DEVELOPMENT OF A NATIONAL METHODOLOGY FOR RISK-BASED HUMAN HEALTH SOIL GUIDELINE VALUES FOR CONTAMINATED LAND ASSESSMENT

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1.0 Introduction

The Ministry for the Environment (MfE) is developing a framework for contaminated land risk assessment and management with a view to there being a National Environmental Standard for contaminated land. A companion paper describes the policy context (Court, et al., 2008). Key to the framework is a consistently-derived set of generic soil guideline values (SGV) to replace and extend the existing guideline values in the so-called *Timber Treatment* (MfE/MoH, 1997), *Gasworks* (MfE, 1997), *Oil Industry* (MfE, 1999) and *Sheep-dip* (MfE, 2006) guidelines. This paper describes the development of the new guidelines by two advisory groups to the Ministry for the Environment, the Toxicological Advisory Group and the Technical Advisory Group, and briefly covers the work set out in more detail in Cavanagh (2008) and Proffitt and Cavanagh (2008).

The new methodology is based on the existing methodology but uses a revised set of generic exposure scenarios and a revised set of generally less conservative exposure parameters, following a review of the international literature. In addition, the fundamentally important toxicological and other contaminant-specific parameters have been revised based on review of those values currently used both nationally and internationally for regulatory purposes and from the international literature. The final outcome should provide robust and transparently-developed values that are conservatively protective for most people for the designated scenarios, but not so conservative as to be unnecessarily onerous if used as default cleanup values.

This paper presents the background to, and values for, the first priority group of contaminants, which includes arsenic, benzo(a)pyrene (BaP), cadmium, copper, chromium, dieldrin and DDT. For all but cadmium, for which New Zealand values did not previously exist, these values are intended to replace SGVs in existing New Zealand guidelines. Values for a further group of priority contaminants are intended to be developed in the near future.

2.0 Derivation of soil guideline values

Soil guideline values for a contaminant are derived by equating an exposed person's weight-normalised daily intake from soil exposure with the allowable daily intake for that contaminant and is given by Equation 1. In other words, the SGV is the soil concentration that exactly results in an intake equal to the allowable intake, known generically as a reference health standard (RHS)[1]. Reference health standards are considered in greater detail in Section 4.0 below.

$$\text{Soil guideline value}_i = \frac{\text{allowable intake}_i \times \text{body weight} \times \text{averaging time}}{\text{contact rate}_i \times \text{exposure frequency} \times \text{exposure duration}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad 1$$

A person can be exposed to near-surface contaminated soil[2] in a number of ways. Most of the contaminant intake from exposure to near-surface soil is generally from a combination of two or three pathways: incidental soil ingestion, dermal adsorption from soil adhering to the skin and, in the case of people growing vegetables, consumption of produce grown in contaminated soil. Contaminants can also be inhaled, either as contaminants bound to particulates, in the case of non-volatile contaminants, or as vapours, in the case of volatile substances.

Where the toxicological mode of action is the same irrespective of the exposure pathway, a combined SGV can be derived assuming the total intake from all significant pathways is additive[3]. This is the practice adopted in the *Timber Treatment*, *Gasworks* and *Sheep-dip* guidelines (but not the *Oil Industry Guidelines*) and follows the practice in the United States (US EPA, 1989; 1996), Britain (Defra & EA, 2002a) and many other countries (but not the Canadian CCME guidelines; CCME, 2006). This gives rise to a combined SGV given by equation 2.

$$\text{Soil guideline value} = \frac{1}{\left(\frac{1}{\text{soil guideline value}_1} + \frac{1}{\text{soil guideline value}_2} + \frac{1}{\text{soil guideline value}_3} + \cdots\right)} \quad \ldots\ldots \; 2$$

New Zealand has closely followed United States practice in using these equations. Following a review of several overseas jurisdictions it has been decide to continue this practice but with some small differences.

For their generic guidelines the US EPA, for simplicity, uses two standard receptors; a child aged 1 - 6 (represented by a 15 kg toddler) and an older child/adult (represented by a 70 kg body weight). This has been adopted in all the existing New Zealand guidelines and will continue on the basis that these body weights remains reasonably representative of New Zealanders and are consistent with international methodologies.

