Chapter 3
Exposure Scenario Selection

What's covered in Chapter 3:

- Recommended Exposure Scenarios
  - Adult Resident
  - Child Resident
- Exposure Scenario Locations
- Quantifying Exposure

This chapter summarizes the exposure scenarios selected for U.S. EPA risk assessment evaluation of wastes petitioned for delisting. The purpose of this chapter is to identify the types of human exposure to waste constituent emissions associated with the selected waste management scenarios (landfill and surface impoundment). The chapter addresses both identification of recommended exposure scenarios and selection of standardized exposure scenario locations.

An exposure scenario is a combination of exposure pathways through which a single receptor may be exposed to a waste constituent. Receptors may come into contact with waste constituent emissions associated with the selected waste management scenarios via two primary exposure routes, either (1) directly via inhalation or ingestion of water or (2) indirectly via subsequent ingestion of soil and foodstuffs (such as fish) that become contaminated by waste constituents through the food chain. Receptors may also be exposed to waste constituents released from a waste management unit to surface media (for example, via volatilization to air or via windblown particulate matter) or to groundwater (for example, via ingestion of groundwater).

Exposure pathways represent combinations of receptors and exposure routes. Each exposure pathway consists of four fundamental components: (1) a source and mechanism of waste constituent release (see Chapter 2); (2) a retention medium, or a transport mechanism and subsequent retention medium in cases involving media transfer of waste constituents (see Chapter 2); (3) an exposure route; and (4) a point of potential human contact with the contaminated medium, which is referred to as the POE and involves exposure of a specific receptor at a specific point.

The exposure scenarios recommended for evaluation in this chapter are generally conservative in nature and are not intended to be entirely representative of actual scenarios at all sites. Rather, they are intended to allow standardized and reproducible evaluation of risks across most sites and land use areas. Conservatism is incorporated to ensure protection of potential receptors not directly evaluated, such as special subpopulations, and land uses that are region-specific. The U.S. EPA Delisting Program believes that the recommended exposure scenarios and associated assumptions presented in this chapter are reasonable and conservative and that they represent a scientifically sound approach that allows protection of human health and the environment while recognizing the uncertainty associated with evaluating real-world exposure. Unless site-specific conditions warrant an exception approved by the delisting authority, the U.S. EPA Delisting Program recommends that these scenarios be used, at a minimum, in an initial site evaluation to identify primary risk concerns. Any exceptions, particularly deletion or modification of a recommended exposure scenario, should be well documented and approved by the delisting authority.

The following sections discuss (1) the default exposure scenarios, (2) selection of the POEs to be evaluated in the risk assessment, and (3) quantification of exposure.

3.1 DEFAULT EXPOSURE SCENARIOS

Adult and child residents are the two receptors evaluated in this analysis. These receptors are discussed below along with special subpopulation characteristics.

3.1.1 Adult Resident

The adult resident exposure scenario is evaluated to account for the combination of exposure pathways to which an adult receptor may be exposed in an urban or rural (non-farm) setting. The adult resident is assumed to be exposed to waste constituents from an emission source through the following exposure pathways:

- Surface Pathways
  - Direct inhalation of vapors and particles
  - Ingestion of fish
  - Ingestion of drinking water from surface water sources
- Groundwater Pathways
  - Ingestion of drinking water from groundwater sources

- Dermal absorption from groundwater sources via bathing
- Inhalation from groundwater sources via showering

Further discussion of these exposure pathways, including numerical equations, parameter values, and waste constituent-specific inputs, can be found in Chapter 4. No other exposure pathways are evaluated for the adult resident exposure scenario.

