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SITE-SPECIFIC EXPOSURE AND RISK ASSESSMENT FOR POLYCHLORINATED BIPHENYLS, ESTABROOK SCHOOL, LEXINGTON, MASSACHUSETTS

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LIST OF ABBREVIATIONS AND ACRONYMS

ATSDR	Agency for Toxic Substances and Disease Registry
Committee	Estabrook Advisory Committee
EH&E	Environmental Health & Engineering, Inc.
EPA	U.S. Environmental Protection Agency
FDA	U.S. Food and Drug Administration
kg	kilograms
LPS	Lexington Public Schools
PCBs	polychlorinated biphenyls
RfD	reference dose
School	stabrook Elementary School
TDS	Total Diet Study
Town	representatives of Lexington Public Schools and Lexington Public Facilities
ng kg^{-1} d^{-1}	nanograms of PCBs per kilogram body weight per day
ng m^{-3}	nanograms per cubic meter
μg m^{-3}	micrograms per cubic meter
°F	degrees Fahrenheit

1.0 INTRODUCTION

This report describes the site-specific risk assessment for polychlorinated biphenyls (PCBs) at Estabrook Elementary School (the School), Lexington, Massachusetts, prepared by Environmental Health & Engineering, Inc. (EH&E) for the Town of Lexington. Preliminary versions of the site-specific risk assessment have been reviewed by the Estabrook Advisory Committee (the Committee) as well as by representatives of Lexington Public Schools (LPS) and Lexington Public Facilities (the Town). This interim report reflects assessment questions and exposure scenarios developed with input from the Committee and Town, including decisions made during the Committee meetings on October 6, 2010, and October 12, 2010. The site-specific risk assessment will be updated if any additional information becomes available on background or school-related exposure conditions.

1.1 OBJECTIVE

The objective of the site-specific risk assessment is to develop information intended to help understand and manage potential health risks of PCBs in the indoor air of the School. The risk assessment is used to identify targets for concentrations of PCBs in the indoor air of the School. The targets are intended to be protective of health and to reflect exposure concentrations and time-location patterns that are representative of students, teachers, and staff at the School. As with any health risk assessment, the results of the site-specific assessment do not define “unsafe” levels of exposure, but instead establish exposures that are unlikely to present an appreciable likelihood of adverse effect.

1.2 BACKGROUND

Human health risk assessment is a process for estimating the likelihood of an adverse effect on an organism or population following exposure to a particular agent (WHO 2004). Risk assessment takes into account the inherent characteristics of the agent of concern as well as the characteristics of the specific population of interest. In general terms, assessment of human health risk requires identification, compilation, and integration of information on (i) health hazards of a chemical, (ii) human exposure to the chemical, (iii) and relationships among exposure, dose and adverse effects (WHO

2010). Identification of uncertainties is an important component of human health risk assessments. The results of a risk assessment are useful for identifying options to manage risk and also for communicating with interested audiences.

2.0 METHODOLOGY

The approach to the site-specific risk assessment for the School follows the methods in a tool developed by the U.S. Environmental Protection Agency (EPA) for evaluating concentrations of PCBs in indoor air of schools (EPA 2009). EPA applied the tool to background exposure and activity patterns in a school reported to be representative of a typical school population in the United States. In the site-specific assessment, EH&E relied upon information about exposure concentrations and time spent in various parts of the School that are specific to the School community. The EPA and site-specific exposure estimation tools are described further in Sections 2.1 and 2.2.

2.1 EPA EXPOSURE ESTIMATION TOOL

EPA developed a PCB Exposure Estimation Tool (an electronic spreadsheet) in which total exposure to PCBs from a variety of sources is compared to the reference dose (RfD) for a specific commercial mixture of PCBs known as Aroclor 1254. EPA defines the RfD as, “An estimate of a daily oral exposure for a given duration to the human population (including susceptible subgroups) that is likely to be without an appreciable risk of adverse effects over a lifetime.” Both exposure and the RfD are expressed in units of nanograms of PCBs per kilogram body weight per day (ng kg^{-1} d^{-1}). Details of the EPA methodology and input parameters are available elsewhere (EPA 2009).

PCB exposure from background levels in the environment and indoor air of the School are both considered in the spreadsheet. Background exposure is derived from measured levels of PCBs in food, air, soil, and dust reported in scientific literature and assumptions about age-specific rates of food consumption, inhalation, incidental ingestion, and skin contact with soil and dust. The difference between the RfD for Aroclor 1254 and background exposure is used to calculate PCB exposure at a school that would limit the total exposure rate to a level below the RfD. The concentration of PCBs in indoor air of a school equivalent to that exposure is then calculated from the amount of time in the school and standard age-specific inhalation rates. The analysis is done for a typical individual in each of several age groups.

2.2 SITE-SPECIFIC ASSESSMENT

2.2.1 Overview

EH&E built upon the EPA Exposure Estimation Tool to develop an assessment of school-related PCB exposure that is based upon time-location and ventilation conditions specific to the School. As described below, both time-location patterns and ventilation conditions in the School vary by time of year. Therefore, a temporally-resolved analysis is required to simulate potential exposure to PCBs in indoor air.

The site-specific assessment is based on the day-by-day academic calendar published by LPS. The LPS calendar indicates start and end dates of a school year, distinguishes full days from partial days, and identifies school days and holidays over the course of a calendar year.

The site-specific assessment has a seasonal component as well. The seasonal component reflects the two ventilation strategies available to the School. During temperate seasons when heating is not required inside the School, ventilation rates can be maintained that yield air exchange rates in the range of 2 to 8 per hour. In the remainder of the year, the ventilation system is set to attain air exchange rates of 1 to 4 per hour (approximately half of the previous rates).

By incorporating daily time-location patterns and seasonal heating conditions, the site-specific assessment provides a more accurate simulation of potential exposures than the generic assessment for schools available from EPA. Details of inputs to the site-specific assessment are provided in the remainder of Section 2.2.

2.2.2 Background Exposure

The site-specific assessment relies upon background concentrations of PCBs that were measured at the School, derived from studies of background PCB exposure, or replicated from the EPA Exposure Estimation Tool. Details of the background concentrations of PCBs for the site-specific assessment, including comparisons to the corresponding values used in the EPA assessment for a generic school are described in the following sections.

2.2.2.1 Dietary Exposure

Background rates of exposure to PCBs in food were based on results of a national market basket study of substances in food conducted by the U.S. Food and Drug Administration (FDA) and known as the Total Diet Study (TDS). The site-specific assessment drew upon the most recent (2003) data available from the TDS (FDA 2010). The food types, PCB concentration, and consumption amounts reported by FDA for 2003 are shown in Table 2.1. The average PCB concentration for each food type was calculated across the 4 quarters of sampling during 2003. Non-detect samples were treated as zero. Food consumption rates for the 3 to <6 year age group were based upon the average food-specific consumption rates for 2 and 6 year old children as reported for the TDS. A body weight of 18.6 kilograms (kg) was used for children less than 6 years old.

Table 2.1 PCB Concentrations and Food Consumption Rates for 2-Year and 6-Year Old Children, U.S. Food and Drug Administration Total Diet Study,1997 and 2003

Food Type Containing PCBs	PCB Concentration (ppm) First Qtr	Second Qtr	Third Qtr	Fourth Qtr	Food Consumption Rate ($g\ day^{-1}$)
1997					
Eggs, fried with added fat	ND	ND	0.01 T	ND	6.98 [5.46]
Raisins, dried	ND	ND	0.01 T	ND	1.39 [0.65]
2003					
Salmon, steaks/fillets, baked	0.038	0.016	0.022	0.045	0.84 [1.29]
Catfish, pan-cooked w/ oil	ND	0.017	ND	ND	0.71 [0.98]

PCB polychlorinated biphenyl
ppm parts per million
Qtr quarter
$g\ day^{-1}$ grams per day
ND not detected
T Trace; greater than or equal to the limit of detection but less than the limit of quantification.
[ ] consumption for 6 year old

Background dietary exposure to PCBs in the EPA Exposure Estimation Tool is also based upon the FDA TDS. However, dietary exposure in the EPA assessment is based upon results of the 1997 TDS as listed in Tables 6-24 and 6-25 of the Toxicological

Profile for PCBs published by the Agency for Toxic Substances and Disease Registry (ATSDR 2000). Based upon TDS data available from FDA (FDA 2010), PCBs were detected in one of four samples of each of two food types sampled in the 1997 TDS (see Table 2.1). The concentrations were reported as 'trace', which for the TDS is defined as result greater than the limit of detection but less than the limit of quantitation (MacIntosh et al. 1996). The other three samples from that year for both foods were presumably below the limit of detection.

