October 2015

ATTACHMENT H

Part 201 Generic Exposure Assumption Values Update

TECHNICAL SUPPORT DOCUMENT

SUBJECT: Soil Dermal Adherence Factor (AF)

MDEQ Introduction

MDEQ contracted SRC, Inc. to evaluate and update the exposure assumptions and fate and transport values, consistent with the Collaborative Stakeholder Advisory (CSA) recommendations. This work is a component of the DEQ's comprehensive cleanup criteria update and is incorporated in the calculations of the health-based cleanup values. The CSA recommendations pertinent to exposure assumptions and fate and transport values are presented in the Decision Framework for Determination of Exposure Values (CSA, 2014). To satisfy the "best available information" requirement of the Framework, SRC followed the Framework's process for evaluating data against the Data Quality Objectives (DQOs) and selecting the values for their recommendations. Refer to the CSA Report (2014) and Cleanup Criteria and Screening Levels Development and Application Resource Materials (Resource Materials) Section 4.3.

The MDEQ protects for pregnant receptors (residents and workers) from direct contact exposure to developmental and reproductive (DR) toxicants. The MDEQ Toxics Steering Group (TSG) developed a process to calculate health-based values for DR toxicants that includes exposure assumptions for DR receptors. The TSG recommended an adherence factor (AF) value of 0.2 mg/cm^2 for pregnant workers. This value is preferred to that developed by SRC (0.07 mg/cm^2) to adequately protect for DR effects. For more details on the DR process, refer to the Resource Materials Section 3.2.5 and Attachment F.

Background

This Technical Support Document (TSD) describes the process used to update generic exposure assumption values for soil dermal adherence factors (AFs) for use by Michigan Department of Environmental Quality (MDEQ) in deriving Part 201 Soil Direct Contact Criteria (DCC). The TSD follows the Decision Framework for Updating the Michigan Part 201 Generic Cleanup Criteria Exposure Assumptions (TAG, 2014). As outlined in the Decision Framework, the update process involves searching for Michigan-specific data pertinent to each exposure assumption, revised U.S. Environmental Protection Agency (EPA) exposure assumptions, and other sources of relevant data (e.g., state and federal government agencies, published

literature), and evaluating both the existing and any new information against the Data Quality Objectives (DQOs) provided in the Decision Framework.

To identify new information pertinent to each exposure assumption, the following search process was followed. First, Michigan government agencies and select research universities were contacted to determine if relevant data could be provided. Second, exposure parameters recommended by U.S. EPA's most recent (2011) Exposure Factors Handbook and U.S. EPA's (2014) Office of Solid Waste and Emergency Response (OSWER) were considered. Third, searches of the published scientific literature for data or analyses specific to Michigan or to the U.S. as a whole were conducted. U.S. EPA (2011) performed comprehensive searches of scientific literature and other data sources, and indicated that the document included literature published through July, 2011. For the purpose of this TSD, searches of the published literature were restricted to papers published in 2009 or later. An earlier date than 2011 was selected to ensure that no papers published near the time of completion of the 2011 document were missed. Fourth, websites for U.S. governmental organizations were searched for readily accessible data relevant to the exposure assumptions. Fifth, selected state (including Illinois, Indiana, Minnesota, Ohio, Wisconsin, California, Oregon, Washington, Texas, and Massachusetts) and international (Health Canada and Environment Canada, Ontario Ministry of the Environment, European Commission Joint Research Centre [ECJRC], and the European Centre for Ecotoxicology and Toxicology of Chemicals [ECETOC]) environmental agency websites were searched to identify default exposure assumptions used by these agencies.

The TSD describes the results of each of the searches and the evaluation of new, relevant information against the DQOs. The DQOs in the framework (TAG, 2014) address the following:

- Relevant and applicable to Michigan;
- Clear and comprehensive;
- Sound and credible;
- Transparent and objective; and
- Certainty.

The current Part 201 generic exposure assumptions (MDEQ, 2005) and new relevant information were evaluated against the DQOs and given a rating of high, medium, or low; an explanation of the ratings is provided as Appendix A of this document. Based on the ratings, the data or information that best meets the DQOs, are recommended as the basis for updated values.

