



environmental affairs

Department:
Environmental Affairs
REPUBLIC OF SOUTH AFRICA

FRAMEWORK

For the Management of Contaminated Land

May 2010

PREFACE

The remediation of contaminated land forms part of a comprehensive environmental strategy for the sustainable management of environmental resources in South Africa and reflects the constitutional rights of all South Africans to an environment that is not harmful to human health.

At present, although remediation of contaminated land is well established in South Africa, there is not a single consistent set of guidelines or legally applied regulations to assess the status and risk posed by contaminated land or to provide the basis for the acceptance of remediation plans.

The Framework for the Management of Contaminated Land was compiled in support of Part 8 of the National Environmental Management: Waste Act (Act 59 of 2008) in order to provide 'norms and standards' for enabling the identification and registration of contaminated sites, to provide a risk-based decision support protocol for assessing sites, and to offer a set of guidelines for the submission of site assessment reports.

The Framework for the Management of Contaminated Land includes a tiered system of Soil Screening Values for priority soil contaminants. The listing is not exhaustive and it is considered that further chemical compounds of concern will be added in future. A regular review of toxicological data that underpins the listing will be undertaken and updated as international research continues to inform decision-making. In this regard the document should be regarded as 'living' and will be subject to further development and revision in years to come.

The Framework for the Management of Contaminated Land was the product of a consultative process of engagement with stakeholders from government, industry, specialist consultants and members of the public, which included national workshops and industry sector specific forum groups. The outputs of this public process are reflected in the appendix to this document.

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Glossary

Acceptable risk	A risk that is so small and consequences so slight, or associated benefits (perceived or real) so great, that society is willing to take or be subjected to that risk.
Activity patterns	Time-use studies explore how children and adults spend their time, and the types, duration and location of activities, including eating, sleeping, working, and playing. Such activities that occur regularly according to discrete boundaries, such as land use, can be grouped together to form a pattern of behaviour that can be used to predict likely exposure.
Air dispersion factor	Describes the dispersion of fugitive dusts emitted from soils and is defined as the inverse of the ratio of geometric mean air concentration to the emission/flux at the centre of the source.
Aquifer	Groundwater-bearing formations sufficiently permeable to transmit and yield water in usable quantities. As guidance in assessing the sensitivity of groundwater resources to contamination, the following general definitions should be applied. A non-aquifer is defined as: ■ Having insignificant yield of good quality water or ■ Moderate yield of poor quality water or ■ An aquifer which will never be utilised for water supply or which will not contaminate other aquifers Poor aquifers are defined by yield: ■ Low yield: 1 litres/second ■ Moderate yield: 1-5 litres/second
Asbestos	The asbestiform varieties of mineral silicates belonging to the serpentine and amphibole groups of rock-forming minerals, including actinolite, amosite (brown asbestos), anthophyllite, crocidolite (blue asbestos), chrysotile (white), tremolite, or any mixture of these.
Asbestos-Containing Material (ACM)	Products or materials that contain asbestos in an inert bound matrix such as cement or resin. Here taken to be sound material, even as fragments and not fitting through a 7 x 7 mm sieve.
Asbestos Fines (AF)	Includes asbestos-free fibres, small fibre bundles and also ACM fragments that pass through a 7 x 7 mm sieve.
Attenuation factor	Ratio of chemical concentration between two media, assuming that the concentration decreases from the source media to the receptor media. For example, the attenuation factor from the soil gas to the indoor air is used to assess vapour intrusion.
Average daily exposure	The average daily amount of a contaminant per kg bodyweight, which a critical human receptor might take in over the duration of exposure.
Averaging time	Time period over which aggregated exposure is averaged to derive a daily exposure that can be compared to a relevant Health Criteria Value. In deriving Soil Guideline Values, averaging time is equal to the exposure duration.
Background concentration	A representative ambient level for a contaminant in soil or water. Ambient concentrations may reflect natural geological variations in relatively undeveloped areas or the influence of generalised industrial or urban activity in a region.
Background sources	Sources of human exposure to a chemical other than the soil itself, either directly or indirectly. For example, ambient air, diet, and drinking water.
Bioaccessability	The degree to which a chemical is released from soil into solution (and thereby becomes available for absorption) when that soil is ingested and undergoes digestion.

Bioavailability	The degree to which a substance is absorbed and becomes available to the target tissue (that is, without first being metabolised). The amount of chemical available to the target tissue following exposure.
Carcinogen	A substance or agent that causes the development or increases the incidence of cancer. A carcinogen can also act upon a population to change its total frequency of cancer in terms of numbers of tumours or distribution by site and age.
Carcinogenic	Of or pertaining to the ability to cause the development of cancer.
Chemical intake/uptake rate	The daily amount of a soil contaminant expressed as an intake or an uptake from exposure to chemicals in soil, food, water and air.
Conceptual model	A representation of the characteristics of a site in diagrammatic or written form that shows the possible relationships between contaminants, pathways and receptors.
Contaminant	Any harmful substance present in an environmental medium at concentrations in excess of natural background concentrations.
Clean Fill	Material of definable quality and not having harmful environmental or health effects. Consists of rocks, sand or soil from the excavation of undisturbed material or derived from a known source.
Detailed quantitative risk assessment	The purpose of detailed quantitative risk assessment is to establish and use more detailed site-specific information and criteria to decide whether there are unacceptable risks. It may be used as the sole method for quantitative risk assessment of risks, or it may be used to refine earlier assessments using generic assessment criteria.
Dermal absorption fraction	An empirical measure of the proportion of chemical compound in soil that is absorbed through the skin by a typical soiling event.
Dose/dosage	The amount of a substance absorbed into the body exposed to the substance (see Reference Dose).
Dose-response relationship	Relationship between the dose of a chemical taken into an organism and the response (in the form of a measured biological, systemic or physiological effect) that is detected.
Ecological receptor	A non-human organism potentially experiencing adverse effects from exposure to contaminated soil either directly (contact) or indirectly (food chain transfer).
Estimated daily intake	Total 'background' exposure to a chemical substance, arising from low levels of contamination commonly found in air, water, food, soil and consumer products.
Exposure	Contact between a chemical and the external surfaces of the human body. Quantitatively, it is the amount of a chemical that is available for intake by a target receptor/population. Exposure may be quantified as the dose or the concentration of the chemical in the medium (for example, air, water, food) integrated over the duration of exposure, expressed in terms of mass of substance per kg of soil, cubic metre of air, or litre of water over the specified duration.
Exposure assessment	The process of estimating or measuring the magnitude, frequency, and duration of exposure to an agent, along with the number and characteristics of the population exposed. Ideally, it describes the sources, pathways, routes, and uncertainties in the risk assessment.
Exposure duration	The specified period of exposure in years over which the chemical intake/uptake rate for a critical receptor is accumulated.
Exposure frequency	The number of days per year in which a daily exposure event is considered to occur.
Exposure pathway	The route by which an organism comes into contact with a contaminant. Direct pathways include soil ingestion, dust inhalation and dermal absorption. An indirect pathway involves migration or transport of contamination from one environmental medium to another before contact occurs. Inhalation of vapours arising from contaminated soil or groundwater is an example.
Exposure route	The mode of entry of a chemical into the body.
Fibrous Asbestos (FA)	Friable asbestos material, such as weathered ACM, and asbestos in the form of loose fibrous material such as insulation products.

Free-phase	Chemical present in soil or water in its natural physical form under ambient conditions, for example, solid, liquid or gas.
Groundwater	Water in fully or partially saturated geological formations.
Hard Standing Area	An area that is covered by impervious construction material such as asphalt, concrete or brick.
Hazard	Hazard refers to the potential to cause harm.
Index Dose	The term used in this Framework to refer to an estimate of the amount of a soil contaminant (expressed as daily intake) that can be experienced over a lifetime with minimal cancer risk.
Intake	Amount of a chemical entering the human body at the point of entry (that is, mouth, nose or skin) by ingestion, inhalation, or skin contact.
Long term exposure	Exposure to a contaminant in a medium lasting from several weeks to years and often includes a reproductive or life cycle of the test organism. Often referred to as a chronic exposure.
Mean daily intake	The average intake of a soil contaminant from other, non-soil sources, expressed as an amount per day. The mean daily intake is estimated for each route of exposure and arises principally from exposure to the contaminant in food, water, and air.
Multimedia exposure assessment	The quantitative estimate of total exposure to a chemical arising from all sources (air, water, soil, food, consumer products), by all routes (ingestion, inhalation, dermal absorption).
Particle Emission Factor (PEF)	The relationship between the concentration of a contaminant in soil and its concentration in air as a consequence of dust resuspension.
Partition coefficient	The experimental or calculated ratio of the concentrations of the same chemical species in two phases.
Pathway	The route or means that controls the release and migration of a contaminant to environmental media, for instance soil to water or soil to air.
Porosity	Fraction of void space within a porous media such as a rock or soil.
Receptor	The person or organism exposed to a chemical. For human health risk assessment it is common to define a critical receptor as the person expected to experience the most severe exposure (due to age, sex, diet, lifestyle) or the most severe effects (due to state of health, genetic disposition, sex, age) as a result of that exposure.
Reference Dose/Dosage	An estimate of a daily exposure to the human population, including sensitive subgroups, that is likely to be without an appreciable risk of deleterious effects during a lifetime.
Remediation	The management of a contaminated site to prevent, minimise, or mitigate damage to human health or the environment. Remediation may include both direct physical actions (e.g. removal, destruction, and containment of contaminants) and institutional controls.
Remediation objective	A numerical limit or narrative statement that has been established to protect and maintain a specified use of soil at a particular site by taking into account site-specific conditions.
Risk	Risk is the likelihood of harm under defined circumstances, and usually qualified by some statement of the severity of the harm.
Risk assessment	A process designed to determine the qualitative aspects of hazard identification and usually a quantitative determination of the level of risk based on deterministic or probabilistic techniques.
Risk perception	An intuitive judgement about the nature and magnitude of a risk. Perceptions of risk involve the judgements people make when they characterise and evaluate hazardous substances, activities and situations.
Short term exposure	Exposure to a contaminant in a medium usually severe enough to induce an effect. Often referred to as an acute exposure.

Site-specific assessment criteria	Values for concentrations of contaminants that have been derived using detailed site-specific information on the characteristics and behaviour of contaminants, pathways and receptors, and that correspond to relevant criteria in relation to harm or pollution for deciding whether there is an unacceptable risk.
Site Use	A category for site assessment based on assumed receptor activity patterns associated with different exposure scenarios in a South African context. Includes the following: Residential and Urban Parkland: sites where the primary land use is residential with associated public open spaces for recreational use. Informal residential settlements: residential sites where open ground has been settled without the construction of roads and paved areas of hard standing, and where houses may not have concrete floor slabs. Commercial/Industrial: Commercial: sites where the primary activity is related to commercial and industrial operations and occupancy is not for residential purposes.
Slope Factor	An upper bound estimate of the probability of a response per unit intake of a chemical over a lifetime. Used to assess probability of an individual developing cancer as a result of exposure to a chemical over a lifetime.
Soil	Normally defined as the unconsolidated material on the immediate surface of the earth that serves as a natural medium for terrestrial plant growth.
Soil Screening Values	Soil Screening Value 1: soil quality values, expressed as mass of contaminant per mass of soil, that are protective of both human health and ecotoxicological risk for multi-exposure pathways, inclusive of contaminant migration to the water resource. Soil Screening Values 1 are applicable to all land-uses, and thus represent an 'acceptable-risk' situation, with no adverse effects on human health and the aquatic environment. Soil Screening Value 2: soil quality values, expressed as mass of contaminant per mass of soil, that are protective of risk to human health in the absence of a water resource. Soil Screening Values 2 are land-use specific and have been calculated for three key land-uses namely, standard residential, informal residential settlements and commercial/industrial land-uses.
Soil gas	The gaseous elements and compounds in the small spaces between particles of soil.
Soil vapour	The gaseous elements and compounds from a soil source found within the small spaces within and between the fabric and structure of buildings.
Source	Contaminant source contains a concentration of contaminant(s) – a substance that is in or on land, that has the potential to cause an impact to human health or the environment.
Threshold	The dose/concentration of a chemical below which no adverse effect is expected to occur.
Tolerable Daily Intake	Originally defined as an estimate of the amount of a soil contaminant, expressed on a body weight basis, that can be ingested daily over a lifetime without appreciable health risk, the term has been expanded to apply to exposure via inhalation and dermal contact.
Toxicity	The inherent property of a substance to cause injury or an adverse effect in a living organism. Defined as either cancer slope factor (SF in mg/kg/day-1) for carcinogens and reference dose (Rfd in mg/kg/day) for non carcinogens.
Uncertainty	A lack of knowledge about specific factors in a risk or exposure assessment including parameter uncertainty, model uncertainty and scenario uncertainty.
Validation	The process of demonstrating that an investigation area has been delineated or remediated successfully.
Vapour intrusion	Generic term used to describe the migration of volatile chemicals in soil gas from the subsurface into overlying buildings.
Volatilisation	The chemical process by which chemicals convert from a liquid or solid state into a gas and then disperse into the air above contaminated soil.
Volatilisation Factor	Descriptor of rate of volatilisation of a compound from soil to air.

1 Introduction

1.1 BACKGROUND

The National Environmental Management: Waste Act of 2008 (hereafter referred to as the 'Waste Act'), clearly identifies the status and risk of contaminated sites and provides a legal mechanism for remediation activities to be instigated and controlled. This document is the National Framework for the Management of Contaminated Land (hereafter referred to as the 'Framework') and provides national norms and standards for the practical implementation of remediation activities in compliance with Section 7 (2) (d) of the Waste Act (2008) pertaining to 'the remediation of contaminated land and soil quality'.

Due to various factors, including the high cost involved in remediation interventions, it is essential that a holistic and tiered, risk-based approach be adopted that is founded on international best practice, to address remediation in a uniform manner across the country. This is relevant irrespective of the sector of occurrence to safeguard both human health and the natural environment.

The Framework is based on a review of international practice in the developed countries of the world and the emergence of remediation policy from developing countries, and an assessment of alternative approaches and methodologies that may find application in the development of a South African remediation framework. The proposals have been presented and reviewed by a wide range of governmental, industry and civic stakeholders. The background to this process of stakeholder engagement is included in Appendix D to the main document.

1.2 FRAMEWORK - DECISION SUPPORT MEASURES

The National Framework provides decision-support measures for the management of contaminated land in South Africa, and are based on the following key criteria for successful implementation of:

- Nationally consistent methods and numerical values for the assessment of contaminated land that protect human health and the environment.
- A consistent policy on future land use and related activity patterns for human receptors for contaminated sites based on remediation objectives conforming to the above mentioned guidance.
- A contaminated land register that provides for transparent recording of remediation activities and current land status.

The Framework consists of the following components:

Section 2: Protocol for Site Risk Assessment

Section 3: Reporting Norms and Standards for Contaminated Land

Section 4: The Derivation and Use of Soil Screening Values

Section 5: Application of Site Specific Risk Assessment

Section 6: Quality Control and Quality Assurance of Field Sampling and Laboratory Analysis

2 Protocol for Site Risk Assessment

2.1 ASSESSMENT PROTOCOL AND DECISION SUPPORT TOOL

In order to apply a multi-tiered risk based methodology for the assessment of contaminated land it is necessary to construct a simple conceptual process that defines the contaminant linkage to the potential environmental receptor. There are thus three essential elements that need to be understood so that risk can be quantified and the definition of a contaminated site realised.

The concept is referred to as the source-pathway-receptor model, where;

- The source contains a concentration of a contaminant(s) – a substance that is in, or on land that has the potential to cause an impact to human health or the environment.
- The pathway is the route or means that controls the release and migration of a contaminant to environmental media, for instance soil to water or soil to air.
- The receptor in general terms is something that can be adversely affected by exposure to the contaminants. Receptors include humans but may also include animals and plants.

Each of the three elements can exist independent of each other. A risk only exists when the linkage is complete and the receptors are exposed to the contaminants. The risk can be assessed in either qualitative or quantitative terms and can also be expressed in terms of probability, as some pathways may pose a very low probability of risk to receptors.

The protocol of Site Assessment has been developed to provide a conceptual risk-based decision-support tool for widespread use by proponent and regulator, and is based on the recognition of pathway-receptor linkages. The decision tree is shown diagrammatically in Figure 1.

The conceptual model involves the derivation of a tiered system of Soil Screening Values (see Section 4 for the derivation of Soil Screening Values) which can be used for comparison with contaminant concentrations measured for soils on the investigated site.

Soil Screening Value 1

At the first tier for site screening, Soil Screening Value 1 is a conservative concentration that is the lowest of three potential source-pathway-receptor model calculations:

- Direct pathways for the protection of the child receptor, taken as the most sensitive receptor in the context of potentially high exposures anticipated for *informal residential* settlements in South Africa.
- Indirect pathway for the *protection of water resources* in terms of human health based on the ingestion of drinking water. The model for contaminant transfer from soil to water is based on simplified partitioning model with allowance for finite limited dispersion, dilution and attenuation within the groundwater-surface water medium, assuming a shallow water table within a typical porous sand aquifer.
- Indirect pathway for the protection of *aquatic ecosystems* by applying aquatic ecotoxicology to the same assumptions used to define the soil-to-surface water pathway used in the calculation of the human-health related water resource protection.

The lowest concentration provided by the three pathway-receptor models is selected as the Soil Screening Value 1. This is thus a multi-functional soil quality criterion that is conservative under a large number of potential exposure scenarios.

It is recognised that for a number of sites the source-pathway-receptor is poorly developed or entirely absent. For practical reasons it is important that risk assessments do not protect receptors that do not exist and do not invoke pathways that are unrealistic. The decision on the status of contaminated land does require that the contaminant exposure risk in one environmental medium does exist to the detriment of

another medium. The guidelines derived for water related receptors are thus an important point of departure, with the ecologically driven Soil Screening Values (refer to Section 4) being lower than human-health based values. It is thus an important step in the Site Assessment Protocol to define a conceptual model of the risk to water resources to decide on whether or not a realistic risk to water resources could exist. For a site where there is a genuine lack of knowledge on the water resource related pathways the default approach would be to assume a water resource is present and is at risk. The Soil Screening Value 1 would, therefore, define the contaminated status of the site until proven otherwise by factual data, on soil and water quality and taking into consideration background concentrations.

The key questions to be addressed can be summarised as follows:

- Is there risk to groundwater resources?
- Are there groundwater users with 1 km of the site?
- Are there surface water bodies that could be impacted by off-site migration?

If no, then protection of human health via direct exposure criteria will apply.

The 1 km radius for the influence of contaminated land on groundwater users is a default value normally requested as a minimum requirement by the Department of Water Affairs for conducting hydrocensus studies on sites where groundwater contamination is suspected. It does not imply that no risk to receptors occurs outside the 1 km zone, but that in general the assumption of short term acceptable risk would apply unless there was a very large and mobile source of contamination on a site.

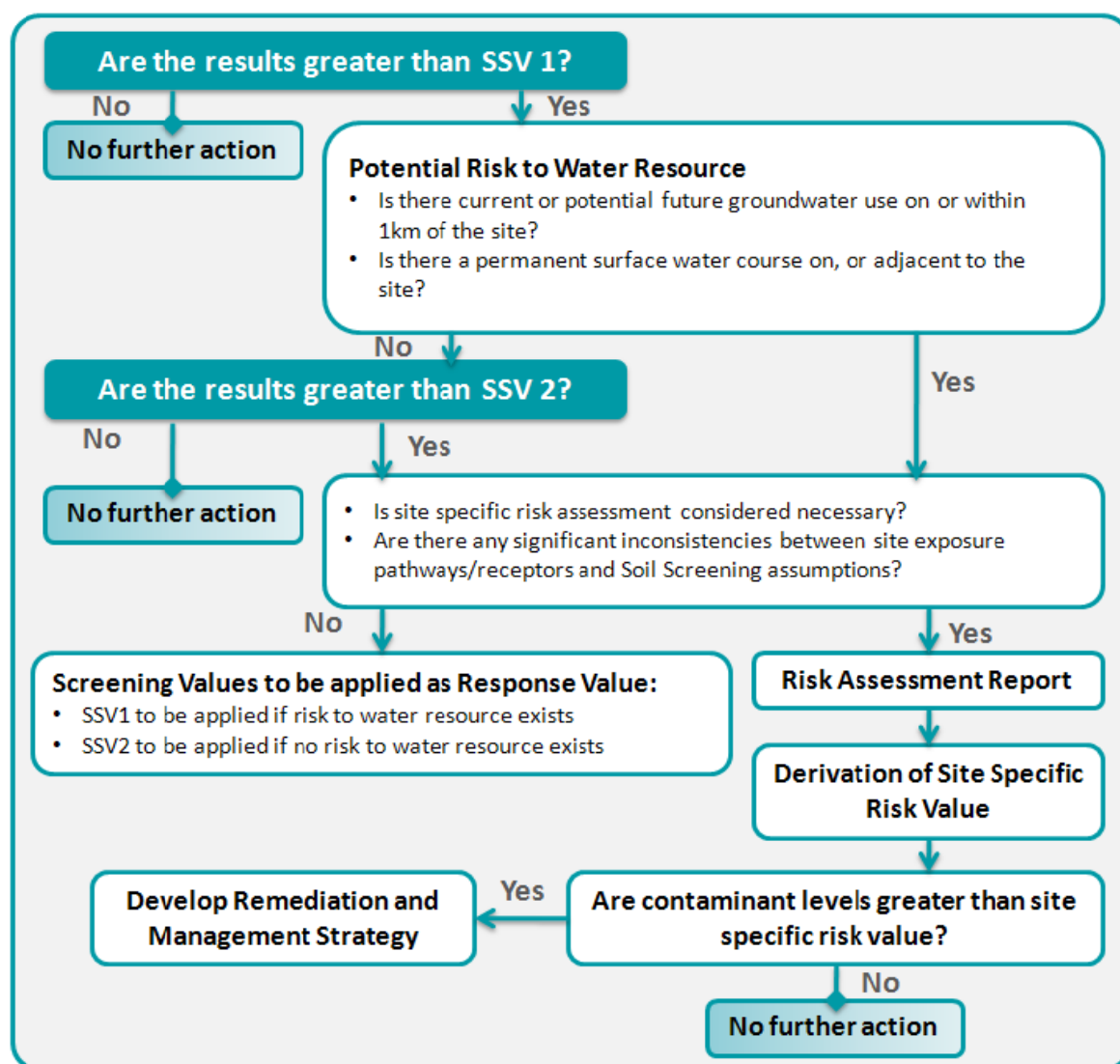


Figure 1: Diagrammatic decision-tree for assessment of contaminated land

The protocol for the protection of water resources is described in Section 2.2, Section 2.

If water resource protection is identified in the initial step of the protocol then the assessment criteria for groundwater protection needs to be applied as the remediation objective throughout the assessment protocol into the site specific risk assessment phase. The lowest of the assessment screening values shall be adopted as the target value for assessing soil quality and the requirements for remediation.

Soil Screening Value 2

If no risk to the water resource can be identified, then soil contaminant levels should be compared to Soil Screening Values 2. Soil Screening Value 2 has three sub-categories which are based on risk to receptors that are defined by activity patterns and associated exposure related to land use. There are two values derived for residential land use and development. The most sensitive is the child receptor, taken as the sensitive receptor for informal settlements, since the exposure levels for the child on a standard residential development define a slightly higher level of contaminant concentration. Commercial and industrial land use is defined by exposure criteria for an adult maintenance worker based on outdoor exposure criteria. If the values are less than the most appropriate of the three categories of Soil Screening Value 2, then the site is not a risk to human health and is not defined as being contaminated.

If soil contaminant concentrations are higher than the Soil Screening Value 2 criteria then the decision can be made to either proceed to a site specific risk assessment to define acceptable risk levels, or a decision can be made to adopt the Soil Screening Value 2 concentrations as remediation values for development of a remediation plan. For either Soil Screening Values 1 or 2 to be promoted as remediation target values it is important that the assumptions used in their derivation are broadly consistent with the site conditions. When setting remediation target values it is also important to consider the site-specific potential for ecological and aesthetic impacts not implicit in the calculation of soil screening values, and to amend the risk assessment and remediation objectives accordingly.

2.2 WATER RESOURCE SENSITIVITY AND PROTECTION

The initial stage of risk assessment for contaminated land requires a decision on the sensitivity of surface water and groundwater resources with respect to land-based contamination sources. In general the groundwater pathway is most likely to be impacted by contaminants in soil particularly if the contaminants are in a liquid form or easily mobilised by infiltration and leaching processes. However there are many geological environments in South Africa where groundwater quantity or quality is not sufficient to be considered a viable water resource. Therefore, the protection of water resource quality would not always be a key criteria in assessing contamination risk and setting of soil screening values, i.e. excessive caution and resultant costs are involved in the protection of receptors that do not exist or for pathways that are closed to contaminant migration. If the groundwater conditions on site are unknown it is advisable that a precautionary approach is followed and that the groundwater pathway is considered to be a relevant exposure route and that drinking water quality should be a point of compliance for risk assessment until proven conclusively to be otherwise.

The approach below assumes that a sound conceptual understanding of the relationship between the soil conditions and groundwater-surface water interactions is established and can be supported wherever possible with factual information from boreholes and trial pits. Key questions that need to be addressed are as follows:

- Is there current or potential groundwater use on the contaminated site or within the likely groundwater migration pathway of the site?
- Is there a surface water course on, or adjacent to the site?
- Where a water resource classification has been applied to the local area, assess the qualitative sensitivity of the water resources to pollution risk.

Local user requirements and quality of life considerations together with contaminant transfer risk will determine aquifer status in terms of resource protection. The sole source aquifer is the term used to define domestic potable groundwater wells where despite low yield or marginal water quality the available

groundwater resource is adequate to support the water needs of a single domestic dwelling and critically the pathway for contaminant exposure is regarded as inevitable and must be assessed in any risk assessment for protection of human health.

It should be remembered that the assessment of contamination risk to groundwater and surface water is based on establishing whether or not an exposure pathway exists and that a human or ecological receptor can be affected. It therefore does not require the application of complex resource related designations or classifications rather a broad conceptual understanding based on conservation assumptions.

3 Reporting Norms and Standards for Contaminated Land

3.1 COMPLIANCE WITH SECTION 37 OF THE WASTE ACT

Section 37 deals with the consequences of identification and notification of investigation areas. The aim is to investigate whether the land has been contaminated, and if contamination has occurred whether the contamination presents a significant risk of harm.

37 (2) (a) A site assessment report must comply with any directions that may have been published or given by the Minister or MEC in a notice contemplated in section 36 (1) or (6) and must at least include information on whether the investigation area is contaminated.

(b) Where the findings of the site assessment report are that the investigation area is contaminated, the site assessment report must at least contain information on whether-

- (i) the contamination has impacted on the environment;*
- (ii) the substances present in or on the land are toxic, persistent or bioaccumulative or are in large quantities or high concentrations or occur in combinations;*
- (iii) there are exposure pathways available to the substances;*
- (iv) the uses of the land and land adjoining increases or is likely to increase the risk to health or the environment;*
- (v) the substances have migrated or are likely to migrate from the land;*
- (vi) the acceptable exposure for human and environmental receptors in that environment have been exceeded;*
- (vii) any applicable standards have been exceeded; and*
- (viii) the area should be remediated or any other measures should be taken to manage or neutralise the risk.*

To provide a clear and consistent application of Section 37 of the Waste Act (2008) a reporting structure for contaminated land has been developed. The commonly encountered international practice consists of three distinct reporting phases. It progresses from Phase 1 desktop and site walkover assessments with limited investigation and testing to a Phase 2 detailed invasive investigation and testing for site characterisation to a comprehensive Phase 3 report with an evaluation of remediation objectives and a proposed remediation plan, supported by control and monitoring measures for the activities.

The reporting system requires norms and standards of practice to be strictly applied, but also must retain flexibility to allow for decisions on the contaminated status of sites to be made in the most beneficial manner (considering ecological, social and economic aspects) also taking into account timeframes. In some cases, urgent priority works may require that the phased approach to reporting has to move forward in a concurrent single report.

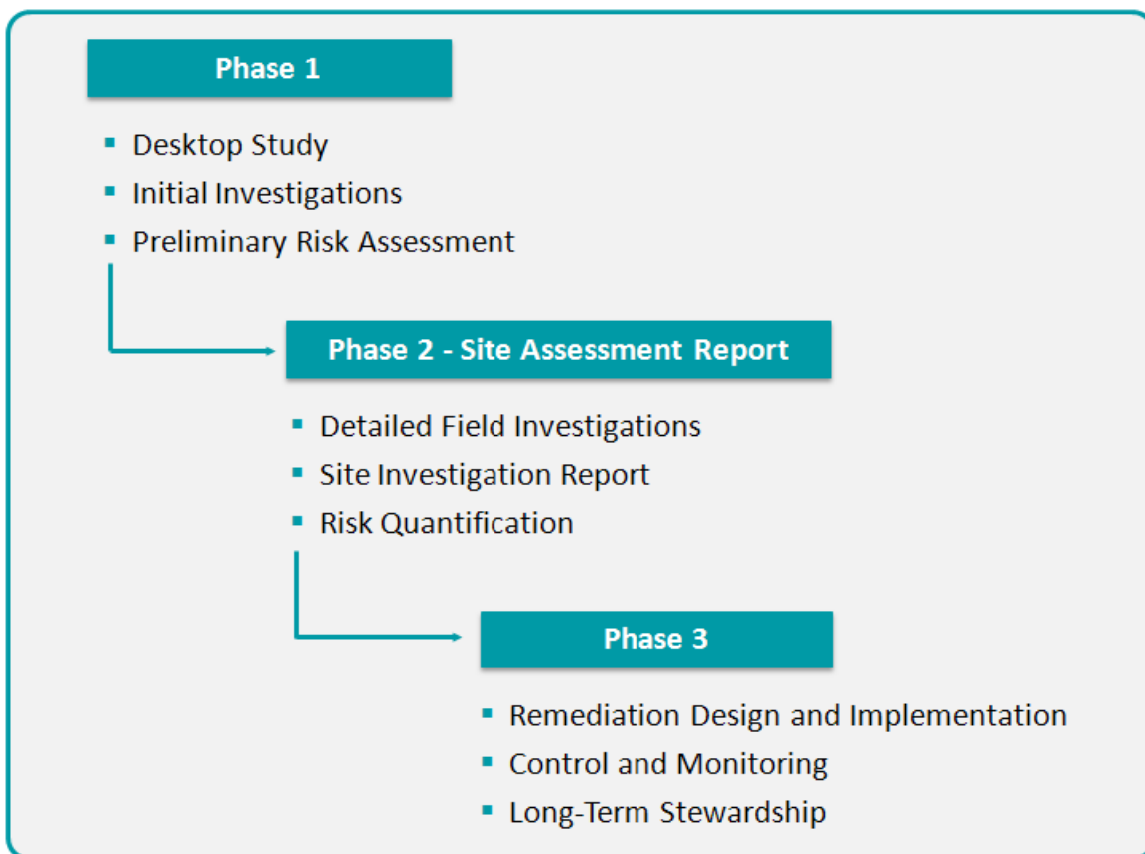


Figure 2: A phased approach for the assessment and remediation of contaminated land

3.2 REQUIREMENTS FOR PRELIMINARY SITE ASSESSMENTS – PHASE 1

A preliminary site evaluation must consider the following elements:

- Site description – location and size;
- Nature and extent of contamination, contaminants of concern or historical activities that may be sources of contamination. List all past and present activities at the site that involved the storage, production, use, treatment or disposal of hazardous materials that could contaminate the site;
- Describe the current condition of the site and the contents and results of any previous assessment reports;
- Local topography and geology, drainage, surface cover, vegetation;
- Status of groundwater, approximate depth to water table;
- Proximity to surface water;
- Proximity to drinking water supplies;
- Annual rainfall and flood potential;
- Land and water use for the site and nearby areas;
- Any other requirements as Regulated by the Minister under Section 69 (u) and (v) of the Waste Act (2008).

The reporting format has been developed in the form of a uniform checklist that can be used for all applications to the Department of Environmental Affairs, see Table 1.

All data may not be available, or data may vary in terms of uncertainty, it is thus important to recognise gaps in the knowledge base and to decide whether additional data must be obtained on the site characterisation. This may trigger the commencement of Phase 2 Investigations.

The Phase 1 report must make clear recommendations on the status of the contamination risk posed by the site. If a complete site history clearly demonstrates that the site activities do not pose a contamination threat then no further investigation is warranted and the site should be recommended as suitable for re-use. In most cases it is likely that some level of preliminary investigation will be required to provide the level of certainty required to enable property re-development or transfer in compliance with the Waste Act (2008). A limited investigation of certain subsurface activities, for example, underground storage tanks, would be necessary to obtain a waiver on the contamination status of a site at a Phase 1 level of reporting. This type of limited investigation of soil and groundwater is already common practice for certain industries in South Africa and is thus reflected in the norms and standards approach.

Table 1: Guidance Notes for Phase 1 Site Assessment Reports

Site identification   ■ Street number, street name, suburb and town/city   ■ Contact details of owners and occupiers of the site   ■ Legal description with erf number and title deed   ■ Geographic co-ordinates irrespective of the size of the facility   ■ Current site plan with scale bar showing north direction, local water drainage and other locally significant features on-site and immediately off-site. The plan should also show the historical location of structures that may have affected the distribution of contamination (e.g. building, underground storage tanks, treatment baths, etc)   ■ Locality map
Site history   ■ Chronological list of site ownership and uses, indicating information gaps, unoccupied periods and, if relevant, proposed uses   ■ An outline of those contaminants commonly associated with each land use based on site-specific information   ■ Zoning – previous, present and, if relevant, proposed, with summary of reasons for changes to zoning that have occurred   ■ Details of relevant building and related permits, licences, resource consents, approvals and trade waste agreements, with records of compliance   ■ Local usage of ground and surface water resources, including presence, rate and location of abstractions (current and historical)   ■ Site layout plans showing present and past industrial processes   ■ Sewer and services plans identifying active and abandoned services   ■ Historical uses of adjacent land   ■ Relevant complaint history   ■ Local knowledge of site by staff and residents – present and former   ■ Summary of literature relating to the site   ■ Review of aerial and site photography with date and location (including direction of photography) indicated on site maps   ■ Description of manufacturing processes   ■ Inventory of materials and waste products associated with site use and their on-site storage and/or disposal locations   ■ Details and locations of current and former underground and aboveground storage tanks, with details of integrity testing   ■ Product spill and loss history   ■ Recorded discharges to land, water and air (authorised and unauthorised)   ■ On-site and off-site disposal locations   ■ Contaminant source areas and pathways on-site and off-site   ■ Assessment of the accuracy of the information

Site condition and surrounding environment

- Topography and site map
- Condition of buildings and roadways
- Presence of drums, wastes and fill materials
- Odours
- Visual or quantified details of surface water quality
- Flood potential described or mapped
- Conditions at site boundary such as type and conditioning of fencing , soil stability, erosion, and stormwater discharge
- Visible signs of contamination, such as identifiable waste products, discoloration or staining of soil, bare soil patches – on-site and at site boundary
- Visible signs of plant stress
- Details of any relevant local sensitive environments – rivers, streams, lakes, wetlands, local habitat areas, sensitive flora and fauna

Geology and hydrology

- Background groundwater and surface water quality
- Summary of local rainfall and meteorology data
- Summary of all previous relevant information related to soils, geology, groundwater and hydrology of the site and neighbouring areas
- Regional geological and hydrogeological setting
- Likely soil types and depth to bedrock
- Anticipated depth to water table
- Sensitivity of aquifers and surface water to contaminants
- Likely geological pathways for contaminant migration

Phase 1 Preliminary Site Assessment Report

Reports must make clear statements with respect to the status of contamination of the site and satisfy the following requirements of the Waste Act (2008):

- State whether or not the area should be investigated further or remediated immediately or whether any other measures should be taken to manage or neutralise the risk.
- Alternatively, if all the information available in conformance with the checklist for Phase 1 Reporting leads to the conclusion that the site poses no risk to human health or the environment the proponent should motivate in writing that the site is not a contaminated site and obtain approval and confirmation on the contaminated status of the site from the Department of Environmental Affairs.

3.3 REQUIREMENTS FOR CONTAMINATED SITE ASSESSMENT REPORTS – PHASE 2

Phase 2 investigations include the sampling and analysis of soil, sediment, groundwater and surface water. It is stressed that the adequacy of the investigation must be related to site specific conditions and is a natural progression from the Phase 1 Contaminated Site Assessment. It is thus a focussed and designed programme of investigation and reporting.

The Phase 2 reporting must give information on:

- the type, extent and level of contamination anticipated on site and the issues raised in previous reports;
- the nature of samples collected, the sampling procedures followed, including field sampling quality assurance and quality control requirements;
- the analyses undertaken, methodologies used and laboratory quality assurance / quality control procedures, including laboratory certificates and appropriate accreditation listed;
- the actual extent and concentrations of contaminants in all appropriate environmental media on site based on verified test data;
- any likely dispersal in air, surface water, groundwater, soil and dust from the detected contaminants; and

- any potential effects of contaminants on human health, the environment, or building structures and property.

Phase 2 Site Assessment Reports must list the results of chemical analyses of soils obtained against the Soil Screening Values listed in Section 4 of the Framework and clearly demonstrate that the selection of guideline values is consistent with the principles of the Framework, together with all assumptions and limitations of Soil Screening Values used.

The report must make a clear statement regarding the adequacy and completeness of all information used in the assessment and list any further studies or investigations that may be required to verify the status of the site and the risks posed.

The findings of the report must satisfy the requirements of Section 37 of the Waste Act (2008) as well as any other regulations in terms of Site Assessment Reports as Regulated by the Minister under Section 69 (u) and (v) of the Waste Act and determine and state whether or not the following triggering clauses have been breached:

A site assessment report must comply with any directions that may have been published or given by the Minister or MEC in a notice contemplated in section 36 (1) or (6) and must at least include information on whether the investigation area is contaminated.

(b) Where the findings of the site assessment report are that the investigation area is contaminated, the site assessment report must at least contain information on whether-

(i) the contamination has impacted on the environment;

(ii) the substances present in or on the land are toxic, persistent or bioaccumulative or are in large quantities or high concentrations or occur in combinations;

(iii) there are exposure pathways available to the substances;

(iv) the uses of the land and land adjoining increases or is likely to increase the risk to health or the environment;

(v) the substances have migrated or are likely to migrate from the land;

(vi) the acceptable exposure for human and environmental receptors in that environment have been exceeded

(vii) any applicable standards have been exceeded: and

(viii) the area should be remediate or any other measures should be taken to manage or neutralise the risk.

Report recommendations should be made to inform the regulatory status of contamination as required under Section 38 (1) of the Waste Act:

(a) the investigation area is contaminated, presents a risk to health or the environment, and must be remediated urgently;

(b) the investigation area is contaminated, presents a risk to health or the environment and must be remediated within a specified period;

(c) the investigation area is contaminated and does not present an immediate risk, but that measures are required to address the monitoring and management of that risk;

or

(d) the investigation area is not contaminated.

Table 2: Guidance for Phase 2 Contaminated Land Assessment Reports

Summary of Phase 1 Reporting

Basic site information as compiled for Phase 1 should be summarised and referenced together with the conclusions of the Preliminary Site Assessment that triggered the site investigation and Phase 2 Contaminated Site Assessment.

Investigation of site geology and hydrology

- Detailed map and description of location, design and construction of on-site wells, boreholes and pits
- Site borehole / test pit logs showing stratigraphy, depth to underground water table
- Reported range of water table depths below ground surface
- Description and location of springs and wells in the vicinity
- Location, depth and extent of imported and locally derived fill
- Direction(s) and rate of groundwater flow including, where applicable, groundwater levels surveyed to a common datum
- Direction(s) of surface water run-off and identification of ponding areas
- Preferential flow paths (surface and groundwater)

Sampling and analysis plan and sampling methodology

- Sampling and analysis data quality objectives
- Rationale for the selection of:
  - sampling pattern, locations and depths (as shown on site maps)
  - sampling density, including estimated size of the residual hotspots that may remain undetected and statistical confidence in the estimate
  - which samples are/were submitted for analysis and which samples are/were not analysed
  - the analytes for each sample and the analytical methods used
- Detailed description of the sampling methods including:
  - sampling devices and equipment type used
  - sampling containers and the type of seal used
  - sample preservation methods and reference to recognised protocols
  - sample handling procedures
  - equipment decontamination procedures
- Detailed description of any field-screening protocols, methods and equipment, and their calibration

Field quality assurance and quality control (QA/QC)

- Details of the sampling team, identifying unique initials for each member
- Statement of intended duplicate and blank frequency
- Records for each sample collected, including date, time and location, samplers' initials, duplicate/blank location and type, analyses to be performed, site observations and weather conditions
- Chain of custody, identifying for each sample: sampler, nature of the sample, collection date, analysis to be performed, sample preservation method, departure time from site, dispatch courier used
- Background sample, field blank, trip blank, and rinsate sample results and laboratory-prepared trip spike results for volatile analytes
- Decontamination procedures carried out between sampling events
- Sample-splitting techniques and field instrument calibrations (where used)

Laboratory QA/QC

- All samples should be sent to a properly accredited laboratory for testing
- Signed laboratory receipt of signed chain of custody form identifying date/time of receipt and identity of samples included in shipment
- Record of holding times, where not consistent with method specifications
- Analytical methods used by laboratory and laboratory accreditation for analytical methods used
- Inter-laboratory comparisons for analytical methods used (where available)
- Description of spikes and surrogates used, with percent recoveries
- Instrument, method detection and practical quantification limits
- Standard solution, reference sample and check sample (including daily) results
- Laboratory duplicate, blank and standard results
- Signed laboratory certificates of analysis

Results

- Summary of previous results (where applicable)
- Site plan(s) showing all samples and sampling locations, giving sample identification numbers and sample depth
- Summary of all results in tabular form:
  - identifying essential details such as sample identification numbers and sample depth
  - showing comparison with relevant guideline values
  - highlighting every result exceeding the guideline values
- A summary table of results containing the following statistics: minimum, maximum, arithmetic average and 95% upper confidence limit on the arithmetic average for each analyte
- Site plan showing the extent of soil and/or groundwater contamination exceeding the relevant guideline values for the medium, location and sample depth

Site characterization

- Assessment of the type of all environmental contamination, particularly in soil and groundwater
- Assessment of the extent of soil and groundwater contamination, including identifiable off-site contamination that may cause environmental effects
- Assessment of the potential for chemical degradation or interaction products
- Assessment of possible exposure routes and risk to exposed populations (human and ecological risk)

Report Recommendations – Status of Contamination Risk

The report must reach a conclusion as to whether the site requires urgent clean-up, remediation measures over a period of time, the application of management measures, on-going monitoring or a combination thereof.

Alternatively, if all the information available in conformance with the checklist for Phase 2 Reporting and Soil Screening Values arrived at by either comparison with the Soil Screening Values in Section 4 of the Framework, or contaminant concentrations calculated on the basis of site specific acceptable risk, leads to the conclusion that the site poses no risk to human health or the environment the proponent should motivate in writing that the site is not a contaminated site and obtain approval and confirmation on the contaminated status of the site from the Department of Environmental Affairs.

3.4 REQUIREMENTS FOR CONTAMINATED SITE REMEDIATION PLANS – PHASE 3

The establishment of a final soil remediation objective for site clean-up must take consideration of technical feasibility, and overall risk management strategies throughout the remediation process and not simply the end point of the remediation process. All risk-based management decisions should be fully documented and justified.

The site remediation plan should be prepared as follows:

- Set remediation or management objectives (including numerical soil and groundwater targets) that ensure the site will be suitable for its current or future proposed land-use and will pose no unacceptable risk to human health or the environment, either on-site or off-site.
- Document in detail all procedures to be adopted to achieve the remediation objective. Establish safeguards and contingency measures for safe implementation of all remediation activities.
- Develop a quality assurance monitoring plan that establishes a record of activities that must be carried out to ensure compliance with the approved action plan.
- Obtain the relevant approvals, permits or licenses required by regulatory authorities to undertake the proposed remediation activities in terms of Section 20(b) of the Waste Act (2008).

Table 3: Guidance for Phase 3 Contaminated Site Remediation Plans

Remedial actions

For large projects with complex remediation activities, a detailed Remediation Plan should be submitted as a stand alone document with a dedicated Operational Controls and Monitoring Plan. Reporting to include the following:

- Remediation objectives (including numerical soil and groundwater targets where relevant)
- Discussion of the remedial options available, assessment of alternatives including the status quo, identifying the means of risk reduction proposed in each
- Rationale for selection of the recommended remedial option
- Discussion of the remediation required to achieve the remedial objectives
- Risk assessment of proposed remediation activities and mitigatory measures required to minimize environmental hazards and impacts during remediation
- Identification of regulatory requirements such as permits, licences and approvals
- Proposed monitoring and testing to validate the site during, and on completion of the remedial activities
- Contingency plan if remedial strategy fails to reach the remediation objectives.

Remediation plans require approval under Section 20(b) of the Waste Act (2008) before any activities other than emergency activities can be instigated.

4 Determination of Preliminary Soil Screening Values for Assessment of Contaminated Land

4.1 INTRODUCTION

Numerical criteria for priority contaminants of concern have been determined so that they can be used to define appropriate management actions. The numerical values will serve as initial points of reference for site assessment for authorisation of remediation activities and can be applied with discretion:

- as conservative clean-up targets;
- to inform management actions to reduce the potential for adverse effects; and
- to trigger further investigations to determine site specific risk-based criteria.

The consequences of not doing this would lead to continuing uncertainty about the most appropriate criteria and method to apply in the assessment of contaminated land, and as a result, conflict on the definition of a contaminated site and requirements for statutory remediation orders.

It is acknowledged that although the use of Soil Screening Values is common in international practice, the derivation of such values is a complex process and depends on the acceptability of certain scientific assumptions used in the development of standard equations used to model risk. Although there is broad consensus internationally on the concepts of risk assessment, the detailed methodology applied is based on expert judgement and is not a precise science.

The development of Soil Screening Values to protect human health via direct exposures routes and indirect exposure routes is the key starting point. The incorporation of ecotoxicological criteria for water resource protection can be achieved. It may however be difficult to assess the ecological impact of contaminated soils at a simple generic level and this is perhaps an issue that is best resolved by site specific risk assessment.

The Waste Act (2008) and National Environmental Management Act (2008) require land to be investigated if hazardous substances are likely to have been used in or on the land. In addition, the redevelopment of sites and property transfer are triggering clauses for environmental authorisations. Investigations are thus required to assess the presence and quantify the risk posed by any hazardous substances on or in the land.

Risk assessment criteria are thus dependant on the activity patterns of human receptors associated with particular land use categories.

The land use categories for use in development of Soil Screening Values are:

- Residential and urban parkland;
- Informal residential settlement; and
- Commercial/industrial.

The land use categories are based on well documented receptor activity patterns and are not directly applicable to spatial development land use planning without applying sound judgement. For example, a mixed use development (a development that includes residential, office and or retail) would be regarded as a residential area for the purposes of determining the status of contaminated land and any remediation objectives that may be required to enable the change of land use.

For the purposes of deriving Soil Screening Values the receptor for commercial and industrial land use is assumed to be an adult outdoor maintenance worker. Although this receptor is likely to be a minority receptor in the population group as a whole the exposure criteria will represent a conservative scenario and can be assumed to be protective of human health except under extreme and unusual conditions. For

human receptors that spend the majority of time indoors in commercial properties, the values will tend to be an over-conservative assessment of exposure.

It is important to consider adjoining land use in terms of defining the appropriate soil quality guideline as the migration of contaminants may contaminate surrounding areas with more susceptible land uses. For example, the off-site migration of dust from remediated commercial/industrial sites should not pose any unacceptable risk to nearby residential sites.

4.2 CONCEPTUAL APPROACH FOR DERIVATION AND USE OF SOIL SCREENING VALUES

The conceptual approach for derivation of soil screening values is based on original USEPA methodologies, along with consideration of more recent derivatives, particularly the Canadian Environmental Quality Guidelines. Key assumptions for South Africa are related to the groundwater pathway, with typical rainfall, infiltration and recharge considerations applied. In addition, the human health exposure criteria have been revised to take into account the activity patterns and increased risk to residents of informal settlements. This sensitive population group is very significant in South Africa and has been previously overlooked in the application of risk-based health assessments in the past.

The use of existing, published Department of Water Affairs water quality guidelines as the target for water quality used in the equations is to create internal harmonisation and is not an indication of our unequivocal acceptance of their scientific validity. As the derived screening values for protection of the water resource are based on a back calculation from a desired concentration in the receiving body of water, the Soil Screening Values can be modified to be consistent with specific water quality objectives derived for individual catchments on the basis of an integrated water resource management approach that is flexible and adaptable to user needs.

The calculations used for derivation of Soil Screening Values are not intended to provide a stand alone series of regulatory standards for deriving clean-up targets. The use of site specific quantitative risk assessment within an overall framework of holistic risk assessment that is ethically based and takes into consideration societal values and practical implementation is advised.

The Soil Screening Values can be considered conservative under a broad range of assumptions, however, it must be accepted that there are exposure scenarios that may not be adequately addressed by these screening values. The use of the Soil Screening Values as an indication of a 'safe' or 'clean' site is thus only valid in the absence of a specific risk exposure scenario not covered in the generic equations (for example, the screening lists are not fully protective of soil biota).

Soil Screening Values are not:

- Default remediation standards
- Applicable to every site under all circumstances
- Absolute minimum values
- Screening values applicable to occupational exposures
- Applicable to risk of property damage
- Valid unless the assumptions inherent in the Soil Screening Values are broadly consistent with the actual site conditions
- A substitute for a thorough conceptual and qualitative understanding of a site's condition and the risks it might pose to human health and the environment.

Equations for the deriving the levels and input parameters are discussed in Section 4.3.

4.3 TECHNICAL BASIS FOR CALCULATION OF SOIL SCREENING VALUES

4.3.1 Protection of Human Health

Exposure Routes

Soil Screening Values were calculated by determining dosages associated with the following direct exposure routes:

- Soil Ingestion;
- Dermal Contact;
- Particulate Inhalation; and
- Volatile Inhalation.

Exposure Parameters

Exposure parameters used for dosage calculations are summarised below in Table 4 (exposure parameters used for calculation of threshold or non-carcinogenic health effects) and Table 5 (exposure parameters used for calculation of non-threshold or carcinogenic health effects).

Exposure parameters for both forms of residential land-use were based on a child as the most sensitive receptor, while commercial/industrial land-use was based on adult exposure for an outdoor maintenance worker. Although a minority receptor within the overall population, the outdoor maintenance worker is representative of an important sensitive receptor for South Africa.

Exposures for the child receptor under informal residential land-use were modified to account for increased dermal contact, ingestion and dust inhalation. The modifications represent preliminary estimates in the absence of specific studies and data on activity patterns and exposures for informal residential land-use settings in South Africa.

Toxicological Parameters

Toxicological data required for calculation of Soil Screening Values is provided below in Tables 6 (metals and metaloids), 7 (hydrocarbon organics) and 8 (organics).

The data provided in Tables 6, 7 and 8 has been sourced from internationally reviewed databases and was considered at the time of writing to be scientifically defensible. Reference dosages (RfD) have been provided for assessment of threshold (or non-carcinogenic) health effects and are an estimate of the daily exposure to the human population, including sensitive subgroups, that is likely to be without an appreciable risk of deleterious effects during a lifetime.

Slope Factors (SF) have been provided for assessment of threshold (or carcinogenic) health effects. The slope factor is an upper bound estimate of the probability of a response per unit intake of a chemical over a lifetime and is used to assess probability of an individual developing cancer as a result of exposure to a chemical over a lifetime.

Calculation Method

Soil values for combined direct exposure routes were calculated using the equations provided in Table 9. The soil values were calculated based on a Target Risk (TR) of 1.0×10^{-5} for non-threshold (carcinogenic) substances and a Target Hazard Index (THI) of 1 for threshold (non-carcinogenic) substances.

Soil Screening Values

The lowest soil value for threshold and non-threshold effects was selected as the Soil Screening Value for each land-use and parameter as summarised in Table 10 below.

Table 4: Input parameters for derivation of Soil Screening Values based on protection of human health (threshold or non-carcinogenic health effects)

Parameter			Standard Residential	Informal Residential	Commercial/ Industrial
Description	Symbol	Unit	child	child	adult
Body Weight	BW	kg	15	15	70
Averaging Time	AT	days	2190	2190	10950
Exposure Frequency	EF	days/yr	350	365	250
Exposure Duration	ED	yrs	6	6	30
Ingestion Rate (soil)	IR _s	mg/day	200	400	100
GI absorption factor	GI	-	chemical specific*		
Surface Area Exposed Skin	SA	cm ²	2100	4200	13110
Soil to Skin Adherence Factor	AF	mg/cm ² /day	0.2	0.2	0.07
Dermal Absorption Factor	ABS _d	-	chemical specific*		
Inhalation Rate (air)	IR _a	m ³ /day	10	10	10.4
Particulate Emission Factor	PEF	m ³ /kg	1.30E+09**	7.25E+08**	3.22E+08**
Soil to Air Volatilisation Factor	VF	m ³ /kg	chemical specific*		

* Refer Appendix A for chemical specific data

** Refer Appendix A for further detail on PEF

Table 5: Input parameters for derivation of Soil Screening Values based on protection of human health (non-threshold or carcinogenic health effects)

Parameter			Standard Residential	Informal Residential	Commercial/ Industrial
Description	Symbol	Unit	adult	adult	adult
Body Weight	BW	kg	70	70	70
Averaging Time	AT	days	25550	25550	25550
Exposure Frequency	EF	days/yr	350	365	250
Exposure Duration	ED	yr	70	70	30
Ingestion Rate (soil)	IR _s	mg/day	100	200	100
GI absorption factor	GI	-	chemical specific*		
Surface Area Exposed Skin	SA	cm ²	5800	11600	13110
Soil to Skin Adherence Factor	AF	mg/cm ² /day	0.07	0.07	0.07
Dermal Absorption Factor	ABS _d	-	chemical specific*		
Inhalation Rate (air)	IR _a	m ³ /day	20	20	10.4
Particulate Emission Factor	PEF	m ³ /kg	1.30E+09**	7.25E+08**	3.22E+08**
Soil to Air Volatilisation Factor (indoor and outdoor)	VF _{i/o}	m ³ /kg	chemical specific**		

* Refer Appendix A for chemical specific data

** Refer Appendix A for further detail on PEF

Table 6: Reference Doses and Slope Factors – Metals and Metalloids

Contaminant	RfD _o (mg/kg-day)	RfD _i (mg/kg-day)	RfD _d * (mg/kg-day)	SF _o 1/(mg/kg/day)	SF _i 1/(mg/kg/day)	SF _d 1/(mg/kg/day)
As	3.00 x 10 ⁻⁰⁴	-	3.00 x 10 ⁻⁰⁴	1.5	15	-
Cd	5.00 x 10 ⁻⁰⁴	-	5.00 x 10 ⁻⁰⁴	-	6.3	-
Cr(III)	1.50	-	1.50	-	-	-
Cr(VI)	3.00 x 10 ⁻⁰³	2.20 x 10 ⁻⁰⁶	3.00 x 10 ⁻⁰³	0.5***	290	-
Co	0.01	2.86E-05	0.01	-	-	-
Cu	0.037	-	0.037	-	-	-
Pb	3.60 x 10 ^{-03**}	-	3.60 x 10 ^{-03**}	-	-	-
Zn	0.3	-	0.3	-	-	-
Ni	0.02	-	0.02	-	0.84	-
Mn	0.024	1.43E-03	0.024	-	-	-
Hg	3.00 x 10 ⁻⁰⁴	8.60E-05	3.00 x 10 ⁻⁰⁴	-	-	-
V	5.04 x 10 ⁻⁰³	-	5.04 x 10 ⁻⁰³	-	-	-

Notes:

Data sourced from USEPA Integrated Risk Information System unless otherwise noted.

- no accepted value available.

* RfD_d is assumed to be same as RfD_o

** Data sourced from World Health Organisation

*** Data sourced from New Jersey Department of Environmental Protection

Table 7: Reference Doses and Slope Factors – Petroleum Organics

	RfDo (mg/kg-day)	RfDi (mg/kg-day)	RfDd* (mg/kg-day)	SFo 1/(mg/kg/day)	SFi 1/(mg/kg/day)	SFd 1/(mg/kg/day)
Alkanes**						
C7-C9	5	5	5	-	-	-
C10-C14	0.1	0.1	0.1	-	-	-
C15-C36	1.5	1.5	1.5	-	-	-
MAH's***						
Benzene	-	-	-	0.029	0.029	0.029
Toluene	0.2	0.11	0.2	-	-	-
Ethylbenzene	0.1	0.029	0.1	-	-	-
Xylene	2	0.09	2	-	-	-
Aromatic***						
Naphthalene	0.004	0.004	0.004	-	-	-
Pyrene	0.03	0.03	0.03	-	-	-
Benzo(a)pyrene	-	-	-	7.3	7.3	7.3
Petroleum Additives***						
MTBE	-	0.857	-	-	-	-

* RfDd is set to same as RfDo

** Data sourced from Total Petroleum Hydrocarbon Criteria Working Group

*** Data sourced from USEPA Integrated Risk Information System

Table 8: Reference Doses and Slope Factors – Organics

	RfD _o (mg/kg-day)	RfD _i (mg/kg-day)	RfD _d * (mg/kg-day)	SF _o 1/(mg/kg/day)	SF _i 1/(mg/kg/day)	SF _d 1/(mg/kg/day)
Carbon Tetrachloride	7.00 x 10 ⁻⁰⁴	-	7.00 x 10 ⁻⁰⁴	0.13	0.052	-
Chlorobenzene	0.02	-	0.02	-	-	-
Chloroform	0.01	-	0.01	-	0.0805	-
2 Chlorophenol	5.00 x 10 ⁻⁰³	-	5.00 x 10 ⁻⁰³	-	-	-
1,2 Dichlorobenzene	0.09	-	0.09	-	-	-
1,4-Dichlorobenzene	-	0.229	-	-	-	-
1,2-Dichloroethane	-	-	-	0.091	0.091	-
1,1 Dichloroethene	0.05	0.0571	0.05	-	-	-
1,2 Dichloroethene	0.02	-	0.02	-	-	-
Trichlorobenzenes (total)	0.01	-	0.01	-	-	-
Nitrobenzene	2.00 x 10 ⁻⁰³	2.57 x 10 ⁻⁰³	2.00 x 10 ⁻⁰³	-	0.14	-
1,1,2,2 Tetrachloroethane	-	-	-	20	0.203	-
Trichloroethene	-	-	-	-	-	-
2,4,6-Trichlorophenol	-	-	-	0.011	0.0109	-
Vinyl Chloride	3.00 x 10 ⁻⁰³	0.0286	3.00 x 10 ⁻⁰³	1.5	0.0308	-

Notes:

Data sourced from USEPA Integrated Risk Information System

- no accepted value available

* RfDd is assumed to be same as RfDo

Table 9: Equations

Equation 1: SSV Threshold Contaminants (metals and metalloids)

$$SSV(mg/kg) = \frac{THI \times BW \times AT}{\left[EF \times ED \times \left(\left(\frac{1}{RfD_0} \right) \times 10^{-6} \times IR_s \times GI \right) + \left(\left(\frac{1}{RfD_i} \right) \times IR_a \times \left(\frac{1}{PEF} + \frac{1}{VF} \right) \right) + \left(\left(\frac{1}{RfD_d} \right) \times SA \times AF \times ABS \times 10^{-6} \right) \right]}$$

Equation 2: SSV Threshold Contaminants (Organics)

$$SSV(mg/kg) = \frac{THI \times BW \times AT}{\left[EF \times ED \times \left(\left(\frac{1}{RfD_i} \right) \times 10^{-6} \times IR_s \times GI \right) + \left(\left(\frac{1}{RfD_i} \right) \times \left(IR_a \times \frac{1}{PEF} \right) + \left(\frac{IR_a}{2} \times \left(\frac{1}{VF_i} + \frac{1}{VF_0} \right) \right) \right) \right] + \left(\left(\frac{1}{RfD_d} \right) \times SA \times AF \times ABS \times 10^{-6} \right) \right]}$$

Equation 3: SSV Non-Threshold Contaminants (Metals and Metalloids)

$$SSV(mg/kg) = \frac{TR \times BW \times AT}{\left[EF \times ED \times \left((SF_0 \times 10^{-6} \times IR_s \times GI) + \left(SF_a \times IR_a \times \left(\frac{1}{PEF} + \frac{1}{VF} \right) \right) + (SF_d \times SA \times AF \times ABS \times 10^{-6}) \right) \right]}$$

Equation 4: SSV Non-Threshold Contaminants (Organics)

$$SSV(mg/kg) = \frac{TR \times BW \times AT}{\left[EF \times ED \times \left((SF_0 \times 10^{-6} \times IR_s \times GI) + \left(SF_a \times \left(IR_a \times \frac{1}{PEF} \right) + \left(\frac{IR_a}{2} \times \left(\frac{1}{VF_1} + \frac{1}{VF_0} \right) \right) \right) \right) + (SF_d \times SA \times AF \times ABS \times 10^{-6}) \right]}$$

Where:

SSV	= Soil Screening Value
THI	= Target Hazard Index
TR	= Target Risk
BW	= Body Weight
AT	= Averaging Time
EF	= Exposure Frequency
ED	= Exposure Duration
RfDo	= Reference Dosage (Oral)
RfDi	= Reference Dosage (Inhalation)
RfDd	= Reference Dosage (Dermal)
SFo	= Slope Factor (Oral)
SFa	= Slope Factor (Air)
SFd	= Slope Factor (Dermal)
IRs	= Ingestion Rate (Soil)
IRa	= Ingestion Rate (Air)
GI	= GI Absorption Factor
PEF	= Particulate Emission Factor
VF	= Volatilisation Factor
SA	= Surface Area of Exposed Skin
AF	= Skin Adherence Factor
ABS	= Dermal Absorption Factor

Table 10: Summary of Soil Screening Values for each land-use

Parameter	Units	Informal Residential	Land Use Standard Residential	Commercial/ Industrial
Metals and metalloids				
Arsenic	mg/kg	23	48	150
Cadmium	mg/kg	15	32	260
Chromium (III)	mg/kg	46,000	96,000	790,000
Chromium (VI)	mg/kg	6.5	13	40
Cobalt	mg/kg	300	630	5,000
Copper	mg/kg	1,100	2,300	19,000
Lead	mg/kg	110	230	1,900
Manganese	mg/kg	740	1,500	12,000
Mercury	mg/kg	0.93	1.0	6.5
Nickel	mg/kg	620	1,200	10,000
Vanadium	mg/kg	150	320	2,600
Zinc	mg/kg	9,200	19,000	150,000
Petroleum Organics				
Alkanes				
C7-C9	mg/kg	2,300	2,400	23,000
C10-C14	mg/kg	440	500	4,400
C15-C36	mg/kg	45,000	91,000	740,000
MAHs				
Benzene	mg/kg	1.3	1.4	10
Toluene	mg/kg	110	120	1,100
Ethylbenzene	mg/kg	57	60	540

Parameter	Units	Informal Residential	Land Use Standard Residential	Commercial/ Industrial
Xylenes	mg/kg	91	95	890
Aromatics				
Naphthalene	mg/kg	28	33	290
Pyrene	mg/kg	920	1,900	15,000
Benzo(a)pyrene	mg/kg	0.34	0.71	1.7
Petroleum Additives				
MTBE	mg/kg	360	370	5,800
Organics				
Carbon Tetrachloride	mg/kg	0.26	0.27	4.0
Chlorobenzene	mg/kg	620	1,200	10,000
Chloroform	mg/kg	0.11	0.11	1.70
2 Chlorophenol	mg/kg	150	320	2,600
1,2 Dichlorobenzene	mg/kg	2,700	5,800	47,000
1,4-Dichlorobenzene	mg/kg	1,100	1,200	19,000
1,2-Dichloroethane	mg/kg	0.23	0.24	3.7
1,1 Dichloroethene	mg/kg	10	10	150
1,2 Dichloroethene	mg/kg	620	1,200	10,000
Trichlorobenzenes (total)	mg/kg	310	640	5,300
Nitrobenzene	mg/kg	2.8	2.9	45
1,1,2,2 Tetrachloroethane	mg/kg	0.32	0.34	5
2,4,6-Trichlorophenol	mg/kg	210	320	1,700
Vinyl Chloride	mg/kg	0.10	0.11	1.5
PCBs	mg/kg	1.70	3.60	11
Cyanide	mg/kg	620	1,200	10,000

4.3.2 Protection of Water Resources

Exposure Routes

Partitioning of contaminants between solid and liquid phases within soils may result in impacts to groundwater or surface water resources, thereby giving rise to potential human health risks (ingestion of contaminated water via the drinking water supply if this is from natural untreated surface water or groundwater from boreholes) or the risk of adverse impacts on the aquatic ecosystem. Soil Screening Values that are protective of these potential exposure risks were calculated for protection of human health (ingestion of contaminated water) and aquatic ecosystem health based on a two phase equilibrium partitioning and dilution model.