Table 2.2 Summary of Average Daily Background Dietary Exposure to PCBs in the Site-Specific Assessment and EPA's Assessment for a Generic School

Parameter	Site-Specific (ng kg^{-1} d^{-1})	EPA Generic Assessment (ng kg^{-1} d^{-1})
3 to <6 years	1.9	8
6 to <12 years	1.2	3
Staff	1.7	2
	FDA Total Diet Study, 2003	FDA Total Diet Study, 1997

PCB polychlorinated biphenyl
EPA U.S. Environmental Protection Agency
ng kg^{-1} d^{-1} nanograms of PCBs per kilogram body weight per day
FDA U.S. Food and Drug Administration

Background rates of exposure to PCBs through diet for the site-specific assessment conducted by EH&E and the generic school assessment conducted by EPA are shown in Table 2.2. Because of differences in PCB levels measured in the 1997 and 2003 TDS, site-specific dietary background exposures were lower than those used in the EPA assessment. Interestingly, however, EH&E was not able to reproduce the dietary exposure rate of 8 ng kg^{-1} d^{-1} reported in the EPA Exposure Estimation Tool for the 3 to <6 year age group. The highest background rate of exposure that could be attained directly from the 1997 TDS data was 6.5 ng kg^{-1} d^{-1} based upon the trace levels of PCBs reported for foods in the 1997 market basket study and corresponding food consumption rates and body weight of 12.9 kg for a 2-year old (EPA CSEFH 2008). This unexplained difference represents a source of uncertainty in the assessment.

Use of the 2003 dietary exposure data, rather than the 1997 data, makes the site-specific assessment more current than the EPA assessment. To account for what may be a difference in methods of using the TDS data between EH&E and EPA, a sensitivity analysis was conducted in which background dietary exposure derived from the 2003 TDS for the site-specific assessment was increased by 20%. Details are provided in section 4.2.

2.2.2.2 Non-Dietary Background Exposure

Non-dietary background rates of exposure in the site-specific assessment were identical to the values used by EPA in its generic assessment. However, to evaluate the sensitivity of the results to choices about inputs to the assessment, concentrations of PCBs in background indoor air, soil, and dust reported for homes in New Bedford, Massachusetts were also used to estimate target levels for PCBs in indoor air of the School. The New Bedford background concentrations are greater than the values relied upon by EPA and may reflect the extensive and well documented history of PCB contamination in that community, even when using the data from homes not considered to be impacted ("control homes") in those studies (EPA 2010). Use of the New Bedford data for background concentrations makes results of the sensitivity analysis more conservative, (i.e., unlikely to underestimate actual background exposure), than the EPA generic assessment or the site-specific assessment.

2.2.3 Time in School

The site-specific assessment also relies upon information about time spent inside and outside of the School. Site-specific time-location data were obtained from the Principal and teachers. Details of the site-specific inputs are described in this section and compared to the values used by EPA in its assessment for a generic school.

As shown in Table 2.3, children and staff were reported to spend more days per year and more hours per full day of school in the School in comparison to the generic time-location information relied upon by EPA. However, the academic calendar for the School includes 141 full days of school (7 hours per day) and 41 partial days of school (about 4 hours per day) on the remaining school days. As a result, total time in the School for students is 1,151 hours, approximately 2% less than the 1,180 hours used in the generic assessment conducted by EPA.

Table 2.3 Time-Location Inputs to the EH&E Site-Specific and EPA Generic Assessments

Parameter	Unit	3 to <6 yr	6 to <12 yr	Staff	Basis
EPA Generic Assessment					
School Days	days/year	180	180	185	EPA Exposure Estimation Tool. (EPA, 2009)
School Hours	hour/day	6.5	6.5	8	
Indoors at School	hour/day	6	6	8	
Specialty Classroom Hours	hour/day	NA	NA	NA	
Outdoors at School	hour/day	0.5	0.5	0	
Site-Specific Assessment					
School Days	days/year	182	182	184	Based on information obtained from Principal and teachers, Estabrook School
School Hours	hour/day	7	7	8.5	
Indoors at School	hour/day	6.5	6.5	8.5	
Specialty Classroom Hours	hour/day	1.2	1.1	0	
Outdoors at School	hour/day	0.5	0.5	0	

EH&E Environmental Health & Engineering, Inc.
EPA U.S. Environmental Protection Agency

The site-specific assessment also reflects time-location patterns within the School. This is important because measurements of PCB concentrations in indoor air of the School show that concentrations in interior rooms and rooms with the highest ventilation rates are lower than corresponding levels in rooms around the building perimeter. Air samples collected on September 6, 2010, indicate that the median PCB concentration in homeroom classes was approximately twice the median level measured simultaneously in specialty rooms (art room, library and teacher's work room). This relationship in concentration between homerooms and specialty class rooms was carried throughout the site-specific assessment. Differences of concentrations between perimeter and interior rooms are attributable primarily to PCB-containing caulk on the curtain wall in each of the perimeter rooms, but also variability of ventilation rates among rooms.

Art, music, and library classes in addition to wellness activities (nurse, etc.) are held in either interior rooms or rooms with ventilation rates among the highest measured in the

School. Homerooms are located along the building perimeter. Information on time spent in specialty classes was obtained from educational staff of the School and is summarized in the following sections. Accounting for actual time in the building makes the site-specific assessment more accurate for the School than the generic assessment prepared by EPA.

2.2.3.1 Students

Children were reported to be at school from 8:15 a.m. through 3:15 p.m. Every Thursday and 5 additional days were reported to be partial days where children are dismissed at 12:15 p.m. Outdoor recess was reported to account for 0.5 hour per day on full school days and 0.25 hour per day during partial school days, except for days with daytime high temperatures below 30 degrees Fahrenheit (°F). In those cases, children were assumed to have recess inside the gym, thereby increasing time indoors during the heating season. Meteorological records from Logan International Airport for the winter of 2009 – 2010 indicate there were 21 days with daytime highs less than 30 °F.

Information on time-location patterns in the School also showed that students spend time in specialty class rooms such as music, art, library, and physical education, in addition to time in their homeroom class room. Information gathered by EH&E from educational staff indicate that weekly time outside of the homeroom class is 30 minutes in library, 60 minutes in the art room, 60 minutes in the music room, and 60 minutes in the gym per week. For kindergarten children, an additional 10 minutes per day is spent in the music room at dismissal.

2.2.3.2 Educational Staff

Educational staff were reported to be inside the School from 8:00 a.m. to 4:30 p.m. on each school day, except for on short days (each Thursday and assorted other days through the year) when professional development activities were reported to end at 3:15 p.m. Educational staff are assumed to spend the entire time at school in their homeroom classrooms.

2.2.3.3 Lextended Day

Potential exposures to PCBs were also evaluated for children in the Lextended Day Program. Lextended Day is a privately run program that provides after school care for children at the School. The time location pattern for this subgroup of the School community provides an opportunity to evaluate the sensitivity of the site-specific assessment to assumptions about time spent in school. Information provided by the School indicates that the Lextended program officially starts at 3:35 p.m. on full-school days and 12:25 p.m. on half-school days. However, for this site-specific assessment the program was assumed to begin upon dismissal (3:15 p.m. on full-school days and 12:15 p.m. on partial school days) and end at 6:00 p.m. Monday through Friday. Based on information received from teachers at the School, children were assumed to spend equal amounts of time in room 31A, library, gym, and outdoors during Lextended sessions, except for periods of outdoor temperatures less than 30 °F when children in the Lextended Day program were assumed to stay indoors.

2.2.4 Risk Characterization

The site specific assessment relies upon three relevant sources of information for characterizing risk of exposure to PCBs.

1. EPA Reference Dose for Aroclor 1254
2. EPA Reference Dose for Aroclor 1016
3. Epidemiological studies of exposure to PCB-containing construction materials

2.2.4.1 Reference Doses

The RfD derived by EPA for Aroclor 1254 and Aroclor 1016 were both used in the site-specific assessment because of similarities between the mixture of PCB homologs observed in indoor air of the School and the respective commercial mixtures. An illustration of the similarities is provided in Figure 2.1 in which the average homolog distribution in indoor air of the School is compared to the homolog distribution for Aroclor 1016 and Aroclor 1254 reported by the ATSDR (ATSDR 2000). As shown in Figure 2.1, PCBs in the air of the School and Aroclor 1016 are primarily composed of three-chlorine and four-chlorine congeners, while five-chlorine and six-chlorine congeners are the most abundant homologs in Aroclor 1254.

