPA's IRIS database and were used in EPA's HHRA.

RMCs based on potential carcinogenic effects (for children and adults combined) have been developed for both the RME and CTE exposure scenarios using a range of target risks from one-in-a-million (1×10^{-6}) to one-in-ten thousand (1×10^{-4}). This risk range is consistent with EPA's acceptable risk range. RMCs for non-cancer effects have been developed for the RME and CTE scenarios for adult and young children separately, based on a target Hazard Index of 1.

Summary of Results

Estimated RMCs for cancer and non-cancer endpoints are presented in the Table 21b and are summarized as follows.

	RME (mg/kg)				**CTE (mg/kg)**			
	Cancer Risk			**Non-cancer**	**Cancer Risk**			**Non-cancer**
	$1x10^{-6}$	**$1x10^{-5}$**	**$1x10^{-4}$**	**HI = 1**	**$1x10^{-6}$**	**$1x10^{-5}$**	**$1x10^{-4}$**	**HI = 1**
Child/Adult	0.000032	0.00032	0.0032	NC	0.00016	0.0016	0.016	NC
Child	NC	NC	NC	0.00030	NC	NC	NC	0.00047
Adult	NC	NC	NC	0.0012	NC	NC	NC	0.0010

Table 21a. Summary of Pathway- and Age-Specific Exposure Assumptions Used in the Backyard Farm Dairy Consumption Scenario

Parameters	Units	Symbol	RME	CTE	Basis
Common Parameters					
Exposure frequency	days/year	EF			
Adult Resident			350	350	HHRA, Vol. V; Appendix D; Table 4-10. EPA Assumed.
Child			350	350	HHRA, Vol. V; Appendix D; Table 4-10. EPA Assumed.
Exposure duration	years	ED			
Adult Resident			39	9	HHRA, Vol. V; Appendix D; Table 4-10. Based on MDPH 2001a
Child			6	6	HHRA, Vol. V; Appendix D; Table 4-10. EPA Assumed (1-7 year old).
Averaging time (cancer endpoint)	days	ATc	25,550	25,550	HHRA, Vol. V; Appendix D; Table 4-10. Based on 70 years * 365 days/year
Averaging time (noncancer endpoint)	days	ATnc			
Adult Resident			14,235	3,285	HHRA, Vol. V; Appendix D; Table 4-10. Based on ED * 365 days/year
Child			2,190	2,190	HHRA, Vol. V; Appendix D; Table 4-10. Based on ED * 365 days/year
Tissue Ingestion Pathway					
Dairy Ingestion Rate	kg/kg-day	IR			
Adult Resident			0.0181	0.0209	HHRA, Vol. V; Appendix D; Table 4-10. Based on EPA, 1997; Table 13-28 & Table 11-2
Child			0.0703	0.0441	HHRA, Vol. V; Appendix D; Table 4-10. Based on EPA, 1997; Table 13-28 & Table 11-2
Age-Adjusted	(kg-year/kg-day)	IR_{adj}	1.1277	0.4527	GE-derived value for aggregate risk RMC. Based on EPA ED and IR.
Milk Loss Factor	unitless	$Loss_{cook}$	0	0	HHRA, Vol V; Appendix D; Table 4-10. EPA Assumed.
Fraction absorbed in GI tract	unitless	F_{GI}	1.0	1.0	HHRA, Vol. V; Appendix D; Table 4-10. EPA Assumed.

EPA 1997. *Exposure Factors Handbook, Volume I; General Factors.*
EPA 2005. *Human Health Risk Assessment GE/Housatonic River Site Rest of River Volume V; Appendix D Agricultural Product Consumption Risk Assessment.*
MDPH 2001a. Letter from Suzanne K. Condon, Assistant Commissioner of the Bureau of environmental Health Assessment to Bryan Olson, U.S. Environmental Protection Agency, Region I. *Hunting Information of Individual Family Members Who Reported Hunting Birds from the HRA, PCB Exposure Assessment Study, Volunteer Study, and Hotline Study, and Calls from Individuals Concerned About Hunting After Hearing About the PCB Duck Advisory. 21 August.*

Table 21b. RMCs for PCBs (mg/kg) in Dairy Products for Target Risk Range and HI of 1
Backyard Farm

Parameter	EPA RME Analysis			EPA CTE Analysis		
Common Parameters						
Exposure duration (yrs)						
Child	6	6	6	6	6	6
Adult	39	39	39	9	9	9
Averaging time - noncarcinogenic (days)						
Child	2,190	2,190	2,190	2,190	2,190	2,190
Adult	14,235	14,235	14,235	3,285	3,285	3,285
Averaging time - carcinogenic (days)	25,550	25,550	25,550	25,550	25,550	25,550
Pathway Specific Parameters						
Dairy Consumption						
Ingestion rate (kg/kg-day)						
Child	0.0703	0.0703	0.0703	0.0441	0.0441	0.0441
Adult	0.0181	0.0181	0.0181	0.0209	0.0209	0.0209
Age-Adjusted (kg-year/kg-day)	1.1277	1.1277	1.1277	0.4527	0.4527	0.4527
Milk Loss Factor (unitless)	0	0	0	0	0	0
Fraction absorbed in GI tract (unitless)	1.0	1.0	1.0	1.0	1.0	1.0
Exposure frequency (days/year)	350	350	350	350	350	350
*Exposure (dairy ing)-carcinogenic (kg/kg-day)	0.01545	0.01545	0.01545	0.00620	0.00620	0.00620
*Exposure (dairy ing)-noncarcinogenic (kg/kg-day) - child	0.06741	0.06741	0.06741	0.04229	0.04229	0.04229
*Exposure (dairy ing)-noncarcinogenic (kg/kg-day)-adult	0.01736	0.01736	0.01736	0.02004	0.02004	0.02004
CARCINOGENIC	**EPA RME Analysis**			**EPA CTE Analysis**		
Total Exposure, dairy ingestion (kg/kg-day)	1.5E-02	1.5E-02	1.5E-02	6.2E-03	6.2E-03	6.2E-03
Cancer Slope Factor (CSF) (mg/kg-day)$^{-1}$	2	2	2	1	1	1
Target Risk Level	1.0E-04	1.0E-05	1.0E-06	1.0E-04	1.0E-05	1.0E-06
Risk-based Media Concentration (mg/kg-wet weight)	**0.0032**	**0.00032**	**0.000032**	**0.016**	**0.0016**	**0.00016**
NONCARCINOGENIC	**Child**			**Child**		
Total Exposure, dairy ingestion (kg/kg-day)	6.7E-02			4.2E-02		
Reference Dose (RfD) (mg/kg-day)	2.00E-05			2.00E-05		
Target Hazard Index	1			1		
Risk-based Media Concentration (mg/kg-wet weight)	**0.00030**			**0.00047**		
NONCARCINOGENIC	**Adult**			**Adult**		
Total Exposure, dairy ingestion (kg/kg-day)	1.7E-02			2.0E-02		
Reference Dose (RfD) (mg/kg-day)	2.00E-05			2.00E-05		
Target Hazard Index	1			1		
Risk-based Media Concentration (mg/kg-wet weight)	**0.0012**			**0.0010**		

Attachment 22
Risk-based Media Concentrations for Ingestion of Beef Cow Tissue from Commercial Farms

A range of Risk-based Media Concentrations (RMCs) has been developed for PCBs based on potential consumption of beef cow tissue from commercial farms by adult farmers and children. Consistent with the approach used in EPA's HHRA, potential ingestion of beef cow tissue by adult farmers and children have been evaluated under reasonable maximum exposure (RME) and central tendency exposure (CTE) conditions. For each set of exposure conditions, RMCs have been calculated based on potential cancer risks (for children and adults combined) and potential non-cancer impacts (for children and adults separately), using the exposure assumptions and toxicity values used in the HHRA.

The tissue-specific RMCs based on the potential for carcinogenic effects from ingesting beef tissue from commercial farms were derived using the following general equation:

$$RMC_{cancer} = \frac{Risk * AT_c}{CSF * IR_{adj} * F_{GI} * EF * (1 - Loss_{cook}) * (1 - Loss_{post})}$$

Where:

RMC_{cancer}	=	RMC based on the cancer endpoint (mg/kg)
Risk	=	Target risk level (unitless)
AT_c	=	Averaging time for carcinogenic exposure (days)
CSF	=	Cancer slope factor $(mg/kg\text{-}day)^{-1}$
IR_{adj}[1]	=	Age-adjusted ingestion rate (kg-year/kg-day)
F_{GI}	=	Fraction absorbed in the GI tract (unitless)
EF	=	Exposure frequency (days/year)
$Loss_{cook}$	=	Beef cooking loss (unitless)
$Loss_{post}$	=	Beef post-cooking loss (unitless)

The tissue-specific RMCs based on potential non-carcinogenic effects from ingesting beef tissue from commercial farms were derived using the following equation:

$$RMC_{noncancer} = \frac{HI * RfD * AT_{nc}}{IR * F_{GI} * EF * ED * (1 - Loss_{cook}) * (1 - Loss_{post})}$$

Where:

$RMC_{noncancer}$	=	RMC based on the non-cancer endpoint (mg/kg)
HI	=	Target hazard index (unitless)
RfD	=	Reference dose (mg/kg-day)
AT_{nc}	=	Averaging time for non-carcinogenic exposure (days)
IR	=	Ingestion rate (kg/kg-day)

[1] The age-adjusted ingestion rate was derived using the following equation: (IRa*EDa)+(IRc*EDc), where IRa is the adult ingestion rate, EDa is the adult exposure duration, IRc is the child ingestion rate, and EDc is the child exposure duration.

F_{GI} = Fraction absorbed in the GI tract (unitless)
EF = Exposure frequency (days/year)
ED = Exposure duration (years)
$Loss_{cook}$ = Beef cooking loss (unitless)
$Loss_{post}$ = Beef post-cooking loss (unitless)

The specific exposure assumptions used for each age group in this analysis, and the basis of each, are summarized in Table 22a. In all cases, the assumptions and parameters used are the same as those used by EPA in its 2005 HHRA.

Standard upper-bound EPA toxicity values have been used for PCBs. These include a cancer slope factor (CSF) of 2 $(mg/kg\text{-}day)^{-1}$ for the RME scenarios and a CSF of 1 $(mg/kg\text{-}day)^{-1}$ for the CTE scenarios, and a chronic reference dose of 2E-05 for both the RME and CTE scenario. These values are published in EPA's IRIS database and were used in EPA's HHRA.

RMCs based on potential carcinogenic effects (for children and adults) have been developed for both the RME and CTE exposure scenarios using a range of target risks from one-in-a-million (1×10^{-6}) to one-in-ten thousand (1×10^{-4}). This risk range is consistent with EPA's acceptable risk range. RMCs for non-cancer effects have been developed for the RME and CTE scenarios for adults and children based on a target Hazard Index of 1.

Summary of Results

Estimated RMCs for cancer and non-cancer endpoints are presented in Table 22b and are summarized as follows.

	RME (mg/kg)				**CTE (mg/kg)**			
	Cancer Risk			**Non-cancer**	**Cancer Risk**			**Non-cancer**
	$1x10^{-6}$	**$1x10^{-5}$**	**$1x10^{-4}$**	**HI = 1**	**$1x10^{-6}$**	**$1x10^{-5}$**	**$1x10^{-4}$**	**HI = 1**
Child/Adult	0.00033	0.0033	0.033	NC	0.0015	0.015	0.15	NC
Child	NC	NC	NC	0.0077	NC	NC	NC	0.010
Adult	NC	NC	NC	0.014	NC	NC	NC	0.017

Table 22a. Summary of Pathway- and Age-Specific Exposure Assumptions Used in the Commercial Farm Beef Consumption Scenario

Parameters	Units	Symbol	RME	CTE	Basis
Common Parameters					
Exposure frequency	days/year	EF			
Adult Farmer			350	350	HHRA, Vol. V; Appendix D; Table 4-10. EPA Assumed.
Child			350	350	HHRA, Vol. V; Appendix D; Table 4-10. EPA Assumed.
Exposure duration	years	ED			
Adult Farmer			64	29	HHRA, Vol. V; Appendix D; Table 4-10. EPA Assumed.
Child			6	6	HHRA, Vol. V; Appendix D; Table 4-10. EPA Assumed (1-7 year old).
Averaging time (cancer endpoint)	days	ATc	25,550	25,550	HHRA, Vol. V; Appendix D; Table 4-10. Based on 70 years * 365 days/year
Averaging time (noncancer endpoint)	days	ATnc			
Adult Farmer			23,360	10,585	HHRA, Vol. V; Appendix D; Table 4-10. Based on ED * 365 days/year
Child			2,190	2,190	HHRA, Vol. V; Appendix D; Table 4-10. Based on ED * 365 days/year
Tissue Ingestion Pathway					
Beef Ingestion Rate	kg/kg-day	IR			
Adult Farmer			0.00265	0.00226	HHRA, Vol. V; Appendix D; Table 4-10. Based on EPA, 1997; Table 13-36 & Table 11-3
Child			0.00486	0.00372	HHRA, Vol. V; Appendix D; Table 4-10. Based on EPA, 1997; Table 13-36 & Table 11-3
Age-Adjusted	(kg-year/kg-day)	IR_{adj}	0.19876	0.08786	GE-derived value for aggregate risk RMC. Based on EPA ED and IR.
Beef cooking loss	unitless	$Loss_{cook}$	0.27	0.27	HHRA, Vol. V; Appendix D; Table 4-10.EPA, 1997; Table 13-5.
Beef post-cooking loss	unitless	$Loss_{post}$	0.24	0.24	HHRA, Vol. V; Appendix D; Table 4-10.EPA, 1997: Table 13-5.
Fraction absorbed in GI tract	unitless	F_{GI}	1.0	1.0	HHRA, Vol. V; Appendix D; Table 4-10. EPA Assumed.