3.1.2 Child Resident

For child receptors, the U.S. EPA Delisting Program evaluates two exposure pathways: (1) the dermal absorption while bathing with groundwater pathway and (2) the ingestion of soil contaminated with air particulate pathway. Child residents (1 to 6 years old) were not selected as receptors for the groundwater ingestion and inhalation pathways, the surface water pathways, or the direct air inhalation pathways because the adult resident receptor scenario has been found to be protective of children with regard to these pathways (U.S. EPA 1995a, 1995b). For most routes of exposure (*e.g.*, drinking water ingestion, air inhalation, food ingestion), the intake rate remains relatively proportional to body weight throughout the lifetime. Child intake rates may be slightly higher (U.S. EPA 1990f, 1997b). However, the exposure duration for children would be considerably shorter than for adults. After consideration of the weighted average of exposure over a lifetime, the adult evaluation becomes the more sensitive scenario and no increased adverse effects would be seen by considering the child exposure pathway. The dermal absorption pathway and the soil ingestion pathway are two exceptions.

The dermal absorption while bathing with groundwater exposure pathway is evaluated differently for child residents than it is for adult residents because of the following considerations: (1) the ratio of exposed skin surface area to body weight is slightly higher for children than for adults, resulting in a slightly larger average daily exposure for children than for adults; and (2) the exposure duration for such children is limited to 6 years, thus lowering the lifetime average exposure to carcinogens. Typically, the adult scenario is more protective with regard to carcinogens (because of the longer exposure duration), and the child scenario is more protective with regard to noncarcinogens (because of the greater skin surface area to body weight ratio) (U.S. EPA 1995b).

For soil ingestion, the receptor is a resident who ingests soil from childhood through adulthood. Young children (to 6 years) typically ingest a greater quantity of soil than adults while at the same time have a much smaller average body weight than an adult. This results in a greater average daily exposure for children than adults. However, the exposure duration for the child is limited to the 6 years that a young individual would fall into the appropriate age range, thus lowering lifetime average exposure for carcinogens. Therefore, OSW policy for assessing exposure via soil ingestion to carcinogenic constituents is to consider exposure to a single individual through childhood and adulthood for soil ingestion exposures. This practice accounts for both the greater average daily dose of childhood and the longer exposure duration of adulthood. For noncarcinogens, the greater average daily dose has the stronger influence on the effects assessment and the child exposure pathway is considered. Further discussion of the exposure pathways, including algorithms, parameter values, and waste constituent-specific inputs, can be found in Chapter 4.

3.1.3 Special Subpopulation Characteristics

Special subpopulations are defined as human receptors or segments of the population that may be at higher risk because of receptor sensitivity to waste constituents (for example, the elderly, infants and children, and fetuses of pregnant women). The assumptions and methodology specified in the DTSD to complete the risk assessment (such as the conservative EPACMTP assumptions discussed in Section 2.2.2 and the use of reference doses [RfD] developed to account for toxicity to sensitive receptors) have been developed to protect human health, including that of special subpopulations.

3.2 EXPOSURE SCENARIO LOCATIONS

This section describes the exposure locations (POEs) for the groundwater, surface water, and air pathways (Sections 3.2.1, 3.2.2, and 3.2.3, respectively). A delisted waste may be disposed of by the petitioner in any authorized landfill or surface impoundment without regulatory control (see Section 1.2.1); therefore, the POEs selected for the risk assessment of a waste petitioned for delisting are individually standardized.

3.2.1 Downgradient Groundwater-Drinking Water Well POE

The EPACMTP, a probabilistic groundwater fate and transport model, is used to predict groundwater constituent concentrations at a hypothetical receptor well located downgradient from a waste management unit (as described in Section 2.2). This receptor well represents the POE at which potential exposure to the groundwater is measured; that is, the estimated constituent concentration at the POE is used to assess risk. The distance to the well is based on the results of a U.S. EPA OSW survey performed to determine the distance to the nearest drinking water well downgradient from municipal landfills (U.S. EPA 1988b). The survey data are entered in the EPACMTP model as an empirical distribution: minimum = 0 m, median = 427 m, and maximum = 1,610 m (approximately 1 mile) (U.S. EPA 1997e). At most of the facilities included in the survey, the direction of ambient groundwater flow is not precisely known; therefore, it cannot be ascertained whether the nearest receptor well is located along the plume center line or even within the plume. To reflect uncertainties and variations in the location of the receptor well in relation to the direction of ambient groundwater flow, the modeled well is located anywhere on the downgradient side of the waste management unit within a 1-mile radius (U.S. EPA 1997e). In contrast to the 1990 TC Rule (U.S. EPA 1990d), there is no requirement that the well lie within the leachate plume.

