
Chapter 6

Quantifying Exposure

What's Covered in Chapter 6:

- ◆ Generic Exposure Rate Equation
 - ◆ Consumption Rate
 - ◆ Exposure Frequency
 - ◆ Exposure Duration
 - ◆ Averaging Time
 - ◆ Body Weight
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This chapter describes the factors to be evaluated in quantifying the exposure received under each of the recommended exposure scenarios described in Chapter 4. The calculation of COPC-specific exposure rates for each exposure pathway evaluated involves (1) the estimated COPC media concentrations calculated in Chapter 5, (2) consumption rate, (3) receptor body weight, and (4) the frequency and duration of exposure. This calculation is repeated for each COPC and for each exposure pathway included in an exposure scenario. Exposure pathway-specific equations are presented in Appendix C. The following sections describe a general exposure rate calculation and the exposure pathway-specific variables that may affect this calculation. Acute exposure resulting from direct inhalation is also evaluated as a separate issue in Section 7.5.

6.1 GENERIC EXPOSURE RATE EQUATION

Exposure can occur over a period of time. In the calculation of an average exposure per unit of time, the total exposure can be divided by the time period. An average exposure can be expressed in terms of body weight. All exposures quantified in the risk assessment (1) should be unitized for time and body weight, (2) are presented in units of milligrams per kilogram of body weight per day, and (3) are termed “intakes.” Equation 6-1 is a generic equation used to calculate chemical intake (U.S. EPA 1989e):

$$I = \frac{C_{gen} \cdot CR \cdot EF \cdot ED}{BW \cdot AT} \quad \text{Equation 6-1}$$

where

<i>I</i>	=	Intake—the amount of COPC at the exchange boundary (mg/kg/day); for evaluating exposure to noncarcinogenic COPCs, the intake is referred to as average daily dose (<i>ADD</i>); for evaluating exposure to carcinogenic compounds, the intake is referred to as lifetime average daily dose (<i>LADD</i>)
<i>C_{gen}</i>	=	Generic COPC concentration in media of concern (e.g., mg/kg for soil or mg/L for surface water; see Chapter 5)
<i>CR</i>	=	Consumption rate—the amount of contaminated medium consumed per unit of time or event (e.g., kg/day for soil and L/day for water)
<i>EF</i>	=	Exposure frequency (days/year)
<i>ED</i>	=	Exposure duration (years)
<i>BW</i>	=	Average body weight of the receptor over the exposure period (kg)
<i>AT</i>	=	Averaging time—the period over which exposure is averaged (days); for carcinogens, the averaging time is 25,550 days, based on a lifetime exposure of 70 years; for noncarcinogens, averaging time equals <i>ED</i> (years) multiplied by 365 days per year.

Variations of Equation 6-1 are used to calculate receptor-specific exposures to COPCs; the equations used for each exposure pathway are presented in Appendix C. The variation of input variables when exposure is quantified is also described in Appendix C.

The exposures calculated in a risk assessment are intended to represent reasonable maximum exposure (RME) conditions as further described in U.S. EPA (1989e). The use of RME values is consistent with other U.S. EPA guidance (1994g). Studies of the compounding of conservatism in probabilistic risk assessments show that setting as few as two factors at RME levels or high end (e.g., near the 90th percentile), while the remaining variables are set at less conservative, typical or “central tendency” values (e.g., near the 50th percentile) resulted in a product of all input variables at an RME level (e.g., 99th percentile value) (Cullen 1994).

As described in Chapter 2 (Section 2.2.1), the estimated air concentrations and depositional rates are based on RME emissions from trial or risk burns. U.S. EPA OSW recommends that the variables set at RME

values include (1) the highest ISCST3 modeled air parameter values at current and reasonable potential future exposure scenario locations, (2) the exposure frequency, and (3) the exposure duration. Body weight is typically set at average values.

6.2 CONSUMPTION RATE

Consumption rate is the amount of contaminated medium consumed per unit of time or event.

Consumption rates for subsistence food types (e.g., beef for the subsistence farmer; fish for the subsistence fisher), is assumed to be 100 percent from the assessment area (e.g., farm, water body) being evaluated.