EPA 1997. *Exposure Factors Handbook, Volume I; General Factors.*
EPA 2005. *Human Health Risk Assessment GE/Housatonic River Site Rest of River Volume V; Appendix D Agricultural Product Consumption Risk Assessment.*

Table 22b. RMCs for PCBs (mg/kg) in Beef Tissue for Target Risk Range and HI of 1
Commercial Farm

Parameter	EPA RME Analysis			EPA CTE Analysis		
Common Parameters						
Exposure duration (yrs)						
Child	6	6	6	6	6	6
Adult	64	64	64	29	29	29
Averaging time - noncarcinogenic (days)						
Child	2,190	2,190	2,190	2,190	2,190	2,190
Adult	23,360	23,360	23,360	10,585	10,585	10,585
Averaging time - carcinogenic (days)	25,550	25,550	25,550	25,550	25,550	25,550
Pathway Specific Parameters						
Beef Consumption						
Ingestion rate (kg/kg-day)						
Child	0.00486	0.00486	0.00486	0.00372	0.00372	0.00372
Adult	0.00265	0.00265	0.00265	0.00226	0.00226	0.00226
Age-Adjusted (kg-year/kg-day)	0.19876	0.19876	0.19876	0.0879	0.0879	0.0879
Beef cooking loss (unitless)	0.27	0.27	0.27	0.27	0.27	0.27
Beef post-cooking loss (unitless)	0.24	0.24	0.24	0.24	0.24	0.24
Fraction absorbed in GI tract (unitless)	1.0	1.0	1.0	1.0	1.0	1.0
Exposure frequency (days/year)	350	350	350	350	350	350
*Exposure (beef ing)-carcinogenic (kg/kg-day)	0.00151	0.00151	0.00151	0.00067	0.00067	0.00067
*Exposure (beef ing)-noncarcinogenic (kg/kg-day) - child	0.00259	0.00259	0.00259	0.00198	0.00198	0.00198
*Exposure (beef ing)-noncarcinogenic (kg/kg-day) - adult	0.00141	0.00141	0.00141	0.00120	0.00120	0.00120
CARCINOGENIC	**EPA RME Analysis**			**EPA CTE Analysis**		
Total Exposure, beef ingestion (kg/kg-day)	1.5E-03	1.5E-03	1.5E-03	6.7E-04	6.7E-04	6.7E-04
Cancer Slope Factor (CSF) (mg/kg-day)$^{-1}$	2	2	2	1	1	1
Target Risk Level	1.0E-04	1.0E-05	1.0E-06	1.0E-04	1.0E-05	1.0E-06
Risk-based Media Concentration (mg/kg-wet weight)	**0.033**	**0.0033**	**0.00033**	**0.15**	**0.015**	**0.0015**
NONCARCINOGENIC	**Child**			**Child**		
Total Exposure, beef ingestion (kg/kg-day)	2.6E-03			2.0E-03		
Reference Dose (RfD) (mg/kg-day)	2.00E-05			2.00E-05		
Target Hazard Index	1			1		
Risk-based Media Concentration (mg/kg-wet weight)	**0.0077**			**0.010**		
NONCARCINOGENIC	**Adult**			**Adult**		
Total Exposure, beef ingestion (kg/kg-day)	1.4E-03			1.2E-03		
Reference Dose (RfD) (mg/kg-day)	2.00E-05			2.00E-05		
Target Hazard Index	1			1		
Risk-based Media Concentration (mg/kg-wet weight)	**0.014**			**0.017**		

Attachment 23
Risk-based Media Concentrations for Ingestion of Beef Cow Tissue from Backyard Beef Farms

A range of Risk-based Media Concentrations (RMCs) has been developed for PCBs based on potential consumption of beef cow tissue from backyard farms by adult residents and children. Consistent with the approach used in EPA's HHRA, potential ingestion of beef cow tissue by adult residents and children have been evaluated under reasonable maximum exposure (RME) and central tendency exposure (CTE) conditions. For each set of exposure conditions, RMCs have been calculated based on potential cancer risks (for children and adults combined) and potential non-cancer impacts (for children and adults separately), using the exposure assumptions and toxicity values used in the HHRA.

The tissue-specific RMCs based on the potential for carcinogenic effects from ingesting beef tissue from backyard farms were derived using the following general equation:

$$RMC_{cancer} = \frac{Risk * AT_c}{CSF * IR_{adj} * F_{GI} * EF * (1 - Loss_{cook}) * (1 - Loss_{post})}$$

Where:

RMC_{cancer}	=	RMC based on the cancer endpoint (mg/kg)
Risk	=	Target risk level (unitless)
AT_c	=	Averaging time for carcinogenic exposure (days)
CSF	=	Cancer slope factor $(mg/kg\text{-}day)^{-1}$
IR_{adj}[1]	=	Age-adjusted ingestion rate (kg-year/kg-day)
F_{GI}	=	Fraction absorbed in the GI tract (unitless)
EF	=	Exposure frequency (days/year)
$Loss_{cook}$	=	Beef cooking loss (unitless)
$Loss_{post}$	=	Beef post-cooking loss (unitless)

The tissue-specific RMCs based on potential non-carcinogenic effects from ingesting beef tissue from backyard farms were derived using the following equation:

$$RMC_{noncancer} = \frac{HI * RfD * AT_{nc}}{IR * F_{GI} * EF * ED * (1 - Loss_{cook}) * (1 - Loss_{post})}$$

Where:

$RMC_{noncancer}$	=	RMC based on the non-cancer endpoint (mg/kg)
HI	=	Target hazard index (unitless)
RfD	=	Reference dose (mg/kg-day)
AT_{nc}	=	Averaging time for non-carcinogenic exposure (days)

[1] The age-adjusted ingestion rate was derived using the following equation: (IRa*EDa)+(IRc*EDc), where IRa is the adult ingestion rate, EDa is the adult exposure duration, IRc is the child ingestion rate, and EDc is the child exposure duration.

IR	=	Ingestion rate (kg/kg-day)
F_{GI}	=	Fraction absorbed in the GI tract (unitless)
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)
$Loss_{cook}$	=	Beef cooking loss (unitless)
$Loss_{post}$	=	Beef post-cooking loss (unitless)

The specific exposure assumptions used for each age group in this analysis, and the basis of each, are summarized in Table 23a. In all cases, the assumptions and parameters used are the same as those used by EPA in its 2005 HHRA.

Standard upper-bound EPA toxicity values have been used for PCBs. These include a cancer slope factor (CSF) of 2 $(mg/kg\text{-}day)^{-1}$ for the RME scenarios and a CSF of 1 $(mg/kg\text{-}day)^{-1}$ for the CTE scenarios, and a chronic reference dose of 2E-05 for both the RME and CTE scenario. These values are published in EPA's IRIS database and were used in EPA's HHRA.

RMCs based on potential carcinogenic effects (for children and adults combined) have been developed for both the RME and CTE exposure scenarios using a range of target risks from one-in-a-million (1×10^{-6}) to one-in-ten thousand (1×10^{-4}). This risk range is consistent with EPA's acceptable risk range. RMCs for non-cancer effects have been developed for the RME and CTE scenarios for adults and young children based on a target Hazard Index of 1.

Summary of Results

Estimated RMCs for cancer and non-cancer endpoints are presented in Table 23b and are summarized as follows.

	RME (mg/kg)				**CTE (mg/kg)**			
	Cancer Risk			**Non-cancer**	**Cancer Risk**			**Non-cancer**
	$1x10^{-6}$	**$1x10^{-5}$**	**$1x10^{-4}$**	**HI = 1**	**$1x10^{-6}$**	**$1x10^{-5}$**	**$1x10^{-4}$**	**HI = 1**
Child/Adult	0.00047	0.0047	0.047	NC	0.0027	0.027	0.27	NC
Child	NC	NC	NC	0.0077	NC	NC	NC	0.010
Adult	NC	NC	NC	0.013	NC	NC	NC	0.013

Table 23a. Summary of Pathway- and Age-Specific Exposure Assumptions Used in the Backyard Farm Beef Consumption Scenario

Parameters	Units	Symbol	RME	CTE	Basis
Common Parameters					
Exposure frequency	days/year	EF			
Adult Resident			350	350	HHRA, Vol. V; Appendix D; Table 4-10. EPA Assumed.
Child			350	350	HHRA, Vol. V; Appendix D; Table 4-10. EPA Assumed.
Exposure duration	years	ED			
Adult Resident			39	9	HHRA, Vol. V; Appendix D; Table 4-10. Based on MDPH 2001a
Child			6	6	HHRA, Vol. V; Appendix D; Table 4-10. EPA Assumed (1-7 year old).
Averaging time (cancer endpoint)	days	ATc	25,550	25,550	HHRA, Vol. V; Appendix D; Table 4-10. Based on 70 years * 365 days/year
Averaging time (noncancer endpoint)	days	ATnc			
Adult Resident			14,235	3,285	HHRA, Vol. V; Appendix D; Table 4-10. Based on ED * 365 days/year
Child			2,190	2,190	HHRA, Vol. V; Appendix D; Table 4-10. Based on ED * 365 days/year
Tissue Ingestion Pathway					
Beef Ingestion Rate	kg/kg-day	IR			
Adult Resident			0.00283	0.00286	HHRA, Vol. V; Appendix D; Table 4-10. Based on EPA, 1997; Table 13-36 & Table 11-3
Child			0.00486	0.00372	HHRA, Vol. V; Appendix D; Table 4-10. Based on EPA, 1997; Table 13-36 & Table 11-3
Age-Adjusted	(kg-year/kg-day)	IR_{adj}	0.13953	0.04806	GE-derived value for aggregate risk RMC. Based on EPA ED and IR.
Beef cooking loss	unitless	$Loss_{cook}$	0.27	0.27	HHRA, Vol. V; Appendix D; Table 4-10.EPA, 1997; Table 13-5.
Beef post-cooking loss	unitless	$Loss_{post}$	0.24	0.24	HHRA, Vol. V; Appendix D; Table 4-10.EPA, 1997: Table 13-5.
Fraction absorbed in GI tract	unitless	F_{GI}	1.0	1.0	HHRA, Vol. V; Appendix D; Table 4-10. EPA Assumed.