The algorithms used by MDEQ to derive Part 201 DCC employ a combination of central tendency and upper percentile estimates for exposure parameters. Specifically, in accordance with U.S. EPA guidance (1992a), central tendency values are used for life span, body weight, and surface area, while high-end values are used for exposure duration, exposure frequency, soil ingestion rate, and soil adherence factor. Thus, the recommendations for AF presented in this TSD are based on values representative of reasonable maximum exposures.

Introduction

Soil dermal adherence factor (AF) represents the amount of soil that adheres to the surface of the skin per unit of surface area (SA). Soil adherence can vary depending upon the type of activity being performed as well as soil characteristics. For example, gardening activities involve higher contact with soil than raking, and moist, loamy soil will adhere to skin better than dry, sandy soil. In addition, due to varying degrees of moisture content and skin texture, as well as likelihood of contact with soil, some body parts may collect more soil than others; in particular, more soil tends to adhere to the hands than to other body parts under typical exposure conditions (U.S. EPA, 2011).

This TSD consists of one section. Table 1 below provides a comparison of the MDEQ (2005) and 2015 updated values for AF.

Table 1. Summary of Existing and Updated MDEQ Values for Soil AF (mg/cm^2)

Parameter	MDEQ (2005) Value	2015 Updated Value
$AF_{ages <2}$ = Soil adherence factor: ages < 2	NV	0.3
$AF_{ages 2-<6}$= Soil adherence factor: ages 2 to <6	NV	0.3
$AF_{ages birth-<6}$ = Soil adherence factor: ages birth to <6	0.2	0.3
$AF_{ages 6-<16}$= Soil adherence factor: ages 6 to <16	NV	0.07
$AF_{ages 16-<EDr}$= Soil adherence factor: ages 16 to <EDr[a]	NV	0.07
$AF_{ages 6-<EDr}$= Soil adherence factor: ages 6 to <EDr[a]	0.07	0.07
AFn= Soil adherence factor: adult, nonresidential	0.2	0.2
AFnrdev = Soil adherence factor, nonresidential, developmental toxicant	NV	0.07

NV = no value.
[a]EDr is exposure duration for the residential scenario. MDEQ (2005) used 30 years for EDr (and thus $BW_{ages 6-30}$ and $BW_{ages 16-30}$), while the 2015 updated value for EDr is 32 years.

Section 1. Soil Adherence Factors (AF)

1.1. Introduction

For residential exposure scenarios, MDEQ uses AF values to represent the amount of soil that adheres to the surface of the skin of children (AFc) and adults (AFa) during outdoor activities at a typical residence. For nonresidential exposure scenarios, MDEQ uses AF values (AFn) to represent the amount of soil that adheres to the surface of the skin of workers during outdoor activities at a typical workplace.

1.2. MDEQ (2005) Value

1.2.1. Description of MDEQ (2005) Value

For residential scenarios, MDEQ (2005) recommended default AF values of 0.2 mg/cm^2 for children and 0.07 mg/cm^2 for adults. For the nonresidential scenario, MDEQ (2005) recommended a default AF of 0.2 mg/cm^2.

The basis for the AF values recommended by MDEQ was described in a Draft Technical Support Document (MDEQ, 1999). As described in that document, MDEQ based the default soil AFs on recommendations in U.S. EPA's 1997 Exposure Factors Handbook and in a draft 1998 version of U.S. EPA Risk Assessment Guidance for Superfund (RAGS) Part E. U.S. EPA (1998) was an interim dermal risk assessment guidance document that is no longer available through U.S. EPA's website and has been superseded by U.S. EPA (2004). Review of U.S. EPA (2004) and the discussion in MDEQ (1999) indicates that the AF values recommended in the interim document (U.S. EPA, 1998) were based on the same data as the final (U.S. EPA, 2004). MDEQ followed the approach outlined in U.S. EPA (1998) in calculating the default AF values based on the data described in U.S. EPA (1997). U.S. EPA (1997) AF recommendations were in the form of geometric mean and geometric standard deviations of soil adherence for specific body parts during specific activities. In their analysis of dermal adherence, U.S. EPA (1997) considered three studies to be key (Kissel et al. (1998, 1996a,b); however, their recommendations (shown in U.S. EPA [1997] Table 6-12) were ultimately based on Kissel et al. (1998; 1996b) and a paper that was unpublished at the time (Holmes et al. 1996, as cited in U.S. EPA, 1997) but later published as Holmes et al. (1999; cited as such in U.S. EPA, 2004). Kissel et al. (1996b) measured the mass of soil on specific body parts (hands, arms, legs, faces, feet) on individuals engaged in specific indoor and outdoor activities at various locations in Washington State. Activities included greenhouse gardening, Tae Kwon Do, soccer, rugby, reed gathering, irrigation installation, truck farming, outdoor gardening and landscaping (i.e., groundskeepers), and playing in mud. Subjects ranged in age from 8 years up to 67 years, depending on the activity. The mass of soil recovered from participants was converted to soil loading by dividing the mass by an estimate of the body part-specific SA. For each participant, the total SA was calculated from the participants' height and weight, and combined with the recommended fraction of total body SA by body part reported by U.S. EPA (1985) to calculate SA of individual body parts.

