Acute Toxicity Guidance
Acronyms

BW  body weight  
CF  conversion factor  
CTL cleanup target level  
DU decision unit  
EFH Exposure Factors Handbook  
EU exposure unit  
FDEP Florida Department of Environmental Protection  
HEAST Health Effects Assessment Summary Tables  
IR Soil ingestion rate  
IRIS Integrated Risk Information System  
ISM Incremental Sampling Methodology  
LOAEL lowest observable adverse effect level  
MF modifying factor  
NOAEL no observable adverse effect level  
PPRTV Provisional Peer Review Toxicity Values for Superfund  
RfD reference dose  
RfD_{acute} acute reference dose  
PCP pentachlorophenol  
SCTL soil cleanup target level  
UF uncertainty factor  
USEPA United States Environmental Protection Agency  
WHO World Health Organization
1. Introduction

This guidance document was developed to provide updated information on acute toxicity with regard to the cleanup of contaminated sites. Persons conducting site cleanup should use these soil cleanup target levels if current or plausible future exposure scenarios include contact with soil by small children and contaminants with the potential to cause acute toxicity are present.

1.2. Purpose

This acute toxicity guidance is intended for use in the evaluation of risk to human health from contaminants in soil that may lead to an adverse health effect under an acute exposure scenario. For the purposes of this guidance, an acute exposure scenario is defined as a one-time soil pica event in a small child. This guidance updates acute toxicity-based SCTLs for barium, cadmium, copper, cyanide, fluoride, nickel, phenol, and vanadium developed previously in Chapter 62-777, F.A.C. by incorporating a more recent estimate of the amount of soil ingested by a child during a pica event and updating acute toxicity values. Acute toxicity-based SCTLs are only needed if they are lower than chronic toxicity-based SCTLs for the same chemical. Consequently, a second step in the update is a comparison of revised acute toxicity-based SCTLs with their chronic toxicity-based counterparts to determine whether the need for an acute toxicity soil criterion still exists. Based on this update, risk of acute toxicity from barium, copper, and fluoride exists at concentrations lower than chronic toxicity SCTLs. Consequently, acute toxicity SCTLs for these chemicals in soil are retained, albeit with higher concentrations than the original values from 2005.

As a caveat to this update, proposed revisions to Chapter 62-777, F.A.C are under consideration, including the use of updated toxicity values, exposure assumptions, and chemical-physical properties to derive chronic toxicity based SCTLs. For the purpose of this guidance, consensus changes in terms of an updated pica ingestion rate was applied in calculating the revised acute toxicity SCTLs and consensus changes in terms of updated toxicity values and chemical-physical parameters were used to derive chronic toxicity SCTLs for these chemicals for comparison. As potential updates to other exposure assumptions are still in discussion, changes in these assumptions could further alter the chronic toxicity SCTLs and conceivably change the chemicals for which acute toxicity SCTLs are needed. When the Florida Department of Environmental Protection (FDEP) finalizes updates to the chronic exposure assumptions, the acute and chronic SCTLs presented in this guidance will need to be re-visited.

2. Background

Children and adults are often exposed to soil and dust (called soil throughout the remainder of the guidance) through incidental ingestion. By ingesting soil, a receptor is exposed to the contaminants present, which may
cause adverse health effects. Children are of particular concern when addressing this exposure pathway as their behaviors may lead to an increased amount of soil consumed, particularly relative to body weight. These behaviors may be incidental or deliberate and include playing on the ground outdoors and indoors, mouthing objects or their hands, and eating food that has fallen on the floor. Children are also known to exhibit soil-pica behavior where a child may intentionally ingest an unusually high amount of soil (i.e. 1,000-5,000 mg/day or more) (USEPA, 2011).