EPA 1997. *Exposure Factors Handbook, Volume I; General Factors.*
EPA 2005. *Human Health Risk Assessment GE/Housatonic River Site Rest of River Volume V; Appendix D Agricultural Product Consumption Risk Assessment.*

Table 23b. RMCs for PCBs (mg/kg) in Beef Tissue for Target Risk Range and HI of 1
Backyard Farm

Parameter	EPA RME Analysis			EPA CTE Analysis		
Common Parameters						
Exposure duration (yrs)						
Child	6	6	6	6	6	6
Adult	39	39	39	9	9	9
Averaging time - noncarcinogenic (days)						
Child	2,190	2,190	2,190	2,190	2,190	2,190
Adult	14,235	14,235	14,235	3,285	3,285	3,285
Averaging time - carcinogenic (days)	25,550	25,550	25,550	25,550	25,550	25,550
Pathway Specific Parameters						
Beef Consumption						
Ingestion rate (kg/kg-day)						
Child	0.00486	0.00486	0.00486	0.00372	0.00372	0.00372
Adult	0.00283	0.00283	0.00283	0.00286	0.00286	0.00286
Age-Adjusted (kg-year/kg-day)	0.13953	0.13953	0.13953	0.04806	0.04806	0.04806
Beef cooking loss (unitless)	0.27	0.27	0.27	0.27	0.27	0.27
Beef post-cooking loss (unitless)	0.24	0.24	0.24	0.24	0.24	0.24
Fraction absorbed in GI tract (unitless)	1.0	1.0	1.0	1.0	1.0	1.0
Exposure frequency (days/year)	350	350	350	350	350	350
*Exposure (beef ing)-carcinogenic (kg/kg-day)	0.00106	0.00106	0.00106	0.00037	0.00037	0.00037
*Exposure (beef ing)-noncarcinogenic (kg/kg-day) - child	0.00259	0.00259	0.00259	0.00198	0.00198	0.00198
*Exposure (beef ing)-noncarcinogenic (kg/kg-day) -adult	0.00151	0.00151	0.00151	0.00152	0.00152	0.00152
CARCINOGENIC	**EPA RME Analysis**			**EPA CTE Analysis**		
Total Exposure, beef ingestion (kg/kg-day)	1.1E-03	1.1E-03	1.1E-03	3.7E-04	3.7E-04	3.7E-04
Cancer Slope Factor (CSF) $(mg/kg\text{-}day)^{-1}$	2	2	2	1	1	1
Target Risk Level	1.0E-04	1.0E-05	1.0E-06	1.0E-04	1.0E-05	1.0E-06
Risk-based Media Concentration (mg/kg-wet weight)	**0.047**	**0.0047**	**0.00047**	**0.27**	**0.027**	**0.0027**
NONCARCINOGENIC	**Child**			**Child**		
Total Exposure, beef ingestion (kg/kg-day)	2.6E-03			2.0E-03		
Reference Dose (RfD) (mg/kg-day)	2.00E-05			2.00E-05		
Target Hazard Index	1			1		
Risk-based Media Concentration (mg/kg-wet weight)	**0.0077**			**0.010**		
NONCARCINOGENIC	**Adult**			**Adult**		
Total Exposure, beef ingestion (kg/kg-day)	1.5E-03			1.5E-03		
Reference Dose (RfD) (mg/kg-day)	2.00E-05			2.00E-05		
Target Hazard Index	1			1		
Risk-based Media Concentration (mg/kg-wet weight)	**0.013**			**0.013**		

Attachment 24
Risk-based Media Concentrations for Ingestion of Poultry Meat from Commercial Farms

A range of Risk-based Media Concentrations (RMCs) has been developed for PCBs based on potential consumption of poultry meat from commercial farms by adult farmers and children. Consistent with the approach used in EPA's HHRA, potential ingestion of poultry meat by adult farmers and children have been evaluated under reasonable maximum exposure (RME) and central tendency exposure (CTE) conditions. For each set of exposure conditions, RMCs have been calculated based on potential cancer risks (for children and adults combined) and potential non-cancer impacts (for children and adults separately), using the exposure assumptions and toxicity values used in the HHRA.

The tissue-specific RMCs based on the potential for carcinogenic effects from ingesting poultry meat from commercial farms were derived using the following general equation:

$$RMC_{cancer} = \frac{Risk * AT_c}{CSF * IR_{adj} * F_{GI} * EF * (1 - Loss_{cook}) * (1 - Loss_{post})}$$

Where:

RMC_{cancer}	=	RMC based on the cancer endpoint (mg/kg)
Risk	=	Target risk level (unitless)
AT_c	=	Averaging time for carcinogenic exposure (days)
CSF	=	Cancer slope factor $(mg/kg\text{-}day)^{-1}$
IR_{adj}[1]	=	Age-adjusted ingestion rate (kg-year/kg-day)
F_{GI}	=	Fraction absorbed in the GI tract (unitless)
EF	=	Exposure frequency (days/year)
$Loss_{cook}$	=	Poultry cooking loss (unitless)
$Loss_{post}$	=	Poultry post-cooking loss (unitless)

The tissue-specific RMCs based on potential non-carcinogenic effects from ingesting poultry meat from commercial farms were derived using the following equation:

$$RMC_{noncancer} = \frac{HI * RfD * AT_{nc}}{IR * F_{GI} * EF * ED * (1 - Loss_{cook}) * (1 - Loss_{post})}$$

Where:

$RMC_{noncancer}$	=	RMC based on the non-cancer endpoint (mg/kg)
HI	=	Target hazard index (unitless)
RfD	=	Reference dose (mg/kg-day)

[1] The age-adjusted ingestion rate was derived using the following equation: (IRa*EDa)+(IRc*EDc), where IRa is the adult ingestion rate, EDa is the adult exposure duration, IRc is the child ingestion rate, and EDc is the child exposure duration.

AT_{nc} = Averaging time for non-carcinogenic exposure (days)
IR = Ingestion rate (kg/kg-day)
F_{GI} = Fraction absorbed in the GI tract (unitless)
EF = Exposure frequency (days/year)
ED = Exposure duration (years)
$Loss_{cook}$ = Poultry cooking loss (unitless)
$Loss_{post}$ = Poultry post-cooking loss (unitless)

The specific exposure assumptions used for each age group in this analysis, and the basis of each, are summarized in Table 24a. In all cases, the assumptions and parameters used are the same as those used by EPA in its 2005 HHRA.

Standard upper-bound EPA toxicity values have been used for PCBs. These include a cancer slope factor (CSF) of 2 $(mg/kg\text{-}day)^{-1}$ for the RME scenario and a CSF of 1 $(mg/kg\text{-}day)^{-1}$ for the CTE scenario, and a chronic reference dose of 2E-05 for both the RME and CTE scenario. These values are published in EPA's IRIS database and were used in EPA's HHRA.

RMCs based on potential carcinogenic effects (for children and adults combined) have been developed for both the RME and CTE exposure scenarios using a range of target risks from one-in-a-million (1×10^{-6}) to one-in-ten thousand (1×10^{-4}). This risk range is consistent with EPA's acceptable risk range. RMCs for non-cancer effects have been developed for the RME and CTE scenarios for adults and young children separately, based on a target Hazard Index of 1.

Summary of Results

Estimated RMCs for cancer and non-cancer endpoints are presented in Table 24b and are summarized as follows.

	RME (mg/kg)				**CTE (mg/kg)**			
	Cancer Risk			**Non-cancer**	**Cancer Risk**			**Non-cancer**
	$1x10^{-6}$	**$1x10^{-5}$**	**$1x10^{-4}$**	**HI = 1**	**$1x10^{-6}$**	**$1x10^{-5}$**	**$1x10^{-4}$**	**HI = 1**
Child/Adult	0.00052	0.0052	0.052	NC	0.0030	0.030	0.30	NC
Child	NC	NC	NC	0.015	NC	NC	NC	0.019
Adult	NC	NC	NC	0.021	NC	NC	NC	0.034

Table 24a. Summary of Pathway- and Age-Specific Exposure Assumptions Used in the Commercial Farm Poultry Meat Consumption Scenario

Parameters	Units	Symbol	RME	CTE	Basis
Common Parameters					
Exposure frequency	days/year	EF			
Adult Farmer			350	350	HHRA, Vol. V; Appendix D; Table 4-10. EPA Assumed.
Child			350	350	HHRA, Vol. V; Appendix D; Table 4-10. EPA Assumed.
Exposure duration	years	ED			
Adult Farmer			64	29	HHRA, Vol. V; Appendix D; Table 4-10. EPA Assumed.
Child			6	6	HHRA, Vol. V; Appendix D; Table 4-10. EPA Assumed (1-7 year old).
Averaging time (cancer endpoint)	days	ATc	25,550	25,550	HHRA, Vol. V; Appendix D; Table 4-10. Based on 70 years * 365 days/year
Averaging time (noncancer endpoint)	days	ATnc			
Adult Farmer			23,360	10,585	HHRA, Vol. V; Appendix D; Table 4-10. Based on ED * 365 days/year
Child			2,190	2,190	HHRA, Vol. V; Appendix D; Table 4-10. Based on ED * 365 days/year
Tissue Ingestion Pathway					
Poultry Ingestion Rate	kg/kg-day	IR			
Adult Farmer			0.00208	0.00132	HHRA, Vol. V; Appendix D; Table 4-10. Based on EPA, 1997; Table 13-55 & Table 11-5
Child			0.00288	0.00235	HHRA, Vol. V; Appendix D; Table 4-10. Based on EPA, 1997; Table 13-55 & Table 11-5
Age-Adjusted	(kg-year/kg-day)	IR_{adj}	0.1504	0.05238	GE-derived value for aggregate risk RMC. Based on EPA ED and IR.
Poultry cooking loss	unitless	$Loss_{cook}$	0.32	0.32	HHRA, Vol. V; Appendix D; Table 4-10.EPA, 1997; Table 13-5.
Poultry post-cooking loss	unitless	$Loss_{post}$	0.31	0.31	HHRA, Vol. V; Appendix D; Table 4-10.EPA, 1997; Table 13-5.
Fraction absorbed in GI tract	unitless	F_{GI}	1.0	1.0	HHRA, Vol. V; Appendix D; Table 4-10. EPA Assumed.

EPA 1997. *Exposure Factors Handbook, Volume I; General Factors.*
EPA 2005. *Human Health Risk Assessment GE/Housatonic River Site Rest of River Volume V; Appendix D Agricultural Product Consumption Risk Assessment.*

Table 24b. RMCs for PCBs (mg/kg) in Poultry Meat for Target Risk Range and HI of 1
Commercial Farm

Parameter	EPA RME Analysis			EPA CTE Analysis		
Common Parameters						
Exposure duration (yrs)						
Child	6	6	6	6	6	6
Adult	64	64	64	29	29	29
Averaging time - noncarcinogenic (days)						
Child	2,190	2,190	2,190	2,190	2,190	2,190
Adult	23,360	23,360	23,360	10,585	10,585	10,585
Averaging time - carcinogenic (days)	25,550	25,550	25,550	25,550	25,550	25,550
Pathway Specific Parameters						
Poultry Consumption						
Ingestion rate (kg/kg-day)						
Child	0.00288	0.00288	0.00288	0.00235	0.00235	0.00235
Adult	0.00208	0.00208	0.00208	0.00132	0.00132	0.00132
Age-Adjusted (kg-year/kg-day)	0.1504	0.1504	0.1504	0.05238	0.05238	0.05238
Poultry cooking loss (unitless)	0.32	0.32	0.32	0.32	0.32	0.32
Poultry post-cooking loss (unitless)	0.31	0.31	0.31	0.31	0.31	0.31
Fraction absorbed in GI tract (unitless)	1.0	1.0	1.0	1.0	1.0	1.0
Exposure frequency (days/year)	350	350	350	350	350	350
*Exposure (poultry ing)-carcinogenic (kg/kg-day)	0.00097	0.00097	0.00097	0.00034	0.00034	0.00034
*Exposure (poultry ing)-noncarcinogenic (kg/kg-day) - child	0.00130	0.00130	0.00130	0.00106	0.00106	0.00106
*Exposure (poultry ing)-noncarcinogenic (kg/kg-day) - adult	0.00094	0.00094	0.00094	0.00059	0.00059	0.00059
CARCINOGENIC	**EPA RME Analysis**			**EPA CTE Analysis**		
Total Exposure, poultry ingestion (kg/kg-day)	9.7E-04	9.7E-04	9.7E-04	3.4E-04	3.4E-04	3.4E-04
Cancer Slope Factor (CSF) (mg/kg-day)$^{-1}$	2	2	2	1	1	1
Target Risk Level	1.0E-04	1.0E-05	1.0E-06	1.0E-04	1.0E-05	1.0E-06
Risk-based Media Concentration (mg/kg-wet weight)	**0.052**	**0.0052**	**0.00052**	**0.30**	**0.030**	**0.0030**
NONCARCINOGENIC	**Child**			**Child**		
Total Exposure, poultry ingestion (kg/kg-day)	1.3E-03			1.1E-03		
Reference Dose (RfD) (mg/kg-day)	2.00E-05			2.00E-05		
Target Hazard Index	1			1		
Risk-based Media Concentration (mg/kg-wet weight)	**0.015**			**0.019**		
NONCARCINOGENIC	**Adult**			**Adult**		
Total Exposure, poultry ingestion (kg/kg-day)	9.4E-04			5.9E-04		
Reference Dose (RfD) (mg/kg-day)	2.00E-05			2.00E-05		
Target Hazard Index	1			1		
Risk-based Media Concentration (mg/kg-weight)	**0.021**			**0.034**		

Attachment 25
Risk-based Media Concentrations for Ingestion of Poultry Meat from Backyard Farms

A range of Risk-based Media Concentrations (RMCs) has been developed for PCBs based on potential consumption of poultry meat from backyard farms by adult residents and children. Consistent with the approach used in EPA's HHRA, potential ingestion of poultry meat by adult residents and children have been evaluated under reasonable maximum exposure (RME) and central tendency exposure (CTE) conditions. For each set of exposure conditions, RMCs have been calculated based on potential cancer risks (for children and adults combined) and potential non-cancer impacts (for children and adults separately), using the exposure assumptions and toxicity values used in the HHRA.