Kissel et al. (1998) measured soil adherence of children playing in an 8 foot x 8 foot soil bed filled with sieved sandy loam. Soils were obtained from a topsoil producer in Washington State. Measurements were made under both dry and wet soil conditions, and all participants wore similar clothing (short sleeves/short pants or long sleeves/long pants) under the same conditions. Children (ages 8-12 years; n=18) played for 20 minutes with an assortment of toys and tools, and soil was collected by washing target skin areas (hands, forearms, lower legs, faces). The mass of soil recovered from participants was converted to soil loading using the same method as Kissel et al. (1996b).

Holmes et al. (1999) measured the mass of soil on various body parts (hands, arms, legs, faces, feet) of individuals engaged in specific occupational and recreational activities, both before and after the activity. These studies were conducted at various locations in Washington State. Participants included children at a daycare center involved in both indoor and outdoor play, children playing indoors at home, archeologists, construction workers, heavy equipment operators, rugby players, utility workers involved with jack-hammering and excavating trenches, landscapers, and gardeners. Subjects ranged in age from 1 year old up to 54 years old, depending on the activity. The authors recorded information on types of clothing worn by participants and activity durations, but did not control these. The mass of soil recovered from participants was converted to soil loading using the same method as Kissel et al. (1996b).

U.S. EPA (2004) used the data described above and considered by U.S. EPA (1997) to calculate SA-weighted geometric mean and 95th percentile soil AFs for specific activities based on assumed exposed body parts according to the following equation:

$$Weighted\ AF = \frac{(AF_1)(SA_1) + (AF_2)(SA_2) + \cdots + (AF_i)(SA_i)}{SA_1 + SA_2 + \cdots + SA_i}$$

Where:

AF	=	adherence factor, and
SA	=	surface area

MDEQ (1999) considered two options to select an upper percentile value for AF: the first was to select an activity with high soil contact and choose the central tendency estimate of adherence for that activity, while the second was to select an activity with moderate soil contact and choose the upper percentile estimate of adherence for that activity. This is consistent with U.S. EPA guidance (U.S. EPA, 2004).

For the child resident, U.S. EPA (2004) considered two separate scenarios: 1) select the daycare scenario representative of a central tendency soil contact activity and use the high-end weighted AF (i.e., 95th percentile) based on adherence to hands, forearms, lower legs, and feet, and 2) select playing in wet soil representative of a high-end soil contact activity and use the 50th percentile weighted AF based on adherence to faces, hands, forearms, and lower legs. For the adult resident, U.S. EPA (2004) selected gardening to represent a reasonable, high-end activity and derived a central tendency weighted AF (50th percentile) based on the geometric mean AFs for face, hands, forearms, and lower legs. For the worker, U.S. EPA (2004) selected the utility worker scenario to represent a high-end contact activity and derived a 50th percentile weighted AF based on the geometric mean AFs for faces, hands, and forearms. U.S. EPA (2004, Exhibit 3-5) provided final recommendations consisting of central tendency and reasonable maximum exposure (RME) estimates of AF for child and adult residents and for adult workers. The RME values were 0.2 and 0.07 mg/cm^2 for child and adult residents, respectively, and 0.2 mg/cm^2 for adult workers. MDEQ (2005) default AF values were calculated in the same manner as described in U.S. EPA (2004).

1.2.2. Evaluation of Data Quality Objectives

The AF values recommended by MDEQ (1999, 2005) were evaluated using the Part 201 DQOs. A summary of the evaluation follows.