For carcinogenic waste constituents, the exposure concentration is defined as the maximum 30-year average receptor well concentration; for noncarcinogens, the exposure concentration is taken to be the highest receptor well concentration during the modeled 10,000-year period (U.S. EPA 1996b). A 10,000-year limit was imposed on the exposure period; that is, the calculated exposure concentration is the peak or highest 30-year average concentration occurring within 10,000 years following the initial release from the waste management unit (U.S. EPA 1996b). The Monte Carlo fate and transport simulation provides a probability distribution of receptor well concentrations as a function of expected leachate concentration. Regulatory leachate concentration limits were determined using a back-calculation procedure corresponding to a 90^{th} percentile protection level. These leachate concentration limits are the maximum leachate concentrations at which groundwater concentrations at 90 percent of the hypothetical downgradient receptor wells are not expected to exceed the given toxicity benchmark (usually either an MCL or HBN value) (U.S. EPA 1996b).

3.2.2 Downgradient Surface Water Body POE

Human exposure routes for surface water include ingestion of surface water used as drinking water and ingestion of fish from nearby surface water bodies. For the surface water ingestion exposure route, the surface water POE modeled is a fifth-order stream 100 m from the waste management unit (U.S. EPA 1993c). Fifth-order streams were chosen for analysis because U.S. EPA assumes that a fifth-order stream is the smallest stream capable of serving as a community water supply (U.S. EPA 1993c). The assumption of a 100-m distance to the nearest surface water body is a conservative assumption based on available data. A U.S. EPA survey of municipal landfill facilities showed that 3.6 percent of the surveyed facilities are located within 1 mile of a river or stream and that the average distance from these facilities to the closest river or stream is 586 m (U.S. EPA 1988b).

For the fish ingestion exposure route, a second-order stream was chosen for analysis. This stream segment was determined to be the smallest stream capable of supporting fisheries (U.S. EPA 1993c). The surface water body POE for collection of fish is assumed to be 100 m downgradient from the disposal facility (U.S. EPA 1993c).

3.2.3 Downwind POE

Human exposure to emissions of windblown particulate from landfills and to emissions of volatiles from landfills and surface impoundments includes inhalation of these particulate and volatiles. These are the exposure routes evaluated for the U.S. EPA Delisting Program. For the air pathway, the POE is 305 m (1,000 feet) downwind of the facility (U.S. EPA 1993c, 1994a).

3.3 QUANTIFICATION OF EXPOSURE

This section describes the factors to be evaluated in quantifying the exposure received under each of the exposure scenarios outlined above. The calculation of constituent-specific exposure rates for each exposure pathway evaluated is based on (1) the estimated concentration in a given medium as calculated in Chapter 2, (2) the contact rate, (3) receptor body weight, and (4) the frequency and duration of exposure. This calculation is repeated for each constituent and for each exposure pathway included in an exposure scenario. Exposure pathway-specific equations are presented in the appropriate sections of Chapter 4. Sections 3.3.1 through 3.3.8 describe a generic exposure rate calculation and the exposure pathway-specific variables that may affect this calculation. The default exposure parameters (*e.g.*, body weight, skin surface area) used in RCRA delisting risk assessment are reported in the *US EPA Exposure Factors Handbook* (EFH) (U.S. EPA 1990f, 1997b).