Partition Coefficients

Partition coefficients provide a measure for assessing the potential movement of a soil contaminant from being bound or sorbed to a solid soil particle (mineral or organic) to a liquid phase. There is currently insufficient information available to define partition coefficients (K_d values) for specific soil types in South Africa. Partition coefficients were therefore sourced from the international literature, primarily from broad based statistical studies of K_d values undertaken in the US and Canada. The K_d values that were used for calculation purposes were selected based on professional judgement. Neutral (pH 7) soil conditions were assumed. Data used is provided in Appendix A.

Dilution Attenuation Factor

The Dilution Attenuation Factor (DAF) accounts for the effects of groundwater recharge on dilution and mixing of the 'partitioned' phase. A conservative approach has been followed and chemical attenuation has been assumed to be 1 thereby placing the focus on dilution potential only.

An estimated DAF of 20 is assumed for the protection of a drinking water borehole based on transport pathway of 50m from contaminant source to point of compliance. It should be noted that site specific DAF factors may vary from 1 to 10 000. Most commonly encountered productive aquifers tend to have DAF values between 10 and 30.

The above factor does not account for attenuation of contaminants within the saturated zone. It should be noted that it was beyond the scope of these initial calculations to define generic attenuation relationships in the saturated zone. Both dilution and attenuation relationships require detailed research to define appropriate and meaningful values for South African conditions.

In the calculation of DAF factors for the protection of aquatic ecosystems it is assumed that groundwater mixes as a baseflow component to a surface water body at a ratio of 1:100 (1% of the volume of the surface water body). The total DAF is thus a factor of 2000 for this pathway allowing for the dilution within the aquifer and then mixing with the surface water body.

Soil Screening Values for Protection of Water Resources

The equation used for calculation of Soil Screening Values for protection of water resources is provided below in Table 11.

Table 11: Calculation Method: Soil Screening Values for Protection of Water Resources

<i>Calculation Method: Soil Screening Values for Protection of Water Resources</i>	
$Y = C_w \times K_d \times DAF$	
Where: Y = total contaminant concentration in soil at equilibrium with pore water at defined water quality standard C_w = water quality standard (aquatic ecosystem / domestic drinking water use guideline) K_d = partition coefficient DAF = dilution attenuation factor	

The results of the calculations are provided below in Table 12. These represent soil values required to achieve Department of Water Affairs Water Quality Guideline levels for aquatic ecosystem protection and domestic water use, and are consistent both in terms of method of derivation and acceptable risk level applied in the development of the existing Water Quality Guidelines. The water quality values used in the calculations for Table 12 are provided in Appendix A. Where Department of Water Affairs Water Quality Guidelines are not currently available for certain contaminants, international literature has been referenced and this is also indicated in Appendix A.

Table 12: Summary of Soil Screening Values for protection of water resource

Parameter	Units	Water Resource Protection	
		Protection of Human Health (drinking water usage)	Protection of Ecosystem Health
Metals and metalloids			
Arsenic	mg/kg	5.8	580
Cadmium	mg/kg	7.5	37
Chromium (III)	mg/kg	n/a	n/a
Chromium (VI)	mg/kg	19	260
Cobalt	mg/kg	-	22,000
Copper	mg/kg	200	16
Lead	mg/kg	20	100
Manganese	mg/kg	10,000	36,000
Mercury	mg/kg	1.0	4.1
Nickel	mg/kg	91	1,400
Vanadium	mg/kg	2,000	-
Zinc	mg/kg	3,700	240
Petroleum Organics			
Alkanes			
C7-C9	mg/kg	n/a	-
C10-C14	mg/kg	n/a	-
C15-C36	mg/kg	n/a	-
MAHs			
Benzene	mg/kg	0.027	81
Toluene	mg/kg	25	170
Ethylbenzene	mg/kg	26	1,700
Xylenes	mg/kg	45	260

Parameter	Units	Water Resource Protection	
		Protection of Human Health (drinking water usage)	Protection of Ecosystem Health
Aromatics			
Naphthalene	mg/kg	-	28
Pyrene	mg/kg	-	5.3
Benzo(a)pyrene	mg/kg	-	280
Petroleum Additives			
MTBE	m/kg	0.0036	810
Organics			
Carbon Tetrachloride	mg/kg	0.25	62
Chlorobenzene	mg/kg	-	960
Chloroform	mg/kg	3	11
2 Chlorophenol	mg/kg	-	140
1,2 Dichlorobenzene	mg/kg	89	1,400
1,4-Dichlorobenzene	mg/kg	26	520
1,2-Dichloroethane	mg/kg	0.37	2,400
1,1 Dichloroethene	mg/kg	-	-
1,2 Dichloroethene	mg/kg	0.4	18
Trichlorobenzenes (total)	mg/kg	0.0069	0.14
Nitrobenzene	mg/kg	-	710
1,1,2,2 Tetrachloroethane	mg/kg	-	190
2,4,6-Trichlorophenol	mg/kg	4	-
Vinyl Chloride	mg/kg	0.0037	-
PCBs	mg/kg	0.62	n/a
Cyanide	mg/kg	14	20

4.3.3 Soil Screening Values

Two tiers of Soil Screening Value have been defined as follows:

- Soil Screening Value (SSV) 1 represents the lowest value calculated for each parameter from both the Human Health and Water Resource Protection pathways calculations as detailed under the preceding sections. SSV1 values are not land-use specific.
- Soil Screening Value (SSV) 2 represents the land-use specific soil value calculated following the methods as detailed under the preceding sections. SSV2 values are land-use specific and are appropriate for screening level site assessment in cases where protection of water resource is not an applicable pathway for consideration.

Soil Screening Values 1 and 2 are provided below in Table 13.

Table 13: Soil Screening Values

Parameter	Units	SSV1 All Land-Uses Protective of the Water Resource	Informal Residential	SSV2 Standard Residential	Commercial/ Industrial
Metals and metalloids					
Arsenic	mg/kg	5.8	23	48	150
Cadmium	mg/kg	7.5	15	32	260
Chromium (III)	mg/kg	46,000	46,000	96,000	790,000
Chromium (VI)	mg/kg	6.5	6.5	13	40
Cobalt	mg/kg	300	300	630	5,000
Copper	mg/kg	16	1,100	2,300	19,000
Lead	mg/kg	20	110	230	1,900
Manganese	mg/kg	740	740	1,500	12,000
Mercury	mg/kg	0.93	0.93	1.0	6.5
Nickel	mg/kg	91	620	1,200	10,000
Vanadium	mg/kg	150	150	320	2,600
Zinc	mg/kg	240	9,200	19,000	150,000
Petroleum Organics					
Alkanes					
C7-C9	mg/kg	2,300	2,300	2,400	23,000
C10-C14	mg/kg	440	440	500	4,400
C15-C36	mg/kg	45,000	45,000	91,000	740,000
MAHs					
Benzene	mg/kg	0.03	1.3	1.4	10
Toluene	mg/kg	25	120	120	1,100
Ethylbenzene	mg/kg	26	57	60	540
Xylenes	mg/kg	45	91	95	890
Aromatics					
Naphthalene	mg/kg	28	28	33	290
Pyrene	mg/kg	5.3	920	1,900	15,000
Benzo(a)pyrene	mg/kg	0.34	0.34	0.71	1.7
Petroleum Additives					
MTBE	mg/kg	0.0036	360	370	5,800
Organics					
Carbon Tetrachloride	mg/kg	0.25	0.27	0.26	4
Chlorobenzene	mg/kg	620	620	1,200	10,000
Chloroform	mg/kg	0.11	0.11	0.11	1.7
2 Chlorophenol	mg/kg	140	150	320	2,600
1,2 Dichlorobenzene	mg/kg	89	2,700	5,800	47,000
1,4-Dichlorobenzene	mg/kg	26	1,100	1,200	19,000
1,2-Dichloroethane	mg/kg	0.23	0.23	0.24	3.7
1,1 Dichloroethene	mg/kg	10	10	10	150
1,2 Dichloroethene	mg/kg	0.4	620	1,200	10,000

Parameter	Units	SSV1 All Land-Uses Protective of the Water Resource	Informal Residential	SSV2 Standard Residential	Commercial/ Industrial
Trichlorobenzenes (total)	mg/kg	0.069	310	650	5,300
Nitrobenzene	mg/kg	2.8	2.8	2.9	45
1,1,2,2 Tetrachloroethane	mg/kg	0.32	0.32	0.34	5
2,4,6-Trichlorophenol	mg/kg	4	210	320	1,800
Vinyl Chloride	mg/kg	0.0037	0.10	0.11	1.5
PCBs	mg/kg	0.61	1.7	3.6	11
Cyanide	mg/kg	14	620	1,200	10,000

Investigation Values for Salts

In addition to the suite of metals and organics detailed above, guidance has also been provided on salts as land contaminated with excessive levels of salt is also a major cause of deterioration of water quality in South African catchments.

Commonly occurring anions are rarely encountered at concentrations that may impact on human health by direct exposure pathways, but they do however have an important influence on soil quality from an ecological and agricultural perspective.

The Soil Screening Values listed below should be used as investigation levels requiring the development of a site specific risk assessment where contaminant release mechanisms and migration pathways such as leaching and soil erosion and transport are evaluated in relation to on-site dilution and attenuation factors and the seasonal carrying capacity of the water resource.

Investigation values are calculated on the basis of human health considerations for drinking water for a dilution-attenuation factor of 20. Aesthetic criteria related to taste are not considered in the determination of Soil Screening Values but could become remediation objectives for specific sites.

It is important to take into consideration a number of soil related chemical parameters that may provide useful indicators of potential environmental contamination of soils or may control the mobility of salts and other soil contaminants, for example soil pH or Exchangeable Sodium Percentage. These factors are best assessed in Site Specific Risk Assessments.

Anions	Soil Screening Level (mg/kg)
Chlorides	12 000
Fluorides	30
Nitrates-nitrite	120
Sulphates	4000

5 Application of Site Specific Quantitative Risk Assessment

5.1 APPROACH AND APPLICABILITY

The use of site specific forms of risk assessment is recognised as international best practice. The deficiencies of simplistic generic assumptions used at preliminary levels of assessment may provide for remediation objectives that are either, unrealistic in terms of the actual identified exposure pathways, or fail to allow sufficiently for the assessment of risk to sensitive or non-standard receptors, or where the contaminants of concern are complex in nature are thus excluded from preliminary screening lists.

The development of a consistent methodology for quantitative risk assessment for contaminated land together with standard equations as a guidance measure is an objective of this Framework.

Site-specific quantitative risk assessment provides a means of determining the contamination status of a site. It establishes whether site remediation, or other action, is necessary and helps to determine whether a tolerable level of contamination can remain in place or enable comparison of potential impacts of various remediation techniques.

International best practice for quantitative risk assessments follows a four step process as follows;

- Hazard Identification – identification of the key physical and chemical hazards associated with contaminants on the site;
- Toxicity Assessment – evaluation of the toxicological properties of the contaminants of concern on the site that pose a hazard including assessment of safe exposure levels;
- Exposure Assessment - identification and exposure assessment of human and ecological receptors on or near the site; and
- Risk Characterisation – numerical quantification of the risk.

All four components are interlinked and numerical risk models are critically dependant on the validity and appropriateness of all the input data and related assumptions.

Risk assessment is based on probabilities rather than absolutes and this should be reflected in the decision-making. Spurious and misleading risk assessment reports generated to motivate for minor adjustments to Soil Screening Values represent poor professional practice and will not be tolerated.

Due to complexity of site conditions it is not possible to derive a full prescriptive standard for reporting, however a checklist for assessing site specific risk assessment reports is provided for guidance purposes in Table 14 located at the end of this Chapter.

Competent persons involved in the specific components of the process should be adequately qualified and/or have demonstrable experience with broad understanding of health risk assessment and the practical realities of contaminated sites. Although major reports are likely to involve the input of a variety of specialists there should be a principal coordinator who takes responsibility for the overall risk assessment report.

5.2 EXPOSURE ASSESSMENT

Exposure Assessment involves the determination of the *frequency*, *extent* and *duration* of exposures for receptors and should include the identification of exposed populations and particularly sensitive subpopulations as well as potential exposure pathways. A combination of predictive models and environmental monitoring should be used to determine the levels of exposure at particular points on the exposure pathways. The contaminant intakes from the various pathways can be estimated under a range of

scenarios. Uncertainties in the models can be addressed by gathering further information or by including safety factors and other forms of conservatism by professional judgement.

Exposure Assessment involves the estimation of the magnitude, frequency, extent and duration of exposure in the past, present, and in the future.

The process involves:

- Estimate of contaminant releases;
- Identification of exposed populations;
- Identification and estimation of exposure concentrations for each pathway; and
- Estimation of contaminant intakes for each pathway for a range of scenarios.

Direct measurement of the exposure of the affected population provides the best exposure data but is not always available or practicable.

The approach has strengths and weaknesses and the limitations of exposure assessments need to be understood and communicated.

5.2.1 Key factors for consideration in Exposure Assessments

- Children usually receive a higher exposure to soil contaminants per unit body weight than adults.
- Soil ingestion by small children (including geophagic behaviour) is usually by far the most important exposure route.
- In South Africa exposure to soil contaminants is likely to be far higher in informal settlements than other forms of residential land use and the adoption of default exposure parameters from other countries are likely to underestimate the risk for these receptor populations.
- One exposure route will normally predominate and determine the risk.
- The inhalation route will be most important for highly volatile contaminants, but if the source of volatiles is relatively small, as they rapidly evaporate and disperse in air, they will rapidly disappear from a site unless new sources are added.
- For large scale (regional) contamination assessment more exposure pathways are likely to be relevant than when dealing with localised small-scale contamination.

5.2.2 Errors in Exposure Assessments

Factors that tend to result in the underestimation of exposure include the following:

- Overlooking a significant exposure or metabolic pathway;
- Failure to evaluate all the contaminants of concern in the soil mixture;
- Comparison of exposure-related data against contaminated media or exposed populations rather than appropriate background levels;
- Using insufficiently sensitive detection limits so that meaningful values are reported as being not detected; and
- Relevant individual pathways within the same exposure route may not have been summed.

Factors which can cause overestimation of exposure include the following:

- The use of unrealistically conservative exposure parameters;
- Portraying hypothetical potential exposures as existing exposures; and
- Attributing a significant value to results that fall below an appropriate detection limit.

Factors that may cause either underestimates or overestimates include:

- quality assurance/quality control problems with the field chemical data;
- computational errors;
- use of inappropriate input parameters for intake routes;
- insufficient uncertainty assessment;
- use of inappropriate number of significant figures in numeric estimates; and
- unthinking and uncritical use of models.

5.3 TOXICITY ASSESSMENT

Toxicity Assessment considers the nature of adverse effects related to exposure, the dose response relationship of the various effects, and the weight of evidence for effects such as carcinogenicity.

For specific contaminants of concern that are not included in the generic Soil Screening Values a more detailed review of relevant toxicological data is required.

Toxicological Assessment is necessarily preceded in any Risk Assessment by Hazard Identification which examines the capacity of an agent to cause adverse health effects in humans and other animals. The key issues to address in a Hazard Assessment are:

- nature, reliability and consistency of human and animal studies;
- the available information on the mechanism of toxic effect; and
- the relevance of the animal studies to humans.

The Toxicological Assessment is focused on the dose-response of contaminants and examines the quantitative relationship between exposure and effects.

Internationally recognised sources of Toxicological Assessment data include, but are not limited to:

- World Health Organisation (WHO). Includes the International Programme on Chemical Safety (IPCS) which produces Environmental Health Criteria monographs and Concise International Chemical Assessment documents (CICADs). Documents detailing internationally Acceptable Daily Intakes (ADIs), Tolerable Daily Intakes (TDI) or Tolerable Weekly Intakes (TWI) may also be found in WHO/FAO Joint Meeting on Pesticide Residues and by the Joint WHO/FAO Expert Committee on Food Additives.
- International Agency for Research on Cancer (IARC) monographs.
- NICNAS Priority Existing Chemical (PEC) reports.
- Integrated Risk Information System (IRIS) for cancer slope factors.
- US Agency for Toxic Substances and Disease Registry (ASTDR) for general toxicological reviews and Reference Doses.

The direct reference of toxicological data and opinion may be cited from peer reviewed scientific journals particularly if no guidance values are available, accompanied by an appraisal of methodology stating the level of conservatism and uncertainty.

Occupational health and safety sources of information are a useful source for toxicological data and reviews but occupational exposure criteria must not be used in a general public health context without appropriate adjustment for the different durations of exposure, the inclusion of susceptible sub-populations in the general community (children) and the differences in methodology in the setting of criteria.

5.4 GUIDELINE CHECKLIST FOR QUANTITATIVE RISK ASSESSMENT

A guideline checklist for the compilation of Site Specific Quantitative Risk Assessments is provided below in Table 14. It is noted this guidance checklist is particularly relevant to Quantitative Risk Assessments being applied to complex sites with multiple contaminants and/or receptors and that not all aspects of the checklists may be deemed to be relevant for simpler site specific risk assessments.

Table 14: Guidance checklist for Site Specific Quantitative Risk Assessment Reports

Report Preparation and Review

- Has the objective and level (preliminary or detailed) of report been clearly defined?
- Is there a clear understanding of land use and site constraints?
- Is the sampling reasonably sufficient to identify, locate and demarcate any potential contamination?
- How are the results interpreted?
- Have data been analysed for the appropriate soil horizons, surface water sources and groundwater sources?
- Were environmental fate and transport mechanisms understood?
- Have data been modelled to develop a spatial and time dependant understanding of the site conditions?
- How were anomalous results or findings addressed?
- Were the uncertainties of the assessment identified and understood?

Contaminants of Concern

- State objectives of data collection and risk assessment.
- Identify chemicals of concern (CoC).
- Identify sources of CoC.
- Identify environmental fate and transport of contaminants.

Integrity of Data

- Are the data collection objectives consistent with the requirements of the risk assessment?
- Note laboratories used. Are they suitably accredited to perform the chemical analyses?
- Quality Assurance/Quality Control (QA/QC) (refer Chapter 6):
  - Has laboratory QA/QC been reported and assessed?
  - Has field QA/QC been reported and assessed?
  - Have statements of laboratory accuracy for each contaminant been made?

Toxicology

- Check accuracy and currency of toxicological data.
- Is the available toxicological database adequate?
- Has human health data been appraised for the relevant exposure pathways?
- Has the critical toxic effects and organ/body system been identified?
- Have synergistic and antagonistic effects of multiple contaminants been considered?
- Have uncertainties in the toxicological basis of the guidance values been discussed?
- Has the dose-response relationship for contaminants been appraised and discussed?

Receptors

- Have potentially exposed populations been identified?
- Have unusually susceptible individuals been identified?
- Have estimates of chemical exposure for each significant exposure route and for each contaminant been adequately quantified and tabulated?
- Has the significance of each exposure pathway been discussed on the basis of risk?

Risk equations and calculations

- Have all equations used in the report been listed?
- Are all equations consistent?
- Have all parameters in each equation been clearly defined?
- Have the correct units been allocated to the parameters?
- Are the equations dimensionally correct?
- Have all unit correction factors, where applicable been included in the equations?
- Has all pertinent information been provided to enable calculations to be checked through in a stepwise manner?

Report Conclusions and Recommendations

- Have all assumptions and default data been identified and justified?
- Has the analysis been undertaken based on up-to date data and literature?
- Have all conclusions been justified?
- If toxicological data and exposure scenario lead to the conclusion that a high concentration of contaminant is permissible in terms of human health, does the result violate ecological, aesthetic, land use or other physical principles?
- Has a risk management decision been made that influences the calculation of risk?
- Has uncertainty been discussed?
- Has the information been presented coherently and in an appropriate sequence to enable efficient appraisal of the report?

6 Quality Control and Quality Assurance of Field Sampling and Laboratory Analysis

6.1 INTRODUCTION

The following section provides guidance on Quality Assurance and Quality Control (QA/QC) procedures for the investigation of potentially contaminated sites, with a focus on the sampling of soils. It is not intended to provide prescriptive comments on laboratory testing but rather to highlight measures to maintain the integrity of field samples by applying simple and consistent routines that allow discrepancies in data to be traced and assessed. The primary objective is to ensure that the minimum level of QA/QC expected for the undertaking of site investigations in South Africa is clearly understood.

An additional objective of this guidance is to standardise and to provide a degree of consistency with respect to QA/QC procedures for site investigation. However, it is also acknowledged that these guidelines may need to be adapted for the specific conditions of a particular site investigation. Where deviations from standard QA/QC procedures occur, these must be documented in the reporting of the site investigation, so that any limitations of the investigation are clearly understood.

Good data quality is essential for practical implementation of this Framework. The data used to determine risk and the status of contaminated land must be relevant, sufficient, reliable and transparent.

In general terms data quality can be judged taking into account the following factors :

- Choice of sampling points. Is it judgemental or random? How certain is it that contamination has been identified?
- Sampling method. Does it follow good practice guidance? Does it maximise the integrity of the sample?
- Sample handling and storage. Does it minimise contaminant losses or transformation?
- Sample preparation. Is it in accordance with good practice and appropriate for the accurate determination of the contaminant?
- Analytical detection limit relative to the Soil Screening Value. The analytical limit of detection (LOD) should be sufficiently below the Soil Screening Value to satisfactorily address quantification uncertainty.
- Analytical method quality assurance. Properly accredited laboratory analytical methods must be used when available.

It is noted that total reliance cannot be placed on the results of laboratory testing. Even if one adheres to accepted test measures and uses appropriately accredited laboratories, it does not guarantee that the analytical results will be representative of the actual site conditions. It is incumbent on the proponent and appointed specialist advisors to provide control measures in order to understand any possible variance in the accuracy and precision of test results used in the assessment of a potentially contaminated site. It is also worth noting that use of multiple laboratories with duplicate and sometimes triplicate testing on a large number of samples also does not necessarily result in a high level of confidence in results – particularly when simple QA/QC measures were not applied at the commencement of investigation and sampling itself. Therefore it is essential that the potential limitations of sampling and testing techniques are considered and that reasonable measures to assess variance and its consequences in the compilation and interpretation of test results are applied.

The characterisation of a contaminated site is fundamentally based on a combination of sound judgement of potential risks, identification of contaminants of concern and a clear conceptual understanding of possible exposure pathways, release mechanisms and fate and transport of contaminants in the environment. Effective QA/QC protocols do not replace a strong conceptual understanding of the site being

investigated nor can they compensate for a deficient site investigation and sampling strategy, such as inappropriate drilling/excavation techniques or poorly selected sampling locations. However, provided that the other elements of a site investigation are sound, QA/QC procedures are an essential part of an effective site investigation, ensuring that scientifically defensible and validated factual data can be produced to support the findings of contaminated site assessment reports.

The QA/QC procedures outlined below are largely based upon the Australian Schedule B(2) Guidelines on Data Collection, Sample Design and Reporting (NEPC, 1999) as well as the British Standard BS10175:2001 Investigation of Potentially Contaminated Sites – Code of Practice (BSi, 2001). Should additional guidance be sought with respect to QA/QC, reference can be made to relevant sections of the above documents.

For specific guidance on groundwater sampling the following reference documents define good practice in South Africa and are adopted for the purpose of this Framework.

- o Weaver JMC, Cave L, Talma, AS (2007) *Groundwater Sampling: a comprehensive guide for sampling methods. Second Edition*, Water Research Commission, Pretoria Report No TT 303.
and its precursor document;
- o Weaver JMC (1992) *Groundwater Sampling Manual*, Water Research Commission, Pretoria Report No TT 54/92.

6.2 PRE-SAMPLING ACTIVITIES

In order to implement a cost effective and technically feasible site investigation, it is necessary to have a properly formulated sampling strategy, based upon a strong conceptual understanding of the site conditions and history, as well as a clear understanding of the objectives of the site investigation itself. Without this preparation, it is unlikely that any investigation will be successful.

Sampling of contaminated land is a forensic screening process and there is the possibility that both false positive and false negative results will occur. From a health and environmental perspective the aims of sampling are to reduce the likelihood of a false negative scenario that could result in an underestimation of contaminant concentration and hence risk that could ultimately lead to significant adverse effects. A considerable amount of expert judgement based on site history information is required to determine the density of sampling. The final amount will depend on an integrated appraisal of factors including:

- proposed use(s) and users;
- current use;
- the likely shape(s) of contamination and its distribution;
- the size of contaminated areas to be detected;
- the number of stages of sampling considered feasible;
- the size of the site and final subdivided sites (if the site is to be subdivided);
- the distribution of uses on the site and the disposition of structures;
- the site history; and
- potential remediation and management strategies.

If a site is to be subdivided the size of the subdivided sites should be taken into account when planning the sampling density. While predictions may be able to be made on a 'macro' scale, residents or owners may seek information about their particular area of land and the risks associated with a smaller piece of land, especially if the potential contamination on the original site was uneven in magnitude and type. The detection of 'hot spots' is an important issue for sites to be used for residential purposes or other sensitive uses where children have regular access to soil or where there is potential groundwater contamination. A greater sampling density is usually required for these sites. The toxicity of the contaminant, and the size and magnitude of the potential 'hot spot(s)' need to be considered in determining grid size. An explanation of, and justification for, the sampling density chosen should be provided.

- It is necessary to have some understanding of the following issues prior to sampling:
  - Clear objectives for the sampling plan;
  - Sampling media (likely soil types);
  - Sampling locations;
  - Analyses to be performed; and
  - Testing laboratory (and the laboratory's requirements for QA/QC).

6.2.1 The Sampling Plan

Sampling plans should be designed on the basis of site history and site conditions, including geological and hydrogeological characteristics. Soil contamination is rarely homogenous, either laterally or vertically through the soil column, and may be present in differing geological strata, discontinuous lenses or within various fill horizons across a site. Professional experience and judgement should be used to ensure adequate coverage. The sampling plan and decisions regarding the number, type and location of samples need to be developed with an understanding of the potential exposure pathways and routes. The proposed use for the site will also critically affect the nature of the sampling program.

The objectives of the sampling plan are usually stated in terms of:

- Determining the presence/absence of contamination;
- Determining the extent/magnitude of contamination;
- Determining the contaminant migration pathways; and
- Identifying risk to sensitive receptors within the context of a particular land-use setting.

The sampling plan should consider the purpose of the investigation, such as:

- determining the nature of contamination;
- determining the concentration and distribution of contamination both laterally and vertically;
- identifying types and concentrations of contaminants, for assessing potential exposure levels and risks;
- monitoring site conditions to determine if remedial action/intervention is required;
- designing and implementing remedial action; and
- determining if clean-up has been achieved.

6.2.2 Sampling Patterns

It is the responsibility of the site investigator to formulate an appropriate sampling program based upon accurate and reliable site specific information as far as practicable, and the reasoning behind the sampling plan should be made clear within any subsequent reporting. The following sampling patterns are listed in the preferred order for determining sampling patterns:

■ Site history-based (judgemental) sampling

Sampling is localised to known or potentially contaminated areas identified from knowledge of the site i.e. known existing or historical sources of contamination. To undertake site-history based / judgemental sampling there needs to be a high level of confidence in the reliability of information about the site. With respect to historical sources of contamination, access to reliable data can be particularly challenging.

■ Grid (systematic) sampling

This permits the whole of the site to be covered and for sampling points to be more readily identified for further sampling. Grid sampling typically involves the use of a regular or offset grid or herringbone pattern,

with the pattern selected being essentially dependant on the site size and topography. Grid sampling is useful for covering the remainder of the site once judgemental sampling has been applied to those areas of the site considered most likely to be contaminated, or if there is inadequate information regarding site history.

■ Stratified sampling

This involves dividing the site up into different sections and applying different sampling patterns and densities in each sub-section. It is sometimes a useful technique for large and complex sites.

Composite Sampling

Composite sampling entails the mixing of two or more samples to form a single composite sample for analysis.

Composite sampling is often incompatible with health risk assessment methodologies and is generally unsuitable for the definitive assessment of site contamination due to the inherent uncertainties in the resultant data. Composite sampling should not be used for site-specific health and ecological risk assessments but may be acceptable for the appraisal of stockpiled material or buried dumps characterised by the presence of non volatile contaminants. It is also the preferred choice of sampling method if leaching tests are required for waste classification or for sites where it may be desirable to leave a portion of the material in the ground in the form of an isolate-contain and monitor remediation plan. For example, a contaminated soil stockpile of 100m³. The contamination may be adequately characterised for the purpose of determining a bulk chemical concentration by composite sampling. Four composite samples may be formed by partitioning the stockpile into quarters and taking 5 individual samples (greater than 5 meters apart) at surface and depth from each quarter. The five samples are thoroughly mixed and sub-sampled to form the final composite.

Clustered composite sampling (where samples from a stratum are taken within a 1 to 5 metre diameter area and combined to represent a sampling point) may be acceptable. Clustered samples must be thoroughly mixed to ensure a true average test result is obtained. Certain contaminants are highly viscous and tend to form localised zones of high concentration, in this case the use of composite samples may be highly misleading and should not be attempted.

6.3 QA/QC PROCEDURES

The QA/QC sample policy has been established to provide a minimum standard of QA/QC that will allow for the evaluation of field or trip conditions and situations that may affect the results of chemical tests by the laboratory. These procedures will apply to typical projects performed by suitably qualified competent persons. These include sites having sample media consisting of soil sediment, sludge, or water.

The following section describes the QA/QC (Quality Assurance/Quality Control) policy for environmental sampling for chemical testing. The first subsection defines QA/QC samples and is followed by the basic philosophy, a sample collection, and sample analysis policy.

6.3.1 Definitions

Field duplicate samples are samples that have been divided into two or more portions in the field collection process from project samples. Each portion is then carried through the laboratory analysis. A sample may be duplicated at other points in the analytical process; however it would not be called a field duplicate. Examples of field duplicated samples include a soil sample that has been collected and mixed before being split and placed into individual sample containers. Correctly splitting and mixing a soil sample is especially important because of its inhomogeneous nature. In cases where volatile analyses are to be performed on soil, mixing the sample will liberate the volatiles. Therefore, duplicate samples for volatile analysis should be taken from the same source without mixing and splitting. Water samples are not mixed, but poured from the same sampling device. Both soil and water duplicates should be taken from the location of expected high contamination.

Equipment blanks are defined as samples which are obtained by running analyte-free deionized water through sample collection equipment (bailer, pump, auger, split-tube, Shelby tube, spatula, etc.) after decontamination, and placing it in the appropriate sample containers, with project samples, for analysis. These samples are used to determine whether decontamination procedures have been sufficient. Deionized water is used to make equipment blanks for both water and soil samples.

Field blanks are defined as samples which are obtained in the field by pouring analyte-free deionized water into appropriate sample containers for analysis. These samples are packaged with the project samples and sent to the laboratory for analysis. Field blanks are used to determine if contamination entered the sample during field collection to laboratory analysis.

Trip blanks are prepared in actual sample containers prior to the sampling event and are kept with the project samples throughout the sampling event. They are then packaged for shipment with the project samples and sent for analysis. At no time after their preparation are the sample containers opened before they reach the laboratory.

6.3.2 QA/QC Sampling

The following standards apply to typical projects as previously defined and may be raised to higher standards by the competent person for special projects requiring more rigorous forms of quality control applied to specific contaminants.

Sample Collection

An equipment blank and field duplicate sample should be prepared for every ten project samples collected, or for every day of sampling, or for each project - whichever is more. When the number of field duplicates is controlled by the number of project days, the number of field duplicate samples shall be controlled by the one-in-ten rule, if it results in less duplicate samples. This rule will generally apply when soil borings are being drilled and converted to wells, and only a few project samples (less than ten) are being collected each day for chemical testing. The QA/QC samples will be treated in accordance with project sampling procedures, and shipped to the chemical laboratory under project chain-of-custody protocol. For projects involving the collection of one project sample, this means that two QA/QC samples will be prepared. The proportion of QA/QC samples decreases with an increase in project samples collected.

A field blank will not be required in most cases as field conditions/situations affecting the field blank will also affect the equipment blank. By having only an equipment blank, the question is only whether sampling contamination or other field conditions/situations affected the sample, if contaminants are found upon chemical testing. Field conditions requiring a field blank would be if there is a high likelihood of windblown contamination or rain affecting the sample. The need for field blanks would be decided by the competent person.

Under normal conditions, a trip blank will not be required as conditions/situations affecting the trip to the field rarely happen. If contamination occurs, the equipment blank would show those effects. Although similar to the field blank, a trip blank could not be used to differentiate between sampling contamination, field, or trip effects. Trip blanks will be required if trip conditions are unusual. An example of such conditions would be an out-of-town sampling event in which the sampler in the field has little control over time duration of sample shipments to and from the field, or where environmental conditions during the trip could potentially introduce contamination.

Sample Analysis

The field duplicate sample will be analyzed for the same chemical constituents as the normal project samples. This includes the same laboratory extraction procedure(s) and any clean-up that the project samples undergo.

The equipment blank for all chemical tests (including, but not limited to, metals, volatiles, semi-volatiles and pesticides) will always be prepared for analysis. Except for volatiles, the actual chemical testing will be performed only if a problem is suspected in the test results or at the discretion of the competent person.

Except for volatiles, there is ample holding time for the extraction from these samples to wait for chemical tests to be performed, and the results reviewed.

The equipment blank for volatile organics will always be extracted and tested because the holding time for volatiles is only 14 days (from sampling to testing). However, if a seven day turnaround on project samples can be guaranteed, then, at the discretion of the competent person, the chemical test for volatile equipment blanks can wait until the results of the project samples have been reviewed. However, analysis of the equipment blank for volatiles, if required, must be done within the 14-day holding time.

If field and trip blanks are prepared, they shall always be prepared and analyzed for the chemical constituents tested for in the project samples.

6.4 FIELD TESTING METHODS

A variety of field testing methods have been developed as field screening devices for contaminated sites. These include photoionisation detectors (PIDs), flame ionisation (FIDs), gas detectors and field portable laboratories including x-ray fluorescence (FPXRF) and field gas chromatography. These methods provide real-time or fast turnaround data to assist in rapid site characterisation. Their use as the sole source of analytical data in the assessment is however not supported by the analytical precision and detection limits available for much of this technology. When assessing the application of field testing equipment the following issues need to be addressed.

- The equipment must be capable of detecting the contaminants of concern.
- There must be adequate understanding of the methods for use of the particular instrument and any limitations that may affect the results.
- Appropriate calibration must be recorded for the contaminants being tested.
- Wherever site conditions may effect the results (high temperatures or high moisture contents).

It is strongly recommended that laboratory testing is used to provide correlation with any field measurements. If good correlation exists between the results of field testing method and certified laboratory results the results of such field tests can be applied to determine extent and severity of contamination and can be used in monitoring programmes. Risk Assessment Reports and remediation objectives based solely on non-validated field test results are unacceptable.

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  - Schedule B(5) Guideline on Ecological Risk Assessment
  - Schedule B(6) Guideline on Risk Based Assessment of Groundwater Contamination
  - Schedule B(7A) Guidelines on Health Based Investigation Levels

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APPENDIX A:

Chemical Specific Data for Soil Screening Value Calculations

Chemical Specific Data for Soil Screening Value calculations

1. Gastrointestinal and Dermal Absorption (GI and ABS)

Metals & metalloids

- Gastrointestinal absorption was assumed to be 100% for all metals and metalloids with the exception of arsenic for which a gastrointestinal absorption of 10% was applied. This modification of the arsenic value to a less conservative and more realistic assumption was deemed necessary due to the unrealistically low (below background) soil screening value derived using latest carcinogenic risk data for arsenic.
- Dermal absorption was assumed to be 10%.

Petroleum & Non-Petroleum Organics

- Gastrointestinal absorption was assumed to be 100% throughout all calculations for petroleum and non petroleum organic calculations.
- Dermal absorption was assumed to be 10%.

2. Particulate emission factors used for each land-use were as follows:

Land-Use	PEF (m ³ /kg)	Key assumption
Residential (standard)	1.30E+09	Fraction vegetative cover – 50% Wind speed & diffusion height – 2.25m/s and 2m
Residential (informal)	7.25E+08	Fraction vegetative cover – 10% Wind speed & diffusion height – 2.25m/s and 2m
Commercial/Industrial	3.22E+08	Fraction vegetative cover – 10% Wind speed & diffusion height – 2m/s and 1m (semi-confined working environment)

3. Volatisation Factors (VF)

Petroleum Organics

Volatisation factors for petroleum hydrocarbons were sourced from New Zealand Ministry for the Environment. Calculations were based on a high permeability (sandy) soil using the modified Johnson and Ettinger Model. The calculations are consistent with ASTM E1739-95 (2002) as applied to the VF calculations for all other organics listed below.

Parameter	Indoor Air		Outdoor Air
	Residential m ³ /kg	Commercial/ Industrial m ³ /kg	All Land-Uses m ³ /kg
Alkanes			
C7-C9	1.61E+02	2.42E+02	1.31E+04
C10-C14	1.92E+03	2.87E+03	1.83E+04
C15-C36	1.16E+06	1.74E+06	4.46E+05
MAHs			
Benzene	5.85E+02	6.67E+02	5.59E+04
Toluene	3.75E+02	5.62E+02	1.31E+04

Parameter	Indoor Air		Outdoor Air
	Residential m ³ /kg	Commercial/ Industrial m ³ /kg	All Land-Uses m ³ /kg
Ethylbenzene	7.09E+02	1.05E+03	1.31E+04
Xylene	3.48E+02	5.24E+02	1.31E+04
Aromatics			
Napthalene	3.42E+03	5.15E+03	2.57E+04
Pyrene	2.94E+07	4.41E+07	2.46E+06
Benzo(a)pyrene	2.32E+09	1.13E+10	4.52E+07
Petroleum Additive			
MTBE	7.14E-03	2.90E-03	7.82E-07

Organics

The VF_s for organics were calculated following ASTM E1739-95 (2002) and are detailed below.

Parameter	Indoor Air		Outdoor Air
	Residential m ³ /kg	Commercial/Industrial m ³ /kg	All Land-Uses m ³ /kg
Carbon Tetrachloride	5.14E-03	2.09E-03	1.75E-06
Chlorobenzene	9.05E-04	3.67E-04	2.65E-07
Chloroform	8.08E-03	3.28E-03	2.49E-06
2 Chlorophenol	4.12E-03	1.67E-03	2.95E-07
1,2 Dichlorobenzene	5.04E-04	2.04E-04	1.13E-07
1,4-Dichlorobenzene	5.79E-04	2.35E-04	1.46E-07
1,2-Dichloroethane	3.29E-03	1.33E-03	5.53E-07
1,1 Dichloroethene	1.79E-02	7.26E-03	6.87E-06
1,2 Dichloroethene	9.01E-03	3.66E-03	2.33E-06
Trichlorobenzenes (total)	5.43E-03	2.20E-03	5.79E-07
Nitrobenzene	1.76E-04	7.14E-05	9.85E-09
1,1,2,2 Tetrachloroethane	1.06E-03	4.29E-04	1.01E-07
Trichloroethene	4.07E-03	1.65E-03	1.54E-06
2,4,6-Trichlorophenol	1.05E-05	4.25E-06	5.66E-10
Vinyl Chloride	2.20E-02	8.91E-03	9.66E-06

4. Soil Partition Coefficients (K_d Values)

Soil partition coefficients used in the water resource protection pathway calculations are detailed below.

Metals & Metalloids

Parameter	K _d Value (L/kg)
As	29
Cd	75
Cr(III)	1800000

Parameter	Kd Value (L/kg)
Cr(VI)	19
Co	100
Copper	10
Lead	100
Zn	62
Ni	65
Mn	100
Hg	52
V	1000

Petroleum Organics

Parameter	Kd* (L/kg)
Alkanes	
C7-C9	39.8
C10-C14	2510
C15-C36	63100
MAHs	
Benzene	1.35
Toluene	1.78
Ethylbenzene	4.37
Xylene	4.47
Aromatics	
Napthalene	12.9
Pyrene	1050
Benzo(a)pyrene	10200
Petroleum Additive	
MTBE	0.12

* Calculated from octanol-carbon coefficient assuming fraction organic carbon of 0.01

Organics

Parameter	Kd* (L/kg)
Carbon Tetrachloride	3.09
Chlorobenzene	3.72
Chloroform	0.457
2 Chlorophenol	0.15
1,2 Dichlorobenzene	4.43

Parameter	Kd* (L/kg)
1,4-Dichlorobenzene	4.34
1,2-Dichloroethane	0.617
1,1 Dichloroethene	0.59
1,2 Dichloroethene	0.36
Trichlorobenzenes (total)	0.172
Nitrobenzene	0.646
1,1,2,2 Tetrachloroethane	0.861
Trichloroethene	1.62
2,4,6-Trichlorophenol	0.89
Vinyl Chloride	0.617
Polychlorinated biphenyls	3090
Cyanide	10

* Calculated from octanol-carbon coefficient assuming fraction organic carbon of 0.01

Appendix B:

Contaminated Profiles

ARSENIC

ARSENIC

Environmental Occurrence

Arsenic poses a significant health risk to humans. Elemental arsenic is a steel grey metal-like material rarely found naturally. As a compound with other elements, such as oxygen, chlorine, and sulphur, arsenic is widely distributed throughout the earth's crust, especially in minerals and ores that contain copper or lead. Arsenic in groundwater is largely the result of dissolved minerals from weathered rocks and soils.

Arsenic is fairly widespread in the environment with average concentrations in the Earth's crust being approximately 2 mg/kg. Concentrations in surface water are generally low, less than 0.01 µg/l.

Arsenic was used extensively in the production of chromated copper arsenate (CCA), a preservative that renders wood resistant to rotting and decay. Increased environmental regulation, along with the decision of the wood treating industry to eliminate arsenical wood preservatives from residential application, has caused arsenic consumption to decline. Other industrial products containing arsenic include lead-acid batteries, light-emitting diodes, paints, dyes, metals, pharmaceuticals, pesticides, herbicides, soaps, and semiconductors. Man-made sources of arsenic in the environment include mining and smelting operations, agricultural applications, and disposal of wastes that contain arsenic.

Arsenic is a contaminant of concern at many remediation sites. Because arsenic readily changes valency states and reacts to form species with varying toxicity and mobility, effective treatment of arsenic can be challenging.

Toxicity

Arsenic accumulates in the body and once-off exposure to a high concentration of arsenic can have serious long term health effects.

Single high dose exposure to arsenic may occur by ingestion or inhalation and causes nausea, diarrhea and abdominal pain, with multi-organ failure after severe exposure via ingestion. Arsenic compounds are irritants to eyes and skin and cause a variety of vascular diseases. Chronic exposure can affect the respiratory tract, central nervous system, liver, kidneys and gastrointestinal system. Arsenic is a known human carcinogen with exposure linked to the development of skin cancer, bladder and lung cancer and acts via genotoxic mechanism.

Soil Screening Values

	All land uses Protective of the Water Resource	Informal Residential	Standard Residential	Commercial/ Industrial
As	5.8 mg/kg	23 mg/kg	48 mg/kg	150 mg/kg

Target Water Quality

	Drinking Water (DWAF, 1996)	Aquatic Water Quality (DWAF, 1996)
As	0.01 mg/kg	0.01 mg/l

Equation Sample

Table 1: Exposure Parameters As

Parameter		Informal Residential	Standard Residential	Commercial/ Industrial
THI	Target Hazard Index	1	1	1
TR	Target Risk	1E-05	1E-05	1E-05
BW	Body Weight (kg)	70	70	70
AT	Averaging Time (days)	25,550	25,550	25,550
EF	Exposure Frequency (days/yr)	365	350	250
ED	Exposure Duration (yrs)	70	70	30
IRs	Ingestion Rate (Soil) (mg/day)	200	100	100
IRa	Ingestion Rate (Air) (mg/day)	20	20	10.4
GI	GI Absorption Factor	0.1	0.1	0.1
PEF	Particulate Emission Factor (m3/kg)	7.25E+08	1.30E+09	3.22E+08
VF	Volatilisation Factor (m3/kg)	-	-	-
SA	Surface Area of Exposed Skin (cm ²)	11,600	5,800	13,110
AF	Skin Adherence Factor (mg/ cm ² /day)	0.07	0.07	0.07
ABS	Dermal Absorption Factor	0.1	0.1	0.1

Table 2: Toxicological Data As

Parameter		Informal Residential	Standard Residential	Commercial/ Industrial
RfDo	Reference Dosage (Oral)	-	-	-
RfDi	Reference Dosage (Inhalation)	-	-	-
RfDd	Reference Dosage (Dermal)	-	-	-
SFo	Slope Factor (Oral)	1.5	1.5	1.5
SFa	Slope Factor (Air)	15	15	15
SFd	Slope Factor (Dermal)	-	-	-

Arsenic (As)

Threshold calculation with no Dermal Slope Factor (SF_D) available

$$SSV(mg/kg) = \frac{TR \times BW \times AT}{EF \times ED \times \left[(SF_O \cdot 10^{-6} \times IR_S \times GI) + \left(SF_I \times IR_a \times \left(\frac{1}{PEF} \right) \right) \right]}$$

Informal Residential

$$SSV(mg/kg) = \frac{1 \cdot 10^{-5} \times 70 \times 25,550}{365 \times 70 \times \left[(1.5 \cdot 10^{-6} \times 200 \times 0.1) + \left(15 \times 20 \times \left(\frac{1}{7.25 \cdot 10^8} \right) \right) \right]} = 23$$

Standard Residential

$$SSV(mg/kg) = \frac{1 \cdot 10^{-5} \times 70 \times 25,550}{350 \times 70 \times \left[(1.5 \cdot 10^{-6} \times 100 \times 0.1) + \left(15 \times 20 \times \left(\frac{1}{1.3 \cdot 10^9} \right) \right) \right]} = 48$$

Commercial/Industrial

$$SSV(mg/kg) = \frac{1 \cdot 10^{-5} \times 70 \times 25,550}{250 \times 30 \times \left[(1.5 \cdot 10^{-6} \times 100 \times 0.1) + \left(15 \times 10.4 \times \left(\frac{1}{3.22 \cdot 10^8} \right) \right) \right]} = 150$$

CADMIUM

CADMIUM

Environmental Occurrence

Cadmium has a relatively low crustal abundance and is found in close association with zinc mineralization and has a strong affinity for sulphur.

Cadmium background concentrations in soils are generally very low, ranging from 0.6 to 2.7 mg/kg. Anthropogenic sources of cadmium are thus much more significant than natural occurrences. Trace quantities of cadmium from phosphate fertilizers or the use of sewage sludge on land are likely to give rise to detectable cadmium levels in soils.

Cadmium is not usually found in water at concentrations of greater than 1 µg/l.

Currently most cadmium is used in the production of nickel-cadmium batteries for industrial and commercial use. Cadmium is used as a semi-conductor and a photo-conductor in solar cells and other electronic devices. Cadmium has been used in steel coatings, pigments for plastics, glass and ceramics and has minor application in photography, photocopying, dyeing, and printing.

Adsorption of cadmium by soil strongly depends on pH, with mobility decreasing with increasing alkalinity.

Toxicity

Cadmium binds strongly to sulphhydryl groups and thus has a pronounced tendency to bioaccumulate in the food chain.

Long term exposure to cadmium is associated with toxicity to the kidney and bones arising via ingestion and inhalation. Rapid and irreversible uptake by the kidneys occurs. Cadmium also causes acute gastroenteritis. Lung carcinogenicity occurs in exposed workers following inhalation of cadmium fumes.

The effects of dermal exposure to cadmium are not expected to be significant.

Soil Screening Values

	All land uses Protective of the Water Resource	Informal Residential	Standard Residential	Commercial/ Industrial
Cadmium	7.5 mg/kg	15 mg/kg	32 mg/kg	260 mg/kg

Target Water Quality

	Drinking Water (DWAf, 1996)	Aquatic Water Quality (DWAf, 1996)
Cadmium	0.005 mg/l	0.00025 mg/l

Equation Sample

Table 3: Exposure Parameters Cd

Parameter		Informal Residential	Standard Residential	Commercial/ Industrial
THI	Target Hazard Index	1	1	1
TR	Target Risk	1E-05	1E-05	1E-05
BW	Body Weight (kg)	15	15	70
AT	Averaging Time (days)	2,190	2,190	10,950
EF	Exposure Frequency (days/yr)	365	350	250
ED	Exposure Duration (yrs)	6	6	30
IR _s	Ingestion Rate (Soil) (mg/day)	400	200	100
IR _a	Ingestion Rate (Air) (mg/day)	10	10	10.4
GI	GI Absorption Factor	1	1	1
PEF	Particulate Emission Factor (m ³ /kg)	7.25E+08	1.30E+09	3.22E+08
VF	Volatilisation Factor (m ³ /kg)	-	-	-
SA	Surface Area of Exposed Skin (cm ²)	4,200	2,100	13,110
AF	Skin Adherence Factor (mg/cm ² /day)	0.2	0.2	0.07
ABS	Dermal Absorption Factor	0.1	0.1	0.1

Table 4: Toxicological Data Cd

Parameter		Informal Residential	Standard Residential	Commercial/ Industrial
RfD _o	Reference Dosage (Oral)	0.0005	0.0005	0.0005
RfD _i	Reference Dosage (Inhalation)	-	-	-
RfD _d	Reference Dosage (Dermal)	0.0005	0.0005	0.0005
SF _o	Slope Factor (Oral)	-	-	-
SF _a	Slope Factor (Air)	-	-	-
SF _d	Slope Factor (Dermal)	-	-	-

Cadmium (Cd)

Threshold calculation with no inhalation RfD available.

$$SSV(mg/kg) = \frac{THI \times BW \times AT}{\left[EF \times ED \times \left(\left(\left(\frac{1}{RfD_o} \right) \times 10^{-6} \times IR_s \times GI \right) + \left(\left(\frac{1}{RfD_D} \right) \times SA \times AF \times ABS \times 10^{-6} \right) \right) \right]}$$

Informal Residential

$$SSV(mg/kg) = \frac{1 \times 15 \times 2,190}{\left[365 \times 6 \times \left(\left(\left(\frac{1}{0.0005} \right) \times 10^{-6} \times 400 \times 1 \right) + \left(\left(\frac{1}{0.0005} \right) \times 4200 \times 0.2 \times 0.1 \times 10^{-6} \right) \right) \right]} = 15$$

Standard Residential

$$SSV(mg/kg) = \frac{1 \times 15 \times 2,190}{\left[350 \times 6 \times \left(\left(\left(\frac{1}{0.0005} \right) \times 10^{-6} \times 200 \times 1 \right) + \left(\left(\frac{1}{0.0005} \right) \times 2100 \times 0.2 \times 0.1 \times 10^{-6} \right) \right) \right]} = 32$$

Commercial/Industrial

$$SSV(mg/kg) = \frac{1 \times 70 \times 10,950}{\left[250 \times 30 \times \left(\left(\left(\frac{1}{0.0005} \right) \times 10^{-6} \times 100 \times 1 \right) + \left(\left(\frac{1}{0.0005} \right) \times 13,110 \times 0.07 \times 0.1 \times 10^{-6} \right) \right) \right]} = 260$$

CHROMIUM

CHROMIUM

Environmental Occurrence

Chromium (Cr) is an element found naturally in rocks, soil, plants, and animals, including people. It occurs in combination with other elements such as chromium salts, some of which are soluble in water. The pure metallic form does not occur naturally. There are extensive deposits of chromium in the rocks of the Bushveld Complex in South Africa in the form of the mineral Chromite (FeCr_2O_4).

Chromium is used to make steel and other alloys, as well as for chrome plating, and as an additive to limit corrosion. Chromium salts have distinctive colours and have been used to make dyes and pigments for paints. Chromium is used to make refractory bricks for furnaces, tan leather, and also to preserve wood.

Chromium is abundant in nature. Its valency states range from -2 to +6, but in natural environments, it is generally found as trivalent chromium (Cr (III)). Trivalent chromium occurs naturally in many fresh vegetables, fruits, meat, grains, and yeast and is often added to vitamins as a dietary supplement. Hexavalent chromium is most often produced by industrial processes and may be an indicator of environmental contamination. This form exists in oxidizing conditions and is more leachable than Cr (III), and thus can move down through soil to underlying groundwater.

In general the pH and redox conditions in natural water bodies favour the reduction of Cr (VI) to the less toxic Cr (III).

The concentration of naturally occurring chromium in South African surface soils ranges from 5.8 to 353 mg/kg, but may be considerably higher in mineralized areas and even exceed 2,000 mg/kg.

Hexavalent chromium concentrations in air are generally low because it can react with dust and other air pollutants to form trivalent chromium and can be removed by atmospheric fallout and precipitation. In air, the concentrations generally range between 0.01 and 0.03 $\mu\text{g}/\text{m}^3$. In drinking water, levels are generally less than 2 $\mu\text{g}/\text{l}$.

Toxicity

Hexavalent chromium can be toxic. When inhaled, it can damage the lining of the nose and throat and irritate the lungs. Based on studies of workers in chromium processing factories, hexavalent chromium is classified as a known human carcinogen due to chronic inhalation exposures and the occurrence of lung cancer. When swallowed, it can upset the gastrointestinal tract and damage the liver and kidneys, and is possibly carcinogenic; however evidence suggests that hexavalent chromium is rapidly converted to the trivalent form after entering the stomach.

Cr (II) and Cr (III) have much lower toxicities than Cr (VI) and are threshold contaminants.

Soil Screening Values

	All land uses Protective of the Water Resource	Informal Residential	Standard Residential	Commercial/ Industrial
Cr (III)	46,000 mg/kg	46,000 mg/kg	96,000 mg/kg	790,000 mg/kg
Cr (VI)	6.5 mg/kg	6.5 mg/kg	13 mg/kg	40 mg/kg

Target Water Quality

	Drinking Water (DWAF, 1996)	Aquatic Water Quality (DWAF, 1996)
Cr (III)	0.05 mg/l	0.012 mg/l
Cr (VI)	0.05 mg/l	0.007 mg/l

Equation Samples - Soil Screening Value Chromium

Table 5: Exposure Parameters Cr (III)

Parameter		Informal Residential	Standard Residential	Commercial/ Industrial
THI	Target Hazard Index	1	1	1
TR	Target Risk	1E-05	1E-05	1E-05
BW	Body Weight (kg)	15	15	70
AT	Averaging Time (days)	2,190	2,190	10,950
EF	Exposure Frequency (days/yr)	365	350	250
ED	Exposure Duration (yrs)	6	6	30
IR _s	Ingestion Rate (Soil) (mg/day)	400	200	100
IR _a	Ingestion Rate (Air) (mg/day)	10	10	10.4
GI	GI Absorption Factor	1	1	1
PEF	Particulate Emission Factor (m ³ /kg)	7.25E+08	1.30E+09	3.22E+08
VF	Volatilisation Factor (m ³ /kg)	-	-	-
SA	Surface Area of Exposed Skin (cm ²)	4,200	2,100	13,110
AF	Skin Adherence Factor (mg/cm ² /day)	0.2	0.2	0.07
ABS	Dermal Absorption Factor	0.1	0.1	0.1

Table 6: Toxicological Data Cr (III)

Parameter		Informal Residential	Standard Residential	Commercial/ Industrial
RfD _o	Reference Dosage (Oral)	1.5	1.5	1.5
RfD _i	Reference Dosage (Inhalation)	-	-	-
RfD _d	Reference Dosage (Dermal)	1.5	1.5	1.5
SF _o	Slope Factor (Oral)	-	-	-
SF _a	Slope Factor (Air)	-	-	-
SF _d	Slope Factor (Dermal)	-	-	-

Chromium

Threshold calculation with no inhalation RfD available.

$$SSV(mg / kg) = \frac{THI \times BW \times AT}{\left[EF \times ED \times \left(\left(\left(\frac{1}{RfD_o} \right) \times 10^{-6} \times IR_S \times GI \right) + \left(\left(\frac{1}{RfD_d} \right) \times SA \times AF \times ABS \times 10^{-6} \right) \right) \right]}$$

Informal Residential

$$SSV(mg / kg) = \frac{1 \times 15 \times 2,190}{\left[365 \times 6 \times \left(\left(\left(\frac{1}{1.5} \right) \times 10^{-6} \times 400 \times 1 \right) + \left(\left(\frac{1}{1.5} \right) \times 4200 \times 0.2 \times 0.1 \times 10^{-6} \right) \right) \right]} = 46,000$$

Standard Residential

$$SSV(mg / kg) = \frac{1 \times 15 \times 2,190}{\left[350 \times 6 \times \left(\left(\left(\frac{1}{1.5} \right) \times 10^{-6} \times 200 \times 1 \right) + \left(\left(\frac{1}{1.5} \right) \times 2100 \times 0.2 \times 0.1 \times 10^{-6} \right) \right) \right]} = 96,000$$

Commercial/Industrial

$$SSV(mg / kg) = \frac{1 \times 70 \times 10,950}{\left[250 \times 30 \times \left(\left(\left(\frac{1}{1.5} \right) \times 10^{-6} \times 100 \times 1 \right) + \left(\left(\frac{1}{1.5} \right) \times 13,110 \times 0.07 \times 0.1 \times 10^{-6} \right) \right) \right]} = 790,000$$

Soil Screening Values Chrome (VI)

Table 7: Exposure Parameters Cr (VI)

Parameter		Informal Residential	Standard Residential	Commercial/ Industrial
THI	Target Hazard Index	1	1	1
TR	Target Risk	1E-05	1E-05	1E-05
BW	Body Weight (kg)	70	70	70
AT	Averaging Time (days)	25,550	25,550	25,550
EF	Exposure Frequency (days/yr)	365	350	250
ED	Exposure Duration (yrs)	70	70	30
IR _s	Ingestion Rate (Soil) (mg/day)	200	100	100
IR _a	Ingestion Rate (Air) (mg/day)	20	20	10.4
GI	GI Absorption Factor	1	1	1
PEF	Particulate Emission Factor (m ³ /kg)	7.25E+08	1.30E+09	3.22E+08
VF	Volatilisation Factor (m ³ /kg)	-	-	-
SA	Surface Area of Exposed Skin (cm ²)	11,600	5,800	13,110
AF	Skin Adherence Factor (mg/cm ² /day)	0.07	0.07	0.07
ABS	Dermal Absorption Factor	0.1	0.1	0.1

Table 8: Toxicological Data Cr (VI)

Parameter		Informal Residential	Standard Residential	Commercial/ Industrial
RfD _o	Reference Dosage (Oral)	-	-	-
RfD _i	Reference Dosage (Inhalation)	-	-	-
RfD _d	Reference Dosage (Dermal)	-	-	-
SFo	Slope Factor (Oral)	0.5	0.5	0.5
SF _a	Slope Factor (Air)	290	290	290
SF _d	Slope Factor (Dermal)	-	-	-

Chrome (VI)

Threshold calculation with no Dermal Slope Factor (SF_D) available

$$SSV(mg/kg) = \frac{TR \times BW \times AT}{EF \times ED \times \left[(SF_O \cdot 10^{-6} \times IR_S \times GI) + \left(SF_i \times IR_a \times \left(\frac{1}{PEF} \right) \right) \right]}$$

Informal Residential

$$SSV(mg/kg) = \frac{1 \cdot 10^{-5} \times 70 \times 25,550}{365 \times 70 \times \left[(0.5 \cdot 10^{-6} \times 200 \times 0.1) + \left(290 \times 20 \times \left(\frac{1}{7.25 \cdot 10^8} \right) \right) \right]} = 6.5$$

Standard Residential

$$SSV(mg/kg) = \frac{1 \cdot 10^{-5} \times 70 \times 25,550}{350 \times 70 \times \left[(0.5 \cdot 10^{-6} \times 100 \times 0.1) + \left(290 \times 20 \times \left(\frac{1}{1.3 \cdot 10^9} \right) \right) \right]} = 13$$

Commercial/Industrial

$$SSV(mg/kg) = \frac{1 \cdot 10^{-5} \times 70 \times 25,550}{250 \times 30 \times \left[(0.5 \cdot 10^{-6} \times 100 \times 0.1) + \left(290 \times 10.4 \times \left(\frac{1}{3.22 \cdot 10^8} \right) \right) \right]} = 40$$

CHROMIUM

COBALT

Environmental Occurrence

Cobalt has a relatively low crustal abundance and is found in close association with iron and nickel.