2.1. Long-term soil exposure to soil

Typically the focus of a risk assessment at a site is to evaluate the long-term (chronic) exposure of receptors to contaminants present. Considering current and future land use, if children are potential receptors at the site, risk is assessed by assuming a child soil ingestion rate of 200 mg/day. The U.S. Environmental Protection Agency (USEPA) suggests 200 mg/day as the default child soil ingestion rate as it represents the upper 95th percentile of soil ingestion in children and is thought to be protective when calculating risk (USEPA, 2014, USEPA, 2011; Ozkaynak et al., 2011; Stanek and Calabrese, 1995).

2.2. Soil-pica behavior

When children exhibit soil-pica behavior their soil ingestion rates can vary between 400 to 41,000 mg/day (USEPA, 2011; Stanek et al., 1998; Calabrese et al., 1989; 1991; 1997a&b; Calabrese and Stanek, 1993; Barnes, 1990; Wong, 1988; Vermeer and Frate, 1979). When assessing risk to children that may exhibit soil-pica behavior, the USEPA suggests using a soil ingestion rate of 1,000 mg/day (1 g/day), for evaluating acute exposures (USEPA, 2011). As soil-pica exposure scenarios lead to a higher ingestion of soil over a shorter period of time than is assumed in chronic exposure scenarios, there may be an increased risk for adverse health effects in children at contaminant concentrations considered protective of long-term exposures. It is important to note that while soil-pica behavior is often seen in children, it can occur in adults up to age 21 (USEPA, 2011; Hyman et al., 1990).

2.3. Chemicals causing acute toxicity

In a 1997 study, thirteen chemicals were evaluated for their potential toxicity in an acute scenario (Calabrese et al., 1997c). In this scenario, estimates of child exposure to soil with contaminant concentrations similar to chronic guidance concentrations (at or below the USEPA Soil Screening Levels and USEPA Region 3 Risk-Based Soil Concentrations) were calculated for a soil-pica event. The thirteen chemicals evaluated were antimony, arsenic, barium, cadmium, copper, cyanide, fluoride, lead, naphthalene, nickel, pentachlorophenol (PCP), phenol, and vanadium. Contaminant doses resulting from a one time exposure event of between 5 to 50 g of soil were estimated and then compared
with acute doses known to produce toxicity in humans during poisoning events. Of the thirteen chemicals evaluated, ingestion of contaminated soil containing cyanide, fluoride, phenol, or vanadium were estimated to result in doses exceeding a reported acute human lethal dose. Ingestion of contaminated soils containing barium, cadmium, copper, lead, or nickel were estimated to produce doses associated with acute toxicity other than death (Calabrese et al., 1997c).

The chemicals found to produce acute toxicity at doses above chronic guidance concentrations were assessed in Chapter 62-777, F.A.C., and acute toxicity-based SCTLs were derived. This document is intended to re-examine those acute toxicity-based SCTLs using an updated assumption regarding soil ingestion rate (Section 3) and a review of the recent literature on acute toxicity of these chemicals in humans. Derivation of updated acute toxicity-based SCTLs can be found in Section 4 of this guidance.

3. Updated soil-pica ingestion rate

The soil-pica ingestion rate of 1 g/day applied in this guidance is a revised exposure assumption. The Chapter 62-777, F.A.C. Technical Report (CEHT, 2005) previously calculated risk to acute exposures using an ingestion rate of 10 g/day as recommended by USEPA at that time (USEPA, 2000). More recently, however, the USEPA has updated their recommended soil-pica ingestion rate to 1 g/day as stated in the 2011 Exposure Factors Handbook (EFH) (USEPA, 2011). To be consistent with current USEPA practice, an ingestion rate of 1 g/day is used to calculate the revised acute toxicity-based SCTLs, as described below.

4. Acute toxicity-based SCTLs

Acute toxicity-based SCTLs were derived previously in the Technical Report for Chapter 62-777, F.A.C. for barium, cadmium, copper, cyanide, fluoride, nickel, phenol, and vanadium. Safe doses intended specifically for acute exposures are not provided by the USEPA for these chemicals. The analysis of these chemicals was primarily focused on reports and studies of acute poisonings in humans. The little data available regarding acute toxicity in animals tend to assess severe endpoints such as death, which are of little value when assessing more sensitive endpoints in humans. Additionally, the use of human data avoids uncertainty involved in extrapolating observations across species (CEHT, 2005).