Consumption rates for non-subsistence food types (e.g., home grown garden vegetables) are assumed to be a fraction of the total dietary intake for this food type.

As described in Section 6.1, exposures calculated in a risk assessment are intended to represent RME conditions. Accordingly, the HHRAP recommends default values for exposure parameters that will result in estimated RME exposures. However, there are likely to be differences between recommended default, and regional and site-specific exposure parameter values. This may be especially true for the parameter consumption rate (a general term including both intake rate and inhalation rate). The risk assessment performed using recommended default parameter values may be later refined to include supplemental calculations based on regional- or site-specific exposure parameter values, provided documentation for these regional- or site-specific exposure parameter values is provided. These supplemental calculations should be provided in addition to and should not replace calculations based on recommended default exposure parameter values. The following subsections describe exposure pathway-specific considerations regarding consumption rate.

6.2.1 Air Exposure Pathways

Direct inhalation of vapors and particulate emissions from combustion sources is a potential pathway of exposure. Chapter 2 presented various variables and conditions that affect the rate, type, and quantity of combustion emissions. Chapter 3 presented the air dispersion and deposition modeling techniques used to estimate airborne concentrations of vapors and particulates in the assessment area.

Receptors in the assessment area are directly exposed to COPCs in vapor, particulate, and particle-bound phases; as a result of normal respiration. The factors that affect exposure from vapor and particulate inhalation include vapor and particulate COPC concentrations, respiration rate during the period of exposure, and length of exposure.

As presented in Appendix C, a single default inhalation rate is provided for use across all adult receptor scenarios. However, if site-specific data is available to show that subsistence farmers and fishers have higher respiration rates due to rigorous physical activities than other receptors that data may be appropriate. Also, farmers could be assumed to typically spend more time each day in the vicinity of contaminated vapors and particulates, because farms are places of business, and typically their homes. However, any modifications of the respiration rates of receptors should be considered on a site-specific basis, and supported by documentation.

Intakes related to direct inhalation of vapors and particulates are calculated based on variations of Equation 6-1. However, as described in Chapter 7, Appendix A-3, and Appendix C, noncarcinogenic hazards and carcinogenic risks associated with direct inhalation exposures are preferentially characterized using toxicity factors (inhalation unit risk factors [URF] and reference concentrations [RfC]) based on data collected under, or normalized to, a particular set of respiratory and body weight parameters (e.g., 20 cubic meters per day [m^3/day] and 70 kg).

Inhalation of vapors and particulates will be influenced by the relative amount of time that a receptor spends indoors. Although vapors entering buildings and residences as a result of air exchange are likely to remain airborne and, therefore, may be inhaled, particulates entering these same buildings are more likely to settle out and not be inhaled. However for the purpose of the risk assessment, it should be assumed that vapor and particulates may both be inhaled throughout the day, both indoors and outdoors.

6.2.2 Food Exposure Pathways

Plants and animals impacted by emission sources may take up emitted COPCs in the air or deposited COPCs in soil. Humans are exposed to COPCs via the food chain when they consume these plants and

animals as a food source. Human intake of COPCs is determined on the basis of (1) the types of foods consumed, (2) the amount of food consumed per day, (3) the concentration of COPCs in the food, and (4) the percentage of the diet contaminated by COPCs. Chapter 5 describes procedures for determining the concentration of COPCs in food; and consideration of variations in exposure resulting from food preparation methods and type of food item (e.g., protected versus unprotected produce). Other variables, described below, may also significantly affect the estimation of exposure.

6.2.2.1 Types of Foods Consumed

The types of foods consumed will affect exposure, because different plants and animal tissues will take up COPCs at different rates. Therefore, COPC concentrations in food are determined, in part, by the type of food, and they vary with the types of food in the diet. Furthermore, the types of foods consumed vary with age, geographical region, and sociocultural factors.

6.2.2.2 Food Consumption Rate

The amount of daily food consumption varies with age, sex, body weight, and geographic region, and it also varies within these categories. U.S. EPA (1990e) recommended that values from USDA food consumption surveys be used to complete the risk assessment process. U.S. EPA (1990e) recommended that the 1987-1988 USDA Food Consumption Survey be used to represent consumption rates for urban and suburban areas. However, if site-specific information indicates that the population is in a more rural or agricultural area, U.S. EPA (1990e) recommended that the 1966-67 USDA Food Consumption Survey be used to represent the consumption rates of a more agrarian population.