New Zealand has also adopted the approach of slightly different derivations for so-called threshold and non-threshold contaminants. Threshold contaminants are considered to manifest toxic effects only if exposure exceeds a threshold concentration, including (by convention), non-genotoxic carcinogens and non-carcinogens. Non-threshold contaminants are conventionally considered to include genotoxic carcinogens, and are considered to have effects at all levels of exposure.

For threshold contaminants, averaging time in Equation 1 is set to the exposure duration for the critical receptor (a child for residential situations and an adult for occupational settings)

[1] Reference Health Standard is a general term used to describe an estimated daily amount of a substance that can be taken into the body without either any risk, or an unacceptable additional risk, of detrimental health effects occurring based on available scientific information, that has been set by a regulatory or advisory body

[2] Generic SGVs are applicable to soil that a person would be exposed to in their normal activities. For a residential site this generally means soil at or close to the surface (an exception being where volatile contaminants are present). Deeper soil will not be contacted as frequently and therefore applying SGVs for non-volatile substances to deeper soil is conservative.

[3] Where the toxicological mode of action of the contaminant is different for different exposure pathways, then the pathways for only the critical mode(s) of action should be combined.

and the daily intake is simply the weight-normalised daily contact rate prorated for the number of days in the year that the exposure occurs (the exposure frequency). However, in a variation to the US EPA practice, but in common with British practice, the RHS is modified by subtracting the estimated background intake from dietary and other sources, with all the residual assumed to be available for intake from contaminated soil. This results in a more conservative SGV than if background intake was not subtracted but is considered to be a more realistic approach.

For non-threshold substances the US EPA approach is followed by calculating a weighted average contact rate across all receptors, with the averaging time set to a lifetime by convention. For residential scenarios this averaging process results in "age-adjusted" rates that take into account the different body weights and exposure durations of the receptors. This averaging is to recognise that exposure to a non-threshold substance could have a health effect at any point in a person's subsequent life.

Using the soil ingestion pathway as an example, the SGV for the pathway is then calculated from:

Threshold substance: $$SGV_{ing} = \frac{(RHS - BI) \times BW \times 365 \times 10^6}{IR \times EF} \text{ mg/kg}$$

where: IR = soil ingestion rate (mg/day)

Non-threshold substance: $$SGV_{ing} = \frac{RHS \times AT \times 10^6}{IR_{adj} \times EF} \text{ mg/kg}$$

With IR_{adj} being represented by:

$$IR_{adj} = \sum \frac{IR_i \times ED_i}{BW_i}$$

where: RHS = chemical specific reference health standard (mg/kg-bw/day)
BI = background intake (mg/kg-bw/day)
ED = exposure duration (years)
EF = exposure frequency (days/year)
AT = averaging time ED × 365 days for a threshold substance, or 75 × 365 = 27, 375 days for non-threshold, 75 years being a lifetime.
BW = body weight (kg)
IR_{adj} = the age adjusted soil ingestion rate (mg-yr/kg-day) with ∑ signifying summation over receptor groups *i* = 1 to n
IR_i = soil ingestion for receptor group *i* (mg/day)
BW_i = body weight for receptor group *i* (kg); and
10^6 is a conversion factor

Similar equations are used for the produce ingestion and dermal absorption pathways. New Zealand has chosen to consider consumption of home-grown produce in the derivation of generic guidelines for residential settings because, as a matter of policy, it is considered that growing vegetables at home is a common pastime that could contribute significantly to a person's contaminant exposure. This is in common with British policy but contrary to US EPA and Australian policy, both the latter considering the produce pathway to be the subject of site-specific assessment. All other things being equal, this will mean that generic New Zealand guidelines will be more conservative than generic guidelines from either the United States or Australia, for contaminants that are taken up into vegetables. This has implications for when guidelines are adopted from these countries in the absence of a New Zealand value.

For the produce pathway equation, the soil ingestion rate is replaced by the contaminant intake rate from produce, which is the daily produce consumption rate multiplied by a chemical-specific produce bioconcentration factor (BCF)[4]. A further factor is applied to take into account the proportion of daily produce consumption grown in contaminated soil.

The dermal absorption pathway calculates the mass of contaminant attached to the skin by multiplying the soil concentration by a soil adherence factor (mg/cm^2) and a skin area (cm^2). The amount of contaminant passing through the skin is then calculated using a dermal absorption factor.