Cobalt background concentrations in surface soils are generally very low with concentrations ranging from 1.5 to 68 mg/kg. Anthropogenic sources of cobalt are from the burning of fossil fuels, with trace quantities from phosphate fertilizers or the use of sewage sludge on land.

Cobalt is used in the manufacture of super-alloys in gas turbine aircraft engines and as pigments used in the manufacture of glass, ceramics and paints.

Radioactive cobalt ⁶⁰Co is used in radiation therapy for treating cancer patients and irradiating food.

Toxicity

Inhalation exposure to cobalt is associated with diminished pulmonary function, asthma and interstitial lung disease. Respiratory tract effects are noted from workers exposed to the cobalt ion and free radicals associated with hard metal, a tungsten carbide – cobalt mix. Long term exposure to cobalt is associated with toxicity to the thyroid gland, cardiomyopathy and to allergic dermatitis.

Adequate chronic studies are not presently available for cobalt.

Soil Screening Values

	All land uses Protective of the Water Resource	Informal Residential	Standard Residential	Commercial/ Industrial
Cobalt	300 mg/kg	300 mg/kg	630 mg/kg	5,000 mg/kg

Target Water Quality

	Drinking Water	Aquatic Water Quality (BC Aquatic, 2006)
Cobalt	-	0.11 mg/l

Equation Sample

Table 9: Exposure Parameters Co

Parameter		Informal Residential	Standard Residential	Commercial/ Industrial
THI	Target Hazard Index	1	1	1
TR	Target Risk	1E-05	1E-05	1E-05
BW	Body Weight (kg)	15	15	70
AT	Averaging Time (days)	2,190	2,190	10,950
EF	Exposure Frequency (days/yr)	365	350	250
ED	Exposure Duration (yrs)	6	6	30
IRs	Ingestion Rate (Soil) (mg/day)	400	200	100
IRa	Ingestion Rate (Air) (mg/day)	10	10	10.4
GI	GI Absorption Factor	1	1	1
PEF	Particulate Emission Factor (m3/kg)	7.25E+08	1.30E+09	3.22E+08
VF	Volatilisation Factor (m3/kg)	-	-	-
SA	Surface Area of Exposed Skin (cm2)	4,200	2,100	13,110
AF	Skin Adherence Factor (mg/cm2/day)	0.2	0.2	0.07
ABS	Dermal Absorption Factor	0.1	0.1	0.1

Table 10: Toxicological Data Co

Parameter		Informal Residential	Standard Residential	Commercial/ Industrial
RfDo	Reference Dosage (Oral)	0.01	0.01	0.01
RfDi	Reference Dosage (Inhalation)	2.85E-05	2.85E-05	2.85E-05
RfDd	Reference Dosage (Dermal)	0.01	0.01	0.01
SFo	Slope Factor (Oral)	-	-	-
SFa	Slope Factor (Air)	-	-	-
SFd	Slope Factor (Dermal)	-	-	-

Cobalt (Co)

$$SSV(mg / kg) = \frac{THI \times BW \times AT}{\left[EF \times ED \times \left(\left(\left(\frac{1}{RfD_o} \right) \times 10^{-6} \times IR_S \times GI \right) + \left(\frac{1}{RfD_i} \times IR_a \times \left(\frac{1}{PEF} \right) \right) + \left(\left(\frac{1}{RfD_d} \right) \times SA \times AF \times ABS \times 10^{-6} \right) \right) \right]}$$

Informal Residential

$$SSV(mg / kg) = \frac{1 \times 15 \times 2190}{\left[365 \times 6 \times \left(\left(\left(\frac{1}{0.01} \right) \times 10^{-6} \times 400 \times 1 \right) + \left(\frac{1}{2.86 \cdot 10^{-5}} \times 10 \times \left(\frac{1}{7.25 \cdot 10^8} \right) \right) + \left(\left(\frac{1}{0.01} \right) \times 4200 \times 0.2 \times 0.1 \times 10^{-6} \right) \right) \right]} = 300$$

Standard Residential

$$SSV(mg / kg) = \frac{1 \times 15 \times 2190}{\left[350 \times 6 \times \left(\left(\left(\frac{1}{0.01} \right) \times 10^{-6} \times 200 \times 1 \right) + \left(\frac{1}{2.86 \cdot 10^{-5}} \times 10 \times \left(\frac{1}{1.3 \cdot 10^9} \right) \right) + \left(\left(\frac{1}{0.01} \right) \times 2100 \times 0.2 \times 0.1 \times 10^{-6} \right) \right) \right]} = 630$$

Commercial/Industrial

$$SSV(mg / kg) = \frac{1 \times 70 \times 10,950}{\left[250 \times 30 \times \left(\left(\left(\frac{1}{0.01} \right) \times 10^{-6} \times 100 \times 1 \right) + \left(\frac{1}{2.86 \cdot 10^{-5}} \times 10.4 \times \left(\frac{1}{3.22 \cdot 10^8} \right) \right) + \left(\left(\frac{1}{0.01} \right) \times 13,110 \times 0.07 \times 0.1 \times 10^{-6} \right) \right) \right]} = 5,000$$

COPPER

COPPER

Environmental Occurrence

Copper is an essential trace element to plants, animals and humans.

Copper occurs as native metal, but more commonly as insoluble sulphides, carbonates and hydroxides and soluble sulphates, nitrates and chlorides.

Copper levels in surface soils range from 3 to 117 mg/kg. The daily intake of copper in the diet in food and water is about 1 mg/kg.

Copper is used extensively in the electrical industry due to its excellent conducting property. It is also used in the production of metal alloys and in the production of paints and pigments.

Environmental sources of copper relate to smelters and refiners with the exposure route being via inhalation of dust.

A significant amount of copper in domestic water arises from dissolution of copper from plumbing systems.

Toxicity

Ingestion of high concentrations of copper results in gastrointestinal disturbances and possible liver, kidney, red blood cell damage. Copper in water has a strongly astringent taste and ingestion of high levels of dissolved copper in water is unlikely to occur as vomiting rids the body of the excess dose.

Copper is an irritant of the respiratory tract and high levels of dust exposure may result in coughing and nausea.

Copper is an important ecological toxin particularly with respect to aquatic flora and fish.

Soil Screening Values

	All land uses Protective of the Water Resource	Informal Residential	Standard Residential	Commercial/ Industrial
Copper	16 mg/kg	1,100 mg/kg	2,300 mg/kg	19,000 mg/kg

Target Water Quality

	Drinking Water (DWAF, 1996)	Aquatic Water Quality (DWAF, 1996)
Copper	1.0 mg/l	0.0008 mg/l

Equation Sample

Table 11: Exposure Parameters Cu

	Parameter	Informal Residential	Standard Residential	Commercial/ Industrial
THI	Target Hazard Index	1	1	1
TR	Target Risk	1E-05	1E-05	1E-05
BW	Body Weight (kg)	15	15	70
AT	Averaging Time (days)	2,190	2,190	10,950
EF	Exposure Frequency (days/yr)	365	350	250
ED	Exposure Duration (yrs)	6	6	30
IR _s	Ingestion Rate (Soil) (mg/day)	400	200	100

Parameter		Informal Residential	Standard Residential	Commercial/ Industrial
IR _a	Ingestion Rate (Air) (mg/day)	10	10	10.4
GI	GI Absorption Factor	1	1	1
PEF	Particulate Emission Factor (m ³ /kg)	7.25E+08	1.30E+09	3.22E+08
VF	Volatilisation Factor (m ³ /kg)	-	-	-
SA	Surface Area of Exposed Skin (cm ²)	4,200	2,100	13,110
AF	Skin Adherence Factor (mg/cm ² /day)	0.2	0.2	0.07
ABS	Dermal Absorption Factor	0.1	0.1	0.1

Table 12: Toxicological Data Cu

Parameter		Informal Residential	Standard Residential	Commercial/ Industrial
RfD _o	Reference Dosage (Oral)	0.037	0.037	0.037
RfD _i	Reference Dosage (Inhalation)	-	-	-
RfD _d	Reference Dosage (Dermal)	0.037	0.037	0.037
SF _o	Slope Factor (Oral)	-	-	-
SF _a	Slope Factor (Air)	-	-	-
SF _d	Slope Factor (Dermal)	-	-	-

Copper (Cu)

Threshold calculation with no inhalation RfD available.

$$SSV(mg/kg) = \frac{THI \times BW \times AT}{\left[EF \times ED \times \left(\left(\left(\frac{1}{RfD_o} \right) \times 10^{-6} \times IR_S \times GI \right) + \left(\left(\frac{1}{RfD_d} \right) \times SA \times AF \times ABS \times 10^{-6} \right) \right) \right]}$$

Informal Residential

$$SSV(mg/kg) = \frac{1 \times 15 \times 2,190}{\left[365 \times 6 \times \left(\left(\left(\frac{1}{0.037} \right) \times 10^{-6} \times 400 \times 1 \right) + \left(\left(\frac{1}{0.037} \right) \times 4200 \times 0.2 \times 0.1 \times 10^{-6} \right) \right) \right]} = 1100$$

Standard Residential

$$SSV(mg/kg) = \frac{1 \times 15 \times 2,190}{\left[350 \times 6 \times \left(\left(\left(\frac{1}{0.037} \right) \times 10^{-6} \times 200 \times 1 \right) + \left(\left(\frac{1}{0.037} \right) \times 2100 \times 0.2 \times 0.1 \times 10^{-6} \right) \right) \right]} = 2,300$$

Commercial/Industrial

$$SSV(mg/kg) = \frac{1 \times 70 \times 10,950}{\left[250 \times 30 \times \left(\left(\left(\frac{1}{0.037} \right) \times 10^{-6} \times 100 \times 1 \right) + \left(\left(\frac{1}{0.037} \right) \times 13,110 \times 0.07 \times 0.1 \times 10^{-6} \right) \right) \right]} = 19,000$$

LEAD

LEAD

Environmental Occurrence

Lead is a heavy, low melting, bluish-grey metal that occurs naturally in the Earth's crust. However, it is rarely found naturally as a metal.

Metallic lead is resistant to corrosion. When exposed to air or water, thin films of lead compounds are formed that protect the metal from further attack. Lead is easily molded and shaped. Lead can be combined with other metals to form alloys. Lead and lead alloys are commonly found in pipes, storage batteries, weights, shot and ammunition, and cable covers. The largest use for lead is in storage batteries in cars and other vehicles.

Lead compounds are used as a pigment in paints, dyes, and ceramic glazes and in caulk. The amount of lead used in these products has been reduced in recent years to minimize lead's harmful effect on people and animals. Tetraethyl lead and Tetramethyl lead were used in South Africa as petrol additives to increase octane rating. However, their use is being phased out in South Africa. Tetraethyl lead may still be used in fuels for off-road vehicles and airplanes. Lead used in ammunition, which is the largest non-battery end-use, has remained fairly constant in recent years. However, even the use of lead in bullets and shot, as well as in fishing sinkers is being reduced because of its harm to the environment.

Lead background concentrations in surface soils range from 3.0 to 65.8 mg/kg. Lead is present in surface waters at concentrations of less than 0.01 mg/l. Dissolution of lead from lead pipes occurs with acidic soft waters.

Most of the lead released into the environment comes from vehicle exhaust emissions and there have been substantial increases in lead levels in air, soil and water between 1950 and 2000 and higher levels of lead in soil are found near roadways. Most of the lead in inner city soils comes from old houses with paint containing lead and previous automotive exhaust emitted when gasoline contained lead.

Toxicity

Exposure to lead, particularly young children should be minimized. At relatively low concentrations with continuous exposure, lead can cause neurological impairment in young children and fetuses.

In general, if adults and children swallow the same amount of lead, a bigger proportion of the amount swallowed will enter the blood in children than in adults. Children absorb about 50% of ingested lead.

The effects of lead are the same whether it enters the body through breathing or swallowing. The main target for lead toxicity is the nervous system, both in adults and children. Long-term exposure of adults to lead at work has resulted in decreased performance in functions of the nervous system. Lead exposure may also cause weakness in fingers, wrists, or ankles. Lead exposure can also cause slight increases in blood pressure, particularly in middle-aged and older people. Lead exposure may also cause anaemia. At high levels of exposure, lead can severely damage the brain and kidneys in adults or children and ultimately cause death. In pregnant women, high levels of exposure to lead may cause a miscarriage. High-level exposure in men can damage the organs responsible for sperm production.

There is no conclusive proof that lead causes cancer in humans. Kidney tumors have developed in rats and mice that had been given large doses of lead compounds.

Soil Screening Values

	All land uses Protective of the Water Resource	Informal Residential	Standard Residential	Commercial/ Industrial
Pb	20 mg/kg	110 mg/kg	230 mg/kg	1,900 mg/kg

Target Water Quality

	Drinking Water (DWAF, 1996)	Aquatic Water Quality (DWAF, 1996)

Pb	0.01 mg/kg	0.0005 mg/l

Equation Sample

Table 13: Exposure Parameters Pb

Parameter		Informal Residential	Standard Residential	Commercial/ Industrial
THI	Target Hazard Index	1	1	1
TR	Target Risk	1E-05	1E-05	1E-05
BW	Body Weight (kg)	15	15	70
AT	Averaging Time (days)	2,190	2,190	10,950
EF	Exposure Frequency (days/yr)	365	350	250
ED	Exposure Duration (yrs)	6	6	30
IRs	Ingestion Rate (Soil) (mg/day)	400	200	100
IRa	Ingestion Rate (Air) (mg/day)	10	10	10.4
GI	GI Absorption Factor	1	1	1
PEF	Particulate Emission Factor (m3/kg)	7.25E+08	1.30E+09	3.22E+08
VF	Volatilisation Factor (m3/kg)	-	-	-
SA	Surface Area of Exposed Skin (cm ²)	4,200	2,100	13,110
AF	Skin Adherence Factor (mg/ cm ² /day)	0.2	0.2	0.07
ABS	Dermal Absorption Factor	0.1	0.1	0.1

Table 14: Toxicological Data Pb

Parameter		Informal Residential	Standard Residential	Commercial/ Industrial
RfDo	Reference Dosage (Oral)	0.0036	0.0036	0.0036
RfDi	Reference Dosage (Inhalation)	-	-	-
RfDd	Reference Dosage (Dermal)	0.0036	0.0036	0.0036
SFo	Slope Factor (Oral)	-	-	-
SFa	Slope Factor (Air)	-	-	-
SFd	Slope Factor (Dermal)	-	-	-

Lead (Pb)

Threshold calculation with no inhalation RfD available.

$$SSV(mg/kg) = \frac{THI \times BW \times AT}{\left[EF \times ED \times \left(\left(\left(\frac{1}{RfD_o} \right) \times 10^{-6} \times IR_S \times GI \right) + \left(\left(\frac{1}{RfD_d} \right) \times SA \times AF \times ABS \times 10^{-6} \right) \right) \right]}$$

Informal Residential

$$SSV(mg/kg) = \frac{1 \times 15 \times 2,190}{\left[365 \times 6 \times \left(\left(\left(\frac{1}{0.0036} \right) \times 10^{-6} \times 400 \times 1 \right) + \left(\left(\frac{1}{0.0036} \right) \times 4200 \times 0.2 \times 0.1 \times 10^{-6} \right) \right) \right]} = 110$$

Standard Residential

$$SSV(mg/kg) = \frac{1 \times 15 \times 2,190}{\left[350 \times 6 \times \left(\left(\left(\frac{1}{0.0036} \right) \times 10^{-6} \times 200 \times 1 \right) + \left(\left(\frac{1}{0.0036} \right) \times 2100 \times 0.2 \times 0.1 \times 10^{-6} \right) \right) \right]} = 230$$

Commercial/Industrial

$$SSV(mg/kg) = \frac{1 \times 70 \times 10,950}{\left[250 \times 30 \times \left(\left(\left(\frac{1}{0.0036} \right) \times 10^{-6} \times 100 \times 1 \right) + \left(\left(\frac{1}{0.0036} \right) \times 13,110 \times 0.07 \times 0.1 \times 10^{-6} \right) \right) \right]} = 1,900$$

MANGANESE

MANGANESE

Environmental Occurrence

Manganese (Mn) is a naturally occurring globally abundant element that constitutes approximately 0.1% of the earth's crust. In South Africa there is an extensive manganese mining and processing industry.

Manganese is found in rock, soil, water, and food and is an essential element for humans and animals. Thus, all humans are exposed to manganese, and it is a normal component of the human body. Food is usually the most important route of exposure for humans. Estimated Safe and Adequate Daily Intakes of 1 - 5 mg manganese have been established for children one year of age and older, through to adults. These levels generally parallel amounts of the compound delivered via the diet. Above average exposures to manganese are most likely to occur in people who work at, or live near a factory or other site where significant amounts of manganese dust are released into the air.

At concentrations usually encountered in water manganese has aesthetic rather than toxic effects.

Manganese concentrations in freshwater range from 0.02 to 130 µg/l. Soil background concentrations can reach 1,000 mg/kg.

Manganese is used in the manufacture of steel and manganese alloys. Salts of manganese are used as drying compounds in varnishes and oils. Manganese chloride is used to manufacture dry cell batteries. Manganese is also used as a pigment and in the making of glass and porcelain.

Toxicity

In chronic inhalation exposure to manganese, the main organ systems affected are the lungs, nervous system, and reproductive system, although effects on other organ systems have also been observed. A recurring manganic pneumonia and acute respiratory effects have been associated with chronic inhalation exposures to manganese. Effects on the nervous system include neurological and neuropsychiatric symptoms that can culminate in a Parkinsonism-like disease known as manganism.

Limited evidence also suggests that adverse neurological effects can be associated with ingestion of excess manganese in environmental settings. As a result of predisposing factors, certain individuals might be more susceptible to adverse effects from exposure to excess manganese. These might include people with lung disease.

The dermal route does not appear to be of significant concern and has not been investigated to any extent.

Adverse aesthetic effects limit the acceptability of manganese containing water for domestic use at concentrations exceeding 0.15 mg/l.

Soil Screening Values

	All land uses Protective of the Water Resource	Informal Residential	Standard Residential	Commercial/ Industrial
Mn	740 mg/kg	740 mg/kg	1,500 mg/kg	12,000 mg/kg

Target Water Quality

	Drinking Water (DWAF, 1996)	Aquatic Water Quality (DWAF, 1996)
Mn	5 mg/l	0.18 mg/l

Equation Sample

Table 15: Exposure Parameters Mn

Parameter		Informal Residential	Standard Residential	Commercial/ Industrial
THI	Target Hazard Index	1	1	1
TR	Target Risk	1E-05	1E-05	1E-05
BW	Body Weight (kg)	15	15	70
AT	Averaging Time (days)	2,190	2,190	10,950
EF	Exposure Frequency (days/yr)	365	350	250
ED	Exposure Duration (yrs)	6	6	30
IRs	Ingestion Rate (Soil) (mg/day)	400	200	100
IRa	Ingestion Rate (Air) (mg/day)	10	10	10.4
GI	GI Absorption Factor	1	1	1
PEF	Particulate Emission Factor (m3/kg)	7.25E+08	1.30E+09	3.22E+08
VF	Volatilisation Factor (m3/kg)	-	-	-
SA	Surface Area of Exposed Skin (cm ²)	4,200	2,100	13,110
AF	Skin Adherence Factor (mg/ cm ² /day)	0.2	0.2	0.07
ABS	Dermal Absorption Factor	0.1	0.1	0.1

Table 16: Toxicological Data Mn

Parameter		Informal Residential	Standard Residential	Commercial/ Industrial
RfDo	Reference Dosage (Oral)	0.024	0.024	0.024
RfDi	Reference Dosage (Inhalation)	1.43E-03	1.43E-03	1.43E-03
RfDd	Reference Dosage (Dermal)	0.024	0.024	0.024
SFo	Slope Factor (Oral)	-	-	-
SFa	Slope Factor (Air)	-	-	-
SFd	Slope Factor (Dermal)	-	-	-

Manganese (Mn)

$$SSV(mg / kg) = \frac{THI \times BW \times AT}{\left[EF \times ED \times \left(\left(\left(\frac{1}{RfD_o} \right) \times 10^{-6} \times IR_s \times GI \right) + \left(\frac{1}{RfD_i} \times IR_a \times \left(\frac{1}{PEF} \right) \right) + \left(\left(\frac{1}{RfD_d} \right) \times SA \times AF \times ABS \times 10^{-6} \right) \right) \right]}$$

Informal Residential

$$SSV(mg / kg) = \frac{1 \times 15 \times 2190}{\left[365 \times 6 \times \left(\left(\left(\frac{1}{0.024} \right) \times 10^{-6} \times 400 \times 1 \right) + \left(\frac{1}{1.43 \cdot 10^{-3}} \times 10 \times \left(\frac{1}{7.25 \cdot 10^8} \right) \right) + \left(\left(\frac{1}{0.024} \right) \times 4200 \times 0.2 \times 0.1 \times 10^{-6} \right) \right) \right]} = 740$$

Standard Residential

$$SSV(mg / kg) = \frac{1 \times 15 \times 2190}{\left[350 \times 6 \times \left(\left(\left(\frac{1}{0.024} \right) \times 10^{-6} \times 200 \times 1 \right) + \left(\frac{1}{1.43 \cdot 10^{-3}} \times 10 \times \left(\frac{1}{1.3 \cdot 10^9} \right) \right) + \left(\left(\frac{1}{0.024} \right) \times 2100 \times 0.2 \times 0.1 \times 10^{-6} \right) \right) \right]} = 1500$$

Commercial/Industrial

$$SSV(mg / kg) = \frac{1 \times 70 \times 10,950}{\left[250 \times 30 \times \left(\left(\left(\frac{1}{0.024} \right) \times 10^{-6} \times 100 \times 1 \right) + \left(\frac{1}{1.43 \cdot 10^{-3}} \times 10.4 \times \left(\frac{1}{3.22 \cdot 10^8} \right) \right) + \left(\left(\frac{1}{0.024} \right) \times 13,110 \times 0.07 \times 0.1 \times 10^{-6} \right) \right) \right]} = 12,000$$

MERCURY

MERCURY

Environmental Occurrence

Mercury (Hg) occurs naturally in the environment and can be found in metallic, inorganic, and organic forms. The most common natural forms of mercury found in the environment are metallic mercury, mercuric sulphide (cinnabar ore), mercuric chloride, and methylmercury. Mercury and its compounds have a long history of human use for industrial, medicinal, cosmetic, and spiritual purposes. Modern uses for mercury include electrical switches, thermometers, dental amalgams, lighting (mercury vapor and fluorescent lamps), flow meters, batteries, fungicides, electrochemistry, catalysis, explosives, gold recovery, and bactericides.

Mercury is the only metal that is liquid at room temperature (20°C). The element is easily separated from its parent minerals through the application of heat, which enhances its ability to be recovered in a pure state. Mercury has the highest solubility in water of any metal and easily vaporizes into the air; these two properties make it very mobile in the environment. Mercury vapour can be carried over great distances in the atmosphere and be deposited into lakes and streams. Some microorganisms (bacteria and fungi) and natural processes can change the mercury in the environment from one form to another, usually under anaerobic (oxygen-deficient) conditions. The most common organic mercury compound that these microorganisms and natural processes generate from other forms is methylmercury.

The understanding that bioaccumulation of mercury in the food chain can harm populations of animals and humans have been the main impetus for greater regulatory control of mercury. In the past, management and regulatory responses to the problem of bioaccumulation generally has been constrained by a lack of information on sources, methods of transport, chemical interaction, and biological significance of mercury in the environment.

Toxicity

Mercury is a potent neurotoxin capable of impairing neurological development in fetuses and young children and damaging the central nervous system of adults. People are most likely to be exposed to harmful quantities of mercury through consumption of fish contaminated with methylmercury. Exposure to elemental mercury vapour in indoor air also can cause serious harm. Exposure to inorganic mercury also can occur from drinking contaminated water and touching contaminated water and soil, although harmful exposures are much less likely through these routes. Mercury poisoning via the ingestion route is likely to take the form of kidney disturbances.

Since mercury accumulates in the body, a single exposure to a high concentration of mercury can have serious health effects.

Elemental mercury is more volatile than inorganic mercury compounds and is most toxic via the vapour inhalation route. For inorganic and methylmercury, the ingestion of soil and indoor dust is the most significant exposure pathway.

Further assessment in the form of soil vapour monitoring is recommended, should soil screening values be exceeded.

Soil Screening Values

	All land uses Protective of the Water Resource	Informal Residential	Standard Residential	Commercial/ Industrial
Mercury	0.93 mg/kg	0.93 mg/kg	1.0 mg/kg	6.5 mg/kg

Target Water Quality

	Drinking Water (DWAF, 1996)	Aquatic Water Quality (DWAF, 1996)
Mercury	0.001 mg/l	0.00004 mg/l

Equation Sample

Table 17: Exposure Parameters Hg

Parameter		Informal Residential	Standard Residential	Commercial/ Industrial
THI	Target Hazard Index	1	1	1
TR	Target Risk	1E-05	1E-05	1E-05
BW	Body Weight (kg)	15	15	70
AT	Averaging Time (days)	2,190	2,190	10,950
EF	Exposure Frequency (days/yr)	365	350	250
ED	Exposure Duration (yrs)	6	6	30
IRs	Ingestion Rate (Soil) (mg/day)	400	200	100
IRa	Ingestion Rate (Air) (mg/day)	10	10	10.4
GI	GI Absorption Factor	1	1	1
PEF	Particulate Emission Factor (m3/kg)	7.25E+08	1.30E+09	3.22E+08
VF	Volatilisation Factor (m3/kg)	8028.297	8028.297	8028.297
SA	Surface Area of Exposed Skin (cm ²)	4,200	2,100	13,110
AF	Skin Adherence Factor (mg/ cm ² /day)	0.2	0.2	0.07
ABS	Dermal Absorption Factor	0.1	0.1	0.1

Table 18: Toxicological Data Hg

Parameter		Informal Residential	Standard Residential	Commercial/ Industrial
RfDo	Reference Dosage (Oral)	0.003	0.003	0.003
RfDi	Reference Dosage (Inhalation)	0.000086	0.000086	0.000086
RfDd	Reference Dosage (Dermal)	0.003	0.003	0.003
SFo	Slope Factor (Oral)	-	-	-
SFa	Slope Factor (Air)	-	-	-
SFd	Slope Factor (Dermal)	-	-	-

Mercury (Hg)

$$SSV(mg / kg) = \frac{THI \times BW \times AT}{\left[EF \times ED \times \left(\left(\frac{1}{RfD_o} \right) \times 10^{-6} \times IR_S \times GI \right) + \left(\frac{1}{RfD_i} \times IR_a \times \left(\frac{1}{PEF} + \frac{1}{VF} \right) \right) + \left(\left(\frac{1}{RfD_d} \right) \times SA \times AF \times ABS \times 10^{-6} \right) \right]}$$

Informal Residential

$$SSV(mg / kg) = \frac{1 \times 15 \times 2190}{\left[365 \times 6 \times \left(\left(\left(\frac{1}{0.0003} \right) \times 10^{-6} \times 400 \times 1 \right) + \left(\frac{1}{8.6 \cdot 10^{-5}} \times 10 \times \left(\frac{1}{7.25 \cdot 10^8} + \frac{1}{8028.297} \right) \right) + \left(\left(\frac{1}{0.0003} \right) \times 4200 \times 0.2 \times 0.1 \times 10^{-6} \right) \right] \right]} = 0.93$$

Standard Residential

$$SSV(mg / kg) = \frac{1 \times 15 \times 2190}{\left[350 \times 6 \times \left(\left(\left(\frac{1}{0.0003} \right) \times 10^{-6} \times 200 \times 1 \right) + \left(\frac{1}{8.6 \cdot 10^{-5}} \times 10 \times \left(\frac{1}{1.3 \cdot 10^9} + \frac{1}{8028.297} \right) \right) + \left(\left(\frac{1}{0.0003} \right) \times 2100 \times 0.2 \times 0.1 \times 10^{-6} \right) \right] \right]} = 1.0$$

Commercial/Industrial

$$SSV(mg / kg) = \frac{1 \times 70 \times 10,950}{\left[250 \times 30 \times \left(\left(\left(\frac{1}{0.0003} \right) \times 10^{-6} \times 100 \times 1 \right) + \left(\frac{1}{8.6 \cdot 10^{-5}} \times 10.4 \times \left(\frac{1}{3.22 \cdot 10^8} + \frac{1}{8028.297} \right) \right) + \left(\left(\frac{1}{0.0003} \right) \times 13,110 \times 0.07 \times 0.1 \times 10^{-6} \right) \right] \right]} = 6.5$$

NICKEL

NICKEL

Environmental Occurrence

Nickel occurs naturally in the environment, but rarely in its elemental form. Nickel has a strong affinity for iron and sulphur and is associated with sulphide mineralization of basic igneous rocks. Nickel is associated with copper, chromium and cobalt in rocks from the platinum mining areas of the Bushveld Complex.

In addition to mining and smelting sources of nickel, anthropogenic activity has resulted in widespread distribution of nickel from the burning of oil and coal.

Nickel concentrations in surface soils range from 3.4 to 159 mg/kg and can be higher in mineralized areas.

The primary use of nickel metal is in the production alloys including stainless steel and in nickel plating. Nickel is commonly used in the manufacture of batteries and welding electrodes. Nickel chemicals are used in the manufacture of pigments.

Toxicity

Nickel is a potent skin sensitizer. Ingestion of nickel can cause skin reactions in previously sensitized individuals.

Soluble nickel salts and the mixture of nickel sulphides and oxides present in refinery dust are carcinogenic to lung and nasal tissues. Other toxic effects of nickel associated with inhalation exposure include chronic bronchitis, emphysema, reduced vital capacity and asthma.

Background exposure is a significant contributor to total exposure for all land uses. Soil ingestion makes the greatest contribution to total exposure.

The critical effects of ingested nickel are developmental effects on the offspring of females exposed during pregnancy. Thus the critical receptor for oral exposure to nickel is a woman of child-bearing age.

Soil Screening Values

	All land uses Protective of the Water Resource	Informal Residential	Standard Residential	Commercial /Industrial
Nickel	91 mg/kg	620 mg/kg	1,200 mg/kg	10,000 mg/kg

Target Water Quality

	Drinking Water (WHO, 2008)	Aquatic Water Quality (ANZECC, 2000)

Nickel	0.07 mg/l	0.011 mg/l

Equation Sample

Table 19: Exposure Parameters Ni

Parameter		Informal Residential	Standard Residential	Commercial/ Industrial
THI	Target Hazard Index	1	1	1
TR	Target Risk	1E-05	1E-05	1E-05
BW	Body Weight (kg)	15	15	70
AT	Averaging Time (days)	2,190	2,190	10,950
EF	Exposure Frequency (days/yr)	365	350	250
ED	Exposure Duration (yrs)	6	6	30
IRs	Ingestion Rate (Soil) (mg/day)	400	200	100
IRa	Ingestion Rate (Air) (mg/day)	10	10	10.4
GI	GI Absorption Factor	1	1	1
PEF	Particulate Emission Factor (m3/kg)	7.25E+08	1.30E+09	3.22E+08
VF	Volatilisation Factor (m3/kg)	-	-	-
SA	Surface Area of Exposed Skin (cm ²)	4,200	2,100	13,110
AF	Skin Adherence Factor (mg/ cm ² /day)	0.2	0.2	0.07
ABS	Dermal Absorption Factor	0.1	0.1	0.1

Table 20: Toxicological Data Ni

Parameter		Informal Residential	Standard Residential	Commercial/ Industrial
RfDo	Reference Dosage (Oral)	0.02	0.02	0.02
RfDi	Reference Dosage (Inhalation)	-	-	-

RfDd	Reference Dosage (Dermal)	0.02	0.02	0.02
SFo	Slope Factor (Oral)	-	-	-
SFa	Slope Factor (Air)	-	-	-
SFd	Slope Factor (Dermal)	-	-	-

Nickel (Ni)

Threshold calculation with no inhalation RfD available.

$$SSV(mg / kg) = \frac{THI \times BW \times AT}{\left[EF \times ED \times \left(\left(\left(\frac{1}{RfD_o} \right) \times 10^{-6} \times IR_S \times GI \right) + \left(\left(\frac{1}{RfD_d} \right) \times SA \times AF \times ABS \times 10^{-6} \right) \right) \right]}$$

Informal Residential

$$SSV(mg / kg) = \frac{1 \times 15 \times 2,190}{\left[365 \times 6 \times \left(\left(\left(\frac{1}{0.02} \right) \times 10^{-6} \times 400 \times 1 \right) + \left(\left(\frac{1}{0.02} \right) \times 4200 \times 0.2 \times 0.1 \times 10^{-6} \right) \right) \right]} = 620$$

Standard Residential

$$SSV(mg / kg) = \frac{1 \times 15 \times 2,190}{\left[350 \times 6 \times \left(\left(\left(\frac{1}{0.02} \right) \times 10^{-6} \times 200 \times 1 \right) + \left(\left(\frac{1}{0.02} \right) \times 2100 \times 0.2 \times 0.1 \times 10^{-6} \right) \right) \right]} = 1,200$$

Commercial/Industrial

$$SSV(mg / kg) = \frac{1 \times 70 \times 10,950}{\left[250 \times 30 \times \left(\left(\left(\frac{1}{0.02} \right) \times 10^{-6} \times 100 \times 1 \right) + \left(\left(\frac{1}{0.02} \right) \times 13,110 \times 0.07 \times 0.1 \times 10^{-6} \right) \right) \right]} = 10,000$$

VANADIUM

VANADIUM

Environmental Occurrence

Vanadium has a moderate to high crustal abundance. Vanadium minerals are widespread and include sulphides and vanadates. Vanadium (IV) and (V) salts are soluble in water and tend to remain in solution, whereas the vanadium (II) and (III) compounds are insoluble and are found in soils and sediments.

Vanadium background concentrations in soils can reach 100 mg/kg. Anthropogenic sources of vanadium are associated with the burning of fossil fuels.

The concentration of vanadium in surface waters is usually less than 1 µg/l.

Vanadium is used in the manufacture of tool steels and as catalysts in the chemical industry. Vanadium pentoxide is used in certain glassware and ceramics.

Food uptake is the primary route of vanadium uptake.

Toxicity

Long term exposure to vanadium is primarily oral and inhalation. Adverse respiratory effects include airway irritation, sore throat, coughing and wheezing. Exposure to high levels of vanadium results in severe chronic bronchitis. Oral exposure can result in gastrointestinal effects including diarrhoea, cramps and nausea. Haematological impacts may follow inhalation or oral exposure.

Total dietary intake of vanadium is of relevance in assessing the effects of vanadium.

There are inadequate studies to classify the carcinogenicity of vanadium.

Soil Screening Values

	All land uses Protective of the Water Resource	Informal Residential	Standard Residential	Commercial/ Industrial
Vanadium	150 mg/kg	150 mg/kg	320 mg/kg	2,600 mg/kg

Target Water Quality

	Drinking Water (DWAf, 1996)	Aquatic Water Quality

Vanadium	0.1 mg/l	-

Equation Sample

Table 21: Exposure Parameters V

Parameter		Informal Residential	Standard Residential	Commercial/ Industrial
THI	Target Hazard Index	1	1	1
TR	Target Risk	1E-05	1E-05	1E-05
BW	Body Weight (kg)	15	15	70
AT	Averaging Time (days)	2,190	2,190	10,950
EF	Exposure Frequency (days/yr)	365	350	250
ED	Exposure Duration (yrs)	6	6	30
IRs	Ingestion Rate (Soil) (mg/day)	400	200	100
IRa	Ingestion Rate (Air) (mg/day)	10	10	10.4
GI	GI Absorption Factor	1	1	1
PEF	Particulate Emission Factor (m3/kg)	7.25E+08	1.30E+09	3.22E+08
VFi	Volatilisation Factor (m3/kg)	-	-	-
VFo	Volatilisation Factor (m3/kg)	4,200	2,100	13,110
SA	Surface Area of Exposed Skin (cm ²)	0.2	0.2	0.07
AF	Skin Adherence Factor (mg/ cm ² /day)	0.1	0.1	0.1

Table 22: Toxicological Data V

Parameter		Informal Residential	Standard Residential	Commercial/ Industrial
RfDo	Reference Dosage (Oral)	0.00504	0.00504	0.00504
RfDi	Reference Dosage (Inhalation)	-	-	-
RfDd	Reference Dosage (Dermal)	0.00504	0.00504	0.00504

SFo	Slope Factor (Oral)	-	-	-
SFa	Slope Factor (Air)	-	-	-
SFd	Slope Factor (Dermal)	-	-	-

Vanadium (V)

Threshold calculation with no inhalation RfD available.

$$SSV(mg / kg) = \frac{THI \times BW \times AT}{\left[EF \times ED \times \left(\left(\frac{1}{RfD_o} \right) \times 10^{-6} \times IR_s \times GI \right) + \left(\left(\frac{1}{RfD_d} \right) \times SA \times AF \times ABS \times 10^{-6} \right) \right]}$$

Informal Residential

$$SSV(mg / kg) = \frac{1 \times 15 \times 2,190}{\left[365 \times 6 \times \left(\left(\frac{1}{0.00504} \right) \times 10^{-6} \times 400 \times 1 \right) + \left(\left(\frac{1}{0.00504} \right) \times 4200 \times 0.2 \times 0.1 \times 10^{-6} \right) \right]} = 150$$

Standard Residential

$$SSV(mg / kg) = \frac{1 \times 15 \times 2,190}{\left[350 \times 6 \times \left(\left(\frac{1}{0.00504} \right) \times 10^{-6} \times 200 \times 1 \right) + \left(\left(\frac{1}{0.00504} \right) \times 2100 \times 0.2 \times 0.1 \times 10^{-6} \right) \right]} = 320$$

Commercial/Industrial

$$SSV(mg / kg) = \frac{1 \times 70 \times 10,950}{\left[250 \times 30 \times \left(\left(\frac{1}{0.00504} \right) \times 10^{-6} \times 100 \times 1 \right) + \left(\left(\frac{1}{0.00504} \right) \times 13,110 \times 0.07 \times 0.1 \times 10^{-6} \right) \right]} = 2,600$$

ZINC

ZINC

Environmental Occurrence

Zinc is a metallic element ubiquitous in the environment. Zinc occurs naturally as zinc oxide or as the principal ore mineral sphalerite (ZnS).

Zinc is commonly associated with copper and cadmium.

Zinc is an essential nutrient for plants and animals. Humans have a high tolerance for zinc. Fish are highly susceptible to zinc poisoning.

Environmental releases of zinc are associated with zinc mining and smelting. Zinc background levels in surface soils range from 12 -115 mg/kg and can reach 2,900 mg/kg.

Zinc concentrations in natural surface waters are usually low, typically about 0.015 mg/l.

Zinc and zinc salts are used in many industrial processes. Zinc is used in galvanizing processes and in alloys, including brass and bronze, and in electrical components. Zinc salts are used in paint pigments, in cosmetics and in the manufacture of pharmaceuticals, dyes and insecticides.

Toxicity

Zinc levels in drinking water are an aesthetic concern. At concentrations that would cause gastrointestinal irritation, zinc imparts a bitter astringent taste. Acute toxicity is rarely hazardous as the taste induces vomiting which rids the body of the excessive dose.

Zinc exposure is primarily through ingestion with an average food intake of between 5 to 16 mg/day.

Inhalation of zinc oxide is associated with the occupational 'metal fume fever' which affects the respiratory tract, but is reversible. Zinc chloride has a similar, but more caustic impact. Excessive zinc intake results in gastrointestinal irritation.

Zinc salts are caustic and may result in severe skin irritation.

Zinc exposure can cause decreased absorption of copper and decreased iron stores which results in anaemia and leucopenia.

Soil Screening Values

	All land uses Protective of the Water Resource	Informal Residential	Standard Residential	Commercial/ Industrial
Zinc	240 mg/kg	9,200 mg/kg	19,000 mg/kg	150,000 mg/kg

Target Water Quality

	Drinking Water (DWAf, 1996)	Aquatic Water Quality (DWAf, 1996)
Zinc	3.0mg/l	0.002 mg/l

Equation Sample

Table 23: Exposure Parameters Zn

Parameter		Informal Residential	Standard Residential	Commercial/ Industrial
THI	Target Hazard Index	1	1	1
TR	Target Risk	1E-05	1E-05	1E-05
BW	Body Weight (kg)	15	15	70
AT	Averaging Time (days)	2,190	2,190	10,950
EF	Exposure Frequency (days/yr)	365	350	250
ED	Exposure Duration (yrs)	6	6	30
IRs	Ingestion Rate (Soil) (mg/day)	400	200	100
IRa	Ingestion Rate (Air) (mg/day)	10	10	10.4
GI	GI Absorption Factor	1	1	1
PEF	Particulate Emission Factor (m ³ /kg)	7.25E+08	1.30E+09	3.22E+08
VFi	Volatilisation Factor (m ³ /kg)	-	-	-
VFo	Volatilisation Factor (m ³ /kg)	4,200	2,100	13,110
SA	Surface Area of Exposed Skin (cm ²)	0.2	0.2	0.07
AF	Skin Adherence Factor (mg/ cm ² /day)	0.1	0.1	0.1

Table 24: Toxicological Data Zn

Parameter		Informal Residential	Standard Residential	Commercial/ Industrial
RfDo	Reference Dosage (Oral)	0.3	0.3	0.3
RfDi	Reference Dosage (Inhalation)	-	-	-
RfDd	Reference Dosage (Dermal)	0.3	0.3	0.3
SFo	Slope Factor (Oral)	-	-	-
SFa	Slope Factor (Air)	-	-	-
SFd	Slope Factor (Dermal)	-	-	-

Zinc (Zn)

Threshold calculation with no inhalation RfD available.

$$SSV(mg / kg) = \frac{THI \times BW \times AT}{\left[EF \times ED \times \left(\left(\left(\frac{1}{RfD_o} \right) \times 10^{-6} \times IR_S \times GI \right) + \left(\left(\frac{1}{RfD_d} \right) \times SA \times AF \times ABS \times 10^{-6} \right) \right) \right]}$$

Informal Residential

$$SSV(mg / kg) = \frac{1 \times 15 \times 2,190}{\left[365 \times 6 \times \left(\left(\left(\frac{1}{0.3} \right) \times 10^{-6} \times 400 \times 1 \right) + \left(\left(\frac{1}{0.3} \right) \times 4200 \times 0.2 \times 0.1 \times 10^{-6} \right) \right) \right]} = 9,200$$

Standard Residential

$$SSV(mg / kg) = \frac{1 \times 15 \times 2,190}{\left[350 \times 6 \times \left(\left(\left(\frac{1}{0.3} \right) \times 10^{-6} \times 200 \times 1 \right) + \left(\left(\frac{1}{0.3} \right) \times 2100 \times 0.2 \times 0.1 \times 10^{-6} \right) \right) \right]} = 19,000$$

Commercial/Industrial

$$SSV(mg / kg) = \frac{1 \times 70 \times 10,950}{\left[250 \times 30 \times \left(\left(\left(\frac{1}{0.3} \right) \times 10^{-6} \times 100 \times 1 \right) + \left(\left(\frac{1}{0.3} \right) \times 13,110 \times 0.07 \times 0.1 \times 10^{-6} \right) \right) \right]} = 150,000$$

PETROLEUM ORGANICS: ALKANES

Petroleum Hydrocarbons - Alkanes

Environmental Occurrence

Total petroleum hydrocarbons (TPHs) is a term used to describe a large family of several hundred chemical compounds that originally come from crude oil. Crude oil is used to make petroleum products. Because there are so many different chemicals in crude oil and in other petroleum products, it is not practical to measure each one separately. However, it is useful to measure the TPHs and the fractions of different hydrocarbons according to their molecular weights.

Some chemicals that may be found in TPHs are hexane, jet fuels, mineral oils, benzene, toluene, xylenes, naphthalene, as well as other petroleum products. The aromatic compounds commonly associated with petroleum hydrocarbons are dealt with separately in the Framework.

The Framework is based on the Massachusetts Department of Environmental Protection (MADEP) and Total Petroleum Hydrocarbon Criteria Working Group approach. The common analytical method is to report the concentration of purgeable and extractable hydrocarbons by their carbon number which roughly corresponds to their boiling point range. In this section we consider the aliphatic hydrocarbons. Light fractions are typified by compounds such as n-Hexane and characterize petrol range hydrocarbons. The mid range of aliphatic hydrocarbons is paraffinic and includes diesel, jet fuel and kerosene. The heavy fractions are typical of mineral oils and greases.

TPHs may enter the environment through accidents from industrial releases or as by-products from commercial or private uses. TPHs may be released directly into water through spills or leaks. Some TPHs fractions will float on the water and form surface films. Other TPH fractions will sink to the bottom sediments. Bacteria and microorganisms in the water may break down some of the TPHs fractions.

The volume of petroleum products used today dwarfs all other contaminants of environmental concern.

Toxicity

Exposure is most likely from breathing air at gasoline stations, using chemicals at home or work, or using certain pesticides. Drinking water contaminated with TPHs is a possible ingestion route. Living in an area near a spill or leak of petroleum products could expose residents to vapours via the inhalation exposure or by dermal contact with soil contaminated with TPHs.

The typical alkanes associated with commonly encountered petroleum hydrocarbons are generally low toxicity mixtures requiring high chronic exposure levels before health effects are observed. There are however highly toxic and carcinogenic compounds that may form part of the hydrocarbon mixture.

The International Agency for Research on Cancer (IARC) has determined that one TPHs compound (benzene) is carcinogenic to humans. IARC has determined that other TPHs compounds (benzo(a)pyrene) are probably and possibly carcinogenic to humans. Most of the other TPH compounds are considered not to be classifiable by IARC.

Soil Screening Values

Alkanes	All land uses Protective of the Water Resource	Informal Residential	Standard Residential	Commercial/ Industrial
C7-C9	2,300 mg/kg	2,300 mg/kg	2,400 mg/kg	23,000 mg/kg
C10-C14	440 mg/kg	440 mg/kg	500 mg/kg	4,400 mg/kg
C15-C36	45,000 mg/kg	45,000 mg/kg	91,000 mg/kg	740,000 mg/kg

Target Water Quality

Alkanes	Drinking Water (WHO, 2008)	Aquatic Water Quality
C7-C9	15,000 mg/l	-
C10-C14	300 mg/l	-
C15-C36	90 mg/l	-

Equation Samples

Soil Screening Value C7-C9

Table 25: Exposure Parameters C7-C9

Parameter		Informal Residential	Standard Residential	Commercial/ Industrial
THI	Target Hazard Index	1	1	1
TR	Target Risk	1E-05	1E-05	1E-05
BW	Body Weight (kg)	15	15	70
AT	Averaging Time (days)	2,190	2,190	10,950
EF	Exposure Frequency (days/yr)	365	350	250
ED	Exposure Duration (yrs)	6	6	30
IRs	Ingestion Rate (Soil) (mg/day)	400	200	100
IRa	Ingestion Rate (Air) (mg/day)	10	10	10.4
GI	GI Absorption Factor	1	1	1
PEF	Particulate Emission Factor (m ³ /kg)	7.25E+08	1.30E+09	3.22E+08
VFi	Volatilisation Factor (m ³ /kg)	161	161	242
VFo	Volatilisation Factor (m ³ /kg)	13,072	13,072	13,072
SA	Surface Area of Exposed Skin (cm ²)	4,200	2,100	13,110
AF	Skin Adherence Factor (mg/ cm ² /day)	0.2	0.2	0.07
ABS	Dermal Absorption Factor	0.1	0.1	0.1

Table 26: Toxicological Data C7-C9

Parameter		Informal Residential	Standard Residential	Commercial/ Industrial
RfDo	Reference Dosage (Oral)	5	5	5
RfDi	Reference Dosage (Inhalation)	5	5	5
RfDd	Reference Dosage (Dermal)	5	5	5
SFo	Slope Factor (Oral)	-	-	-
SFa	Slope Factor (Air)	-	-	-
SFd	Slope Factor (Dermal)	-	-	-

C7-C9

$$SSV(mg / kg) = \frac{THI \times BW \times AT}{EF \times ED \times \left(\left(\frac{1}{RfD_O} \cdot 10^{-6} \times IR_S \times GI \right) + \left(\frac{1}{RfD_i} \times \left(\left(IR_a \times \frac{1}{PEF} \right) + \left(\frac{IR_a}{2} \times \left(\frac{1}{VF_i} + \frac{1}{VF_O} \right) \right) \right) \right) + \left(\frac{1}{RfD_D} \cdot 10^{-6} \times SA \times AF \times ABS \cdot 10^{-6} \right) \right)}$$

Informal Residential

$$SSV(mg / kg) = \frac{1 \times 15 \times 2,190}{365 \times 6 \times \left(\left(\frac{1}{5} \cdot 10^{-6} \times 400 \times 1 \right) + \left(\frac{1}{5} \times \left(\left(10 \times \frac{1}{7.25 \cdot 10^8} \right) + \left(\frac{10}{2} \times \left(\frac{1}{161} + \frac{1}{13,072} \right) \right) \right) \right) + \left(\frac{1}{5} \cdot 10^{-6} \times 4,200 \times 0.2 \times 0.1 \cdot 10^{-6} \right) \right)} = 2,300$$

Standard Residential

$$SSV(mg / kg) = \frac{1 \times 15 \times 2,190}{350 \times 6 \times \left(\left(\frac{1}{5} \cdot 10^{-6} \times 200 \times 1 \right) + \left(\frac{1}{5} \times \left(\left(10 \times \frac{1}{1.3 \cdot 10^9} \right) + \left(\frac{10}{2} \times \left(\frac{1}{161} + \frac{1}{13,072} \right) \right) \right) \right) + \left(\frac{1}{5} \cdot 10^{-6} \times 2100 \times 0.2 \times 0.1 \cdot 10^{-6} \right) \right)} = 2,400$$

Commercial/Industrial

$$SSV(mg / kg) = \frac{1 \times 70 \times 10,950}{250 \times 30 \times \left(\left(\frac{1}{5} \cdot 10^{-6} \times 100 \times 1 \right) + \left(\frac{1}{5} \times \left(\left(10.4 \times \frac{1}{3.22 \cdot 10^8} \right) + \left(\frac{10.4}{2} \times \left(\frac{1}{242} + \frac{1}{13,072} \right) \right) \right) \right) + \left(\frac{1}{5} \cdot 10^{-6} \times 13,110 \times 0.07 \times 0.1 \cdot 10^{-6} \right) \right)} = 23,000$$

Soil Screening Value C10-C14

Table 27: Exposure Parameters C10-C14

Parameter		Informal Residential	Standard Residential	Commercial/ Industrial
THI	Target Hazard Index	1	1	1
TR	Target Risk	1E-05	1E-05	1E-05
BW	Body Weight (kg)	15	15	70
AT	Averaging Time (days)	2,190	2,190	10,950
EF	Exposure Frequency (days/yr)	365	350	250
ED	Exposure Duration (yrs)	6	6	30
IRs	Ingestion Rate (Soil) (mg/day)	400	200	100
IRa	Ingestion Rate (Air) (mg/day)	10	10	10.4
GI	GI Absorption Factor	1	1	1
PEF	Particulate Emission Factor (m ³ /kg)	7.25E+08	1.30E+09	3.22E+08
VFi	Volatilisation Factor (m ³ /kg)	1,919	1,919	2,874
VFo	Volatilisation Factor (m ³ /kg)	18,282	18,282	18,282
SA	Surface Area of Exposed Skin (cm ²)	4,200	2,100	13,110
AF	Skin Adherence Factor (mg/ cm ² /day)	0.2	0.2	0.07
ABS	Dermal Absorption Factor	0.1	0.1	0.1

Table 28: Toxicological Data C10-C14

Parameter		Informal Residential	Standard Residential	Commercial/ Industrial
RfDo	Reference Dosage (Oral)	0.1	0.1	0.1
RfDi	Reference Dosage (Inhalation)	0.1	0.1	0.1
RfDd	Reference Dosage (Dermal)	0.1	0.1	0.1
SFo	Slope Factor (Oral)	-	-	-
SFa	Slope Factor (Air)	-	-	-
SFd	Slope Factor (Dermal)	-	-	-

C10-C14

$$SSV(mg / kg) = \frac{THI \times BW \times AT}{EF \times ED \times \left(\left(\frac{1}{RfD_O} \cdot 10^{-6} \times IR_S \times GI \right) + \left(\frac{1}{RfD_i} \times \left(\left(IR_a \times \frac{1}{PEF} \right) + \left(\frac{IR_a}{2} \times \left(\frac{1}{VF_i} + \frac{1}{VF_O} \right) \right) \right) \right) + \left(\frac{1}{RfD_D} \cdot 10^{-6} \times SA \times AF \times ABS \cdot 10^{-6} \right) \right)}$$

Informal Residential

$$SSV(mg / kg) = \frac{1 \times 15 \times 2,190}{365 \times 6 \times \left(\left(\frac{1}{0.1} \cdot 10^{-6} \times 400 \times 1 \right) + \left(\frac{1}{0.1} \times \left(\left(10 \times \frac{1}{7.25 \cdot 10^8} \right) + \left(\frac{10}{2} \times \left(\frac{1}{1,919} + \frac{1}{18,282} \right) \right) \right) \right) + \left(\frac{1}{0.1} \cdot 10^{-6} \times 4,200 \times 0.2 \times 0.1 \cdot 10^{-6} \right) \right)} = 440$$

Standard Residential

$$SSV(mg / kg) = \frac{1 \times 15 \times 2,190}{350 \times 6 \times \left(\left(\frac{1}{0.1} \cdot 10^{-6} \times 200 \times 1 \right) + \left(\frac{1}{0.1} \times \left(\left(10 \times \frac{1}{1.3 \cdot 10^9} \right) + \left(\frac{10}{2} \times \left(\frac{1}{1,919} + \frac{1}{18,282} \right) \right) \right) \right) + \left(\frac{1}{0.1} \cdot 10^{-6} \times 2100 \times 0.2 \times 0.1 \cdot 10^{-6} \right) \right)} = 500$$

Commercial/Industrial

$$SSV(mg / kg) = \frac{1 \times 70 \times 10,950}{250 \times 30 \times \left(\left(\frac{1}{0.1} \cdot 10^{-6} \times 100 \times 1 \right) + \left(\frac{1}{0.1} \times \left(\left(10.4 \times \frac{1}{3.22 \cdot 10^8} \right) + \left(\frac{10.4}{2} \times \left(\frac{1}{1,919} + \frac{1}{18,282} \right) \right) \right) \right) + \left(\frac{1}{0.1} \cdot 10^{-6} \times 13,110 \times 0.07 \times 0.1 \cdot 10^{-6} \right) \right)} = 4,400$$

Soil Screening Value C15-C36

Table 29: Exposure Parameters C15-C36

Parameter		Informal Residential	Standard Residential	Commercial/ Industrial
THI	Target Hazard Index	1	1	1
TR	Target Risk	1E-05	1E-05	1E-05
BW	Body Weight (kg)	15	15	70
AT	Averaging Time (days)	2,190	2,190	10,950
EF	Exposure Frequency (days/yr)	365	350	250
ED	Exposure Duration (yrs)	6	6	30
IRs	Ingestion Rate (Soil) (mg/day)	400	200	100
IRa	Ingestion Rate (Air) (mg/day)	10	10	10.4
GI	GI Absorption Factor	1	1	1
PEF	Particulate Emission Factor (m ³ /kg)	7.25E+08	1.30E+09	3.22E+08
VFi	Volatilisation Factor (m ³ /kg)	1.16E+06	1.16E+06	1.74E+06
VFo	Volatilisation Factor (m ³ /kg)	4.46+05	4.46+05	4.46+05
SA	Surface Area of Exposed Skin (cm ²)	4,200	2,100	13,110
AF	Skin Adherence Factor (mg/ cm ² /day)	0.2	0.2	0.07
ABS	Dermal Absorption Factor	0.1	0.1	0.1

Table 30: Toxicological Data C15-C36

Parameter		Informal Residential	Standard Residential	Commercial/ Industrial
RfDo	Reference Dosage (Oral)	1.5	1.5	1.5
RfDi	Reference Dosage (Inhalation)	1.5	1.5	1.5
RfDd	Reference Dosage (Dermal)	1.5	1.5	1.5
SFo	Slope Factor (Oral)	-	-	-
SFa	Slope Factor (Air)	-	-	-
SFd	Slope Factor (Dermal)	-	-	-

C15-C36

$$SSV(mg / kg) = \frac{THI \times BW \times AT}{EF \times ED \times \left(\left(\frac{1}{RfD_O} \cdot 10^{-6} \times IR_S \times GI \right) + \left(\frac{1}{RfD_i} \times \left(\left(IR_a \times \frac{1}{PEF} \right) + \left(\frac{IR_a}{2} \times \left(\frac{1}{VF_i} + \frac{1}{VF_O} \right) \right) \right) \right) + \left(\frac{1}{RfD_D} \cdot 10^{-6} \times SA \times AF \times ABS \cdot 10^{-6} \right) \right)}$$

Informal Residential

$$SSV(mg / kg) = \frac{1 \times 15 \times 2,190}{365 \times 6 \times \left(\left(\frac{1}{1.5} \cdot 10^{-6} \times 400 \times 1 \right) + \left(\frac{1}{1.5} \times \left(\left(10 \times \frac{1}{7.25 \cdot 10^8} \right) + \left(\frac{10}{2} \times \left(\frac{1}{1.16 \cdot 10^6} + \frac{1}{4.46 \cdot 10^5} \right) \right) \right) \right) + \left(\frac{1}{1.5} \cdot 10^{-6} \times 4,200 \times 0.2 \times 0.1 \cdot 10^{-6} \right) \right)} = 45,000$$

Standard Residential

$$SSV(mg / kg) = \frac{1 \times 15 \times 2,190}{350 \times 6 \times \left(\left(\frac{1}{1.5} \cdot 10^{-6} \times 200 \times 1 \right) + \left(\frac{1}{1.5} \times \left(\left(10 \times \frac{1}{1.3 \cdot 10^9} \right) + \left(\frac{10}{2} \times \left(\frac{1}{1.16 \cdot 10^6} + \frac{1}{4.46 \cdot 10^5} \right) \right) \right) \right) + \left(\frac{1}{1.5} \cdot 10^{-6} \times 2100 \times 0.2 \times 0.1 \cdot 10^{-6} \right) \right)} = 91,000$$

Commercial/Industrial

$$SSV(mg / kg) = \frac{1 \times 70 \times 10,950}{250 \times 30 \times \left(\left(\frac{1}{1.5} \cdot 10^{-6} \times 100 \times 1 \right) + \left(\frac{1}{1.5} \times \left(\left(10.4 \times \frac{1}{3.22 \cdot 10^8} \right) + \left(\frac{10.4}{2} \times \left(\frac{1}{1.74 \cdot 10^6} + \frac{1}{4.46 \cdot 10^5} \right) \right) \right) \right) + \left(\frac{1}{1.5} \cdot 10^{-6} \times 13,110 \times 0.07 \times 0.1 \cdot 10^{-6} \right) \right)} = 740,000$$

MAH: BENZENE

BENZENE

Environmental Occurrence

Benzene is a naturally occurring aromatic hydrocarbon with a sweet clear odour. Pure benzene is a clear, colourless liquid which is highly flammable. It is slightly soluble in water and readily soluble in most organic solvents. Benzene, toluene, ethylbenzene and xylene are referred to as the BTEX compounds and are commonly used together in petroleum fuels and products and have related chemical structures and similar fate and transport properties.

Benzene is naturally present in emissions from volcanic eruptions and forest fires and is a constituent of crude oil. The bulk of benzene in the environment is derived from anthropogenic sources. Other than its use as an additive to petrol to improve octane rating, it is used as a chemical intermediate in the production of other organic chemicals. Historically benzene was widely used as a solvent in manufacturing processes for paints, rubber cements and degreasing agents and in consumer products.

Most soils will contain very little benzene as a result of natural processes. No natural background levels can be established. Benzene is highly mobile in the soil environment. Upon release benzene will tend to sink through the unsaturated zone until it reaches the water table where a Non-Aqueous Phase Liquid (NAPL) will form if benzene and related compounds are present in sufficient volumes. Benzene readily volatilizes from surface soil given its high vapour pressure and high air-water partition coefficient. Vapour release and inhalation is thus the most important exposure pathway for benzene. Exposure via dermal pathways is negligible and only applies for maintenance workers in direct contact with liquid products. Although biodegradation may occur, benzene volatilization usually ensures that benzene does not remain in the soil long enough for significant biodegradation to occur.

Sorption to organic matter (SOM) may significantly affect the vapour inhalation risk and plant uptake of benzene from soils.

When mixtures of benzene, toluene, xylene and ethylbenzene are present in an anaerobic environment there is a sequential utilization of the substrate hydrocarbons with toluene being the first to be degraded, followed by the isomers of xylene in varying order. Benzene and ethylbenzene tend to be degraded last.

