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Leah J. Smith
District and Business Support Program
Division of Waste Management
Florida Department of Environmental Protection
2600 Blair Stone Road
Tallahassee, FL 32399-2400

Re: Consideration of child exposure at a 55 and older community

Dear Ms. Smith:

At your request, we have evaluated the exposure parameters and considerations necessary for establishing an alternative soil cleanup target level (ASCTL) for child exposure at a 55 and older community. Adult residential communities differ from the typical residential scenario since they were intended for residents over the age of 55. The scenario specific ASCTL for these communities do not include childhood exposure. As stated in our letter to the Florida Department of Environmental Protection (FDEP) for the derivation of ASCTLs for 55 and older communities (dated February 26, 2021), not every house in an older adult community is required to have a resident over the age of 55. Up to 20% of the housing units may be occupied by people under age 55 and the community will still qualify as an older adult community. The 55 and older ASCTLs may not be protective of children who reside in these communities. Additionally, non-resident children may visit residents for overnight stays. Using arsenic as an example, this evaluation calculates the maximum exposure frequency protective of children under a 55 and older community ASCTL.

Equations for the derivation of carcinogenic and non-carcinogenic soil cleanup target levels (SCTLs) promulgated in Chapter 62-777, F.A.C. are shown in Figures 1 and 2 and the abbreviations used in these equations are defined in Table 1. Child-specific assumptions for the derivation of ASCTLs in an older adult community are listed in Table 1 and are discussed below.

Exposure duration: The exposure duration is dependent on whether the chemical of concern is a non-carcinogen or a carcinogen. For non-carcinogens, childhood exposure is assumed to last six years (Chapter 62-777, F.A.C.; OSWER Directive 9200.1-120). For carcinogens, childhood exposure is calculated as an average exposure dose over the residential exposure duration. The 90th percentile estimate for current resident time is 26 years (OSWER Directive 9200.1-120).

Body weight: Body weight estimates were updated by the United States Environmental Protection Agency (US EPA) in 2014 using the 2011 Exposure Factors Handbook. For non-carcinogens, an

average child body weight is used. The recommended body weight for a child is 15 kg, which represents the weighted average of mean body weights for a child ages birth to 6 years old. It is important to note this age category is slightly different from the FDEP age range of a child, which is ages 1 through 7 years old. For carcinogens, the average body weight over the residential period is the more appropriate metric. The mean body weight of a resident from ages 1 to 27 calculated using NHANES III data is 48.4 kg (CEHT, 2005).

Surface area: Surface area is correlated to body weight with larger body weights corresponding to larger skin surface areas. Chapter 62-777, F.A.C. uses a univariate model by Burmaster (1998) to calculate total body surface area from body weight:

$$Surface\ area = Body\ weight^{0.6821} \times 1025$$

Assuming the head, hands, forearms, feet, and lower legs are exposed for children ages 1 through 7, a total of 42.9% of the body surface area is exposed. For adults, only the head, hands, forearms, and lower legs are considered to be exposed. A total of 34.9% of the body is exposed for residents/visitors ages 1-27 (CEHT, 2005). Total exposed surface area for children is 2788 cm^2 and 5044 cm^2 for residents/visitors staring as children (aggregate resident/visitor scenario).

Soil ingestion rate: The Exposure Factors Handbook September 2017 update for soil and dust ingestion (US EPA, 2017) provides a critical review of the soil and dust ingestion studies available. The recommendation for adults is 100 mg/day. These values are equivalent to the updated recommendation for adult soil ingestion rates in OSWER Directive 9200.1-120. For non-carcinogens, the child soil ingestion rate is used. For exposure to carcinogens, soil ingestion occurs from ages 1-27 years old. Using the recommended ingestion rates for the age ranges above, the average soil ingestion rate for carcinogens is 142 mg/day.

Inhalation rate: Inhalation rates for the general population are also summarized in the Exposure Factors Handbook. Recommended long-term exposure values for males and females combined are listed in Table 6-1 (US EPA, 2011). The weighted mean inhalation rate for males and females from ages 1 through 7 is 9.9 m^3/day. This value represents the non-carcinogenic inhalation rate. The weighted mean inhalation rate for males and females from ages 1 through 27 is13.8 m^3/day. This is used as the carcinogenic inhalation rate.

Soil adherence factor: Soil adherence factors are usually determined based on the activity being performed and the type of soil. Without site-specific data, the most appropriate adherence factor is the default. For non-carcinogens, the default soil adherence factor is 0.2 mg/cm^2 for children (Chapter 62-777, F.A.C., OSWER Directive 9200.1-120). For carcinogens, the adherence factor is a weighted average between 6 years as a child with an adherence factor of and 0.2 mg/cm^2 and 20 years as an adult with an adherence factor of 0.07 mg/cm^2, resulting in an adherence factor of 0.1 mg/cm^2 (Chapter 62-777, F.A.C.).

Exposure frequency: Exposure frequency for a child at an adult community is scenario specific. It can vary from 350 d/y for a child resident to less than 30 days for a short-term child visitor. Therefore, a specific exposure frequency was not proposed. Instead, using arsenic as an example, the maximum exposure frequency protective of children living at a community with a 55 and older arsenic ASCTL was calculated.