Inhalation of particulates has been included in existing New Zealand guidelines and is included in the US EPA generic derivation. However, inhalation of particulates contributes negligibly to exposure and has not been included in the revised derivation. Inhalation of volatiles can be a significant contributor, but requires significantly more complex derivation than presented above. As none of the contaminants considered in this paper are volatile, inhalation of volatiles will not be considered here.

3.0 Generic exposure scenarios

To assist their application, SGVs are derived for a set of standard exposure scenarios based on land use. By selecting an appropriate range of typical land uses, SGVs can be developed to cover most of the population. Six generic exposure scenarios have been developed. These are similar to those in existing New Zealand guidelines, but have been refined to better represent typical New Zealand lifestyles, urban development practices and occupational settings. Generic scenarios from several overseas jurisdictions were considered in the process of refining the existing scenarios. The revised generic scenarios are:

Rural/Lifestyle Block: Rural-residential land use, including high home-grown produce consumption (50% of vegetable consumption). Intended to cover the rural-residential “lifestyle block” but also applicable to the vicinity of farm houses for the protection of farming families. Not intended to cover land used for agricultural production as risks from contaminants in food grown commercially are monitored through industry and regulatory testing regimes. Risks to those people working on agricultural land would require site-specific assessment.

Residential: Standard, single-dwelling sites with gardens, including low home-grown produce consumption (10% of vegetable consumption), intended to cover most residential properties. As a sub-scenario, a residential no-produce SGV can be calculated by leaving out the produce consumption component.

High-density residential: Urban residential with limited opportunity for soil contact, applicable to urban townhouses, flats and ground floor apartments with small gardens, but not vegetable gardens. Does not apply to multi-storey apartments, for which soil exposure is negligible.

Parks/recreational: Public and private green areas that are used for active sports and recreation. Covers sports fields, including secondary school sports fields, and suburban green spaces and road berms actively used by children. Not intended for children’s playgrounds,

[4] The BCF relates the concentration of the contaminant in produce to the soil concentration. Separate factors can be used for leafy and root vegetables.

and more passive recreational areas such as botanical gardens, nature reserves and central city parks (see later comment).

Commercial/Industrial Indoor Worker: Applies to adults working in buildings on largely paved commercial/industrial sites where they have little exposure to soil. The scenario includes factories, warehouses, shopping centres, high-rise apartments and other fully-paved residential properties.

Commercial/Industrial Outdoor Worker (unpaved): Applies to adult outdoor workers on commercial/industrial sites which have varying degrees of exposed soil. The scenario assumes exposure to near-surface soil during routine maintenance and landscaping activities, and occasional exposure to deeper soil during excavation. This scenario is also applicable to outdoor workers on a largely unpaved site.

For the rural residential and standard residential scenarios, exposure to soil is considered for three pathways: soil ingestion, dermal absorption and produce consumption. The other land use scenarios consider just soil ingestion and dermal absorption. The only difference between the rural and standard residential scenarios is the amount of home-grown produce consumed. (Existing guidelines are inconsistent, with some having 100% and others 50% home-grown produce for the rural scenario, while the standard residential has variously used 50% and 10%). The current work has followed the *Sheep-dip Guidelines* (MfE, 2006), which settled on 50% for rural and 10% for residential as a matter of policy, largely based on professional judgement.

Soil guideline values have not currently been developed for the indoor worker scenario as exposure to all but volatile substances will be negligible (SGV = no limit). Soil guideline values for volatile substances (e.g. benzene) will be considered in later stages of this work.

The generic scenarios and SGVs are not intended to cover land uses and activities that deviate markedly from the exposure rates used in the derivation, such as construction and excavation workers, primary schools, childcare centres and playgrounds. It may be that the generic scenarios are suitable for a conservative first screening for land uses that involve less exposure than the chosen generic scenario; otherwise, site-specific assessment will be necessary.

4.0 Toxicological and other contaminant-specific parameters

The SGV equations above rely on a number of contaminant-specific values, the most important being the "allowable" intake for a given contaminant. The "allowable" intake for threshold contaminants is often referred to as a tolerable daily intake (TDI) or chronic reference dose (RfD), and is the estimated daily amount that can be taken into the body over a lifetime of exposure without any detrimental health effects occurring, based on available scientific information. The potency of non-threshold contaminants is typically expressed either as (1) a slope factor which is the increased risk per daily dose, or (2) a risk-specific or index dose, which can be obtained by dividing an acceptable increased risk level[5] by the slope factor. Other contaminant-specific parameters required are background intake (threshold contaminants only[6]), dermal absorption and plant bioconcentration factors (BCF). Parameters specific to the contaminants considered to date are shown in Table 1.