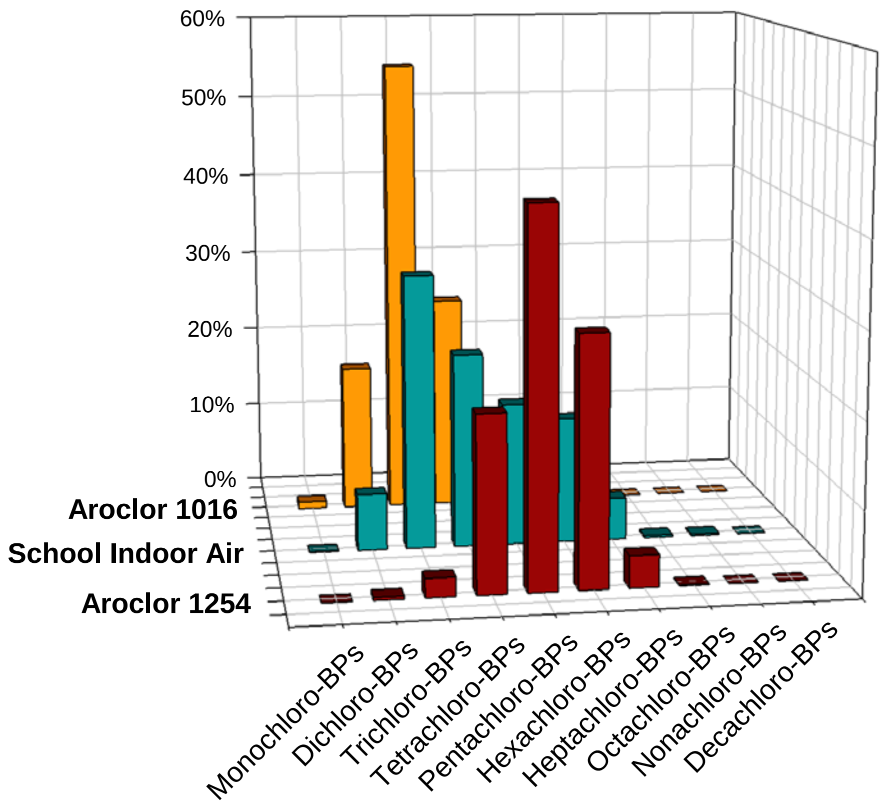

Figure 2.1 Comparison of the Composition of PCBs in Air Samples inside the School to Commercial Mixtures

A summary of both the Aroclor 1254 and Aroclor 1016 RfD is presented in Table 2.4.

Table 2.4 Comparison of EPA Reference Dose for Aroclor 1254 and Aroclor 1016

Parameter	Aroclor 1254[a]	Aroclor 1016[b]
NOAEL	None	0.007 mg kg^{-1} d^{-1}
LOAEL	0.005 mg kg^{-1} d^{-1}	0.028 mg kg^{-1} d^{-1}
Endpoint	Ocular exudate, inflamed and prominent Meibomian glands, distorted growth of finger and toe nails; IgG and IgM antibodies in response to SRBC were reduced after 23 months of exposure but only the IgM antibodies were clearly decreased after 55 months.	Adult monkeys that ingested 0.007 or 0.028 mg kg^{-1} d^{-1} doses of Aroclor 1016 for approximately 22 months showed no evidence of overt toxicity. Effects occurring in the offspring of these monkeys consisted of hairline hyper-pigmentation at greater than or equal to 0.007 mg/kg-day, and decreased birth weight and possible neurologic impairment at 0.028 mg kg^{-1} d^{-1}.[d]
Uncertainty Factors	**300 Total** 10 (Sensitive sub-populations) 3 (Inter-species) 10 (LOAEL instead of NOAEL)	**100 Total** 3 (Sensitive sub-populations) 3 (Inter-species) 3 (Limitations of data) 3 (subchronic to chronic)
RfD (Oral)	0.00002 mg kg^{-1} d^{-1} (20 ng kg^{-1} d^{-1})	0.00007 mg kg^{-1} d^{-1} (70 ng kg^{-1} d^{-1})
Confidence in Oral RfD	Study—medium Database—medium RfD—medium	Study—medium Database—medium RfD—medium

EPA U.S. Environmental Protection Agency
NOAEL no observed adverse effect level
LOAEL lowest observed adverse effect level
mg kg^{-1} d^{-1} milligrams per kilograms per day
RfD reference dose
ng kg^{-1} d^{-1} nanograms of PCBs per kilogram body weight per day

[a] EPA Integrated Risk Information System (IRIS). Aroclor 1254 (CASRN 11097-69-1). Accessed September 16, 2010. http://www.epa.gov/iris/subst/0389.htm

[b] EPA Integrated Risk Information System (IRIS). Aroclor 1016 (CASRN 12674-11-2). Accessed September 16, 2010. http://www.epa.gov/iris/subst/0462.htm

[c] Principal and Supporting References for Oral RfD for Aroclor 1254:
Arnold DL, Bryce F, Stapley R, et al. 1993a. Toxicological consequences of Aroclor 1254 ingestion by female Rhesus (Macaca mulatta) monkeys, Part 1A: Prebreeding phase - clinical health findings. Food Chem. Toxicol. 31: 799-810.
Arnold DL, Bryce F, Karpinski K, et al. 1993b. Toxicological consequences of Aroclor 1254 ingestion by female Rhesus (Macaca mulatta) monkeys, Part 1B: Prebreeding phase - clinical and analytical laboratory findings. Food Chem. Toxicol. 31: 811-824.
Tryphonas H, Hayward S, O'Grady L, et al. 1989. Immunotoxicity studies of PCB (Aroclor 1254) in the adult rhesus (Macaca mulatta) monkey - preliminary report. Int. J. Immunopharmacol. 11: 199-206.
Tryphonas H, Luster MI, Schiffman G, et al. 1991a. Effect of chronic exposure of PCB (Aroclor 1254) on specific and nonspecific immune parameters in the rhesus (Macaca mulatta) monkey. Fund. Appl. Toxicol. 16(4): 773-786.
Tryphonas H, Luster MI, White KL, et al. 1991b. Effects of PCB (Aroclor 1254) on non-specific immune parameters in Rhesus (Macaca mulatta) monkeys. Int. J. Immunopharmacol. 13: 639-648.

[d] Principal and Supporting References for Oral RfD for Aroclor 1016:
Barsotti DA and van Miller JP. 1984. Accumulation of a commercial polychlorinated biphenyl mixture (Aroclor 1016) in adult rhesus monkeys and their nursing infants. Toxicology. 30: 31-44.
Levin ED, Schantz SL and Bowman RE. 1988. Delayed spatial alternation deficits resulting from perinatal PCB exposure in monkeys. Arch. Toxicol. 62: 267-273.
Schantz SL, Levin ED, Bowman RE, et al. 1989. Effects of perinatal PCB exposure on discrimination-reversal learning in monkeys. Neurotoxicol. Teratol. 11: 243-250.
Schantz SL, Levin ED and Bowman RE. 1991. Long-term neurobehavioral effects of perinatal polychlorinated biphenyl (PCB) exposure in monkeys. Environ. Toxicol. Chem. 10: 747-756.

In both the EH&E site-specific and EPA generic assessments, the calculated rate of exposure to PCBs is compared to the RfD for Aroclor 1254, a manufactured mixture of PCBs that was used for many purposes, including as a component of construction materials commonly found in schools. The EPA derived the RfD for this mixture of PCBs by applying an uncertainty factor of 300 to the lowest dose of PCBs found to produce an effect during a laboratory test with animals. In the laboratory test, rhesus monkeys were fed high concentrations of PCBs for more than five years. The lowest amount of PCBs fed to the monkeys was about 500 times higher than levels to which humans routinely encounter PCBs in food and air. EPA took the lowest dose that led to any adverse effects in the monkeys, and then divided that by 300 to account for uncertainties about differences between monkeys and humans, duration of the test compared to duration of a lifetime, and differences in how sensitive individuals might respond. The resulting value is the RfD that is used as a benchmark for evaluating exposures to Aroclor 1254.

The RfD for Aroclor 1016 (70 ng kg^{-1} d^{-1}) was also derived from laboratory studies with rhesus monkeys and is 3.5 times higher than the RfD for Aroclor 1254 (20 ng kg^{-1} d^{-1}). The direction of the difference indicates that the mixture of PCBs in Aroclor 1016 is less potent toxicologically than Aroclor 1254. Use of the RfD for both Aroclor 1254 and Aroclor 1016 provides a plausible range of dose-response information for use in the site-specific assessment considering the mixture of PCBs present in indoor air of the School.