The method used to derive acute toxicity-based SCTLs in Chapter 62-777 F.A.C. in 2005 was as follows: From the literature on acute poisonings in humans, the acute lowest observable adverse effect level (LOAEL) or no observable adverse effect level (NOAEL) was identified. For systemic endpoints, the LOAEL or NOAEL was then divided by uncertainty factors (UFs) or modifying factors (MFs) to produce a provisional acute toxicity reference dose (RfD<sub>acute</sub>), analogous to the procedure used by the USEPA to derive chronic RfDs.
UFs were used to address uncertainty when extrapolating (e.g., from animals to humans, from healthy subjects to sensitive subjects, etc.) and the MFs were applied to extend the safety margin when the database being assessed is limited or weak. Gastrointestinal effects were considered to be of lesser concern and no UFs were applied in deriving the provisional RfD_{acute} for most chemicals with this critical effect. The RfD_{acute} for each chemical was then compared to the chemical’s chronic RfD. A safe dose for chronic exposure was expected to be the same or lower than a safe dose for acute exposure. If the provisional RfD_{acute} was greater than the chronic RfD for a chemical, the provisional RfD_{acute} was used to derive the acute toxicity-based SCTL. If the RfD_{acute} was less than the chronic RfD for the chemical, the chronic RfD was assumed to be also protective for acute exposure and used to derive the acute toxicity-based SCTL. Acute toxicity-based SCTLs were calculated using the following equation and assumptions:

\[ SCTL = \frac{1}{\frac{RfD_{acute}}{BW} \times IR \times CF} \]

where,

- \( BW \) = body weight (16.8 kg)
- \( RfD_{acute} \) = reference dose for acute exposure (mg/kg)
- \( IR \) = amount of soil ingested (10 g)
- \( CF \) = conversion factor for units (kg/g) \((10^{-3})\)

Note that this equation assumes a single exposure event. Additionally, as acute toxicity to contaminants in soil is driven almost exclusively by ingestion, the SCTL equation does not include inhalation or dermal routes of exposure.

For this update, the following changes were made:

1. The soil ingestion rate (IR) was decreased from 10 g to 1 g, consistent with current guidance from the USEPA *Exposure Factors Handbook* (USEPA, 2011).

2. The RfD_{acute} values were updated based upon a review of the current literature. Also, the use of a MF was eliminated, as these are no longer used by the USEPA to derive reference doses.

As part of the update process, the need for an acute toxicity-based SCTL was re-evaluated for each of the eight chemicals (barium, cadmium, copper, cyanide, fluoride, nickel, phenol, and vanadium). This re-evaluation consisted of comparing the updated acute toxicity-based SCTL with the chronic SCTL for that chemical. If the acute toxicity-based SCTL was lower, it was retained as
necessary to protect health in scenarios where small children might be exposed to soil. If the acute toxicity-based SCTL was greater than the chronic SCTL, promulgation of the acute toxicity-based SCTL was considered unnecessary as the chronic SCTL would be protective of both acute and chronic exposure.

In order to compare acute and chronic SCTLs for these chemicals, some updating of the chronic SCTLs was required as well. In order to do this, a provisional updated chronic SCTL was derived using the equation found in Figure 5 in the Chapter 62-777, F.A.C., updated toxicity values, and updated chemical physical parameters. Exposure assumptions for calculation of the chronic SCTL are those stated in Table 3 of Chapter 62-777, F.A.C. As stated in Section 1.2, updates to the exposure assumptions are currently being proposed for derivation of contemporary chronic SCTLs but have not been adopted at the time this guidance was written. The lower of either the acute or chronic SCTL should be used as the residential SCTL. It is important to note that these SCTLs may change pending the adoption of updated exposure assumptions. A brief summary of the analysis for each of the eight chemicals appears below. Updated reference doses are summarized in Table 1 of this document, and SCTL comparisons are summarized in Table 2.