[5] The level of increased health risk arising from exposure to contaminants is a policy decision; currently an increased risk of 1 in 100,000 is considered to be acceptable in New Zealand policy settings.
[6] Background intake is not relevant for non-threshold contaminants as it is assumed that exposure to these contaminants is minimised (to a practicable and reasonable extent) as a matter of policy.

Recommendations on the allowable and background intakes, and dermal absorption of individual contaminants, are underpinned by a critical review of the relevant toxicological information on each contaminant. Such review is a critical step in the derivation of SGVs. Reviews of arsenic, BaP, benzene, DDT, dieldrin, copper, chromium and cadmium have been undertaken to date (Cavanagh 2008). This review especially focused on the toxicological evidence for "allowable" intakes or Reference Health Standards (RHS) developed by different international agencies including the US EPA, the United States Agency for Toxic Substances and Disease Registry (ATSDR), UK Department of Environment, Food and Rural Affairs (DEFRA), Canadian Council of Ministers of the Environment (CCME), World Health Organization (JMPR, JECFA meetings), Dutch Ministry, as well as those adopted in New Zealand e.g. Drinking-water Standards. The review was overseen by the toxicological advisory group consisting of toxicologists from the Ministry of Health, Environmental Risk Management Agency, Department of Labour, New Zealand Food Safety Authority and Ministry of Agriculture and Forestry. The group was supported in their decisions by a regional council representative and the first author of this paper. The intention is to re-convene the group in the near future to consider up to seven more contaminants and thus expand the list of contaminants being considered to around 15.

The recommended toxicological criteria for most contaminants differ from that previously used in New Zealand guidelines, most significantly for arsenic and BaP. In both of these cases the recommended values are based on more recent data than was available at the time of the previous considerations. For arsenic, the revised estimates are based on epidemiological data regarding the likelihood of increased incidence of bladder and liver cancers.[7]

For BaP, the revised estimates for oral ingestion are based on recent laboratory studies using rats. In addition, a separate dermal slope factor has been proposed for use instead of a dermal absorption factor because there is some evidence that BaP acts as a point of contact mutagen, and doesn't elicit systemic responses; therefore dermal and oral ingestion pathways should be considered separately. It is also notable that recent evaluations by the European Union Scientific Committee on Food (EC, 2002) and JECFA (FAO/WHO, 2006) have derived an RHS for BaP that represent the toxicity of the whole polycyclic aromatic hydrocarbons (PAH) mixture (surrogate approach). This contrasts with the conventional approach of deriving an RHS for BaP as a single component, and determining the toxicity of a PAH mixture through the use of potency equivalence factors (PEFs), which express the toxicity of a given PAH relative to that of BaP. This latter approach has been used in previous New Zealand guidance, following the US EPA, and remains the preferred approach. A revised set of PEFs (formerly known as toxicity equivalency factors – TEF) is shown in Table 2.

For both arsenic and BaP, different potency estimates based largely on the same data are available in the literature. These different estimates arise from the use of different dose-response models. The use of different models is partly policy-driven and New Zealand guidance on which model is preferred is needed to ensure that RHS proposed for other non-threshold contaminants have a consistent derivation basis.

Dermal exposure to contaminants is typically assumed to contribute to the systemic response primarily elicited by ingestion of the contaminant. As such, a dermal absorption factor is used to estimate the amount absorbed. The dermal absorption factors recommended were based on median estimates from available scientific literature.

[7] However, it should also be noted that there is currently extensive international debate over the mechanism of action of arsenic and whether a threshold of effect may in fact exist. This would potentially alter the derivation of this SGV i.e. it would then be treated as a threshold contaminant - see Section 2.0

For non-threshold contaminants it is assumed that, as a matter of policy, exposure from all sources (including food air and water) is minimised to an extent that is reasonable and practicable, thus background exposure is not taken into account for these contaminants. However, for threshold contaminants background exposure may comprise a significant portion of an individual's total exposure to a contaminant, thus it is important to take into consideration. For the contaminants considered to date, dietary intake (food and water) typically dominates background exposure. Dietary intakes were estimated from the most recent New Zealand Total Diet Survey (Vannoort and Thomson 2005) and surveys of drinking water quality (Davies et al. 2001).