2.2.4.2 Epidemiologic Studies

In addition to reliance upon RfDs, risk assessments for PCB exposure through inhalation can also be informed by evaluating results of relevant epidemiological studies. The vast majority of epidemiological studies that report associations between human health and PCBs are based on (i) contrasts in the prevalence of a certain health status between groups with differential levels of PCBs in blood serum or other tissue or (ii) contrasts of PCB concentrations in blood serum or other tissue between groups with and without a specific illness or disease.

EH&E performed a detailed search and review of the scientific literature that focused on PCB body burdens among occupants of buildings with indoor air impacted by PCB-containing construction materials. Findings from those studies were considered in the context of exposure conditions within the School, primarily the concentrations of PCBs measured in indoor air of the building.

2.2.5. Assessment Scenarios

The site-specific exposure calculator was applied to four scenarios (A – D) that were developed to address specific assessment questions. In each scenario, the output of the analysis is an estimate of the average concentration of PCBs in indoor air of the School that yields an exposure rate equivalent to the RfD for Aroclor 1254 and Aroclor 1016, including background exposures (Scenario C only accounts for exposures at the School). For scenarios A – C, exposure calculations were performed for several age groups: 3 to less than 6 years old, 6 to less than 12 years old, and staff.

2.2.5.1 Scenario A: November 7, 2010 – November 6, 2011

This scenario addresses a target for PCBs in indoor air of the School in consideration of exposures over one calendar year beginning the week of November 7, 2010. The start date for this scenario reflects an annual period during which students, teachers, and staff members are expected to occupy their regularly assigned rooms and engage in their regularly scheduled activities.

2.2.5.2 Scenario B: August 29, 2010 – August 28, 2011

This scenario addresses a target for PCBs in indoor air of the School in consideration of exposures over one calendar year beginning on the first day of school for students in the 2010 – 2011 academic calendar. The date range for this scenario reflects a full year that includes the entire period during which measurements of indoor air PCB levels are available and the School was occupied according to a regular schedule. As a result, this scenario considers actual conditions in the School during the present academic year in the estimate of target concentrations for the remainder of the year. Details of exposure concentrations and activity patterns for Scenario B are provided in Table 2.5 and 2.6.

Table 2.5 Timeline for Scenario B of the Site-Specific Risk Assessment, Estabrook Elementary, Lexington, Massachusetts

Time Period	Number of Full-Day Equivalent School Days	School Activities	Building Remediation Activity
8/29/2010 through 9/11/2010	1.5/2	Partial day on 8/31 for K students; full day on 9/1; no students inside school building during second week of school	PCB-containing caulk removed from exterior window frames and window glazing encapsulated
9/12/2010 through 9/18/2010	4.5	Regular school schedule	Improved ventilation throughout school; supplemental ventilation in Rooms 1 – 4
9/19/2010 through 9/25/2010	4.5	Regular school schedule	Further improvements to ventilation; continued supplemental ventilation in Rooms 1 – 4; encapsulation of interior caulk.
9/26/2010 through 11/6/2010	24	Regular school schedule. All kindergarten classes in modular rooms (Room7A-C)	Evaluation of remaining contributions to indoor air PCBs, Rooms 1 – 6.
11/7/2010 through 8/28/2011	123	Regular school schedule	To be determined

PCB polychlorinated biphenyl

Table 2.6 Inputs for Scenario B of the Site-Specific Risk Assessment, Estabrook Elementary, Lexington, Massachusetts

Time Period	Homeroom Indoor Air PCB Concentration (ng m^{-3})	Special Classroom PCB Concentration (ng m^{-3})
3 to <6 Years		
8/31/2010 through 9/11/2010	460	460
9/12/2010 through 9/18/2010	120	190
9/19/2010 through 9/25/2010	63	97
9/26/2010 through 11/6/2010	5	5
6 to <12 Years		
8/31/2010 through 9/11/2010	460	460
9/12/2010 through 9/18/2010	370	190
9/19/2010 through 9/25/2010	180	97
9/26/2010 through 10/2/2010	180	97
10/3/2010 through 11/6/2010	310	194
Staff		
8/31/2010 through 9/11/2010	460	460
9/12/2010 through 9/18/2010	370	190
9/19/2010 through 9/25/2010	180	97
9/26/2010 through 11/6/2010	180	97
10/3/2010 through 11/6/2010	310	194

PCB polychlorinated biphenyl
ng m^{-3} nanograms per cubic meter

2.2.5.3 Scenario C: Time in School August 29, 2010 – August 28, 2011

This scenario addresses a target for PCBs in indoor air of the school that is specific to exposures occurring during school hours, a period during which the town of Lexington has an ability to influence concentrations and activities. The exposure concentrations and activity patterns for Scenario C are the same as those of the in-school period of Scenario B.

2.2.5.4 Scenario D: Kindergarten – Twelfth Grade

This scenario addresses a target for PCBs in indoor air of the School in consideration of exposures over a hypothetical 13-year period in the LPS system. Long-term average exposure is considered for a student who is currently a fifth grader at the School and who was also a student at Estabrook School from Kindergarten through fourth grade. The time scale and cohort for this scenario reflects a 6-year accumulation of School-related exposure. Because these children are assumed to have the longest duration of School-related background exposure to PCBs, the results for this group are also health protective for children who are currently in Grade 4 or lower. Details of exposure concentrations and activity patterns for Scenario D are provided in Table 2.7.

Table 2.7 Inputs of Annual Average Concentrations of PCBs in Indoor Air to the Site-specific Risk Assessment as well as Selected Intermediate Outputs for Scenario D, Estabrook Elementary, Lexington, Massachusetts

School	Estabrook Elementary School						Middle School			High School			
Grade	**K**	**1**	**2**	**3**	**4**	**5**[c]	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Inputs to the Site-Specific Risk Assessment													
School indoor concentration ($ng\ m^{-3}$)	459[a]	459	459	459	459		45[b]	45	45	45	45	45	45
Intermediate Outputs of the Site-Specific Risk Assessment													
School-related exposure ($ng\ kg^{-1}\ day^{-1}$)	36	36	36	36	36		1.6	1.6	1.6	1.6	1.4	1.4	1.4
Background exposure ($ng\ kg^{-1}\ day^{-1}$)	6.7	4.2	4.2	4.2	4.2		2.9	2.9	2.9	2.9	2.7	2.7	2.7
Total exposure ($ng\ kg^{-1}\ day^{-1}$)	43	28	28	28	28		4.5	4.5	4.5	4.5	4.1	4.1	4.1

PCBs polychlorinated biphenyls
$ng\ m^{-3}$ nanograms per cubic meter
$ng\ kg^{-1}\ day^{-1}$ nanograms of PCBs per kilogram body weight per day

a Median concentration of total PCBs in indoor air of the School measured on July 22, 2010
b Median concentration of total PCBs in indoor air of Clarke Middle School on July 21, 2010
c Concentration for Grade 5 is calculated subject to period average exposures for grades K – 4 and 6 – 12 and both the Aroclor 1254 and Aroclor 1016 benchmarks

3.0 RESULTS

3.1 BACKGROUND EXPOSURE

Aggregate background exposure for ages 3 to less than 6 years old was 4.6 and 5.7 ng kg^{-1} d^{-1} for school and non-school days, respectively. Background exposures were lower for 6 - <12 year old children and adults. PCBs in food and indoor air outside of school accounted for greater than 95% of aggregate background exposure for all age groups.

Table 3.1 Background Exposure by Pathway and Age Group, Site-Specific Assessment, Estabrook Elementary School, Lexington, Massachusetts

Pathway	**Exposure (ng kg^{-1} day^{-1})**	
	School Day	**Non-school Day**
3 to <6 Years		
Indoor Inhalation	2.6	3.7
Outdoor Inhalation	0.02	0.02
Ingestion-soil/dust	0.03	0.03
Dermal-dust	0.01	0.01
Diet	1.9	1.9
Aggregate Background	**4.6**	**5.7**
6 to <12 Years		
Indoor Inhalation	1.7	2.4
Outdoor Inhalation	0.02	0.02
Ingestion-soil/dust	0.02	0.02
Dermal-dust	0.01	0.01
Diet	1.2	1.2
Aggregate Background	**3.0**	**3.7**
Staff		
Indoor Inhalation	0.85	1.4
Outdoor Inhalation	0.01	0.01
Ingestion-soil/dust	0.01	0.01
Dermal-dust	0.01	0.01
Diet	1.7	1.7
Aggregate Background	**2.6**	**3.1**

ng kg^{-1} day^{-1} nanograms of PCBs per kilogram body weight per day

3.2 SITE-SPECIFIC TARGETS FOR PCBS IN INDOOR AIR

The average concentrations of PCBs in indoor air of the School that yield time-weighted average daily exposures equivalent to the RfDs for Aroclor 1016 and 1254 are listed in

Table 3.2. The concentrations for a child in the age range of 3 to less than 6 years old range from 230 ng m^{-3} based on the Aroclor 1254 RfD for Scenario A and B to 1,100 ng m^{-3} for Scenario C and the Aroclor 1016 RfD. Because children in this age group are assumed to have the highest rate of background exposure to PCBs, these concentrations are health protective for older ages as well. These target indoor air concentrations for the School reflect the background PCB exposure rates and in-school conditions described previously for each scenario.