Relevance and applicability to Michigan (g*eographic, temporal, and demographic representativeness*). The studies that form the basis of the MDEQ (1999, 2005) recommendations (Kissel et al. 1998; 1996b; Holmes et al. 1999) were conducted in Washington State in the mid-to-late 1990s. These field studies included activities that are considered applicable to the general U.S. population as well as Michigan residents. AF values are not expected to change significantly over time, but they may vary geographically depending on soil type, moisture content of skin and soil, activity, and the amount of exposed skin surfaces (i.e., clothing worn). None of the three studies evaluated the characteristics (e.g., moisture or organic carbon content, particle size, etc.) of the soils to which participants were exposed. The recommended AF values are based on body part-specific SA estimates, which are a function of body weight (BW). As noted in the TSD for SA, U.S. EPA (1997) estimated SAs using height and BW data from the Centers of Disease Control and Prevention's (CDC) National Health and Examination Survey (NHANES) conducted between 1976 and 1980. It is likely that SAs of U.S. and Michigan residents have changed over time with changes in BWs; however, it is not likely that such changes would substantially alter the weighted average AF values. Rating: Medium.

Clarity and comprehensiveness (completeness of method and data reporting, completeness of literature search). The basis of the AF values is clearly described in MDEQ (1999) and U.S. EPA (1997, 2004). The literature considered by MDEQ (1999) and U.S. EPA (1997, 2004) as potentially relevant to the selection of AF values appear to be comprehensive. Additionally, the data collection and analysis methodologies used by Kissel et al. (1996b, 1998) and Holmes et al. (1999) appear to be well-reported. Rating: High.

Soundness and credibility (*adequacy of approach; intrinsic sources of bias; sample size*). The key studies used as the basis for the MDEQ (1999, 2005) AFs were all field studies that directly measured soil adherence to the skin for a variety of receptors that ranged in age from 1 up to 67 years old. However, the studies were limited by small sample sizes of four to eight subjects per activity, and very young children were underrepresented. These are small sample sizes relative to the population of Michigan. Also, a limited number of activities were evaluated. Soil mass loading was estimated using a skin-rinsing technique that is widely employed for such purposes and is assumed to be adequate. The study authors did not describe the information provided to participants in the studies; thus, it is uncertain whether the activities of the participants may have been influenced by prior knowledge of the study goals (e.g., participants could have endeavored to increase contact with soil to ensure that measureable amounts were detected). Rating: Low.

Transparency and objectivity (availability of supporting data; funding source; peer-review). Reports by U.S. EPA (1997, 2004) are available on the internet; the interim U.S. EPA (1998) report cited by MDEQ (1999) is no longer available. Prior to publication, the U.S. EPA (1997;

2004) reports were reviewed internally by U.S. EPA staff, and also reviewed by a Science Advisory Board or Peer Consultation Workshop and other peer reviewers. The three key studies used as the basis for the MDEQ (1999, 2005) AFs appear in peer-reviewed publications. However, all three key studies were conducted by researchers working out of the same Department at the University of Washington. Rating: Medium.

Certainty (number and agreement of studies). The AFs recommended by MDEQ (1999, 2005) were based on three key field studies that were analyzed by U.S. EPA (1997, 2004). U.S. EPA (1997) included evaluation of 6 additional relevant studies. U.S. EPA (1997) characterized the AF values as highly uncertain, as they were derived from small sample sizes for a limited set of activities. In addition, all of the studies were conducted in a single state and provided no information on soil characteristics. Rating: Low.

1.3. Evaluation of New Information Using Decision Framework

1.3.1. Michigan-Specific Data

1.3.1.1. Summary of Search Results

MDEQ Remediation and Redevelopment Division (RRD) and the Michigan Department of Community Health were contacted by email and phone to determine if they were aware of research or could provide data pertinent to AF of Michigan residents; however, neither Department was aware of research or data relevant to this exposure parameter. The following research universities were contacted by email and phone to determine if each was aware of research or could provide data: University of Michigan, Michigan State University, Western Michigan University, and Michigan Technological University. Additional research or relevant data were not provided within the time-frame of the development of this TSD.

1.3.2. Most Recent EPA Recommended Value(s)

1.3.2.1. Summary of Search Results

The U.S. EPA (2011) Exposure Factors Handbook and (2008) Child-specific Exposure Factors Handbook recommended body part specific mean AFs for children and adults based on direct contact with soil during various indoor and outdoor activities as shown in Table 2.