Toxicity

The blood and immune system are the main targets of chronic exposure to benzene. The critical effect of both oral and inhalation exposure is considered to be the potential for leukaemia.

Benzene is listed as a Hazardous Air Pollutant. Background inhalation exposure to benzene from its presence in ambient air is estimated to be approximately 200 µg/day.

Soil Screening Values

	All land uses Protective of the Water Resource	Informal Residential	Standard Residential	Commercial/ Industrial
Benzene	0.03 mg/kg	1.3 mg/kg	1.4 mg/kg	10 mg/kg

Target Water Quality

	Drinking Water (WHO, 2008)	Aquatic Water Quality (UK EQS Salmonid, Current)
Benzene	0.001 mg/l	0.03 mg/l

Equation Sample

Table 31: Exposure Parameters Benzene

Parameter		Informal Residential	Standard Residential	Commercial/ Industrial
THI	Target Hazard Index	1	1	1
TR	Target Risk	1E-05	1E-05	1E-05
BW	Body Weight (kg)	70	70	70
AT	Averaging Time (days)	25,550	25,550	25,550
EF	Exposure Frequency (days/yr)	365	350	250
ED	Exposure Duration (yrs)	70	70	30
IRs	Ingestion Rate (Soil) (mg/day)	200	100	100
IRa	Ingestion Rate (Air) (mg/day)	20	20	10.4
GI	GI Absorption Factor	1	1	1
PEF	Particulate Emission Factor (m ³ /kg)	7.25E+08	1.3E+09	3.22E+08
VFi	Volatilisation Factor (m ³ /kg)	585	585	667
VFo	Volatilisation Factor (m ³ /kg)	55,866	55,866	55,866
SA	Surface Area of Exposed Skin (cm ²)	11,600	5,800	13,110
AF	Skin Adherence Factor (mg/ cm ² /day)	0.07	0.07	0.07
ABS	Dermal Absorption Factor	0.1	0.1	0.1

Table 32: Toxicological Data Benzene

Parameter		Informal Residential	Standard Residential	Commercial/ Industrial
RfDo	Reference Dosage (Oral)	-	-	-
RfDi	Reference Dosage (Inhalation)	-	-	-
RfDd	Reference Dosage (Dermal)	-	-	-
SFo	Slope Factor (Oral)	0.029	0.029	0.029
SFa	Slope Factor (Air)	0.029	0.029	0.029
SFd	Slope Factor (Dermal)	0.029	0.029	0.029

Benzene

$$SSV(mg/kg) = \frac{TR \times BW \times AT}{EF \times ED \times \left((SF_0 \times 10^{-6} \times IR_s \times GI) + \left(SF_0 \times \left(\left(IR_a \times \frac{1}{PEF} \right) + \left(\frac{IR_a}{2} \times \left(\frac{1}{VF_i} + \frac{1}{VF_0} \right) \right) \right) \right) + (SF_D \times SA \times AF \times ABS \times 10^{-6}) \right)}$$

Informal Residential

$$SSV(mg/kg) = \frac{1 \cdot 10^{-5} \times 70 \times 25,550}{365 \times 70 \times \left((0.029 \times 10^{-6} \times 200 \times 1) + \left(0.029 \times \left(\left(20 \times \frac{1}{7.25 \cdot 10^8} \right) + \left(\frac{20}{2} \times \left(\frac{1}{585} + \frac{1}{55,866} \right) \right) \right) \right) + (0.029 \times 11,600 \times 0.07 \times 0.1 \times 10^{-6}) \right)} = 1.3$$

Standard Residential

$$SSV(mg/kg) = \frac{1 \cdot 10^{-5} \times 70 \times 25,550}{350 \times 70 \times \left((0.029 \times 10^{-6} \times 100 \times 1) + \left(0.029 \times \left(\left(20 \times \frac{1}{1.3 \cdot 10^9} \right) + \left(\frac{20}{2} \times \left(\frac{1}{585} + \frac{1}{55,866} \right) \right) \right) \right) + (0.029 \times 5,800 \times 0.07 \times 0.1 \times 10^{-6}) \right)} = 1.4$$

Commercial/Industrial

$$SSV(mg/kg) = \frac{1 \cdot 10^{-5} \times 70 \times 25,550}{250 \times 30 \times \left((0.029 \times 10^{-6} \times 100 \times 1) + \left(0.029 \times \left(\left(10.4 \times \frac{1}{3.22 \cdot 10^8} \right) + \left(\frac{10.4}{2} \times \left(\frac{1}{667} + \frac{1}{55,866} \right) \right) \right) \right) + (0.029 \times 13,110 \times 0.07 \times 0.1 \times 10^{-6}) \right)} = 10$$

MAH: TOLUENE

TOLUENE

Environmental Occurrence

Toluene is the common name for methylbenzene and it is a naturally occurring aromatic hydrocarbon found in low concentrations in crude oil and released to the environment by wood burning and forest fires. Most soils contain very little or any toluene as a result of natural processes or diffuse pollution sources. Benzene, toluene, ethylbenzene and xylene are referred to as BTEX compounds and have similar chemical properties and are commonly found together in petroleum products.

Toluene is used as a petrol additive to improve octane rating. Toluene is also used as a raw material in the manufacture of other chemical products and as an intermediate or solvent in the manufacture of paints, varnishes, adhesives, explosives, dyes, detergents, pesticides, pharmaceuticals, printing and leather tanning.

Rapid volatilisation of toluene from surface soils can be expected within 24 hours, however for soils at a depth of over 1 m the volatilisation can be less than 3% in a year. Upon release to the soil, toluene will tend to sink through the unsaturated zone until it reaches the saturated zone where it can form a non-aqueous phase liquid (NAPL).

Toluene in soil is also subject to microbial degradation under both aerobic and anaerobic conditions. Environmental half-lives are dependant on contaminant concentrations, soil conditions, particularly oxygen levels, soil temperature, microbial population and the presence of other contaminants.

Toxicity

Toxicity to the central nervous system is the main concern following medium to long term exposure.

Exposure via dermal pathways is negligible. Due to high vapour pressures, inhalation of dust is unlikely to be of concern.

Toluene is a solvent and thus has the potential to react with and permeate certain types of plastic water pipes particularly if free phase toluene is present.

Soil Screening Values

	All land uses Protective of the Water Resource	Informal Residential	Standard Residential	Commercial/ Industrial
Toluene	25 mg/kg	110 mg/kg	120 mg/kg	1,100 mg/kg

Target Water Quality

	Drinking Water (WHO, 2008)	Aquatic Water Quality (UK EQS Salmonid, Current)
Toluene	0.7 mg/l	0.05 mg/l

Equation Sample

Table 33: Exposure Parameters Toluene

Parameter		Informal Residential	Standard Residential	Commercial/ Industrial
THI	Target Hazard Index	1	1	1
TR	Target Risk	1E-05	1E-05	1E-05
BW	Body Weight (kg)	15	15	70
AT	Averaging Time (days)	2,190	2,190	10,950
EF	Exposure Frequency (days/yr)	365	350	250
ED	Exposure Duration (yrs)	6	6	30
IRs	Ingestion Rate (Soil) (mg/day)	400	200	100
IRa	Ingestion Rate (Air) (mg/day)	10	10	10.4
GI	GI Absorption Factor	1	1	1
PEF	Particulate Emission Factor (m ³ /kg)	7.25E+08	1.30E+09	3.22E+08
VFi	Volatilisation Factor (m ³ /kg)	375	375	562
VFo	Volatilisation Factor (m ³ /kg)	13,072	13,072	13,072
SA	Surface Area of Exposed Skin (cm ²)	4,200	2,100	13,110
AF	Skin Adherence Factor (mg/ cm ² /day)	0.2	0.2	0.07
ABS	Dermal Absorption Factor	0.1	0.1	0.1

Table 34: Toxicological Data Toluene

Parameter		Informal Residential	Standard Residential	Commercial/ Industrial
RfDo	Reference Dosage (Oral)	0.2	0.2	0.2
RfDi	Reference Dosage (Inhalation)	0.11	0.11	0.11
RfDd	Reference Dosage (Dermal)	0.2	0.2	0.2
SFo	Slope Factor (Oral)	-	-	-
SFa	Slope Factor (Air)	-	-	-
SFd	Slope Factor (Dermal)	-	-	-

Toluene

$$SSV(mg / kg) = \frac{THI \times BW \times AT}{EF \times ED \times \left(\left(\frac{1}{RfD_O} \cdot 10^{-6} \times IR_S \times GI \right) + \left(\frac{1}{RfD_i} \times \left(\left(IR_a \times \frac{1}{PEF} \right) + \left(\frac{IR_a}{2} \times \left(\frac{1}{VF_i} + \frac{1}{VF_O} \right) \right) \right) \right) + \left(\frac{1}{RfD_D} \cdot 10^{-6} \times SA \times AF \times ABS \cdot 10^{-6} \right) \right)}$$

Informal Residential

$$SSV(mg / kg) = \frac{1 \times 15 \times 2,190}{365 \times 6 \times \left(\left(\frac{1}{0.2} \cdot 10^{-6} \times 400 \times 1 \right) + \left(\frac{1}{0.11} \times \left(\left(10 \times \frac{1}{7.25 \cdot 10^8} \right) + \left(\frac{10}{2} \times \left(\frac{1}{375} + \frac{1}{13,072} \right) \right) \right) \right) + \left(\frac{1}{0.2} \cdot 10^{-6} \times 4,200 \times 0.2 \times 0.1 \cdot 10^{-6} \right) \right)} = 110$$

Standard Residential

$$SSV(mg / kg) = \frac{1 \times 15 \times 2,190}{350 \times 6 \times \left(\left(\frac{1}{0.2} \cdot 10^{-6} \times 200 \times 1 \right) + \left(\frac{1}{0.11} \times \left(\left(10 \times \frac{1}{1.3 \cdot 10^9} \right) + \left(\frac{10}{2} \times \left(\frac{1}{375} + \frac{1}{13,072} \right) \right) \right) \right) + \left(\frac{1}{0.2} \cdot 10^{-6} \times 2100 \times 0.2 \times 0.1 \cdot 10^{-6} \right) \right)} = 120$$

Commercial/Industrial

$$SSV(mg / kg) = \frac{1 \times 70 \times 10,950}{250 \times 30 \times \left(\left(\frac{1}{0.2} \cdot 10^{-6} \times 100 \times 1 \right) + \left(\frac{1}{0.11} \times \left(\left(10.4 \times \frac{1}{3.22 \cdot 10^8} \right) + \left(\frac{10.4}{2} \times \left(\frac{1}{562} + \frac{1}{13,072} \right) \right) \right) \right) + \left(\frac{1}{0.2} \cdot 10^{-6} \times 13,110 \times 0.07 \times 0.1 \cdot 10^{-6} \right) \right)} = 1,100$$

MAH: ETHYLBENZENE

ETHYLBENZENE

Environmental Occurrence

Ethylbenzene is a naturally occurring aromatic hydrocarbon compound found in crude oil and released from wood burning and forest fires. Ethylbenzene has a low aqueous solubility. Most soils contain very little or any ethylbenzene as a result of natural processes or diffuse pollution sources. Benzene, toluene, ethylbenzene and xylene are referred to as BTEX compounds and have similar chemical properties and are commonly found together in petroleum products.

Ethylbenzene is produced in the fractionation of crude oil and as a by-product in xylene manufacturing. The primary use of ethylbenzene is in the manufacturing of styrene. Ethylbenzene is used as a petrol additive to improve octane rating. Ethylbenzene is also used as a raw material as a solvent in the manufacture of paints, varnishes and rubbers.

Ethylbenzene will volatilize from surface soils, but less rapidly than benzene and toluene. Upon release to the soil, ethylbenzene will tend to sink through the unsaturated zone until it reaches the saturated zone where it can form a non-aqueous phase liquid (LNAPL).

Ethylbenzene in soil is also subject to microbial degradation under both aerobic and anaerobic conditions. Environmental half-lives are dependent on contaminant concentrations, soil conditions, particularly oxygen levels, soil temperature, microbial population and the presence of other contaminants.

Toxicity

The principal target organs for the toxicity of oral and inhaled ethylbenzene are the liver and kidneys. Depression of the central nervous system can occur.

Ethylbenzene is primarily a membrane irritant which causes erythema and blistering of the skin.

Due to high vapour pressures, inhalation of dust is unlikely to be of concern.

Ethylbenzene is a solvent and thus has the potential to react with, and permeate certain types of plastic water pipes, particularly if free phase is present.

Soil Screening Values

	All land uses Protective of the Water Resource	Informal Residential	Standard Residential	Commercial/ Industrial
Ethylbenzene	26 mg/kg	57 mg/kg	60 mg/kg	540 mg/kg

Target Water Quality

	Drinking Water (WHO, 2008)	Aquatic Water Quality (BC Aquatics, 2006)
Ethylbenzene	0.3 mg/l	0.2 mg/l

Equation Sample

Table 35: Exposure Parameters Ethylbenzene

Parameter		Informal Residential	Standard Residential	Commercial/ Industrial
THI	Target Hazard Index	1	1	1
TR	Target Risk	1E-05	1E-05	1E-05
BW	Body Weight (kg)	15	15	70
AT	Averaging Time (days)	2,190	2,190	10,950
EF	Exposure Frequency (days/yr)	365	350	250
ED	Exposure Duration (yrs)	6	6	30
IRs	Ingestion Rate (Soil) (mg/day)	400	200	100
IRa	Ingestion Rate (Air) (mg/day)	10	10	10.4
GI	GI Absorption Factor	1	1	1
PEF	Particulate Emission Factor (m ³ /kg)	7.25E+08	1.30E+09	3.22E+08
VFi	Volatilisation Factor (m ³ /kg)	709	709	1,052
VFo	Volatilisation Factor (m ³ /kg)	13,072	13,072	13,072
SA	Surface Area of Exposed Skin (cm ²)	4,200	2,100	13,110
AF	Skin Adherence Factor (mg/ cm ² /day)	0.2	0.2	0.07
ABS	Dermal Absorption Factor	0.1	0.1	0.1

Table 36: Toxicological Data Ethylbenzene

Parameter		Informal Residential	Standard Residential	Commercial/ Industrial
RfDo	Reference Dosage (Oral)	0.1	0.1	0.1
RfDi	Reference Dosage (Inhalation)	0.029	0.029	0.029
RfDd	Reference Dosage (Dermal)	0.1	0.1	0.1
SFo	Slope Factor (Oral)	-	-	-
SFa	Slope Factor (Air)	-	-	-
SFd	Slope Factor (Dermal)	-	-	-

Ethylbenzene

$$SSV(mg / kg) = \frac{THI \times BW \times AT}{EF \times ED \times \left(\left(\frac{1}{RfD_O} \cdot 10^{-6} \times IR_S \times GI \right) + \left(\frac{1}{RfD_i} \times \left(\left(IR_a \times \frac{1}{PEF} \right) + \left(\frac{IR_a}{2} \times \left(\frac{1}{VF_i} + \frac{1}{VF_O} \right) \right) \right) \right) + \left(\frac{1}{RfD_D} \cdot 10^{-6} \times SA \times AF \times ABS \cdot 10^{-6} \right) \right)}$$

Informal Residential

$$SSV(mg / kg) = \frac{1 \times 15 \times 2,190}{365 \times 6 \times \left(\left(\frac{1}{0.1} \cdot 10^{-6} \times 400 \times 1 \right) + \left(\frac{1}{0.029} \times \left(\left(10 \times \frac{1}{7.25 \cdot 10^8} \right) + \left(\frac{10}{2} \times \left(\frac{1}{709} + \frac{1}{13,072} \right) \right) \right) \right) + \left(\frac{1}{0.1} \cdot 10^{-6} \times 4,200 \times 0.2 \times 0.1 \cdot 10^{-6} \right) \right)} = 57$$

Standard Residential

$$SSV(mg / kg) = \frac{1 \times 15 \times 2,190}{350 \times 6 \times \left(\left(\frac{1}{0.1} \cdot 10^{-6} \times 200 \times 1 \right) + \left(\frac{1}{0.029} \times \left(\left(10 \times \frac{1}{1.3 \cdot 10^9} \right) + \left(\frac{10}{2} \times \left(\frac{1}{709} + \frac{1}{13,072} \right) \right) \right) \right) + \left(\frac{1}{0.1} \cdot 10^{-6} \times 2100 \times 0.2 \times 0.1 \cdot 10^{-6} \right) \right)} = 60$$

Commercial/Industrial

$$SSV(mg / kg) = \frac{1 \times 70 \times 10,950}{250 \times 30 \times \left(\left(\frac{1}{0.1} \cdot 10^{-6} \times 100 \times 1 \right) + \left(\frac{1}{0.029} \times \left(\left(10.4 \times \frac{1}{3.22 \cdot 10^8} \right) + \left(\frac{10.4}{2} \times \left(\frac{1}{1,052} + \frac{1}{13,072} \right) \right) \right) \right) + \left(\frac{1}{0.1} \cdot 10^{-6} \times 13,110 \times 0.07 \times 0.1 \cdot 10^{-6} \right) \right)} = 540$$

MAH: XYLENES

XYLENE

Environmental Occurrence

Xylenes is the common name for a mixture of three isomers of dimethylbenzene and ethylbenzene. Xylenes are naturally occurring aromatic hydrocarbon compounds found in crude oil, coal tar and released from wood burning and forest fires.

Xylenes have a low aqueous solubility, lower than benzene. Most soils contain very little or any xylene as a result of natural processes or diffuse pollution sources. Benzene, toluene, ethylbenzene and xylene are referred to as BTEX compounds and have similar chemical properties and are commonly found together in petroleum products.

Almost all xylenes produced are used as additives in petrol. They are also used as industrial solvents in the production of printing inks and paints, and in the manufacturing of plastics, rubbers, pesticides and pharmaceuticals.

Xylene will volatilise from surface soils, but at less rapidly than benzene and toluene. Upon release to the soil xylene will tend to sink through the unsaturated zone until it reaches the saturated zone where it can form a non-aqueous phase liquid (NAPL).

Xylene in soil is also subject to microbial degradation under both aerobic and anaerobic conditions. Environmental half-lives are dependant on contaminant concentrations, soil conditions, particularly oxygen levels, soil temperature, microbial population and the presence of other contaminants. m-Xylene and p-xylene are readily biodegradable and o-xylene is more persistent.

Toxicity

Toxicity to the central nervous system is the main human health concern following long term inhalation exposure. Based on recorded experimental studies on laboratory animals, indicate inhalation of xylene can affect the kidneys and can reduce bodyweight.

Xylene is primarily a membrane irritant which causes erythema, dehydration, defatting and blistering of the skin.

Due to high vapour pressures, inhalation of dust is unlikely to be of concern.

Xylene is a solvent and thus has the potential to react with and permeate certain types of plastic water pipes particularly if free phase is present.

Soil Screening Values

	All land uses Protective of the Water Resource	Informal Residential	Standard Residential	Commercial/ Industrial
Xylene	45 mg/kg	91 mg/kg	95 mg/kg	890 mg/kg

Target Water Quality

	Drinking Water (WHO, 2008)	Aquatic Water Quality (UK EQS Salmonid, Current)
Xylene	0.5 mg/l	0.03 mg/l

Equation Sample

Table 37: Exposure Parameters Xylene

Parameter		Informal Residential	Standard Residential	Commercial/ Industrial
THI	Target Hazard Index	1	1	1
TR	Target Risk	1E-05	1E-05	1E-05
BW	Body Weight (kg)	15	15	70
AT	Averaging Time (days)	2,190	2,190	10,950
EF	Exposure Frequency (days/yr)	365	350	250
ED	Exposure Duration (yrs)	6	6	30
IRs	Ingestion Rate (Soil) (mg/day)	400	200	100
IRa	Ingestion Rate (Air) (mg/day)	10	10	10.4
GI	GI Absorption Factor	1	1	1
PEF	Particulate Emission Factor (m ³ /kg)	7.25E+08	1.30E+09	3.22E+08
VFi	Volatilisation Factor (m ³ /kg)	348	348	524
VFo	Volatilisation Factor (m ³ /kg)	13,072	13,072	13,072
SA	Surface Area of Exposed Skin (cm ²)	4,200	2,100	13,110
AF	Skin Adherence Factor (mg/ cm ² /day)	0.2	0.2	0.07
ABS	Dermal Absorption Factor	0.1	0.1	0.1

Table 38: Toxicological Data Xylene

Parameter		Informal Residential	Standard Residential	Commercial/ Industrial
RfDo	Reference Dosage (Oral)	2	2	2
RfDi	Reference Dosage (Inhalation)	0.09	0.09	0.09
RfDd	Reference Dosage (Dermal)	2	2	2
SFo	Slope Factor (Oral)	-	-	-
SFa	Slope Factor (Air)	-	-	-
SFd	Slope Factor (Dermal)	-	-	-

Xylene

$$SSV(mg / kg) = \frac{THI \times BW \times AT}{EF \times ED \times \left(\left(\frac{1}{RfD_o} \cdot 10^{-6} \times IR_s \times GI \right) + \left(\frac{1}{RfD_i} \times \left(\left(IR_a \times \frac{1}{PEF} \right) + \left(\frac{IR_a}{2} \times \left(\frac{1}{VF_i} + \frac{1}{VF_o} \right) \right) \right) \right) + \left(\frac{1}{RfD_D} \cdot 10^{-6} \times SA \times AF \times ABS \cdot 10^{-6} \right) \right)}$$

Informal Residential

$$SSV(mg / kg) = \frac{1 \times 15 \times 2,190}{365 \times 6 \times \left(\left(\frac{1}{2} \cdot 10^{-6} \times 400 \times 1 \right) + \left(\frac{1}{0.09} \times \left(\left(10 \times \frac{1}{7.25 \cdot 10^8} \right) + \left(\frac{10}{2} \times \left(\frac{1}{348} + \frac{1}{13,072} \right) \right) \right) \right) + \left(\frac{1}{2} \cdot 10^{-6} \times 4,200 \times 0.2 \times 0.1 \cdot 10^{-6} \right) \right)} = 91$$

Standard Residential

$$SSV(mg / kg) = \frac{1 \times 15 \times 2,190}{350 \times 6 \times \left(\left(\frac{1}{2} \cdot 10^{-6} \times 200 \times 1 \right) + \left(\frac{1}{0.09} \times \left(\left(10 \times \frac{1}{1.3 \cdot 10^9} \right) + \left(\frac{10}{2} \times \left(\frac{1}{348} + \frac{1}{13,072} \right) \right) \right) \right) + \left(\frac{1}{2} \cdot 10^{-6} \times 2100 \times 0.2 \times 0.1 \cdot 10^{-6} \right) \right)} = 95$$

Commercial/Industrial

$$SSV(mg / kg) = \frac{1 \times 70 \times 10,950}{250 \times 30 \times \left(\left(\frac{1}{2} \cdot 10^{-6} \times 100 \times 1 \right) + \left(\frac{1}{0.09} \times \left(\left(10.4 \times \frac{1}{3.22 \cdot 10^8} \right) + \left(\frac{10.4}{2} \times \left(\frac{1}{524} + \frac{1}{13,072} \right) \right) \right) \right) + \left(\frac{1}{2} \cdot 10^{-6} \times 13,110 \times 0.07 \times 0.1 \cdot 10^{-6} \right) \right)} = 890$$

AROMATICS: NAPHTHALENE

NAPHTHALENE

Environmental Occurrence

Naphthalene is a very common, relatively light, semi-volatile polyaromatic hydrocarbon (PAH) found in petroleum products, particularly in diesel and fuel oils. Naphthalene is present in coal tars, asphalt and creosote, and occurs in wood smoke and cigarette smoke.

Most soils will contain very little naphthalene as a result of natural processes. No natural background levels can be established. Naphthalene is relatively mobile in the aqueous environment and is especially hazardous due to its toxicity.

Toxicity

The primary source of naphthalene exposure is via inhalation of vapours. Chronic exposure may result in irritation of eyes, skin and the respiratory tract. Ingestion and dermal exposure can lead to impacts on the liver, kidney, blood, skin and central nervous system. Commonly encountered exposure to naphthalene in the form of mothballs can result in hemolytic anemia, and nausea, vomiting and abdominal pain.

Soil Screening Values

	All land uses Protective of the Water Resource	Informal Residential	Standard Residential	Commercial/ Industrial
Naphthalene	28 mg/kg	28 mg/kg	33 mg/kg	290 mg/kg

Target Water Quality

	Drinking Water	Aquatic Water Quality (NOAA, 2008)
Naphthalene	-	0.0011 mg/l

Equation Samples

Table 39: Exposure Parameters Naphthalene

Parameter		Informal Residential	Standard Residential	Commercial/ Industrial
THI	Target Hazard Index	1	1	1
TR	Target Risk	1E-05	1E-05	1E-05
BW	Body Weight (kg)	15	15	70
AT	Averaging Time (days)	2,190	2,190	10,950
EF	Exposure Frequency (days/yr)	365	350	250
ED	Exposure Duration (yrs)	6	6	30
IR _s	Ingestion Rate (Soil) (mg/day)	400	200	100
IR _a	Ingestion Rate (Air) (mg/day)	10	10	10.4
GI	GI Absorption Factor	1	1	1
PEF	Particulate Emission Factor (m ³ /kg)	7.25E+08	1.30E+09	3.22E+08
VF _i	Volatilisation Factor (m ³ /kg)	3,425	3,425	5,155
VF _o	Volatilisation Factor (m ³ /kg)	25,707	25,707	25,707
SA	Surface Area of Exposed Skin (cm ²)	4,200	2,100	13,110
AF	Skin Adherence Factor (mg/ cm ² /day)	0.2	0.2	0.07
ABS	Dermal Absorption Factor	0.1	0.1	0.1

Table 40: Toxicological Data Naphthalene

Parameter		Informal Residential	Standard Residential	Commercial/ Industrial
RfD _o	Reference Dosage (Oral)	0.004	0.004	0.004
RfD _i	Reference Dosage (Inhalation)	0.004	0.004	0.004
RfD _d	Reference Dosage (Dermal)	0.004	0.004	0.004
SF _o	Slope Factor (Oral)	-	-	-
SF _a	Slope Factor (Air)	-	-	-
SF _d	Slope Factor (Dermal)	-	-	-

Naphthalene

$$SSV(mg / kg) = \frac{THI \times BW \times AT}{EF \times ED \times \left(\left(\frac{1}{RfD_o} \cdot 10^{-6} \times IR_s \times GI \right) + \left(\frac{1}{RfD_i} \times \left(\left(IR_a \times \frac{1}{PEF} \right) + \left(\frac{IR_a}{2} \times \left(\frac{1}{VF_i} + \frac{1}{VF_o} \right) \right) \right) \right) + \left(\frac{1}{RfD_D} \cdot 10^{-6} \times SA \times AF \times ABS \cdot 10^{-6} \right) \right)}$$

Informal Residential

$$SSV(mg / kg) = \frac{1 \times 15 \times 2,190}{365 \times 6 \times \left(\left(\frac{1}{0.004} \cdot 10^{-6} \times 400 \times 1 \right) + \left(\frac{1}{0.004} \times \left(\left(10 \times \frac{1}{7.25 \cdot 10^8} \right) + \left(\frac{10}{2} \times \left(\frac{1}{3,425} + \frac{1}{25,707} \right) \right) \right) \right) + \left(\frac{1}{0.004} \cdot 10^{-6} \times 4,200 \times 0.2 \times 0.1 \cdot 10^{-6} \right) \right)} = 28$$

Standard Residential

$$SSV(mg / kg) = \frac{1 \times 15 \times 2,190}{350 \times 6 \times \left(\left(\frac{1}{0.004} \cdot 10^{-6} \times 200 \times 1 \right) + \left(\frac{1}{0.004} \times \left(\left(10 \times \frac{1}{1.3 \cdot 10^9} \right) + \left(\frac{10}{2} \times \left(\frac{1}{3,425} + \frac{1}{25,707} \right) \right) \right) \right) + \left(\frac{1}{0.004} \cdot 10^{-6} \times 2100 \times 0.2 \times 0.1 \cdot 10^{-6} \right) \right)} = 33$$

Commercial/Industrial

$$SSV(mg / kg) = \frac{1 \times 70 \times 10,950}{250 \times 30 \times \left(\left(\frac{1}{0.004} \cdot 10^{-6} \times 100 \times 1 \right) + \left(\frac{1}{0.004} \times \left(\left(10.4 \times \frac{1}{3.22 \cdot 10^8} \right) + \left(\frac{10.4}{2} \times \left(\frac{1}{5,155} + \frac{1}{25,707} \right) \right) \right) \right) + \left(\frac{1}{0.004} \cdot 10^{-6} \times 13,110 \times 0.07 \times 0.1 \cdot 10^{-6} \right) \right)} = 290$$

AROMATICS: PYRENE

Poly Aromatic Hydrocarbons (PAH)

Environmental Occurrence

Polycyclic aromatic hydrocarbons (PAHs) are a group of over 100 different chemicals that are formed during the incomplete burning of coal, oil and gas, garbage, or other organic substances like tobacco or meat. PAHs are usually found as a mixture containing two or more of these compounds, such as soot.

Some PAHs are manufactured. These pure PAHs usually exist as colorless, white, or pale yellow-green solids. PAHs are found in coal tar, crude oil, creosote, and roofing tar, but a few are used in medicines or to make dyes, plastics, and pesticides.

PAHs enter the air mostly as releases from volcanoes, forest fires, burning coal, and automobile exhausts. PAHs can occur in air attached to dust particles. Some PAH particles can readily evaporate into the air from soil or surface waters. PAHs can break down by reacting with sunlight and other chemicals in the air, over a period of days to weeks. Most PAHs do not dissolve easily in water. They stick to solid particles and settle to the bottoms of lakes or rivers. In soils, PAHs are most likely to stick tightly to the soil particles; certain PAHs move through soil to contaminate underground water and form dense non-aqueous phase liquids (DNAPL).

For the purpose of the Framework two indicative PAH compounds: Pyrene and Benzo(a)pyrene are listed.

Toxicity

Animal studies have also shown that PAHs can cause harmful effects on the skin, body fluids, and ability to fight disease after both short- and long-term exposure, but these effects have not been seen in people.

Some people who have breathed or touched mixtures of PAHs and other chemicals for long periods of time have developed cancer. Some PAHs have caused cancer in laboratory animals when they breathed air containing them (lung cancer), ingested them in food (stomach cancer), or had them applied to their skin (skin cancer).

In the Framework two PAH compounds as broad indicators of risk. Pyrene is a heavy PAH compound which is toxic but is not classified as a human carcinogen. Benzo(a)pyrene is a commonly occurring PAH compound which is considered to be a human carcinogen.

Soil Screening Values

	All land uses Protective of the Water Resource	Informal Residential	Standard Residential	Commercial/ Industrial
Pyrene	5.3 mg/kg	920 mg/kg	1,900 mg/kg	15,000 mg/kg
Benzo(a)pyrene	0.34 mg/kg	0.34 mg/kg	0.71 mg/kg	1.7 mg/kg

Target Water Quality

	Drinking Water	Aquatic Water Quality (NOAA, 2008)
Pyrene	-	0.0000025 mg/l
Benzo(a)pyrene	-	0.95 mg/l

Equation Samples

Soil Screening Value - Pyrene

Table 41: Exposure Parameters Pyrene

Parameter		Informal Residential	Standard Residential	Commercial/ Industrial
THI	Target Hazard Index	1	1	1
TR	Target Risk	1E-05	1E-05	1E-05
BW	Body Weight (kg)	15	15	70
AT	Averaging Time (days)	2,190	2,190	10,950
EF	Exposure Frequency (days/yr)	365	350	250
ED	Exposure Duration (yrs)	6	6	30
IR _s	Ingestion Rate (Soil) (mg/day)	400	200	100
IR _a	Ingestion Rate (Air) (mg/day)	10	10	10.4
GI	GI Absorption Factor	1	1	1
PEF	Particulate Emission Factor (m ³ /kg)	7.25E+08	1.30E+09	3.22E+08
VF _i	Volatilisation Factor (m ³ /kg)	2.94E+07	2.94E+07	4.41E+07
VF _o	Volatilisation Factor (m ³ /kg)	2.46E+06	2.46E+06	2.46E+06
SA	Surface Area of Exposed Skin (cm ²)	4,200	2,100	13,110
AF	Skin Adherence Factor (mg/ cm ² /day)	0.2	0.2	0.07
ABS	Dermal Absorption Factor	0.1	0.1	0.1

Table 42: Toxicological Data Pyrene

Parameter		Informal Residential	Standard Residential	Commercial/ Industrial
RfD _o	Reference Dosage (Oral)	0.03	0.03	0.03
RfD _i	Reference Dosage (Inhalation)	0.03	0.03	0.03
RfD _d	Reference Dosage (Dermal)	0.03	0.03	0.03
SF _o	Slope Factor (Oral)	-	-	-
SF _a	Slope Factor (Air)	-	-	-
SF _d	Slope Factor (Dermal)	-	-	-

Pyrene

$$SSV(mg / kg) = \frac{THI \times BW \times AT}{EF \times ED \times \left(\left(\frac{1}{RfD_O} \cdot 10^{-6} \times IR_S \times GI \right) + \left(\frac{1}{RfD_i} \times \left(\left(IR_a \times \frac{1}{PEF} \right) + \left(\frac{IR_a}{2} \times \left(\frac{1}{VF_i} + \frac{1}{VF_O} \right) \right) \right) \right) + \left(\frac{1}{RfD_D} \cdot 10^{-6} \times SA \times AF \times ABS \cdot 10^{-6} \right) \right)}$$

Informal Residential

$$SSV(mg / kg) = \frac{1 \times 15 \times 2,190}{365 \times 6 \times \left(\left(\frac{1}{0.03} \cdot 10^{-6} \times 400 \times 1 \right) + \left(\frac{1}{0.03} \times \left(\left(10 \times \frac{1}{7.25 \cdot 10^8} \right) + \left(\frac{10}{2} \times \left(\frac{1}{2.94 \cdot 10^7} + \frac{1}{1.46 \cdot 10^6} \right) \right) \right) \right) + \left(\frac{1}{0.03} \cdot 10^{-6} \times 4,200 \times 0.2 \times 0.1 \cdot 10^{-6} \right) \right)} = 920$$

Standard Residential

$$SSV(mg / kg) = \frac{1 \times 15 \times 2,190}{350 \times 6 \times \left(\left(\frac{1}{0.03} \cdot 10^{-6} \times 200 \times 1 \right) + \left(\frac{1}{0.03} \times \left(\left(10 \times \frac{1}{1.3 \cdot 10^9} \right) + \left(\frac{10}{2} \times \left(\frac{1}{2.94 \cdot 10^7} + \frac{1}{1.46 \cdot 10^6} \right) \right) \right) \right) + \left(\frac{1}{0.03} \cdot 10^{-6} \times 2100 \times 0.2 \times 0.1 \cdot 10^{-6} \right) \right)} = 1,900$$

Commercial/Industrial

$$SSV(mg / kg) = \frac{1 \times 70 \times 10,950}{250 \times 30 \times \left(\left(\frac{1}{0.03} \cdot 10^{-6} \times 100 \times 1 \right) + \left(\frac{1}{0.03} \times \left(\left(10.4 \times \frac{1}{3.22 \cdot 10^8} \right) + \left(\frac{10.4}{2} \times \left(\frac{1}{4.41 \cdot 10^7} + \frac{1}{1.46 \cdot 10^6} \right) \right) \right) \right) + \left(\frac{1}{0.03} \cdot 10^{-6} \times 13,110 \times 0.07 \times 0.1 \cdot 10^{-6} \right) \right)} = 15,000$$

AROMATICS: BENZO(A)PYRENE

Soil Screening Value – Benzo(a)pyrene

Table 43: Exposure Parameters Benzo(a)pyrene

Parameter		Informal Residential	Standard Residential	Commercial/ Industrial
THI	Target Hazard Index	1	1	1
TR	Target Risk	1E-05	1E-05	1E-05
BW	Body Weight (kg)	70	70	70
AT	Averaging Time (days)	25,550	25,550	25,550
EF	Exposure Frequency (days/yr)	365	350	250
ED	Exposure Duration (yrs)	70	70	30
IR _s	Ingestion Rate (Soil) (mg/day)	200	100	100
IR _a	Ingestion Rate (Air) (mg/day)	20	20	10.4
GI	GI Absorption Factor	1	1	1
PEF	Particulate Emission Factor (m ³ /kg)	7.25E+08	1.3E+09	3.22E+08
VF _i	Volatilisation Factor (m ³ /kg)	2.32E+09	2.32E+09	1.13E+10
VF _o	Volatilisation Factor (m ³ /kg)	4.52E+07	4.52E+07	4.52E+07
SA	Surface Area of Exposed Skin (cm ²)	11,600	5,800	13,110
AF	Skin Adherence Factor (mg/cm ² /day)	0.07	0.07	0.07
ABS	Dermal Absorption Factor	0.1	0.1	0.1

Table 44: Toxicological Data Benzo(a)pyrene

Parameter		Informal Residential	Standard Residential	Commercial/ Industrial
RfD _o	Reference Dosage (Oral)	-	-	-
RfD _i	Reference Dosage (Inhalation)	-	-	-
RfD _d	Reference Dosage (Dermal)	-	-	-
SF _o	Slope Factor (Oral)	7.3	7.3	7.3
SF _a	Slope Factor (Air)	7.3	7.3	7.3
SF _d	Slope Factor (Dermal)	7.3	7.3	7.3

Benzo(a)pyrene

$$SSV(mg / kg) = \frac{TR \times BW \times AT}{EF \times ED \times \left((SF_o \times 10^{-6} \times IR_s \times GI) + \left(SF_o \times \left(\left(IR_a \times \frac{1}{PEF} \right) + \left(\frac{IR_a}{2} \times \left(\frac{1}{VF_i} + \frac{1}{VF_o} \right) \right) \right) \right) + (SF_D \times SA \times AF \times ABS \times 10^{-6}) \right)}$$

Informal Residential

$$SSV(mg / kg) = \frac{1 \cdot 10^{-5} \times 70 \times 25,550}{365 \times 70 \times \left((7.3 \times 10^{-6} \times 200 \times 1) + \left(7.3 \times \left(\left(20 \times \frac{1}{7.25 \cdot 10^8} \right) + \left(\frac{20}{2} \times \left(\frac{1}{2.32 \cdot 10^9} + \frac{1}{4.52 \cdot 10^7} \right) \right) \right) \right) + (7.3 \times 11,600 \times 0.07 \times 0.1 \times 10^{-6}) \right)} = 0.34$$

Standard Residential

$$SSV(mg / kg) = \frac{1 \cdot 10^{-5} \times 70 \times 25,550}{350 \times 70 \times \left((7.3 \times 10^{-6} \times 100 \times 1) + \left(7.3 \times \left(\left(20 \times \frac{1}{1.3 \cdot 10^9} \right) + \left(\frac{20}{2} \times \left(\frac{1}{2.32 \cdot 10^9} + \frac{1}{4.52 \cdot 10^7} \right) \right) \right) \right) + (7.3 \times 5,800 \times 0.07 \times 0.1 \times 10^{-6}) \right)} = 0.71$$

Commercial/Industrial

$$SSV(mg / kg) = \frac{1 \cdot 10^{-5} \times 70 \times 25,550}{250 \times 30 \times \left((7.3 \times 10^{-6} \times 100 \times 1) + \left(7.3 \times \left(\left(10.4 \times \frac{1}{3.22 \cdot 10^8} \right) + \left(\frac{10.4}{2} \times \left(\frac{1}{1.13 \cdot 10^{10}} + \frac{1}{4.52 \cdot 10^7} \right) \right) \right) \right) + (7.3 \times 13,110 \times 0.07 \times 0.1 \times 10^{-6}) \right)} = 1.7$$

PETROLEUM ADDITIVES: MTBE

METHYL TERTIARY BUTYL ETHER (MTBE)

Environmental Occurrence

Methyl tertiary butyl ether (methyl tert-butyl ether, methyl t-butyl ether, or MTBE) is a chemical compound used as a fuel additive in petrol. MTBE is an oxygenate, meaning it increases the oxygen content of the fuel, and is also a source of octane in petrol.

While the use of MTBE as a fuel additive in petrol has helped to reduce harmful air emissions, it is a potential contaminant of surface water and groundwater. Leakage from the petrol storage and distribution system is a major source of contamination, but the contamination also comes from spills, emissions from marine engines into lakes and reservoirs, and to some extent from air deposition.

The presence of MTBE in drinking water sources presents two major problems. The first concern is that MTBE contamination may render water supplies unusable as drinking water. MTBE has an offensive taste and odor which can be detected in water even at low levels.

Once MTBE contaminates a drinking water source, its chemical nature makes it difficult, expensive, and time-consuming to remediate. For example, it is much harder and more expensive to remove MTBE from drinking water than it is to remove other organic components of petrol. Furthermore, MTBE does not biodegrade as readily as other components of gasoline.

Toxicity

The majority of the human health-related research conducted to date on MTBE has focused on adverse effects that might result through inhalation of the chemical. At high doses by the inhalation route, MTBE has caused non-cancer health effects as well as tumors in two strains of rat and one strain of mouse in a variety of organs; however, studies have been lacking for human or animal health effects resulting from the ingestion of MTBE in drinking water.

USEPA classified MTBE as a 'possible' human carcinogen under its 1986 cancer risk assessment guidelines on the basis of results of inhalation cancer tests and has suggested that it be regarded as posing a potential carcinogenic hazard and risk to humans, though no quantitative estimate of the cancer potency of MTBE has been established by USEPA because of limitations in the available data.

USEPA reviewed available health effects information on MTBE in its 1997 drinking water advisory guidance and determined that there was insufficient information available on MTBE health effects and exposure to allow EPA to establish a national primary drinking water regulation. The drinking water advisory document indicated there is little likelihood that MTBE concentrations between 20 and 40 µg/L would cause adverse health effects.

Soil Screening Values

	All land uses Protective of the Water Resource	Informal Residential	Standard Residential	Commercial/ Industrial
MTBE	0.0036 mg/kg	360 mg/kg	370 mg/kg	5,800 mg/kg

Target Water Quality

	Drinking Water (WHO, 2008)	Aquatic Water Quality (BC Aquatic, 2006)
MTBE	0.0015 (odour)	3.4 mg/l

Equation Sample

Table 45: Exposure Parameters MTBE

Parameter		Informal Residential	Standard Residential	Commercial/ Industrial
THI	Target Hazard Index	1	1	1
TR	Target Risk	1E-05	1E-05	1E-05
BW	Body Weight (kg)	15	15	70
AT	Averaging Time (days)	2,190	2,190	10,950
EF	Exposure Frequency (days/yr)	365	350	250
ED	Exposure Duration (yrs)	6	6	30
IR _s	Ingestion Rate (Soil) (mg/day)	400	200	100
IR _a	Ingestion Rate (Air) (mg/day)	10	10	10.4
GI	GI Absorption Factor	1	1	1
PEF	Particulate Emission Factor (m ³ /kg)	7.25E+08	1.30E+09	3.22E+08
VF _i	Volatilisation Factor (m ³ /kg)	140	140	345
VF _o	Volatilisation Factor (m ³ /kg)	1.28E+06	1.28E+06	1.28E+06
SA	Surface Area of Exposed Skin (cm ²)	4,200	2,100	13,110
AF	Skin Adherence Factor (mg/cm ² /day)	0.2	0.2	0.07
ABS	Dermal Absorption Factor	0.1	0.1	0.1

Table 46: Toxicological Data MTBE

Parameter		Informal Residential	Standard Residential	Commercial/ Industrial
RfD _o	Reference Dosage (Oral)	-	-	-
RfD _i	Reference Dosage (Inhalation)	0.857	0.857	0.857
RfD _d	Reference Dosage (Dermal)	-	-	-
SF _o	Slope Factor (Oral)	-	-	-
SF _a	Slope Factor (Air)	-	-	-
SF _d	Slope Factor (Dermal)	-	-	-

MTBE

Threshold calculation with no oral and dermal RfD available.

$$SSV(mg / kg) = \frac{THI \times BW \times AT}{EF \times ED \times \left(\frac{1}{RfD_i} \times \left(IR_a \times \frac{1}{PEF} \right) + \left(\frac{IR_a}{2} \times \left(\frac{1}{VF_i} + \frac{1}{VFO} \right) \right) \right)}$$

Informal Residential

$$SSV(mg / kg) = \frac{1 \times 15 \times 2,190}{365 \times 6 \times \left(\frac{1}{0.857} \times \left(10 \times \frac{1}{7.25 \cdot 10^8} \right) + \left(\frac{10}{2} \times \left(\frac{1}{140} + \frac{1}{1.28 \cdot 10^6} \right) \right) \right)} = 360$$

Standard Residential

$$SSV(mg / kg) = \frac{1 \times 15 \times 2,190}{350 \times 6 \times \left(\frac{1}{0.857} \times \left(10 \times \frac{1}{1.3 \cdot 10^9} \right) + \left(\frac{10}{2} \times \left(\frac{1}{140} + \frac{1}{1.28 \cdot 10^6} \right) \right) \right)} = 370$$

Commercial/Industrial

$$SSV(mg / kg) = \frac{1 \times 70 \times 2,190}{250 \times 30 \times \left(\frac{1}{0.857} \times \left(10.4 \times \frac{1}{3.22 \cdot 10^8} \right) + \left(\frac{10.4}{2} \times \left(\frac{1}{345} + \frac{1}{1.28 \cdot 10^6} \right) \right) \right)} = 5,800$$

ORGANICS: CARBON TETRACHLORIDE

CARBON TETRACHLORIDE

Environmental Occurrence

Carbon Tetrachloride was used mainly as a solvent, degreasing fluid and in the manufacturing of refrigeration fluids and propellants for aerosols. Use is mostly discontinued, but Carbon Tetrachloride is environmentally persistent and is thus widely distributed as a trace contaminant associated with previous use and in solvent wastes.

There are no natural sources of Carbon Tetrachloride in the environment.

Toxicity

Inhalation of vapour is the most common route of environmental exposure. Carbon Tetrachloride has a high vapour pressure and a low affinity for soil adsorption. Ingestion of contaminated water is a possible exposure route. Dermal exposure is unlikely to be a significant route of environmental exposure.

Depression of the central nervous system and irritation of the gastrointestinal tract is associated with mild exposure. The liver and kidneys are sensitive organs for chronic exposure. High levels of inhalation exposure are associated with anemia and reduced platelet function.

Carbon Tetrachloride is a probable human carcinogen. Genotoxicity may result from binding to the DNA in the liver. Carbon Tetrachloride is carcinogenic in animals via chronic inhalation or oral exposure. Cancers of the liver, kidneys and lymphatic system are recorded for animals.

Soil Screening Values

	All land uses Protective of the Water Resource	Informal Residential	Standard Residential	Commercial/ Industrial
Carbon Tetrachloride	0.25 mg/kg	0.26 mg/kg	0.27 mg/kg	4 mg/kg

Target Water Quality

	Drinking Water (WHO, 2008)	Aquatic Water Quality (UK EQS Salmonid, Current)
Carbon Tetrachloride	0.004 mg/l	0.01 mg/l

Equation Sample

Table 47: Exposure Parameters Carbon Tetrachloride

Parameter		Informal Residential	Standard Residential	Commercial/ Industrial
THI	Target Hazard Index	1	1	1
TR	Target Risk	1E-05	1E-05	1E-05
BW	Body Weight (kg)	70	70	70
AT	Averaging Time (days)	25,550	25,550	25,550
EF	Exposure Frequency (days/yr)	365	350	250
ED	Exposure Duration (yrs)	70	70	30
IR _s	Ingestion Rate (Soil) (mg/day)	200	100	100
IR _a	Ingestion Rate (Air) (mg/day)	20	20	10.4
GI	GI Absorption Factor	1	1	1
PEF	Particulate Emission Factor (m ³ /kg)	7.25E+08	1.30E+09	3.22E+08
VF _i	Volatilisation Factor (m ³ /kg)	95,414	95,414	235,120
VF _o	Volatilisation Factor (m ³ /kg)	1.77E+09	1.77E+09	1.77E+09
SA	Surface Area of Exposed Skin (cm ²)	11,600	5,800	13,110
AF	Skin Adherence Factor (mg/cm ² /day)	0.07	0.07	0.07
ABS	Dermal Absorption Factor	0.1	0.1	0.1

Table 48: Toxicological Data Carbon Tetrachloride

Parameter		Informal Residential	Standard Residential	Commercial/ Industrial
RfD _o	Reference Dosage (Oral)	-	-	-
RfD _i	Reference Dosage (Inhalation)	-	-	-
RfD _d	Reference Dosage (Dermal)	-	-	-
SF _o	Slope Factor (Oral)	0.13	0.13	0.13
SF _a	Slope Factor (Air)	0.053	0.053	0.053
SF _d	Slope Factor (Dermal)	-	-	-

Carbon Tetrachloride

Threshold calculation with no dermal slope factor available

$$SSV(\text{mg/kg}) = \frac{TR \times BW \times AT}{EF \times ED \times \left((SF_o \times 10^{-6} \times IR_s \times GI) + \left(SF_i \times \left(\left(IR_a \times \frac{1}{PEF} \right) + \left(\frac{IR_a}{2} \times \left(\frac{1}{VF_i} + \frac{1}{VF_o} \right) \right) \right) \right) \right)}$$

Informal Residential

$$SSV(\text{mg/kg}) = \frac{1 \cdot 10^{-5} \times 70 \times 25,550}{365 \times 70 \times \left((0.13 \times 10^{-6} \times 200 \times 1) + \left(0.053 \times \left(\left(20 \times \frac{1}{7.25 \cdot 10^8} \right) + \left(\frac{20}{2} \times \left(\frac{1}{194} + \frac{1}{571,047} \right) \right) \right) \right) \right)} = 0.26$$

Standard Residential

$$SSV(\text{mg/kg}) = \frac{1 \cdot 10^{-5} \times 70 \times 25,550}{350 \times 70 \times \left((0.13 \times 10^{-6} \times 100 \times 1) + \left(0.053 \times \left(\left(20 \times \frac{1}{1.3 \cdot 10^9} \right) + \left(\frac{20}{2} \times \left(\frac{1}{194} + \frac{1}{571,047} \right) \right) \right) \right) \right)} = 0.27$$

Commercial/Industrial

$$SSV(\text{mg/kg}) = \frac{1 \cdot 10^{-5} \times 70 \times 25,550}{250 \times 30 \times \left((0.13 \times 10^{-6} \times 100 \times 1) + \left(0.053 \times \left(\left(10.4 \times \frac{1}{3.22 \cdot 10^8} \right) + \left(\frac{10.4}{2} \times \left(\frac{1}{479} + \frac{1}{571,047} \right) \right) \right) \right) \right)} = 4$$

ORGANICS: CHLOROBENZENE

CHLOROBENZENE

Environmental Occurrence

Chlorobenzene is a colourless, flammable liquid with an almond-like odour, which is partially soluble in water and readily evaporates in air.

Chlorobenzene is used as a solvent for some pesticide formations and was used in the manufacture of DDT. It is used as an automotive degreaser and as an intermediate in chemical production.

There are no natural sources of chlorobenzene in the environment.

Chlorobenzene is volatile and is lost from surface soil readily by evaporation. Breakdown by bacterial action also occurs.

Toxicity

High levels of exposure to chlorobenzene can damage the liver and kidneys and can affect the brain. Impacts on the central nervous system include headaches, nausea, numbness and vomiting.

Chlorobenzene is not considered to be carcinogenic.

Soil Screening Values

	All land uses Protective of the Water Resource	Informal Residential	Standard Residential	Commercial/ Industrial
Chlorobenzene	620 mg/kg	620 mg/kg	1,200 mg/kg	10,000 mg/kg

Target Water Quality

	Drinking Water	Aquatic Water Quality (NOAA Squirts, 2008)
Chlorobenzene	-	0.13 mg/l

Equation Sample

Table 49: Exposure Parameters Chlorobenzene

Parameter		Informal Residential	Standard Residential	Commercial/ Industrial
THI	Target Hazard Index	1	1	1
TR	Target Risk	1E-05	1E-05	1E-05
BW	Body Weight (kg)	15	15	70
AT	Averaging Time (days)	2,190	2,190	10,950
EF	Exposure Frequency (days/yr)	365	350	250
ED	Exposure Duration (yrs)	6	6	30
IR _s	Ingestion Rate (Soil) (mg/day)	400	200	100
IR _a	Ingestion Rate (Air) (mg/day)	10	10	10.4
GI	GI Absorption Factor	1	1	1
PEF	Particulate Emission Factor (m ³ /kg)	7.25E+08	1.30E+09	3.22E+08
VF _i	Volatilisation Factor (m ³ /kg)	1,106	1,106	2,724
VF _o	Volatilisation Factor (m ³ /kg)	3.77E+06	3.77E+06	3.77E+06
SA	Surface Area of Exposed Skin (cm ²)	4,200	2,100	13,110
AF	Skin Adherence Factor (mg/cm ² /day)	0.2	0.2	0.07
ABS	Dermal Absorption Factor	0.1	0.1	0.1

Table 50: Toxicological Data Chlorobenzene

Parameter		Informal Residential	Standard Residential	Commercial/ Industrial
RfD _o	Reference Dosage (Oral)	0.02	0.02	0.02
RfD _i	Reference Dosage (Inhalation)	-	-	-
RfD _d	Reference Dosage (Dermal)	0.02	0.02	0.02
SF _o	Slope Factor (Oral)	-	-	-
SF _a	Slope Factor (Air)	-	-	-
SF _d	Slope Factor (Dermal)	-	-	-

Chlorobenzene

Threshold calculation with no inhalation RfD available.

$$SSV(mg/kg) = \frac{THI \times BW \times AT}{EF \times ED \times \left(\left(\frac{1}{RfD_o} \times 10^{-6} \times IR_s \times GI \right) + \left(\frac{1}{RfD_D} \times SA \times AF \times ABS \times 10^{-6} \right) \right)}$$

Informal Residential

$$SSV(mg/kg) = \frac{1 \times 15 \times 2,190}{365 \times 6 \times \left(\left(\frac{1}{0.02} \times 10^{-6} \times 400 \times 1 \right) + \left(\frac{1}{0.02} \times 4,200 \times 0.2 \times 0.1 \times 10^{-6} \right) \right)} = 620$$

Standard Residential

$$SSV(mg/kg) = \frac{1 \times 15 \times 2,190}{350 \times 6 \times \left(\left(\frac{1}{0.02} \times 10^{-6} \times 200 \times 1 \right) + \left(\frac{1}{0.02} \times 2100 \times 0.2 \times 0.1 \times 10^{-6} \right) \right)} = 1,200$$

Commercial/Industrial

$$SSV(mg/kg) = \frac{1 \times 70 \times 10,950}{250 \times 30 \times \left(\left(\frac{1}{0.02} \times 10^{-6} \times 100 \times 1 \right) + \left(\frac{1}{0.02} \times 13,110 \times 0.07 \times 0.1 \times 10^{-6} \right) \right)} = 10,000$$

ORGANICS: CHLOROFORM

CHLOROFORM

Environmental Occurrence

Chloroform (also known as trichloromethane) is a colourless liquid with a pleasant non-irritating odour. Chloroform was originally used as an anaesthetic, but this has been discontinued to the risk to health. Chloroform is mainly used in the manufacture of other organic chemicals.

Chloroform readily evaporates in air and dissolves in water and can be environmentally persistent as a contaminant of water. Chloroform breakdown products may be toxic and include phosgene and hydrogen chloride.

Chloroform has a low affinity for soil adsorption and is thus likely to migrate from soil to groundwater or partition into the vapour phase.

There are no natural sources of chloroform in the environment. Trace quantities may arise from the use of chlorine in water treatment and in swimming pools.

Toxicity

Inhalation of vapour is the most common route of environmental exposure. Inhalation of chloroform depresses the central nervous system and causes dizziness, fatigue and headaches. Chronic exposure causes damage to liver and kidneys.

Chloroform is a probable human carcinogen. Cancer of liver and kidneys is recorded for animals.

Soil Screening Values

	All land uses Protective of the Water Resource	Informal Residential	Standard Residential	Commercial/ Industrial
Chloroform	0.11 mg/kg	0.11 mg/kg	0.11 mg/kg	1.7 mg/kg

Target Water Quality

	Drinking Water (WHO, 2008)	Aquatic Water Quality (UK EQS Salmonid, Current)
Chloroform	0.3 mg/l	0.012 mg/l

Equation Sample

Table 51: Exposure Parameters Chloroform

Parameter		Informal Residential	Standard Residential	Commercial/ Industrial
THI	Target Hazard Index	1	1	1
TR	Target Risk	1E-05	1E-05	1E-05
BW	Body Weight (kg)	70	70	70
AT	Averaging Time (days)	25,550	25,550	25,550
EF	Exposure Frequency (days/yr)	365	350	250
ED	Exposure Duration (yrs)	70	70	30
IR _s	Ingestion Rate (Soil) (mg/day)	200	100	100
IR _a	Ingestion Rate (Air) (mg/day)	20	20	10.4
GI	GI Absorption Factor	1	1	1
PEF	Particulate Emission Factor (m ³ /kg)	7.25E+08	1.30E+09	3.22E+08
VF _i	Volatilisation Factor (m ³ /kg)	124	124	305
VF _o	Volatilisation Factor (m ³ /kg)	402,304	402,304	402,304
SA	Surface Area of Exposed Skin (cm ²)	11,600	5,800	13,110
AF	Skin Adherence Factor (mg/cm ² /day)	0.07	0.07	0.07
ABS	Dermal Absorption Factor	0.1	0.1	0.1

Table 52: Toxicological Data Chloroform

Parameter		Informal Residential	Standard Residential	Commercial/ Industrial
RfD _o	Reference Dosage (Oral)	-	-	-
RfD _i	Reference Dosage (Inhalation)	-	-	-
RfD _d	Reference Dosage (Dermal)	-	-	-
SF _o	Slope Factor (Oral)	-	-	-
SF _a	Slope Factor (Air)	0.081	0.081	0.081
SF _d	Slope Factor (Dermal)	-	-	-

Chloroform

Threshold calculation with no oral or dermal slope factor available

$$SSV(mg/kg) = \frac{TR \times BW \times AT}{EF \times ED \times \left(SF_i \times \left(\left(IR_a \times \frac{1}{PEF} \right) + \left(\frac{IR_a}{2} \times \left(\frac{1}{VF_i} + \frac{1}{VF_o} \right) \right) \right) \right)}$$

Informal Residential

$$SSV(mg/kg) = \frac{1 \cdot 10^{-5} \times 70 \times 25,550}{365 \times 70 \times \left(0.081 \times \left(\left(20 \times \frac{1}{7.25 \cdot 10^8} \right) + \left(\frac{20}{2} \times \left(\frac{1}{124} + \frac{1}{402,304} \right) \right) \right) \right)} = 0.11$$

Standard Residential

$$SSV(mg/kg) = \frac{1 \cdot 10^{-5} \times 70 \times 25,550}{350 \times 70 \times \left(0.081 \times \left(\left(20 \times \frac{1}{1.3 \cdot 10^9} \right) + \left(\frac{20}{2} \times \left(\frac{1}{124} + \frac{1}{402,304} \right) \right) \right) \right)} = 0.11$$

Commercial/Industrial

$$SSV(mg/kg) = \frac{1 \cdot 10^{-5} \times 70 \times 25,550}{250 \times 30 \times \left(0.081 \times \left(\left(10.4 \times \frac{1}{3.22 \cdot 10^8} \right) + \left(\frac{10.4}{2} \times \left(\frac{1}{305} + \frac{1}{402,304} \right) \right) \right) \right)} = 1.7$$

ORGANICS: 2 CHLOROPHENOL

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2 CHLOROPHENOL

Environmental Occurrence

Chlorophenols are a group of chemicals that are produced by adding chlorines to phenol. Phenol is an aromatic compound derived from benzene. There are 5 basic types of chlorophenols and 19 different chlorophenols.

Most chlorophenols are solid at room temperature. They have a strong, medicinal taste and smell.

Some chlorophenols are used as pesticides. Others are used in antiseptics. Small amounts are produced when water is disinfected with chlorine. They are also produced while bleaching wood pulp with chlorine to make paper.

Chlorophenols tend to adhere to soils and sediments and are broken down in air and water by microorganisms.

There are no natural sources of chlorophenols in the environment. Very low trace levels may be associated with chlorinated drinking water.

Toxicity

Workers exposed to pesticides that contain chlorophenols have developed acne and mild injury to their livers.

In laboratory studies, animals that received high levels of chlorophenols in food or water developed liver and immune system effects.

There is evidence to suggest that people exposed to chlorophenols for a long time may have slightly higher incidences of cancer. However, the people studied were exposed to other chemicals as well.

In animal studies, 1 chlorophenol, 2,4,6 trichlorophenol, caused leukaemia in rats and liver cancer in mice. 2,4,6 trichlorophenol may reasonably be anticipated to be a carcinogen. 2 Chlorophenol is not considered to be carcinogenic.