4.1. Barium

The toxicity of barium is dependent upon the solubility of the barium salt present. Insoluble barium salts, such as barium sulfate, are poorly absorbed. However, soluble barium salts can be very toxic (e.g., barium sulfide, barium carbonate, barium chloride). These salts have a variety of uses, including as rodenticides, as components in explosives and ammunition, and in manufacturing processes such as plastic fabrication. A recent review of acute barium poisoning identified 39 case reports involving 226 subjects (Bhoelan et al., 2014). A typical clinical progression is described as beginning 45-90 minutes after ingestion, with symptoms including nausea, vomiting, diarrhea, and abdominal pain. Paresthesia begins around the mouth and neck and transfers to the hands and feet over the next 2-3 hours. Neuromuscular symptoms then begin to develop, beginning with abnormal reflexes and proceeding to general muscle paralysis on the second day. Paralysis of respiratory muscles can lead to difficulty breathing, and in some patients, to respiratory arrest. Hypokalemia occurs commonly, as well as cardiac arrhythmias. Among the cases considered in this review, the mortality rate was 12%.

The LOAEL for barium toxicity in humans is generally considered to be 200 mg, and lethality can result from doses ranging from 1 to 30 g (Dawson, 2015). An acute toxicity LOAEL of 200 mg corresponds to a dose of approximately 3 mg/kg assuming a 70 kg body weight. Application of a UF of 100 (10 for sensitive subjects and 10 for extrapolation from a LOAEL to a NOAEL) would yield an acute oral RfD of 0.03 mg/kg. This value is lower than
the current USEPA Integrated Risk Information System (IRIS) chronic oral RfD of 0.2 mg/kg/day. As the safe acute dose cannot be lower than the safe chronic dose, the RfD\textsubscript{acute} was made equivalent to the chronic RfD, resulting in an acute toxicity SCTL for barium of 3,400 mg/kg. This value is lower than the chronic SCTL for barium of 16,000 mg/kg/day. The acute toxicity-based SCTL (3,400 mg/kg) is the residential SCTL as this value is protective of both acute toxicity and chronic toxicity. The previous residential SCTL for barium was 120 mg/kg.

4.2. Cadmium

Acute exposure to cadmium may lead to gastrointestinal health effects including nausea, vomiting, salivation, abdominal pain, cramps, and diarrhea (ATSDR, 2012a; Traub and Hoffman, 2015). Case reports of acute poisonings from cadmium in food and beverages consumed by children suggest that an emetic dose is 0.07 mg/kg (ATSDR, 2012a). Because the endpoint is gastrointestinal effects, no UF\textsubscript{s} are applied, yielding a provisional RfD\textsubscript{acute} of 0.07 mg/kg. This value is higher than the current USEPA IRIS chronic oral RfD of 0.001 mg/kg/day, and is therefore used to derive the acute toxicity-based SCTL. The resulting acute toxicity-based SCTL for cadmium is 1,200 mg/kg. This value is higher than the chronic SCTL for cadmium of 78 mg/kg/day. Therefore, the chronic SCTL (78 mg/kg) is the residential SCTL, as this value is protective of both acute and chronic toxicity. The previous residential SCTL for cadmium was also the chronic SCTL, which was 82 mg/kg.

4.3. Copper

Numerous studies involving both accidental exposures and controlled exposure in human volunteers have shown acute gastrointestinal effects following copper ingestion. These effects include nausea, vomiting, and abdominal pain, and infrequently, gastroduodenal hemorrhage, ulceration, or perforation has occurred (Nelson, 2015). GI effects appear to be the most sensitive endpoints for acute copper toxicity in humans (ATSDR, 2004). The ATSDR has developed an acute oral Minimal Risk Level (MRL) of 0.1 mg/kg/day for copper (ATSDR, 2004). This value is higher than the current USEPA Health Effects Assessment Summary Tables (HEAST) oral RfD of 0.04 mg/kg/day, and is therefore the RfD\textsubscript{acute}. The resulting acute toxicity-based SCTL for copper is 1,700 mg/kg. This value is lower than the chronic SCTL for copper of 3,500 mg/kg/day. Therefore, the acute toxicity-based SCTL (1,700 mg/kg) is the residential SCTL, as this value is protective of both acute toxicity and chronic toxicity. The previous residential SCTL for copper was 150 mg/kg.