The tissue-specific RMCs based on the potential for carcinogenic effects from ingesting poultry meat from backyard farms were derived using the following general equation:

$$RMC_{cancer} = \frac{Risk * AT_c}{CSF * IR_{adj} * F_{GI} * EF * (1 - Loss_{cook}) * (1 - Loss_{post})}$$

Where:

RMC_{cancer}	=	RMC based on the cancer endpoint (mg/kg)
Risk	=	Target risk level (unitless)
AT_c	=	Averaging time for carcinogenic exposure (days)
CSF	=	Cancer slope factor $(mg/kg\text{-}day)^{-1}$
IR_{adj}[1]	=	Age-adjusted ingestion rate (kg-year/kg-day)
F_{GI}	=	Fraction absorbed in the GI tract (unitless)
EF	=	Exposure frequency (days/year)
$Loss_{cook}$	=	Poultry cooking loss (unitless)
$Loss_{post}$	=	Poultry post-cooking loss (unitless)

The tissue-specific RMCs based on potential non-carcinogenic effects from ingesting poultry meat from backyard farms were derived using the following equation:

$$RMC_{noncancer} = \frac{HI * RfD * AT_{nc}}{IR * F_{GI} * EF * ED * (1 - Loss_{cook}) * (1 - Loss_{post})}$$

Where:

$RMC_{noncancer}$	=	RMC based on the non-cancer endpoint (mg/kg)
HI	=	Target hazard index (unitless)
RfD	=	Reference dose (mg/kg-day)

[1] The age-adjusted ingestion rate was derived using the following equation: (IRa*EDa)+(IRc*EDc), where IRa is the adult ingestion rate, EDa is the adult exposure duration, IRc is the child ingestion rate, and EDc is the child exposure duration.

AT_{nc}	=	Averaging time for non-carcinogenic exposure (days)
IR	=	Ingestion rate (kg/kg-day)
F_{GI}	=	Fraction absorbed in the GI tract (unitless)
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)
$Loss_{cook}$	=	Poultry cooking loss (unitless)
$Loss_{post}$	=	Poultry post-cooking loss (unitless)

The specific exposure assumptions used for each age group in this analysis, and the basis of each, are summarized in Table 25a. In all cases, the assumptions and parameters used are the same as those used by EPA in its 2005 HHRA.

Standard upper-bound EPA toxicity values have been used for PCBs. These include a cancer slope factor (CSF) of 2 $(mg/kg\text{-}day)^{-1}$ for the RME scenarios and a CSF of 1 $(mg/kg\text{-}day)^{-1}$ for the CTE scenarios, and a chronic reference dose of 2E-05 for both the RME and CTE scenario. These values are published in EPA's IRIS database and were used in EPA's HHRA.

RMCs based on potential carcinogenic effects (for children and adults combined) have been developed for both the RME and CTE exposure scenarios using a range of target risks from one-in-a-million (1×10^{-6}) to one-in-ten thousand (1×10^{-4}). This risk range is consistent with EPA's acceptable risk range. RMCs for non-cancer effects have been developed for the RME and CTE scenarios for adults and young children based on a target Hazard Index of 1.

Summary of Results

Estimated RMCs for cancer and non-cancer endpoints are presented in Table 25b and are summarized as follows.

	RME (mg/kg)				**CTE (mg/kg)**			
	Cancer Risk			**Non-cancer**	**Cancer Risk**			**Non-cancer**
	$1x10^{-6}$	**$1x10^{-5}$**	**$1x10^{-4}$**	**HI = 1**	**$1x10^{-6}$**	**$1x10^{-5}$**	**$1x10^{-4}$**	**HI = 1**
Child/Adult	0.0009	0.009	0.09	NC	0.0054	0.054	0.54	NC
Child	NC	NC	NC	0.015	NC	NC	NC	0.019
Adult	NC	NC	NC	0.026	NC	NC	NC	0.027

Table 25a. Summary of Pathway- and Age-Specific Exposure Assumptions Used in the Backyard Farm Poultry Meat Consumption Scenario

Parameters	Units	Symbol	RME	CTE	Basis
Common Parameters					
Exposure frequency	days/year	EF			
Adult Resident			350	350	HHRA, Vol. V; Appendix D; Table 4-10. EPA Assumed.
Child			350	350	HHRA, Vol. V; Appendix D; Table 4-10. EPA Assumed.
Exposure duration	years	ED			
Adult Resident			39	9	HHRA, Vol. V; Appendix D; Table 4-10. Based on MDPH 2001a
Child			6	6	HHRA, Vol. V; Appendix D; Table 4-10. EPA Assumed (1-7 year old).
Averaging time (cancer endpoint)	days	ATc	25,550	25,550	HHRA, Vol. V; Appendix D; Table 4-10. Based on 70 years * 365 days/year
Averaging time (noncancer endpoint)	days	ATnc			
Adult Resident			14,235	3,285	HHRA, Vol. V; Appendix D; Table 4-10. Based on ED * 365 days/year
Child			2,190	2,190	HHRA, Vol. V; Appendix D; Table 4-10. Based on ED * 365 days/year
Tissue Ingestion Pathway					
Poultry Ingestion Rate	kg/kg-day	IR			
Adult Resident			0.00173	0.00162	HHRA, Vol. V; Appendix D; Table 4-10. Based on EPA, 1997; Table 13-55 & Table 11-5
Child			0.00288	0.00235	HHRA, Vol. V; Appendix D; Table 4-10. Based on EPA, 1997; Table 13-55 & Table 11-5
Age-Adjusted	(kg-year/kg-day)	IR_{adj}	0.08475	0.02868	GE-derived value for aggregate risk RMC. Based on EPA ED and IR.
Poultry cooking loss	unitless	$Loss_{cook}$	0.32	0.32	HHRA, Vol. V; Appendix D; Table 4-10.EPA, 1997; Table 13-5.
Poultry post-cooking loss	unitless	$Loss_{post}$	0.31	0.31	HHRA, Vol. V; Appendix D; Table 4-10.EPA, 1997; Table 13-5.
Fraction absorbed in GI tract	unitless	F_{GI}	1.0	1.0	HHRA, Vol. V; Appendix D; Table 4-10. EPA Assumed.

EPA 1997. *Exposure Factors Handbook, Volume I; General Factors.*
EPA 2005. *Human Health Risk Assessment GE/Housatonic River Site Rest of River Volume V; Appendix D Agricultural Product Consumption Risk Assessment.*

Table 25b. RMCs for PCBs (mg/kg) in Poultry Meat for Target Risk Range and HI of 1
Backyard Farm

Parameter	EPA RME Analysis			EPA CTE Analysis		
Common Parameters						
Exposure duration (yrs)						
Child	6	6	6	6	6	6
Adult	39	39	39	9	9	9
Averaging time - noncarcinogenic (days)						
Child	2,190	2,190	2,190	2,190	2,190	2,190
Adult	14,235	14,235	14,235	3,285	3,285	3,285
Averaging time - carcinogenic (days)	25,550	25,550	25,550	25,550	25,550	25,550
Pathway Specific Parameters						
Poultry Consumption						
Ingestion rate (kg/kg-day)						
Child	0.00288	0.00288	0.00288	0.00235	0.00235	0.00235
Adult	0.00173	0.00173	0.00173	0.00162	0.00162	0.00162
Age-Adjusted (kg-year/kg-day)	0.08475	0.08475	0.08475	0.02868	0.02868	0.02868
Poultry cooking loss (unitless)	0.32	0.32	0.32	0.32	0.32	0.32
Poultry post-cooking loss (unitless)	0.31	0.31	0.31	0.31	0.31	0.31
Fraction absorbed in GI tract (unitless)	1.0	1.0	1.0	1.0	1.0	1.0
Exposure frequency (days/year)	350	350	350	350	350	350
*Exposure (poultry ing)-carcinogenic (kg/kg-day)	0.00054	0.00054	0.00054	0.00018	0.00018	0.00018
*Exposure (poultry ing)-noncarcinogenic (kg/kg-day) - child	0.00130	0.00130	0.00130	0.00106	0.00106	0.00106
*Exposure (poultry ing)-noncarcinogenic (kg/kg-day) -adult	0.00078	0.00078	0.00078	0.00073	0.00073	0.00073
CARCINOGENIC	**EPA RME Analysis**			**EPA CTE Analysis**		
Total Exposure, poultry ingestion (kg/kg-day)	5.4E-04	5.4E-04	5.4E-04	1.8E-04	1.8E-04	1.8E-04
Cancer Slope Factor (CSF) (mg/kg-day)$^{-1}$	2	2	2	1	1	1
Target Risk Level	1.0E-04	1.0E-05	1.0E-06	1.0E-04	1.0E-05	1.0E-06
Risk-based Media Concentration (mg/kg-wet weight)	**0.09**	**0.009**	**0.0009**	**0.54**	**0.054**	**0.0054**
NONCARCINOGENIC	**Child**			**Child**		
Total Exposure, poultry ingestion (kg/kg-day)	1.3E-03			1.1E-03		
Reference Dose (RfD) (mg/kg-day)	2.00E-05			2.00E-05		
Target Hazard Index	1			1		
Risk-based Media Concentration (mg/kg-wet weight)	**0.015**			**0.019**		
NONCARCINOGENIC	**Adult**			**Adult**		
Total Exposure, poultry ingestion (kg/kg-day)	7.8E-04			7.3E-04		
Reference Dose (RfD) (mg/kg-day)	2.00E-05			2.00E-05		
Target Hazard Index	1			1		
Risk-based Media Concentration (mg/kg-wet weight)	**0.026**			**0.027**		

Attachment 26
Risk-based Media Concentrations for Ingestion of Poultry Eggs from Commercial Farms

A range of Risk-based Media Concentrations (RMCs) has been developed for PCBs based on potential consumption of eggs from commercial farms by adult farmers and children. Consistent with the approach used in EPA's HHRA, potential ingestion of eggs by adult farmers and children have been evaluated under reasonable maximum exposure (RME) and central tendency exposure (CTE) conditions. For each set of exposure conditions, RMCs have been calculated based on potential cancer risks (for children and adults combined) and potential non-cancer impacts (for children and adults separately), using the exposure assumptions and toxicity values used in the HHRA.

The tissue-specific RMCs based on the potential for carcinogenic effects from ingesting poultry eggs from commercial farms were derived using the following general equation:

$$RMC_{cancer} = \frac{Risk * AT_c}{CSF * IR_{adj} * F_{GI} * EF * (1 - Loss_{cook})}$$

Where:

RMC_{cancer}	=	RMC based on the cancer endpoint (mg/kg)
Risk	=	Target risk level (unitless)
AT_c	=	Averaging time for carcinogenic exposure (days)
CSF	=	Cancer slope factor $(mg/kg\text{-}day)^{-1}$
IR_{adj}[1]	=	Age-adjusted ingestion rate (kg-year/kg-day)
F_{GI}	=	Fraction absorbed in the GI tract (unitless)
EF	=	Exposure frequency (days/year)
$Loss_{cook}$	=	Cooking loss (Egg loss factor) (unitless)

The tissue-specific RMCs based on potential non-carcinogenic effects from ingesting poultry eggs from commercial farms were derived using the following equation:

$$RMC_{noncancer} = \frac{HI * RfD * AT_{nc}}{IR * F_{GI} * EF * ED * (1 - Loss_{cook})}$$

Where:

$RMC_{noncancer}$	=	RMC based on the non-cancer endpoint (mg/kg)
HI	=	Target hazard index (unitless)
RfD	=	Reference dose (mg/kg-day)
AT_{nc}	=	Averaging time for non-carcinogenic exposure (days)
IR	=	Ingestion rate (kg/kg-day)
F_{GI}	=	Fraction absorbed in the GI tract (unitless)

[1] The age-adjusted ingestion rate was derived using the following equation: (IRa*EDa)+(IRc*EDc), where IRa is the adult ingestion rate, EDa is the adult exposure duration, IRc is the child ingestion rate, and EDc is the child exposure duration.