Soil Screening Values

	All land uses Protective of the Water Resource	Informal Residential	Standard Residential	Commercial/Industrial
2-Chlorophenol	140 mg/kg	150 mg/kg	320 mg/kg	2,600 mg/kg

Target Water Quality

	Drinking Water	Aquatic Water Quality (NOAA Squirts, 2008)
2-Chlorophenol	-	0.49 mg/l

Equation Sample

Table 53: Exposure Parameters 2 Chlorophenol

Parameter		Informal Residential	Standard Residential	Commercial/ Industrial
THI	Target Hazard Index	1	1	1
TR	Target Risk	1E-05	1E-05	1E-05
BW	Body Weight (kg)	15	15	70
AT	Averaging Time (days)	2,190	2,190	10,950
EF	Exposure Frequency (days/yr)	365	350	250
ED	Exposure Duration (yrs)	6	6	30
IR _s	Ingestion Rate (Soil) (mg/day)	400	200	100
IR _a	Ingestion Rate (Air) (mg/day)	10	10	10.4
GI	GI Absorption Factor	1	1	1
PEF	Particulate Emission Factor (m ³ /kg)	7.25E+08	1.30E+09	3.22E+08
VF _i	Volatilisation Factor (m ³ /kg)	243	243	598
VF _o	Volatilisation Factor (m ³ /kg)	3.4E+06	3.4E+06	3.4E+06
SA	Surface Area of Exposed Skin (cm ²)	4,200	2,100	13,110
AF	Skin Adherence Factor (mg/cm ² /day)	0.2	0.2	0.07
ABS	Dermal Absorption Factor	0.1	0.1	0.1

Table 54: Toxicological Data 2 Chlorophenol

Parameter		Informal Residential	Standard Residential	Commercial/ Industrial
RfD _o	Reference Dosage (Oral)	0.005	0.005	0.005
RfD _i	Reference Dosage (Inhalation)	-	-	-
RfD _d	Reference Dosage (Dermal)	0.005	0.005	0.005
SF _o	Slope Factor (Oral)	-	-	-
SF _a	Slope Factor (Air)	-	-	-
SF _d	Slope Factor (Dermal)	-	-	-

2 Chlorophenol

Threshold calculation with no inhalation RfD available.

$$SSV(mg / kg) = \frac{THI \times BW \times AT}{EF \times ED \times \left(\left(\frac{1}{RfD_o} \times 10^{-6} \times IR_s \times GI \right) + \left(\frac{1}{RfD_D} \times SA \times AF \times ABS \times 10^{-6} \right) \right)}$$

Informal Residential

$$SSV(mg / kg) = \frac{1 \times 15 \times 2,190}{365 \times 6 \times \left(\left(\frac{1}{0.005} \times 10^{-6} \times 400 \times 1 \right) + \left(\frac{1}{0.005} \times 4,200 \times 0.2 \times 0.1 \times 10^{-6} \right) \right)} = 150$$

Standard Residential

$$SSV(mg / kg) = \frac{1 \times 15 \times 2,190}{350 \times 6 \times \left(\left(\frac{1}{0.005} \times 10^{-6} \times 200 \times 1 \right) + \left(\frac{1}{0.005} \times 2100 \times 0.2 \times 0.1 \times 10^{-6} \right) \right)} = 320$$

Commercial/Industrial

$$SSV(mg / kg) = \frac{1 \times 70 \times 10,950}{250 \times 30 \times \left(\left(\frac{1}{0.005} \times 10^{-6} \times 100 \times 1 \right) + \left(\frac{1}{0.005} \times 13,110 \times 0.07 \times 0.1 \times 10^{-6} \right) \right)} = 2,600$$

ORGANICS: DICHLOROBENZENES

Dichlorobenzenes

Environmental Occurrence

Dichlorobenzenes (DCB) are chlorinated aromatic compounds that have three isomers.

1,2 DCB is a colourless to pale yellow liquid and is used as a precursor in the manufacture of dichloro aniline herbicides. 1,3 DCB is a colourless liquid and is used in the manufacture of herbicides, pesticides, pharmaceuticals and dyes. 1,4 DCB is commercially important and is a volatile, colourless to white crystalline substance with a penetrating odour. 1,4 DCB is used in the production of polyphenylene sulphide (PPS) resin and has been commonly used as a toilet deodorant.

DCBs are volatile and are degraded in the atmosphere by reaction with hydroxyl radicals. They are moderately mobile in soil and readily volatilize.

DCBs are not naturally occurring in the environment.

Toxicity

Inhalation of vapours is the most likely form of exposure. DCBs are irritants to the eyes and respiratory tract. The liver is the target organ for oral exposure. Dermal absorption is likely to be very low. DCBs are rapidly absorbed and metabolised.

1,4 DCB is a possible human carcinogen. In animal studies, chronic exposure via inhalation and oral exposures resulted in liver cancer. 1,2 DCB is not considered to be a human carcinogen.

Soil Screening Values

	All land uses Protective of the Water Resource	Informal Residential	Standard Residential	Commercial/ Industrial
1,2 Dichlorobenzene	89 mg/kg	2,700 mg/kg	5,800 mg/kg	47,000 mg/kg
1,4 Dichlorobenzene	26 mg/kg	1,100 mg/kg	1,200 mg/kg	19,000 mg/kg

Target Water Quality

	Drinking Water (WHO, 2008)	Aquatic Water Quality (ANZECC, 2000)
1,2 Dichlorobenzene	1 mg/l	0.16 mg/l
1,4 Dichlorobenzene	0.3 mg/l	0.06 mg/l

Equation Sample

Table 55: Exposure Parameters 1, 2 Dichlorobenzene

Parameter		Informal Residential	Standard Residential	Commercial/ Industrial
THI	Target Hazard Index	1	1	1
TR	Target Risk	1E-05	1E-05	1E-05
BW	Body Weight (kg)	15	15	70
AT	Averaging Time (days)	2,190	2,190	10,950
EF	Exposure Frequency (days/yr)	365	350	250
ED	Exposure Duration (yrs)	6	6	30
IR _s	Ingestion Rate (Soil) (mg/day)	400	200	100
IR _a	Ingestion Rate (Air) (mg/day)	10	10	10.4
GI	GI Absorption Factor	1	1	1
PEF	Particulate Emission Factor (m ³ /kg)	7.25E+08	1.30E+09	3.22E+08
VF _i	Volatilisation Factor (m ³ /kg)	1,985	1,985	4,891
VF _o	Volatilisation Factor (m ³ /kg)	8.85E+06	8.85E+06	8.85E+06
SA	Surface Area of Exposed Skin (cm ²)	4,200	2,100	13,110
AF	Skin Adherence Factor (mg/cm ² /day)	0.2	0.2	0.07
ABS	Dermal Absorption Factor	0.1	0.1	0.1

Table 56: Toxicological Data 1, 2 Dichlorobenzene

Parameter		Informal Residential	Standard Residential	Commercial/ Industrial
RfD _o	Reference Dosage (Oral)	0.09	0.09	0.09
RfD _i	Reference Dosage (Inhalation)	-	-	-
RfD _d	Reference Dosage (Dermal)	0.09	0.09	0.09
SF _o	Slope Factor (Oral)	-	-	-
SF _a	Slope Factor (Air)	-	-	-
SF _d	Slope Factor (Dermal)	-	-	-

1, 2 Dichlorobenzene

Threshold calculation with no inhalation RfD available

$$SSV(mg / kg) = \frac{THI \times BW \times AT}{EF \times ED \times \left(\left(\frac{1}{RfD_o} \times 10^{-6} \times IR_s \times GI \right) + \left(\frac{1}{RfD_D} \times SA \times AF \times ABS \times 10^{-6} \right) \right)}$$

Informal Residential

$$SSV(mg / kg) = \frac{1 \times 15 \times 2,190}{365 \times 6 \times \left(\left(\frac{1}{0.09} \times 10^{-6} \times 400 \times 1 \right) + \left(\frac{1}{0.09} \times 4,200 \times 0.2 \times 0.1 \times 10^{-6} \right) \right)} = 2,700$$

Standard Residential

$$SSV(mg / kg) = \frac{1 \times 15 \times 2,190}{350 \times 6 \times \left(\left(\frac{1}{0.09} \times 10^{-6} \times 200 \times 1 \right) + \left(\frac{1}{0.09} \times 2100 \times 0.2 \times 0.1 \times 10^{-6} \right) \right)} = 5,800$$

Commercial/Industrial

$$SSV(mg / kg) = \frac{1 \times 70 \times 10,950}{250 \times 30 \times \left(\left(\frac{1}{0.09} \times 10^{-6} \times 100 \times 1 \right) + \left(\frac{1}{0.09} \times 13,110 \times 0.07 \times 0.1 \times 10^{-6} \right) \right)} = 47,000$$

1,4 Dichlorobenzene

Table 57: Exposure Parameters 1, 4 Dichlorobenzene

Parameter		Informal Residential	Standard Residential	Commercial/ Industrial
THI	Target Hazard Index	1	1	1
TR	Target Risk	1E-05	1E-05	1E-05
BW	Body Weight (kg)	15	15	70
AT	Averaging Time (days)	2,190	2,190	10,950
EF	Exposure Frequency (days/yr)	365	350	250
ED	Exposure Duration (yrs)	6	6	30
IR _s	Ingestion Rate (Soil) (mg/day)	400	200	100
IR _a	Ingestion Rate (Air) (mg/day)	10	10	10.4
GI	GI Absorption Factor	1	1	1
PEF	Particulate Emission Factor (m ³ /kg)	7.25E+08	1.30E+09	3.22E+08
VF _i	Volatilisation Factor (m ³ /kg)	1,727	1,727	4,256
VF _o	Volatilisation Factor (m ³ /kg)	6.87E+06	6.87E+06	6.87E+06
SA	Surface Area of Exposed Skin (cm ²)	4,200	2,100	13,110
AF	Skin Adherence Factor (mg/cm ² /day)	0.2	0.2	0.07
ABS	Dermal Absorption Factor	0.1	0.1	0.1

Table 58: Toxicological Data 1, 4 Dichlorobenzene

Parameter		Informal Residential	Standard Residential	Commercial/ Industrial
RfD _o	Reference Dosage (Oral)	-	-	-
RfD _i	Reference Dosage (Inhalation)	0.229	0.229	0.229
RfD _d	Reference Dosage (Dermal)	-	-	-
SF _o	Slope Factor (Oral)	-	-	-
SF _a	Slope Factor (Air)	-	-	-
SF _d	Slope Factor (Dermal)	-	-	-

1, 4 Dichlorobenzene

Threshold calculation with no oral and dermal RfD available

$$SSV(mg / kg) = \frac{THI \times BW \times AT}{EF \times ED \times \left(\frac{1}{RfD_i} \times \left(IR_a \times \frac{1}{PEF} \right) + \left(\frac{IR_a}{2} \times \left(\frac{1}{VF_i} + \frac{1}{VF_o} \right) \right) \right)}$$

Informal Residential

$$SSV(mg / kg) = \frac{1 \times 15 \times 2,190}{365 \times 6 \times \left(\frac{1}{0.229} \times \left(10 \times \frac{1}{7.25 \cdot 10^8} \right) + \left(\frac{10}{2} \times \left(\frac{1}{1,727} + \frac{1}{6.87 \cdot 10^6} \right) \right) \right)} = 1,100$$

Standard Residential

$$SSV(mg / kg) = \frac{1 \times 15 \times 2,190}{350 \times 6 \times \left(\frac{1}{0.229} \times \left(10 \times \frac{1}{1.3 \cdot 10^9} \right) + \left(\frac{10}{2} \times \left(\frac{1}{1,727} + \frac{1}{6.87 \cdot 10^6} \right) \right) \right)} = 1,200$$

Commercial/Industrial

$$SSV(mg / kg) = \frac{1 \times 70 \times 2,190}{250 \times 30 \times \left(\frac{1}{0.229} \times \left(10.4 \times \frac{1}{3.22 \cdot 10^8} \right) + \left(\frac{10.4}{2} \times \left(\frac{1}{4,256} + \frac{1}{6.87 \cdot 10^6} \right) \right) \right)} = 19,000$$

ORGANICS: 1,2 DICHLOROETHANE

1,2 Dichloroethane

Environmental Occurrence

1,2 Dichloroethane (DCE) is a volatile, clear liquid with a pleasant odour.

DCE is readily soluble in water and other solvents.

DCE is used in the manufacture of vinyl chloride, and was formerly used in varnish removers, soaps and scouring compounds, metal degreasers, paints, coatings and adhesives.

DCE is moderately mobile in soil and is expected to leach to groundwater and readily volatilises. Biodegradation in soil and groundwater is slow.

DCBs are not naturally occurring in the environment.

Toxicity

Inhalation of vapours is the most likely form of exposure; alternatively ingestion of contaminated water could occur.

DCE is highly toxic and can impact most organs and functions of the body including liver, kidneys, neurological, cardiovascular and immune systems. High levels of exposure result in nausea, vomiting, respiratory distress, hemorrhagic gastritis and possible death by myocardial arrhythmia.

DCE is acutely nephrotoxic via inhalation or ingestion routes. Immunological and lymphoreticular effects are recorded in animals. Low levels of chronic exposure may result in impacts to the central nervous system, including headaches, drowsiness and tremors. Developmental effects include cardiac malformation.

1,2 DCE is considered to be potentially carcinogenic in humans and is mutagenic.

Soil Screening Values

	All land uses Protective of the Water Resource	Informal Residential	Standard Residential	Commercial/ Industrial
1,2 Dichloroethane	0.23 mg/kg	0.23 mg/kg	0.24 mg/kg	3.7 mg/kg

Target Water Quality

	Drinking Water (WHO, 2008)	Aquatic Water Quality (BC Aquatics, 2006)
1,2 Dichloroethane	0.03 mg/l	2 mg/l

Equation Sample – Soil Screening Value 1,2 Dichloroethane

Table 59: Exposure Parameters 1, 2 Dichloroethane

Parameter		Informal Residential	Standard Residential	Commercial/ Industrial
THI	Target Hazard Index	1	1	1
TR	Target Risk	1E-05	1E-05	1E-05
BW	Body Weight (kg)	70	70	70
AT	Averaging Time (days)	25,550	25,550	25,550
EF	Exposure Frequency (days/yr)	365	350	250
ED	Exposure Duration (yrs)	70	70	30
IR _s	Ingestion Rate (Soil) (mg/day)	200	100	100
IR _a	Ingestion Rate (Air) (mg/day)	20	20	10.4
GI	GI Absorption Factor	1	1	1
PEF	Particulate Emission Factor (m ³ /kg)	7.25E+08	1.30E+09	3.22E+08
VF _i	Volatilisation Factor (m ³ /kg)	304	304	750
VF _o	Volatilisation Factor (m ³ /kg)	1.81E+06	1.81E+06	1.81E+06
SA	Surface Area of Exposed Skin (cm ²)	11,600	5,800	13,110
AF	Skin Adherence Factor (mg/cm ² /day)	0.07	0.07	0.07
ABS	Dermal Absorption Factor	0.1	0.1	0.1

Table 60: Toxicological Data 1, 2 Dichloroethane

Parameter		Informal Residential	Standard Residential	Commercial/ Industrial
RfD _o	Reference Dosage (Oral)	-	-	-
RfD _i	Reference Dosage (Inhalation)	-	-	-
RfD _d	Reference Dosage (Dermal)	-	-	-
SF _o	Slope Factor (Oral)	0.091	0.091	0.091
SF _a	Slope Factor (Air)	0.091	0.091	0.091
SF _d	Slope Factor (Dermal)	-	-	-

1, 2 Dichloroethane

Threshold calculation with no dermal slope factor available

$$SSV(mg/kg) = \frac{TR \times BW \times AT}{EF \times ED \times \left((SF_o \times 10^{-6} \times IR_s \times GI) + \left(SF_i \times \left(\left(IR_a \times \frac{1}{PEF} \right) + \left(\frac{IR_a}{2} \times \left(\frac{1}{VF_i} + \frac{1}{VF_o} \right) \right) \right) \right) \right)}$$

Informal Residential

$$SSV(mg/kg) = \frac{1 \cdot 10^{-5} \times 70 \times 25,550}{365 \times 70 \times \left((0.091 \times 10^{-6} \times 200 \times 1) + \left(0.091 \times \left(\left(20 \times \frac{1}{7.25 \cdot 10^8} \right) + \left(\frac{20}{2} \times \left(\frac{1}{304} + \frac{1}{1.81 \cdot 10^6} \right) \right) \right) \right) \right)} = 0.23$$

Standard Residential

$$SSV(mg/kg) = \frac{1 \cdot 10^{-5} \times 70 \times 25,550}{350 \times 70 \times \left((0.091 \times 10^{-6} \times 100 \times 1) + \left(0.091 \times \left(\left(20 \times \frac{1}{1.3 \cdot 10^9} \right) + \left(\frac{20}{2} \times \left(\frac{1}{304} + \frac{1}{1.81 \cdot 10^6} \right) \right) \right) \right) \right)} = 0.24$$

Commercial/Industrial

$$SSV(mg/kg) = \frac{1 \cdot 10^{-5} \times 70 \times 25,550}{250 \times 30 \times \left((0.091 \times 10^{-6} \times 100 \times 1) + \left(0.091 \times \left(\left(10.4 \times \frac{1}{3.22 \cdot 10^8} \right) + \left(\frac{10.4}{2} \times \left(\frac{1}{750} + \frac{1}{1.81 \cdot 10^6} \right) \right) \right) \right) \right)} = 3.7$$

ORGANICS: TRICHLOROBENZENE

Trichlorobenzenes

Environmental Occurrence

1,2,4 Trichlorobenzene (TCB) is a colourless liquid used as a solvent in chemical manufacturing and in dyes. TCB is also used in synthetic transformer oils, and in the production of insecticides and herbicides. It is used in degreasing agents, cleaners and in wood preservatives.

TCB is persistent in the environment and is strongly absorbed by organic-rich soils although is likely to leach to groundwater in most soil environments.

TCB is not naturally occurring in the environment.

Toxicity

Inhalation of vapours is the most likely form of exposure; alternatively ingestion of contaminated water could occur.

Exposure to TCB vapours results in eye irritation and impacts on the respiratory tract. Chronic dermal exposure results in dermatitis.

The target organs include the blood, liver, kidney, lungs, heart and skin. Chronic exposure may result in impacts to the central nervous system, including headaches, drowsiness and tremors, increase in blood pressure and heart rate.

Gastrointestinal impacts include nausea, vomiting and diarrhoea.

1,2,4 Trichlorobenzene is not classifiable as to its human carcinogenicity.

Soil Screening Values

	All land uses Protective of the Water Resource	Informal Residential	Standard Residential	Commercial/ Industrial
Trichlorobenzene	0.069 mg/kg	310 mg/kg	640 mg/kg	5,300 mg/kg

Target Water Quality

	Drinking Water (WHO, 2008)	Aquatic Water Quality (UK EQS Salmonid, Current)
Trichlorobenzene	0.02 mg/l	0.0004 mg/l

Equation Sample

Table 61: Exposure Parameters Trichlorobenzene

Parameter		Informal Residential	Standard Residential	Commercial/ Industrial
THI	Target Hazard Index	1	1	1
TR	Target Risk	1E-05	1E-05	1E-05
BW	Body Weight (kg)	15	15	70
AT	Averaging Time (days)	2,190	2,190	10,950
EF	Exposure Frequency (days/yr)	365	350	250
ED	Exposure Duration (yrs)	6	6	30
IR _s	Ingestion Rate (Soil) (mg/day)	400	200	100
IR _a	Ingestion Rate (Air) (mg/day)	10	10	10.4
GI	GI Absorption Factor	1	1	1
PEF	Particulate Emission Factor (m ³ /kg)	7.25E+08	1.30E+09	3.22E+08
VF _i	Volatilisation Factor (m ³ /kg)	184	184	454
VF _o	Volatilisation Factor (m ³ /kg)	1.73E+06	1.73E+06	1.73E+06
SA	Surface Area of Exposed Skin (cm ²)	4,200	2,100	13,110
AF	Skin Adherence Factor (mg/cm ² /day)	0.2	0.2	0.07
ABS	Dermal Absorption Factor	0.1	0.1	0.1

Table 62: Toxicological Data Trichlorobenzene

Parameter		Informal Residential	Standard Residential	Commercial/ Industrial
RfD _o	Reference Dosage (Oral)	0.01	0.01	0.01
RfD _i	Reference Dosage (Inhalation)	-	-	-
RfD _d	Reference Dosage (Dermal)	0.01	0.01	0.01
SF _o	Slope Factor (Oral)	-	-	-
SF _a	Slope Factor (Air)	-	-	-
SF _d	Slope Factor (Dermal)	-	-	-

Trichlorobenzene

Threshold calculation with no inhalation RfD available.

$$SSV(mg/kg) = \frac{THI \times BW \times AT}{EF \times ED \times \left(\left(\frac{1}{RfD_o} \times 10^{-6} \times IR_s \times GI \right) + \left(\frac{1}{RfD_D} \times SA \times AF \times ABS \times 10^{-6} \right) \right)}$$

Informal Residential

$$SSV(mg/kg) = \frac{1 \times 15 \times 2,190}{365 \times 6 \times \left(\left(\frac{1}{0.01} \times 10^{-6} \times 400 \times 1 \right) + \left(\frac{1}{0.01} \times 4,200 \times 0.2 \times 0.1 \times 10^{-6} \right) \right)} = 310$$

Standard Residential

$$SSV(mg/kg) = \frac{1 \times 15 \times 2,190}{350 \times 6 \times \left(\left(\frac{1}{0.01} \times 10^{-6} \times 200 \times 1 \right) + \left(\frac{1}{0.01} \times 2100 \times 0.2 \times 0.1 \times 10^{-6} \right) \right)} = 640$$

Commercial/Industrial

$$SSV(mg/kg) = \frac{1 \times 70 \times 10,950}{250 \times 30 \times \left(\left(\frac{1}{0.01} \times 10^{-6} \times 100 \times 1 \right) + \left(\frac{1}{0.01} \times 13,110 \times 0.07 \times 0.1 \times 10^{-6} \right) \right)} = 5,300$$

ORGANICS: NITROBENZENE

NITROBENZENE

Environmental Occurrence

Nitrobenzene is an oily yellow liquid with an almond-like odour, used mainly as a chemical intermediate in the manufacture of aniline, commonly used in the production of dyes.

Nitrobenzene is also used in the production of lubricating oils in motors and machinery. Small amounts are used in the manufacture of dyes, pesticides, synthetic rubber and pharmaceuticals.

There are no natural sources of nitrobenzene in the environment.

Toxicity

The outstanding toxic effect associated with inhalation or ingestion of nitrobenzene is methemoglobinemia causing hypoxia. The iron component of the blood is converted from a ferrous to ferric state (oxidized), which results in reduced oxygen release capacity, leading to anaemic symptoms of fatigue and dizziness. Liver damage is suspected for inhalation and ingestion exposure routes. Neurological effects include headache, nausea and vertigo.

Data related to dermal exposure are considered sufficient to clearly assess the potential effect, but nitrobenzene is a mild irritant to eyes and skin.

Soil Screening Values

	All land uses Protective of the Water Resource	Informal Residential	Standard Residential	Commercial/ Industrial
Nitrobenzene	2.8 mg/kg	2.8 mg/kg	2.9 mg/kg	45 mg/kg

Target Water Quality

	Drinking Water	Aquatic Water Quality (NOAA Squirts, 2008)
Nitrobenzene	-	0.55 mg/l

Equation Sample

Table 63: Exposure Parameters Nitrobenzene

Parameter		Informal Residential	Standard Residential	Commercial/ Industrial
THI	Target Hazard Index	1	1	1
TR	Target Risk	1E-05	1E-05	1E-05
BW	Body Weight (kg)	70	70	70
AT	Averaging Time (days)	25,550	25,550	25,550
EF	Exposure Frequency (days/yr)	365	350	250
ED	Exposure Duration (yrs)	70	70	30
IR _s	Ingestion Rate (Soil) (mg/day)	200	100	100
IR _a	Ingestion Rate (Air) (mg/day)	20	20	10.4
GI	GI Absorption Factor	1	1	1
PEF	Particulate Emission Factor (m ³ /kg)	7.25E+08	1.30E+09	3.22E+08
VF _i	Volatilisation Factor (m ³ /kg)	5,683	5,683	14,002
VF _o	Volatilisation Factor (m ³ /kg)	1.02E+08	1.02E+08	1.02E+08
SA	Surface Area of Exposed Skin (cm ²)	11,600	5,800	13,110
AF	Skin Adherence Factor (mg/cm ² /day)	0.07	0.07	0.07
ABS	Dermal Absorption Factor	0.1	0.1	0.1

Table 64: Toxicological Data Chloroform

Parameter		Informal Residential	Standard Residential	Commercial/ Industrial
RfD _o	Reference Dosage (Oral)	-	-	-
RfD _i	Reference Dosage (Inhalation)	-	-	-
RfD _d	Reference Dosage (Dermal)	-	-	-
SF _o	Slope Factor (Oral)	-	-	-
SF _a	Slope Factor (Air)	0.14	0.14	0.14
SF _d	Slope Factor (Dermal)	-	-	-

Nitrobenzene

Threshold calculation with no oral or dermal slope factor available

$$SSV(mg/kg) = \frac{TR \times BW \times AT}{EF \times ED \times \left(SF_i \times \left(\left(IR_a \times \frac{1}{PEF} \right) + \left(\frac{IR_a}{2} \times \left(\frac{1}{VF_i} + \frac{1}{VF_o} \right) \right) \right) \right)}$$

Informal Residential

$$SSV(mg/kg) = \frac{1 \cdot 10^{-5} \times 70 \times 25,550}{365 \times 70 \times \left(0.14 \times \left(\left(20 \times \frac{1}{7.25 \cdot 10^8} \right) + \left(\frac{20}{2} \times \left(\frac{1}{5,683} + \frac{1}{1.02 \cdot 10^8} \right) \right) \right) \right)} = 2.8$$

Standard Residential

$$SSV(mg/kg) = \frac{1 \cdot 10^{-5} \times 70 \times 25,550}{350 \times 70 \times \left(0.14 \times \left(\left(20 \times \frac{1}{1.3 \cdot 10^9} \right) + \left(\frac{20}{2} \times \left(\frac{1}{5,683} + \frac{1}{1.02 \cdot 10^8} \right) \right) \right) \right)} = 2.9$$

Commercial/Industrial

$$SSV(mg/kg) = \frac{1 \cdot 10^{-5} \times 70 \times 25,550}{250 \times 30 \times \left(0.14 \times \left(\left(10.4 \times \frac{1}{3.22 \cdot 10^8} \right) + \left(\frac{10.4}{2} \times \left(\frac{1}{14,002} + \frac{1}{1.02 \cdot 10^8} \right) \right) \right) \right)} = 45$$

ORGANICS: 1,1,2,2 TETRACHLOROETHANE

1,1,2,2 Tetrachloroethane

Environmental Occurrence

1,1,2,2 Tetrachloroethane is used as a chemical intermediate in the production of chlorinated hydrocarbons. In the past it was used as a solvent.

1,1,2,2 Tetrachloroethane is partly volatile. Airborne breakdown occurs by photochemically generated hydroxyl radicals. Degradation in soil and groundwater is via hydrolysis and biodegradation.

1,1,2,2 Tetrachloroethane is not naturally occurring in the environment.

Toxicity

Inhalation of vapours is the most likely form of exposure; alternatively ingestion of contaminated water could occur.

Exposure to tetrachloroethane vapours is likely to result in depression of the central nervous system with irritation of the respiratory tract.

Repeated inhalation exposures can affect the liver. Chronic exposure may result in impacts to the central nervous system, including headaches, drowsiness and tremors.

1,1,2,2 Tetrachloroethane has been linked to the development of liver cancer in animals and is classified as a possible carcinogen.

Soil Screening Values

	All land uses Protective of the Water Resource	Informal Residential	Standard Residential	Commercial/ Industrial
1,1,2,2 Tetrachloroethane	0.32 mg/kg	0.32 mg/kg	0.34 mg/kg	5 mg/kg

Target Water Quality

	Drinking Water	Aquatic Water Quality (NOAA Squirts, 2008)
1,1,2,2 Tetrachloroethane	-	0.111 mg/l

Equation Sample

Table 65: Exposure Parameters 1,1,2,2 Tetrachloroethane

Parameter		Informal Residential	Standard Residential	Commercial/ Industrial
THI	Target Hazard Index	1	1	1
TR	Target Risk	1E-05	1E-05	1E-05
BW	Body Weight (kg)	70	70	70
AT	Averaging Time (days)	25,550	25,550	25,550
EF	Exposure Frequency (days/yr)	365	350	250
ED	Exposure Duration (yrs)	70	70	30
IR _s	Ingestion Rate (Soil) (mg/day)	200	100	100
IR _a	Ingestion Rate (Air) (mg/day)	20	20	10.4
GI	GI Absorption Factor	1	1	1
PEF	Particulate Emission Factor (m ³ /kg)	7.25E+08	1.30E+09	3.22E+08
VF _i	Volatilisation Factor (m ³ /kg)	945	945	2,329
VF _o	Volatilisation Factor (m ³ /kg)	9.87E+06	9.87E+06	9.87E+06
SA	Surface Area of Exposed Skin (cm ²)	11,600	5,800	13,110
AF	Skin Adherence Factor (mg/cm ² /day)	0.07	0.07	0.07
ABS	Dermal Absorption Factor	0.1	0.1	0.1

Table 66: Toxicological Data 1,1,2,2 Tetrachloroethane

Parameter		Informal Residential	Standard Residential	Commercial/ Industrial
RfDo	Reference Dosage (Oral)	-	-	-
RfDi	Reference Dosage (Inhalation)	-	-	-
RfDd	Reference Dosage (Dermal)	-	-	-
SFo	Slope Factor (Oral)	0.2	0.2	0.2
SFa	Slope Factor (Air)	0.203	0.203	0.203
SFd	Slope Factor (Dermal)	-	-	-

1,1,2,2 Tetrachloroethane

Threshold calculation with no dermal slope factor available

$$SSV(mg/kg) = \frac{TR \times BW \times AT}{EF \times ED \times \left((SF_o \times 10^{-6} \times IR_s \times GI) + \left(SF_i \times \left(IR_a \times \frac{1}{PEF} \right) + \left(\frac{IR_a}{2} \times \left(\frac{1}{VF_i} + \frac{1}{VF_o} \right) \right) \right) \right) \right)}$$

Informal Residential

$$SSV(mg/kg) = \frac{1 \cdot 10^{-5} \times 70 \times 25,550}{365 \times 70 \times \left((0.2 \times 10^{-6} \times 200 \times 1) + \left(0.203 \times \left(\left(20 \times \frac{1}{7.25 \cdot 10^8} \right) + \left(\frac{20}{2} \times \left(\frac{1}{945} + \frac{1}{9.87 \cdot 10^6} \right) \right) \right) \right) \right) \right)} = 0.32$$

Standard Residential

$$SSV(mg/kg) = \frac{1 \cdot 10^{-5} \times 70 \times 25,550}{350 \times 70 \times \left((0.2 \times 10^{-6} \times 100 \times 1) + \left(0.203 \times \left(\left(20 \times \frac{1}{1.3 \cdot 10^9} \right) + \left(\frac{20}{2} \times \left(\frac{1}{945} + \frac{1}{9.87 \cdot 10^6} \right) \right) \right) \right) \right) \right)} = 0.34$$

Commercial/Industrial

$$SSV(mg/kg) = \frac{1 \cdot 10^{-5} \times 70 \times 25,550}{250 \times 30 \times \left((0.2 \times 10^{-6} \times 100 \times 1) + \left(0.203 \times \left(\left(10.4 \times \frac{1}{3.22 \cdot 10^8} \right) + \left(\frac{10.4}{2} \times \left(\frac{1}{2,329} + \frac{1}{9.87 \cdot 10^6} \right) \right) \right) \right) \right) \right)} = 5$$

ORGANICS: 2,4,6 TRICHLOROPHENOL

Trichlorophenols

Environmental Occurrence

Chlorophenols are a group of chemicals that are produced by adding chlorines to phenol. Phenol is an aromatic compound derived from benzene. There are 5 basic types of chlorophenols and 19 different chlorophenols.

Most chlorophenols are solid at room temperature. They have a strong, medicinal taste and smell. Small amounts can be tasted in water.

Some chlorophenols are used as pesticides. Others are used in antiseptics. Small amounts are produced when water is disinfected with chlorine. They are also produced while bleaching wood pulp with chlorine to make paper.

Most chlorophenols released to the environment go into water. Small amounts of chlorophenols enter the air. In the air, sunlight helps destroy these compounds and rain washes them out of the air. Low levels of chlorophenols in water, soil, or sediment are broken down and removed from the environment in a few days to weeks by microorganisms.

Toxicity

Workers exposed to pesticides that contain chlorophenols have developed acne and mild injury to their livers.

In laboratory studies, animals that received high levels of chlorophenols in food or water developed liver and immune system effects.

There is evidence to suggest that people exposed to chlorophenols for a long time may have slightly higher incidences of cancer. However, the people studied were exposed to other chemicals as well.

In animal studies, 1 chlorophenol, 2,4,6 trichlorophenol, caused leukaemia in rats and liver cancer in mice. 2,4,6 trichlorophenol may reasonably be anticipated to be a carcinogen.

Soil Screening Values

	All land uses Protective of the Water Resource	Informal Residential	Standard Residential	Commercial/ Industrial
2,4,6 Trichlorophenol	4 mg/kg	210 mg/kg	320 mg/kg	1,700 mg/kg

Target Water Quality

	Drinking Water (WHO, 2008)	Aquatic Water Quality
2,4,6 Trichlorophenol	0.2 mg/l	-

Equation Sample

Table 67: Exposure Parameters 2,4,6 Trichlorophenol

Parameter		Informal Residential	Standard Residential	Commercial/ Industrial
THI	Target Hazard Index	1	1	1
TR	Target Risk	1E-05	1E-05	1E-05
BW	Body Weight (kg)	70	70	70
AT	Averaging Time (days)	25,550	25,550	25,550
EF	Exposure Frequency (days/yr)	365	350	250
ED	Exposure Duration (yrs)	70	70	30
IR _s	Ingestion Rate (Soil) (mg/day)	200	100	100
IR _a	Ingestion Rate (Air) (mg/day)	20	20	10.4
GI	GI Absorption Factor	1	1	1
PEF	Particulate Emission Factor (m ³ /kg)	7.25E+08	1.30E+09	3.22E+08
VF _i	Volatilisation Factor (m ³ /kg)	95,414	95,414	235,120
VF _o	Volatilisation Factor (m ³ /kg)	1.77E+09	1.77E+09	1.77E+09
SA	Surface Area of Exposed Skin (cm ²)	11,600	5,800	13,110
AF	Skin Adherence Factor (mg/cm ² /day)	0.07	0.07	0.07
ABS	Dermal Absorption Factor	0.1	0.1	0.1

Table 68: Toxicological Data 2,4,6 Trichlorophenol

Parameter		Informal Residential	Standard Residential	Commercial/ Industrial
RfD _o	Reference Dosage (Oral)	-	-	-
RfD _i	Reference Dosage (Inhalation)	-	-	-
RfD _d	Reference Dosage (Dermal)	-	-	-
SF _o	Slope Factor (Oral)	0.011	0.011	0.011
SF _a	Slope Factor (Air)	0.011	0.011	0.011
SF _d	Slope Factor (Dermal)	-	-	-

2,4,6 Trichlorophenol

Threshold calculation with no dermal slope factor available

$$SSV(mg / kg) = \frac{TR \times BW \times AT}{EF \times ED \times \left((SF_o \times 10^{-6} \times IR_s \times GI) + \left(SF_i \times \left(\left(IR_a \times \frac{1}{PEF} \right) + \left(\frac{IR_a}{2} \times \left(\frac{1}{VF_i} + \frac{1}{VF_o} \right) \right) \right) \right) \right)}$$

Informal Residential

$$SSV(mg / kg) = \frac{1 \cdot 10^{-5} \times 70 \times 25,550}{365 \times 70 \times \left((0.011 \times 10^{-6} \times 200 \times 1) + \left(0.011 \times \left(\left(20 \times \frac{1}{7.25 \cdot 10^8} \right) + \left(\frac{20}{2} \times \left(\frac{1}{95,414} + \frac{1}{1.77 \cdot 10^9} \right) \right) \right) \right) \right)} = 210$$

Standard Residential

$$SSV(mg / kg) = \frac{1 \cdot 10^{-5} \times 70 \times 25,550}{350 \times 70 \times \left((0.011 \times 10^{-6} \times 100 \times 1) + \left(0.011 \times \left(\left(20 \times \frac{1}{1.3 \cdot 10^9} \right) + \left(\frac{20}{2} \times \left(\frac{1}{95,414} + \frac{1}{1.77 \cdot 10^9} \right) \right) \right) \right) \right)} = 320$$

Commercial/Industrial

$$SSV(mg / kg) = \frac{1 \cdot 10^{-5} \times 70 \times 25,550}{250 \times 30 \times \left((0.011 \times 10^{-6} \times 100 \times 1) + \left(0.011 \times \left(\left(10.4 \times \frac{1}{3.22 \cdot 10^8} \right) + \left(\frac{10.4}{2} \times \left(\frac{1}{235,120} + \frac{1}{1.77 \cdot 10^9} \right) \right) \right) \right) \right)} = 1,700$$

ORGANICS: VINYL CHLORIDE

Vinyl Chloride

Environmental Occurrence

Vinyl Chloride (VC) is used to manufacture polyvinyl chloride (PVC) and is thus one of the highest product volume chemicals in the world.

Most VC released to the environment partitions to the air and is broken down in the atmosphere by hydroxyl radicals.

VC is highly mobile in soil and readily volatilises. The potential to leach from soil to groundwater is reduced by the rapid rate of volatilisation.

VC is not naturally occurring in the environment.

Toxicity

Exposure by inhalation or the oral exposure routes are most likely to occur for contamination sources. VC is highly toxic and exposure results in neurological, liver and cancer effects, as well as respiratory, reproductive, developmental and lymphoreticular impacts. The liver is the most sensitive target organ.

Inhalation causes dizziness, drowsiness, fatigue, euphoria, visual and hearing disturbance. High levels of exposure cause damage to nerve endings and degeneration of brain tissue.

VC is a known human carcinogen by inhalation and oral route. VC is highly likely to be carcinogenic by dermal route.

Cancer risks include liver, lung, respiratory tract, brain, lymphoid system, skin, spleen. VC is considered to be mutagenic.

Soil Screening Values

	All land uses Protective of the Water Resource	Informal Residential	Standard Residential	Commercial/ Industrial
Vinyl Chloride	0.0037 mg/kg	0.10 mg/kg	0.11 mg/kg	1.5 mg/kg

Target Water Quality

	Drinking Water (WHO, 2008)	Aquatic Water Quality
Vinyl Chloride	0.0003 mg/l	-

Equation Sample

Table 69: Exposure Parameters Vinyl Chloride

Parameter		Informal Residential	Standard Residential	Commercial/ Industrial
THI	Target Hazard Index	1	1	1
TR	Target Risk	1E-05	1E-05	1E-05
BW	Body Weight (kg)	70	70	70
AT	Averaging Time (days)	25,550	25,550	25,550
EF	Exposure Frequency (days/yr)	365	350	250
ED	Exposure Duration (yrs)	70	70	30
IR _s	Ingestion Rate (Soil) (mg/day)	200	100	100
IR _a	Ingestion Rate (Air) (mg/day)	20	20	10.4
GI	GI Absorption Factor	1	1	1
PEF	Particulate Emission Factor (m ³ /kg)	7.25E+08	1.30E+09	3.22E+08
VF _i	Volatilisation Factor (m ³ /kg)	46	46	112
VF _o	Volatilisation Factor (m ³ /kg)	103,490	103,490	103,490
SA	Surface Area of Exposed Skin (cm ²)	11,600	5,800	13,110
AF	Skin Adherence Factor (mg/cm ² /day)	0.07	0.07	0.07
ABS	Dermal Absorption Factor	0.1	0.1	0.1

Table 70: Toxicological Data Vinyl Chloride

Parameter		Informal Residential	Standard Residential	Commercial/ Industrial
RfD _o	Reference Dosage (Oral)	-	-	-
RfD _i	Reference Dosage (Inhalation)	-	-	-
RfD _d	Reference Dosage (Dermal)	-	-	-
SF _o	Slope Factor (Oral)	1.5	1.5	1.5
SF _a	Slope Factor (Air)	0.031	0.031	0.031
SF _d	Slope Factor (Dermal)	-	-	-

Vinyl Chloride

Threshold calculation with no dermal slope factor available

$$SSV(mg/kg) = \frac{TR \times BW \times AT}{EF \times ED \times \left((SF_o \times 10^{-6} \times IR_s \times GI) + \left(SF_i \times \left(\left(IR_a \times \frac{1}{PEF} \right) + \left(\frac{IR_a}{2} \times \left(\frac{1}{VF_i} + \frac{1}{VF_o} \right) \right) \right) \right) \right)}$$

Informal Residential

$$SSV(mg/kg) = \frac{1 \cdot 10^{-5} \times 70 \times 25,550}{365 \times 70 \times \left((1.5 \times 10^{-6} \times 200 \times 1) + \left(0.031 \times \left(\left(20 \times \frac{1}{7.25 \cdot 10^8} \right) + \left(\frac{20}{2} \times \left(\frac{1}{46} + \frac{1}{103,490} \right) \right) \right) \right) \right)} = 0.10$$

Standard Residential

$$SSV(mg/kg) = \frac{1 \cdot 10^{-5} \times 70 \times 25,550}{350 \times 70 \times \left((1.5 \times 10^{-6} \times 100 \times 1) + \left(0.031 \times \left(\left(20 \times \frac{1}{1.3 \cdot 10^9} \right) + \left(\frac{20}{2} \times \left(\frac{1}{46} + \frac{1}{103,490} \right) \right) \right) \right) \right)} = 0.11$$

Commercial/Industrial

$$SSV(mg/kg) = \frac{1 \cdot 10^{-5} \times 70 \times 25,550}{250 \times 30 \times \left((1.5 \times 10^{-6} \times 100 \times 1) + \left(0.031 \times \left(\left(10.4 \times \frac{1}{3.22 \cdot 10^8} \right) + \left(\frac{10.4}{2} \times \left(\frac{1}{112} + \frac{1}{103,490} \right) \right) \right) \right) \right)} = 1.5$$

ORGANICS: POLYCHLORINATED BIPHENYLS (PCBs)

Polychlorinated Biphenyls (PCBs)

Environmental Occurrence

Polychlorinated biphenyls (PCBs) are mixtures of up to 209 individual chlorinated compounds called congeners. The compounds are man-made, with no known natural sources. PCBs appear as colourless to light yellow, oily liquids or waxy solids. These chemicals have no known smell or taste. Many commercial PCB mixtures are known by the trade name Aroclor.

PCBs have been used as coolants and lubricants in transformers, capacitors, and other electrical equipment because they do not burn easily and are good insulators. The manufacture of the compounds stopped in most countries by 1980 because evidence showed that they build up in the environment and can cause harmful health effects.

PCBs have entered the air, water, and soil during their manufacture, use, and disposal; from accidental spills and leaks during their transport; and from leaks or fires in products containing PCBs. The compounds can be released to the environment from hazardous waste sites, illegal or improper disposal of industrial wastes and consumer products, leaks from old electrical transformers containing PCBs, and burning of some wastes in incinerators. PCBs do not readily break down in the environment and thus may remain there for very long periods of time. Some PCBs can exist as a vapour in air that can travel long distances and be deposited in areas far away from the point of release. In water, a small amount of PCBs might remain dissolved, but most stick to organic particles and bottom sediments. PCBs also bind strongly to soil.

PCBs are taken up by small organisms and fish in sediments and water. They also are taken up by other animals that eat these aquatic animals as food. PCBs accumulate in fish and marine mammals, reaching levels that may be many thousands of times higher than in sediments and water.

Incineration is the conventional destruction technology for these extremely recalcitrant compounds, but other technologies, such as solvent extraction and thermal desorption, also are being applied.

Toxicity

Animal studies have shown that PCBs can cause harmful effects on the immune system, skin and can also cause neurobehavioral changes.

Some people who have ingested mixtures of PCBs and other chemicals for long periods of time have developed cancer, although there is no conclusive proof that congeners may have caused these effects.

Soil Screening Values

	All land uses Protective of the Water Resource	Informal Residential	Standard Residential	Commercial / Industrial
PCBs	0.61 mg/kg	1.7 mg/kg	3.6 mg/kg	11 mg/kg

Target Water Quality

	Drinking Water (Dutch, 2001)	Aquatic Water Quality (US EPA, 2001)
PCBs	0.00001 mg/l	0.014 mg/l

Equation Sample

Table 71: Exposure Parameters Polychlorinated Biphenyls

Parameter		Informal Residential	Standard Residential	Commercial/ Industrial
THI	Target Hazard Index	1	1	1
TR	Target Risk	1E-05	1E-05	1E-05
BW	Body Weight (kg)	70	70	70
AT	Averaging Time (days)	25,550	25,550	25,550
EF	Exposure Frequency (days/yr)	365	350	250
ED	Exposure Duration (yrs)	70	70	30
IR _s	Ingestion Rate (Soil) (mg/day)	200	100	100
IR _a	Ingestion Rate (Air) (mg/day)	20	20	10.4
GI	GI Absorption Factor	1	1	1
PEF	Particulate Emission Factor (m ³ /kg)	7.25E+08	1.30E+09	3.22E+08
VF _i	Volatilisation Factor (m ³ /kg)	1.0E+12	1.0E+12	1.0E+12
VF _o	Volatilisation Factor (m ³ /kg)	1.0E+12	1.0E+12	1.0E+12
SA	Surface Area of Exposed Skin (cm ²)	11,600	5,800	13,110
AF	Skin Adherence Factor (mg/cm ² /day)	0.07	0.07	0.07
ABS	Dermal Absorption Factor	0.1	0.1	0.1

Table 72: Toxicological Data Polychlorinated Biphenyls

Parameter		Informal Residential	Standard Residential	Commercial/ Industrial
RfD _o	Reference Dosage (Oral)	-	-	-
RfD _i	Reference Dosage (Inhalation)	-	-	-
RfD _d	Reference Dosage (Dermal)	-	-	-
SF _o	Slope Factor (Oral)	2	2	2
SF _a	Slope Factor (Air)	0.35	0.35	0.35
SF _d	Slope Factor (Dermal)	-	-	-

Polychlorinated Biphenyls

Threshold calculation with no dermal slope factor available

$$SSV(mg / kg) = \frac{TR \times BW \times AT}{EF \times ED \times \left((SF_o \times 10^{-6} \times IR_s \times GI) + \left(SF_i \times \left(\left(IR_a \times \frac{1}{PEF} \right) + \left(\frac{IR_a}{2} \times \left(\frac{1}{VF_i} + \frac{1}{VF_o} \right) \right) \right) \right) \right)}$$

Informal Residential

$$SSV(mg / kg) = \frac{1 \cdot 10^{-5} \times 70 \times 25,550}{365 \times 70 \times \left((2 \times 10^{-6} \times 200 \times 1) + \left(0.35 \times \left(\left(20 \times \frac{1}{7.25 \cdot 10^8} \right) + \left(\frac{20}{2} \times \left(\frac{1}{1 \cdot 10^{12}} + \frac{1}{1 \cdot 10^{12}} \right) \right) \right) \right) \right)} = 1.7$$

Standard Residential

$$SSV(mg / kg) = \frac{1 \cdot 10^{-5} \times 70 \times 25,550}{350 \times 70 \times \left((2 \times 10^{-6} \times 100 \times 1) + \left(0.35 \times \left(\left(20 \times \frac{1}{1.3 \cdot 10^9} \right) + \left(\frac{20}{2} \times \left(\frac{1}{1 \cdot 10^{12}} + \frac{1}{1 \cdot 10^{12}} \right) \right) \right) \right) \right)} = 3.6$$

Commercial/Industrial

$$SSV(mg / kg) = \frac{1 \cdot 10^{-5} \times 70 \times 25,550}{250 \times 30 \times \left((2 \times 10^{-6} \times 100 \times 1) + \left(0.35 \times \left(\left(10.4 \times \frac{1}{3.22 \cdot 10^8} \right) + \left(\frac{10.4}{2} \times \left(\frac{1}{1 \cdot 10^{12}} + \frac{1}{1 \cdot 10^{12}} \right) \right) \right) \right) \right)} = 11$$

ORGANICS: CYANIDE

CYANIDE

Environmental Occurrence

Cyanides are a diverse group of compounds containing the highly reactive CN^- anion. Cyanide released into the environment is mainly from industrial use and from incomplete combustion of nitrogen containing organic compounds (including cigarette smoke).

Cyanides occur naturally in low amounts in a number of foods and plants and as part of sugars.

Cyanide and hydrogen cyanide are used in electroplating, metallurgical processes, production of organic chemicals, photographic development, the manufacture of plastics and in some mining processes.

Cyanide can be present in air, water and soil from both natural processes and industrial release.

Cyanides are fairly mobile in soil at low concentrations. Cyanide can be chemically transformed by microorganisms, but a high concentration is toxic to soil microorganisms. Leaching to groundwater is likely to occur.

Toxicity

Toxicity depends on the ease with which the cyanide compounds release the CN^- anion. Simple cyanides such as potassium cyanide and sodium cyanide are highly toxic, whereas iron-containing cyanide compounds do not readily release CN^- and have a low toxicity.

Adverse effects of cyanides on the central nervous system are due to the high metabolic demand for oxygen which leads to histotoxic hypoxia leading to death. Non lethal exposure is associated with upper respiratory irritation, nausea, vomiting, hypertension and heart palpitation.

The most significant effects occur in the central nervous system, especially the brain. Chronic exposure in the workplace is associated with fatigue, dizziness and headaches.

Soil Screening Values

	All land uses Protective of the Water Resource	Informal Residential	Standard Residential	Commercial/ Industrial
Cyanides	14 mg/kg	620 mg/kg	1,200 mg/kg	10,000 mg/kg

Target Water Quality

	Drinking Water (DWAf, 1996)	Aquatic Water Quality (DWAf, 1996)
Cyanides	0.07 mg/l	0.001 mg/l

Equation Sample

Table 73: Exposure Parameters Cyanide

Parameter		Informal Residential	Standard Residential	Commercial/ Industrial
THI	Target Hazard Index	1	1	1
TR	Target Risk	1E-05	1E-05	1E-05
BW	Body Weight (kg)	15	15	70
AT	Averaging Time (days)	2,190	2,190	10,950
EF	Exposure Frequency (days/yr)	365	350	250
ED	Exposure Duration (yrs)	6	6	30
IR _s	Ingestion Rate (Soil) (mg/day)	400	200	100
IR _a	Ingestion Rate (Air) (mg/day)	10	10	10.4
GI	GI Absorption Factor	1	1	1
PEF	Particulate Emission Factor (m ³ /kg)	7.25E+08	1.30E+09	3.22E+08
VF _i	Volatilisation Factor (m ³ /kg)	1E+12	1E+12	1E+12
VF _o	Volatilisation Factor (m ³ /kg)	1E+12	1E+12	1E+12
SA	Surface Area of Exposed Skin (cm ²)	4,200	2,100	13,110
AF	Skin Adherence Factor (mg/cm ² /day)	0.2	0.2	0.07
ABS	Dermal Absorption Factor	0.1	0.1	0.1

Table 74: Toxicological Data Cyanide

Parameter		Informal Residential	Standard Residential	Commercial/ Industrial
RfD _o	Reference Dosage (Oral)	0.02	0.02	0.02
RfD _i	Reference Dosage (Inhalation)	-	-	-
RfD _d	Reference Dosage (Dermal)	0.02	0.02	0.02
SF _o	Slope Factor (Oral)	-	-	-
SF _a	Slope Factor (Air)	-	-	-
SF _d	Slope Factor (Dermal)	-	-	-

Cyanide

Threshold calculation with no inhalation RfD available.

$$SSV(mg / kg) = \frac{THI \times BW \times AT}{EF \times ED \times \left(\left(\frac{1}{RfD_o} \times 10^{-6} \times IR_s \times GI \right) + \left(\frac{1}{RfD_D} \times SA \times AF \times ABS \times 10^{-6} \right) \right)}$$

Informal Residential

$$SSV(mg / kg) = \frac{1 \times 15 \times 2,190}{365 \times 6 \times \left(\left(\frac{1}{0.02} \times 10^{-6} \times 400 \times 1 \right) + \left(\frac{1}{0.02} \times 4,200 \times 0.2 \times 0.1 \times 10^{-6} \right) \right)} = 620$$

Standard Residential

$$SSV(mg / kg) = \frac{1 \times 15 \times 2,190}{350 \times 6 \times \left(\left(\frac{1}{0.02} \times 10^{-6} \times 200 \times 1 \right) + \left(\frac{1}{0.02} \times 2100 \times 0.2 \times 0.1 \times 10^{-6} \right) \right)} = 1,200$$

Commercial/Industrial

$$SSV(mg / kg) = \frac{1 \times 70 \times 10,950}{250 \times 30 \times \left(\left(\frac{1}{0.02} \times 10^{-6} \times 100 \times 1 \right) + \left(\frac{1}{0.02} \times 13,110 \times 0.07 \times 0.1 \times 10^{-6} \right) \right)} = 10,000$$

APPENDIX C:

Measures for the Asbestos Contaminated Sites

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1 Measures for the Asbestos Contaminated Sites

1.1 ASBESTOS SOIL CONTAMINATION

The risk of asbestos is mainly associated with inhalation of fibres which is a severe risk to human health compared with other commonly occurring exposure routes. Asbestos fibres are considered to be carcinogenic and therefore even low levels of exposure to dust or fibres can pose an unacceptable level of risk. There is no definitive 'safe' level of exposure to asbestos.

Asbestos is not a chemical toxin in the sense applied within the overall Framework for the Management of Contaminated Land in South Africa and thus a slightly different approach has to be adopted when assessing sites which may be potentially contaminated with asbestos.

Recently various administrations have attempted to develop asbestos soil guidelines based on a reduction of risk approach supported by cancer risk assessments based on 'weight of evidence', however the uncertainty in target risk levels may deviate by several orders of magnitude from actual relevant values and thus numerical screening values are not sufficiently underpinned by scientific data to have a wide practical application in assessing contaminated soils.

It should be noted that the application of asbestos regulations and advisories intended for the protection of workers in an occupational scenario have limited application in assessing asbestos risk associated with contaminated soils and that monitoring techniques applied in the occupational environment may need to be modified for monitoring environmental health concerns. Furthermore although asbestos is a hazardous air pollutant no Air Quality Standards for ambient air quality have been published in South Africa.

The South African Occupational Health and Safety Asbestos Regulations (2001) define 'Regulated Asbestos Fibre' as follows:

Regulated Asbestos Fibre means a particle of asbestos with a length to diameter ratio of greater than 3 to 1, a length greater than 5 micrometers and diameter of less than 3 micrometers.

Asbestos is a term that includes naturally occurring silicate minerals. In South Africa asbestos is defined as:

amosite, chrysotile, crocidolite, fibrous actinolite, fibrous anthophyllite, and fibrous tremolite, or any mixture containing any of these minerals.

As the ingestion of asbestos fibres from contaminated water is an unusual pathway to develop under normal circumstances and the exposure route is not particularly sensitive in terms of human health risk the soil screening values for protection of water resources is several orders of magnitude greater than the those determined for the inhalation pathway and thus only gross levels of asbestos contamination far in excess of human health limits for inhalation exposure would be trigger the need for remedial action. In this case remediation criteria will always be governed by the risk of asbestos inhalation and other pathways are not generally worth detailed consideration.

The 1996 Department of Water Affairs guideline for Drinking Water Quality is 1 million fibres/litre

In the overall context of the 'Framework' the Section on Asbestos Soil Contamination is included as an initial guidance based on a risk management approach. No soil screening values are proposed for asbestos in soil. For detailed discussion of asbestos soil contamination, sampling and analytical methods and the assessment of risk and remediation and management of asbestos contaminated sites, as best international practice, the reader is referred to the following reference:

Western Australia Department of Health (2009) 'Guidelines for the Assessment of Asbestos-Contaminated Sites in Western Australia.

1.2 CHARACTERISTICS OF ASBESTOS CONTAMINATION

Asbestos is a priority contaminant of concern in South Africa due to a long history of mining, manufacturing and use as construction and building materials. There are thus a wide variety of potentially contaminated sites from primary and secondary contamination associated with mining waste dumps, manufacturing dumps and residues and demolition wastes and activities.

Asbestos soil contamination can take the form of either bulk material in a primary setting as waste dumps or as residual demolition rubble and aggregate, or can be more widely distributed as Secondary Asbestos Contamination in the form of scattered fragments of asbestos aggregate or as fibres in soil.

In terms of physical properties that influence the risk release of asbestos to air four forms can be recognised.

Asbestos Containing Material (ACM)

Asbestos which is cemented and physically bound in a matrix commonly used as building materials. The ACM is defined as fragments that cannot pass through a 7mm diameter sieve (i.e. the typical thickness of asbestos cement sheeting), The smaller fragments of ACM are crushed and therefore have a higher likelihood for fibre release. ACM is generally a highly stable form of asbestos with a low risk of fibre release unless severely weathered or crushed by construction traffic. ACM is defined as containing at least 1% asbestos by weight. Normally the concentration of asbestos in building materials does not exceed 15% by weight.

Fibrous Asbestos (FA)

Fibrous poorly bound asbestos, typical of asbestos insulation materials. Includes degraded and weathered ACM which crumbles under hand pressure.

Asbestos Fines (AF)

Described as free-fibres, or as asbestos dust, consisting of single fibres and small fibre bundles. A high risk category of asbestos that can pose a significant health risk if fibres are made airborne.

Naturally Occurring Asbestos (NOA)

Consideration of natural background values is important in the derivation of site specific remediation criteria for asbestos. As a natural occurring mineral in rocks it can be expected that widespread background levels of asbestos contamination will be a feature of most asbestos mining areas and can also occur in non-mining areas where the soils are derived from greenstone rocks with a high proportion of chrysotile or asbestiform amphiboles.

1.3 ASBESTOS CONTAMINATION OCCURRENCE

Asbestos contamination can occur in a wide variety of situations the most common sites which are associated with widespread asbestos use are as follows:

Known and likely asbestos contamination is associated with the following activities:

- Asbestos mines and associated stockpiles and dumps, including adjoining land.
- Asbestos manufacturing facilities
- Power Stations,
- Rail-yards and ship-yards, especially workshops and depots

- Waste disposal or dumping sites, particularly where building waste has been disposed of.

Suspect or possible asbestos contamination is associated with following situations:

- Derelict building sites, particularly where structures have been damaged by fire or storm and complete demolition or removal has not been undertaken
- Disused sites where asbestos was used as a building material and where redundant underground services are likely to consist of ACM piping.
- Land with fill of unknown composition.

The widespread use of asbestos building material in South Africa has also lead to the contamination of various natural soil and gravel aggregates used in the construction of roads and even in some building concrete aggregates. This may be particularly prevalent in former mining areas.

Areas that are covered by hardstanding and are likely to remain undisturbed do not require investigation.

1.4 ASBESTOS CONTAMINATION SITE ASSESSMENT

Phase 1 Site Assessment should identify the risk posed by possible asbestos contamination as detailed below.. Asbestos concentrations need to be determined for specific locations and specific soil strata and thus the weight of ACM should not be averaged across the total mass of soil at a site to determine a bulk site contaminant loading. Determination of asbestos concentrations from bulk soil samples is only valid where there is no visible evidence of asbestos contamination and the bulk soil material can be regarded as being homogeneous and representative of the uppermost 100mm of soil on site.

For ACM

$$\text{Soil Asbestos \%} = \frac{\% \text{ Asbestos Content} \times \text{ACM (kg)}}{\text{soil volume (L)} \times \text{soil density (kg/L)}}$$

% Asbestos content for ACM is normally a maximum of 15%

Soil density can be assumed to vary from 1.65 kg/L for uncompacted sands and sandy fill to 1.8 kg/L for compacted soils.

1.4.1 Site assessment process

The assessment of asbestos soil contamination is highly dependant on field sampling and analytical detection. Interpretation of the results of sampling programmes need to be evaluated with care and their limitations understood before arriving at a risk assessment or remediation objective.

A simple stepwise criteria for qualitative site assessment is as follows :

- Visually determine existence of asbestos contamination of soil by type and condition.
- Determine existence of asbestos fibres in soil by laboratory testing.
- Determine type of land use and anticipated activity patterns of human receptors and relate this to be likelihood of fibre release from soil to airborne exposure routes.

Judgemental sampling which targets a particular area of a site that is known or likely to be contaminated by asbestos is the preferred approach to site characterisation. If visible asbestos is recognised it can be assumed that the soil surrounding the visible asbestos is also contaminated within a 1m radius of the asbestos to account for uncertainty in sampling.

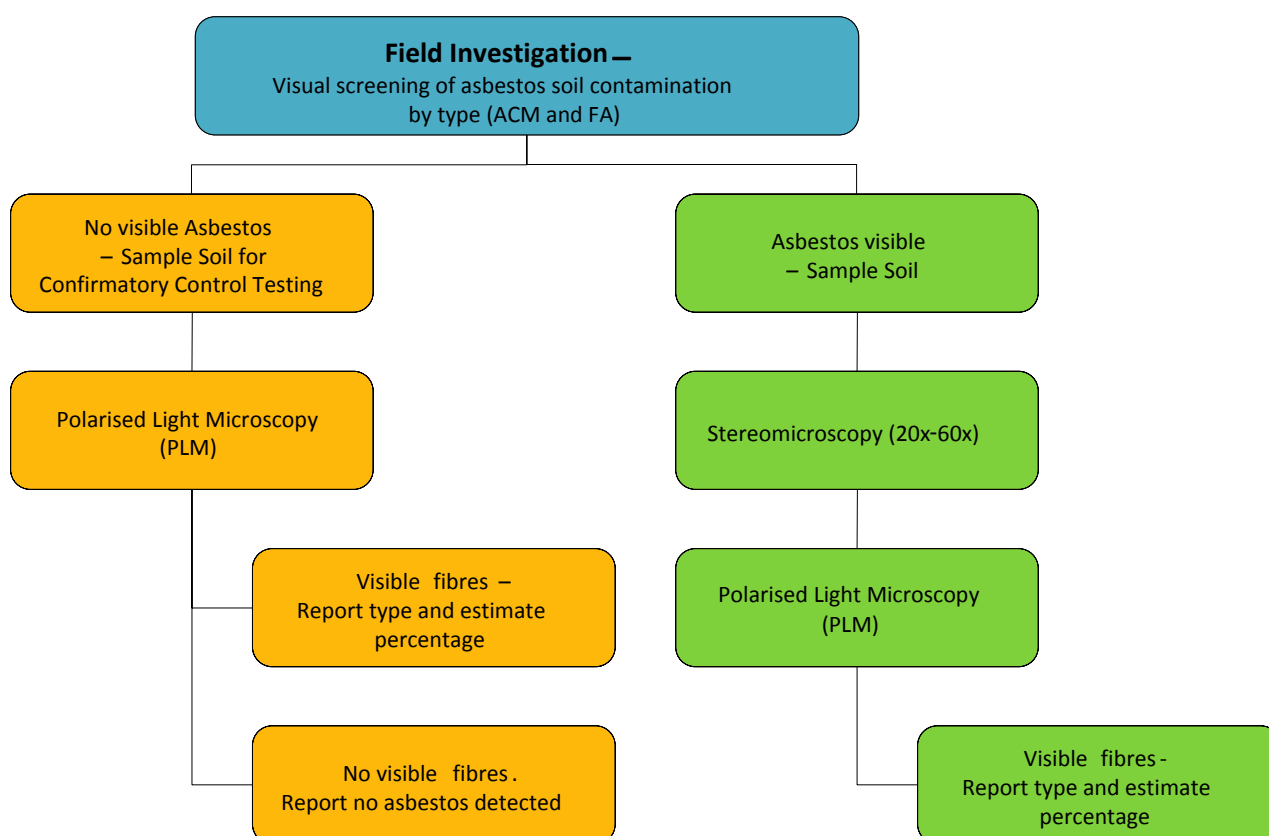
Surface soil sampling is by visual inspection and manual collection of soil samples and ACM where possible using a rake (teeth spacing must be <7mm). Care should be taken not to damage or bury asbestos during sampling.