The current use of 100% oral bioavailability has also been reviewed but as a matter of policy it has been decided that SGVs will continue to be derived assuming 100% of the contaminant in ingested soil will be absorbed from the gastrointestinal tract into the body. This is conservative but continues to be the default position internationally. Currently the science is insufficiently developed to allow oral bioavailability factors to be determined with any certainty and available laboratory tests have been only partially validated overseas and have not been validated for New Zealand soils and type of contamination.

Finally, contaminant intake via consumption of home-grown produce can be a significant exposure pathway in a residential land-use scenario. However, the potential contaminant intake estimated for this exposure pathway is the most uncertain and variable of intakes estimated for all exposure pathways. Part of this uncertainty stems from the lack of national statistics on the total amount of fruit and vegetables (produce) consumed, and on the proportion of home-grown produce consumed. However, probably the most significant source of uncertainty and variability arises from estimating the uptake of soil contaminants by plants. The uptake of contaminants from soil and transport within plant tissues differs for different plant species as well as for different contaminants and different soil types. There are many approaches for determining plant uptake for use in deriving generic SGVs, and all have difficulties. As such, a pragmatic approach of using the median BCF determined from review of the available scientific literature has been adopted in the current work.

5.0 Scenario and pathway-specific exposure parameters

Numerical values have to be assigned to approximately 25 parameters in the derivation equations. In addition to the chemical-specific values, described above, there are two other broad types of parameters: the general parameters relating to such things as body weights and averaging times that are common to all pathways; and pathway-specific parameters such as soil ingestion rates, skin areas and produce consumption rates, that vary with the receptor (adult or child) and across the different scenarios. The various factors are listed in Table 3.

The general philosophy has been to choose average or central tendency values for most parameters, with upper-bound (95^{th} percentile) for exposure frequency and exposure duration, the intent being to avoid compounding conservatism. The aim is to have SGVs that are conservative, and therefore protective of most people exposed to a contaminated site, but not so conservative that using SGVs as default clean-up values would be too conservative in the event that a site owner does not want to go to the expense of a site-specific or "Tier 2", assessment. This is a slightly less conservative philosophy to the US EPA's "Reasonable Maximum Exposure" (RME) which uses high-end estimates for exposure frequency, exposure duration and soil ingestion to obtain a "high-end" but not maximum possible exposure.

It is noteworthy that there has been criticism of the derivation of both United States and United Kingdom generic values as being two conservative because of compounding conservatism (US EPA, 2004a; Defra, 2006), with overly-conservative soil ingestion rates being a particular criticism. However, in the United States the US EPA's generic guidelines are designed for the initial screening of what are often large, complex "Superfund" sites that will typically go through multiple stages of further investigation and site-specific assessment. The US EPA's generic guidelines are not intended to be used as clean-up targets.

Following a review of all the various exposure parameters for consistency with the revised philosophy on risk, the New Zealand lifestyle, and activities thought typical, the following changes to existing guidelines have been proposed (Cavanagh and Proffitt, 2008):

- Lifetime (non-threshold averaging time) increased to 75 years (from 70 years), based on census data.
- Adult residential exposure duration reduced to 14 years (from 24 years) based on census data.
- Childhood soil ingestion rate reduced to 45 mg/day (from 100 mg/day) based on a review of soil ingestion studies by Van Holderbeke et al (2007), and other soil ingestion rates adjusted based on professional judgement.
- Dermal soil adherence rates reduced and skin areas adjusted, based on US EPA (2004b)

6.0 Derived soil guideline values

The draft SGVs derived using the revised equations, toxicological criteria and exposure parameters are shown in Table 4. It is considered these represent the best SGVs for New Zealand conditions and the New Zealand policy context. However, the exposure parameters and the toxicological criteria on which they are based are subject to further review (and in the case of some arsenic and cadmium SGVs, replacement with adopted values based on background concentrations – see below) and stakeholder consultation before being confirmed. The revised SGVs do not represent current government policy.

It will be immediately obvious to those familiar with existing New Zealand guideline values that many of the new values are quite different to the old values. Some are more conservative and some are less conservative. The differences are a result of a combination of new toxicological criteria and revised exposure rates. There is no particular pattern on whether a value has increased or decreased, as the chemical-specific factors tend to dominate.