EF = Exposure frequency (days/year)
ED = Exposure duration (years)
$Loss_{cook}$ = Cooking loss (Egg loss factor) (unitless)

The specific exposure assumptions used for each age group in this analysis, and the basis of each, are summarized in Table 26a. In all cases, the assumptions and parameters used are the same as those used by EPA in its 2005 HHRA.

Standard upper-bound EPA toxicity values have been used for PCBs. These include a cancer slope factor (CSF) of 2 $(mg/kg\text{-}day)^{-1}$ for the RME scenarios and a CSF of 1 $(mg/kg\text{-}day)^{-1}$ for the CTE scenarios, and a chronic reference dose of 2E-05 for both the RME and CTE scenario. These values are published in EPA's IRIS database and were used in EPA's HHRA.

RMCs based on potential carcinogenic effects (for children and adults combined) have been developed for both the RME and CTE exposure scenarios using a range of target risks from one-in-a-million (1×10^{-6}) to one-in-ten thousand (1×10^{-4}). This risk range is consistent with EPA's acceptable risk range. RMCs for non-cancer effects have been developed for the RME and CTE scenarios based on a target Hazard Index of 1.

Summary of Results

Estimated RMCs for cancer and non-cancer endpoints are presented in Table 26b and are summarized as follows.

	RME (mg/kg)				**CTE (mg/kg)**			
	Cancer Risk			**Non-cancer**	**Cancer Risk**			**Non-cancer**
	$1x10^{-6}$	**$1x10^{-5}$**	**$1x10^{-4}$**	**HI = 1**	**$1x10^{-6}$**	**$1x10^{-5}$**	**$1x10^{-4}$**	**HI = 1**
Child/Adult	0.00055	0.0055	0.055	NC	0.0025	0.025	0.25	NC
Child	NC	NC	NC	0.011	NC	NC	NC	0.013
Adult	NC	NC	NC	0.025	NC	NC	NC	0.031

Table 26a. Summary of Pathway- and Age-Specific Exposure Assumptions Used in the Commercial Farm Egg Consumption Scenario

Parameters	Units	Symbol	RME	CTE	Basis
Common Parameters					
Exposure frequency	days/year	EF			
Adult Farmer			350	350	HHRA, Vol. V; Appendix D; Table 4-10. EPA Assumed.
Child			350	350	HHRA, Vol. V; Appendix D; Table 4-10. EPA Assumed.
Exposure duration	years	ED			
Adult Farmer			64	29	HHRA, Vol. V; Appendix D; Table 4-10. EPA Assumed.
Child			6	6	HHRA, Vol. V; Appendix D; Table 4-10. EPA Assumed (1-7 year old).
Averaging time (cancer endpoint)	days	ATc	25,550	25,550	HHRA, Vol. V; Appendix D; Table 4-10. Based on 70 years * 365 days/year
Averaging time (noncancer endpoint)	days	ATnc			
Adult Farmer			23,360	10,585	HHRA, Vol. V; Appendix D; Table 4-10. Based on ED * 365 days/year
Child			2,190	2,190	HHRA, Vol. V; Appendix D; Table 4-10. Based on ED * 365 days/year
Tissue Ingestion Pathway					
Egg Ingestion Rate	kg/kg-day	IR			
Adult Farmer			0.00085	0.00067	HHRA, Vol. V; Appendix D; Table 4-10. Based on EPA, 1997; Table 13-43 & Table 11-7
Child			0.00191	0.00159	HHRA, Vol. V; Appendix D; Table 4-10. Based on EPA, 1997; Table 13-43 & Table 11-7
Age-Adjusted	(kg-year/kg-day)	IR_{adj}	0.06586	0.02897	GE-derived value for aggregate risk RMC. Based on EPA ED and IR.
Egg loss factor	unitless	$Loss_{cook}$	0	0	HHRA, Vol. V; Appendix D; Table 4-10. EPA Assumed.
Fraction absorbed in GI tract	unitless	F_{GI}	1.0	1.0	HHRA, Vol. V; Appendix D; Table 4-10. EPA Assumed.

EPA 1997. *Exposure Factors Handbook, Volume I; General Factors.*
EPA 2005. *Human Health Risk Assessment GE/Housatonic River Site Rest of River Volume V; Appendix D Agricultural Product Consumption Risk Assessment.*

Table 26b. RMCs for PCBs (mg/kg) in Eggs for Target Risk Range and HI of 1
Commercial Farm

Parameter	EPA RME Analysis			EPA CTE Analysis		
Common Parameters						
Exposure duration (yrs)						
Child	6	6	6	6	6	6
Adult	64	64	64	29	29	29
Averaging time - noncarcinogenic (days)						
Child	2,190	2,190	2,190	2,190	2,190	2,190
Adult	23,360	23,360	23,360	10,585	10,585	10,585
Averaging time - carcinogenic (days)	25,550	25,550	25,550	25,550	25,550	25,550
Pathway Specific Parameters						
Egg Consumption						
Ingestion rate (kg/kg-day)						
Child	0.00191	0.00191	0.00191	0.00159	0.00159	0.00159
Adult	0.00085	0.00085	0.00085	0.00067	0.00067	0.00067
Age-Adjusted (kg-year/kg-day)	0.06586	0.06586	0.06586	0.02897	0.02897	0.02897
Egg loss factor (unitless)	0	0	0	0	0	0
Fraction absorbed in GI tract (unitless)	1.0	1.0	1.0	1.0	1.0	1.0
Exposure frequency (days/year)	350	350	350	350	350	350
*Exposure (egg ing)-carcinogenic (kg/kg-day)	0.00090	0.00090	0.00090	0.00040	0.00040	0.00040
*Exposure (egg ing)-noncarcinogenic (kg/kg-day) -child	0.00183	0.00183	0.00183	0.00152	0.00152	0.00152
*Exposure (egg ing)-noncarcinogenic (kg/kg-day) -adult	0.00082	0.00082	0.00082	0.00064	0.00064	0.00064
CARCINOGENIC	**EPA RME Analysis**			**EPA CTE Analysis**		
Total Exposure, egg ingestion (kg/kg-day)	9.0E-04	9.0E-04	9.0E-04	4.0E-04	4.0E-04	4.0E-04
Cancer Slope Factor (CSF) (mg/kg-day)$^{-1}$	2	2	2	1	1	1
Target Risk Level	1.0E-04	1.0E-05	1.0E-06	1.0E-04	1.0E-05	1.0E-06
Risk-based Media Concentration (mg/kg-wet weight)	**0.055**	**0.0055**	**0.00055**	**0.25**	**0.025**	**0.0025**
NONCARCINOGENIC	**Child**			**Child**		
Total Exposure, egg ingestion (kg/kg-day)	1.8E-03			1.5E-03		
Reference Dose (RfD) (mg/kg-day)	2.00E-05			2.00E-05		
Target Hazard Index	1			1		
Risk-based Media Concentration (mg/kg-wet weight)	**0.011**			**0.013**		
NONCARCINOGENIC	**Adult**			**Adult**		
Total Exposure, egg ingestion (kg/kg-day)	8.2E-04			6.4E-04		
Reference Dose (RfD) (mg/kg-day)	2.00E-05			2.00E-05		
Target Hazard Index	1			1		
Risk-based Media Concentration (mg/kg-wet weight)	**0.025**			**0.031**		

Attachment 27
Risk-based Media Concentrations for Ingestion of Poultry Eggs from Backyard Farms

A range of Risk-based Media Concentrations (RMCs) has been developed for PCBs based on potential consumption of eggs from backyard farms by adult residents and children. Consistent with the approach used in EPA's HHRA, potential ingestion of eggs by adult residents and children have been evaluated under reasonable maximum exposure (RME) and central tendency exposure (CTE) conditions. For each set of exposure conditions, RMCs have been calculated based on potential cancer risks (for children and adults combined) and potential non-cancer impacts (for children and adults separately), using the exposure assumptions and toxicity values used in the HHRA.

The tissue-specific RMCs based on the potential for carcinogenic effects from ingesting poultry eggs from backyard farms were derived using the following general equation:

$$RMC_{cancer} = \frac{Risk * AT_c}{CSF * IR_{adj} * F_{GI} * EF * (1 - Loss_{cook})}$$

Where:

RMC_{cancer}	=	RMC based on the cancer endpoint (mg/kg)
Risk	=	Target risk level (unitless)
AT_c	=	Averaging time for carcinogenic exposure (days)
CSF	=	Cancer slope factor $(mg/kg\text{-}day)^{-1}$
IR_{adj}[1]	=	Age-adjusted ingestion rate (kg-year/kg-day)
F_{GI}	=	Fraction absorbed in the GI tract (unitless)
EF	=	Exposure frequency (days/year)
$Loss_{cook}$	=	Cooking loss (Egg loss factor) (unitless)

The tissue-specific RMCs based on potential non-carcinogenic effects from ingesting poultry eggs from backyard farms were derived using the following equation:

$$RMC_{noncancer} = \frac{HI * RfD * AT_{nc}}{IR * F_{GI} * EF * ED * (1 - Loss_{cook})}$$

Where:

$RMC_{noncancer}$	=	RMC based on the non-cancer endpoint (mg/kg)
HI	=	Target hazard index (unitless)
RfD	=	Reference dose (mg/kg-day)
AT_{nc}	=	Averaging time for non-carcinogenic exposure (days)
IR	=	Ingestion rate (kg/kg-day)
F_{GI}	=	Fraction absorbed in the GI tract (unitless)

[1] The age-adjusted ingestion rate was derived using the following equation: (IRa*EDa)+(IRc*EDc), where IRa is the adult ingestion rate, EDa is the adult exposure duration, IRc is the child ingestion rate, and EDc is the child exposure duration.

EF = Exposure frequency (days/year)
ED = Exposure duration (years)
$Loss_{cook}$ = Cooking loss (Egg loss factor) (unitless)

The specific exposure assumptions used for each age group in this analysis, and the basis of each, are summarized in Table 27a. In all cases, the assumptions and parameters used are the same as those used by EPA in its 2005 HHRA.

Standard upper-bound EPA toxicity values have been used for PCBs. These include a cancer slope factor (CSF) of 2 $(mg/kg\text{-}day)^{-1}$ for the RME scenarios and a CSF of 1 $(mg/kg\text{-}day)^{-1}$ for the CTE scenarios, and a chronic reference dose of 2E-05 for both the RME and CTE scenario. These values are published in EPA's IRIS database and were used in EPA's HHRA.

RMCs based on potential carcinogenic effects (for children and adults) have been developed for both the RME and CTE exposure scenarios using a range of target risks from one-in-a-million (1×10^{-6}) to one-in-ten thousand (1×10^{-4}). This risk range is consistent with EPA's acceptable risk range. RMCs for non-cancer effects have been developed for the RME and CTE scenarios for adults and young children separately, based on a target Hazard Index of 1.

Summary of Results

Estimated RMCs for cancer and non-cancer endpoints are presented in the Table 27b and are summarized as follows.

	RME (mg/kg)				**CTE (mg/kg)**			
	Cancer Risk			**Non-cancer**	**Cancer Risk**			**Non-cancer**
	$1x10^{-6}$	**$1x10^{-5}$**	**$1x10^{-4}$**	**HI = 1**	**$1x10^{-6}$**	**$1x10^{-5}$**	**$1x10^{-4}$**	**HI = 1**
Child/Adult	0.00082	0.0082	0.082	NC	0.0044	0.044	0.44	NC
Child	NC	NC	NC	0.011	NC	NC	NC	0.013
Adult	NC	NC	NC	0.025	NC	NC	NC	0.026

Table 27a. Summary of Pathway- and Age-Specific Exposure Assumptions Used in the Backyard Farm Egg Consumption Scenario

Parameters	Units	Symbol	RME	CTE	Basis
Common Parameters					
Exposure frequency	days/year	EF			
Adult Resident			350	350	HHRA, Vol. V; Appendix D; Table 4-10. EPA Assumed.
Child			350	350	HHRA, Vol. V; Appendix D; Table 4-10. EPA Assumed.
Exposure duration	years	ED			
Adult Resident			39	9	HHRA, Vol. V; Appendix D; Table 4-10. Based on MDPH 2001a
Child			6	6	HHRA, Vol. V; Appendix D; Table 4-10. EPA Assumed (1-7 year old).
Averaging time (cancer endpoint)	days	ATc	25,550	25,550	HHRA, Vol. V; Appendix D; Table 4-10. Based on 70 years * 365 days/year
Averaging time (noncancer endpoint)	days	ATnc			
Adult Resident			14,235	3,285	HHRA, Vol. V; Appendix D; Table 4-10. Based on ED * 365 days/year
Child			2,190	2,190	HHRA, Vol. V; Appendix D; Table 4-10. Based on ED * 365 days/year
Tissue Ingestion Pathway					
Egg Ingestion Rate	kg/kg-day	IR			
Adult Resident			0.00085	0.00079	HHRA, Vol. V; Appendix D; Table 4-10. Based on EPA, 1997; Table 13-43 & Table 11-7
Child			0.00191	0.00159	HHRA, Vol. V; Appendix D; Table 4-10. Based on EPA, 1997; Table 13-43 & Table 11-7
Age-Adjusted	(kg-year/kg-day)	IR_{adj}	0.04461	0.01665	GE-derived value for aggregate risk RMC. Based on EPA ED and IR.
Egg loss factor	unitless	$Loss_{cook}$	0	0	HHRA, Vol. V; Appendix D; Table 4-10. EPA Assumed.
Fraction absorbed in GI tract	unitless	F_{GI}	1.0	1.0	HHRA, Vol. V; Appendix D; Table 4-10. EPA Assumed.