3.3.1 Generic Exposure Rate Equation

Exposure to hazardous constituents is assumed to occur over a period of time. To calculate an average exposure per unit of time, the total exposure can be divided by the time period. In this analysis, the exposures are intended to represent reasonable maximum exposure (RME) estimates for each applicable exposure route. The RME approach is intended to combine upper-bound and mid-range exposure factors so that the result represents an exposure scenario that is both protective and reasonable, not the worst possible case (U.S. EPA 1991a). All exposures quantified in this analysis are (1) normalized for time and body weight, (2) presented in units of milligrams per kilogram of body weight per day, and (3) termed "intakes." Equation 3-1 is a generic equation used to calculate constituent dose (U.S. EPA 1997b).

$$I = \frac{C_{gen} \cdot CR_{gen} \cdot EF \cdot ED}{BW \cdot AT} \qquad \textbf{(3-1)}$$

where:

I	=	intake — the amount of constituent at the exchange boundary (mg/kg/day); for evaluating exposure to noncarcinogenic constituents, this intake is referred to as the average daily dose (ADD); for evaluating exposure to carcinogenic constituents, this intake is referred to as the lifetime average daily dose (LADD)
C_{gen}	=	generic constituent concentration — the media average concentration contacted over the exposure period (for example, mg/kg for soil and mg/L for water)
CR_{gen}	=	generic contact rate — the amount of contaminated medium contacted per unit of time or per event (for example, kg/day for soil and L/day for water) (upper-bound value)
EF	=	exposure frequency (days/yr) (upper-bound value)
ED	=	exposure duration (yrs) (upper-bound value)
BW	=	body weight of the receptor over the exposure period (kg) (average value)
AT	=	averaging time — the period over which the exposure is averaged (days); for carcinogens, the averaging time is 27,375 days, based on a lifetime exposure of 75 yrs; for noncarcinogens, averaging time equals exposure duration (in yr) multiplied by 365 days/yr

3.3.2 Contact Rate

The contact rate is the amount of contaminated medium contacted per unit of time or event. Contact rates for subsistence food types (for example, fish for the fish ingestion pathway), are assumed to be 100 percent from the hypothetical assessment area (for example, water body). The following sections describe exposure pathway-specific considerations regarding contact rate.

3.3.2.1 Groundwater and Surface Water Exposure Pathway Parameters

This section describes the following variables specific to the groundwater and surface water exposure pathways: drinking water intake, other contact with groundwater, individual inhalation rate, and individual skin surface area.

Drinking Water Intake

For groundwater and surface water ingestion, the intake rate is assumed to be 2.0 L/day, the average amount of water that an adult ingests (U.S. EPA 1991a). This value, which is currently used to set drinking water standards, is close to the current 90th percentile value for adult drinking water ingestion (2.3 L/day) reported in the *US EPA Exposure Factors Handbook* (EFH) (U.S. EPA 1997b). Also, this value is comparable to the 8 glasses of water per day historically recommended by health authorities (U.S. EPA 1991a).

Other Contact with Groundwater

For the groundwater pathway of dermal exposure during bathing, the contact with water is assumed to occur in the shower. In this analysis, it is assumed that the average adult resident is in contact with groundwater during bathing for 0.25 hour per event and that the average child resident is in contact with groundwater during bathing for 0.33 hour per event, with one event per day (U.S. EPA 1991a, 1997b).

For the groundwater pathway of inhalation exposure during showering, the contact with water is assumed to occur principally in the shower and in the bathroom, although an additional longer exposure to much lower concentrations in the house following shower and bathroom use is also included. In this analysis, it is assumed that the average adult resident spends 11.4 minutes per day in the shower, an additional 48.6 minutes per day in the bathroom, and another 900 minutes (15 hours) in the house after shower and bathroom use (U.S. EPA 1991a, 1997b).

Individual Inhalation Rate

Daily inhalation rates vary depending on activity, gender, age, and so on (U.S. EPA 1997b). Citing a need for additional research, the latest EFH does not recommend a reasonable upper-bound inhalation rate value (U.S. EPA 1997b). The EFH-recommended value for the average inhalation rate is 15.2 m^3/day for males and 11.3 m^3/day for females (U.S. EPA 1997b). The inhalation rate of 20 m^3/day has been commonly used in past U.S. EPA risk assessments (U.S. EPA 1997b). The upper-bound value for an individual's inhalation rate has been established as 0.83 m^3/hr (20 m^3/day) (U.S. EPA 1991a). This value was derived by combining inhalation rates for indoor and outdoor activities in a residential setting (U.S. EPA 1991a). A conservative inhalation rate of 20 m^3/day has been selected for use in this analysis.