Table 3.2 Estimated Targets for Concentrations (ng m^{-3}) of Polychlorinated Biphenyls in Indoor Air of Estabrook Elementary School, Lexington, Massachusetts, for Three Scenarios

Scenario		**Target Concentration in Indoor Air**	
Identifier	**Description**	**Aroclor 1254 RfD[a]**	**Aroclor 1016 RfD[b]**
3 to <6 Years			
A	November 7, 2010 – November 6, 2011	<230	<990
B	August 29, 2010 – August 28, 2011	<230	<1,010
C	Time in School, August 29, 2010 – August 28, 2011	<310	<1,100
6 to <12 Years			
A	November 7, 2010 – November 6, 2011	<380	<1,500
B	August 29, 2010 – August 28, 2011	<380	<1,500
C	Time in School, August 29, 2010 – August 28, 2011	<460	<1,600
Staff			
A	November 7, 2010 – November 6, 2011	<450	<1,800
B	August 29, 2010 – August 28, 2011	<460	<1,800
C	Time in School, August 29, 2010 – August 28, 2011	<540	<1,900

ng m^{-3} nanograms per cubic meter
RfD reference dose for chronic exposure developed by U.S. Environmental Protection Agency

[a] RfD of 20 nanograms Aroclor 1254 per kilogram body weight per day.
[b] RfD of 70 nanograms Aroclor 1016 per kilogram body weight per day.

The site-specific indoor air target concentration for Scenario D, a current fifth grade student who attended Estabrook from kindergarten through fourth grade, is 1,400 ng m^{-3}.

3.3 SIMULATED SITE-SPECIFIC TOTAL EXPOSURE

As described in Section 2.1, daily exposure to PCBs from background sources while at the School were calculated for Scenarios A – C based on the academic calendar for LPS. Maximum concentrations of PCBs in indoor air of the School were computed from the difference between background exposure rates and the RfD for Aroclor 1254 and Aroclor 1016, respectively. Time-weighted average indoor air concentrations of PCBs at the School were subject to the heating and non-heating season constraints described in Section 2.2.

An example of the time-series of temporal variation in exposure simulated by this approach is illustrated in Figure 3.1 using results for the 3 – 6 years age group. Although the simulation was conducted with temporal resolution of one day, weekly average results are shown in the figure to facilitate viewing. Daily average exposures over each week are the sum of background and school-related exposure. The profile shown in the figure reflects an annual average concentration of PCBs in classroom air of 230 ng m^{-3}, which corresponds to an average daily exposure equal to the RfD for Aroclor 1254 (20 ng kg^{-1} d^{-1}). Daily average minima shown in the plot correspond to weeks when school is not in session and reflect background exposure. Daily average maxima correspond to weeks when school is in session during the heating season and reflect background plus school-related exposure. Values between the minimum and maximum represent weeks that include both school and non-school days.

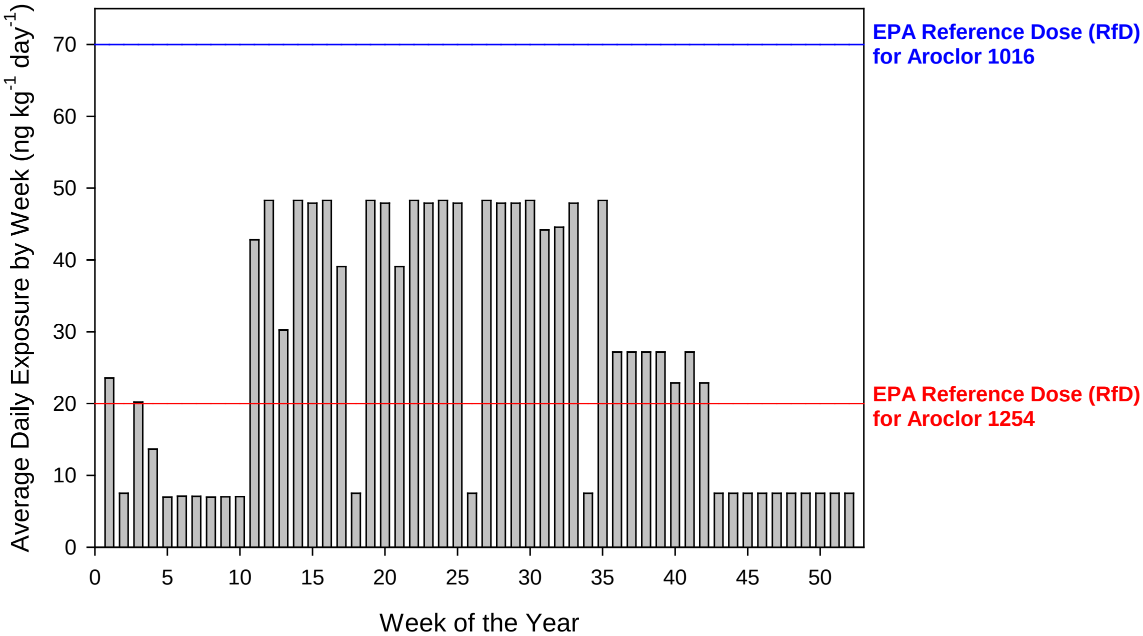

Figure 3.1 Average Daily Exposure to PCBs Arising from an Annual Average Concentration of PCBs in Classroom Air of 230 ng m^{-3} and Site-Specific Background Sources of Exposure, which Leads to Annual Average Daily Exposure of 20 ng kg^{-1} d^{-1}, the EPA Reference Dose for Aroclor 1254

3.4 REVIEW OF EPIDEMIOLOGIC STUDIES

EH&E has not found any study to date that reports adverse health effects in children or adults who have occupied buildings with airborne levels of PCBs equivalent to those in the School. In addition, studies published in the scientific literature indicate that exposure to PCBs in indoor air of buildings with concentrations similar to the School does not result in increased amounts of total PCBs in the blood when compared to a reference population.

Gabrio et al. (2000) studied PCBs in blood of 151 teachers from 3 schools with PCB-containing materials (mean PCB indoor air concentration: 635 ng m^{-3}, 3,541 ng m^{-3}, 7,490 ng m^{-3}) and 2 control schools. Concentrations of three higher chlorinated PCB congeners in blood did not differ among the four groups (control schools considered as a single group). No statistically significant difference was found in PCB congener levels for occupants of the school with the lowest average PCB concentration indoor air of 635 ng m^{-3}, although the average concentration was nominally higher compared to the control group (Table 3.3). In addition, the lighter PCBs comprised a small fraction of total PCB body burden. Consequently, Gabrio et al. (2000) concluded that indoor air concentrations composed of mixtures of lower chlorinated PCBs below 1,000 ng m^{-3} do not have a discernible effect on the overall PCB level in blood of those individuals.

Table 3.3 Overview of PCB Concentrations in Indoor Air and Blood from a Study of Schools in Germany[1]

Parameter	School 1	School 2	School 3	Control
Total PCBs in Air (ng m^{-3})				
Average (max)	635 (1,587)	7,490 (10,655)	3,541 (10,125)	NA
PCBs in Blood (μg/L)				
PCB 28	0.045	0.098	0.057	0.035
PCB 138	0.66			
PCB 153	0.95			
PCB 180	0.7			
Total PCBs	"Taking together the present results and observations of other authors, it may be concluded that indoor air concentrations with PCB mixtures of low and medium chlorination, that are below 1,000 ng m^3 have no observable effect to the PCB level of exposed individuals."			

PCB polychlorinated biphenyl
ng m^{-3} nanograms per cubic meter
NA not available
μg/L micrograms per liter

[1] Gabrio T, et al. 2000. PCB-blood levels in teachers, working in PCB-contaminated schools. *Chemosphere 40*: 1055-1062.

Similar results are reported in other epidemiologic investigations of adults in schools with PCB-containing construction materials. In a study of 18 teachers in a school with PCBs present in indoor air (maximum indoor air concentration >12,000 ng m^{-3}), the authors report an increase in low chlorinated congeners (PCB 28 and PCB 52) in blood but conclude that this contribution is small when compared to total PCB body burden (Schwenk, et al. 2002).