For example, the values for arsenic are somewhat lower than the derived values in the *Timber Treatment Guidelines* (the derived guideline for 100% produce was 4.2 mg/kg and for 50% produce, 8.1 mg/kg) and significantly lower than the adopted value of 30 mg/kg. This is mainly because the toxicological criterion is more conservative, although this is partly offset by the lower childhood soil ingestion rate. The derived value for the rural residential scenario may often be below background concentrations, which is impractical. Moreover, the background concentration of 30 mg/kg adopted in the *Timber Treatment Guidelines* to avoid this issue has an uncertain basis. The Ministry for the Environment is currently collating background concentrations throughout New Zealand in order to decide on an appropriate value to adopt in place of the derived value.

The values for BaP are generally less conservative than past values. The main reasons are that the toxicological criteria for oral and dermal intakes are higher than previously and consider the oral (soil and produce) and dermal pathways separately, taking the critical pathway as the SGV. The latter is because the toxic mode of action for the dermal pathway is different to the oral pathway. The produce pathway is dominant for the exposure scenarios where that pathway exists, but the dermal pathway is dominant for all other scenarios.

A New Zealand SGV for cadmium has not existed before. There is a marked dominance of the produce pathway for the residential scenarios at low soil pH, with the derived values potentially being below the local background concentration. New Zealand soils typically have a low pH (MAF, 2008). As for arsenic, MfE is collating background soil concentrations for cadmium so as to adopt a value in place of the derived value.

The derived values are not dissimilar to the United Kingdom values (Defra & EA, 2002b), which included consideration of produce ingestion, but very much lower than residential values from the United States or Australia, which do not include produce ingestion. Both the Australian and U.S. values have been commonly used in New Zealand in the past. The cadmium SGV is a particularly good illustration of the danger of using an overseas value without considering its derivation.

7.0 Notes on the application of guidelines

Policy guidance on the way the SGVs are to be applied is still being developed. However, the SGVs are designed to be conservatively protective of 95% of people. This means that most people on a particular contaminated site should not be at risk from health effects at concentrations up to the SGV, but a small proportion of people might because those particular people have extreme exposure (the upper 5%) due to their particular lifestyle or circumstances. However, many people will not be at risk of any health effects even if concentrations exceed the SGV, given that most people, by definition, will have a smaller soil exposure than the 95th percentile person. For non-threshold substances the SGVs assume the critical receptor is a 15 kg toddler and will therefore be more protective for adults and children heavier than 15 kg (i.e. most people). This should be considered on a site-by-site basis rather than automatically using the values as clean-up targets.

The SGVs have been calculated for land use scenarios that assume exposure integrated across a site or, in other words, exposure not just from one location. It is therefore appropriate to compare SGVs with average concentrations within an appropriate exposure area (e.g. a residential lot or back yard). A single or small number of sampling results may not provide a good estimate of average concentrations and therefore should be used with caution when comparing with SGVs. As noted previously, for non-volatile contaminants SGVs are intended for surface or near-surface soil. Applying a SGV to a deeper sample location that would not normally be contacted is conservative.

The produce pathway is possibly the least reliable pathway, because of uncertainty in the BCF values yet it sometimes contributes significantly to, or even dominates, the combined SGV. This should be taken into consideration when applying an SGV to a given site that is dominated by this exposure pathway.

Table 1: Chemical-specific parameters for seven priority contaminants

Contaminant		Status	RHS (mg/kg-bw/day)	Background Intake Child/Adult (mg/kg-bw/day)	Dermal Absorption	Plant BCF (root/leaf)
Arsenic		Non-threshold	0.0000086	NA	0.005	0.025/0.025
Benzo(a)pyrene		Non-threshold	0.0000083 (oral) 0.0000004 (dermal)	NA	0.06	0.048/0.047
Cadmium	pH5	Threshold	0.001	0.00041/0.00026	0.001	19/21
	pH6					3.7/4.1
	pH7					0.71/0.78
Chromium III		Threshold	1.5	0.0012/0.00053	0	0.0324/0.0324
Chromium (VI)		Threshold	0.003	0.0012/0.00053	0	0.0324/0.0324
Copper		Threshold	0.15	0.056/0.02	0	NA
∑DDT		Threshold	0.0005	0.0000511/0.0000193	0.018	0.136/0.136
Dieldrin		Threshold	0.00005	0.0000036/0.0000014	0.1	0.41/0.41