U.S. EPA OSW recommends that food consumption rate information (ingestion rates) be obtained from the 1997 *Exposure Factors Handbook* (U.S. EPA 1997c); specifically, the section regarding home produced food items. Consumption rate information is presented in Appendix C as follows: Appendix C, Table C-1-2 (produce); Appendix C, Table C-1-3 (beef, milk, pork, chicken, and eggs); and Appendix C, Table C-1-4 (fish). Wet weight to dry weight conversion factors were also obtained from the 1997 *Exposure Factors Handbook* (U.S. EPA 1997c).

6.2.2.3 Percentage of Contaminated Food

The percentage of home grown food consumed by the individual will affect exposure, because not all of an individual's dietary intake may be contaminated. Receptors, located in a rural or suburban area, who can raise animals and grow food in gardens will have a larger percentage of their food produced locally than people living in the city.

U.S. EPA OSW, in accordance with existing U.S. EPA guidance (1990e), recommends the following assumptions regarding the percentage of contaminated food:

- With regard to aboveground and belowground produce, it is assumed that the subsistence farmer and the subsistence farmer child consumes 100 percent contaminated produce; it is assumed that 25 percent of the produce consumed by receptors for the remaining recommended exposure scenarios (adult resident, child resident, and subsistence fisher, and subsistence fisher child) is contaminated (see Appendix C, Table C-1-2).
- With regard to beef, milk, pork, chicken, and eggs, it is assumed that 100 percent of these animal tissues consumed by the subsistence farmer and the subsistence farmer child are contaminated (see Appendix C, Table C-1-3). No other receptors are assumed to consume these animal tissues.
- With regard to fish, it is assumed that 100 percent of the fish consumed by the subsistence fisher and subsistence fisher child are contaminated (see Appendix C, Table C-1-4). No other receptors are assumed to consume fish.

6.2.3 Soil Exposure Pathways

Soil ingestion, dermal exposure to soil, and inhalation of resuspended dust are potential soil exposure pathways. For the purpose of RCRA combustion permitting decisions, U.S. EPA OSW recommends that soil ingestion be considered in all risk assessments. However, dermal exposure to soil and inhalation of resuspended dust are currently recommended for evaluation only if site-specific exposure setting characteristics require that these exposure pathways be evaluated. Based on air dispersion modeling and deposition of COPCs, emission concentrations in soil will vary with distance from the source. Potential routes of exposure should be determined by the way in which the soils in the area are used. Soil used for

farming or recreation will be involved in pathways of human exposure that differ from those of soil on roadways or in urban areas.

6.2.3.1 Soil Ingestion

Children and adults are directly exposed to COPCs in soil when they consume soil that has adhered to their hands. Factors that influence exposure by soil ingestion include soil concentration, the rate of soil ingestion during the time of exposure, and the length of time spent in the vicinity of contaminated soil. Soil ingestion rates in children are based on studies that measure the quantities of nonabsorbable tracer minerals in the feces of young children. Ingestion rates for adults are based on assumptions about exposed surface area and frequency of hand-to-mouth consumption. Indoor dust and outdoor soil may both contribute to the total daily ingestion. Exposure levels are also influenced by the amount of time that the individual spends in the vicinity of soil exposed to deposition of emitted pollutants.

In addition, some young children—referred to as “pica” children—may intentionally eat soil. As discussed in U.S. EPA (1989f), the typical medical and scientific use of the term “pica” refers to the ingestion of nonfood items, such as soil, chalk, and crayons. Such behavior is considered a temporary behavior and a normal part of a child’s development. For risk assessment purposes, pica is typically defined as “an abnormally high soil ingestion rate” and is believed to be uncommon in the general population (U.S. EPA 1989f). U.S. EPA risk assessment documents do not identify a default “pica” soil ingestion rate (U.S. EPA 1989e; 1989f ; 1991b). Therefore, U.S. EPA OSW does not recommend addressing pica behavior as part of risk assessments.