4.4. Cyanide

Cyanide is a potently toxic inhibitor of cellular respiration. Symptoms of acute cyanide intoxication are consistent with progressive hypoxia and include
CNS symptoms ranging from headache, anxiety, and agitation, to seizures and coma (Holstege and Kirk, 2015). Tachycardia or bradycardia may be produced, with the latter occurring near death. Hemorrhagic gastritis may also occur with ingestion. Any dose of cyanide capable of producing symptoms is potentially serious and medical attention is required.

The average human lethal dose is reported to be 1.52 mg/kg and the lowest fatal dose reported in the literature is 0.56 mg/kg (USEPA, 1987 and Gettler and Baine, 1938; as cited in ATSDR 2006). Because the best dose-toxicity information for cyanide includes death as an endpoint, an RfD_{acute} was not suggested by the Chapter 62-777, F.A.C. Technical Report. This is because there is no standard set of uncertainty factors to develop a safe dose based on a lethal dose, particularly one established in humans. However, applying a UF of 10,000 to the average human lethal dose (approx. 1.5 mg/kg) would give an RfD_{acute} that corresponds to an acute toxicity-based SCTL of 2.5 mg/kg, which is larger than the updated chronic cyanide SCTL of 1 mg/kg. This provides some assurance that the chronic SCTL (1 mg/kg) will be protective of both acute and chronic toxicity. The previous residential SCTL for cyanide was 34 mg/kg.

4.5. Fluoride

There are many case reports of acute fluoride poisoning, including fatalities. The acute lethal dose in adults appears to be 32-64 mg/kg (Hodge and Smith, 1965). The lowest fluoride dose producing death in a child was reported for a case involving a 27-month old who ingested 100 fluoride tablets, corresponding to a dose of approximately 8 mg/kg (Whitford, 1990; as cited in ATSDR, 2003). In another case, a 3-year old died from ingesting fluoride tablets at a dose of 16 mg/kg fluoride (Eichler et al., 1982; as cited in ATSDR, 2003).

Fluoride is corrosive to the gastrointestinal tract, and symptoms from most fluoride poisoning episodes include nausea, vomiting, diarrhea, and abdominal pain, although more severe cases can include hypocalcemia, hyperkalemia, cardiac arrhythmias, muscle spasm, tetany, and convulsions (Augenstein et al., 1991; Spoerke et al., 1980). Flavored fluoride supplements are a frequent source of accidental fluoride poisonings in the home. Spoerke et al. (1980) reviewed 150 reported cases of accidental poisonings with fluoride and found no GI symptoms when the fluoride dose was below 5 g (absolute dose, not mg/kg), 10% with symptoms when the dose was 5-9 g, 21% with symptoms when the dose was 10-19 g, 50% with symptoms from doses of 20-29 g, and 100% with symptoms from doses of 30-39 g. Augenstein et al. (1991) surveyed 87 cases of fluoride ingestion referred to a poison control center and found 8% were symptomatic with fluoride doses < 1 mg/kg, 17% were symptomatic with fluoride doses of 1-2 mg/kg, 27% were symptomatic from 2-3 mg/kg, 50% were symptomatic from 3-4 mg/kg fluoride, and 100% were symptomatic when the fluoride dose was 4.8 mg/kg.
Whitford (1992) proposed 5 mg/kg as a “probably toxic dose” of fluoride, and this value has been repeated by others as a recommendation for doses above which immediate medical attention is required. As Akiniwa (1997) has pointed out, this value is not a threshold for toxicity, and in fact a number of studies have found GI symptoms in children ingesting fluoride in doses extending down to 0.1 mg/kg. Using this toxicity threshold and applying no uncertainty factor [as the critical effect is gastrointestinal effects] results in a provisional RfD_{acute} of 0.1 mg/kg. This value is higher than the current USEPA IRIS chronic oral RfD of 0.06 mg/kg/day, and is therefore used as the RfD_{acute}. The corresponding acute toxicity-based SCTL would be 1,700 mg/kg. This value is lower than the chronic SCTL for fluoride of 5,200 mg/kg/day. Therefore, the acute toxicity SCTL (1,700 mg/kg) is the residential SCTL. The previous residential SCTL for fluoride was 840 mg/kg.