Deeper soils should be investigated by trial pitting or trenching. Precautions to protect samplers, workers and the general public from excavation hazards and potential fibre release must be implemented. Boreholes are less suitable means of investigation as the opportunity for visual assay is very limited. Borehole sampling may be acceptable if the site has restricted access or obstructions that make trial pitting difficult or if the risk of asbestos dust release during excavation is unacceptable.

Sampling patterns should allow for secondary distribution of asbestos;

- due to vandalism or degradation of structures containing asbestos
- removal and demolition of structures containing asbestos
- cross contamination by construction earthworks, transport of asbestos wastes, crushing and fibre release by vehicle activity, storm damage to structures containing asbestos.
- dispersion and deposition of asbestos contamination by wind erosion and erosion and deposition of asbestos by stormwater flow

Figure 1. Testing methodology for assessing asbestos contamination in soils



Although the approach to sampling and testing of asbestos in soils is based on a tiered system of visual assay it is important to include a number of samples of soil for microscopic analysis that do not appear to have any visible asbestos. These control samples can be used to validate the visual assessment of the site and to provide detection screening for asbestos fibres that may not be apparent to the naked eye. The number of control samples is site dependant but at least 1 sample in 10 should be used for quality control purposes.

1.4.2 Analytical Methods for Asbestos in Soils

It is important to note that the accuracy and precision of all forms of asbestos determination is not comparable to chemical laboratory techniques. Most techniques require visual estimation of asbestos fibres in sub-samples derived from larger bulk samples of soil. As the distribution of asbestos in soil is highly variable the choice of a more precise (and expensive) high magnification technique may not provide more confidence in the bulk concentration of asbestos in soil than a similar semi-quantitative technique applied to a large number of samples.

The preferred method above includes visual screening using stereomicroscopy followed by more detailed visual estimation using Polarised Light Microscopy (PLM). It should be noted that a number of samples that have no visible asbestos should be subjected to examination by PLM in order to validate the results of the less precise screening step.

Asbestos dust in soil is very difficult to analyse for and requires the use of advanced microscopic techniques including Scanning Electron Microscopy (SEM) Or Transmission Electron Microscopy. In general this step is unlikely to be required for assessing asbestos soil contamination. The presence of abundant asbestos fibres in a soil sample can be taken as an indication of a substantial amount of asbestos fines and the high risk status of the site will not be influenced by the results of the more precise testing which can be regarded as a confirmatory measurement.

The limitations of microscopic methods of asbestos detection are not related to the sensitivity of the technique. Asbestos fibres are optically distinctive and even very low numbers of fibres can be detected with time and patience. It is however difficult to achieve consistent reproducible quantitative analyses and this problem tends to be most critical at the levels that may best define an acceptable risk. For instance an asbestos level in soil of 0.01% weight/weight asbestos may find general acceptance as a criteria for defining an acceptable risk. It is however unlikely that the available analytical techniques can provide a level of certainty at levels much below 0.025%. The limitations of laboratory determination must be considered when setting practical target levels for asbestos remediation. Reduction of risk by taking all reasonable measures to reduce exposure to asbestos by elimination of the exposure pathways is thus the favoured and precautionary approach to remediation and is not over-reliant on analytical certainty.

APPENDIX D:

Synopsis of Stakeholder Engagement



DEA Remediation Framework:
Contaminated Land Norms and Standards
Final Stakeholder Engagement Report
Department of Environmental Affairs

May 2010

QM

Issue/revision	Issue 1	Revision 1	Revision 2	Revision 3
Remarks	Final Report			
Date	May 2010			
Prepared by	H Konigkramer			
Signature				
Checked by	J McStay			
Signature				
Authorised by	J McStay			
Signature				
Project number	90428CL			
File reference	90428CL			

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Synopsis of Stakeholder Engagement

Stakeholder engagement has formed an important component of Department of Environmental Affairs (DEA) Remediation Framework project. Stakeholder consultation has provided the opportunity to communicate DEA's objectives to key stakeholders, and in turn allow stakeholders to provide valuable input on options and critical issues to be addressed.

The approach was one of broad stakeholder participation on a national scale coupled with focused sector based consultations. The project has been well received by stakeholders overall response has been positive. The key element of the stakeholder consultation process are summarised below.

STAKEHOLDER DATABASE

The development, and on going maintenance of a comprehensive, national stakeholder database provided the foundation for the stakeholder engagement process. Following initiation of the project, the primary objective was to establish a database which was inclusive of all relevant government departments from all three spheres of government, as well as non-governmental organisation, industry and business, and other interested and affected parties.

The database was continually updated to accommodate new stakeholder as the project progresses. The stakeholder database provided the means for the distribution of information and continued communications (including registrations, invitation, minutes of meetings, and availability of report for review).

REGISTRATION OF STAKEHOLDERS

A notice of registration (Appendix A) was distributed to all contacts contained within the stakeholder database (~ 820 contacts). Interested and affected parties were requested to register their interest in the process. In addition, companies and organisations were requested to nominate a representative for the purposes of stakeholder engagement.

The registration process allowed WSP to develop a national database of registered stakeholders (Appendix B) which formed the basis of continued engagement throughout the process.

WORKSHOPS

National Workshops

At the outset of the DEA Remediation Framework, a national approach to stakeholder engagement was adopted, with two national workshops proposed:

- ❖ The 1st National Workshop, held on 5 November 2009 in Pretoria, consisted of a number of presentations introducing the objectives of the DEA Remediation Framework Project and presenting the initial findings of the reporting on comparative assessment of options. The workshop was well attended, with over 80 stakeholders present, providing an opportunity for stakeholders to raised comments and issues for consideration (Appendix C).
- ❖ The 2nd National Workshop, held on 31 March 2010, consisted of a number of presentations. The presentations focussed on key issues arising from feedback obtained from the stakeholder participation and presented the findings of the project, allowing for discussion (Appendix C). The workshop allowed for final level of input to facilitate the finalisation of the framework document.



Sector Workshops

Sector level input was considered highly significant in the context of contaminated land in South Africa, in the light of the possible need to develop special measures to address sector specific issues. A number of specific sector orientated workshops were organised with key role players:

- ❖ Petrochemical Sector
- ❖ Mining Sector
- ❖ Chemical and Allied Industries (CAIA)
- ❖ Iron and Steel Industry

The focused group workshops provided the environment for constructive discussion. Presentations were given at these workshops and all issues, concerns and comments captured (Appendix C).

ACCESSIBILITY OF INFORMATION

At various stages in the DEA Remediation Framework Project, stakeholders were notified for the availability of information and document for review and comment. Documents were made available on 2 websites (namely South African Waste Information Centre website: www.sawic.org.za; and WSP Environmental (Pty) Ltd website: www.wspenvironmental.co.za) or forwarded directly to stakeholders on request.

SUBMISSION OF COMMENTS

In addition to the capturing of comments arising at workshop, stakeholders were encouraged to submit written comments throughout the process. A number of written comments were received and have been responded to accordingly (Appendix D). All comments submitted were given due consideration in the development of the framework documentation.

The Draft Remediation Framework Report, dated March 2010, was circulated to all stakeholders (the full database of ~820 contacts) for comment. In addition, the report was made available on the South African Waste Information Centre (SAWIC) website. A 7 week comment period was provided (9 March 2010 to 30 April 2010). Comments submitted, and responses thereto, are included in Appendix E. The comment submitted were considered in the preparation of the Final Remediation Framework Report, dated May 2010

'FREQUENTLY ASKED QUESTIONS'

From the input received during the stakeholder engagement process, a list of commonly raised technical questions in the form of a Frequently Asked Questions' (FAQs) document was compiled. These FAQ's were included in the legal presentation given at the second national workshop (Appendix F)

Appendix A Notice of Registration





environmental affairs
Department:
Environmental Affairs
REPUBLIC OF SOUTH AFRICA

Registration of Interest

**Development of
Norms and Standards
for the Management of
Contaminated Land**

October 2009

Dear Stakeholder

The Department of Environmental Affairs (DEA) has embarked upon a process of developing a framework for the remediation of contaminated land. This involves the development of norms and standards for the effective implementation of contaminated land legislation contained within Part 8 of the National Environmental Management:Waste Act (Act 59 of 2008).

WSP Environment and Energy (WSP) have been appointed by DEA to assist with the development of the contaminated land remediation framework.

National Workshops

Stakeholder involvement is an essential part of the remediation framework. A series of National Workshops are proposed. The purpose of the first workshop, scheduled for **5 November 2009** (in the Johannesburg area), will be to present the aim and objectives of the framework together with an international review of good practice and assessment of alternative methodologies.

Registration of Interest

To participate in the National Workshops, you are invited to register your interest by completing the registration slip below and forwarding this to the address provided. Due to space limitations, companies/organisations are requested to **nominate only one representative** for the National Workshops.

UNITED
BY OUR
DIFFERENCE



Appendix B List of Registered Stakeholders

DAE REMEDIATION FRAMEWORK: STAKEHOLDER DATABASE (AUGUST 2009 - FEBRUARY 2010)

REGISTERED STAKEHOLDERS*

First Names	Surname	Co/Org
INDUSTRY		
Gary	Cundill	AECI
Ellen	Van Dongen	African Explosives Limited
Paul	Botha	Afrisam
Alan	Cluett	AfriSam
Jurgens	du Toit	Afrisam (South Africa)(Pty)Ltd
Glyn	Lewis	Afrisam (South Africa)(Pty)Ltd
Dirk	Maritz	Afrisam (South Africa)(Pty)Ltd
Peter	Pretorius	Afrisam (South Africa)(Pty)Ltd
Gerhardt	Roets	Afrisam (South Africa)(Pty)Ltd
Avesh	Sookhoo	Afrisam (South Africa)(Pty)Ltd
Baronese	Vere	Alumicor Maritzburg (Pty) Ltd
Carol	Dixon	Anglo American
Frank	Schwegler	Anglo American plc (technical division)
Henk	Lodewijks	Anglo Coal
Kim	McCann	Anglo Coal
Dave	Salmon	Anglo Coal
Paul	Meulenbeld	Anglo Coal (Bank and Goedehoop Colliery)
Nanette	Marx	Anglo Coal (Greenside Colliery)
Vusi	Maseko	Anglo Coal (Greenside Colliery)
Steve	Clarke	Anglo Coal (Isibonelo Colliery)
Dipuo	Molamu	Anglo Coal (Isibonelo Colliery)
Erika	Prinsloo	Anglo Coal (Kleinkopje Colliery)
Francis Celokuhle	Nkosi	Anglo Coal (Landau Colliery)
Cindy	Taljaard	Anglo Coal (Landau Colliery)
Colin	Mabada	Anglo Coal (Mafube Colliery)
Malebabo	Sakoane	Anglo Coal (Mafube Colliery)
Burger	du Toit	Anglo Coal (New Denmark Colliery)
Galaletsang	Mosetho	Anglo Coal (New Denmark Colliery)
Godfrey Magamola	Themba	Anglo Coal (New Denmark Colliery)
Nicola	Crawshaw	Anglo Coal (New Vaal Colliery)
Carl	Stensby	Anglo Coal (New Vaal Colliery)
Francois	Grove	Anglo Coal (Waterberg Coal Bed)
M W	Sutton	AngloGold Ashanti Limited
Ettiene	Grond	AngloGold Ashanti Limited
Jozua	Ellis	AngloGold Ashanti Limited
Charl	Human	AngloGold Ashanti Limited
Mark	Aken	Anglo Base Metals
Nishi	Haripursad	Anglo Platinum
Louis	Buhrmann	Anglo Platinum



Peter	Lentsoane	Anglo Platinum - Union Section V
Hope	Tyira	Anglo Platinum Limited
Stephen	Bullock	Anglo Platinum
Andre	Britz	Anglo Platinum
Thulani	Ntshanga	Anglo Platinum
Hermanus	Prinsloo	Anglo Platinum Limited
Henri	Linde	ArceloMittal South Africa , Newcastle Works
Siegfried	Spanig	ArcelorMittal South Africa Limited
Johan	Hattingh	ArcelorMittal South Africa Limited
Karien	Zantow	ArcelorMittal South Africa Limited
Liandia	Taljaard	ArcelorMittal South Africa Limited
Thabang	Tsubane	Assmang Manganese/Ferrolloys
Muna	Forbang	BHP Billiton
Ntsako	Baloyi	BHP Billiton
Mariette	Bylsma	BHP Billiton
Heiko	Stoelting	BHP Billiton
Raj	Reddy	BP
Les	Sayed	BP
Hugh	Morgan	BP SA (Castrol)
Laurainne	Lotter	CAIA
M P	Coldrey	Caltex
S J	Hlastshwayo,SJ	Caltex
L	Joubert	Caltex
Terence	Parker	Caltex / Chevron Texaco
Steve	de Bruyn	Caltex Oil SA (Pty) Ltd
Matome	Makwela	Chamber of Mines
Reginald	Mabalane	Chamber of Mines
Nikisi	Lesufi	Chamber of Mines
Lindie	Hassan	Chevron Environmental Management Company (CEMC)
Peter	Scurr	Columbus Stainless Pty Ltd
Debbie	van Rensburg	Cape Gate Pty Ltd
Les	Hillowitz	CropLife Africa Middle East
		Coal of Africa
Riaan	van der Merwe	Coal of Africa
Sazi	Lutseke	DOW Southern Africa Pty Ltd
Garth	La Fleur	DOW Southern Africa Pty Ltd
Danie	Gous	DOW Agri Science/ DOW Southern Africa Pty Ltd
Tsidi	Luse	ECO2/ Lafarge-SA
Sandra	Redelinghuys	Engen Refinery
Mike	Edwards	Engen Petroleum Limited
Namo	Thambiran	Engen Petroleum Limited
Mike	Stead	Engen Petroleum Limited
Peter	Kemp	Engen Petroleum Limited
Johan	Schoonraad	Enviroserv
Richard	Daneel	Enviroserv
Iris	Cloete	Eskom - Waste Management
Ian	Jameson	Eskom (Holdings)
Octavia	Gama	Eskom Research & Renovation Centre



Charl	Nolte	Exxaro
Charl	van der Merwe	Exxaro (Zincor Exxaro Base Metals)
Vinny	Moodley	Exxaro (Zincor Exxaro Base Metals)
Neil	Anderson	Exxaro
Morne	Viljoen	Exxaro (legal advisor from CLS Consulting Services (Pty) Ltd)
Koos	Smit	Exxaro Resources
Alison	Haycock	FFS Refiners
Boitumelo	Shibambo	Go-Awaste Management Services
Danny	Ramsuchit	Goldfields
Graham	Smith	GRS Waste Management Services cc
Yolandi	Bezuidenhout	Highveld Steel and Vanadium Corporation (Ltd)
Gerhard	Van Dyk	Impala Platinum
Carina	Burger	Impala Platinum Refineries
Suan	Mulder	Impala Platinum
Mike	Nicholls	Interwaste
Jaap	Viljoen	Ingwe Coal Corporation
George	Thom	Karbochem
Anke	Berling	Karbochem
Gerhard	Venter	Karbochem
Stef	Durandt	Kumba Resources
Ian	Hunt	Kumba Resources
Fanie	Lotter	Kumba Resources
Theo	Hacking	Kumba Resources (Sishen Iron Ore)
Daniel	Mahlangu	Langalami Import and Export \$ Projects
Kas	Moodley	Lanxess
Hazel	Fiehn	Lonmin Platinum
Moses Gembe	Mahlangu	Margen Industrials Services
Kirsten	Otten	Mills & Otten
Charles	Mills	Mills & Otten Env Consultant
Bridget	Corrigan	Mills & Otten Env Consultant
Ian	Naidoo	Natal Portland Cement
Pieter	Hayward	Natcos
Christo	van der Bergh	NCP Chlorchem Pty Ltd
Cobus	Grove	NCP Yeast
Egmont	Ottermann	Oil Separation Solutions/ Pretoria Portland Cement Company Ltd
Sanet	Jacobs	Omnia Group Limited
Nomasonto	Mnisi	Parsons Brinckerhoff
Jessica	Courtoreille	PetroSA
Andre	Le Roux	Phambili/Wasteman
Urishanie	Govender	PPC Cement
Hamied	Mazema	PRO & RM cc
Raj	Lochan	Rose Foundation
Shamitha	Lalthaparsadh	S A Calcium Carbide (Pty) Ltd
Heather	Booyesen	Samancor Chrome (FAPA)
John	Botha	Samancor
Cobus	Westhuizen	Samancor (CR Ferrometals)
Jeff	Leader	Samancor (Manganese)
Bertus	van der Merwe	Samancor Chrome



Steve	Walker	Sappi Enstra Fine Paper
Lehlohonolo Michael	Lesemane	Sappi Enstra Fine Paper
Sakkie	van der Westhuizen	Sappi Management Services
Samuel	Mokoena	Sappi Stanger
Beth	Brockbank	SAPREF
Raj	Hooblal	SAPREF
Martin	Ginster	Sasol
Shamini	Harrington	Sasol Mining
Raylene	de Villiers	Sasol Technology (Pty) Ltd
Vaneshrie	Govender	Sasol Oil (Pty) Ltd
Vierah	Hulley	Sasol Technology (Pty) Ltd
Dr Jaap	Smit	Sasol Technology (Pty) Ltd
Vivek	Kasseepursad	Sasol Technology (Pty) Ltd
Mpho	Mosima	Shell SA Marketing Pty Ltd
Erica	Reynold	Shell Oil
A	Lawrence	Shell SA
G	Holding	Shell SA Marketing Pty Ltd
Meloney	Hallett	Shell South Africa (Pty) Ltd
Nelson	Mbatha	Shell SA
N	Moodley	Shell (Chemicals)
R	Bosman	Shell marketing
Nkosinathi	Skaka	Skhakha Waste Management
Peet	Kotze	South African Coal Mining Holdings
Avhapfani	Tshifularo	South African Petroleum Industry Association
Anton	Moldan	South African Petroleum Industry Association
Siegi	Spaniy	South Africa Iron and Steel Institute
Franz	Schmidt	TATA Stell KZN
Edward	Legg	Teal Mining Co
Noleen	Pauls	The Mineral Corporation
Dean	Harding	Total
Nerusha	Govender	Total South Africa (Pty) Ltd
Cornwell	Dauds	Trillanium Waste Management Pty Ltd t/a Tri-Waste
Peter	Allen	Veolia Environmental Services
Lukas	Vermaak	Veolia Environmental Services
Albert	Herbst	Veolia Environmental Services
Carla	Manion	Vopak Terminal Durban (Pty) Ltd
Vuyani	Nakani	Vuluthuba Rural Developers
Dave	Marock	Wasteman Holdings
Redge	Gerber	Wasteman KZN (Pty) Ltd
Chantelle	Koekemoer	Xstrata
Hugh	Stewart	Xstrata
Tommie	Hurter	Xstrata Alloys
Racheal	Venter	Xstrata Alloys (Lion Ferrochrome)
Christo	Van Der Walt	
Thabo Eugene	Dithane	
PARASTATALS		
Nicole	Jansen	National Ports Authority of South Africa
Khosi	Zondi	Transnet National Ports Authority



Peter	Balfour	Transnet - National Port Authority
Lesedi	Boihang	Transnet National Ports Authority
Leticia	Greyling	Transnet National Ports Authority
Mmalaka Dorothy	Phejane	Transnet National Ports Authority
Emma	Du Plooy	Transnet National Ports Authority
Michael	Melato	Transnet National Ports Authority
Darryl	Ritson	Transnet National Ports Authority
Nonosy	Mananela	Transnet Freight Rail Legal Services
Cecil	Dikgale	

GOVERNMENT

Obed	Baloyi	DEAT
Shauna	Costley	DEAT
Timothy	Fasheun	DAEA (KZN)
Siyabonga	Gqalangile	DEDEA
Ntsoaki	Khomo	DTEA (Free State)
Given	Mashiane	DEA
Sarah Mahadi	Mofokeng	DWAF
Basadi	Moselakgomo	DACE North West
Trevor	Mphahlele	DEDET Limpopo
Stranton	Narain	DEA
Kelello	Ntoampe	DEA
Michelle	Poonyane	DTEA (Free State)
Collins T	Ramavhona	DTEEA Free State (DEA)
Donald	Sehashwa	DEAT
Mpho	Tshitangoni	DEAT
Rhulani	Baloyi	DEAT
Mashudu	Nevuvha	DEAT
Mangaka	Moloi	DEAT
Mashudu	Mposi	DWEA (DEA)
Lucas	Mahlangu	DEA
Thapelo	Loabile	DAFF
Mpho	Sebola	DEA
Berneditte	Moitse	DEA
Pamela	Nyuswa	DEA
Nomphele	Daniel	DEA
Vincent	Qwabe	DEA
C	Bill	DEADP
C	Lesch	DEADP
Lance	McBain-Charles	DEADP
E	Hanekom	DEAAP
Sindisiwe	Duma	DEA
Richard	Moseki	DEA
Shiba	Sebone	DEA
Kamaseelan	Chetty	DEA & DD
Phaladi	Majelele	DEA
Tembela	Mapukata	DEDEA
D	Fischer	DEA
Steve	Makuwa	LEDET



Shaine	Naidoo	DWAF
CONSULTANTS & BEE CONTRACTORS		
Vuyani	Nyathi	Amaqhawwe consulting
Babalwa	Fatyi	Myezo Environmental Management Services
		Enviroxcellence Services
Joyce Thiffhelimbilu	Khorommbi	Mulinda Environmental Consulting
Jacob L	Mphatswe	Vantage Medical Waste Management
Mbudzeni	Mutangwa	Musengavhadzimu Business Enterprise
Nomsa	Mavhungu	Musengavhadzimu Business Enterprise
		Musengavhadzimu Business Enterprise
		Musengavhadzimu Business Enterprise
Othani	Mudau	Gondwana Agri and Waste Holdings
Boitumelo	Shibambo	Go-Awaste Management Services
Sipho	Dhladhla	Dhladhla & Associates Consulting
Graham	Smith	GRS Waste Management Services cc
Zanele	Phoku	La Terra Earth Sciences Pty Ltd
Nkosinathi	Skaka	Skhakha Waste Management
Annette Thandiwe	Ndlovu	Annecia Civil Construction
Vuyani	Nakani	Vulithuba Rural Developers
Thabo	Dithane	Blackgold Consulting
Kelello	Molapo	
Daniel	Mahlangu	Langalami Import and Export \$ Projects
Kenneth	Netshiombo	Khensa Mills Projects & Construction
Zamuxolo Lennox	Gudu	Siphumelele Youth organisation
Jabulani	Tshuma	Songimvelo Consulting
Moses Gembe	Mahlangu	Margen Industrials Services
Saai	Mahlangu	Mpumalanga Tourism & Parks Agency
Neil	Philipson	PD Naidoo and Associates Consulting Engineers Pty Ltd
Langa	Sangoni	Apple Green Holding
Tim	Mohulatsi	Apple Green Holding
Mpumi	Msezane	Parsens Brinckerhoff
Bongi	Duma	SSI
Shareetha	Ismail	Shareetha Ismail Consulting
Liz	Anderson	Responsible Container Management Assoc. of SA (RCMASA)
Riette	Badenhorst	Rapid Spill Response
Denel	van Tonder	Council for Geoscience
John	Glendinning	Jones & Wagener Consulting Engineers
Alan	Cooke	AC Environmental Products Pty Ltd
Norman	Dittberner	DRC Process (Pty) Ltd
Panganai	Dzanga	TES Environmental Specialists/ Global EnviroExperts
Johanita	Kotze	ERM Southern Africa
Michael	Pottinger	ERM Southern Africa
Meris	Mills	ERM Southern Africa
Michael	Pottinger	ERM Southern Africa
Hermanus Ockert	Fourie	Ockie Fourie Toxicologist
Elize	Herselman	Golder Associates Africa (Pty) Ltd
David	Hughes	Plastics Federation of South Africa
Laurraine	Lotter	Business Unity SA (BUSA) / Chemical & Allied Industries Association (CAIA)
Godfrey	Mvuma	CSIR



Dr Darrell	Myrick	National Development Agency
Thilivhali Samuel	Phophi	Geo Pollution Technologies - Gauteng Pty Ltd
Dhiraj	Rama	Association of Cementitious Materials Producers (ACMP)
Carl Edward	Steyn	Golder Associates Africa (Pty) Ltd
Mervyn Derick	Traut	MDTraut Consulting
Johan Hilgard	Van der Waals	Terra Soil Science CC
Willie	van Niekerk	Infotox (Pty) Ltd
Brett	Wilson Jones	Moore Spence Jones (Pty) Ltd
Andrew	Wood	SRK Consulting
Chippy	Olver	
Lulu	Dutton	IMBEWU Sustainability Legal Specialists (Pty) Ltd
Kagiso	Tshose	Tianathii Projects/ Igoda
Nokuthula	Khumalo	Tianathii Projects
Aletta Johanna	Plomp	SSI Engineers and Environmental Consultants (Pty) Ltd
T	Pfotenhauer	Kantey & Templer
Kelello	Molapo	
Nomsa	Mavhungu	Musengavhadzimu Business Enterprise
Joyce Thifhelimbilu	Khorommbi	Mulinda Environmental Consulting
Jacob L	Mphatswe	Vantage Medical Waste Management
Kenneth	Netshiombo	Khensa Mills Projects & Construction
Zamuxolo Lennox	Gudu	Siphumelele Youth Organisation
Dr Shenaz	Moola	PD Naidoo and Associates Consulting Engineers Pty Ltd
Vanessa	Talbot	Talbot & Talbot Pty Ltd
Thabo	Dithane	Blackgold Consulting
Annette Thandiwe	Ndlovu	Annecia Civil Construction
Sipho	Dhladhla	Dhladhla & Associates Consulting
Zanele	Phoku	La Terra Earth Sciences Pty Ltd
Cornwell	Dauds	Trillium Waste Management Pty Ltd
Carmen	Carstens	
Kofane Boas	Kgotle	Bokang Lesedi Trading cc
Jabulani	Tshuma	Songimvelo Sonsulting
Rodney	De Klerk	Hearland Properties
NGO's / GENERAL		
Karen	Marx	WESSA North
Lyn	Archer	Umgini Water
Morgan	Griffiths	WESSA
Rico	Euripidou	groundWork
Saai	Mahlangu	Mpumalanga Tourism & Parks Agency
Neville James	Smith	Pikitung (Pty) Ltd
Mahlatsi	Ramashala	Pikitung (Pty) Ltd
Bryan	Havemann	WESSA
Melanie	Traut	City of Cape Town - Scientific Services

* Registered Stakeholders are individuals or company representatives that have (a) requested information, (b) attended national workshops and/or sector workshops (c) submitted comments and/or (d) requested to be kept informed during the process



Appendix C Workshop Documentation

National Workshops

Minutes of 1st National Workshop held on 5 November 2009

Minutes of 2nd National Workshop held on 31 March 2010

Sector Workshops

Minutes:

- Petrochemical Sector Workshop
- Mining Sector Workshop
- Chemical and Allied Industries Association (CAIA) workshop
- Iron and Steel Industry Workshop

DEA Contaminated Land Framework: 1st National Workshop held 5 November 2009

1. Summary of Events

1.1 WELCOME – MS KELELLO NTOAMPE (DEA)

The meeting opened at 9am.

1.2 PROJECT MOTIVATION AND OBJECTIVES - MS KELELLO NTOAMPE (WSP)

No comments or questions were raised.

1.3 OVERVIEW FOR LEGAL FRAMEWORK FOR CONTAMINATED LAND - MR CARL HAYCOCK (WSP)

	Question / Comment	Response
1.3.1	In Gauteng there is large scale underground pollution in the form of heavy metals and Acid Rock Drainage as a result of mining related legacies. Is the National Environmental Management: Waste Act (NEM:WA) framework relevant to large scale issues as it refers to a 'land use' or 'land based' approach?	This is an example of widespread contamination. The remediation framework will provide broad principles which would be applied on a case by case basis in terms of the nature and extent of the contamination. The example given would be a case for a regional strategy: pollution on a large scale needs a local and regional scale of response and a long term phased strategy. We are looking to develop an integrated and holistic framework that can achieve a broad level of application.
1.3.2	Mining activities are currently excluded under the National Environmental Management Act (NEMA) EIA regulations. Clauses in the NEM:WA refer the reader to the Minerals Petroleum Resources Development Act (MPRDA). How will mining activities be dealt with?	Exclusions pertain to large mine waste such as mine residues and tailings only. Other wastes, such as hazardous waste fall within the ambit of the NEM:WA. Legislation does not exclude pollution and waste management control. There are broad responsibilities in terms of waste and contamination which would apply to mining activities.

	Question / Comment	Response
1.3.3	Case studies would inform the legal overview of the NEM:WA. The lack of case studies has led to poor enforcement in the case of Section 20 of the Environment Conservation Act. There is a need for a framework of decisions that can be taken by the authorities during the due diligence process. Decisions taken can have significant cost implications.	Confidential due diligence studies have been undertaken by companies for many years. Often the legal implications and associated costs (liability) are overlooked. The Waste Act requires that authorities be notified of contamination. However, disclosure is very difficult to enforce.
1.3.4	The pace of EIA processing may be slow as the departments may not be able to handle the many applications. Which government department will be responsible for processing applications?	Remediation approval will be the responsibility of the national department (i.e. Department of Environment and Water Affairs. This is to ensure a speedy response and adherence with timeframe as the national department does not have backlogs.
1.3.5	What are the legal implications with respect to sites which are currently under remediation? Will companies be required to apply the EIA regulations retrospectively?	Those businesses currently undertaking remediation activities should be advised by their provincial authorities with regard to any requirements. Documentary proof of existing authorisations and appropriate written directions will be taken into account.
1.3.6	It is necessary to develop qualification criteria for specialists involved in the assessment of contaminated land. As specialist expertise is require, we need to ensure we have norms and standards to ensure that the standard of reporting is maintained and avoid the rejections of poor quality reports by the regulators.	Environmental practitioners/consultants/experts will have to adhere to the requirements stipulated in Regulation 69(1) (u) and (v) of the Waste Act. The framework will include reporting norms and standards to define a minimum code of practice for contaminated land practitioners. .
1.3.7	Remediation is costly. There is a need for legislation / norms and standards to ensure businesses make provision for site assessment and remediation costs.	It would be appropriate for high risk industries to set aside provisions for remediation. The Duty of Care principle applies. Some industries have already done this. it is a responsibility of high risk industries to ensure that situations giving rise to contamination can be dealt with. If a particular industry sector is posing a high risk, the law allows the minister to provide for measures for the identification and management of priority wastes which could apply to that specific sector and its contaminants of concern. .



1.4 INTERNATIONAL BEST PRACTICE AND ASSESSMENT OF ALTERNATIVES REVIEW - DR JON MCSTAY (WSP)

	Question / Comment	Response
1.4.1	We need a risk based approach. The norms and standards are guidelines but we need site specific considerations.	Agreed.
1.4.2	The cost of remediation must be considered. In some cases the cost of remediation may exceed the value of the land.	Noted. Hence the provision for management measures and land use restrictions to applied for certain sites.
1.4.3	Local government needs to be aware of the risks posed by contaminated land	Agreed.
1.4.4	South Africa needs to adopt a framework which suits our local conditions. We can use international guidelines for direction.	Agreed.

GENERAL DISCUSSION BEFORE TEA BREAK:

	Question / Comment	Response
1.4.5	What is your interpretation of the word 'remediation'?	There are several definitions of 'remediation'. 'Remediation' is defined in the discussion documents prepared by WSP, and a definition will be arrived at in the framework. This question points to the issue of the scale of activities. The legal definitions provided in the Waste Act and other applicable legislation need to come together to create a common understanding. Other terms such as "rehabilitation" (which relates to the physical environment), can be bolted onto the concept of remediation. "Restoration" is another term which refers to restoring to pre-existing conditions. All these terms are open to debate and final agreement.
1.4.6	The NEM:WA provides a definition of 'waste'.? In terms of this definition, treated and or remediated soil would be considered a 'waste' in terms of the definition.	The framework will provide guidance on the status of remediated soil. The Act aims to reduce waste to landfill. The onus is on the proponent to ensure that the risk to the environment is reduced, as such the owner of the waste should look at reuse rather than landfill. A successful remediation plan would aim to reduce resultant hazardous waste generation to a minimum. The approach should be one of sustainable remediation, with only defined hazardous wastes disposed to landfill. The hierarchy of waste management should be supported within the framework with disposal being a last resort.. Previously a 'dig and dump' approach has been applied. This can give rise to human health risks during remediation. The remediation process needs to be understood and a risk assessment undertaken on the remedial works as well as the land use based final remediation end point.

	Question / Comment	Response
1.4.7	In terms of the legislation, when is it acceptable to dispose of contaminated material at a H:H landfill? In most cases disposal is more cost effective than remediation.	In some cases it is not possible to treat material to an acceptable level, and landfill is the most suitable option. In many countries permission to landfill contaminated soil is required. It is not taken by default as being a lawful activity as it has been in the past in South Africa It is important to consider the best practical environmental option. It is necessary to look at better technologies for treating contaminated material both in-situ and ex-situ. Finance should not be the sole driver of a remediation objective, but rather human health and socio-economic aspects must be the priority when dealing with contaminated sites.
1.4.8	The NEM:WA provides a schedule of listed activities which require a Basic Assessment or full EIA process. In the event of an emergency spill, how are the requirements applied	The principle of 'duty of care' applies which empowers companies to take reasonable measures to rectify environmental risk. To clarify, the NEM:WA listed activities require a licence and it is this licence which triggers the need for a Basic Assessment or EIA. An emergency spill, depending on its nature and extent may trigger Section 30 of NEMA which refers to emergency incident response. Emergency incidents which require immediate response; may also require secondary cleanup measures to be put in place. In such cases the longer term remediation activities is likely to require a Basic Assessment, even if Section 30 has been applied to the immediate emergency. In the event of an emergency, contact the authorities for guidance on legal requirements.

	Question / Comment	Response
1.4.9	Will norms and standards be developed for certain industries i.e. a hazardous activities list?	At present there is no need for this however the merits of adopting this approach will be considered when the need arises.
1.4.10	What is the definition of “significantly contaminated land”?	A key element of the framework is to establish what is ‘significant’ contamination with respect to different receptors and land use scenarios.

TEA BREAK

1.5 REPORTING GUIDELINES FOR CONTAMINATED SITES - SEAN DOEL (WSP)

	Question / Comment	Response
1.5.1	Two points to consider: Quality control with regard to laboratory testing is a challenge. Reports need to be standardised and need to contain a specific list of criteria. This assists the authorities with the review process.	Agreed. The framework will contain guidance on testing methods and the basic requirements for quality control/quality assurance from sampling to laboratory testing. Professional judgement and expertise is required in the preparation and review of reports. The framework includes norms and standards for reporting.
1.5.2	Two aspects which should be considered for inclusion in the Phase 1 checklist: 1. Background levels for comparison 2. Capability of the soil (good description of soil – profile and stratification)	Noted. These issues may be assessed in Phase 1 reports and detailed in Phase 2 report in a consistent manner according to the risk posed by the site..

	Question / Comment	Response
1.5.3	The checklist approach is correct, however, there is a need to differentiate between Phase 1 and 2. There needs for consistency, on the part of government officials in the application of requirements.	A checklist cannot achieve consistency or be used to ensure compliance by 'ticking the boxes'. It is a tool to assist in the identification of information gaps and requirements. Government officials need to evaluate documents on a case by case basis and they need to be confident that the information presented is correct. The approach is designed to improve consistency in decision and to safeguard against regulatory oversight.

1.6 DEVELOPMENT OF SOIL SCREENING VALUES - DR JON MCSTAY (WSP)

	Question / Comment	Response
1.6.1	Why does the defining of pollution pathways refer to 1 km for groundwater.	DWAF applied the 1km radius as a precautionary principle based on the hydro-census method. This is an element of initial site screening. For groundwater, attenuation mechanisms need to be evaluated. Human consumption of groundwater can be a direct pathway and needs to correctly identified at an early stage of site assessment..
1.6.2	There has been some discussion with regard to natural water systems however there is a need to refer to the National Water Act's definition of water systems. Artificial water bodies need to be given equal consideration.	Agreed, there needs to be a consistent approach to the protection of water resources.
1.6.3	With regards to exposure to a child, you need to note that carcinogens are not based on exposure to a child but on the lifetime exposure duration of an individual	Correct.
	We also need to consider house dust as a specific pathway e.g. lead exposure to infants.	The framework risk assessment is in development and all model assumptions are in a process of review.

	Question / Comment	Response
1.6.4	The presentation referred to three land uses: residential, informal settlement, commercial. Where does agricultural land fall?	Agricultural site screenings are the most complex to develop because receptors include livestock and crops and indirect linkages to human health via the food chain. Agricultural land use standards should be developed on a site specific basis.
1.6.5	The 1 st level of assessment (phase 1) is conservative. This level needs to be conservative enough to protect agricultural land. There is a need to define the same levels for agricultural land that can protect environmental resources.	Agreed. The Phase 1 screening levels might not be conservative to protect all agricultural land as there is a difference between human health exposure and other environmental receptors. There is thus a need to consider typical agriculture scenarios and see if they apply well enough and gain the level of protection required. The agricultural land use is best assessed on a site specific basis particularly where protection of ecological receptors is required.
1.6.6	Contaminated land is remediated with a land use in mind. Rezoning of industrial land to agricultural land is unlikely and uncommon. Usually industrial land is rezoned to either residential or other industrial uses.	Agreed. It's a low priority issue. The most likely trigger would be land contaminated by mining activities being re-used for agricultural purposes. In such cases the scale of this activity would be consistent with application of a site specific risk assessment.
1.6.7	Spillages and industrial activities impact on agricultural land.	Agricultural land use studies would require the identification of agriculture land use receptors. Residential land use guidelines do apply to direct human health exposure routes.
1.6.8	The scope and types of contaminated land to be addressed seemed to dwell on metals and mining and not give enough attention to the important issue of organic compounds and solvents which are highly mobile and particularly problematic in terms of the water resource.	The organic compounds will form part of the framework. The metals were used simply to illustrate the framework development to provide for discussion of the general concepts and assumptions used in risk-based models for assessing contaminated land.

1.7 APPLICATION OF SITE SPECIFIC QUANTITATIVE RISK ASSESSMENT – MR SEAN DOEL (WSP)

	Question / Comment	Response
1.7.1	Will the framework include screening levels for organics?	Yes, there is a need to define and agree on a list of organics. This is being researched at present.
1.7.2	How will the SSV be applied? Would there be a need to have a professional check the values generated? How strictly will this requirement be applied?	There has to be a statement by landowner/professional confirming that the site meets the limits specified / is appropriate according to the screening levels. The method proposed focuses on receptors and pathways and hence validating assumptions on the linkage is important and not simply the numerical value. The screening values are conservative and thus if correctly applied the level of detailed professional judgement should be minor.
1.7.3	Receptors and pathways have been emphasised. Can we use markers? For instance, initially a sick person needed to undertake 50 blood tests but now three (3) are acceptable. Is it possible that we can define markers and values for contaminated land assessment, and if so how do we decide on markers?	Not all soil screening values will need to be applied in all assessments. Key parameters of concern must be identified. Phase 1 will close out on what is necessary or not. There would be a suite of parameters which would apply to certain industry types. Laboratories are capable of testing large numbers of parameters. There is no intention of having proponents analyse for contaminants that are not reasonably believed to be present on site.
1.7.4	With regards to the Water Quality Guidelines, the USEPA is not consistent with regard to the cancer risk target. For certain SSV, we need to use the 1 per million (10^6) instead of 1 in 10^5 risk especially for the carcinogenic elements. SSV is a precautionary approach as such the cancer risk must be set as low as possible. Emission factors are very problematic. This comes from USEPA and they have states with different soil types dependent of weather conditions etc. Emission factors are only important when you look at highly toxic materials (i.e. chrome VI).	Agreed, there much work to be done in fine tuning of all input parameters and peer review of the key parameters and equations. There are also a number of management decisions required to provide a consistent and scientifically defensible framework. This has affected the development of all international systems to varying degrees in the past and is subject to much on-going debate and research.

	Question / Comment	Response
	There is a need to standardise terminology used in terms of 'pathways' and 'routes of exposure' The dermal absorption factor adopted in the framework is probably lower for metal..	
1.7.5	A system needs to be developed where the numbers can to be revised from time to time based on new information that becomes available.	Agreed, there should always be an opportunity for review and update.

LUNCH

1.8 DISCUSSION FORUM – DR JON MCSTAY (WSP)

	Question / Comment	Response
1.8.1	How are you going to deal with aquatic guidelines?	The revision of the DWAF water quality guidelines has been pending for some time. We have to work within our existing framework for now but can update when the companion guidelines are available.
1.8.2	Has a decision regarding methods to be used been taken? On consideration of the presentation material, the initial feeling is that the proposed approach is too complicated for a first level screening, not because of maths, but because expert input is required to confirm almost every value.	Testing methodologies will be published in the framework along with a set of standard laboratory testing regimes to provide consistent, defensible results. The list take into consideration priority compounds of concern. This is considered an appropriate level of detail for initial SSL's. There will be areas that will require application of professional judgement. From past experience, most contaminated land scenarios would fit within the framework and reduce the need for expert input.

	Question / Comment	Response
1.8.3	Monitored Natural Attenuation has not been mentioned in the presentation, will it be dealt with within the framework?	Monitored Natural Attenuation is a method which requires some guidelines. There is no reason why it can't be applied to South African context, but there is a need for guidelines on monitoring and progress. Monitored Natural Attenuation is not simply about just leaving a product in the ground to naturally decay. Phase 3 remediation plans will need to build in checks and balances for performance monitoring. Authorities will be open to this method, if it is the most suitable method for a site.
1.8.4	How are we going to bridge gap between contaminated land requirements from a small industry perspective i.e. high risk activities (ground water pollution) as a result of the dry cleaning industry?	The dry cleaning industry is problematic with regard to persistent organic pollution. Where small operators can cause significant pollution impacts. No specific measures are identified at this time.
1.8.5	We need to be proactive. Our government development programme is moving towards SMME programmes. How do we build the contaminated land framework into the SMME programme? We need sector specific guidelines to be developed as part of SMME programme.	This will take time to implement and financial incentives and penalties may be required in the future to address SMME issues. The priority at this stage is to put the foundation in place.
1.8.6	There are concerns regarding people's capacity to understand, interpret and apply this methodology. Reference was made to final phase capacity building with I&APs, however there is a need for upfront capacity building. Perhaps a number of ½ day workshops should be considered, to assist people to understand implications of the legislation.	It is an objective of the project to make the framework easily accessible and understandable to a broad range of stakeholders.

	Question / Comment	Response
1.8.7	The concept of background concentrations is included in the definition of contaminated land. This has not been specifically addressed today. This concept is key to the management of sites and could become an issue when considering the logic of values.	Agreed, this is essential as part of the process. A good example would be in terms of metals - we have areas that are naturally enriched with metals. As such consideration of natural background levels is important. There are ways in which this can be dealt with both analytically and statistically. A company cannot be expected to clean up to a level below the natural level. This is an important consideration for the mining industry. There are also background levels due to human influence. In parts of SA have relatively high levels of mercury, above the international level, which can be the result of airborne transfer and bioaccumulation.

Meeting closed at 15H00.



DEA Contaminated Land Framework: 2nd National Workshop held 31 March 2010

1. Summary of Events

1.1 WELCOME AND PROJECT UPDATE – MS KELELLO NTOAMPE (DEA)

The meeting opened at 9am. Apologies for Ms Nolwazi Cobbinah were given.

1.2 LEGAL STATUS OF AUTHORISATION AND POLICY POSITION FOR THE MANAGEMENT OF CONTAMINATED LAND – MR OBED BALOYI (DEA)

DISCUSSION PERTAINING TO LEGISLATION ON REMEDIATION – MR OBED BALOYI (DEA)

	Question / Comment	Response
1.2.1	What will be the legal status of existing and ongoing remediation projects?	If the project has written authorisation from national or regional offices of the Department of Environmental Affairs, or Department of Water Affairs, then it can proceed. Otherwise, the proponent needs to notify the DEA of the activity. The department may review and impose additional standards on a case by case basis.
1.2.2	What is the point of entry with regards to the authorisation of remediation projects? How will the process operate between provincial and national departments?	The point of entry is the DEA Currently authorisation for remediation projects is done at national level in terms of the National Environmental Management: Waste Act (No 28 of 2008). However, the long term intention is that the activity can be authorised by the office of the provincial MEC.

	Question / Comment	Response
1.2.3	Please clarify what is the difference between a Remediation Order and Order?	A Remediation Order is an instruction to remediate. The order will specify the timeframes for remediation either immediately or within a specified timeframe. Where the contaminated land does not pose immediate risk, an Order may be issued to manage and monitor the risk.
1.2.4	We currently have a database of contaminated sites. Should we notify the Minister of such sites given that the norms and standards are not yet finalised?	Notifying the Minister of such information cannot harm. Notification of a contaminated site as a potential pollution risk is a requirement of the National Environmental Management Act (No 107 of 1998) (NEMA), so compliance is not dependant on waiting for the establishment of 'norms and standards'.
1.2.5	We have contacted specialists to assess the contaminated sites. Should we notify the Minister of the outcomes of such assessments?	Notifying the Minister of such information cannot do any harm. The DEA still needs to give regulations of how the assessment should be done and the contents of such assessments. However acceptance
1.2.6	What is the difference between remediation and clean-up?	The two terms are interchangeable although remediation tends to be used in a much broader context and is used to describe the statutory responsibility ie Remediation Orders issued can be issued by DEA. Clean-up is used as a colloquial term for remediation.
1.2.7	At which point can remediated land be sold or transferred?	The seller must inform the purchaser that the land is or was contaminated. The seller must also notify the Minister/MEC that there is a transfer of a contaminated site. A site served with a Remediation Order cannot be transferred without written authorisation of the Minister.
1.2.8	Does the Duty of Care get transferred when the land is sold?	If the new owner accepts the responsibility, the Duty of Care will be held by the new owner. The Minister/MEC can prevent such transaction if there are issues which needs to be resolved first. Proper disclosure and liability transfer is very important and the technical and legal means must be in place to deal with such issues in a commercial transaction. The new owner cannot 'contract out' of compliance with our national environmental legislation and can be held liable for remediation of

	Question / Comment	Response
		historical contamination.
1.2.9	When is a Basic Assessment needed? Is it required when you are doing emergency cleanup?	If it is an emergency, the onus is on the owner to clean up in line with the requirements of Duty of Care. You cannot wait for authorisation if it is an emergency and there is a significant pollution hazard. However notification is a legal requirement and the incident may have long term remediation consequences that would trigger the requirement for the authorisation process.
1.2.10	What can be classified as emergency clean up?	It is defined by the Duty of Care responsibilities. It is where prompt action solves environmental risks or other hazards e.g. fire or explosions. The primary clean up activities can be undertaken to prevent the immediate risk of pollution. However, a Basic Assessment would be required for any long term secondary clean up measures. Section 30 of the NEMA provides definitions and procedures for emergency cleanups. The department can also give directives to remediate in terms of emergency clean ups. A legal opinion was offered from the floor that environmental authorisation for emergency situations are required. The owner is obliged to apply for such authorisation. If emergency remediation is required, the Minister/MEC may issue an order. The powers outlined in Section 24 have been expressed in the courts. Until such time that the Act is amended, the legal advice is to apply for authorisation and not to assume that a Duty of Care undertaking exempts the proponent of an emergency response from obtaining an approval for their actions.

	Question / Comment	Response
1.2.11	With regards to emergency response, how do we deal with it between now and when Part 8 is implemented?	There are no specific clauses in Part 8 of the Waste Act that deals with the handling of emergency situations. Section 30 of NEMA will apply.
1.2.12	We have a site with historical asbestos contamination which we want to remove. Is removal considered clean up and does it require a BA?	Yes. You need to apply for authorisation for the activity and undertake a Basic Assessment.
1.2.13	Will the Basic Assessment (BA) process be subjected to public participation process (PPP) requirements?	Remediation activity requires BA and PPP to be undertaken. PPP will only be excluded in emergency incidences. Once Part 8 is completed, the polluter will submit a Site Assessment Report, under the 'norms and standards' approach for approval by the DEA.
1.2.14	In terms of the NEMA Regulations 23C, decommissioning where land may be contaminated, there is a conflict between NEMA decommissioning and remediation.	The issue has been noted and may be transferred to the Waste Act. However in terms of 23C there is an envisaged change of land use associated with the closure and decommissioning of the industrial facility and this provides a logical trigger for the Basic Assessment process and public participation.
1.2.15	Are there provisions for financial assistance for municipalities to remediate?	At the moment there is nothing. There are suggestions that this may be an issue and it's a proposal that will be looked at.
1.2.16	With regards to the exclusivity of the Minister to issue Remediation Orders and Orders, can a Compliance Notice be used to address the Order? There might be a conflict of authority e.g. if a Minister issues an Order and the Environmental Management Inspectorate (EMI) officials issues a Compliance Notice	EMI will ensure you comply with the Order i.e. EMI enforce compliance.

	Question / Comment	Response
1.2.17	Is there any training that will take place for a variety of sector stakeholders e.g. residential, industrial, property market, with regards to the requirements for clean up?	The Framework is broad and deals with all forms of land use. Training may be required in future to ensure capacity building and awareness of contaminated land issues. All of us will have to drive systems that will address the needs of particular stakeholders.
1.2.18	EMI and Blue Scorpions. Do the two inspectorates communicate with each other? Because there may be a situation where one gives the property owner a Compliance Order at a given time and the other issues a similar Compliance Order at a different time.	There is a need for cooperative governance in enforcement.
1.2.19	There is a systemic risk where municipalities cannot be able to clean up contaminated sites	Municipalities own reclaimed land that could be classified as contaminated land. Also there is a concern that the planning and construction of informal settlements could be undertaken without proper consideration of contamination risks.
1.2.20	At what point will the licensing process start? Is it at the planning phase or during the assessment?	That's the purpose of the Norms and Standards. There are various stages that must be gone through to ensure the site is adequately assessed. The Norms and Standards are aimed at standardising the assessments. If it is apparent at project planning stage that a remediation activity is a highly likely outcome then it would be advisable to commence with a Basic Assessment process while site investigations are being completed.

1.3 PROTOCOL FOR SITE RISK ASSESSMENT & REPORTING NORMS AND STANDARDS FOR SITE ASSESSMENTS - DR JON MCSTAY (WSP)

	Question / Comment	Response
1.3.1	What happens after remediation has been undertaken. Is the site reclassified as clean?	Developing a remediation and management strategy will dictate the requirements that need to be fulfilled to ensure that the site is cleaned up. If you comply with the conditions stipulated in the authorisation, then you are clear and the site will be de-registered.
1.3.2	One step is required before the site specific risk assessment i.e. the definition of the exact screening levels to be used. This will include data reduction with regards to the specific contaminants that need to be analysed.	Correct. An essential part of site characterisation and risk assessment is to develop the sampling and analytical plan and then to assess the most appropriate means of reducing the contaminant data for site screening. We do not believe that prescribing this scientific process is appropriate or desirable within the Framework.
1.3.3	What are the timeframes associated with remediation? Who will set them? Is it the proponent or the DEA?	Timeframes are a part of an extended process and needs to be looked at in the future. It could apply to both parties, but a timeframe for approval of reporting by the regulator is a reasonable measure that will be considered.
1.3.4	Is there is room for preliminary remediation? For instance when you have a complex situation and you do biological remediation in-situ. Once the risk is reduced through biological remediation, to a certain percentage, then the site can be reassessed for final remediation.	Remediation can be a multi-step process and in-situ remediation should be encouraged. It is important that the site specific risk is understood throughout the remediation process and if multi-step long term processes are motivated for then they are monitored and reported on and their short term risks are properly managed. The acceptance of remediation plans should not simply be assessed only in terms of end-point targets.
1.3.5	It is difficult to have a firm timeframe due to environmental constrains. There is need to study the contaminated site and there will be learning experiences as we go. It is a process and sometimes it's not easy to come up with a remediation plan upfront.	Both sides ie the proponent and DEA have to approach the process in a reasonable manner. There may be occasions where either party may prefer to delay the process. This needs to be discouraged and avoided. The proponent could be subject to a Remediation Order if a remediation plan is not forthcoming after a reasonable period has elapsed.

	Question / Comment	Response
1.3.6	What about operational sites that will continue operating for extended periods of time before they can close and remediate?	The Framework applies in the situation where there is contaminated land and you cannot exempt yourself with the promise to clean-up in future on closure or land transfer when the problem is here and now. Part 8 of the Waste Act requires a decision to be made in respect of whether immediate remediation is required. On industrial sites with low levels of contamination exposure pathways may not be fully developed and thus long timeframes for initiating remediation activities are not unusual outcomes for site risk assessments.
1.3.7	There are funds which are usually set up for clean up and rehabilitation but sometimes these funds are exorbitant and have conditions that are almost impossible to comply with. Are there alternatives and guidelines for setting up the funds?	This is beyond the requirements of the Framework. It is difficult to determine the funds that may be required in future now. In South Africa the polluter pays principle applies, however it is recognised that state funding may have to be made available for strategic interventions. This policy has already been implemented in the past for dealing with abandoned mines, particularly by the Department of Water Affairs.
1.3.8	The Framework step by step approach is specific from Phase 2 (assessment) you go to Phase 3 (remediation). we have alternative ways to mitigate the risks which can be applied.	This will be informed by Phase 2. Phase 3 can be addressed differently. Phase 2 is the definitive step. Based on the outcomes of Phase 2, you can discuss new technologies or alternatives for remediation. Part 8 of the Waste Act allows for the implementation of management measures and monitoring so therefore all alternatives can be assessed and authorised depending on the risk status of the site.
1.3.9	Do you foresee PPP in Phase 2 and will it be similar to the current PPP process	The 'norms and standards' approach provides a mechanism for the potential 'delisting' of remediation activities from the Basic Assessment process. Phase 2 Site Assessments are essentially technical in nature and it is difficult to provide for extensive PPP in the compilation of technical reports. However it is acknowledged that where contamination issues may impact on human health that there is a transparent process of access to information and this is ideally dealt with in a PPP process. The development of Environmental Management Plans for remediation projects also provides another opportunity to engage with the public. Change in land use triggers NEMA Basic Assessment and documentation for PPP will be

	Question / Comment	Response
		generated in this specific process.
1.3.10	The proponent may want to withhold information for liability purposes and neighbours may want to know what happens at the facility.	The public may pursue the polluter for other motives as well. This needs to be addressed on a case by case. Site Assessment Reports will be a matter of public record and thus the DEA cannot withhold information subject to a reasonable request from a member of the public.
1.3.11	How closely are you integrating the Framework to the land development application such as future land uses and planning? How closely are you working towards that integration?	This decision making tool works well with the planning phases. You can put it into other authorisation processes. The Framework doesn't change these mechanisms. There are advantages of planning and assessing a site upfront. And that's why Phase 1 reporting, although not mandatory is important.

1.4 USE OF SOIL SCREENING VALUES IN SITE ASSESSMENT REPORTS – MR SEAN DOEL (WSP)

USE OF SITE SPECIFIC QUANTITATIVE RISK ASSESSMENT – MR SEAN DOEL (WSP)

	Question / Comment	Response
1.4.1	The soil screening values (SSV) are site specific, conservative and cannot be applied without much site information. The SSV should be more generic and conservative	SSV are not site specific but receptor specific. They are intended to be broad and generic.
1.4.2	With regards to particulate emissions factor, its only chromium VI and arsenic that have contribution to particulate risk	In the Framework we have considered particulate emission factors for a number of heavy metals and are particularly conscious of the issues associated with Cr IV.

	Question / Comment	Response
1.4.3	In terms of precautionary principle, one driver for water is KD factor. KD obtained was based on natural soils. The method that is used for total analysis is also important to determine KD/partitioning coefficient). The method needs to be defined and very conservative instead of taking an average.	Partition coefficients are dependent on the soil profile and we need to establish the application and not get stuck on the science. Generics are used for the initial site screening purposes and can be superseded by site specific risk assessment where precise determination of the most appropriate Kd values can be applied. With regards to whether the Kd values are over-conservative, which we believe to be the case, we need to make the information usable to consultants. Comments are welcome in these regards.
1.4.4	With regards to the number of substances listed, the US EPA Mid-Atlantic website gives calculations and assumptions for site risk assessment. Why don't we take that system and implement it as a guideline. The results would be similar as it is dependent on land use. We are shortening the list by about 600 contaminants.	The receptor activity patterns for South Africa are believed to be significantly different to assumptions used for calculating soil screening in the United States. Together with adapting approaches to suit our legislative needs the Framework although broadly based on the classic USEPA model equations does differ. It is anticipated that the Framework will have to be updated and revised as there is a continuously evolving toxicological database. It is noticeable that after a period of inactivity the US EPA and other organisations are actively reviewing and revising their advisories and a lot of new information is emerging.
1.4.5	If you have free hydrocarbon product and you can indicate that it doesn't move (i.e. it's not a plume) then you do not have to do anything.	There are situations where free hydrocarbon product doesn't pose a risk. The main issue is whether it poses a risk, and where practical it should be removed. We also need to check the existence of pathways and receptors.
1.4.6	From a duty of care perspective, you are not supposed to walk away from a visible free product. Where it is possible to remove, it should be removed.	Agreed this is the simplest approach to managing a pollution risk.

	Question / Comment	Response
1.4.7	When do we investigate the groundwater pathway?	We do soil characterisation to depth and then assess the potential migration to depth. This pathway is important and needs to be characterised. This can be done conceptually. Sites which have got deep water tables and poor quality water are not generally considered priority sites for detailed groundwater investigation. The proponent and the consultant need to take ownership of the kind of assessment required. Computer models can be brought into play where required. It is not good practice for consultants to ask for types of investigations and assessments that may not be appropriate. There is no substitute for a good investigation.
1.4.8	With regards to land use of informal residential, it is morally wrong to expose people to contaminated dust. In the future, industry may be required to remediate sites to residential levels.	These situations are currently occurring and some of these situations cannot be ignored. It is best to proceed by acknowledging the situation at present. We agree that eventually this receptor risk can be normalised and removed from the Framework.
1.4.9	With regards to agricultural land use, do we skip Phase 2?	The DEA, Department of Agriculture (DoA) and Department of Mineral Resources (DMR) will have to determine the applicable requirements and agree on an approach. Transfer of old mining land to agriculture can occur. And some sites may show improved nutrient levels for trace elements as a result of these activities. Consideration must also be given on the ingestion of contaminated food. These situations need to be addressed on a case by case. Some of the international approaches used to assess the food intake pathways are too contrived to give realistic estimates of risk and thus a site specific approach is preferred for South Africa.
1.4.10	With regards to informal settlements, people put up gardens to limit dust and for vegetables. We need to consider it as a land use and the associated exposure risks.	As discussed above the application of site specific risk assessment is the preferred approach for dealing with this type of activity.

	Question / Comment	Response
1.4.11	Will the documents be available on the website for review?	The documents are posted on the website. www.sawic.org.za . they are available for review for 30 days. The sooner the comments are received, the better.
1.4.12	In the next step, the DWEA is looking to gazette parts of the documents. They will be gazetted for a period of 60 days for comment.	
1.4.13	With regards to the SSV tables, can consultants derive their own?	If it is evaluated appropriately, the consultant can derive their own tables for a specific site. This would also be the case for contaminants not listed in the present Framework.
1.4.14	Dr Jon McStay thanked everyone. Special thanks to the peer reviewers, Dr Willie van Nierkerk of Infotox, and Dr Ahee Coetzee of GPT. Mr Carl Steyn of Golder Associates was thanked for his comments and recognition of errata. He noted the value and benefit of the stakeholder process in the development of the Framework and encouraged all present to add comments and suggestions to improve the final document.	

Meeting closed at 13H30.



DEA Contaminated Land Framework: Petrochemical Sector Workshop - 4 December 2009

1. Summary of Events

1.1 WELCOME – MS KELELLO NTOAMPE (DEA)

Discussion points:

Stakeholder workshop to be held in February 2010.

Focus on BEE status – training of staff in the remediation sector.

Key feedback end January 2010.

Final / updated version to be circulated after the meeting.

All comments to be included as an appendix to the National Framework.

1.2 LEGAL OVERVIEW – MR CARL HAYCOCK (WSP)

Discussion points:

It is suggested that the framework separate the terms “pollution” and “contamination”. “Pollution” is very emotive, referring to a negative / adverse effect.

Framework to give guidance on when to take action.

1.3 REMEDIATION FRAMEWORK BASICS – MR CARL HAYCOCK (WSP)

Discussion points:

First paragraph in report – Please be more specific - Remediation projects are to focus on the pollutant at hand, not **all** land.

1.4 REPORTING NORMS AND STANDARDS – DR JON MCSTAY (WSP)

Discussion points:

This presentation does not focus on remediation techniques.