If available information indicates that there are children exhibiting pica behavior in the assessment area, and it is determined that these children represent a special subpopulation potentially receiving significant exposure (see Chapter 4), these children should be considered for evaluation. This evaluation should be made on a case-by-case basis based on site-specific exposure setting characterization.

6.2.3.2 Dermal Exposure to Soil

For the purpose of RCRA combustion permitting decisions, U.S. EPA OSW does not typically recommend the use, in the evaluation of recommended exposure scenarios, of the pathway of dermal exposure to COPCs through contact with soil. However, site-specific exposure setting characteristics may require that this exposure pathway be evaluated, therefore, this section discusses dermal soil exposure.

Available data indicate that the contribution of dermal exposure to soils to overall risk is typically small (U.S. EPA 1996g; 1995h). For example, the risk assessment conducted for the Waste Technologies Industries, Inc., hazardous waste incinerator in East Liverpool, Ohio, indicated that—for an adult subsistence farmer in a subarea with high exposures—the risk resulting from soil ingestion and dermal contact was 50-fold less than the risk from any other exposure pathway and 300-fold less than the total estimated risk (U.S. EPA 1996g; 1995h).

Humans are exposed to COPCs by absorption through the skin when it comes into contact with contaminated soil. Factors that affect dermal exposure include (1) surface area, (2) contact time, (3) contact amount, (4) amount of time spent near the combustion source, and (5) fraction of COPCs absorbed through the skin. In general, an increased dose of COPCs potentially can be absorbed through the skin as the surface area of the skin is increased. Surface area is affected by age and body weight; for example, children have less total surface area than adults. The amount of surface area available for exposure to soil is also affected by the amount of clothing worn. An adult working in the garden in long sleeves and pants will have a smaller exposed surface than an adult working in shorts and a short-sleeved shirt. For dermal exposure from soil, the exposed surface area affects the amount of soil that can adhere to exposed skin.

As duration for which the contaminated soil stays in contact with the skin increases, so does the amount of COPCs that can be absorbed. Contact time refers to the duration of time each day that contact with soil is possible. Dermal exposure is also affected by the amount of time, each day, spent in the vicinity of the combustion source at which soil is likely to be exposed to emitted pollutants. Indoor dust and outdoor soil

may both increase the daily contact. Seasonal exposure can also be considered, because regional climate will influence this variable.

The amount of COPCs that can be absorbed through the skin depends on the chemical properties of the COPC, properties of the soil matrix, and dermal pharmacokinetics. If a COPC cannot be readily absorbed through the skin, the daily intake of the COPC may be small even if other exposure characteristics, such as contact time, are favorable. However, if either a facility or a permitting authority feel that site-specific conditions indicate dermal exposure to soil may contribute significantly to total soil-related exposures, U.S. EPA OSW recommends following the methodologies described in the U.S. EPA NCEA methodology document, *Methodology for Assessing Health Risks Associated with Multiple Exposure Pathways to Combustor Emissions* (In Press).

6.2.3.3 Soil Inhalation Resulting from Dust Resuspension

U.S. EPA OSW does not typically recommend the use of soil inhalation exposure pathway of resulting from dust resuspension in the evaluation of recommended exposure scenarios. However, site-specific exposure setting characteristics may require that this exposure pathway be evaluated; this section discusses exposure to soil resulting from dust resuspension.

Inhalation of soil resulting from dust resuspension may be an issue for site-specific exposure scenario locations at which there is little vegetative cover. Application of available dust resuspension exposure estimating methodologies to deposited combustion unit emissions indicates that dust resuspension by wind erosion is not a significant pathway (U.S. EPA 1990e). Wind erosion may resuspend pollutants in contaminated soil as particulates in the air. As dust is resuspended, receptors may inhale the pollutant particles (direct inhalation of particulate matter is addressed separately). The amount resuspended depends on (1) the moisture content of the soil, (2) the fraction of vegetation cover, (3) the wind velocity, (4) soil particle size, (5) the pollutant concentration in the soil, and (6) the size of the contaminated area.