Individual Skin Surface Area

For dermal bathing exposure to contaminated groundwater, the selected receptors are an adult and a young child (1 to 6 years old). During bathing, generally all of the skin surface is exposed to water. The total adult body surface area can vary from about 17,000 to 23,000 cm^2. The EFH reports a value of 20,000 cm^2 as the median value for adult skin surface area (U.S. EPA 1997b). A value of 6,900 cm^2 has been commonly used for a child receptor in U.S. EPA risk assessments; this value is approximately the average of the median values for male children aged 2 to 6 years (U.S. EPA 1992b). The EHF presents a range of recommended values for estimates of the skin surface area of children by age (U.S. EPA 1997b). The mean skin surface area at the median for boys and girls 5 to 6 years of age is 0.79 m^2 or 7,900 cm^2 (U.S. EPA 1992b and 1997b). Given that the age for children is defined as 0 to 6 years (see Section 3.3.4), a skin surface area value for ages 5 to 6 years would be a conservative estimate of skin surface area for children. For calculation of dermal exposure to waste constituents, a value of 7,900 cm^2 is assumed for the skin surface area of children, and a value of 20,000 cm^2 is assumed for the skin surface area of adults.

The major factors that must be considered when estimating the intake associated with dermal exposure to groundwater (that is, the absorbed dose per event or DA_{event}) are the constituent concentration in contact with the skin, the surface area of the skin exposed, the duration of exposure, the absorption of the constituent through the skin, and the amount of constituent that can be delivered to a target organ. A detailed discussion of these factors can be found in "Guidelines for Exposure Assessment" (U.S. EPA 1992a) and "Dermal Exposure Assessment: Principles and Applications" (U.S. EPA 1992b). Detailed information concerning the algorithms and parameter values used to calculate DA_{event} is provided in Chapter 4.

3.3.2.2 Air Exposure Pathway Parameters

For air exposure pathways, receptors are assumed to be directly exposed to constituents as a result of normal respiration. Inhalation of vapors and particulate will be influenced by the relative amount of time that a receptor spends indoors. Although vapors entering buildings as a result of air exchange are likely to remain airborne and therefore may be inhaled, particulate entering these buildings are more likely to settle out and not be inhaled. However, for the purposes of this analysis, it is assumed that vapor and particulate may be inhaled throughout the day, both indoors and outdoors. Again, it is assumed that the upper-bound estimate respiration rate for an individual is 0.83 m^3/hr (20 m^3/day) (U.S. EPA 1991a, 1997d).

The U.S. EPA Delisting Program also considers child ingestion of soil contaminated with air-deposited particulate windblown from a nearby landfill. Two different receptors are used for carcinogens and noncarcinogens. For carcinogens, exposure in both childhood and adulthood is considered for the same individual. For noncarcinogens, only exposure in childhood is considered. For carcinogens, exposure is averaged over a lifetime (therefore, the averaging time is 75 years, the average lifetime recommended in the latest EFH). Due to the long-term cumulative effect of carcinogens, exposure to adults is usually assumed. For most routes of exposure (*e.g.*, drinking water ingestion, air inhalation, food ingestion), the intake rate remains relatively proportional to body wight throughout the lifetime. Child intake rates may be slightly higher. After consideration of the weighted average of exposure over a lifetime, little or no effect would be seen by considering child exposure. However, the intake rate of soil is inversely proportional to body weight, because children to 6 years of age are considered more likely to ingest greater quantities of soil than adults and their body weight is a fraction of an adult. Exposure to contaminants via soil ingestion is calculated as a weighted average of exposure for 6 years as a child and as an adult. The total exposure for carcinogenic risk is still averaged over a lifetime. For noncarcinogens, the daily intake is back-calculated by direct comparison to the reference dose (RfD). The RfD being the dose to which a person may be exposed daily over a lifetime or significant portion of a lifetime without adverse effect. Because the RfD is a exposure dose, and because the daily exposure dose from soil ingestion is likely to be considerably higher for children than adults, the daily intake (and therefore the delisting level) is calculated for children. The mean soil ingestion values for children range from 39 to 271 mg/day, with an average of 146 mg/day for soil ingestion and 191 mg/day for soil and dust ingestion (U.S. EPA 1989c, 1997b).