1.5 PETROLEUM SECTOR APPROACH AND ALTERNATIVES – DR JON MCSTAY (WSP)

1.6 DISCUSSION FORUM

	Question / Comment	Response
1	We don't want to apply for remediation licenses for every project. There needs to be boundaries.	Duty of care provision is the focus here. General guidance can be given. Depends on nature of contamination risk and the sensitivity of the site rather than simply the volume of the release. The removal of free-product from the water table is a typical situation than could be regarded as a 'Duty of Care' whereas the longer term treatment of residual contamination would be regarded as an activity requiring a license.
2	How does one look at the potential impact at hand?	The Framework will provide simple standards to define contamination status for typical soil conditions. The Framework has a tiered approach which allows for site specific risk assessment for more complex sites a.

	Question / Comment	Response
3	Is there a transitional period – Do sites need to re-apply for licenses? How do we deal with sites that are currently in the process of being remediated?	If existing remediation works have been authorised by DEAT or DWAF in the past then licenses would not be required. However the status of the authorisation should be reviewed in the context of the activities taking place. Voluntary agreements reached with DWAF should be supported by relevant paperwork. A policy statement by DEA is required to clarify the status of existing remediation projects. It is not the intention of DEA to stop or delay proponents from clean-up their sites.
4	Previous to July 2009, there was no formal approval process, so how does one deal with this?	If DWAF have not 'signed off' on a remediation plan, then there would be a need to undertake an approval process.
5	Public participation is a real challenge. How does this link to the transitional period?	If a project has an authorisation then it will not be subject to a Basic Assessment and public participation. If a project has no formal written authorisation it is potential subject to either the Section 24 G Rectification process of NEMA, or a waste license application for remediation of contaminated land. It may be necessary to review projects on a case by case basis to ensure that existing authorisations are valid.
6	If we are currently undertaking a remediation process, what do we do? Stop the process? What are the timeframes associated with responding to an application?	It is not practical to stop certain forms of remediation, particularly where substantial commercial liability may be a factor. Delays may also impact on the technical feasibility of certain remediation processes. If however remediation works have no formal authorisation then the proponent is non-compliant with the Waste Act. The motivation of the remediation activities must then be consistent with a 'Duty of Care' action to prevent pollution. Authorisations requiring a Basic Assessment are covered by the time related provision of the NEMA Regulations.
7	How many licenses have been issued in the country since July 2009?	None.

	Question / Comment	Response
8	Would the remediation of free phase product undertaken prior to the Waste Act be accepted now?	Yes
9	In terms of calculating SSVs, are they guidelines or standards? This should be a guideline.	If the SSVs are included as a condition in the ROD, then this is mandatory.
10	There has been continual reference to international codes and laws. Will there be a cherry picking approach?	There is a need to develop a conceptual methodology. We are developing a unique South African system. It is however an adaptation of what is already proven to be successful in other parts of the world. We recognise that a 'cherry-picking' 'mix and match' approach leads to inconsistency.
11	In terms of water quality guidelines – are we looking at something as a reserve?	No, we are looking at water use, not a reserve. Looking at water quality objectives that are catchment specific is catered for.
12	Where do you get “a cancer risk level of 1: 100 000 per lifetime”	
13	Benzo(a)pyrene – why is this here? Isn't it naturally occurring?	Be.nzo(a)pyrene is used as a surrogate species for the carcinogenic PAH compounds in certain oils. It can be naturally occurring in low concentrations, and has an anthropogenic background in certain countries where coal ash is used a fertiliser in domestic gardens
14	Consultants are going to continue monitoring TPH.	TPH can be used for monitoring in a general sense but is insufficient for characterising the risk of a site without screening for the BTEX-N compounds.
15	Does the pathway model include reclaimed land?	Yes. The soil types are in effect defining porosity and permeability ranges, which will be listed in the Framework. Any reclaimed land can thus be described in relation to porosity of the fill and then matched to the appropriate soil type in the risk matrix.
16	For the Petroleum Hydrocarbons 7 organic contaminants are listed. What about other contaminants?	If there are other contaminants suspected, ie organo-metal additives, then the investigation and risk assessment must take these into consideration and inform the Department. This may trigger a site specific risk assessment.
17	Do you undertake a risk assessment only after there is no free product?	The removal of free-product can continue whilst a full risk assessment is being undertaken.

	Question / Comment	Response
18	Is a canal a natural water resource? Maybe take out the word “natural”.	Agreed it may not be a natural system, but you don't have the right to pollute the stormwater system.
19	In terms of “land use” where does pipeline servitude fall?	This is an example of a specific exposure scenario. Look at the receptor that is most at risk. In this case it would be a maintenance worker.
20	Is it possible to ensure that this assessment is manageable? How will this be achieved?	The Framework aims to provide guidance on reporting including risk assessments.
21	Lack of consistency in applications? Is this going to be a centralised approach?	The ‘Norms and Standards’ provision that drives the Framework is intended to provide for consistency. The Framework includes a training component for DEA staff with the emphasis being on developing a consistent approach to authorisations.
22	Most refineries have engaged with DWAF. There is a need to formalise the way forward.	There could be options that need to be developed under Section 19 of the Waste Act that would involve the industry in developing a code of practice that could define the Duty of Care responsibilities.
23	Can one develop a forum between the DEA and the industrial sector on a more regular basis? If so, would this extend beyond refineries?	Industrial sectors can develop a set of criteria whereby they can take it to the Department and reach agreement. It would most definitely extend beyond refinery sector. Depots for instance would require a slightly different set of management criteria to be developed.
24	Would the Department distinguish between simple industries and more complex industries?	The entire industry must conform to regulations. There needs to be one national, uniform approach as a starting point.
25	How far back to do we have to look for a license?	The Waste Act includes provision for pre-existing site conditions and legacy contamination. There is no time related amnesty. If the site has been remediated to a ‘clean’ status and is compliant with the norms and standards then there is no action. However, sites with no formal ‘sign-off’ that don't comply with appropriate standards would be regarded as contaminated land.



DEA Contaminated Land Framework: Mining Sector Workshop - 10 December 2009

1. Summary of Events

1.1 WELCOME – MR STRANTON NARAIN (DEA)

1.2 LEGAL OVERVIEW – MR CARL HAYCOCK (WSP)

	Question / Comment	Response
1	By when should the comments on the framework be forwarded for consideration?	As soon as possible. Preferably before or by mid January 2010. Reason being that we are working on a tight deadline and we need to write up the Framework and undertake technical peer review in February 2010. We aim to finalise the Framework in March 2010. The intention is to also include a section to highlight the stakeholder inputs in the form of a Frequently Asked Questions (FAQs) document that will be referenced in the final Framework.
2	Does the duty of care override any requirements to apply for remediation licenses?	Prevention of pollution is a Duty of Care and this should be applied in situations of immediate harm. It does not exempt the proponent from applying for a license for remediation.
3	What is acceptable exposure with regards to soil contamination?	Soil Screening Values (SSV) will be generated for contaminants of concern (addressed further in detail in the following presentation).
4	Will we have different SSVs for the mining industry and SSV values for other industries?	The Framework in not sectoral must be seen as a National Framework however certain contaminants of concern will require particular assessment methodologies to be developed individually and these will be incorporated into the main Framework.

	Question / Comment	Response
5	Why is remediation a listed activity while Part 8 of the National Environmental Management: Waste Act (No 59 of 2008) (NEM:WA) is not in effect yet?	Part 8 of the NEM:WA has been delayed until the Framework comes into effect. It is appreciated that remediation activities cannot be licensed uniformly until the actual 'Norms and Standards' of the Framework are completed. However, for now, it is acceptable to use international norms and standards when applying for a license until the Framework is in place. The issue was noted by Department of Environmental Affairs (DEA) and it will report back with a policy statement.
6	Is there criterion for applying for a license?	The Framework is aimed at developing that protocol. Currently if the activity being undertaken has written approval from the relevant department, it is legal.
7	Is there a draft list of contaminated sites?	No.
8	Can the liability to remediate be transferred?	Yes, the liability can be transferred if you have clearly indicated this to the buyer in the sale contract. Whether or not you can exclude the polluter completely from the liability associated with a contaminated site, is a legal issue between the buyer and seller.
9	If a smaller entity buys property from a large entity e.g. a junior mine buys from a large mine, does all the liability associated with the site transfer to the junior miner, who may in some instances may not be able to remediate the site?	It is the landowners' responsibility to remediate a site. However the polluter pays principle needs to be applied. For instance if the junior miner goes bankrupt, the liability will revert back to the bigger miner i.e. the original polluter.
10	Mines have mining rights in areas owned by other persons e.g. farmers. In these cases therefore the 'polluter pays' principle comes into effect.	Noted. The same applies to government land e.g. slimes dams which are located on government land.
11	What is the definition of decommissioning?	Depends on the application. Can be entire operations or could be specific to an activity or building.
12	What happens when the mine is decommissioning specific areas of operations but not the whole operation?	Currently the mines are excluded from the NEM:WA in terms of mine residue remediation. Decommissioning has been mainly applied when there is a change in land use.

	Question / Comment	Response
13	Decommissioning and closure issues are addressed as a whole in the mining sector in the Environmental Management Programmes (EMPs) and Closure Plans. Why should we decommission each area separately and do we need licenses?	Minerals and Petroleum Resource Development Act (No 28 of 2002) (MPRDA) applies in this case. If there is transfer of the land and change in land use it could trigger remediation activities and the need for a license.
14	A review and update of the NEM:WA needs to be undertaken. For instance the definition of 'contaminated land' needs to be clarified.	At this stage this is not the intention. DEA has no intention to modify the current definition of 'contaminated land' or NEM:WA anytime soon. One objective of the Framework is to provide guidance that makes the current definition more practical and applicable. That is, making it easier to determine what does and does not require remediation. The Framework however will not change the legal definition of contaminated land.
15	Is there an intention in the framework to develop a remediation plan/protocol?	The Framework has adopted an international approach. Remediation plans for contaminated land needs to be developed as the third part of the 'Triad System' of Site Assessment. The plans need to be developed on a case by case analysis based on the contaminants of concern and the risk posed to the environment. Broad guidance will be given on the minimum requirements for a remediation plan.

1.3 REMEDIATION FRAMEWORK BASICS – MR CARL HAYCOCK (WSP)

	Question / Comment	Response
1	There is a contradiction between the 'polluter pays' principle, and the landowners responsibility to remediate a contaminated site.	If the owner can locate the polluter, then the polluter is liable. If not, then the owner is liable.
2	What is the case where the mine is gone or is bankrupt?	The owner of the land is liable. A fund however needs to be developed at a national level to address these cases and the departments concerned need to apply themselves diligently.

1.4 REPORTING NORMS AND STANDARDS – DR JON MCSTAY (WSP)

	Question / Comment	Response
1	How do we address the issue of Acid Mine Drainage (AMD)?	The issue gets complex and is based on the source of contamination but particularly the medium of transport which involves a chemical release mechanism from the metal sulphides and is usually transported via groundwater to surface water. The Framework cannot deal specifically with AMD issues. It is more likely that this form of contamination requires a regional solution and may be better dealt with via Water License measures.
2	When you are referring to international guidelines, does it mean the lowest guideline that can be found?	It has to be the most appropriate and site specific. An assessment of the background conditions is also required. We also need to consider anthropogenic background issues as well.

	Question / Comment	Response
3	Should one refer to the acceptable levels or do we consider the risk associated with the contamination?	The Framework allows for the differentiation between the two. It is a tiered system that is risk based from simple screening values to more advanced forms of risk assessment that can be applied to specific site conditions.. The SSV value shall been set in the Framework. The system is still developing and there will be a continued process of review as experienced is gained in implementation.
4	Will the Framework provide a comprehensive list of SSV values?	The idea is to list commonly encountered priority contaminants and not base the listing solely on high risk toxicity, i.e. rare or unusual contaminants will not be included. You can however recommend a possible list of contaminants when submitting your comments in January 2010.
5	What about salts?	Salts do not pose major human risk, but they pose a major issue in terms of impacts on soil quality in terms of agricultural and ecosystem requirements and particularly in terms of impacts on the water resource. It is intended that these issues will be resolved by applying site specific quantitative risk assessments.
6	What are the triggers? Something needs to trigger the requirements for remediation.	The SSV concept provides a protocol that triggers the requirement for remediation.
7	In instances where the levels exceed the SSV values, do we have to motivate for exclusion from applying for licenses?	If the applicable screening are not exceeded then there is no environmental risk, and the site is 'clean'. If the SSV are exceeded then a site specific risk assessment can be undertaken to determine whether the risk is unacceptable in terms of specific context of the site. It is a tiered approach. Site specific risk assessment need to be supported by comprehensive reporting. In the case of mineral deposits in the mining sector, it is important to refer to the background conditions, which may be significant higher than the norm in the local geology and soils.

	Question / Comment	Response
8	Pyrite occurs naturally. Mining causes disturbances and there is the introduction of oxygen through anthropogenic activities which eventually results in problem (AMD).	AMD is probably best dealt with as water related issue rather than a waste issue.
9	There can be precipitation from capillary action during evaporation where salts are transferred from water to soils.	Agreed. Secondary contamination of soils does occur.
10	Can we label an area with AMD as contaminated?	Yes, if it fits the definition in the Waste Act. Depending on the specific context and impacts of the AMD remediation of the source area may be practical. There is however a level technical impracticability that may exist for certain sites and regions impacted by AMD and thus long term restrictive management measures may have to be applied. In such cases a remediation license may or may not be the most appropriate authorisation mechanism.
11	Is the risk related to final land use?	Strictly speaking it is receptor based. The land use is used to define receptor activity patterns used in the simple risk-based calculations of exposure. These equations will be outlined in the final Framework.
12	Are EMPs and Closure Plans going to be rated against this Framework?	The question the mine has to ask itself is whether they want to apply the standards now or at some later stage. As Closure Plans are intended to be updated on a regular basis there is an opportunity to align with the Framework in terms of proposed future land use.
13	There is a need to be cautious and the Closure Plan has to be sensible. For instance, you cannot promote land uses that are unfeasible, ie industrial site development in a remote mining area.	Noted.
14	There is a need to tie all the applicable documentation together. This includes Integrated Development Plans (IDP), framework documents etc to identify the final land use.	Noted

	Question / Comment	Response
15	It is difficult for mining activities to stick to specific guidelines especially when considering their large use of water.	We understand that the recycling of water and achieving optimal water use is important in mining operations. This activity is controlled by Water Licenses and these licenses can involve terms and conditions that may instruct remediation activities.
16	In the mining industry, buffer zones between the tailings and residential areas are non-existent resulting to exposure to dust to the nearby communities.	Yes, in this case secondary contamination of adjoining land is a concern, and the human health risk may be the trigger for remediation activities.
17	What about radionuclides? What are the limits of consideration?	Uranium has not been put in the list contained in the Framework. Radioactivity is dealt with under different legislation and will not be included in this Framework.
18	What are the triggers for remediation of contaminated land? For instance, if you use contaminated water on site activities, how do you know whether you have a contaminated land? Mines usually have sewage treatment works and they use the treated water for dust suppression on waste rock.	Test and analyse. There are activities that lead to a site being considered as contaminated land. You need to build a history of the site and also consider historical contaminants of concern as well as the risk posed by existing operations..
19	What about sediments? Do they fall under DWA or DEA?	Sediments values would differ from SSV values, and tend to be assessed in relation to aquatic ecotoxicology and thus need to be addressed in relation to catchment specific water quality objectives. They are not specifically included in the Framework.
20	Sediments are also as a result of secondary sources. For instance mercury is contained in the Witwatersrand basin sediments as a result of mining activity.	A site specific risk assessment is required.
21	There is a lack of knowledge among many stakeholders which is of concern?	Agreed. In the absence of 'Norms and Standards' there is much confusion and misunderstanding. The Framework will help to address this.
22	Where there are gaps i.e. SSV values not provided, will the framework point to international guidelines?	Yes. Guidance will be provided.

	Question / Comment	Response
23	How do we ensure that we do not use international guidelines that are not practical in the specific application locally?	We need a South African approach that considers our typical receptor patterns and the priority contaminants of concern for the country and this is exactly the purpose of this Framework.
24	It will be tempting for a person to look at the SSV and state that he/she is below and won't appoint a consultant to undertake analysis.	There will be Norms and Standards for Reporting. If a site is below the appropriate SSV then the DEA simply requires for the proponent to provide the reporting and factual data to support this status.
25	Therefore a desktop/paper study can exclude you from undertaking SSV determination?	Correct e.g. if you have all the records that support the assumption there has been no release of contaminants to the environment there would be no need to undertake invasive sampling and analysis.
26	Will the Framework contain guidance on the method of analysis?	Yes. Method of analysis used must be acceptable. There will be guidance in the framework. Quality Assurance and Quality Control (QA/QC) of chemical data must be adhered to. A guideline will be provided for each contaminant of concern.
27	Will there be a registered body for competent individuals to perform these assessments?	This is not an integral part of the Framework at this stage but the competency of consultants needs to be considered by the respective applicant before the work can be undertaken.
28	Is there an accreditation of laboratories with regards to soil and heavy metal analysis?	Yes, there are several in the country however for legal reasons the Framework will not provide such details. It is therefore up to the applicant to ensure that the laboratory they use is accredited.
29	Is a crop a pathway or a receptor?	Both. It could be impacted directly as a result of soil contamination or could be an indirect risk to human health via ingestion of the crop.
31	Will there be guidance on the appropriate way to remediate a site?	It has to be a risk based decision from the beginning to the end of the remediation process and not only the end result. Guidelines will be provided in the Framework. What risk do you pose during remediation? Remediation Plans need appropriate EMPs and Health and Safety measures to be approved so that environmental risk associated with the works are mitigated and correctly monitored.

	Question / Comment	Response
32	With regards to in-situ remediation, will DEA promote that?	The hierarchy of waste management must apply and methods that reduce reliance on disposal to landfill will be supported. DEA also stated that the applicant needs to provide proof that they have exhausted all other alternative methods before disposal in their application before the remediation activity can be considered for a license.
33	The method of measuring the mobility of contaminants is an important part. Will there be standard protocols provided for this?	There is need to consider release mechanisms in the context of site specific conditions. That would entail the use of various leaching tests. The test method should be chosen to best describe the potential leaching mechanism for the site.
34	We need a standard for analysis. Otherwise people will be doing unnecessary analysis	The tiered system in the Framework requires the proponent to identify the contaminants of concern for the site and thus there is no need to perform unnecessary analyses. Although large sites are likely to require a suitably large database for site characterisation. The approach however will be flexible and is the responsibility of the proponent.
35	What about the distance from natural surface water?	The existing requirements of DWA for hydrocensus have been adopted. That is taken as a nominal radius of 1km. This is however governed by the existence and recognition of a pathway for contaminant migration and the sensitivity of the receiving water body. If you are discharging into the environment, you have to comply with the discharge permit requirements and these discharge consents can be used in the assessment of contaminated land to define the risk to the water resource.
36	The use of modelling in reports? Different models have been developed that are used for analysis. Some models are user-friendly and people who run them do not necessarily understand the assumptions required.	There is no aim to be prescriptive with respect to computer generated models. It is important that model assumptions are clearly stated and will only be signed off if all assumptions/parameters are considered/verified.

1.5 SECTOR APPROACH AND ALTERNATIVES – DR JON MCSTAY (WSP)

	Question / Comment	Response
1	With regards to the critical water management level mentioned in the presentation, is it a water level issue.	Yes, it is a rewatering and decant issue but the concept should be extended to a water quality issue.
2	Mine closure is treated as a separate issue. Will it be linked to the Framework?	No, The Framework should find application as a component of a Closure Plan which covers much broader issues than contamination and remediation.
3	The Framework's approach is reactive. Why don't you prefer a proactive approach in the framework?	This is a remediation framework. The Duty of Care to prevent pollution is a pre-requisite and EMP requirements serve as a means of proactive prevention of hazardous impacts on the environment.

1.6 DISCUSSION FORUM

	Question / Comment	Response
1	Distribute presentation together with minutes	The minutes and presentations will be emailed to all present while the minutes will be posted on the South African Waste Information Center website. (www.sawic.org.za).
2	Some of the most important stakeholders are not present in the workshop. Why is this?	Advertisements have been in the media. However some stakeholders especially from academic institutions have been slow to respond or attend the workshops.
3	DEA is putting together a communication document to clarify some issues of the NEM:WA	These will be posted on sawic in due course. For queries contact Mr Obed Baloyi (Director: Waste Policy and Information Management) – email: obaloyi@deat.gov.za
4	Will a site that has been cleaned up be taken off the register of contaminated sites?	Provided that the applicant can provide documentation proof that the site has been cleaned to the desired level/standard, it will be removed from the register.

	Question / Comment	Response
5	What will happen if a decision from the relevant department is not received in time and the legislated time period lapses? Should you proceed with the cleanup and take into consideration the general environmental management measures provided for in the guidelines? Remediation activities should not be held up by approval timeframes as it is a clean-up process and there might be other processes, risks and costs associated with it. The draft EIA regulations state that if you do not receive a decision within a specified period of time, there are management measures that you need to comply with.	The Duty of Care provision may provide a suitable motivation to proceed without authorisation but it may not be legally defensible for certain activities and then Rectification under section 24G of NEMA may be a consequence. There is a need to identify priority activities where delays may result in adverse impacts. There is the option of issuing a Directive, although this is highly prejudicial to the proponent. .The bottom line is you cannot undertake any listed waste activity until you receive an authorisation (license). If you do so, you will be operating illegally. You can however apply the duty of care principle and apply for a license simultaneously but only if you can prove that the duty of care principles were triggered. You must also contact the department/section and follow-up on the status of your license.
6	DEA noted that for now, applications for the remediation of contaminated sites needs to be lodged with the national department until such time such function is delegated to provincial departments.	

The meeting closed at 14h30.



DEA Remediation Framework: CAIA Focus Group Meeting – 24 November 2009

A Focus Group Meeting was held with CAIA on 24 November 2009 at CAIA Johannesburg offices. Meeting took the form of an open discussion on the Framework Development and the approach going forward.

Attendance at the meeting was as follows:

Kelello Ntoampe (DEA), (KN)

Stranton Narain (DEA),

Jon McStay (WSP), (JM)

Laurraine Lotter (CAIA),

Gary Cundill (AECI),

Jaap Smit (SASOL),

(SASOL),

Johan Schoonraad (Enviroserv)

The meeting started at 14h00. A summary of the key discussion points are presented in the table which follows:

ITEM	ASPECT	ACTION
1.	Framework – Norms and Standards	
1.1	CAIA requested that the technical framework should relate directly to the clauses and language of Section 8 of the Waste Act and not paraphrase the Act. This was agreed. CAIA advised that the draft project documentation supplied to date was not suitable for gazetting.	JM

ITEM	ASPECT	ACTION
	DEA agreed and explained that the project documentation was developed as a technical position paper for discussion with stakeholders. The Framework will include both good practice guidance and numeric guidelines in addition to specific regulations.	
1.2	CAIA commented that industry was interested in the regulatory component of the Framework, and that all new regulations should be dealt with by applying proper consultation as envisaged in Section 72 of the Waste Act. Regulatory instruments will in all likelihood consider a list of High Risk Activities that would require assessment and investigation as being suspected as being contaminated land.	KN
2.	Draft Reports	
2.1	CAIA objected to use of the word 'pollution' on Page 4 of the Position Paper. Remove wording such as 'risk averse' and 'conservative'. It was agreed that emotive language be removed from further drafts and that language consistent with the terms of the Waste Act be applied without ambiguity. The envisaged Framework Process needs to be properly aligned with the Waste Act. Phase 1 Assessment Reporting is not implicitly stated in the Waste Act.	JM
2.2	The proposed approach to investigation and reporting was outlined. The phased approach to contaminated land reporting is internationally recognised and is consistent with the requirements of Section 37 of the Waste Act. If the site history and management measures applied on site are found to provide evidence of no risk of land contamination then detailed investigation would not be required. Investigations are to be limited to the contaminants of concern identified by Phase 1 Reporting. It is not the intention to have all sites screened for all the listed contaminants. CAIA commented that the definition of land-use terms is confusing and does not match terminology used in town planning in South Africa. It was explained that the land-use definitions are based on receptor activity patterns used to determine risk and that this was a necessary convention for the management of contaminated land, particularly if future land use is to be considered. The site specific	

ITEM	ASPECT	ACTION
	risk assessment can be used to define specific receptors and to fit with any town planning scenarios. The socio-economic focus of the Framework was questioned. The Framework has the objective of bringing contaminated land into productive use. This is a socio-economic issue. The decision to select the receptor pattern of the informal settlement as a category for determining soil screening values is another socio-economic policy decision, in that poor communities tend to be most impacted by contaminated land and thus appropriate guidance is required to support measures for protection, intervention and remediation. In this manner socio-economic factors do play a role in management decisions related to the management of contaminated land. CAIA supported the general findings of the Assessment of Alternatives Report, particularly to apply the Norms and Standards as a National approach. The risk-based outcomes orientated approach was also supported. CAIA informed that they would reply with written comments by 16 December 2009.	JM CAIA



DEA Contaminated Land Framework: Focus Group Meeting, Iron and Steel Industry - 21 January 2010

1.1 WELCOME – MS KELELLO NTOAMPE (DEA)

The meeting opened at 10:30am.

Present: As per attendance register

Apologies: Carl Haycock

1.2 PROJECT MOTIVATION AND OBJECTIVES

Ms Kelello Ntoampe (DEA) welcomed everyone present and set the objectives of the meeting as to engage with the Iron and Steel industry on the ongoing formulation of a Framework for the Remediation of Contaminated Land.

1.3 DISCUSSIONS

Questions/Comments	Response	Action
There is a confusion created by the many different legislation and authorisations required by different authorising departments. How can this be streamlined?	The aim of the meeting was not to discuss legislative issues but rather to develop technical norms and standards for the assessment of contaminated sites. The presence of different legislations and their integration required needs to be addressed in a different forum. WSP will be happy to forward these requests in writing to Mr Obed Baloyi, the Director of Waste Policy and Information Management	WSP
Will the legal issues and complications that are currently been experienced be addressed in the framework document?	No The aim of the framework is to enable the adequate implementation of National Environmental Management: Waste Act (No 59 of 2008) (NEM:WA) by providing guidance and the necessary documentation for the assessment and remediation of contaminated sites. The Framework will be used to assess whether a site can be classified as contaminated or not. The norms and standards in the framework document will not solve the legal problems. This specific consultation aims to assist in establishing how to assess contaminated land.	DEA
What will happen to on-going activities where remediation of a contaminated site has been on-going in line with the guidelines provided by DWAF? Will the proponent be required to seek authorisation again in line with the new guidelines in the Framework?	If an activity is listed as high risk in the Framework, a site assessment report will be required in terms of the norms and standards developed. If the contaminant levels at the site are exceed the recommended guidelines, another clean up may be required, depending on the site specific risk posed by the site. For on-going projects much of the required documentation is likely to exist and be broadly compliant withy the norms and standards. Projects will be assessed on a case by case basis and it is not the intention of re-licensing projects which are lawfully authorised under existing legislation. The framework will not differ from other legislated remediation requirements. The environmental criteria developed in the Framework will be aligned with the requirements of DWAF.	DEA
What do you do with legacy and historical sites?	A site may be reviewed especially in the case where changes in land use are anticipated, or where there are pollution issues that haven't been successfully dealt with and need to be addressed and cleaned up.	DEA
If you have been working on a cleanup project with DWAF in terms of the National Water Act (No. 36 of 1998), what do you do when the Framework comes into effect?	You will need to register your project with DEA. However, do not de-register with DWAF as you are required to comply with both legislations i.e. Section 19 of the National Water Act (NWA), Part 8 of the NEMWAt, and the duty of care principles included in the National Environmental Management Act would also apply.	DEA



Questions/Comments	Response	Action
Do you have to keep parallel contact with both departments?	If you have physically started remediating a site, you need to continue with the process until the Minister advises otherwise. DEA would need to be informed of such projects. The idea is not to change the projects which are on track. Projects will be vetted based on merit. It is important to determine the potential receptors in the case of a contaminated site. For instance, the SSV values change if the project requires the protection of the water resource. If there is no risk to the water resource, then the risk is determined by exposure pathways to human health. If the project involves treatment of groundwater but there is no soil contamination the project will continue to be in the hands of the Department of Water Affairs in terms of Section 19 of the NWA.	DEA
The DEA must note that some laboratories in South Africa are under capacitated and the quality control standards are not adequate.	Some laboratories are not able to test certain parameters to appropriate detection levels. The onus is on the proponent to ensure that the data acquired is representative and reliable for the risk assessments required by the Framework. DEA will review the credibility of the information provided. Flawed reporting will not accepted and the reports will be sent back to the proponent. The proponent will be safe if he/she follows the appropriate guidelines as detailed in the Framework, such as using an accredited laboratory, taking duplicate samples etc..	DEA/WSP
Do you consider SSV values or mg/l when dealing with effluent discharge?	Effluent discharge consents have nothing to do with contaminated land. But you need to meet the water quality objectives for lawful discharge. If you are cleaning up water from a contaminated site, you will need to negotiate an effluent discharge consent from DWAF and meet these objectives.	WSP
If you have contaminated groundwater, must it meet the Target Water Quality Objectives (TWQO)?	The Framework is not designed to provide guidance on water quality <i>per se</i> . Water quality criteria are set by DWAF. The Framework is designed to be consistent with standards applied to all other forms of environmental media (air and water). If a remediation directive or remediation order includes a target water quality objective in the Terms and Conditions of the order then this will be legally binding.	WSP
Will sign off be required at each phase of the assessment	While the onus is on the proponent, there needs to be consistency with regard to this. The department is considering the priority criteria and timeframes for authorisation of contaminated land assessments and clean up activities.	WSP/DEA
Unexpected things come up and the target set may not be achieved in the remediation	Over and above the remediation strategies, an EMP is required for a site under remediation, which should address the site specific conditions and any anomalies and contingencies that may possibly arise.	WSP/DEA

	Questions/Comments	Response	Action
	process.	There must be flexibility in the reporting and feedback. Some clean up activities have long timeframes. Monitoring programmes with regular feedback to the Department are the norm for certain types of remediation project. The Terms and Conditions of contaminated land authorisations can be modified to reflect any significant changes in the risk profile of the site.	
	Do you have a realistic approach to Manganese?	We accept that high concentrations of manganese occur on many sites in South Africa and thus a soil screening value is required in order to simplify site assessment. Manganese concerns are also being addressed in the Waste Classification process and discussions on the risks of manganese and the appropriate screening levels for classification will be scientifically compatible. .	WSP
	Will Soil Screening Values (SSV) also include organics/ heavy organics (PAH)	Yes	WSP
	How many clean ups undertaken have been statutory resulting in compliance, decommissioning, property release or change of land use?	Most are on-going remediation activities that fall within operational site boundaries and mainly involve the clean up of legacy sites. There has been no change in land use.	None
	Have you had a clean up operation of major contaminants?	No. Usually the industry cleans up any contamination in accordance with the Waste Hierarchy.	None
	Were the contaminants reported to DEA before disposal?	Yes.	None
	The technicalities in the framework are similar to other clean up procedures. The problem is with the legal aspects and how to integrate the various legislation.	A letter will be sent to Mr Obed Baloyi in DEA on the legal issues. However, a pre-application meeting can be held between the proponent and the authorities for specific projects to clarify the authorisation process required.	DEA
	What about slightly contaminated sites?	There will be cut off limits based on risks to receptors, these are the SSVs. The objective is to define the criteria for a 'clean-site'. There is no need to protect environmental receptors that do not exist, or where pathways do not exist.	WSP



	Questions/Comments	Response	Action
	Will you get a Record of Decision (RoD) or Waste License in Contaminated Land assessment or will you receive an instruction/order to do a BA or EIA?	The initial idea is to get the sites which are slightly contaminated and do not pose a risk out of the way. The process will be done on contaminated sites only and once a site is identified as contaminated, you will be required to undertake a BA before starting with the remediation activities. Once your Risk Assessment Report to confirm the status of contamination is submitted and the propose remediation plan is approved; then only you can commence with these remediation activities. On the other hand, Directives or Remediation Orders may be issued if the situation is severe and immediate actions are required to prevent pollution. However the Duty of Care principle in NEMA still prevails in such cases and the proponent should not wait for a Directive or Remediation Order to act. Discretion must be used.	DEA
	What about a situation where there is an ongoing EIA process?	Continue with the application process with the provincial authorities' office. At the time of authorisation, you may be required to contact the national office. The applicant will be required to fill in an application for a Waste License. In such cases, the applicant will get a License instead of an environmental authorisation (RoD) from DEA.	DEA

MEETING CLOSED AT 13H30.



Appendix D   Comment and Response Report

No.	Comment	Response
	out what will be legal requirements, what is advice which may be followed at the discretion of the responsible person and what will be in the form of published guidance, should be developed and shared with stakeholders.	
1.4	Before developing soil screening levels develop an approach to assess a contaminated site that will form the basis of a phased site assessment it needs to be clear where and when soil screening should apply.	Agreed. This is an integral part of the Framework.
1.5	CAIA does not support an approach similar to the minimum requirements where the legal status of the document remained ambiguous. Any mandatory provisions flowing from the project must be clearly set out in regulations promulgated in terms of the provisions of the Act.	Noted.
1.6	It seems that a tiered approach is likely to be adopted. The purpose of developing norms and standards is to simplify the approach to dealing with contaminated land. It seems that a full quantitative risk assessment would always be an option although the legal basis for providing that option is not well understood. (Consider the situation where the soil screening guidelines and soil limit values indicate that (costly) remediation is required. The land owner could through undertaking a detailed quantitative risk assessment show that the risks are low and manageable thereby avoiding expensive remediation costs)	Correct. The use of quantitative risk assessment by a proponent to motivate for site specific remediation objectives (on the basis of acceptable risk, not on the sole basis of cost) is key part of the Framework. We agree that the legal basis for enabling risk based decision-making are complex and have not been developed.
1.7	Risk-based approach and remediation sites Only sites where there is a link between source, pathway and receptors should be classified as a remediation site.	
1.8	Technical infeasibility Guidance should be provided on what technical infeasibility is? Does it take into account cost implications, time-frames, source characterisation, geological considerations, geomechanic criteria? Will an EIA be required to implement a monitoring system if required for a site where remediation is considered to be a technically infeasible? Or how will that be managed? At which phase (after Phase 2 or 3) will the remediation at a site be considered as	Technical impracticability (TI) is an important concept in the management of contaminated land and is mainly controlled by the technical issues that have been listed in your comment. Sites with these problems will be subject to management measures which could typically involve remediation methods such as isolate, contain and monitor. Management measures would involve restrictive conditions on future land use. The issue of a TI waiver can only be addressed on a case by case basis and would be an important element in the

No.	Comment	Response
	technically infeasible. It is recommended that wherever feasible this should be considered in the phases prior to implementation of remediation technologies that are known to not be effective in similar scenarios.	approval of a Remediation Plan during the authorisation process.
1.9	Soil Remediation Objective This should be changed to remediation objective. The document must consistently apply the holistic approach to remediation. Contamination of water resources cannot be excluded (reiterating the need for concurrent development of guidelines). Remediation objectives must also consider the technical feasibility, socio-economic factors etc for water resources and future land use (in line with current land use definitions).	Agreed. Agreed.
2. Comments from Department of Environmental Affairs		
2.1	Why are the units for Cr (III) SSV's expressed as a percentage as opposed to mg/kg?	Simply to avoid using very large numbers with many noughts, 5 000 000 mg/kg is not a normal convention for listing a high concentration. Likewise for highly toxic compounds they are listed as ug/kg to avoid similar issues eg 0.00001 mg/kg.
2.2	Do SSV1 values take into account the worst case scenario – sandy soil in the case of groundwater being the pathway?	Yes, they are based on drinking water and aquatic ecotox. So point of compliance can be a drinking water borehole in a sand aquifer.
2.3	Does the informal residential value in the SSV2 Table take into account the uptake of contaminants by vegetables grown in someone's back yard? And if so, how?	No, but it can be considered in a site specific risk assessment. From our work in the rural Eastern Cape this indirect pathway is not as sensitive as the dust inhalation direct pathway, but we can review this further. It is a classic scenario, well defined for the English Allotment for example, but may be difficult to refine the intake values for an 'average' African scenario. A gap in the knowledge base.
2.4	How will the framework we have prevent inconsistent numerical values and methodologies during implementation at local level?	The SSV concept is universal and applies across a wide series of receptor exposures. If the option for site specific risk assessment is applied by proponents there may be some inconsistency, thus we stress the need to outline assumptions and to follow the standard equations and methodologies.

No.	Comment	Response
2.5	Site specific Risk Assessment (RA) preferred to screening values, isn't SV required prior to SSRA (Soil Screening Risk Assessment)?	The SSVs are simple forms of SSRA which apply to general situations. If the general assumptions fit the site conditions there is no need to go to the more complex the tier of assessment. It is not a preferential hierarchy in the sense of this question. It is about appropriateness. SSRA should be viewed as the 'last resort' rather than the ultimate or preferred solution.
2.6	If our intention is not to make the management of contaminated land expensive, why is the first step already involving a preliminary RA? Can't a site be roled out based on screening values?	Reporting Standards for Phase I can be used to screen out sites that are no risk without resorting to sampling and analysis. A limited Phase 2 Investigation with reference to SSV1 is a cost effective tool for sites we suspect to be a problem
2.7	If ecologically sensitive environments can be lower that soil screening values, how will the framework take care of this? Will there be a separate equation?	This is in the realm of site specific risk assessment, this is receptor specific so you would apply the appropriate receptor toxicity data into the standard equation or if the pathway is not adequately described a specific pathway equation would have to be motivated for, ie protection of soil biota.
2.8	If remediation objectives are not purely about numbers, what else do they include? How will the framework incorporate this aspect to ensure authorities considers all that has to be included?	There are general environmental issues that arise and there are management decisions that are made in relation to activities and land use which involve other spheres of government. Planning issues at local and regional level are typically incorporated. If the remediation project proceeds through EIA or Basic Assessment these issues will be addressed in the RoD.
2.9	Hazard identification in RA involves identification of substances likely to result in or cause harm. Has the framework in defining SSV considered the main substances in South Africa that have likelihood to do so? If no, why? If yes how were they identified? Through a study of pollution incidents or what?	The final listing has not been decided upon. We are receiving input from stakeholders and need to align our needs with sites already identified together with international practice. This is our priority task.
2.10	How is this RA similar or different to the one used in the Waste Classification project?	Toxicology input will follow the GHS. All indirect pathway calculations are tied to existing and evolving South African Standards. Pathway equations are derived to suit typical contaminated land exposure routes and receptor activity patterns. The risk assessment used in waste classification has not been revealed yet, but we assume that it will be based on a disposal related pathway and will include both human health and ecosystem elements.

No.	Comment	Response
2.11	If the calculation of SSV involves calculation/determination of concentration in a medium, does it mean there is sampling at the first level? Will this not result in expensive remediation?	Phase 1 reporting is non invasive and if the site poses no risk then further investigation is not required. A limited amount of investigation and testing can be used to define status of contamination at this stage. This provides for rapid and cost-effective screening of simple sites and is not barrier to commercial property transfer and provides an appropriate level of regulatory control and intervention. It is a issue of disclosure of information.
2.12	Where does the framework's equation factor the issue of cumulative impacts?	A good question and one of the more important aspects of guideline development we aim to look at this particularly with reference to the organic carcinogens.
2.13	What knowledge and data gaps are barriers for making adequate risk estimation?	This normally an issue arising from toxicological gaps. Unusual contaminants, complex mixtures, unique exposure routes. This is whether the precautionary principle is used to make a conservative management decision. It could also be an issue related to inadequate investigation and reporting, ie oversight. Hence the need to have reporting norms and standards.
2.14	When the RA is complete, decision makers (in this case government) need to make decisions about ecological (including socio-economic) risks. Decisions must be made on the components at risk, their value, and the costs of protecting or failing to protect them. Shouldn't Risk Management form part of the framework?	Correct. The elements of sustainable development run through our environmental legislation and we must follow these policies through the framework. This type of policy related risk assessment tends to play a key role where contamination is regional in extent and solutions need to be holistic.
3. Comments from Lonmin Platinum (22 January 2010)		
3.1	As the remediation of contaminated sites under NEM:WA, 2008, and the closure-based risk assessments and financial provision under the MPRDA, 2002 have the same objective, it is suggested that reporting requirements for the mining industry be aligned with the approach followed with the legislative requirements for the mine closure risk assessment, closure plans, financial provision and reporting thereof in terms of the MPRDA, 2002. The Department of Water Affairs' Best Practice Guideline for water related issues at mine closure was also aligned with the approach followed under the MPRDA, 2002. From the definition of "contaminated" in the NEM:WA is not clear whether it includes contamination of water sources, however, it is assumed it does, as the contamination of land and water sources goes hand-in-hand and the Framework document refers to it.	The requirements for closure planning under MPRDA include provisions for remediation of contaminated land. The norms and standards to be applied in the assessment of contamination risk and the determination of remediation objectives must comply with Part 8 of the Waste Act. The Framework allows for assessment of soil contamination that may have impact on the water resource, on the scale of most mining activities this will be a site specific assessment that can incorporate DWAF guidelines and any other appropriate measures.

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3.2	The NEM:WA and the framework for remediation primarily focuses on clean-up of contaminated land and water. Managing contamination of land and water sources, require immediate clean-up as it happens but also an approach of prevention by managing the short, medium and long term risks of possible contamination until closure and post closure of that activity or project. For the mining sector, the mine closure risk based approach has been well established in order to prevent and manage the short, medium and long term risks of land and water contamination. This is however not the case with non-mining sectors - which may result in managing the contamination of land and water sources by these sectors only on an ad-hoc approach -as it happens. Closure requirements were included in the recent NEMA Amendment Act and it is suggested that this legislative requirements also be made applicable to the sectors/industries, other than mining.	Prevention of pollution is a Duty of Care requirement under NEMA and this provide the fundamental rationale for dealing with immediate contamination risk. Although the closure planning process is well established the specific requirements for remediation of contaminated land in the mining sector are still simple and generic in nature, without guidelines or standardisation of best practice. The extension of a closure planning process to major industrial facilities is a valid point and is already being undertaken by a number of large industries as the decommissioning of an industrial site is a listed activity under NEMA.
3.3	The legal framework provided for in terms of the NEM:WA and the framework for remediation also primarily focuses on addressing contaminated on a smaller scale. Provision is not made in the legislation or framework document for addressing the cumulative impact of contaminated land and water sources within South Africa. It should be mentioned that the contamination of land or water sources that require priority attention in South Africa, results from multiple sources of contamination of land or water, multiple and integrated land uses contributing to the contamination (residential, informal residential, commercial and industrial) and the need to then apportion responsibility/accountability to multiple contributors of the contamination as well as the required financial apportionment to the contributors for the cleaning-up of the contaminated land or water sources. This unfortunately has not been provided for in the NEM Waste Act, 2008, NEMA, 1998 or the Framework for Remediation which may prove to become necessary in addressing cumulative contaminated land and water sources by multiple contributors	Comment is noted. The Framework is best suited to simple site conditions and not multiple source multiple proponent situations. Apportionment of responsibility or accountability is not the purpose of the Framework. This is a complex issue and has to be addressed on a case by case basis. The EMCA process in NEMA provides an administrative option for dealing with multiple stakeholders/contributors. Unfortunately few stakeholders have faith in the system and are willing to participate to the levels required to enable EMCAs to arrive at successful outcomes.
3.4	In what way will they measure or delineate the extent of contamination (dimensions) that would have to be considered as 'Contaminated Land' and managed as such as per the framework. Related to this, to what extent would the difference in toxicity and hazardousness of the contaminant be reflected in this defined measurement (delineation) as indicated above. It is recommended that a single flow diagram be developed for the requirements within the framework with Yes/No categorization.	Contaminated land is assessed in terms of risk to human health and the environment. It is not simply a matter of extent. Small amounts of low hazard substances in soil would not be defined as contaminated land. The clean-up of minor incidents is a Duty of Care requirement.

No.	Comment	Response
	To what extent would timeframes be provided for identification, confirmation, investigation and remediation of contaminated land and how will this be regulated	Timeframes for identification, confirmation, investigation and remediation need to be developed to enable successful implementation of Part 8 of the Waste Act for both regulator and proponent. Proponents who don't comply with timeframes may be subject to the issuing of a Remediation Order.
3.5	To what extent would government be involved in the entire process, i.e. if contaminated land has been identified by the mine, at what point would their involvement need to be considered, or would this only be an application exercise, where they are notified and then we submit a final remediation report for their review. If they are to be involved along the various chain of events, this needs to be reflected in the flow diagram. Will reference dosages be considered for more heavy metals and contaminants other than those reflected on page 15 of the final document (Towards a Framework for the Management of Contaminated Land)?	This is an important point. Your understanding is correct that the authorisation process for contaminated land reflects the phased approach to site characterisation and remediation planning. A process flow diagram will be prepared to explain the general reporting, authorisation and decision-making stages. Yes, the Position Paper, is purely for discussion purposes and the metals listed are used as examples to illustrate a potential approach for site assessment.
3.6	To what extent will the requirements of the MPRDA and this framework under NEMA be aligned in terms of rehabilitation related to closure, where mines will be remediating and rehabilitating land to meet their closure requirements and objectives?	Rehabilitation is distinct to remediation and is not considered within the Framework. The Framework is non-sectoral and can be used as a point of compliance to assess the remediation objectives of a closure plan under MPRDA. The provision for site specific risk assessment in the Framework and the consideration of future land use are the important elements in the Framework that are closely aligned with the principles of closure planning. If applied properly the Framework will significantly improve the technical and financial assumptions that underpin most mine closure plans.
4. Comments from South African Petroleum Industry Association (SAPIA) (04 February 2010)		
4.1	Overall, the framework for the environmental management program outlined in draft form by WSP Environmental and Energy (WSP) is robust and well thought out. The proposed program is founded in international best practices and makes good use of lessons learned from those programs over the last 30 years. We agree that the risk-based approach proposed is well positioned to meet the goals set out for the program of: Identifying and characterizing contaminated land,	Noted.



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	Removing unacceptable risk to human health and the environment, and Bringing contaminated sites into productive use. We especially concur with the conclusion that "... in the development of the South African framework, the norms and standards must reflect the need for sustainable development and protection of the natural environment and not strive for technically unachievable or economically unsustainable target values". Adhering to this principle will undoubtedly enhance the program's ability to bring sites into productive use.	
4.2	Any risk-based program that includes a table of quantitative "screening" values runs the risk of having that table ultimately being used (often inappropriately) as a table of "cleanup" values, even when the original intention of the developers of the screening values is that they be used for screening purposes and that intention is made abundantly clear in guidance developed for the program. The best protection against this misuse is to make sure that adequate education and resources are provided to both the regulated and regulatory communities so that all have the knowledge and tools to adequately develop and evaluate site-specific risk assessments conducted to develop site-specific cleanup goals	Agreed. The over-reliance on screening values and their potential for misuse as default remediation standards is a common problem worldwide. The need for on-going education, communication, training and capacity building is acknowledged.
4.3	One of the final recommendations described in the draft report emphasizes the importance of developing an environmental management program that is implemented by all governmental sectors in a "... coordinated manner by a process of co-operative governance." Attaining cooperation between all of the various oversight agencies has often been one of the major obstacles to successful implementation of risk-based environmental management frameworks in the United States. Gaining cooperation is a critical factor that can determine whether or not the South African program will be efficiently implemented and ultimately successful. In order to attain this goal, the Department of Environmental Affairs may need to explore whether or not concrete incentives for cooperative behavior should be built into the program.	Noted



No.	Comment	Response
4.4	To further bolster the Framework, we suggest that specific statements on "Green and Sustainable Remediation" be incorporated into the guiding principles. Incorporation of green and sustainable remediation practices will enhance the investigation and remediation process through a comprehensive and integrated consideration of environmental, economic, and social factors and will result in a net benefit to the environment. Incorporating best management practices that minimize energy and water usage, greenhouse gas emissions, materials consumption, waste generation, and impacts on water resources, land and ecosystems will improve the greenness of a remedy. Identifying, considering, balancing and maximizing the short and long-term environmental, economic and social goals of the remediation program will improve the sustainability of the process. Green and sustainable practices could be instituted on a voluntary basis by stakeholders including property owners, regulators, environmental consultants and the public to enhance the regulatory process. The ultimate goal is to enhance the decision-making process to fully incorporate green and sustainable remediation practices, while at the same time protecting human health and the environment.	Noted and supported. Proponents should be encouraged to propose sustainable remediation methods and technologies and the Framework will provide for sufficient flexibility to enable this on a site specific basis.
4.5	Technical Comments: With these overall comments in mind, we provide the following detailed comments and suggestions on technical aspects of the program outlined in the "Towards a Framework for the Management of Contaminated Land Position Paper." Phased Approach: Phase 1 is largely a desk-top study in which an initial view (as known at the time) on the nature and extent of contamination is presented. The program should clearly describe that "contamination" is to be defined as areas over which the chemicals of concern at the site are elevated beyond soil screening values. As a risk-based program, it is important to make it completely clear that chemical concentrations in the environment that are below risk-based levels, do not constitute contamination. Phase 2 constitutes the main investigative phase of the process and the primary submittal for this phase is said to be a site assessment report.	Agreed. This element will be included under Reporting Standards. Agreed the Framework provides a scientific basis for defining contamination status. This will be included in Reporting Standards.



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	The type of risk assessment that should accompany the site assessment report to be submitted at the conclusion of Phase 2 should be clarified. Several of the items required to be addressed in the site report are essentially the result of a risk assessment, e.g., (vi) the acceptable exposure for human and environmental receptors in that environment have been exceeded, and (viii) the area should be remediated or any other measures should be taken to manage or neutralize the risk. These are decisions that cannot be made without conducting some form of risk assessment. Phase 2 should include a screening level risk assessment in which site assessment results are compared to soil screening values, or other appropriate screening values, in order to identify potential areas of concern at the site which would then be subject to more detailed analysis in Phase 3. Decisions concerning areas to remediate should be deferred to Phase 3, once all risk assessment work has been completed. Phase 3 focuses on the development of remediation plans and is the primary phase in which risk assessment activity is said to be conducted. Specific recommendations on guidance to be followed for completing the risk assessment should be provided. This can be as simple as providing recommended guidance developed by US EPA and/or other agencies with accompanying recommendations on ways to tailor procedures to South African conditions; for example, recommended exposure parameters and unique exposure scenarios to be considered. Guidance on how potential impacts to ecological receptors are to be addressed in site specific risk assessments and how the results of ecological risk assessments are to be incorporated into the remediation decision making process should be provided. The current draft clearly states that human health effects are of primary concern, but in several places in the framework, the draft program states that potential impacts to ecological receptors are to be addressed with site-specific risk assessment, but further guidance is required. Provisions should be made in the overall program to ensure that agency personnel who receive risk assessments are adequately trained and have sufficient resources to evaluate their results. This is a critical factor in the ultimate success of any risk-based program. Without sufficient training, regulatory personnel will often naturally default to	Guidance on Risk Assessment Reporting will be included in the Framework and is based on a review of international approaches. In some cases direct reference to acceptance of existing international approaches may be appropriate but in the most part the Framework has been developed to suit South Africa needs and align with our existing legislation. It is not intended at this point to provide detailed guidelines on the methodologies for undertaking ecological risk assessments. This topic is still under development in many parts of world and consensus has not been reached. Sites requiring detailed ecological risk assessments are not the norm for most contaminated land scenarios but are well suited to site specific risk assessment. Agreed. An initial training programme is an integral part of the ToR for the Framework. Noted.



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	preliminary soil screening values to determine remediation needs at an individual site, even when the site specific risk assessment concludes that no remediation is necessary. US EPA has developed a number of environmental best management practices for investigation and remediation activities that could be provided to support improving the "greenness" of activities.	
4.6	Preliminary Soil Screening Values: Definitions: Level 1 values are said to be protective of eco-toxicological risk, which is not completely true. In reality, the Level 1 values are designed to protect human health and beneficial uses of potentially impacted water bodies (which includes the health of aquatic receptors). The definition should be revised to clarify this fact. Exposure Parameters: References should be provided for the parameters listed. Many are based on standard parameters used in US EPA or European guidance, but several appear to have been selected based on their appropriateness for South African populations Dermal Absorption Factor: A default assumption of 10% should not be used for all chemicals. Chemical-specific absorption factors should be used when available. In their absence, default assumptions should be made based on the properties of the specific chemical of concern. For example, 10% is used as a default assumption for semi-volatile organic chemicals in many US regulatory programs, but this default assumption is not used for volatile organic chemicals, metals, and other inorganic chemicals which are not assumed to present a significant exposure through dermal absorption. Potential risks for these chemicals are addressed through other exposure pathways that are more consistent with their chemical properties. Soil to Skin Absorption Factor: The default values presented for the residential scenarios are very high. Similar values were used many years ago in US regulatory programs, but have been replaced based on more recent data. Standard defaults have been revised to 0.07 mg/cm² for adult residents and 0.2 mg/cm² for child residents. The rationale used to support the high values assumed for South African communities should be provided.	Correct and agreed. The ecotoxicological aspect is related to protection of aquatic organisms and is aligned to South African Water Quality Guidelines. Correct. A full list of input parameters used in the derivation of Soil Screening Values will be included in the technical appendices of the Framework. There are exposure parameters that have been modified to reflect South African conditions and this is in keeping with most countries in the world who have also developed their model equations from the common root of the USEPA. Noted and agreed. All relevant parameters are under review and require on-going review and update based on a 'weight of evidence' approach. Quantitative risk assessment is not a precise scientific discipline and requires judgement decisions to be made. It is correct that some default assumptions particularly applied to semi-volatile organics have to be assessed in terms of the sensitivity and practicality of the final numerical outcome of an exposure calculation. Noted. As above, this issue is under review. Correct. The value is in error. We agree that skin exposure factors in the



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	In Table 2 the surface area of exposed skin seems quite small even for a child. The value listed for standard residential and informal residential is 365 cm² which is about 5% of the total body surface area for a 50th percentile child (USEPA Exposure Factors Handbook). This value is about equal to the US EPA value presented for just hands (5.5%) of a 6-year old child. This seems low for a temperate climate. We recognize that it may be a typographical error because the values used later in the examples were much higher.	South African context are likely to be higher than USEPA factors.
4.7	Toxicological Parameters: Parameters presented in Table 3 primarily come from US EPA sources, but raise several questions. Most of the chemicals listed in Table 3 have an inhalation RfD equal to 100. It is unclear what this means -it may be a typographical error in the table because later in the first example, the RfDj for Cr (III) is footnoted as "Not defined" (Table 5). US EPA does not present any inhalation reference doses for these chemicals. The way in which the inhalation pathway is to be evaluated has changed in recent years. US EPA no longer relies on inhalation reference doses or slope factors and instead now relies on inhalation reference concentrations (RfCi) for non-carcinogenic chemicals and inhalation unit risk estimates (IUR) for carcinogenic chemicals. The equations used to evaluate inhalation exposures have been revised accordingly.	The error is acknowledged and has been corrected. We acknowledge the use of RfCi and IUR. However these approaches may not adequately address the inhalation exposure of the child as a sensitive receptor used in the generic model. The issue is under review.
4.8	Calculation Method: Equations used to derive soil screening values are based on US EPA methods: The method for deriving soil screening values (SSVs) for carcinogenic chemicals should be re-evaluated because it must account for the total exposure to the chemical over the receptor's lifetime. The exposure scenario used to develop residential SSVs for both non-carcinogenic and carcinogenic chemicals is based on potential effects to a six-year old child. This is the most conservative scenario for exposure to non-carcinogenic chemicals, but it is not the most conservative for exposure to carcinogenic chemicals. The carcinogenic exposure must include the dose received as a child added to the dose received as an adult.	Correct, but with substantial revision and adaptation. Correct. This will be approach followed in the Framework.



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	The equation used to derive SSVs for carcinogenic chemicals relies on the slope factors included in the toxicological parameters. By definition a slope factor is defined as: An upper bound, approximating a 95% confidence limit, on the increased cancer risk from a lifetime exposure to an agent. As such, the exposure received by a receptor should be averaged over a lifetime (70 years if US EPA slope factors are to be used), and not over the assumed exposure duration. This means that the child's exposure of 6 years should be averaged over a lifetime (25,550 days) rather than over the exposure duration (2190 days). This is why screening levels calculated by US EPA and other agencies for carcinogenic chemicals are based on a combined child and adult exposure duration. In deriving SSVs for carcinogenic chemicals, the South African program has selected a target risk of 1×10^{-5}. This is in line with environmental management programs developed in recent years in many countries and will undoubtedly provide adequate protection.	Correct. We have adopted the adult lifetime exposure for the Framework. Agreed. This is often a political issue which has been misunderstood by a number of administrations.
4.9	Site-Specific Quantitative Risk Assessment: A case study is presented to demonstrate the basic principles that may be involved in completing a site-specific risk assessment. As discussed previously in these comments, the final South African program should provide flexible, but more detailed guidance on recommended risk assessment procedures in order to provide a common ground for decision making. Comments on several issues are provided above in the discussion of the derivation of Preliminary Soil Screening Values, with a few additions to highlight some key points: Exposure Scenarios: The example includes quantitative evaluation of typical, reasonable maximum, and modified reasonable maximum exposure scenarios. US EPA guidance has long included a recommendation to include both typical (central tendency) and reasonable maximum exposure scenarios. This recommendation has not always been followed in practice and risk management decisions end up being based almost entirely on reasonable maximum exposures. In reality, including both scenarios provides risk managers with valuable information about the uncertainty associated with risk estimates. In order to make full use of such information, the South African program should include some specific recommendations on how to use this type of information in decision making. Without such guidance, practitioners will	Noted. Noted.

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	undoubtedly fail to include the information and risk managers will have the tendency to rely on the most conservative position, which may not provide the best solution for an individual site. Exposure Parameters: The exposure parameters presented in the example often differ from those that were used to derive the Preliminary Soil Screening Values. The relationship between the values used to derive SSVs and the full range of values that would be acceptable for quantitative risk assessment should be described.	Agreed where possible this will be done. As the Framework will not contain an exhaustive contaminant list it will on occasion be necessary to deal with contaminants that are not listed and require the proponent to reference assumptions and input parameters from authoritative sources.
4.10	Comments on Liquid Phase Hydrocarbon and Environmental Risk: A bullet point in the "Assessment of Hydrocarbon Contaminated Sites" Document (WSP Dr. John McStay -Dec 2009) states, 'A free phase fresh petrol floating layer poses a high risk: high vapour concentrations, high concentrations of BTEX compounds' and "a key risk driver" is not factual in all (or many) cases. Risk based concern should be focused on understanding the potential mobility, pathways and possible receptors for the free phase. Additionally, the chemical makeup of the free phase should be understood as some petroleum products may not contain volatile or soluble chemicals of concern, thus reducing or eliminating those as key risk drivers. A bullet point also states that, a remediation management measure is to recover/ remove the liquid phase hydrocarbon, though it may not be technically feasible / practical to recover the entire volume of the liquid phase (30 to 50% recovery is typical). There really is no "typical" recovery metric, but in theory there is residual and greater than residual free phase distributed in the soil after a release. The fraction recoverable (in theory) is the greater than residual amount, and this fraction can have a wide range of values (i.e. much less than 30%). However, the merits of conducting free phase recovery, at all, should be based on the materials potential risk attributes (is it mobile? does it contain chemicals of concern? etc.) and not on arbitrary recovery fractions or the measured thickness in a well.	The presence of fresh free-phase petrol is in most cases a high risk situation. It is correct that the existence of both a pathway and a receptor is the essential to establish risk. We have outlined the difficulty in recovery of free-phase. It is interesting to note that this issue often results in comments from the oil industry which are similar in content to that received. Unfortunately these comments have been misused in the past to support motivations for no action in cases where immediate risk is apparent. We therefore have to proceed in a risk averse and conservative manner when dealing with volatile contaminants arising from free-phase product.
5. Comments from Chamber of Mines of South Africa (15 January 2010)		
5.1	Policy Perspective: Significant areas of contaminated land are presently resident on industrial sites, military sites, mine sites, agricultural and urban lands. The excessively contaminated land may need to be removed, or remediated and managed in some	Agreed

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	acceptable form so as to reduce the risk the contamination poses to an acceptable level, before further development takes place, especially if the proposed development is recreational or residential. The Chamber of Mines supports the initiative of the DEA towards developing the Framework for remediation and management of contaminated land, on a basis of the practical risk posed by soil and contaminants to the environment and human health. Historical industrialised or contaminated sites represent unutilised and underutilised properties that do not make good use of the existing infrastructure and location, and may pose an environmental or human health risk. These sites need to be assessed for the type and severity of contamination and then be prepared for reuse by cleaning them to a standard appropriate to their type of reuse. Thus the "appropriate land use" concept has to be adopted in this case.	
5.2	Practical Application: From a practical point of view, the link between EMP requirements, application for waste management activity licence and the remediation framework is required as this will have cost implication for the industry. The retrospective application of the sections on contaminated land must be avoided as it may impacts on existing and even closed operations, raising significant legacy concerns from whatever remediation orders imposed. The sudden listing of remediation of contaminated land without the existence of norms and standard will promote licensing which is not uniform. Because of overlapping legislation i.e. Mineral and Petroleum Resources Development Act (MPRDA) and NEMA and NEM:WA as well as the ""National Water Act there is potential for both duplication in requirements to address the same problem and potential for conflict between the authorities and with those parties which may be held liable. Apart from liability it is important that the financial provision requirements under the MPRDA are properly considered for purposes of the remediation framework.	Noted. Legacy contamination is an on-going concern that can have immediate and long term impacts on the environment. It is therefore inappropriate to have a 'carte blanche' exemption for retrospective application. If a site has not been remediated to an acceptable level of risk the site will be classified as contaminated and will be subject to the provisions of Waste Act. Agreed. The Framework will provide the consistency in decision-making to enable Part 8 of the Waste Act. Agreed. There is a need to apply cooperative governance between all tiers of government for effective implementation. The proper application of the Framework will improve both the technical and financial level of confidence in remediation components of mine closure plans.