Methodologies have been developed to assess the exposure to pollutants resuspended by wind erosion for landfills and Superfund sites (U.S. EPA 1985a; 1988b; 1994q); U.S. EPA OSW recommends that facilities consult these reference documents if this exposure pathway must be evaluated because of site-specific

exposure scenario location conditions. Also, U.S. EPA OSW recommends reviewing the methodologies described in the U.S. EPA NCEA document, *Methodology for Assessing Health Risks Associated with Multiple Exposure Pathways to Combustor Emissions* (In Press).

6.2.4 Water Exposure Pathways

Water exposure pathways can be used to determine COPC concentrations in drinking water obtained from surface water or collected precipitation (e.g., cisterns). Water exposure pathways are also used to determine the COPC concentration in fish. Daily exposures of individuals using these water sources for various purposes—such as fishing and drinking water—can be estimated by using various models.

Site-specific information should be used to determine the appropriate exposure pathways for each assessment area. The way in which water is used—whether it is collected precipitation or a surface water body, such as a lake, farm pond, or city reservoir—will determine possible exposure pathways. Use of a surface water body as a drinking water source will introduce water ingestion as a possible exposure pathway. Commercial and or recreational fishing, with subsequent use of the fish and shellfish as a food source, make the food chain an important route of exposure for communities having a surface water body in the vicinity of a combustion unit.

U.S. EPA (1990e) recommended that the water input variables be varied to determine a range of exposures. An average exposure scenario might be represented by an individual that fishes and obtains drinking water from the same water source. A worst-case possibility may involve a person who (1) uses drinking water from a cistern that collects precipitation, and (2) fishes in a small farm pond.

Because annual ground-level concentrations of COPCs generally decrease with distance from the source, important factors in determining the water concentration include (1) the location of the precipitation collection apparatus, (2) surface water body onto which emitted COPCs are deposited, and (3) the COPC soil concentration (which affects runoff and leachate concentrations). In addition, the location and size of the watershed will affect the concentration of COPCs suspended in runoff.

6.2.4.1 Drinking Water Exposure from Surface Water Sources

For evaluation of a surface water body as a drinking water source, exposure is affected by the concentration of the COPC in the water, the daily amount of water ingested, and the percentage of time that the individual spends in the area serviced by that water supply system. The COPC concentration in a surface water body can be calculated as described in Chapter 5 and Appendix B; which includes consideration of contribution of COPC loading from the surrounding watershed. U.S. EPA OSW recommends that water consumption rates specified in the 1997 *Exposure Factors Handbook* (U.S. EPA 1997c) be used as described in Appendix C.

Consistent with previous U.S. EPA guidance (U.S. EPA 1990e), U.S. EPA OSW recommends that it typically be assumed that treatment processes for drinking water do not alter the deposited COPCs.

6.2.4.2 Drinking Water Exposure from Ground Water Sources

For the purpose of RCRA combustion permitting decisions, U.S. EPA OSW does not typically recommend the use, in the evaluation of exposure scenarios, of the pathways of drinking water exposure from ground water sources. Application of the methodology to combustion units has indicated that this is not a significant exposure pathway (U.S. EPA 1990e). However, COPCs may—because of special site-specific exposure scenario locations—infiltrate into ground water, resulting in COPC exposure via ingestion when ground water is used as drinking water. This could be because of extremely shallow aquifers used for drinking water purposes or a karst environment in which the local surface water significantly affects the quality of ground water used as a drinking water source. The methodology developed to calculate risks from the ground water pathway was originally intended for use in evaluating impacts of the landfilling of municipal sludge (U.S. EPA 1990e; 1994q). U.S. EPA OSW recommends that facilities consult these reference documents if this exposure pathway must be evaluated because of site-specific exposure setting characteristics.

6.2.4.3 Dermal Water Exposure

U.S. EPA OSW does not typically recommend the use, in the evaluation of exposure scenarios, of the dermal water exposure pathway. However, if the surface water body affected by combustion unit emissions is used frequently for recreational purposes, such as swimming and boating, dermal absorption of contaminated water becomes another possible route for human exposure. Dermal exposure is affected by (1) the surface area of exposed skin, (2) the COPC concentration in the water, (3) the permeability of the skin to the COPC, and (4) the length of time that the individual is in contact with the water.