EPA 1997. *Exposure Factors Handbook, Volume I; General Factors.*
EPA 2005. *Human Health Risk Assessment GE/Housatonic River Site Rest of River Volume V; Appendix D Agricultural Product Consumption Risk Assessment.*

Table 27b. RMCs for PCBs (mg/kg) in Eggs for Target Risk Range and HI of 1
Backyard Farm

Parameter	EPA RME Analysis			EPA CTE Analysis		
Common Parameters						
Exposure duration (yrs)						
Child	6	6	6	6	6	6
Adult	39	39	39	9	9	9
Averaging time - noncarcinogenic (days)						
Child	2,190	2,190	2,190	2,190	2,190	2,190
Adult	14,235	14,235	14,235	3,285	3,285	3,285
Averaging time - carcinogenic (days)	25,550	25,550	25,550	25,550	25,550	25,550
Pathway Specific Parameters						
Egg Consumption						
Ingestion rate (kg/kg-day)						
Child	0.00191	0.00191	0.00191	0.00159	0.00159	0.00159
Adult	0.00085	0.00085	0.00085	0.00079	0.00079	0.00079
Age-Adjusted (kg-year/kg-day)	0.04461	0.04461	0.04461	0.01665	0.01665	0.01665
Egg loss factor (unitless)	0	0	0	0	0	0
Fraction absorbed in GI tract (unitless)	1.0	1.0	1.0	1.0	1.0	1.0
Exposure frequency (days/year)	350	350	350	350	350	350
*Exposure (egg ing)-carcinogenic (kg/kg-day)	0.00061	0.00061	0.00061	0.00023	0.00023	0.00023
*Exposure (egg ing)-noncarcinogenic (kg/kg-day) - child	0.00183	0.00183	0.00183	0.00152	0.00152	0.00152
*Exposure (egg ing)-noncarcinogenic (kg/kg-day) -adult	0.00082	0.00082	0.00082	0.00076	0.00076	0.00076
CARCINOGENIC	**EPA RME Analysis**			**EPA CTE Analysis**		
Total Exposure, egg ingestion (kg/kg-day)	6.1E-04	6.1E-04	6.1E-04	2.3E-04	2.3E-04	2.3E-04
Cancer Slope Factor (CSF) (mg/kg-day)$^{-1}$	2	2	2	1	1	1
Target Risk Level	1.0E-04	1.0E-05	1.0E-06	1.0E-04	1.0E-05	1.0E-06
Risk-based Media Concentration (mg/kg wet weight)	**0.082**	**0.0082**	**0.00082**	**0.44**	**0.044**	**0.0044**
NONCARCINOGENIC	**Child**			**Child**		
Total Exposure, egg ingestion (kg/kg-day)	1.8E-03			1.5E-03		
Reference Dose (RfD) (mg/kg-day)	2.00E-05			2.00E-05		
Target Hazard Index	1			1		
Risk-based Media Concentration (mg/kg-wet weight)	**0.011**			**0.013**		
NONCARCINOGENIC	**Adult**			**Adult**		
Total Exposure, egg ingestion (kg/kg-day)	8.2E-04			7.6E-04		
Reference Dose (RfD) (mg/kg-day)	2.00E-05			2.00E-05		
Target Hazard Index	1			1		
Risk-based Media Concentration (mg/kg-wet weight)	**0.025**			**0.026**		

Attachment 28
Risk-based Media Concentrations for Ingestion of Fruit and Vegetables from Commercial or Backyard Farms

Risk-based Media Concentrations (RMCs) have been developed for PCBs based on potential consumption of produce (exposed fruit, exposed vegetables and root vegetables) from commercial or backyard farms in the floodplain. As discussed in the text of this IMPG Proposal, RMCs for these types of produce have been calculated based solely on potential non-cancer impacts to children. Separate RMCs have been calculated for each of the individual produce categories (i.e., exposed fruit, exposed vegetables and root vegetables), as well as for total produce based on the assumption that a child would consume all three types of produce grown in the floodplain at the consumption rates specified in the HHRA.

Consistent with the approach used in EPA's HHRA, potential ingestion of fruits and vegetables by children have been evaluated under reasonable maximum exposure (RME) and central tendency exposure (CTE) conditions. For each set of exposure conditions, RMCs have been calculated based on potential non-cancer impacts to children, using the exposure assumptions and toxicity values used in the HHRA. Because the exposure assumptions for a child do not differ between the commercial and backyard farm scenarios, the calculated RMCs apply to both commercial and backyard farms.

The RMCs for each individual produce category have been calculated using the following equation:

$$RMC_{noncancer} = \frac{HI * RfD}{\left(Exp_{ingestion}\right)}$$

Where:

$RMC_{noncancer}$	=	RMC based on the non-cancer endpoint (mg/kg)
HI	=	Target hazard index (unitless)
RfD	=	Reference dose (mg/kg-day)
$Exp_{ingestion}$	=	Exposure due to fruit and vegetable ingestion pathway (kg/kg-day)

In the above equation, the exposure due to ingestion of fruits and vegetables ($Exp_{ingestion}$) has been calculated using the following equation:

$$Exp_{ingestion} = \frac{IR * AF * F_{GI} * EF * ED * \left(1 - Loss_{cook}\right)}{AT}$$

Where:

IR	=	Individual produce ingestion rate (kg/kg-day)
AF	=	Regional consumption adjustment factor (unitless)
F_{GI}	=	Fraction absorbed in the GI tract (unitless)
EF	=	Exposure frequency (days/year)

ED = Exposure duration (years)
AT = Averaging time (days)
$Loss_{cook}$ = Cooking loss (Produce loss factor) (unitless)

For total produce, the RMC has been calculated as follows:

$$RMC(Total)_{noncancer} = \frac{HI}{((Exp_{ing\_exposedfruit} \div RfD) + (Exp_{ing\_exposedvegetable} \div RfD) + (Exp_{ing\_rootvegetable} \div RfD))}$$

Where:

$RMC(Total)_{noncancer}$ = RMC (total produce) based on the non-cancer endpoint (mg/kg)
HI = Target hazard index (unitless)
RfD = Reference dose (mg/kg-day)
$Exp_{ing\_exposedfruit}$ = Exposure due to exposed fruit consumption (kg/kg-day)
$Exp_{ing\_exposedvegetable}$ = Exposure due to exposed vegetable consumption (kg/kg-day)
$Exp_{ing\_rootvegetables}$ = Exposure due to root vegetable consumption (kg/kg-day)

In the above equation, exposure due to ingestion of individual fruits and vegetables (e.g., $Exp_{ing\_exposedfruit)}$ has been calculated using the previously listed $Exp_{ingestion}$ equation.

The specific exposure assumptions used for children in this analysis, and the basis of each, are summarized in Table 28a. In all cases, the assumptions and parameters used are the same as those used by EPA in its 2005 HHRA.

A chronic reference dose of 2E-05 was used for both the RME and CTE scenario. This value is published in EPA's IRIS database and was used in EPA's HHRA. RMCs for non-cancer effects have been developed for each of the RME and CTE scenarios for children based on a target Hazard Index of 1.

Summary of Results

Estimated RMCs for non-cancer endpoints are presented in Table 28b and are summarized as follows.

	RME (mg/kg)	**CTE (mg/kg)**
Child (Commercial and Backyard Farm)	**Noncancer**	**Non-cancer**
Exposed Fruit	0.11	0.15
Exposed Vegetable	0.024	0.037
Root Vegetable	0.030	0.049
Total Produce	0.012	0.018

Table 28a. Summary of Pathway Exposure Assumptions Used in the Fruit (Exposed) and Vegetable (Exposed and Root) Consumption by Child Scenario

Parameters	Units	Symbol	RME	CTE	Basis
Common Parameters					
Exposure frequency Child	days/year	EF	350	350	HHRA, Vol. V; Appendix D; Table 4-10. EPA Assumed.
Exposure duration Child	years	ED	6	6	HHRA, Vol. V; Appendix D; Table 4-10. EPA Assumed (1-7 year old).
Averaging time (noncancer endpoint) Child	days	ATnc	2,190	2,190	HHRA, Vol. V; Appendix D; Table 4-10. Based on ED * 365 days/year
Tissue Ingestion Pathway					
Exposed Fruit Ingestion Rate	kg/kg-day	IR	0.00269	0.00259	HHRA, Vol. V; Appendix D; Table 4-10. Based on EPA, 1997; Table 13-61
AF Exposed Fruit	unitless	AF	0.07	0.07	HHRA, Vol. V; Appendix D; Table 4-10. Based on EPA, 1997; Table 13-33,13-61 and 13-62.
Produce loss factor	unitless	$Loss_{cook}$	0	0.25	HHRA, Vol. V; Appendix D; Table 4-10. Based on EPA, 1997; Table 13-6 and EPA Assumed.
Exposed Vegetable Ingestion Rate	kg/kg-day	IR	0.00294	0.00226	HHRA, Vol. V; Appendix D; Table 4-10. Based on EPA, 1997; Table 13-63
AF Exposed Vegetable	unitless	AF	0.3	0.3	HHRA, Vol. V; Appendix D; Table 4-10. Based on EPA, 1997; Table 13-33,13-63, 13-64 and 13-65.
Produce loss factor	unitless	$Loss_{cook}$	0	0.16	HHRA, Vol. V; Appendix D; Table 4-10. Based on EPA, 1997; Table 13-7 and EPA Assumed
Root Vegetable Ingestion Rate	kg/kg-day	IR	0.00234	0.0017	HHRA, Vol. V; Appendix D; Table 4-10. Based on EPA, 1997; Table 13-65
AF Root Vegetable	unitless	AF	0.3	0.3	HHRA, Vol. V; Appendix D; Table 4-10. Based on EPA, 1997; Table 13-33,13-63, 13-64 and 13-65.
Produce loss factor	unitless	$Loss_{cook}$	0	0.17	HHRA, Vol. V; Appendix D; Table 4-10. Based on EPA, 1997; Table 13-7 and EPA Assumed
Fraction absorbed in GI tract	unitless	F_{GI}	1.0	1.0	HHRA, Vol. V; Appendix D; Table 4-10. EPA Assumed.