Additional epidemiologic studies conducted in schools also report a lack of association between body burdens of total PCBs and indoor air concentrations in the range of, or higher than, the levels observed at the School. Blood samples taken from 77 teachers in a building with indoor air PCB concentrations greater than 1,000 ng m^{-3} in several rooms did not contain elevated levels of PCBs (Burkhardt, et al. 1990). PCBs in blood of 18 teachers working in a school with PCB-containing construction materials (range:

4,580 – 13,500 ng m^{-3}) were not statistically different from an age and gender matched control population of 18 teachers from a control building (Ewers, et al. 1998). A similar lack of association between PCB body burden and indoor air concentrations was reported in a study of 32 women who worked in nursery schools with PCB-containing construction materials (Heudorf, et al. 1995) (average air concentration: 709 ng m^{-3}; maximum air concentration: 1,489 ng m^{-3}) and in a study of staff and students (Heudorf, et al. 1996) (maximum air concentration: 3,200 ng m^{-3}).

Specific to studies of children, PCBs in blood plasma of 377 students attending a school with elevated PCBs in indoor air (median: 2,044 ng m^{-3}; range: 690 – 20,800 ng m^{-3}) were compared to 218 students in a school without PCB-containing construction materials (Liebl, et al. 2004). The authors report higher concentrations of lower chlorinated congeners (PCB 28, 52, 101) in students of the school with PCB-containing construction materials but no difference in higher chlorinated congeners between the two groups. Total concentrations of PCBs in both groups were dominated by higher molecular weight congeners that were present at concentrations 1 to 2 orders of magnitude greater than the lower molecular weight congeners. As a result, the authors conclude that, “the detected excess body burden was very low indicating no additional health risk.” (Liebl, et al. 2004).

A study specific to elementary school children found that PCB concentrations in blood for those attending class in a building with PCB-containing construction materials (indoor air concentration up to 10,220 ng m^{-3}) were not different when compared to children from five representative areas (Neisel, et al. 1999).

EH&E’s own study of over 80 individuals in a building with elevated levels of PCBs in indoor air found no association between levels of over 50 specific congeners in blood serum and length of residency in the building.[1] Instead, variability of PCB levels in blood serum of this cohort was primarily related to age and gender, probably reflecting accumulation from food over time and differences in diet or other lifestyle attributes between men and women.

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1 Although unpublished to protect confidentiality of the client and participants, the design and results of this study were reviewed by EPA Region 1 and an independent group of public health scientists.

4.0 DISCUSSION

This interim report describes the current version of a site-specific risk assessment conducted to identify targets for concentrations of PCBs in indoor air of the School and to inform risk management and risk communication activities. Further refinements to the site-specific risk assessment will be made if additional information on potential exposures becomes available.

The site-specific risk assessment produced target indoor air concentrations of PCBs for children ages 3 to less than 6 years old that are approximately 2-fold greater than results derived for the same age group in a generic assessment conducted by EPA. Differences between the site-specific and EPA assessment are attributable primarily to three factors. First, background exposure to PCBs in the site-specific assessment is approximately 50% lower than in the EPA assessment. The difference in background exposure is the result of using the latest information on PCB levels in food available from the FDA. Second, children at the School spend approximately 2% less time at the School compared to the assumptions made by EPA. Partial school days every Thursday and selected other days is a large source of the difference in time at school between the site-specific and EPA risk assessments. Third, children at the School spend approximately 20% of their time each week in special classes (e.g., art, music, and library) located outside of their regular classroom and where airborne PCB concentrations in those locations have been shown to be approximately 50% less than in regular classrooms.

4.1 Strengths of the Site-Specific Risk Assessment

A principal strength of this assessment is the use of time-location patterns specific to students and staff of the School. Information on time-location patterns was initially gathered through a survey instrument supplied to the School administration by EH&E. Subsequently, EH&E interviewed a group of teachers and the principal to validate responses to the questionnaire, obtain refined information on daily start and end times at the School, and ascertain details on special classes and services offered in the School. This information was used to explore the sensitivity of results to deviations from the baseline time-location patterns described in the Methodology section.

Use of updated information on dietary exposure to PCBs is another positive attribute of this assessment. The updated information is based on the most recent (2003) FDA study of PCBs in food in which samples of over 250 foods were gathered from retail outlets in four regions of the United States. The 2003 FDA data yield lower background exposures than the dietary intake estimates made by the EPA in its risk assessment for a typical school. The EPA relied upon incomplete data from an earlier (1997) dietary intake study conducted by the FDA. The difference between the 1997 and 2003 dietary exposure data is consistent with the commonly accepted scientific understanding that background concentrations of PCBs in the environment and food supply are decreasing over time.

The use of several exposure scenarios is another significant attribute of the site-specific risk assessment. Presentation of multiple scenarios was intended to address the range of interests expressed in the Committee meetings to date. Consideration of both prospective and retrospective exposures, as well as total (i.e., background plus school) and school-only exposures, is intended to inform risk management options more fully than reliance on only a single exposure scenario.

Consideration of site-specific information on measured concentrations of PCBs in the School is another strength of this assessment. Exposure concentrations for the School that were incorporated into the assessment include measurements of PCBs in indoor air, outdoor air, soil, and interior surfaces. In addition to being site-specific and current, these measurements are fully quality assured. Moreover, the provenance and representativeness of these data are also known; attributes which are often not well characterized in many risk assessments.

Incorporation of the RfD for both Aroclor 1016 and Aroclor 1254 as health protective benchmarks also contributes to the rigor of the site-specific assessment. Consideration of both RfDs is an explicit recognition of the similarities between the mixture of PCBs in indoor air of the School and the two commercial mixtures. The use of both benchmarks provides a more complete range of results for consideration by risk managers and the School community.

Finally, the site-specific risk assessment addresses the limitations of animal-based toxicology studies to inform risk characterization and risk management in part by including an evaluation of relevant epidemiological studies. In the case of PCBs in indoor air of schools, no studies have yet been published of health status among occupants of buildings with PCB-containing construction materials in comparison to a reference group. However, epidemiological studies of PCB body burdens among occupants of buildings with PCB-containing construction materials and elevated concentrations of PCBs in indoor air of those buildings have been conducted.

EH&E's evaluation of those studies has shown that exposure to PCBs in indoor air of buildings at concentrations similar to, and in most cases much higher than, levels measured in the School does not result in increased amounts of total PCBs in the blood when compared to a reference population. The lack of association between body burdens and occupancy of buildings with indoor air concentrations in the range of those measured in the School is an indication that PCB vapors at the School are unlikely to pose a substantive risk to health.

Several epidemiologic studies specific to inhalation exposure in PCB-contaminated schools found elevated concentrations of lighter PCB congeners in blood compared to reference groups. However, the contribution of these lighter congeners to total PCB body burden was minimal. Further, for risk-based comparisons using published RfDs, it is important to consider that the lighter congeners comprise a small fraction of Aroclor 1254 (<3% di- and tri-chlorinated biphenyls) whereas Aroclor 1016 is dominated by lighter congeners (>70% di- and tri-chlorinated biphenyls). EPA's current approach to evaluating risk associated with PCB inhalation exposure in schools is based on the RfD for Aroclor 1254. The epidemiologic evidence suggests that evaluations of health risk associated with inhalation of PCBs released from building materials are characterized equally well by using the RfD for Aroclor 1016 or Aroclor 1254. The choice of which RfD to use can have significant impacts on evaluating exposure risks in PCB-contaminated buildings because the RfD for Aroclor 1016 is 3.5 times higher than the RfD for Aroclor 1254.

4.2 Uncertainty

In addition to having numerous notable strengths, the site-specific risk assessment is also subject to uncertainty about actual exposure to PCBs and the level of health risk that corresponds to that exposure. As cited in the World Health Organization guidance on *Uncertainty and Data Quality in Exposure Assessment*, consideration of these uncertainties is an important element of a human health risk assessment.

> *"Constraints, uncertainties, and assumptions having an impact on the risk assessment should be explicitly considered at each step in the risk assessment and documented in a transparent manner. Expression of uncertainty or variability in risk estimates may be qualitative or quantitative, but should be quantified to the extent that is scientifically achievable."*

Incomplete information about actual levels of background exposure to PCBs is one area of uncertainty in the site-specific risk assessment. As part of a sensitivity analysis, estimates of background exposure of the School community were re-calculated based upon concentrations of PCBs in background outdoor air, soil, and interior dust measurements made in reference homes located in New Bedford, Massachusetts (Vorhees et al., 1997 and 1999). Because New Bedford has a history of significant PCB contamination, there is some concern that reference areas in New Bedford are not representative of background PCB exposures in the School community. In particular, reliance on the New Bedford data may lead to overestimates of background PCB exposure among occupants of the School. Nonetheless, the results of this sensitivity analysis indicate that the target indoor air concentrations would decrease by 10% for Scenario A and B, and 19% for Scenario D, assuming background exposure in the School community is more reflective of New Bedford, Massachusetts, than national average values.