6.2.4.4 Ingestion of Fish

U.S. EPA OSW recommends that fish ingestion rates specified in the 1997 *Exposure Factors Handbook* (U.S. EPA 1997c) be used as described in Appendix C. Factors that affect human exposure by ingestion of fish from a surface water body affected by combustion unit emissions include (1) sediment and water COPC concentrations, (2) the types of fish and shellfish consumed, (3) the ingestion rates for the various fish and shellfish groups, and (4) the percent of dietary fish caught in the surface water body affected by the combustion unit. The types of fish consumed will affect exposure, because different types of fish and shellfish take up COPCs at different rates. For example, fatty fish tend to accumulate organic COPCs more readily than lean fish. The amount of fish consumed also affects exposure, because people who eat large amounts of fish will tend to have higher exposures. Fish consumption rates vary greatly, depending on geographic region and social or cultural factors. Because 100 percent of a receptor's dietary fish may not originate from the surface water body near the combustion facility, the percentage of locally caught fish is also a variable for exposure.

6.3 EXPOSURE FREQUENCY

The receptors in each recommended exposure scenario are assumed to be exposed to all of the exposure scenario-specific exposure pathways 350 days per year (U.S. EPA 1989e; 1991b; 1991d). This assumption is based on the conservative estimate that all receptors spend a minimum of 2 weeks at a location other than the exposure scenario location selected in Section 4.3.

6.4 EXPOSURE DURATION

Exposure duration is the length of time that a receptor is exposed via a specific exposure pathway.

Although a receptor is no longer exposed to COPCs via the direct inhalation exposure pathway after an emission source ceases operation, a receptor is exposed via the indirect exposure pathways for as long as the receptor remains in the assessment area. Therefore, U.S. EPA OSW recommends using default RME values to estimate exposure duration for specified receptors.

Consistent with U.S. EPA (1990e), U.S. EPA OSW assumes that receptors are exposed to the long-term average COPC soil or water concentrations (and the subsequent COPC plant or animal concentrations) present in the environment or media following a period of time during which there were continuous hazardous waste unit emissions. For existing facilities, U.S. EPA (1990e) assumes that this period of time can be represented by default time periods of 30, 60, or 100 years. These values are based on the assumptions that the hazardous waste combustion unit or the emission source (1) is already in place, (2) will continue to be used for the rest of its useful life (estimated to be 30 years), and (3) may be replaced when it reaches the end of its useful life (estimated to be possibly as long as 60 or 100 years), because it is an integral part of the facility operations. These assumptions are reasonable for a hazardous waste emission source, such as an industrial boiler burning a continuous stream of facility hazardous waste.

Although a combustion unit may remain in the same location for 100 years—and a person may have a lifetime of exposure to emissions from that combustion unit—U.S. Bureau of the Census data (1986) on population mobility indicate that many Americans do not remain in the same area for their 70-year lifetime. An estimate of the number of years that a person is likely to spend in one area, such as the vicinity of a combustion facility, can be derived from information about mobility rate and median time in a residence. In addition to the number of years at a particular location or residence, the amount of time spent at that location each day directly affects exposure. For example, children that attend day care or adults that work in a different location for part of the day may be exposed to higher or lower COPC levels.

The exposure duration values recommended by U.S. EPA OSW are presented in the following table.

Exposure Duration Values		
Recommended Exposure Scenario Receptor	Value	Source
Child Resident	6 years	U.S. EPA 1990f; 1994r
Adult Resident	30 years	U.S. EPA 1990f; 1994r
Subsistence Fisher	30 years	U.S. EPA 1990f; 1994r
Subsistence Fisher Child	6 years	Assumed to be the same as the Child Resident
Subsistence Farmer	40 years	U.S. EPA 1994i; 1994r
Subsistence Farmer Child	6 years	Assumed to be the same as the Child Resident

6.5 AVERAGING TIME

For noncarcinogenic COPCs, U.S. EPA OSW recommends that a value of exposure duration (years-as specified for each receptor in Section 6.4) x 365 days/year be used as the averaging time (U.S. EPA 1989e; 1991d). However, for carcinogenic COPCs—the effects of which may have long latency periods—the age of the receptor (i.e., child, adult, or elderly) influences that COPC exposure pathway, because the exposure duration and, therefore, the quantity of exposure, will vary.