Table 2. U.S EPA (2011) Recommendations for Mean Soil AF (mg/cm^2)[a]

Receptor	Exposure Scenario	Body Part					Source
		Face	Arms	Hands	Legs	Feet	
Child	Residential (indoor)	ND	0.0041	0.011	0.0035	0.010	Holmes et al. (1999)
	Daycare (indoor/outdoor)	ND	0.024	0.099	0.020	0.071	Holmes et al. (1999)
	Outdoor sports	0.012	0.011	0.11	0.031	ND	Kissel et al. (1996b)
	Indoor sports	ND	0.0019	0.0063	0.002	0.0022	Kissel et al. (1996b)
	Activities with soil (gardeners and archeologists)	0.054	0.046	0.17	0.051	0.20	Holmes et al. (1999)
	Playing in mud	ND	11	47	23	15	Kissel et al. (1996b)
Adult	Outdoor sports (rugby, soccer)	0.0314	0.0872	0.1336	0.1223	ND	Holmes et al. (1999); Kissel et al. (1996b)
	Activities with soil (gardening, farming, etc)	0.0240	0.0379	0.1595	0.0189	0.1393	Holmes et al. (1999); Kissel et al. (1996b)
	Construction activities (construction workers, utility workers, equipment operators)	0.0982	0.1859	0.2763	0.0660	ND	Holmes et al. (1999)

ND: no data
[a]Adapted from U.S. EPA (2011) Table 7-4. Values are based on geometric mean soil loadings reported in the key studies.

The key studies used by U.S. EPA (2008, 2011) to derive AF recommendations were Kissel et al. (1996b) and Holmes et al. (1999), two of the same key studies used to derive the values recommended by MDEQ (1999, 2005).

U.S. EPA (2014) recommended an AF of 0.2 mg/cm^2 for the child resident receptor, an AF of 0.07 mg/cm^2 for the adult resident receptor, and an AF of 0.12 mg/cm^2 for the worker/nonresidential scenario. The residential receptor values recommended by U.S. EPA (2014) were the same values recommended in U.S. EPA (2004) and described earlier in this TSD. The adult nonresidential AF value recommended by U.S. EPA (2014) was calculated using the arithmetic mean body part-specific mean AFs for adults in commercial/industrial

activities from U.S. EPA (2011) weighted by adult SA for those body parts (hands, forearms, and face). U.S. EPA (2014) did not describe the specific activities or data that were considered in calculating the recommended nonresidential default value of 0.12 mg/cm^2.

1.3.2.2. Evaluation of Data Quality Objectives

The key studies (Kissel et al. 1996b, 1998; Holmes et al. 1999) that serve as the basis for the AFs recommended by U.S. EPA (2011, 2014) are the same as those that formed the basis for the AFs recommended by MDEQ (1999, 2005; U.S. EPA 1997, 2004). The only change to the basis for the values in U.S. EPA (2011, 2014) is the use of updated estimates of total SA and fraction of total SA by body part (see TSD for SA). These data likely better reflect current conditions in the U.S. than data from U.S. EPA (1997, 2004). Because the studies used by U.S. EPA (2014, 2011) to obtain activity-specific AF values were the same as those used to obtain the values for MDEQ (1999, 2005; U.S. EPA 1997, 2004), additional assessment of DQOs for the updated values was not conducted.

1.3.3. New Scientific Literature

A search of the open scientific literature (PubMed and ToxLine) for data on AF from studies published since 2009 was conducted. This search did not yield any potentially relevant studies of AF.

1.3.4. New Federal Information

A search of federal sources of data on AF was conducted. The search included evaluating publically available databases, reports, data briefs, and publications from federal agencies. Additional information was not identified.

1.3.5. Other State and/or International Searches

1.3.5.1. Summary of Search Results

State and international agencies listed in the background to this TSD were searched for recommended AF values. Table 3 below summarizes the recommended AF values identified in the searches. As shown in the table, values for AFc, AFa and AFn are, with a few exceptions, based on values reported by U.S. EPA (2004, 2014). Although the state of Massachusetts (MADEP, 2002) considered the same key studies recommended by U.S. EPA (2004, 2011, 2014), the data were considered differently as follows. The AFc value of 0.35 mg/cm^2 was derived using the soil adherence measured on the feet of adult gardeners from Kissel et al. (1996b) to represent the feet of residential children and data from the daycare scenario presented by Holmes et al. (1999) were not considered. The AFa value of 0.13 mg/cm^2 was based on the arithmetic mean value for gardeners from Kissel et al. (1996b, 1998), and the AFn value was based on the arithmetic mean values for commercial groundskeepers from Kissel et al. (1996b, 1998) and Holmes et al. (1999). The state of Minnesota (MPCA, 1999) also