4.6. Nickel

The only information regarding the acute lethal dose for nickel ingestion is from a 2-year old child that ingested nickel sulfate crystals and died from cardiac arrest (Daldrup et al., 1986). The estimated dose was 570 mg/kg. Acute exposure to nickel (nickel sulfate and nickel chloride) in workers has been reported to cause symptoms of gastrointestinal distress including nausea, vomiting, and abdominal cramps with systematic effects including episodes of giddiness, lassitude, headache, and cough (Sunderman et al., 1998). Ten out of 20 of these workers were hospitalized. Estimated ingested nickel doses in this incident ranged from 0.5 to 2.5 g, corresponding approximately to 7 to 36 mg/kg assuming a body weight of 70 kg. Taking the lower end of this range, and applying no uncertainty factor because the effects were primarily gastrointestinal, a provisional RfD_{acute} of 7 mg/kg is derived. This corresponds to an acute toxicity-based SCTL of 120,000 mg/kg for nickel. This is much higher than the chronic SCTL for nickel of 1,600 mg/kg/day. Therefore, the chronic SCTL (1,600 mg/kg/day) is the residential SCTL as this value is protective of both acute and chronic toxicity. The previous residential SCTL for nickel was 340 mg/kg.

It should be noted that gastrointestinal effects are not the most sensitive endpoint in nickel. Nickel has been shown to produce dermal hypersensitivity reaction in individuals with nickel sensitivity. Nickel sensitivities appear to exist in about 15% of women and 3% of men, although more recent studies suggest higher rates (Curtis and Haggerty, 2015). Neither the acute nor chronic SCTLs are protective of nickel sensitive individuals.

4.7. Phenol

Acute exposure to non-fatal doses of phenol has been reported to cause symptoms of burning mouth and gastrointestinal irritation and distress (Diechman, 1969). One case report indicated that ingestion of 14 mg/kg resulted in gastrointestinal effects (Cleland and Kingsbury, 1977). In another study,
consumption for several weeks of water contaminated with phenol was found to produce diarrhea, burning mouth, and mouth sores (Baker et al., 1978). Estimated doses of phenol in these individuals ranged from 0.14 to 3.4 mg/kg/day.

The ATSDR has developed an acute MRL for phenol of 1 mg/kg/day (ATSDR, 2008). A provisional RfD_{acute} of 1 mg/kg is greater than the chronic RfD of 0.06 mg/kg/day, and therefore is an appropriate basis for an acute toxicity-based SCTL. The acute toxicity-based SCTL for phenol of 17,000 mg/kg is higher than the chronic SCTL for phenol of 13,000 mg/kg. Therefore, the chronic SCTL (13,000 mg/kg) is the residential SCTL, as this value is protective of both acute toxicity and chronic toxicity. The previous residential SCTL for phenol was 500 mg/kg.