Table 2 Recommended PEFs for assessing potential carcinogenicity of PAH mixtures

PAH	PEF
Benz(a)anthracene	0.1
Benzo(b)fluoranthene	0.1
Benzo(j)fluoranthene	0.1
Benzo(k)fluoranthene	0.1
Benzo(a)pyrene	1.0
Chrysene	0.01
Dibenz(a,h)anthracene	1.0
Fluoranthene	0.01
Indeno(1,2,3-c,d)pyrene	0.1

Table 3: Recommended general and scenario-specific exposure parameters

Generic Factors							
Body Weight (child)	15 kg		Averaging Time (carc.):		75 yrs		
Body Weight (adult)	70 kg		Averaging Time (non-carc.):		6 yrs		
Scenario-specific factors	Lifestyle Block	Standard Residential	High Density Residential	Parks/ recreational[1]	Comm/Ind Indoor Worker	Comm/Ind Outdoor Worker	Units
Exposure Frequency	350	350	350	200/150	230	50	day/yr
Exposure Duration (child)	6	6	6	6			yrs
Exposure Duration (adult)	24	14	14	14	20	20	yrs
Soil Ingestion Rate(child)	45	45	25	15			mg/day
Soil Ingestion Rate (adult)	25	25	15	75	0	50	mg/day
Age-adjusted Ingestion Factor	26.6	23.0	13.0	6.0/15.0	0	14.3	mg.yr/kg.day
Inhalation Rate (child)	6.8	6.8	6.8	6.8			m^3/day
Inhalation Rate (adult)	13.3	13.3	13.3	20	8	10.4	m^3/day
Age-adjusted Inhalation Rate	7.3	5.4	5.4	2.7/4.0	2.3	3.0	m^3.yr/kg.day
Skin Area (child)	1900	1900	1900	1900			cm^2
Skin Area (adult)	4850	4850	4850	3670	3670	3670	cm^2

Table 3: Recommended general and scenario-specific exposure parameters (cont.)

Scenario-specific factors	Lifestyle Block	Standard Residential	High Density Residential	Parks/ recreational[1]	Comm/Ind Indoor Worker	Comm/Ind Outdoor Worker	Units
Soil Adherence (child)	0.04	0.04	0.02	0.04			mg/cm^2
Soil Adherence (adult)	0.01	0.01	0.01	0.06	0	0.04	mg/cm^2
Age-adjusted Derm. Exp. Factor	47.0	40.1	40.1	30.4/44	0	41.9	
Produce Ingestion (child)	0.0104	0.0104					kg (dry wt.)
Produce Ingestion (adult)	0.0320	0.0320					kg (dry wt.)
Proportion of above-ground produce	0.3	0.3	0.0	0.0	0.0	0.0	unitless
Proportion of root produce	0.7	0.7	0.0	0.0	0.0	0.0	unitless
Age-adjusted Produce Ingestion	0.0151	0.0106					

[1] The parks recreational scenario has alternate scenarios for a child and adult, calculated separately, with the worst case becoming the guideline value. In this cases child and adult parameters are shown child/adult.

Table 4: Soil guideline values for priority contaminants (mg/kg)

[NOT GOVERNMENT POLICY, DO NOT USE, QUOTE OR CITE]

Scenario		Rural/Lifestyle Block (50% produce)	Standard Residential (10% produce)	Standard Residential (No produce)	High Density Residential (No produce)	Parks/ Recreational	Comm./Ind Indoor Worker	Comm/Ind Outdoor Worker
Arsenic		3.1	14	29	51	100	NL	71
BaP		1.7	8.8	13	21	28	NL	19
Cadmium	pH5	0.1	0.5	205	370	1100	NL	1600
	pH6	0.5	2.3	205	370	1100	NL	1600
	pH7	2.4	11	205	370	1100	NL	1600
Chromium III		NL	NL	NL	NL	NL	NL	NL
Chromium VI		130	360	630	1100	3300	NL	5500
Copper		29,000	32,000	33,000	59,000	NL	NL	NL
∑DDT		9.3	37	150	270	750	NL	1000
Dieldrin		0.3	1.5	14	25	56	NL	83

Notes: Shading indicates value may be below local background concentration
NL = exceeds 100,000 mg/kg

References

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