recommended an AFa of 0.13 mg/cm^2 for adult residents (aged 18 to 33 years) based on Kissel et al. (1996b) and U.S. EPA (1992b, 1997). The state of Texas (TCEQ, 2003) and the state of Washington (WAC, 2001) did not provide supporting information for the derivation of their recommended AFa values. The state of Oregon (ODEQ, 2012) derived a default AFn value of 0.1 mg/cm^2 (geometric mean, commercial gardener) based on the key studies identified by U.S. EPA (2011).

Table 3. Comparison of default state and international soil AF values (mg/cm^2)

Parameter	MI	IL	CA	MA	MN	WA	WI	IN	OH	OR	TX	Ontario, Canada	EU JRC	EU ECETOC
AFchild	0.2	ND	0.2	0.35[a]	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	ND	ND
AFadult	0.07	ND	0.07	0.13[b]	0.13[b]	0.2[c]	0.07	ND	0.07	0.07	0.1[d]	0.07	ND	ND
AFnonresident	0.2	ND	0.2	0.03	0.12	0.2	0.2	0.2	0.2	0.1	0.2	0.2	ND	ND

ND: No data
[a]Weighted values derived from Kissel et al. (1996, 1998) and Holmes et al. (1999) for children ages birth to 7 years. The values are weighted by the appropriate skin surface area (face, hands, forearms, lower legs and feet) and intended to represent high-end activity (e.g., gardening activities) for both residential and recreational children (MADEP, 2002). MA DEP did not include children at daycare facilities.
[b]Values are based on an analysis of Kissel et al. (1996).
[c]Age-specific values were not reported.
[d]A description or rationale of this value was not located beyond what was provided by the Texas Commission on Environmental Quality (TCEQ, 2003).

1.3.6. Comparison of Results of DQO Evaluations.

Table 4 provides a comparison of the DQO evaluations for the MDEQ (1999, 2005) and U.S. EPA (2011, 2014). For each DQO, the assessments have been compiled and rated from low to high. As the table shows, all available assessments are based on the same data and result in the same ratings.

Table 4. Summary of DQO evaluation for soil dermal adherence factors

Adherence Factor	MDEQ (1999, 2005) value	U.S. EPA (2011)	U.S. EPA (2014)	New Michigan data	New Scientific Literature
$AF_{birth-<6}$	0.2	Various[a]	0.2	ND	ND
$AF_{6-<EDr}$	0.07		0.07		
AFn	0.2		0.12		
Data Quality Objective Scoring					
Relevance and applicability to Michigan	M			NA	NA
Clarity and comprehensiveness	H				
Soundness and credibility	L				
Transparency and objectivity	M				
Certainty	L				

NA = Not applicable; H = high; M = medium; L = low; M-H = Medium to High; L-M = Low to Medium.
[a]U.S. EPA (2011) recommends activity-specific AF values for specific body parts (see Table 3).

1.4. Conclusion

The studies that formed the basis for the MDEQ (1999, 2005; U.S. EPA, 1997, 2004) AF recommendations were also used as the basis for the values recommended by U.S. EPA (2011, 2014). Table 5 summarizes the updated body part-specific SAs for the age groups used by MDEQ that were derived from U.S. EPA (2011) updated estimates of total SA and fraction of total SA by body part (2011; see TSD for SA). Consistent with U.S. EPA guidance, AFs are calculated using the SA of the face (assumed to be 1/3 the SA for the head) as opposed to the SA for the entire head (U.S. EPA, 2011, 2004).

Table 5. Mean SA by body part (cm^2) for MDEQ Age Ranges

Age Group	Face	Hands	Forearms	Lower Legs	Feet
Ages < 2	266	255	279	409	294
Ages 2 to 6	195	348	457	739	463
Ages birth to 6	219	317	397	629	406
Ages 6 to <16	232	615	851	1588	NA
Ages 16 to <EDr	365	933	1271	2401	NA
Ages 6 to <EDr	313	811	1109	2088	NA
Adult nonresident	417	980	1299	NA	NA

Source: Table 3 of MDEQ SA TSD. SA for face is based on 1/3 SA for head. Based on U.S. EPA (2011) data.
NA = Not applicable.