4.8. Vanadium

Acute toxicity to vanadium primarily occurs following respiratory exposure in occupational settings; however, data are available on the effects of vanadium ingestion due to the examination of its therapeutic applications and use as an athletic performance enhancer (Dimond et al, 1963; Fawcett et al., 1997). Symptoms of acute toxicity include gastrointestinal irritation and distress, including nausea, diarrhea, and abdominal cramps (ATSDR, 2012b). The ATSDR has summarized studies of individuals receiving various doses of vanadium and reported GI complaints. Although the ATSDR did not develop an acute MRL, a LOAEL for gastrointestinal effects of 0.35 mg/kg/day was identified (ATSDR, 2012b). Using this value without an uncertainty factor, a provisional RfD_{acute} of 0.35 mg/kg is obtained. This value is higher than the current USEPA Provisional Peer Reviewed Toxicity Value (PPRTV) of 0.00007 mg/kg/day, and is therefore set as the RfD_{acute}. The resulting acute toxicity SCTL for vanadium is 5,900 mg/kg. This value is higher than the chronic SCTL for vanadium of 5.5 mg/kg/day. Therefore, the chronic SCTL (5.5 mg/kg) is the residential SCTL as this value is protective of both acute toxicity and chronic toxicity. The previous residential SCTL for vanadium was 67 mg/kg.

5. Application

As a result of updating the soil-pica ingestion rate and the chemical toxicity values, the residential SCTLs for cadmium, cyanide, nickel, phenol, and vanadium are driven by the chronic exposure scenario. Previously, only the residential SCTL for cadmium was driven by the chronic exposure scenario. The residential SCTLs for the three remaining chemicals, barium, copper, and fluoride, are driven by acute toxicity. The acute toxicity SCTLs should be used as residential SCTLs for these chemicals in situations where small children might come into contact with soil (e.g. residential areas, schools, daycare facilities, etc.). The residential SCTLs derived in this guidance can be found in Table 2.
6. Addressing acute toxicity with ISM

When assessing a contaminated site, the use of discrete soil samples offers a fairly straightforward approach to evaluating risk from chemicals that may cause acute toxicity. Discrete samples provide risk assessors with a contaminant concentration for a single location. However, when soil is sampled using Incremental Sampling Methodology (ISM), information on variability across the decision unit (DU) is lost and an estimate of the maximum concentration is not straightforward. As ISM is a useful sampling tool at sites due to its ability to reduce data variability and provide a relatively unbiased estimate of the mean concentration, the matter of acute toxicity needs to be addressed (ITRC, 2012).

The size of a DU can be the same size as an exposure unit (EU). Taking three ISM samples from, for example, a residential lot of 0.25-acres would produce data on the average concentration of a contaminant in the DU. With this method, there is potential for areas of higher concentration of a chemical that produces acute toxicity to be missed. To account for this, the mean concentration can be multiplied by the number of increments. By doing this, the assessor is simulating a situation where all the contaminant is present in the area represented by one of the increments. This is a protective approach and may produce an overestimation of the maximum concentration. Another approach would be to multiply the average concentration in a DU by the square root of the increments. Additional formulas for these approaches can be found in Barnett and Bown (2002; as cited in ITRC, 2012).
References:


Wong, MS. (1988) The role of environmental and host behavioural factors in determining exposure to infection with Ascaris lumbricoides and Trichuris trichiura. (Doctoral Dissertation). University of the West Indies, Faculty of the Natural Sciences, Mona, Kingston, Jamaica.
Table 1. Acute and chronic reference doses (RfDs)

<table>
<thead>
<tr>
<th>Contaminants</th>
<th>RfD acute (mg/kg)</th>
<th>Source</th>
<th>Chronic RfD (mg/kg/day)</th>
<th>Source</th>
<th>RfD used in Acute Equation</th>
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* Chronic RfD used in acute equation
IRIS – USEPA’s Integrated Risk Information System
HEAST- USEPA’s Health Effects Assessment Summary Tables
PPRTV- USEPA’s Provisional Peer Reviewed Toxicity Values for Superfund
Table 2. Comparison of Acute Toxicity-Based SCTLs (mg/kg) and Chronic SCTLs (mg/kg/day)

<table>
<thead>
<tr>
<th>Contaminants</th>
<th>Old Acute SCTL</th>
<th>New Acute SCTL</th>
<th>New Chronic SCTL</th>
<th>New Residential SCTL</th>
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* Chronic SCTL used as residential SCTL