Actual exposure to PCBs in food for the School community is another source of uncertainty in the site-specific risk assessment. As noted previously in this report, estimates of background dietary exposure were based upon results of the 2003 TDS, a national survey of PCBs and other substances in food conducted by the FDA. These dietary exposure data indicate that PCBs are present above FDA method detection limits in only two foods: salmon and catfish. The estimate of background dietary exposure for children ages 3 to less than 6 years old assumes that a 1.07 gram serving of salmon and 0.85 gram serving of catfish is consumed every day on average, according to results of a food consumption survey conducted by the U.S. Department of Agriculture. Infrequent consumers of these fish may experience substantially less dietary ingestion of PCBs than the estimate of 2 ng kg^{-1} d^{-1} derived from the 2003 data.

Another interesting feature of the dietary data is that background exposure to PCBs through food for the 3 to less than 6 years old age group decreased approximately 60% between the 1997 and 2003 FDA surveys of foods. The downward trend suggested by these data is consistent with the commonly accepted scientific understanding that background concentrations of PCBs in the environment are decreasing over time. In one recent study, per capita dietary intake of PCBs was reported to be 33 ng d^{-1} or approximately 0.5 ng kg^{-1} d^{-1} for a 70 kg adult (Schecter et al. 2010). This exposure rate is approximately three times less than background dietary exposure estimated from the 2003 TDS data and four times less than the EPA estimates derived from 1997 TDS data. Therefore, current dietary exposure to PCBs in the School community may be lower than estimates derived from the 2003 data. The effect of any such difference on the results of this assessment would be to increase PCB levels in indoor air of the School that are commensurate with rates of PCB exposure equivalent to the RfD for either Aroclor 1254 or Aroclor 1016.

Variability of dietary exposure to PCBs among individuals raises other aspects of accounting for background exposure in the site-specific risk assessment. For instance, food consumption patterns of people who occupy the School have not been quantified. Likewise, PCB levels in foods of markets in and around Lexington, Massachusetts have not been quantified. As a result, no site-specific information on background dietary exposure to PCBs is available at this time. Moreover, ingestion of foods that contain PCBs cannot be controlled, or perhaps even influenced, by the Town or School. The lack of complete information about background dietary exposure to PCBs, and variability of dietary intake among individuals, contributes to uncertainty in the site-specific risk assessment.

The potential impact of uncertainty around dietary ingestion was evaluated by conducting a sensitivity analysis. First, uncertainty surrounding data differences from the 1997 and 2003 FDA diet data was evaluated. The method used in the site-specific risk assessment to estimate daily dose from food ingestion used concentrations reported in 2003 for two types of food with detectable levels of PCBs (catfish and salmon); all other food types had PCBs less than the limit of detection and were therefore excluded from the analysis. When this approach was applied to the 1997 data used in EPA's generic assessment, our estimate of daily dose was approximately 20% less than the 8 ng kg^{-1} day^{-1} reported by EPA. Unfortunately, detailed information on how EPA handled data for foods with non-detectable levels of PCBs is unavailable and the 20% discrepancy cannot be resolved. To estimate the impact of this uncertainty in the site-specific risk assessment, we re-calculated the indoor air target levels assuming a 20% increase in background dose from diet which yielded values of 220 ng m^{-3} for scenarios A and B (Scenario C estimates remain unchanged). Second, uncertainty exists when using 2003 diet data to reflect exposures in 2010. Background dietary exposure decreased by approximately 60% between EPA's estimate using 1997 data and the site-specific assessment using data from 2003 (8 v. 2 ng kg^{-1} day^{-1}). Assuming a linear change over time, dietary dose in 2010 would be expected to be approximately 1.2 ng kg^{-1} day^{-1} (2 ng kg^{-1} day^{-1} * 60%). This would correspond to target air levels of 240 ng m^{-3} for Scenarios A and B (as before, Scenario C estimates remain unchanged).

Assumptions about prior exposure to PCBs in the School are a source of uncertainty about the results for Scenario C, which consider 5 years of retrospective exposure. Actual concentrations of PCBs in indoor air of the school during that time period are unknown. It is known, however, that concentrations are related to ventilation and ambient conditions. Many factors influence ventilation including time of day, exhaust fan operation, supply fan operation, thermostat setting, and use of operable windows. These factors are likely to have varied over time and among rooms in the School. With regard to ambient conditions, it should be noted that first round of air samples from the School was collected under summer conditions, which because of elevated temperatures, may represent worst-case conditions for emissions of PCBs to the air. In EH&E's experience, PCB levels in buildings often change with the seasons, with greatest emissions found in the heat of the summer months.

Assumptions about time in school are another source of uncertainty in the assessment. Evaluation of target indoor air concentrations for children in the Lextended after-school program is useful for characterizing the upper bound of potential targets for indoor air concentrations of PCBs. Results for the Lextended Day scenario are shown in Table 4.1 and are approximately 25% lower than the baseline estimates.

Table 4.1 Lextended School Scenario

Identifier	Description	Percent Contribution to the Total Exposure to reach RfD for Aroclor 1254			Estimated Target Indoor PCB Concentration (ng m^{-3})
		Background (%)	School (%)	Lextended School Program (%)	
3 to <6 Years					
A	November 7, 2010 – November 6, 2011	25	57	19	<170
B	August 29, 2010 – August 28, 2011	25	56	20	<170
C	Time in School, August 29, 2010 – August 28, 2011	0	75	26	<230
6 to <12 Years					
A	November 7, 2010 – November 6, 2011	17	63	21	<280
B	August 29, 2010 – August 28, 2011	17	63	21	<290
C	Time in School, August 29, 2010 – August 28, 2011	0	75	25	<350

RfD reference dose
PCB polychlorinated biphenyl
ng m^{-3} nanograms per cubic meter

The range of results derived from the RfD for Aroclor 1016 and Aroclor 1254 also illustrates the scientific uncertainty present in the site-specific risk assessment. Targets for indoor air concentrations obtained from the two RfDs are intended to be protective of health and to reflect exposure concentrations and time-location patterns that are representative of students, teachers, and staff of the School. As shown in Figure 2.1, the distribution of PCB homologs in indoor air of the School is not identical to the homolog distribution for either Aroclor 1016 or Aroclor 1254. Instead, the observed homolog distribution appears to have elements of both commercial mixtures. While other commercial mixtures of PCBs, such as Aroclor 1221 or Aroclor 1242, may also be similar to the distribution of homologs observed in the air of the School, EPA has yet to establish health protective guideline values (e.g., a RfD) for those mixtures of PCBs. Nonetheless, the target indoor air concentrations that correspond to the Aroclor 1016 and Aroclor 1254 RfDs represent a range of health protective results that can be considered by risk managers.

Uncertainty in the site-specific risk assessment is also related to the methods and information used by EPA to develop the RfDs for Aroclor 1016 and Aroclor 1254. As described in detail by EPA and summarized in Table 2.4, the RfDs were derived from laboratory studies of rhesus monkeys that ingested high concentrations of the respective commercial mixtures. The lowest amount of PCBs fed to the monkeys was up to 500 times higher than levels to which humans routinely encounter PCBs in food and air. The EPA took the lowest dose that led to any adverse effects in the monkeys, and then divided that by 100 or Aroclor 1016 and by 300 for Aroclor 1254 to account for uncertainties about differences between monkeys and humans, duration of the test, sensitive individuals, and other limitations of the tests. In addition to relying upon those extrapolations when estimating target indoor air concentrations of PCBs in schools, both EPA and EH&E assumed that PCBs present the same hazards to health whether ingested or inhaled.

Extrapolation of toxicological results from laboratory studies of animals fed high amounts of commercial mixtures of PCBs to inhalation of much lower amounts of a different mixture of PCBs in schools presents substantial scientific uncertainty. As noted previously, EPA applied an uncertainty factor of 300 to the lowest dose of PCBs found to produce an effect during the laboratory tests with animals to account for the uncertainty in extrapolating that result to humans. Because the uncertainty factor was applied in only one direction and animals are known to sometimes be more sensitive than humans to effects of chemical exposure, the uncertainty factor is similar to a ‘safety factor’. Regardless of the terminology, the RfDs for Aroclor 1016 and Aroclor 1254 are not based on scientific studies of PCB exposure and effects in humans. In EH&E’s view therefore, the RfDs, and target indoor air concentrations derived from them, are most appropriately characterized as human health protective, but not human health-based. Uncertainty associated with the use of the RfDs as an input to the assessment is addressed in part by knowledge of levels of PCBs in blood serum in relation to indoor air concentrations of PCBs from epidemiologic investigations.