Following the approach described above for calculating a weighted AF, the updated SA estimates can be used with the activity specific AF data presented in U.S. EPA RAGS E (2004; Appendix C) and U.S. EPA (2011; Table 7-4 and see Table 3 of this TSD) to calculate updated

weighted AF values. Table 6 below shows the body part-specific AFs used in this TSD; the selection of these values and the calculation of the SA-weighted AFs is detailed in Appendix B and described in brief below.

Table 6. AFs by Body Part (mg/cm^2) Used to Calculate SA-Weighted AFs

Age Group	Basis for selection	Face	Hands	Arms	Legs	Feet
Children in Day Care	95th percentile AF, central tendency soil contact activity	NA	0.394	0.071	0.071	0.853
Adult Gardeners	Geometric mean AF, high-end soil contact activity	0.052	0.19	0.052	0.033	0.197
Adult Activities with Soil (construction workers, utility workers and equipment operators)	Geometric mean AF, high-end soil contact activity	0.0982	0.2763	0.1859	0.066	-

Source: Appendix C of U.S. EPA (2004).
NA = Not available.

For the child resident age groups evaluated by MDEQ, the updated weighted AFs are 0.3 mg/cm^2 for all age groups less than 6 years of age. This value was calculated based on the 95th percentile AFs for hands, arms, legs, and feet of children in daycare as reported in U.S. EPA (2004; Appendix C, and Table 6 above). These body part-specific AFs were weighted by the updated SA values for hands, forearms, lower legs, and feet from Table 5 following the approach outlined above. Selecting the daycare activity to represent a central tendency soil activity, and using the 95th percentile body part AFs is consistent with U.S. EPA guidance (2004). Although it is assumed that the head of a child resident is also exposed, there is no AF available for face from the daycare data set. As per U.S. EPA guidance, the default assumption is that the face has the same amount of soil adhered as the weighted AF (U.S. EPA, 2004). U.S. EPA (2004) also considered AF values for children playing in wet soil, U.S. EPA (2011) did not consider the Kissel et al. (1998) study from which these data were derived as a key study in deriving recommended default AF values due to the controlled exposure, small number of study participants, and short activity duration. Additionally, this study was based on children age 8 to 12 years, whereas the child resident age groups evaluated by MDEQ range from 0 to <6 years.

For the adult resident, the updated weighted AF is 0.07 mg/cm^2. This value was calculated based on the geometric mean AFs for faces, hands, arms, and legs of gardeners from U.S. EPA (2004; Appendix C and Table 6 above) and the corresponding body part-specific SAs for male

and female adults shown in Table 7 below. Selecting gardening to represent a reasonable high-end soil contact activity for a residential adult is consistent with U.S. EPA guidance (2011, 2004). This approach should be applied to ages 6 and older (see Table 8 and Appendix B).

Table 7. Mean SA by body part (cm^2) for adults

Gender	Face	Hands	Forearms	Lower Legs
Male	453	1,070	1,480	2,680
Female	380	890	1,117	2,330

Source: Appendix B of SA TSD. SA for face is based on 1/3 SA for head. Based on U.S. EPA (2011) data.

For the nonresidential adult, the updated weighted AF is 0.2 mg/cm^2. This value was calculated based on the geometric mean AFs for faces, hands, and forearms for construction activities from U.S. EPA (2011; Table 7-4, and Table 6 above) and the corresponding body part-specific SAs for the nonresidential adult from Table 7. The geometric mean AFs for this activity group were based on weighted average of geometric mean soil loadings for 27 construction workers, utility workers and equipment operators (ages 21 to 54) for faces, arms and hands. U.S. EPA (2004) selected utility workers to represent a high-end soil contact scenario for a nonresidential adult. The updated activity category recommended by U.S. EPA (2011) includes the utility worker, and is also considered to be a high end soil contact scenario for a nonresidential adult; in addition, it includes a larger variety of possible soil contact activities.