EPA 1997. *Exposure Factors Handbook, Volume I; General Factors.*
EPA 2005. H*uman Health Risk Assessment GE/Housatonic River Site Rest of River Volume V; Appendix D Agricultural Product Consumption Risk Assessment.*

Table 28b. RMCs for PCBs (mg/kg) in Fruit and Vegetables for Target Risk Range and HI of 1
Commercial and Backyard Farm

Parameter	EPA RME Analysis	EPA CTE Analysis
Common Parameters		
Exposure duration (yrs) Child	6	6
Averaging time - noncarcinogenic (days) Child	2,190	2,190
Fruit and Vegetable Consumption Child		
Exposed Fruit Ingestion rate (kg/kg-day)	0.00269	0.00259
AF Exposed Fruit	0.07	0.07
Product loss factor exposed fruit	0	0.25
Exposed Vegetable Ingestion rate (kg/kg-day)	0.00294	0.00226
AF Exposed Vegetables	0.3	0.3
Produce loss factor exposed vegetables	0	0.16
Root Vegetable Ingestion rate (kg/kg-day)	0.00234	0.0017
AF Root Vegetables	0.3	0.3
Produce loss factor root vegetables	0	0.17
Fraction absorbed in GI tract (unitless)	1.0	1.0
Exposure frequency (days/year)	350	350
*Exposure (Exposed Fruit ing)-noncarcinogenic (kg/kg-day)	0.00018	0.00013
*Exposure (Exposed Vegetable ing)-noncarcinogenic (kg/kg-day)	0.00085	0.00055
*Exposure (Root Vegetable ing)-noncarcinogenic (kg/kg-day)	0.00067	0.00041
NONCARCINOGENIC	**Child**	**Child**
Total Exposure, Fruit ingestion (kg/kg-day)	1.8E-04	1.3E-04
Total Exposure, Exposed Vegetable ingestion (kg/kg-day)	8.5E-04	5.5E-04
Total Exposure, Root Vegetable ingestion (kg/kg-day)	6.7E-04	4.1E-04
Reference Dose (RfD) (mg/kg-day)	2.00E-05	2.00E-05
Target Hazard Index	1	1
Risk-based Media Concentration (mg/kg-wet weight) - Exposed Fruit	**0.11**	**0.15**
Risk-based Media Concentration (mg/kg-wet weight) - Exposed Vegetables	**0.024**	**0.037**
Risk-based Media Concentration (mg/kg-wet weight) - Root Vegetables	**0.030**	**0.049**
Risk-based Media Concentration (mg/kg-wet weight) - Total Produce	**0.012**	**0.018**

APPENDIX D

ATTACHMENT 29

Attachment 29
Proposed Risk-based Media Concentrations Based on
Insectivorous Birds Assessment Endpoint

Risk-based media concentrations (RMCs) for aquatic and terrestrial invertebrates consumed by insectivorous birds have been developed for both total PCBs and dioxin toxicity equivalents (TEQs). As discussed in the text of this IMPG Proposal, these RMCs are based on potential risks to woods ducks, which has been selected as a representative species for the insectivorous birds that reside and breed in the Rest of River area.

The general methodology used to generate RMCs reflects EPA's evaluation of potential risks to wood ducks in its Ecological Risk Assessment (ERA), which was based on modeled exposures and effects. Such endpoints can be expressed as ratios of modeled exposure to toxicity reference values (TRVs) and are referred to as hazard quotients (HQs). The ERA's HQs for the wood duck's exposure to PCBs were "dose-based," in that they were calculated as the ratio of modeled doses to dose-based TRVs. The ERA's HQs for the wood duck's exposure to TEQs, in contrast, were "egg-based," in that they were calculated as the ratio of modeled concentrations of TEQs in wood duck eggs to egg-based TRVs. The calculation of RMCs for PCBs and TEQs followed these same approaches, as described further below. A single RMC has been calculated for PCBs, while a range of RMCs has been calculated for TEQs.

RMCs were calculated by solving the HQ equations for the prey concentration term, while holding the HQ value at a target level of 1.0. Specific methodologies used to generate PCB RMC and TEQ RMCs are detailed below.

RMC for PCBs

The equation employed to calculate the RMC for PCBs in aquatic and terrestrial invertebrates consumed by wood duck was as follows:

$$RMC_{inv} = THQ * TRV / (FT * P_i * FIR) \qquad \text{Equation 1}$$

Where:

RMC_{inv}	=	Concentration of PCBs in invertebrates that will not result in exceedance of dose-based TRV (mg/kg)
THQ	=	Target hazard quotient (unitless)
TRV	=	Toxicity reference value (mg/kg bw/d)
FT	=	Foraging time (unitless)
P_i	=	Proportion of invertebrates in diet (unitless)
FIR	=	Normalized food intake rate (kg/kg bw/d)

As previously noted, the THQ was set at 1.0 to ensure that the dose does not exceed the TRV.

The TRV was based on Lillie et al.'s (1974) study of the reproductive effects of PCBs on chickens. As acknowledged in the ERA (Vol. 2, pp. H-33, H-46; Table H.3-1; Figure H.3-1) and

elsewhere (e.g., Elliott and Harris, 2001/2002; Brunstrom and Halldin, 1998; EPA, 2003; Hoffman et al., 1998; Sanderson et al., 1998), chickens have been consistently shown to be more sensitive – in some cases hundreds to thousands of times more sensitive – than other avian species to the toxicological effects of PCBs. Thus, the Lillie et al. (1974) study provides a conservative basis for avian RMCs.

Lillie et al. (1974) exposed 12 groups of 35 chickens each over a nine-week period to diets containing either 2 or 20 mg/kg (equivalent to 0.12 mg/kg BW/day or 1.2 mg/kg BW/day) of one of several different Aroclor mixtures. Hen and progeny performance were monitored during the nine-week dosing period (Period 1), as well as seven weeks after dosing had stopped (Period 2). Of the Aroclor mixtures tested by Lillie et al. (1974), Aroclor 1254 most closely resembles the PCB mixture in the Housatonic River. Therefore, effects levels – expressed as a percent change relative to controls – were examined for Lillie et al.'s (1974) findings for Aroclor 1254. The Lillie et al. (1974) study results indicated that, for Aroclor 1254, the higher treatment level – i.e., dietary concentration of 20 mg/kg (equal to a dose of 1.2 mg/kg BW/day) – was less than the 20 percent effect level (EC20). Table 1 summarizes the effect levels for all endpoints for which the Aroclor 1254 20 mg/kg dose group had significant differences in performance relative to controls.

Table 1. Significant Results for Aroclor 1254 20 mg/kg Dose Group (Lillie et al., 1974)

Endpoint	Period	Control group	Aroclor 1254 20 mg/kg group	% Effect	Lillie et al. (1974) Table
Egg Production (%)	Period 1	79.4	71.3	10	1
	Period 2	72.5	59.9	17	
	Mean [a]	76.3	66.0	13	
Food Consumption (grams per hen-day)	Period 1	125.8	119.2	5	2
	Period 2	126.7	105.4	17	
	Mean [a]	126.2	113.7	10	
Hatchability (%)	Period 1	93.7	80.7	14	3
	Period 2	91.6	79.9	13	
	Mean [a]	92.8	80.3	13	
Progeny Body Weight Gain (grams)	Period 1	163	141	13	4
	Mean [a]	151	132	13	

[a] Mean values as reported by Lillie et al. (1974).

Differences between controls and the Aroclor 1254 20 mg/kg dose group were not statistically significant for progeny mortality during either period or for progeny body weight gain during Period 2. Although the ERA refers to a slight reduction in growth rate of chicks at the lower treatment level (2 mg/kg in diet, equal to a dose of 0.12 mg/kg BW/day) (Vol. 6, p. H-46), that reduction was only 7 percent, was transitory, and does not constitute a significant reproductive

effect. Thus, the dose of 1.2 mg/kg-day in this study, which is less than the EC20, has been selected as the TRV in the RMC calculation. Use of this TRV is consistent with EPA's specification, in its December 9, 2005 comments on a prior version of the IMPG Proposal, that a 20 percent effect level is an appropriate basis for developing an RMC for receptor groups for which a Maximum Acceptable Threshold Concentration (MATC) was not specified in the ERA (EPA, 2005, p. 4).

Because the Lillie et al. (1974) study provides a conservative estimate of the EC20, the PCB RMC can be calculated deterministically, rather than probabilistically. In cases where the ERA employed a probability distribution function, the average values reported in the ERA were used in the deterministic calculation of the RMC.

Consistent with the ERA (Vol. 2, p. 7-18; Vol. 6, Table G.2-33), the RMC was calculated based on an assumed foraging time (FT) of 100 percent in the Rest of River area. The proportion of invertebrates in the diet (P_i) was assumed to be 76 percent, consistent with the ERA (Vol. 5, Table G.2-33) and based on the diet during the pre-laying period (Drobney and Fredrickson, 1979; Drobney, 1980).

The ERA (Vol. 2, p. 6-8; Vol. 5, p. G-46) indicates that the food intake rate (FIR) was calculated as:

$$FIR = FMR / \sum_{i=1}^{n} (AE_i * G_i) \qquad \text{Equation 2}$$

Where:

FIR	=	Normalized food intake rate (kg/kg bw/d)
FMR	=	Free metabolic rate (kJ/d)
i	=	Prey item type (unitless)
AE	=	Assimilation efficiency (unitless)
G	=	Gross energy (kcal/g)

Equation 2 does not include a factor for the proportion of diet composed of litter invertebrates and aquatic invertebrates because dietary preference was considered implicitly in the ERA's probabilistic analysis of FIR. That is, for each iteration of the probabilistic analysis, the ERA selected a prey type based on a pre-defined dietary composition, and then assigned values for assimilation efficiency (AE) and gross energy (G) according to the prey type selected. In addition, the units used in Equation 2 do not cancel out correctly. Therefore, for purposes of calculating the deterministic RMC, the following modification was made to Equation 2:

$$FIR = (FMR * CF) / \sum_{i=1}^{n} (AE_i * G_i * P_i * BW) \qquad \text{Equation 3}$$

Where:

FIR	=	Normalized food intake rate (kg/kg bw/d)
FMR	=	Free metabolic rate (kJ/d)

CF	=	Conversion factor (0.239 kcal/kJ)
i	=	Prey item type (unitless)
AE	=	Assimilation efficiency (unitless)
G	=	Gross energy (kcal/kg)
P_i	=	Proportion of prey item i in diet (unitless)
BW	=	Body weight (kg)

Consistent with the ERA (Vol. 5, p. G-47, Table G.2-33), the AEs of terrestrial invertebrates and aquatic invertebrates by birds were assumed to be 0.72 and 0.77, respectively, based on Karasov (1990), Ricklefs (1974), and Bryant and Bryant (1988). As also consistent with the ERA (Vol. 5, p. G-47, Table G.2-33), terrestrial and aquatic invertebrates were assumed to have Gs of 1,600 kcal/kg and 1,100 kcal/kg, respectively, based on Cummins and Wuycheck (1971), Collopy (1975), Bell (1990), Tyler (1973), Jorgensen et al. (1991), Minnich (1982), and Thayer et al. (1973). The proportion of diet composed of terrestrial invertebrates was assumed to be 19.6 percent, while the proportion of diet composed of aquatic invertebrates was assumed to be 56.4 percent (ERA, Vol. 5, Tables G.2-3 and G.2-34), based on Drobney and Fredrickson (1979). In order to be consistent with the ERA, which ignored the fraction of diet composed of vegetation in the derivation of the FIR, the proportions of diet assumed to be composed of terrestrial and aquatic invertebrates were scaled up to 26 percent and 74 percent, respectively, in order to sum to 100 percent. The average body weight for wood ducks (0.564 kg) applied in the ERA (Vol. 5, pp. G-45, G-46, Table G.2-33) was also used to estimate the normalized FIR.

As presented in the ERA (Vol. 5, p. G-46, Table G.2-33), the free metabolic rate (FMR) was calculated as:

$$FMR = a * BW^{b} \qquad \text{Equation 4}$$

Where:

FMR	=	Free metabolic rate (kJ/d)
a	=	Slope (kJ/g-d)
BW	=	Body weight (g)
b	=	Power (unitless)

In this deterministic analysis, average values reported in the ERA (Vol. 5, pp. G-45, G-46, Table G.2-33) for slope (10.5), body weight (564 g), and power (0.68) were used to estimate the FMR.

Based on the above equations and assumptions, the resulting RMC for wood ducks is a PCB concentration of 4.4 mg/kg in the invertebrates that form the wood duck's diet. As discussed in the text of this IMPG Proposal, this value will be used as the "point of departure" in evaluations of potential remedies.

For purposes of applying this RMC, it should be noted that the RMC would be achieved if neither the terrestrial nor the aquatic invertebrates in the wood duck's diet have PCB concentrations greater than 4.4 mg/kg. However, the RMC can also be achieved if lower concentrations in terrestrial invertebrates co-occur with higher concentrations in aquatic invertebrates, or vice versa. To determine whether the RMC is achieved for any combination of

aquatic and terrestrial invertebrate concentrations, a weighted average dietary concentration may be calculated based on the wood duck's dietary preferences. As noted above, the ERA assumed that the mean proportions of the wood duck's diet composed of aquatic and terrestrial invertebrates were 56.4 and 19.6 percent, respectively, and that the overall proportion of invertebrates in the diet was 76 percent (Vol. 5, Table G.2-33). Thus, the RMC would be achieved when measured PCB concentrations in terrestrial and aquatic invertebrates in the wood duck's diet are inserted into the following equation and the solution to that equation is true:

$$[(0.564 \times C_{ai}) + (0.196 \times C_{ti})] / 0.76 \leq 4.4 \text{ mg/kg} \qquad \text{Equation 5}$$

Where:

C_{ai} = Concentration of PCBs in aquatic invertebrates (mg/kg)
C_{ti} = Concentration of PCBs in terrestrial invertebrates (mg/kg)

RMCs for TEQs

As noted above, the ERA's HQs for TEQs were calculated based on egg-based TRVs. These TRVs were derived from a field study by White and Seginak (1994) on reproductive effects of TEQs on wood ducks at Bayou Meto, Arkansas. That study reported an effect threshold range (i.e., the lowest range of egg TEQ concentrations determined to have adverse reproductive effects relative to the reference population) of 20 to 50 ng/kg egg wet weight (ww).