5.0 SUMMARY AND CONCLUSION

EH&E completed a preliminary site-specific assessment of human health risk for PCBs at the School to help understand and manage potential risks. The objective of the assessment was to identify targets for concentrations of PCBs in indoor air of the School. These targets are available to support risk management and risk communication activities by the Town.

Application of conventional methods for quantitative risk assessment to various exposure scenarios and two benchmarks for chronic exposure produced a range of target concentrations for PCBs in indoor air of the School. The lowest target concentration for the annual average concentration of PCBs in indoor air of a classroom in the School derived from the site-specific assessment is 230 ng m^{-3}. This value corresponds to an average daily exposure equivalent to the RfD for Aroclor 1254 recommended by EPA. The mixture of PCBs in indoor air of the School is different from the mixture of PCBs in Aroclor 1254 and in fact also resembles the mixture of PCBs in Aroclor 1016. The lowest site-specific target concentration for PCBs in indoor air of a classroom in the School derived from the RfD for Aroclor 1016 is 990 ng m^{-3}.

Principal uncertainties identified in the quantitative risk assessment include incomplete information on background exposure to PCBs for the School population and the type and likelihood of adverse effects in humans associated with inhalation of the mixture of PCBs present in indoor air of the School. Results of the quantitative risk assessment are further informed by studies of human populations known to have occupied buildings with PCB concentrations in indoor air similar to the levels observed in the School. These studies have not found associations between occupancy of the building and body burdens of total PCBs. Because epidemiological studies that report adverse effects of PCBs are predicated on elevated body burdens of total PCBs, the lack of association between body burdens and occupancy of buildings with indoor air concentrations in the range of those measured in the School is an indication that PCB vapors at the School are unlikely to pose a substantive risk to health. The concentration of PCBs in humans is commonly understood to be largely related to age and gender, probably reflecting accumulation from food over time and differences in diet or other lifestyle attributes between men and women. That evidence provides further confidence that health risks at the School would only arise from long-term exposure to higher levels of PCBs than those found at the School.

6.0 REFERENCES

ATSDR 2000. *Toxicological Profile for Polychlorinated Biphenyls*. Agency for Toxic Substances and Disease Registry, U.S. Department of Health and Human Services.

Burkhardt U, Bork M, Balfanz E, and Leidel J. 1990. Indoor Pollution by Polychlorinated Biphenyls (PCB) in Permanent Elastic Sealing Compounds. *Gesundheitswesen,* 51(10):567-574.

EPA. 2008. Child-Specific Exposure Factors Handbook, EPA/600/R-06/096F. U.S. Environmental Protection Agency.

EPA. 2009. Public Health Levels for PCBs in Indoor School Air. Polychlorinated Biphenyls (PCBs). U.S. Environmental Protection Agency. http://www.epa.gov/pcbsincaulk/maxconcentrations.htm.

EPA .2009. PCB Exposure Estimation Tool, Version 1.1, (PCBs-SchoolDose_10-2-09-v1.xls), U.S. Environmental Protection Agency, October 2, 2009.

EPA. 2010. New Bedford Harbor, Waste Site Cleanup & Reuse in New England, U.S. Environmental Protection Agency, http://www.epa.gov/region1/nbh/, accessed October 12, 2010.

Ewers U, Wittsiepe J, Barth G, Bork M, Kaesler C, Leidel J, and Strobel K. 1998. Blutuntersuchungen auf PCB bei Lehrerinnen und Lehrern einer stark PCB-belasteten schule. *Gesundheitswesen,* 60:357-362.

FDA. 2010. Total Diet Study, http://www.fda.gov/Food/FoodSafety/FoodContaminantsAdulteration/TotalDietStudy/default.htm, U.S. Food and Drug Administration, accessed September 8, 2010.

Gabrio T, Piechotowski I, Wallenhorst T, Klett M, Cott L, Friebel P, Link B, and Schwenk M. 2000. PCB-blood Levels in Teachers, Working in PCB-contaminated Schools. *Chemosphere,* 40:1055-1062.

Herrick R, Meeker JD, Hauser R, Altshul L, and Weymouth GA. 2007. Serum PCB levels and congener profiles among US construction workers. *Environmental Health,* 6:25.

Heudorf U, Angerer J, and Goen T. 1995. PCB concentration in blood of female crèche staff exposed to PCB. *Arbeitsmed Sozialmed Umweltmed,* 30(9):398-402.

Heudorf U, Salzmann N, Angerer J, and Wittsiepe J. 1996. Biomonitoring auf PCDD/F und PCBs bei stark erhohten Raumluftbelastungen. *Umweltmed Forsch Prax 1,* 1:6-12.

Konstas H, Pekari K, Riala R, Back B, Rantio T, and Priha E. 2004. Worker Exposure to Polychlorinated Biphenyls in Elastic Polysulphide Sealant Renovation. *Annals of Occupational Hygiene,* 48(1):51-55.

Liebl B, Schettgen T, Kerscher G, Broding HC, Otto A, Angerer J, and Drexler H. 2004. Evidence for increased internal exposure to lower chlorinated polychlorinated biphenyls (PCB) in pupils attending a contaminated school. *International Journal of Hygiene and Environmental Health,* 207:315-324.

MacIntosh D, Spengler J, Ozkaynak H, and Ryan B. 1996. Dietary Exposures to Selected Metals and Pesticides. *Environmental Health Perspectives*, 104(2):202-209.

Neisel F, von Manikowsky S, Schumann M, Feindt W, Hoppe HW, and Melchiors U. 1999. Human biomonitoring of polychlorinated biphenyls in 130 exposed elementary school children. *Gesundheitswesen,* 61(3):137-149.

Schecter A, Colacino J, Haffner D, Patel K, Opel M, Papke O, Birnbaum L. 2010. Perfluorinated compounds, polychlorinated biphenyls, and organochlorine pesticide contamination in composite foods samples from Dallas, Texas, USA. *Environmental Health Perspectives*, 118(6):796-802.

Schwenk M, Gabrio T, Papke O, and Wallenhorst T. 2002. Human biomonitoring of polychlorinated biphenyls and polychlorinated dibenzodioxins and dibenzofuranes in teachers working in a PCB-contaminated school. *Chemosphere,* 47:229-233.

Vorhees D, Cullen AC, and Altshul LM. 1997. Exposure to Polychlorinated Biphenyls in residential Indoor Air and Outdoor Air near a Superfund Site. *Environmental Science & Technology*, 31: 3612-3618, 1997.

Vorhees D, Cullen AC, and Altshul LM. 1999. Polychlorinated Biphenyls in House Dust and Yard Soil near a Superfund Site. *Environmental Science & Technology*, 33: 2151-2156, 1999.

WHO. 2004. *IPCS risk assessment terminology. Part 1: IPCS/OECD key generic terms used in chemical hazard/risk assessment. Part 2: IPCS glossary of key exposure assessment terminology.* Geneva, World Health Organization, International Programme on Chemical Safety

Wingfors H, Selden AI, Nilsson C, and Haglund P. 2006. Identification of markers for PCB exposure in plasma from Swedish construction workers removing old elastic sealants. *Annals of Occupational Hygiene*, 50(1):65-73.

APPENDIX A

LIMITATIONS

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1. Environmental Health & Engineering, Inc.'s (EH&E) indoor environmental quality assessment described in the attached report number 17228, Draft *Site-Specific Exposure and Risk Assessment for Polychlorinated Biphenyls, Estabrook School, Lexington, Massachusetts* (hereafter "the Report"), was performed in accordance with generally accepted practices employed by other consultants undertaking similar studies at the same time and in the same geographical area; and EH&E observed that degree of care and skill generally exercised by such other consultants under similar circumstances and conditions. The observations described in the Report were made under the conditions stated therein. The conclusions presented in the Report were based solely upon the services described therein, and not on scientific tasks or procedures beyond the scope of described services.

2. Observations were made of the site as indicated within the Report. Where access to portions of the site was unavailable or limited, EH&E renders no opinion as to the condition of that portion of the site.

3. The observations and recommendations contained in the Report are based on limited environmental sampling and visual observation, and were arrived at in accordance with generally accepted standards of industrial hygiene practice. The sampling and observations conducted at the site were limited in scope and, therefore, cannot be considered representative of areas not sampled or observed.

4. When an outside laboratory conducted sample analyses, EH&E relied upon the data provided and did not conduct an independent evaluation of the reliability of these data.

5. The purpose of the Report was to assess the characteristics of the subject site as stated within the Report. No specific attempt was made to verify compliance by any party with all federal, state, or local laws and regulations.