There are no data on AF of pregnant women for use in assessing nonresidential exposure to developmental toxicants. However, it is reasonable to assume that AF is not markedly changed by pregnancy. In the absence of AF data relevant to pregnant workers, MDEQ assumed that the gardening activity represents a high end scenario for a pregnant worker. Thus, the AF value recommended for an adult resident should also be used to assess exposure to developmental toxicants in a pregnant worker.

Table 8 summarizes the 2015 updated MDEQ recommendations for AF.

Table 8. Summary of 2015 Updated MDEQ Values for Soil AF (mg/cm^2)

Parameter	2015 Updated Value
$AF_{ages <2}$ = Soil adherence factor: ages < 2	0.3
$AF_{ages 2-<6}$= Soil adherence factor: ages 2 to <6	0.3
$AF_{ages birth-<6}$ = Soil adherence factor: ages birth to <6	0.3
$AF_{ages 6-<16}$= Soil adherence factor: ages 6 to <16	0.07
$AF_{ages 16-<EDr}$= Soil adherence factor: ages 16 to <EDr[a]	0.07
$AF_{ages 6-<EDr}$= Soil adherence factor: ages 6 to <EDr[a]	0.07

Table 8. Summary of 2015 Updated MDEQ Values for Soil AF (mg/cm^2)

Parameter	2015 Updated Value
AFn= Soil adherence factor: adult, nonresidential	0.2
AFnrdev = Soil adherence factor, nonresidential, developmental toxicant	0.07

[a]EDr is exposure duration for the residential scenario. MDEQ (2005) used 30 years for EDr (and thus $BW_{ages\ 6\text{-}30}$ and $BW_{ages\ 16\text{-}30}$), while the 2015 updated value for EDr is 32 years.

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APPENDIX A

EXPLANATION OF RELATIVE DQO RATINGS

This appendix provides a broad outline of how the DQO ratings were applied. To some extent, professional judgment was used in the application of the ratings, as a set of rating characteristics that would apply to the many different data sources used to develop exposure assumptions was not feasible. The ratings should be considered relative rather than absolute. In other words, the ratings may be compared across sources of data for a single exposure assumption, but a rating of high for one exposure assumption may not be equivalent to a rating of high for another exposure assumption.

Relevance and applicability to Michigan (g*eographic, temporal, and demographic representativeness*).

High: Based on recent data obtained in Michigan, in members of its population, or developed based on data specific to Michigan (e.g., exposure frequency based on climate conditions in Michigan).

Medium: Based on recent data obtained outside Michigan or its population, but in an area or population with comparable geographic, temporal, and demographic conditions.

Low: Based on data obtained outside Michigan or its population, in an area or population with different geographic, temporal, and demographic conditions, or with unknown geographic, temporal, and demographic conditions.

Clarity and comprehensiveness (completeness of method and data reporting, completeness of literature search).

High: Derived value with complete documentation of the selection process, and based on known or apparently thorough literature search, OR, single study with thorough description of methods and results.

Medium: Derived value with incomplete documentation of the selection process, and/or based on limited literature search, OR, single study with some noncritical information missing from methods and results.

Low: Derived value with little or no documentation of the selection process, and/or without accompanying literature search, OR, single study lacking critical information from method or results.

Soundness and credibility (*adequacy of approach; intrinsic sources of bias; sample size*).

High: Using an established method to estimate the parameter, without intrinsic sources of bias, and with adequate sample size(s).

Medium: Using an established method to estimate the parameter, with some known or expected intrinsic sources of bias, and with adequate sample size(s).

Low: Using a novel or uncertain method to estimate the parameter, with or without intrinsic sources of bias, and with inadequate sample size(s).

Transparency and objectivity (availability of supporting data; funding source; peer-review).

High: Based on peer-reviewed study(s) performed by researcher(s) without demonstrable conflict of interest and supported by other studies.

Medium: Based on peer-reviewed study(s) performed by researcher(s) without demonstrable conflict of interest but without support from other studies.

Low: Based on unpublished study(s) and/or performed by researcher(s) with potential conflict of interest and/or based on professional judgment, without support from other studies.

Certainty (number and agreement of studies).

High: Based on > 3 studies with values ranging up to ±50% from the selected value.

Medium: Based on at least 2 or 3 studies with values ranging up to ±100% from the selected value.

Low: Based on a single study or more than one study with variability ranging >±100% from the selected value, or based on professional judgment.

APPENDIX B

DETAILED AF CALCULATIONS

[Appendix B_Detailed AF Calculations.xlsx]