This group of mean values is consistent with the 200-mg/day value that U.S. EPA programs have used as a conservative mean estimate. However, considering pica behavior (deliberate ingestion of soil by children), the upper percentile recommended value for soil ingestion by children is 400 mg/day (U.S. EPA 1997b). Because the prevalence of pica behavior is not known, and because the EFH states that 200 mg/day may be used as a conservative estimate of the mean, a delisting risk assessment uses 200 mg/day as the soil ingestion rate for children.

3.3.3 Exposure Frequency

An exposure frequency of 350 days per year is applied to all exposure scenarios (U.S. EPA 1991a, 1997d). Until better data become available, the common assumption that residents take 2 weeks of vacation per year is used to support a value of 15 days per year spent away from home (leaving 350 days per year spent at home) (U.S. EPA 1991a).

3.3.4 Exposure Duration

The exposure duration reflects the length of time that an exposed individual may be expected to reside near the constituent source. For the adult resident, this value is taken to be 30 years, and for the child resident, this value is taken to be 6 years (U.S. EPA 1997d). The adult resident is assumed to live in one house for 30 years, the approximate average of the 90th percentile residence times from two key population mobility studies (U.S. EPA 1997b). For the child resident, the exposure duration is assumed to be 6 years, the maximum age of the young child receptor (U.S. EPA 1997d). For carcinogens, exposures are combined for children (6 years) and adults (24 years).

3.3.5 Averaging Time

For noncarcinogenic constituents, the averaging time (AT) equals the exposure duration in years multiplied by 365 days per year. For an adult receptor, the exposure duration is 30 years, and for a child receptor, the exposure duration is 6 years (U.S. EPA 1991a). For carcinogenic constituents, the AT has typically been 25,550 days, based on a lifetime exposure of 70 years at 365 days per year (U.S. EPA 1991a). The life expectancy value in the 1997 EFH is 75 years (U.S. EPA 1997b). Given this life expectancy value, the AT for a delisting risk assessment is 27,375 days, based on a lifetime exposure of 75 years at 365 days per year.

3.3.6 Body Weight

The choice of body weight for use in the risk characterization equations presented in Chapter 5 depends on the definition of the receptor at risk, which in turn depends on exposure and susceptibility to adverse effects. "Risk Assessment Guidance for Superfund (RAGS)" (U.S. EPA 1989) defines the body weight of the receptor as either adult weight (70 kg) or child weight (1 to 6 years, 15 kg) on the basis of data presented in "Evaluation and Selection of Models for Estimating Air Emissions from Hazardous Waste Treatment, Storage, and Disposal Facilities" (U.S. EPA 1984). However, most U.S. EPA guidance defines the child (1 to 6 years) weight as 15 kg (U.S. EPA 1991a). The EFH-recommended value of 71.8 kg for an adult differs from the 70-kg value commonly used in U.S. EPA risk assessments (U.S. EPA 1997b). The Integrated Risk Information System (IRIS) uses the 70-kg body weight assumption in deriving cancer slope factors and unit risks. In keeping with the latest EFH recommendation, DRAS uses a 72-kg adult weight and a 15-kg child weight in delisting risk assessments.

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 those for soil and foods, are higher for children. Therefore, average daily exposure normalized to body weight would be greater for children than adults. However, when factoring in the exposure duration for adults over children, the overall lifetime exposure would be less and the actual risk/hazard would be greater for adults. Use of two body weights may not account for significant differences between the weights of infants and toddlers or the weights of teenagers and adults. However, average body weight, not actual chronological age, defines a child in this context; obviously, the weight of a child changes significantly over the first 6 years of life. The average weight used is assumed to be a realistic average estimate for all 6 years that overestimates the weight of the child for the early years and then underestimates it for the later years (U.S. EPA 1997b).