U.S. EPA OSW recommends that carcinogenic exposures for different receptor ages be evaluated separately, because the daily activities of these receptors (and, as described in Section 6.6, body weights) vary, including (1) the amounts of food and water consumed, (2) the types of food consumed, and (3) the amount of exposed skin surface. Health-based criteria, such as health advisories for drinking water, are also different for children and adults. As a result, for some exposure pathways, such as soil ingestion, children may have a greater quantifiable exposure and be at greater risk than adults. Some behaviors, such as mouthing of dirty objects or direct ingestion of soil, which could also contribute to exposure, are also much more prevalent in children than adults.

Because quantification of carcinogenic COPC exposure depends on the duration of exposure, the age of the receptor is important. The average human lifespan is generally considered to be 70 years; childhood represents only about 10 percent of the lifespan (6 years) (U.S. EPA 1990e). In actual exposure scenarios, individuals may be exposed only during childhood or adulthood. In other cases, exposure may overlap these periods, such as a child who grows into adulthood and remains in the same geographical area. Based on the age of the receptor and information on the duration of exposure, U.S. EPA (1990e) considered risk to three different receptors: (1) a child who grows to an adult and is exposed for his or her entire 70-year lifetime, (2) a child who grows to an adult and is exposed for only a part of his or her adulthood—a total of 30 years, and (3) an adult exposed for 16 years.

Because the effects of certain carcinogenic COPCs may have long latency periods—in some instances approaching the human lifespan—it may be appropriate to estimate daily intake by using the adult value for body weight and a longer averaging time. In cases where effects have a shorter latency period, U.S. EPA (1990e) recommends a averaging time period of less than 10 years. However, where children are known to be at special risk, it may be more appropriate to use this averaging time with a body weight value for toddlers, infants, or young children. For COPCs classified as carcinogens, U.S. EPA OSW recommends that a longer averaging time and the adult body weight be used to calculate the risk resulting from air or water exposure.

It is significant that childhood is defined differently in the different references. U.S. EPA (1990e) defines childhood as being from 1 to 7 years old. However, consistent with other previous U.S. EPA guidance (U.S. EPA 1991b; 1994r), U.S. EPA OSW defines childhood as being an exposure duration of 6 years. It should be noted that some of the data used for input into the various exposure scenario equations in Appendix C was not available for children or was available for more restrictive age groups, such as 2-year-olds or 4- to 6-year-olds. In such cases, and as noted in Appendix C where such values are presented, (1) the available data were evaluated to ensure that the presented default values are sufficient for conducting a risk assessment, and (2) in cases in which the available data were not sufficient, reasonable interpolations of the available data were possible.

6.6 BODY WEIGHT

The choice of body weight for use in the risk characterization equations presented in Appendix C depends on the definition of the receptor at risk—which, in turn, depends on exposure and susceptibility to adverse effects. U.S. EPA (1990e) defines the body weight of the receptor as either adult weight (70 kilograms) or child weight (1 to 7 years; 17 kilograms) on the basis of data presented in Nelson et al. (1969). However, consistent with other U.S. EPA guidance, U.S. EPA OSW recommends the child (exposure duration of 6 years) weight as 15 kilograms be used in the risk assessment (U.S. EPA 1991b; 1994r; 1994g).

The daily intake for an exposure pathway is expressed as the dose rate per body weight. Because children have lower body weights, typical ingestion exposures per body weight, such as for soil, milk, and fruits, are substantially higher for children—which is the primary reason for evaluating the child resident scenario (U.S. EPA 1996g). However, the use of these two body weights may not account for significant differences between weights of infants and toddlers or weights of teenagers and adults. It is important to remember, however, that the average body weight, not the actual chronological age, defines a child; obviously, the weight of a child changes significantly over the first several years. The average weight used is assumed to be a realistic average estimate for an exposure duration of 6 years that overestimates the weight of the child for the early years and then underestimates it for the later years (U.S. EPA 1996g).