Using the exposure parameters for a 55 and older community proposed in our February 26, 2021 letter to the FDEP, we calculated an adult community arsenic ASCTL of 4.0 mg/kg. Chemical specific parameters used for arsenic are listed in Table 2. In order to determine the

maximum exposure frequency protective of children at a 55 and older community, the equation for calculating carcinogenic SCTLs (Figure 1) was rearranged to solve for exposure frequency and is shown in Figure 3. Using the same inputs presented in Tables 1 and 2 and an ASCTL of 4.0 mg/kg, the maximum exposure frequency is 160 d/y for children at a 55 and older community.

Please let us know if you have any questions regarding this evaluation.

Sincerely,

Leah D. Stuchal, Ph.D.

Stephen M. Roberts, Ph.D.

References:

CEHT (2005) *Final Technical Report: Development of Cleanup Target Levels (CTLs) for Chapter 62-777, F.A.C.* Center for Environmental & Human Toxicology, University of Florida, Gainesville, FL.

US EPA (2011) *Exposure Factors Handbook: 2011 Edition.* United States Environmental Protection Agency, National Center for Environmental Assessment, Office of Research and Development, Washington, DC.

US EPA (2017) *Update for Chapter 5 of the Exposure Factors Handbook, Soil and Dust Ingestion.* United States Environmental Protection Agency, National Center for Environmental Assessment, Office of Research and Development, Washington, DC.

Figure 1 - Equation for Developing Acceptable Soil Cleanup Target Levels for Carcinogens:

$$\text{SCTL} = \frac{TR \times BW_c \times AT_c}{EF \times ED_c \times FC \times \left[(CSF_o \times IR_{oc} \times 10^{-6} kg/mg \times RBA) + (CSF_d \times SA_c \times AF_c \times DA \times 10^{-6} kg/mg) + \left(CSF_i \times IR_{ic} \times \left(\frac{1}{VF} + \frac{1}{PEF}\right)\right)\right]}$$

Figure 2 - Equation for Developing Acceptable Soil Cleanup Target Levels for Non-Carcinogens:

$$\text{SCTL} = \frac{THI \times BW_{nc} \times AT_{nc}}{EF \times ED_{nc} \times FC \times \left[\left(\frac{1}{RfD_o} \times IR_{onc} \times 10^{-6} kg/mg \times RBA\right) + \left(\frac{1}{RfD_d} \times SA_{nc} \times AF_{nc} \times DA \times 10^{-6} kg/mg\right) + \left(\frac{1}{RfD_i} \times IR_{inc} \times \left(\frac{1}{VF} + \frac{1}{PEF}\right)\right)\right]}$$

Figure 3 - Equation for Developing Acceptable Soil Cleanup Target Levels for Carcinogens:

$$\text{EF} = \frac{TR \times BW_c \times AT_c}{SCTL \times ED_c \times FC \times \left[(CSF_o \times IR_{oc} \times 10^{-6} kg/mg \times RBA) + (CSF_d \times SA_c \times AF_c \times DA \times 10^{-6} kg/mg) + \left(CSF_i \times IR_{ic} \times \left(\frac{1}{VF} + \frac{1}{PEF}\right)\right)\right]}$$

Table 1 – Recommended exposure parameters for children at 55 and older communities

Symbol	Definition (units)	Value
AF_c	Soil adherence factor (mg/cm^2) (carcinogens)	0.1
AF_{nc}	Soil adherence factor (mg/cm^2) (non-carcinogens)	0.2
AT_c	Averaging time (days) (carcinogens)	25,550
AT_{nc}	Averaging time (days) (non-carcinogens)	ED × 365
BW_c	Body weight (kg) (carcinogens)	48.4
BW_{nc}	Body weight (kg) (non-carcinogens)	15
CSF_d	Dermal cancer slope factor $(mg/kg\text{-}d)^{-1}$	Chemical-specific
CSF_i	Inhalation cancer slope factor $(mg/kg\text{-}d)^{-1}$	Chemical-specific
CSF_o	Oral cancer slope factor $(mg/kg\text{-}d)^{-1}$	Chemical-specific
DA	Dermal absorption (unitless)	Chemical-specific
ED_c	Exposure duration (years) (carcinogens)	26
ED_{nc}	Exposure duration (years) (non-carcinogens)	6
EF	Exposure frequency (days/yr)	Scenario-specific
IR_{ic}	Inhalation rate (m^3/day) (carcinogens)	13.8
IR_{inc}	Inhalation rate (m^3/day) (non-carcinogens)	9.9
IR_{oc}	Ingestion rate, oral (mg/day) (carcinogens)	142
IR_{onc}	Ingestion rate, oral (mg/day) (non-carcinogens)	200
PEF	Particulate emission factor (m^3/kg)	1.24×10^9
RfD_d	Dermal reference dose (mg/kg-d)	Chemical-specific
RfD_i	Inhalation reference dose (mg/kg-d)	Chemical-specific
RfD_o	Oral reference dose (mg/kg-d)	Chemical-specific
SA_c	Surface area exposed (cm^2/day) (carcinogens)	5,044
SA_{nc}	Surface area exposed (cm^2/day) (non-carcinogens)	2,788

Symbol	Definition (units)	Value
THI	Target hazard index (unitless)	1
TR	Target risk (unitless)	1×10^{-6}

Table 2 – Chemical specific toxicity values used for arsenic

Symbol	Definition (units)	Value
CSF_d	Dermal cancer slope factor $(mg/kg\text{-}d)^{-1}$	1.5
CSF_i	Inhalation cancer slope factor $(mg/kg\text{-}d)^{-1}$	17.2
CSF_o	Oral cancer slope factor $(mg/kg\text{-}d)^{-1}$	1.5
DA	Dermal absorption (unitless)	0.005