3.3.7 Fish Consumption

Factors that affect human exposure via ingestion of fish from a surface water body include (1) sediment and water waste constituent concentrations and (2) the percentage of dietary fish caught in the surface water body affected by the waste management unit. 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 waste management unit, the percentage of locally caught dietary fish is also a variable that must be considered in estimating exposure.

The EFH-recommended value for fish consumption for all fish is 0.28 g fish/kg body weight/day for an average adult (72 kg) (U.S. EPA 1997b). This value equates with a fish consumption rate of 20.1 g/day for all fish. For delisting risk assessments, U.S. EPA Region 6 estimates that an exposed individual eats 20 g of fish per day, representing one 8-ounce serving of fish approximately once every 11 days.

3.3.8 Age-adjusted Contact Rates

Because contact rates may be different for children and adults, carcinogenic risks during the first 30 years of life were calculated using age-adjusted factors (adj). Use of age-adjusted factors is especially important for soil ingestion exposures, which are higher during childhood and decrease with age. However, for the purposes of combining exposures across pathways, additional age-adjusted factors are used for inhalation and dermal exposures. These factors approximate the integrated exposure from birth until age 30 and combine contact rates, body weights, and exposure durations for two age groups: small children and adults. Age-adjusted factors are either obtained from RAGS Part B or developed by analogy.

For soils, noncarcinogenic waste constituents are evaluated for children separately from adults; no age-adjusted factor is used in this case. The focus on children is considered to be protective because of the higher daily rate of soil intake by children and their lower body weight.

Equation 3-2, 3-3, and 3-4 are used to develop age-adjustment factors for soil ingestion, inhalation, and water ingestion, respectively.

Soil ingestion ([mg·yr]/[kg·d]):

$$IFS_{adj} = \frac{ED_c \cdot IRS_c}{BW_c} + \frac{(ED_r - ED_c) \cdot IRS_a}{BW_a} \qquad \textbf{(3-2)}$$

Inhalation ([m^3·yr]/[kg·days]):

$$IFA_{adj} = \frac{ED_c \cdot IRA_c}{BW_c} + \frac{(ED_r - ED_c) \cdot IRA_a}{BW_a} \qquad \textbf{(3-3)}$$

Water ingestion ([L·yr]/[kg·d]):

$$IFW_{adj} = \frac{ED_c \cdot IRW_c}{BW_c} + \frac{(ED_r - ED_c) \cdot IRW_a}{BW_a} \qquad \textbf{(3-4)}$$

where:

			Default
IFS_{adj}	=	Ingestion factor, soils ([mg·yr]/[kg·days])	113 (U.S. EPA 1991a)
ED_c	=	Exposure duration, child (yrs)	6 (U.S. EPA 1991a)
IRS_c	=	Soil ingestion rate, child (mg/day)	200 (U.S. EPA 1997b)
BW_c	=	Body weight, child (kg)	15 E (U.S. EPA 1997b)
ED_r	=	Exposure duration, residential (yrs)	30 (U.S. EPA 1991a)
IRS_a	=	Soil ingestion rate, adult (mg/day)	100 (U.S. EPA 1997b)
BW_a	=	Body weight, adult (kg)	72 (U.S. EPA 1997b)
IFA_{adj}	=	Inhalation factor ([m^3·yr]/[kg·days])	10.7 (U.S. EPA 1991a)
IRA_c	=	Inhalation rate, child (m^3/day)	10 (U.S. EPA 1989a)

IRA_a	=	Inhalation rate, adult (m^3/day)	20 (U.S. EPA 1991a)
IFW_{adj}	=	Ingestion factor, water ([L·yr]/[kg·days])	1.07 (U.S. EPA 1991a)
IRW_a	=	Drinking water ingestion rate, adult (L/day)	2 (U.S. EPA 1989a)
IRW_c	=	Drinking water ingestion rate, child (L/day)	1 (U.S. EPA, 1991a)