To calculate RMCs for wood duck prey (i.e., invertebrates) based on these data, it was necessary to calculate a dose to hens that yields a maternal body burden that in turn results in an egg concentration that can be compared with the egg-based TRVs. A range of RMCs has been derived for TEQs in wood duck prey. The White and Seginak (1994) study does not provide sufficient information to allow calculation of the EC20. Thus, in accordance with EPA's comments (EPA, 2005, p. 4 & Att. A, p. 26), the lower bound of the RMC range, which will be used as the point of departure, was determined by calculating the dietary concentration in the hen's diet that would result in an egg concentration with a 20 percent probability of exceeding the lower end of the egg-based effect threshold range identified by White and Seginak (1994) (i.e., a TRV of 20 ng/kg egg ww). The upper end of the RMC range was determined by calculating the dietary concentration that would result in an egg concentration equal to the geometric mean of the lower and upper ends of that effect threshold range (i.e., a TRV of 32 ng/kg egg ww). The equations used to determine the prey concentrations that would result in those target egg concentrations are described below. The same inputs and assumptions that were employed in the ERA (Vol. 5, Table G.2-34) were also used in this analysis.

The ERA does not explicitly present the system of equations that it used to estimate concentrations of TEQs in wood duck eggs; rather, the ERA provides a narrative description of the approach employed, with most detail offered in the discussion of calculation of bald eagle egg concentrations (ERA, Vol. 6, pp. K-27 to K-29). Although an equation is provided for the tree swallow microexposure model (ERA, Vol. 5, pp. G-14 to G-15), that model differs from the equations described below in that the tree swallow microexposure model focuses on post-hatch accumulation of PCBs and TEQ by nestling tree swallows as a function of the maternal transfer

to eggs and the dietary intake by the nestlings. In contrast, the egg-based TRVs applied in the derivation of wood duck RMCs are pre-hatch egg concentrations.

Based on Drobney (1977), wood ducks were assumed to arrive at the Rest of River 14 days before initiating egg-laying (ERA, Vol. 2, p. 7-11; Vol. 5, p. G-51). It was conservatively assumed that avian species do not metabolize PCBs (ERA, Vol. 5, p. G-51). The concentration of TEQs absorbed by hens during the 14-day prelaying period was calculated as the product of the chemical assimilation efficiency (CAE) and total daily intake (TDI) over each of the 14 days (ERA, Vol. 5, p. G-16):

$$Ca_j = \sum_{j=1}^{14} CAE * TDI * 1day \qquad \text{Equation 6}$$

Where:

Ca	=	Concentration of TEQs absorbed by adult hens (ng/kg)
j	=	Days in pre-laying period
CAE	=	Chemical assimilation efficiency (unitless)
TDI	=	Total daily intake (ng/kg bw/d)

Consistent with the ERA (Vol. 2, p. 7-10; Vol. 5, p. G-14), TDI was calculated as:

$$TDI = FT * FIR \sum_{i=1}^{n} C_i * P_i \qquad \text{Equation 7}$$

Where:

TDI	=	Total daily intake (ng/kg bw/d)
FT	=	Foraging time (unitless)
FIR	=	Normalized food intake rate (kg/kg bw/d) (see Equation 3)
i	=	Prey type
C_i	=	Concentration of TEQs in prey type i (ng/kg)
P_i	=	Proportion of prey type i in diet (unitless)

For days 15 through 27, hens were assumed to lay one egg per day, transferring a portion of the TEQ concentration to each of the 13 eggs, while continuing to absorb additional TEQs via the diet (ERA, Vol. 5, p. G-17). Thus, the concentration of TEQs in hens during each day of the egg-laying period is expressed as:

$$Ca_j = \sum_{j=15}^{27} Ca_{j-1} - [CR_{e:a} * Ca_{j-1} * \frac{EW}{BW}] + [CAE * TDI * 1\ day] \qquad \text{Equation 8}$$

Where:

Ca	=	Concentration of TEQs in adult hens (ng/kg)
j	=	Days in egg-laying period (unitless)

$CR_{e:a}$ = Concentration ratio of eggs to adults (unitless)
EW = Egg weight (g)
BW = Adult body weight (g)
CAE = Chemical assimilation efficiency (unitless)
TDI = Total daily intake (ng/kg bw/day) (see Equation 7)

Consistent with the ERA (Vol. 2, p. 7-19; Vol. 5, p. G-52), the $CR_{e:a}$ was set equal to the mean value of 0.22, as reported by Bargar et al. (2001) for white leghorn chickens. The EW was set equal to 41 g, the mean value employed in the ERA (Vol. 5, Table G.2-34) based on Woodlot Alternatives (2004). Consistent with the ERA (Vol. 2, p. G-52), the CAE was assumed to follow a beta distribution (alpha=242, beta=29.5, scale=1).

The resulting egg concentration was calculated as:

$$Ce = Ca_j * CR_{e:a}$$ Equation 9

Where:

Ce = TEQ concentration in eggs (ng/kg)
Ca = TEQ concentration in adults (ng/kg)
j = Days in egg-laying period (unitless)
$CR_{e:a}$ = Concentration ratio of eggs to adults (unitless)

The lower bound of the RMC range was calculated probabilistically by solving Equations 6 through 9 simultaneously to determine the dietary concentration (C_i) associated with a 20 percent probability that the egg concentrations would exceed an egg-based TEQ TRV of 20 ng/kg egg ww – the lower end of the effect threshold range identified by White and Seginak (1994) (see ERA, Vol. 2, p. 7-40; Vol. 5, p. G-84). Based on these methods and exposure assumptions, that lower-bound RMC, which will be used as the point of departure, is a TEQ concentration of 1.4×10^{-5} mg/kg or 14 ng/kg in aquatic and terrestrial invertebrates consumed by the wood duck.

The upper bound of the RMC range was based on a TRV representing the geometric mean of the lower end (20 ng/kg egg ww) and the upper end (50 ng/kg egg ww) of the effect threshold range reported by White and Seginak (1994), which is 32 ng/kg egg ww. The upper-bound RMC value was calculated by solving Equations 6 through 9 simultaneously to determine the dietary concentration (C_i) predicted to result in an egg concentration equal to that egg-based TRV of 32 ng/kg egg ww. The resulting RMC is a TEQ concentration of 2.2×10^{-5} mg/kg or 22 ng/kg in aquatic and terrestrial invertebrates in the wood duck's diet.

For purposes of applying a given RMC value within this range of 14 to 22 ng/kg to the invertebrates consumed by the wood duck, the same approach described above for the PCB RMC can be used. Thus, while the TEQ RMC would be achieved if both the terrestrial and the aquatic invertebrates in the wood duck's diet have TEQ concentrations at or below the RMC value, it can also be achieved if lower concentrations in terrestrial invertebrates co-occur with higher concentrations in aquatic invertebrates, or vice versa. Specifically, the RMC would be achieved when measured TEQ concentrations in terrestrial and aquatic invertebrates in the

wood duck's diet are inserted into the following equation and the solution to that equation is true:

$$[(0.564 \times C_{ai}) + (0.196 \times C_{ti})] / 0.76 \leq RMC \qquad \text{Equation 10}$$

Where:

C_{ai} = Concentration of TEQs in aquatic invertebrates (ng/kg)
C_{ti} = Concentration of TEQs in terrestrial invertebrates (ng/kg)

References

Bargar, T.A., G.I. Scott, and G.P. Cobb. 2001. Maternal transfer of contaminants: Case study of the excretion of three polychlorinated biphenyl congeners and technical-grade endosulfan into eggs by white leghorn chickens (Gallus domesticus). *Environmental Toxicology and Chemistry* 20:61-67.

Bell, G.P. 1990. Birds and mammals on an insect diet: A primer on diet composition analysis in relation to ecological energetics. *Studies in Avian Biology* 12:391-415.

Brunstrom, B., and K. Halldin. 1998. EROD induction by environmental contaminants in avian embryo livers. *Comparative Biochem. and Physiol. Part C* 121:213-219.

Bryant, D.M., and V.M. Bryant. 1988. Assimilation efficiency and growth of nestling insectivores. *Ibis* 130:268-274.

Collopy, M.W. 1975. *Behavioral and predatory dynamics of kestrels wintering in the Arcata Bottoms*. Master's Thesis. Arcata, California: Humboldt State University.

Cummins, K.W., and J.C. Wuycheck. 1971. *Caloric equivalents for investigations in ecological energetics*. Stuttgart, West Germany: International Association of Theoretical and Applied Limnology.

Drobney, R.D. 1977. *The feeding ecology, nutrition and reproductive bioenergetics of wood ducks*. Ph.D. Thesis, Univ. Missouri, Columbia. 170 pp.

Drobney, R.D. 1980. Reproductive bioenergetics of wood ducks. *Auk* 97:480-490.

Drobney, R.D., and L.H. Fredrickson. 1979. Food selection by wood ducks in relation to breeding status. *Journal of Wildlife Management* 43:109-120.

Elliott, J.E., and M.L. Harris. 2001/2002. An ecotoxicological assessment of chlorinated hydrocarbon effects on bald eagle populations. *Reviews in Toxicology* 4:1-60.

EPA. 2003. *Analyses of Laboratory and Field Studies of Reproductive Toxicity in Birds Exposed to Dioxin-like Compounds for Use in Ecological Risk Assessment*. U.S. Environmental

Protection Agency, Office of Research and Development, Cincinnati, Ohio. April. EPA/600/R-03/114F.

EPA. 2005. Letter from Susan Svirsky, U.S. Environmental Protection Agency New England Office, Region I, to Andrew Silfer, General Electric Company, RE: Interim Media Protection Goals Proposal. December 9.

Hoffman, D.J., M.J. Melancon, P.N. Klein, J.D. Eisemann, and J.W. Spann. 1998. Comparative developmental toxicity of planar polychlorinated biphenyl congeners in chickens, American kestrels, and common terns. *Environmental Toxicology and Chemistry* 17:747-757.

Jorgensen, S.E., S.N. Nielsen, and L.A. Jorgensen. 1991. *Handbook of Ecological Parameters and Ecotoxicoloty.* Elsevier Science Publishers, Amsterdam, The Netherlands.

Karasov, W.H. 1990. Digestion in birds: chemical and physiological determinants and ecological implications. *Studies in Avian Biology* 13:391-415.

Lillie, R.J., H.C. Cecil, J. Bitman, and G.F. Fries. 1974. Differences in response of caged white leghorn layers to various polychlorinated biphenyls (PCBs) in the diet. *Poultry Science* 53:726-732.

Minnich, J.E. 1982. The use of water. In: Gans, C.; Pough, F.H. eds. *Biology of the Reptilia, Physiology C; Physiological Ecology.* V. 12. Academic Press, New York, New York.

Ricklefs, R.E. 1974. Energetics of reproduction in birds. In: Paynter, R.A. ed. *Avian Energetics.* Nuttall Ornithological Club, Cambridge, Massachusetts.

Sanderson, J.T., S.W. Kennedy, and J.P. Giesy. 1998. In vitro induction of ethoxyresorufin-o-deethylase and porphyrins by halogenated aromatic hydrocarbons in avian primary hepatocytes. *Environmental Toxicology and Chemistry* 17:2006-2018.

Thayer, G.W., W.E. Schaaf, J.W. Angelovic, and M.W. LaCroix. 1973. Caloric measurements of some estuarine organisms. *Fishery Bulletin* 71:289-296.

Tyler, A.V. 1973. Caloric values of some North Atlantic invertebrates. *Marine Biology* 19:258-261.

White, D. H., and J.T. Seginak. 1994. Dioxin and furans linked to reproductive impairment in wood ducks. *Journal of Wildlife Management* 58(1):100-106.

Woodlot Alternatives. 2004. *Final Report: Collection and Analysis of Wood Duck (Aix sponsa) Eggs, Housatonic River, Pittsfield, Lenox, and Lee, Massachusetts*. Woodlot Alternatives, Inc., Topsham, Maine. November 4.