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	Because mines have to have closure plans which are properly funded, there is potential again for duplication should operating mine land be identified as requiring remediation for purposes of NEM:WA	
6. Comments from South African Iron and Steel Institute (SAISI) (13 November 2010)		
6.1	What will the legal status of the Framework be? Will it only serve as a guideline document for authorities to base their decision(s) upon?	The purpose of the project is not entirely to provide gazetted norms and standards. The decision to gazette all or part of the documentation has not been pre-determined.
6.2	The proposal to draw up concrete norms and standards including SSV's which are supported by a risk based approach is supported by SAISI.	Noted.
6.3	Will screen values for contaminated ground water also be developed? The current Water Quality Objectives (issued by DWAF previously) cannot always be applied as they are based on drinking water standards.	No. Department of Water Affairs is presently revising Water Quality Guidelines.
6.4	The Framework document and the necessary requirements to address contaminated land should be aligned with the provisions in the Waste Act. We have no doubt that this will be the case.	Noted.
6.5	SAISI is concerned that too many authorisations may be required for remediation activities and which could cause unfortunate delays. The following authorisations could be required: ROD issued by provincial authority ito activity 23(c) of the NEMA EIA regulations 386. Waste Management License to be issued by the Department of Water and Environmental Affairs ito activity 12 of Category A of GN 718 issued ito the waste Act. Remediation Order issued in terms of sections 38(2) or 38(3) of the Waste Act. It is not clear on whether the issue of a Remediation Order exempts a person from requiring any other authorisations? Authorisation ito the Water Act.	Gazetting portions of the Framework will provide for simplifying the authorisation of remediation activities. A remediation order is not an authorisation. It is a form of legal directive to force recalcitrant polluters to comply with Part 8 of the Waste Act. A remediation order does not exempt the polluter from other applicable authorisations.
6.6	SAISI is of the opinion that a path should be created for one authorisation to be issued	Noted.

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	for a remediation activity.	
6.7	What will happen if remediated sites (successfully remediated in the past) do not conform to the standards that are currently developed?	Contaminated sites that still pose a risk to human health and the environment will be subject to the provisions of Part 8 of the Waste Act.
6.8	Can the rights of applicants be protected in any way? A wealth of sensitive information may be released during an EIA process that needs to be followed in order to obtain a Waste Management License.	This is not uncommon for EIA processes. The public process for major remediation projects can lead to adverse public reaction which may lead to legal disputes and claims for compensation. It is however not the responsibility of the DEA to manage the reputational risk of the proponent.
7. Comments from Department of Environmental Affairs (13 November 2010)		
7.1	The formula discussed during presentations for minimum acceptable exposure level, the diffusion factor or rate for hazardous molecules that are being catered by diffusion principle was not included in the formula.	Volatilisation factors are applied for volatile and semi-volatile compounds.
7.2	The reason why these standards are developed is to have understanding of where we could actually say here the action for remediation is required (Threshold). So minimum unacceptable exposure level of hazardous waste should be determined to make it possible to trigger remediation action.	Correct.
7.3	The properties of hazardous waste and chemicals differ, some waste are more harmful to environment even at low concentration while other are harmful at higher concentration, so as such rule of generalization in determination of minimum unacceptable exposure should not be applied.	The Framework aims to define 'acceptable exposure' levels.
8. Comments from Liz Anderson - RCMASA (10 November 2010)		
8.1	Documents were not made available before or at the workshop to assist us to participate better.	Documents have been made available during the consultation process.
8.2	The scope and type of contaminated land to be addressed were not well defined. The process seem to dwell on metal and mining and not give enough to the important issues of organic and solvents which are highly probable and particularly problematic with aquifers and water ways.	The commonly occurring organic compounds will be included in the Framework.



Appendix E   Comments Received in Response to Draft Remediation Framework Report
and Responses thereto

Comments on:

Framework for the Management of Contaminated Land

April 2010

Compilation of soil screening levels (SSL) in this document is appreciated and can contribute towards consistent environmental management.

It is suggested that the following SSL be included.

Soil pH

Soil pH (KCl) (in 1:2.5 soil to 1N KCL solution) value of 4.5, below which most heavy metals will become soluble and mobile in the soil and vadose zone (Farina *et al* 1980; Rosner *et al*, 2001; Hattingh *et al*, 2003) . Gold tailing are especially known to generate acidity (through pyrite oxidation) and acidify soils under and around the sideslopes (Hattingh *et al*, 2003; Bezuidenhout & Rousseau, 2006). Values lower than 4.5 will therefore increase risk of groundwater pollution as well as impair vegetation growth (Farina *et al* 1980). Higher pH (KCl) values will, on the other hand, contribute to precipitation of heavy metals and mitigate groundwater pollution by immobilisation of heavy metals in the soil and vadose zone.

Soil exchangeable sodium percentage

Sodium salts are abundant pollutants from most industries and can cause serious soil and water pollution (Du Preez *et al*, 2000) . Kimberlite tailings are especially known to contain high sodium levels. Exchangeable sodium percentage (ESP) of soil is an important parameter regulating infiltration rate and erosion risks of soils (Du Plessis & Shainberg, 1985 Smith, 1990; Bloem *et al*, 1992) . ESP values of higher than 5% is commonly accepted as a threshold value above which serious infiltration reduction and erosion can take place (Bloem *et al*, 1992, Du Preez *et al*, 2000). This can lead to environmental problems such as erosion, eutrophication of surface water, silting up of dams, salination of surface water and impair vegetation growth.

Soil Uranium

Studies by Coetzee *et al* (2006) and Winde *et al* (2004) have linked contamination of stream water and particularly stream sediments with uranium with gold mine tailings. It is therefore suggested that inclusion of a SSL for Uranium would be of utmost importance.

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AA Bloem (Pr.Sci.Nat.)

GEOLab

geolab@telkomsa.net

083 379 6540

10 May 2010

Attention: Mr Stranton Narain
Deputy Director: Waste Management
Department of Environmental Affairs
Private Bag X447
Pretoria

Dear Stranton

Framework for the Management of Contaminated Land – Reply to Stakeholder Review Comments from GEOLab

Suggested additional Soil Screening Values

We agree that there are other forms of often non-toxic effects that may be applied to contamination and note that these are not only related to the assessment of soil functionality. Damage or corrosion to building materials by salts and acids and microbial contamination are examples of issues that are not addressed by the Framework.

Soil pH can be directly impacted by acid leaching to soils associated with seepage from mine tailings and acid mine drainage. It is also associated with discharges from acid plants on a number of chemical processing plants. There are however natural soils developed over certain rock types ie sandy soils associated with Table Mountain Sandstone which have a naturally low pH and thus the parameter by itself cannot inform the legal definition of contamination .

The difficulty in providing screening values for predominantly non-toxic elements, compounds and parameters are that criteria for soil are too specific to have broad application, this would apply also to exchangeable sodium percentage. Application of site specific risk assessment is preferred for these contaminants rather than over-reliance on generic values.

It is quite possible that these indicator parameters may form part of the remediation objectives for the clean-up of a specific site. The treatment of soils by adjustment of pH is commonly applied to situations where mobility of metals poses a risk to water resources.

Uranium is correctly identified as a contaminant of concern that ideally should be listed. It is however important to note that the management responsibility for the radiological hazard posed by uranium and its compounds is presently under the auspices of the National Nuclear Regulator. It is recommend that uranium contamination issues are dealt with on a site specific basis and by informing and involving all the appropriate regulatory agencies.

We thank you for your comments informing the development of the Framework.

Yours sincerely,



DR JON MCSTAY
Director
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30 April 2010

Reference No. Soil Norms and Standards 01

Jon McStay
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COMMENTS REGARDING THE PROPOSED SOIL NORMS AND STANDARDS

Dear Jon

The "*Framework for the Management of Contaminated Land*" and associated norms and standards for assessment and evaluation of potentially contaminated land in SA, is long overdue. The value of such a document in the protection of soil, water resources, ecological environment and human health is immense. It is invaluable at this early stage to ensure the best possible and appropriate norms and standards for assessment of potentially contaminated land. We have great appreciation for the effort you and your team have put into the development of the framework.

However, we have a number of concerns regarding the framework, which are raised in the sections that follow.

1.0 CONCERNS

1.1 Background concentrations

The principle of determining risk of contaminated land to the environment through a typical source-pathway-receptor methodology is generally accepted and used. However, not only risk assessment methodology can be used to determine screening levels for identification of contaminated land. The concept of contamination is defined in the NEMWA as:

"contaminated", in relation to Part 8 of Chapter 4, means the presence in or under any land, site, buildings or structures of a substance or micro-organism above the concentration that is normally present in or under that land, which substance or micro-organism directly or indirectly affects or may affect the quality of soil or the environment adversely;"

The concept of background concentrations (normally present) is used to define contaminated land and not risk to the environment. A distinction is further made between contaminated and posing a risk to the environment in sections such as 38 (1):

"38 (1) On receipt of a site assessment report contemplated in section 37, the Minister or MEC, as the case may be, may, after consultation with the Minister of Water Affairs and Forestry and any other organ of state concerned, decide that—

(a) the investigation area is contaminated, presents a risk to health or the environment, and must be remediated urgently;



(b) the investigation area is contaminated, presents a risk to health or the environment, and must be remediated within a specified period;

(c) the investigation area is contaminated and does not present an immediate risk, but that measures are required to address the monitoring and management of that risk; or

(d) the investigation area is not contaminated."

Therefore, the evaluation of contaminated land should consider constituents **above normally present concentrations** during the Phase 1 study and hence whether the land is contaminated or not. Once the presence of contamination on land has been established (which is a key focus in respect of the Chapter on contaminated land in NEMWA) further and subsequent studies are required to determine the risk of the contaminated land to the environment and hence whether remediation (a further key focus of NEMWA section on contaminated land) is required.

In NEMWA, the concept of risk is only considered during further assessment of contaminated land (Phase 2). Potential future risk then also needs to be considered as mentioned in section 37 (3) of the act:

37 (3) For the purposes of this section, land may be regarded as being contaminated at any particular time if the risk of harm to health or the environment could eventuate only in certain circumstances and those circumstances do not exist at the time that the site assessment is undertaken, but those circumstances are reasonably foreseeable.

1.2 Partitioning coefficients

Setting of appropriate partitioning coefficients for screening values for soil has too many uncertainties and is not defensible for a high level screening for the following reasons:

- The chemical form in which a contaminant occur influence risk to the environment significantly and is not always known at a screening level;
- Variability in soil partitioning coefficients are very large and influenced by many factors, many of which are unknown at a screening level (Sauvé, Herndershot and Allen (2000));
- Contaminated soils often have far lower partitioning coefficients, due to the soluble nature of many contaminants, than normally occurring in soils and estimating the partitioning coefficients at a screening level may not be appropriate. Solubility of constituents may further change over time depending on the soils ability to attenuate the constituent;
- Many soil conditions for example, redox conditions, presence of organic complexes, pH, cation exchange capacity, soil mineralogy, and other profile conditions may influence partitioning coefficients and are often unknown at a screening level.

Therefore, verifying assumptions made in the setting of partitioning coefficients for a particular site is a Phase 2 risk evaluation and should be considered at that level and not be considered at a phase 1 level. For a Phase 1 screening, more generally applicable, **precautionary** levels should be set. Screening levels should be very conservative to ensure that no areas of potential concern are screened out for further consideration as part of a Phase 2 risk assessment. The extent of contamination, area affected and depth of contamination should also be considered in any decision regarding contaminated land requiring further investigation.

In the current framework, it is assumed that enough information about the site will be available during Phase 1 to be able to make a judgment on an appropriate partitioning coefficient for the site, which will probably not be the case. The partitioning coefficients used in the setting of screening values are not precautionary enough and do not take into account the increased solubility of most elements in contaminated land (lower soil pH due to contamination). Soil pH has a dramatic influence on partitioning coefficients and many contaminated soils have very low pH conditions due to the impact of the contamination. The assumption made of a natural soil with neutral pH is not precautionary, resulting in partitioning coefficients that are not appropriate. It seems as if average partitioning coefficients were used and the precautionary principle is therefore not applied, where the partitioning coefficient should be very close to zero. Sauvé, Herndershot and Allen (2000) illustrate this with the partitioning coefficient they indicated for Cd varying between 0.44 and 192,000 L kg⁻¹. Similar variations were also found for the other elements in the same article.

Taking all of this into account, the lowest partitioning coefficient obtained from literature should be used for screening purpose if the precautionary approach is followed. The same applies to the DAF. As indicated in the framework, the DAF may vary between 1 and 10000, therefore the DAF of 1 should be used. However, this will result in unrealistic screening values for most potentially contaminated sites. Therefore an alternative approach is required which will be discussed in Section 2.

1.3 Analytical methods

In Section 2.2 of the framework (p7) the following statement appears:

"....and are based on the following key criteria for successful implementation:

Nationally consistent methods and numerical values for assessment of contaminated land....."

However, analytical methods are not specified in the framework, and it is assumed that this statement refers to the approach. Previous guidelines in South Africa and abroad have failed to be implemented properly, due to the analytical methodology, used as the bases for the guideline values not being specified clearly. This caused confusion and inappropriate application of guideline values.

1.4 Screening levels based on land-use

Although considering potential future land use in determining risk of contaminated land to the environment and human health are appropriate, it goes against the understanding of land contamination at a screening level. Land is contaminated, irrespective of current or future land use, if any contaminants are present above the natural concentrations.

Land use considerations form part of a level 2 risk evaluation and should be considered as such. It may be better to consider soil properties such as clay percentage and pH at a screening level, rather than land use. Setting values for different broad soil conditions from available knowledge are not farfetched for South Africa.

1.5 Other constituents to be considered

Soil contamination is not only related to its potential impact on the water resources and human health but also on the potential future functioning of the soil. For this purpose other soil degradation such as salinisation, sodification and soil pH may have an impact on the future utilization of the soil. Other constituents such as NH_4 , Mg, Na, K and PO_4 have not been included but may impact soil and even the water resources. These aspects should also be included in the screening for contamination.

1.6 Public participation

Public participation (PP) at a Basic Assessment level should be considered as part of the norms and standards, since it is the responsible approach to take in informing the nearest neighbors of the remediation of contaminated land. To avoid delay in clean-up of small spill areas and other unreasonable triggering of public participation requirements, the reasonable man concept, considering the extent and potential risk, should be used as a measure to provoke public participation.

The Constitution of South Africa, *lex suprema*, and specifically the Bill of Rights presents the right to access of information, the right to an environment that is not harmful to human health or well being and other many of which has been operationalised in various laws and their principle.

Circumventing public participation in the creation of a system in which only certain scenarios of land contamination will require PP, could be construed by the broader public as creating a form of unilateral discretion and disregard for "*Salus populi suprema lex*" i.e. the welfare of the people shall be the supreme law

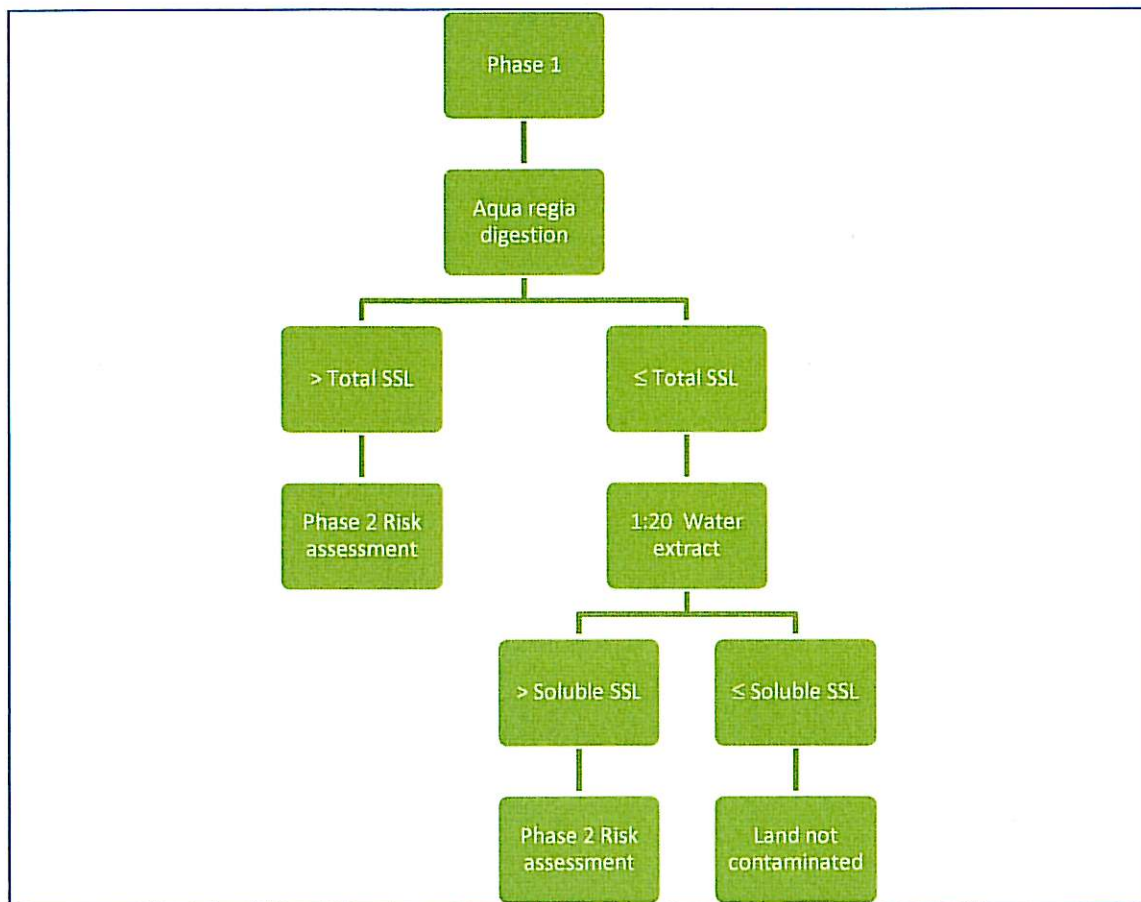
2.0 RECOMMENDATIONS

For the purposes of this comment a detailed proposal on an alternative process for screening cannot be presented here and can be presented in further more detailed consultation.

2.1 Approach

Since the assessment of contaminated land should be based on background concentrations (*"normally present"*) the following approach is proposed for the Phase 1 screening (see Figure below):

- 1) Conduct total analysis on representative soil samples for inorganic (including the additional elements proposed) and organic contaminants;
- 2) Compare results with Total SSL to determine presence of constituents exceeding "background concentrations" (see discussion below);
- 3) If the concentration of any constituents exceed the Total SSL, a Phase 2 Risk assessment is triggered;
- 4) If the concentration of none of the constituents exceed the Total SSL, the soluble fraction of constituents need to be determined (1:20 water extract);
- 5) If the concentrations of any constituents exceed the Soluble SSL, a Phase 2 Risk assessment is triggered;
- 6) If the concentrations of none of the constituents exceed the Soluble SSL, the land can be considered uncontaminated and not requiring registration as contaminated land.



This process will ensure that soils with high total contaminants are identified and evaluated for risk and soils with high soluble constituents due to contamination are also identified for further risk evaluation. Soils with low total and soluble concentrations of elements will then be considered uncontaminated since concentrations are within background ranges.

2.2 Soil screening levels

2.2.1 Total screening levels

A detailed discussion and some additional effort on setting these levels is required and cannot be comprehensively addressed in these comments. However, some proposals are presented here.

For inorganic metals and metalloids, the generalized risk evaluation for protection of the water resources can be used as presented in the norms and standards as one of the considerations. If this is compared to background concentrations as determined for South Africa (Herselman (2006), Herselman, Steyn & Fey (2005), Steyn & Herselman (2001)) the following table can be compiled, including proposed total SSLs.

Table 1: Proposed soil screening levels

Metals and metalloids	Proposed in Framework (mg/kg)	Background concentrations ranges for SA (mg/kg)	Background ranges for the world (mg/kg)	Proposed Total screening levels (mg/kg)
As	5.8	0 - 2.8	1.8 – 7.2	2
Cd	8	0 - 2.7	<0.01 – 41	2
Cr(III)	46,000	5.8 – 353	22 – 80	200
Cr(VI)	6	Normally present in concentrations <1.0	<1.0	1.0
Co	6	1.5 – 69	4.5 – 18	20
Cu	16	3 – 117	14 -109	40
Pb	20	3 – 66	18 – 25	20
Mn	740	82 – 1190	400 – 500	700
Hg	1.0	0 – 0.16	<1.0	1.0
Ni	91	3.4 – 159	0.2 – 450	90
V	155	21 – 182	10 – 500	150
Zn	245	12 - 115	10 – 300	100

Setting total screening levels should be realistic while still being conservative.

Organic contaminants are not normally present in soils and the total screening values should be set conservatively at very low level to not screen out any contaminants to be evaluated in the phase 2 risk assessment.

2.3 Soluble screening levels

For the soluble screening levels the same process as proposed in the Framework can be used except that a K_d value will not be required as a soluble extract is used. A DAF of 20 will therefore be the only factor required to convert water quality standards to screening levels for the soluble soil extract.

2.4 Analytical Methods

It is proposed that analytical methods be carefully considered and clear specifications for the analytical protocol to be followed be made for all the constituents to be assessed. There are many standards available that can be used for this purpose. For the purpose of screening the metals and metalloids an *aqua regia* extract and 1:20 water extract is proposed as appropriate methods. For organic contaminants a similar process need to be followed since different methods have vastly different results.

If there is one screening level, everybody needs to use the same analytical methods for comparison to these levels, otherwise there will be confusion around the assessment of contaminated land.

3.0 REFERENCES

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- Sauvé, S, Herndershot, W. and Allen, H.E. (2000) Solid–solution partitioning of metals in contaminated soils: dependence on pH, total metal burden, and organic matter. *Environ. Sci. Technol.* 34, 1125–1131

Steyn, C.E. and Herselman, J.E. (2001) The status of soil quality in terms of trace elements in the Mpumalanga Province. Agricultural Research Council Report no. GW/A/2001/19.

We wish you and your team the best of luck in finalising the framework document. If you want any further clarification or discussion on these comments, please contact either of us at the Golder Associates Pretoria office (Tel 012 366 0100).

Kind regards

GOLDER ASSOCIATES AFRICA (PTY) LTD

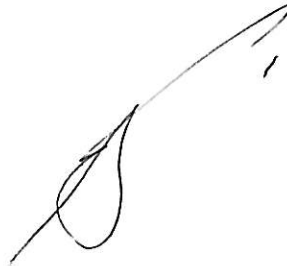


C Steyn / E Herselman
Soil Scientists

CES/LB/ces

CC:

Attachments:



L Bredenhann
Divisional Leader: IWWM Planning

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6 May 2010

Attention: Mr Stranton Narain
Deputy Director: Waste Management
Department of Environmental Affairs
Private Bag X447
Pretoria

Dear Stranton

Framework for the Management of Contaminated Land – Reply to Stakeholder Review Comments from Golder Associates

We would like to thank the specialist staff of Golder Associates for their inputs throughout the stakeholder process and respect their views which have benefited the Framework. In response to comments received 30 April we are able to respond as follows:

1.1 Background Concentrations

The concept of contaminants being chemical constituents above normally present concentrations, is recognised in Part 8 of the Waste Act and it is correct that this forms part of the legal definition of contaminated land.

It is an important role of the Framework to provide a practical means of implementation of Part 8 of the Waste Act in order to prioritise remediation for contamination that poses real risk to human health and the environment. It thus takes the logical step of determining risk based criteria which require statutory decision-making control rather than determining 'natural background' levels that may or may not pose a risk. The original international approaches that emphasised the background concentration as being the legitimate target for regulatory actions (particularly the original Dutch lists) have been revised to reflect risk-based criteria in the acceptance that small amounts of contaminants are inevitable and do not necessarily require intervention. The Framework is thus aligned with current international trends in contaminated land management. Furthermore it is important to note that natural concentrations of certain compounds in geological terrains in South Africa may be well in excess of harmful concentrations. It is thus appropriate not to over-emphasise the role of background concentrations in the Framework.

1.2 Partitioning Coefficients

We agree with the comments on the wide range of partitioning coefficient that could influence environmental risk.

We have endeavoured to provide a conservative set of values that are consistent with international practice in contaminated land assessment. The suggestion that the most conservative literature values for K_d , and a DAF value of 1 could be adopted is rejected as being over-conservative in the majority of cases. It is important to note that the proponent of a Site Assessment Report must make clear whether the assumptions used to derive soil screening values in the Framework are valid for the site in question, this provides the mechanism for the consideration of alternative K_d and DAF. We state clearly that the use of Soil Screening Value is not a substitute for a proper conceptual understanding of the site conditions.

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1.3 Analytical Methods

We understand your concerns over lack of guidance on analytical methodology. As the Framework is based on determination of total concentration in soil there are a number of internationally accredited methods that can be used. Any method based on a pre-analytical extraction technique that fails to provide a full extraction of the compound is unacceptable.

1.4 Screening levels based on land use

Land use is defined by the choice of receptors and their activity patterns and is applied as the second tier of site screening. We agree that incorporation of soil modifiers such as soil pH and clay content may have benefits in the second tier of assessment, particularly for water resource protection, and that this deserves further research in a South African context. The direct exposure pathways for human health are not affected by these factors and thus receptor based values tend to be a more sensitive indicator of risk and were chosen for use in the Framework.

1.5 Other constituents to be considered

We agree that there are other forms of often non-toxic effects that may be applied to contamination and note that these are not only related to the assessment of soil functionality. Damage or corrosion to building materials by salts and acids and microbial contamination are examples of issues that are not addressed by the Framework. The difficulty in provide screening values for predominantly non-toxic elements and compounds is that criteria for soil are too specific to have broad application. Many of the compounds suggested are also soil nutrients that have beneficial effects. The impacts of the common salts and soil nutrients on soil function and water quality are well understood and do not require further generic guidance that is likely to be of a preliminary and superficial nature. Application of site specific risk assessment is preferred for these contaminants rather than over-reliance on generic values.

1.6 Public participation

We agree with the sentiments expressed in this section. The 'norms and standards' approach developed within the Framework could be used to 'delist' the activity from the Basic Assessment process. This may not be appropriate and may disregard public concerns in some cases of remediation. This is however balanced by the concern that overdriven public participation creates unacceptable delays and that perception of risk creates unattainable remediation objectives. Project experience indicates that both these negative issues can be addressed. The issue is under careful consideration by DEA.

2. Recommended Approach

We will not comment on the detail in the approach but have noted shortcomings.

We agree that the starting point is the total contaminant concentration of the soil. Therefore the aqua regia extract is not appropriate for organic contaminants.

It is noted that receptors are not identified in the risk paradigm. In this sense no numerical evaluation of risk can be made.

The solubility of the contaminant in a soil and its extractable concentration determined by laboratory leaching tests is only relevant if a pathway to a water resource exists. The approach fails to recognise the direct exposure pathways for human receptors and thus is only appropriate for site specific assessment in the context of water resource protection.

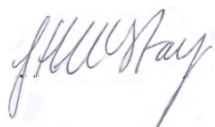
We note that the proposed screening levels based on average background levels are in close agreement with many of the metal values adopted as soil screening levels in the Framework. This supports our view that the Framework soil screening values are conservative and would be expected to be slightly higher than average soil background. It also suggests that the Kd values applied are similarly a fair and reasonable assumption for general use.

Soluble screening levels and analytical methods

The development and use of soil leaching tests is topic that deserves much scrutiny. It is correct that analytical results are method dependant and thus standardisation is preferred. The simple aqueous extract at 1/20 is a good starting point. However the kinetics of leaching, pH, redox, salinity, grain size of sample and solid/liquid ratio are all factors which effect results. It is debatable whether equilibrium is achieved for the majority of these tests. We are of the opinion that use of leaching tests in the risk assessment of contaminated land should cover a range of likely pH values and is best applied in the form of designed tests to suit site specific scenarios. We therefore offer no specific guidance on this issue in the Framework.

We thank you again for engaging in the scientific debate and informing the development of the Framework.

Yours sincerely,

A handwritten signature in blue ink, appearing to read 'J McStay', written over a light blue rectangular stamp.

DR JON MCSTAY

Director

WSP Environmental (Pty) Ltd



INFOTOX (Pty) Ltd

Established 1991

Retrieval and scientific interpretation of ecotoxicological information

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2010-02-20

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Attention: Dr Jon McStay

Dear Jon

Report No 011-2010 Rev 1.0: Review of WSP Methodologies for Soil Norms and Standards

I have reviewed the spreadsheets that were sent to me for assessment. In the absence of supporting WSP documents my comments might not be complete, but these can be amended in further discussions.

1 Terms of reference

The task requires a high level review of the approach and methodology developed for the assessment of contaminated sites in compliance with Section 8 of the Waste Act.

The deliverable is a short report discussing the appropriateness of the proposed methodology and any significant errors or flaws that may hinder or confuse its implementation as a practical means of assessing contamination risk posed to human health and the environment.

Comments on working drafts and draft final documentation will be necessary. (Must still be done.)

Suggestions for future work and further project development should be made. (Must still be done.)

Attendance at one project meeting. (Must still be done.)

2 Review of approach and methodology: General comments

2.1 Introduction

In your e-mail of 18 February 2010 the following statement was made, which I would like to use as a point of departure:

“However our scientific approach to the project is to provide both a generic starting point to risk assessment based (on) a conservative set of assumption for source-pathway-receptor linkages, and to develop the conceptual basis for quantitative site specific risk assessment for situations where the generic assumptions are inappropriate.”

I am concerned about various aspects in the WSP assumptions and methodologies, especially in the application of the equations in quantitative site-specific risk assessments. When we have a project meeting, I will discuss in more detail my concerns about the interpretation of the screening “numbers” and the application of the equations in full risk assessments.

2.2 INFOTOX comments on the principles of soil norms and standards

From a scientific and industry perspective, the concentrations of contaminants in the “*soil norms and standards*” cannot be anything more than screening levels (guidelines), which can be applied from a regulatory perspective in a Tier-1 or Tier-2 assessment primarily to instruct further site investigations according to the Act. Screening guidelines are not legally binding as remediation goals or remediation target levels, but may be applied as legally binding in terms of providing the Authority with norms to support the identification and notification of investigation areas under Section 36. (5 and 6). The guidelines may also be applied as legally binding in the assessment by the Authority of submission of Tier-1 and Tier-2 remediation reports. Where site investigations are not carried through to the Tier-3 investigation level and the sites are remediated following Tier-1 or Tier-2 assessments in accordance with the screening guidelines, the guidelines may become legally binding as remediation targets. This would be as a result of an internal industry decision based on a cost/benefit analysis. It will be the industry’s choice to make the guidelines legally binding.

2.3 Comments on the WSP equations

These risk-based equations are available directly from standard international references at various levels of refinement. I assume that WSP will provide the references for the equations, because I do not think that the intention is to present the equations as an original WSP product.

It is not clear why WSP has deviated from the established methodologies. I have been following the EPA Region 3 approach on this matter since publication of the original risk-based calculations and the concentration table that was developed by the toxicologist Dr Roy L Smith, and which was revised later on by Jennifer Hubbard (in 2003). More recently, the calculation methodologies have been refined further and the calculated guideline concentrations are continually being updated. It is a simple matter to look up screening guidelines in the table for residential and industrial soil on the web, as well as for an assessment of the potential for

groundwater contamination from soil pollution. The USEPA calculations are very similar in structure to the calculations that WSP is proposing, but the USEPA calculations are different in detail and are more relevant in terms of such aspects as mutagenicity and special cases such as vinyl chloride. There are pertinent differences between the WSP equations and parameter selections and the EPA approach, which WSP must attend to. I list the major issues below:

1. The equation for carcinogens should be based on exposure from birth to the age of 30, averaged over lifetime exposure. WSP assumed lifetime exposure, which is not in line with the latest consensus in the USEPA. This requires the application of age-weighted exposure parameters.
2. Age-weighted exposure calculations must be incorporated in the equations to allow for consideration of carcinogens with mutagenic action, which must put more weight on exposure and risk in the early life stages. There is reason to surmise that some chemicals with a mutagenic mode of action, which would be expected to cause irreversible changes to DNA, would exhibit a greater adverse effect in early-life versus later-life exposure. Inhalation rates and other exposure parameters have to be adjusted to account for age-weighted distributions in these calculations.
3. Exposure frequency is never taken as 365 days per year for the residential scenario (as WSP has done), except when considering carcinogens with mutagenic action in the life stage 0-to-2 years. All other exposures assume 350 days per year. There should not be any motivation to change this frequency number.
4. It is unacceptable to apply a generic target cancer risk level of $1.0E-05$ at the screening level. This should always be set at $1.0E-06$, until more site information on the number of carcinogens and their cancer classification has become available. Site-specific screening levels based upon a cancer risk greater than $1.0E-06$ can be calculated and may be appropriate when based upon site-specific considerations. However, caution is recommended to ensure that cumulative cancer risk for all actual and potential carcinogenic contaminants found at the site does not have a residual (after site cleanup, or when it has been determined that no site cleanup is required) cancer risk exceeding $1.0E-04$.

In summary, there is no justification for changing the standard screening cancer risk level from $1.0E-06$ to $1.0E-05$. As explained, this does not mean that the eventual cleanup target level after full site assessment may not be $1.0E-05$.

Similarly, the noncancer target hazard quotient of 1 must be adjusted downwards in situations of multiple chemical exposures, considering the health endpoints on which reference doses or tolerable daily intakes of the various contaminants are based.

5. The WSP equation for cancer-causing agents does not have a term that accounts for relative bioavailability. This must be corrected.
6. The proposed informal scenario requires serious discussion. The WSP approach infers in principle that an industry has to comply with residual soil levels of contaminants that are considerably lower than the norms for residential soil, presumably for allowing the development of an informal settlement on the site that is owned by the industry. This is a questionable land use scenario after site cleanup, because it would not make any

economical sense. Alternatively, the argument might mean that an informal settlement next to a residential area developed on a remediated site may suffer higher exposures from contaminants originating from the residential area than the residents themselves in the residential area. This also does not make logical sense.

The suggestion of assessing remediated sites for informal settlement land use against screening guidelines that would be considerably lower than those for residential scenarios anywhere else in the world cannot be justified. This should be of major concern to industries.

7. The equations do not provide for separate calculation of exposure to indoor (house) dust and outdoor dust associated with contaminated soil. This is important specifically for contaminants such as lead and is an important omission in the WSP equations. This emphasises that equations applied to derive screening guidelines are not in all cases directly suitable for application in quantitative site-specific assessments. The expectation should thus not be created that the proposed equations would provide in all cases the conceptual basis for quantitative site-specific assessments. This may hinder or confuse the process of assessment.
8. Application of a particulate emission factor has many limitations and is of interest mainly for a limited number of heavy metals, notably for Cr (VI). There is an alternative way of determining more accurate site-specific soil screening levels for the inhalation route of exposure by taking into consideration wind data and assuming ambient air particulate levels within the particulate ambient air standards. Also note the narrative about Cr (VI) below.
9. I do not understand why the WSP worker scenario has a dermal exposure area of 13 110 cm², whereas the USEPA number is 3 300 cm². This results in an unnecessary overestimation of exposure.
10. The WSP inhalation rate of 10.4 m³/day for the worker scenario is not correct. It cannot be less than the inhalation rate for adult residents.

3 Comments on specific contaminants

3.1 Mercury

EPA Region 3 has a soil screening level of 5.6 mg/kg for residential sites and 34 mg/kg for industrial sites. The numbers are different from the WSP calculated values.

However, soil contamination with elemental mercury against the screening levels cannot be assessed simply by collecting and analysing soil samples for elemental mercury. The distribution of elemental mercury in soil generally varies considerably over short distances, ranging from non-detects to percentage levels within small areas. A statistical sampling design to be certain that hot spots will not be missed at a 95 % confidence level would require a prohibitively large number of soil samples. It is thus not a simple matter to apply the EPA screening guideline for elemental mercury in soil on a mass-per-mass basis. Instead, the screening level must be expressed as a concentration of mercury vapour in soil, as micrograms mercury per cubic metre of soil gas.

Soil gas concentrations have to be measured on a statistical grid, for example through using flux chamber measurements, and cleanup target levels for mercury vapour have to be calculated by using a vapour intrusion model for risk assessment in confined spaces. This can be done separately for residential and industrial scenarios. The VF calculation for mercury in the WSP spreadsheet is thus not of much value.

A screening guideline can be developed, but expressed as mercury in soil gas in $\mu\text{g}/\text{m}^3$.

3.2 Lead

USEPA has no consensus RfD or cancer slope factor for lead and it is uncertain where WSP obtained the values in their Toxicological Database. USEPA has a long standing screening level for lead of 400 mg/kg for residential use.

Direct ingestion of lead in soil and dust generally drives soil lead cleanup target levels at contaminated sites and house dust is an important consideration for site remediation where the intended land use is for residential development. Generic screening guidelines cannot be derived for lead by following the general paradigm for heavy metals and the available arbitrary USEPA number is probably the best available. For accurate assessment, USEPA has developed models that relate lead exposure to lead levels in blood and which can be used to calculate soil cleanup target levels. These are the Integrated Exposure Uptake Biokinetic Model for children (IEUBK) and the Adult Lead Model (ALM), the latter which is applied to assess lead exposure in pregnant women. This is an important consideration in South Africa, where it is known that there is greater susceptibility for lead uptake and associated impairment of cognitive development (IQ) in South Africa than in the western world. This approach must be followed for site-specific risk assessment for deriving soil cleanup target levels in a Phase-3 site assessment.

There is again concern that the WSP methodology might lead to confused cleanup target levels in the quantitative site-specific risk assessment.

3.3 Manganese

The IRIS RfD (0.14 mg/kg-day) includes manganese from all sources, including diet. The dietary contribution from the normal diet (an upper limit of 5 mg/day in the USA) must be subtracted when evaluating non-food (e.g., drinking water or soil) exposures to manganese, leading to a RfD of 0.071 mg/kg-day for non-food items. Due to a number of uncertainties that are discussed in the IRIS file for manganese, a modifying factor of 3 is recommended when calculating risks associated with non-food sources, leading to a RfD of 0.024 mg/kg-day. This is considerably lower than the RfD applied in the WSP calculations.

3.4 Nickel

It is inappropriate to use the cancer unit risk factor of nickel refinery dust, which is based on occupational inhalation, to calculate a generic cancer slope factor for the derivation of soil screening levels at contaminated sites. Except for nickel subsulphide, USEPA soil screening guidelines for nickel compounds are based on noncarcinogenic effects.

The oral RfD applied by WSP is for soluble nickel salts, which is reasonable. The guidelines

derived on this basis are however lower than the USEPA guidelines based on the same data, which is questionable. The USEPA screening levels are 1 500 mg/kg for residential exposure and 20 000 for exposure on an industrial site.

3.5 Chromium (VI)

The issue of chromium and associated human health risks has been an ongoing subject of study and debate for many years. Generally, Cr (VI) would be expected primarily at operations where chromite ore processing occurred. Currently, the most prominent study relating to public exposure is the *Hudson County Chromium Exposure Route and Pathway Investigation* in New Jersey, which investigates hexavalent chromium in house dust in the vicinity of chromite ore processing residue (COPR) sites in the State of New Jersey. Reference to New Jersey is most appropriate, because during the twentieth century, Hudson County, and particularly Jersey City, was one of the biggest centres of chromate production from chromite ore. The COPR from this production was disposed of in various locations and given away for use as fill material and for construction of berms. This resulted in a legacy of approximately 200 COPR waste sites in Hudson County.

The current study in Hudson County is conducted by the Environmental and Occupational Health Sciences Institute of Robert Wood Johnson Medical School and Rutgers University in Piscataway, NJ. This study is undertaken to establish whether or not people living in some areas of Hudson County may be exposed to hexavalent chromium in household dust coming from historical deposits of chromite ore processing residue. The project is intended to measure the amount of re-suspendable hexavalent chromium adjacent to these sites, and to determine whether the existing caps on selected waste sites are effective at eliminating dust transport to residential areas.

The soil screening guideline for Cr (VI) used at COPR sites to address the inhalation route of exposure has been under much dispute. Soil screening guidelines for substances in airborne dust from surface soil are subject to many assumptions in the derivation of a particulate emission factor, e.g., source area, mean contaminant concentration, fraction of vegetative cover and meteorological conditions. In 1996, the USEPA derived a soil screening level of 270 mg/kg for Cr (VI) in residential scenarios, for protection against inhalation exposure to Cr (VI) in fugitive dust. This is much higher than the guideline applied in the State of New Jersey.

The non-residential land use cleanup criterion of 20 mg Cr (VI)/kg that is applied in the State of New Jersey is much lower than the USEPA residential screening guideline, due to the influence of vehicular traffic. Note that this guideline is for industrial site use, not for residential. For a specific site that we have evaluated, our assessment leans closer to the State of New Jersey interpretation than the USEPA soil screening level.

We are of the opinion that it is very questionable to derive a valid generic Tier-1 soil screening guideline for Cr (VI) in the absence of information on soil particulate size distributions and wind data. The WSP proposed screening level of 158 mg/kg for Cr (VI) for a residential scenario and 255 mg/kg for a commercial/industrial scenario would be difficult to justify, especially since the current USEPA Region 3 guidelines are 0.29 and 5.6 mg/kg for residential and industrial land use, respectively. It is not useful to have a number at all cost when it is known that the number does not have defensible validity.

This statement is over and above the issues that I have raised with the way in which cancer risks are being calculated in the WSP equations.

3.6 General comments

It is not clear what the rationale for the selection of the substances for assessment has been. There are specific compounds of concern that deserve attention, such as vinyl chloride and phthalates, and pesticides, amongst others. The lists are very incomplete, even if the intention had been to select only a few examples.

4 Conclusions and recommendations

I have identified several concerns about the WSP approach and detail in the calculations, which require attention. The spreadsheets with assumptions and equations require substantial revision to make the equations more relevant and complete, and to correct the toxicology data as pointed out in my review. The WSP methodologies and values used must be referenced.

I have noted several problems arising from the application of principles of screening level development to full quantitative human health risk assessment for the development of cleanup target levels for site remediation. This should require specific attention.

We trust that my review will add value. Please do not hesitate to contact us should you require any additional information.

Yours sincerely

A handwritten signature in black ink is written over a circular professional seal. The seal contains the text "PROFESSIONAL ENVIRONMENTAL PRACTICE", "WILLEM C. A. VAN NIEKERK", "QUALIFIED ENVIRONMENTAL PROFESSIONAL", and "No. 07980160". There is a small star at the bottom of the seal.

Willie van Niekerk PhD QEP(USA) Pr Sci Nat
Managing Director

2 March 2010

Attention: Mr Stranton Narain
Deputy Director: Waste Management
Department of Environmental Affairs
Private Bag X447
Pretoria

Dear Stranton

Framework for the Management of Contaminated Land – Reply to Peer Review Comments from Infotox.

In response to initial comments from the toxicological reviewer Infotox we are able to respond as follows:

2.1 Introduction – application of equations to site-specific risk assessment.

It is not our intention that the equations used for derivation of soil screening levels are mandated for use in site specific risk assessment nor has this been stated in the Draft Framework. We recognise that detailed risk assessment requires, in many instances, more detailed pathway analysis, potentially involving mathematical modelling and/or further more detailed calculations, as well a variation of the final risk characterisation equations for the specific site conditions and exposure pathways. Hence our reference in Section 2.1 to developing 'the conceptual basis for quantitative risk assessment' – an aspect that is notably lacking in most remediation projects in South Africa at present – rather than prescribing specific equations for site specific risk assessment.

We do, however, note that there is currently significant overuse of risk models and risk modelling software in South Africa without adequate interrogation or understanding of underlying assumptions and, in this respect, we expect that clear disclosure of risk calculation equations be provided for all site specific risk assessments, see Section 5.

2.2 Comments on principles of soil screening values

Agreed. Screening levels are intended for decision support purposes both for industry and the regulator, as is the case elsewhere in the world. The level of assumptions and uncertainties necessarily involved in screening level derivation means that it is neither good policy practice nor entirely scientifically defensible to mandate screening levels as default remediation targets. Understanding of a site's specific risk profile is required to establish whether a screening level is appropriate for application as a remediation target.

2.3 Comments on equations

Preamble Comments

The calculation of chemical dosages is a universal concept and the equations used are not being claimed as being a WSP derivation nor are they a unique product of the USEPA.

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Item 1 – Carcinogen exposure parameters

We acknowledge that the USEPA assumes a 30 year residential exposure period for carcinogens that is averaged over a full lifetime. We note that this is not a universally accepted approach and that other regulatory agencies have taken different views on both exposure periods and averaging times.

We have assumed that the exposure period could be as long as 70 years (ie full lifetime) for cases where residents live in one home their entire lives. As this seems a reasonable worst scenario for South Africa, and given that it results in a more encompassing and conservative screening level, we propose that the more conservative approach is adopted.

Item 2 – Age-weighted exposure parameters

We recognise that differences in age related exposure characteristics means that the longer the exposure period being considered, the greater the effect of aggregating exposure and 'smoothing out' of daily exposures anticipated across different age classes. The definition of a child receptor for the assessment of exposure for age period 0 to 6 years has been used by many regulatory authorities for derivation of screening levels for non-threshold responses. This is regarded as a pragmatic and defensible approach to addressing the issue of aggregated exposures in the context of deriving soil screening levels for South Africa. It is our opinion that the use of a child receptor, as apposed to a series of age classed receptors and associated exposure parameters, can also be defended in many instances for site specific risk assessments where the level of detail provided by the later approach does not necessarily translate to a significantly different outcome in respect of risk analysis and remediation decision making.

The revised USEPA Guidelines for Carcinogenic Risk Assessment of 2005 and associated Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens focuses on a revised methodology for assessment of carcinogens that have a mutagenic mode. We acknowledge this revised approach that focuses attention on early life stages through use of adjusted potency factors for defined life stages and furthermore support the application of this approach for site specific risk assessments. However, we note that in terms of the USEPA guidance this updated approach only has bearing on two out of the full list of compounds currently being considered for screening levels – these are benzo(a)pyrene and vinyl chloride. The proposed soil screening levels derived for these two compounds are both exceptionally low (below 1 mg /kg for residential) and to modify the calculation methodology to follow latest USEPA advisory for these two compounds is considered to represent a level of refinement and detail that is not warranted for a screening level derivation. Had the revised methodology been applicable to a large range of compounds, and have a significant effect on final screening level value, then we would accept that this is a modification that would need to have been taken into consideration.

Item 3 – Exposure frequency

Standard Residential Scenario

We agree that an exposure frequency of 365 days per year for the standard residential scenario is highly conservative and a lower frequency could be justified based on various assumptions relating to South African working leave provisions and holiday travel.

We note that the USEPA default of 350 days per year is by no means an internationally adopted figure with most regulatory agencies having adopted differing numbers that are deemed appropriate to their particular country and policies. The UK Environment Agency has, for example, taken a conservative approach and assumed 365 days per year exposure frequency for their residential child receptor. The selection of a number for South Africa should be based on consideration of what is appropriate for our country rather than seeking to align with another agency's decisions.

Our Labour Act leave provision is 21 days of leave. Although this legal requirement has numerous exclusions (ie persons earning over a certain salary etc) it would apply to a significant proportion of the South African population. Depending on how much of the 21 days is assumed to be spent away from home, this translates to an exposure frequency ranging from 344 to 365. We accept any number within this range as being appropriate for the standard residential scenario calculations and note that the decision on final number does not have a major consequence on the value of the final screening level.

Informal residential scenario

The USEPA default of 350 days per year for developed country residential conditions is not necessarily appropriate for informal settlements in South Africa, where no formal working leave can be assumed, nor any capacity to travel on holiday away from point of residence be assured. In the absence of appropriate South African population data specifically for informal settlement conditions, it is prudent to assume the most conservative exposure frequency of 365 days per year.

Item 4 – Target cancer risk

The comments provided are appreciated as being reflective of the USEPA position in respect of target cancer risk levels. This position dates back some twenty years or more. It is noted that the USEPA is no longer the sole point of reference in respect of risk based thinking, even though it is acknowledged that much of the original methodologies did originate from the US. The litigious nature of US society and over-driven conservative approach has resulted in many if not most other regulatory authorities having moved away from US approach in respect of aspects such as appropriate target cancer risk. Examples include Sweden, Netherlands and a number of other EU member states.

Item 5 - Bioavailability

The carcinogenic risk calculations include a gastrointestinal absorption factor as applied in the noncarcinogenic calculations. We agree this must be included across both carcinogenic and noncarcinogenic calculations for consistently and acknowledge that the text equation provided in the spreadsheets for carcinogenic risk erroneously omitted this term.

Item 6 – Informal settlement scenario

The presence of informal settlements on contaminated sites must be recognised and accounted for in any remediation norms and standards developed for addressing South African conditions. Although this is primarily a legacy issue it is recognised that new low cost housing initiatives also give rise to the same health concerns in respect of elevated levels of particulates due to either partial or complete lack of formal roads, paving and other surfacing.

Item 7 – Indoor/Outdoor Dust

For the purposes of the screening level calculations indoor dust levels have been assumed to be equal to outdoor dust emissions. This is a highly conservative approach which could quite easily be argued as being over conservative and unrealistic. For example Australian risk assessment guidance recommends an assumption of 75% outdoor dust levels for indoor air screening level calculations. We would be happy to modify the calculations to a less conservative indoor dust assumption.

Item 8 – Application of PEF

Inhalation exposure to particulate emissions from metal contaminated sites represents an important pathway that should be taken into consideration in any screening level calculations. It is noted as particularly pertinent for informal residential settings in South Africa where particulate exposure levels may often be elevated and will contribute to increased exposure levels for all three routes – inhalation, ingestion and dermal. It is acknowledged that these exposure levels have not been quantified and is noted as an important area of exposure research that is required for future study. This does not however preclude the need to provide some initial address of the particulate exposure pathway in the screening level calculations.

The particulate emissions equation used is acknowledged as representing a simple empirical approach. More refined forms of the equations – specifically replacing the dispersion component of the relationship with an air dispersion factor ('Q/C' term) – can be contemplated as part of a further refinement in years to come but will require further studies of South African site/soil conditions as well as air dispersion modelling. Use of Q/C terms from other parts of the world was considered but is not recommended.

The above approach has been reviewed and adopted by a number of regulatory agencies – most recently the UK Environment Agency and is deemed to be sound as for screening level calculations.

Item 9 – Worker dermal exposure area

The working conditions, personal protection equipment and general standard of health and safety of workers undertaking outdoor, manual maintenance type work is not considered comparable to the US work force conditions and hence direct adoption of standard USEPA default numbers is not deemed to be applicable without careful review.

In terms of worker dermal exposure we specifically recognise that outdoor manual labourers (who would necessarily have a higher exposure risk to contaminated ground) in the hotter and/or more humid parts of South Africa may often work without full overalls, unless working within a strictly controlled industrial setting. The total exposed skin surface area in the South Africa context may thus include not only face, hands and forearms but also upper arms and torso.

The total skin surface area of an adult (as detailed in USEPA guidance/upper percentile) is 23,000 cm². The current skin surface area number of 13,110 cm² reflects the reasonable maximum exposure value that has been derived from the same US population data. It is deemed to be conservative and reasonable for South African worker conditions. The standard USEPA worker default parameter of 3300 cm² is not considered appropriate or adequately protective.

Item 10 – Worker inhalation rate

The worker exposure inhalation rate is based on an outdoor hourly average of 1.3 m³/hr for 8 hours a day. The number is expressed in m³/day and thus is lower than the adult residential rate is based on a 24 hr per day exposure at an inhalation rate of 0.83 m³/hr.

3. Comments on specific contaminants

3.1 Mercury

The reviewers comments in respect of **elemental** mercury are fully supported and agreed with. In cases where source removal of elemental mercury spillage to ground has not been undertaken timeously, dispersion and migration of the product through the subsurface environment will result in a complex distribution pattern that (a) cannot be effectively characterised by standard soil sampling methods and (b) poses significant issues of technical impracticability in respect of remediation. This is not substantively different to the issues of characterisation and remediation of free phase hydrocarbon contamination in the subsurface environment.

Evaluation of soil vapour phase concentrations of mercury will provide a more meaningful indication of the extent of mercury contamination and site specific volatisation modelling will be an imperative to define a suitable site specific remediation target. The site specific physical, chemical and hydrological constraints in any such model will, however, necessarily preclude this from being suitable for derivation of a soil gas screening level for generic use.

The above discussion pertains specifically to elemental mercury contamination. However, this is the less frequent form of contamination problem encountered with the majority of mercury contamination being in the non-elemental form such as mercuric salts. The later is both more mobile, soluble and gives rise to significantly higher volatisation rates and hence risks from soil contamination. The distribution of non-elemental mercury contamination does not present the same sampling issues as for elemental and can be quite adequately characterised through conventional soil sampling methods. The derivation of a soil volatisation factor for this form of contamination can be defined (albeit within the same assumption constraints regarding soil partitioning etc as apply to other volatile and semi-volatile compounds) and is an important consideration for derivation of any soil screening level. As non-elemental mercury contamination presents the greater health risk, this is the basis on which the screening level derivation has been based. It does not preclude or conflict with the need for site specific vapour modelling in cases of elemental mercury contamination as highlighted by the reviewer.

As an aside, we note that vapour modelling for gross elemental mercury contamination necessarily needs to focus on prediction of long-term solubisation, partitioning, migration and vapour build-up rates for defining remediation objectives whereas modelling of non-elemental mercury behaviour will more closely resemble equilibrium conditions in respect of partitioning and vapourisation in the soil environment. Hence, soil vapour monitoring in instances of elemental mercury contamination would be primarily for the purpose of model calibration and defence of longer term predictions of remedial efficacy rather than as demonstration of remedial compliance.

3.2 Lead

We acknowledge that use of lead blood levels as a point of compliance for defining remediation objectives is a widely recognised approach. This approach would be entirely acceptable and

appropriate for site specific risk assessment in South Africa. The development of a soil screening level does not preclude in any way the application of models such as the IEUBK or ALM in site specific assessment purposes.

Adoption of the 'arbitrary' USEPA number for lead is not considered a defensible approach. The recognised issues of lead toxicology notwithstanding, it is noted that most regulatory agencies have derived a screening level for lead that serves the purpose of 'initial screening and guide for decision making'. We have thus provided similar guidance for South Africa based on the tolerable daily intake value provided by the WHO and utilised by a range of authorities for the purpose of setting soil screening levels. We note that the WHO value is equivalent to a blood lead level of 5 $\mu\text{g/dL}$ – well below the 10 $\mu\text{g/dL}$ generally considered to be protective of human health.

3.3 Manganese

We agree with the adjustment of RfD for non-food source exposure to manganese and have adjusted the calculations accordingly.

3.4 Nickel

We agree with the comments provided in respect of inhalation exposure and the assessment of nickel based only on non-carcinogenic effects for contaminated sites.

The calculated screening levels for both informal residential and commercial/industrial land-uses will be lower than the USEPA numbers as more conservative assumptions have been used to reflect South African specific conditions.

3.5 Chromium (VI)

The comments provided in respect of the application of particulate emission factors for derivation of screening levels are acknowledged. Our comments on particulate emissions factors are provided earlier in this document.

We do not regard the variances between USEPA and NJDEP Cr(VI) criteria as being indicative of conflicting views or reason for not developing a soil screening value for Cr(VI). Rather we recognise that NJDEP has taken the lead on applying latest NTP research findings for Cr(VI) in their risk assessment considerations (assumably driven by their practical experiences from COPR) whereas the USEPA still lags in respect of formalising the implications of the NTP study into IRIS and their broader risk thinking on Cr(VI).

We would support the adoption of the NJDEP calculated potency factor of 0.5 mg/kg/day-1 for ingestion cancer risk in our soil screening calculations as being reflective of the best state of knowledge on Cr(VI) at this time. Although not expressly stated, we assume from the reviewers comments that this approach would be supported.

4. General Comments – selection of substances

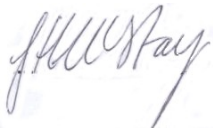
We consider that the initial listing of contaminants can be expanded further and that this should be the long term aim. It is important to note that the Framework is designed to provide a consistent link with South African Water Quality Guidelines, which are presently under review and are likely to be extended to cover more compounds in future. Extending the Soil Screening Values to further

compounds in the absence of supporting water quality guidelines is not the preferred course of action at this point in time.

Yours sincerely,

A handwritten signature in blue ink, appearing to read "Sean Doel", with a long horizontal flourish extending to the right.

Sean Doel
Director
WSP Environmental (Pty) Ltd

A handwritten signature in blue ink, appearing to read "Jon McStay", with a long horizontal flourish extending to the right.

Dr Jon McStay
Director
WSP Environmental (Pty) Ltd

FRAMEWORK FOR THE MANAGEMENT OF CONTAMINATED LAND

COMMENTS BY OCKIE FOURIE TOXICOLOGISTS (OFT)

1. HUMAN HEALTH BEING THE STARTING POINT FOR DEVELOPMENT OF SOIL SCREENING VALUES

The philosophy and science of the last three decades “to protect human health .....” as “**the starting point** for developing soil screening values”, and “incorporation of ecotoxicological criteria for water resource protection” (pp. 23), must be regarded as not to represent current approaches in the rehabilitation of land and soils per se. Science has moved on and we have learned that we have to advance in for example risk assessments, carcinogenic studies, assessments and mechanisms (will be referred to later). Amongst many others have we learned and advanced to the point where universally more funding, time and expertise is allocated to environmental research and risk assessment, acknowledging that the short- and long-term health of the environment, dictates the health and indeed the survival of mankind on planet earth.

The **common denominator** for potential risk to the environment and human health by contaminated soils is **primarily** water resources through environmental habitats, and consumption and use of waters by aquatic life, terrestrial life and human life. The exposure routes of soil ingestion and dermal contact are only remote **secondary** exposure routes (will be referred to later). Anybody who has worked on soil contamination and remediation at industries, mines and soil and sediments of accidental releases and contamination, can testify as to the consequences of ground and surface water pollution, as the exposure route to all life, and **not** the ingestion of contaminated soils by children and others.

In any case, broadly speaking is access in practice to most contaminated soils referred to above, controlled to the extent where the exposure routes of soil ingestion and dermal contact by access to these soils, is to be regarded as minor and remote. Dissipation of contaminants in soils on the other hand is a natural phenomenon controlled by amongst others soils characteristics such as classification and composition, pH, CaCO₃ content, Organic Carbon content, particle size etc., as well as K_d/K_{oc} and T_{1/2} of aerobic and anaerobic degradation, whereby waters are contaminated as a **primary** exposure route to all life.

2. APPROACH BASED ON USEPA METHODOLOGY

This “original USEPA Methodologies” is not an adequate approach, as discussed in paragraph 1, above. There are many developed countries, which differs with the EPA (including some regions in the USA). In this specific document, most fundamental criteria in equations have been copied unchanged, for example the average body weight of a RSA adult is not 70 kg, and the average South African do not consume 2 litre of water per day, yet it is used in the proposed risk assessment for human health! It is to be remembered that the RSA is a country with a huge cultural diversity, which has to be accounted for in risk assessments for human health, as has indeed been applied by toxicologists in the past three decades.

3. TOXICITY ASSESSMENT

Much comment is possible on toxicity assessment, which is referred to on page 43. Very briefly the following:

To study the effects of a chemical compound on human health and the environment is no mean undertaking. It can encompass up to 10 years of research at a cost of up to one billion Rand for a single compound. With regard to human health it includes amongst other acute studies, sensitization, clinical pathology, haematology, urine chemistry, histopathology, neoplastic and non-neoplastic findings, mutagenicity, carcinogenicity, teratogenicity, reproductivity, developmental studies, ADME studies, neurotoxicity, immunotoxicity and many more. Many of the same kind of studies are performed in ecotoxicity with terrestrial and aquatic organisms, avian life and many more, as well as a full range of all parameters in environmental fate. Indeed the international literature reports: "Hazard assessment for environmental organisms should follow the same principles as for man, and (with regard to contaminated land) .....present those values aimed at protecting **ecosystems as the main target at risk** (Urzeli et al, March 2000).

Except for the "ecosystem as the main target of risk" which had been dealt with in paragraph 1 above, we specifically want to comment as follows:

- a) All the toxicological research on a molecule referred to above result in numbers which indicate an exposure level to human health and the environment, referred to as levels at which no adverse effects will be encountered. These scientifically derived numbers at significant cost and expertise are normally the point of departure in our models, equations and calculations of potential risk etc. Yet this valuable data is totally distorted and becomes most oftenly meaningless due to incorporation of assumptions and default values, oftenly without any scientific justification.

This seemingly indiscriminate use of (unscientific) numbers and values, also in this present work, is prominent in the international literature. Soil contamination standards are for example reported to range between 50 – 600 mg/kg for the same compound in 9 developed countries! There most certainly are ways and means by which ecosystem (and man) can be safeguarded using this highly scientific derived values without distortion referred to.

- b) The sources for toxicity assessment (pp. 43) refers to human health assessment., Where are the sources for the toxicological assessment for the protection of terrestrial and aquatic ecosystems, **what were the endpoints measured** for the protection values for "ecosystem health", and which indicator species were used?
- c) A drinking water standard (human health) is not a standard based on toxicity alone, and might for some compounds have little to do with toxicity at all. Soil screening values for human health should be based on health standards in the "water resource protection pathway" and those standards (without distortion of scientifically derived data) must provide for adequate protection of human health.

4. USA NATIONAL ACADEMY OF SCIENCE

With regard to paragraph 3 above, do we have to take note that the USEPA commissioned the US National Academy of Science for an independent study to improve risk analysis by the EPA and to identify improvements that EPA could make in the **near term (2 – 5 years)** and the longer term (10 – 20 years). This was done due to the fact that risk assessment is becoming increasingly more complex which has to be dealt with in risk management decisions, and to **promote more accurate characterization of risk**. (Preuss et al, USEPA, 2009). Such a decision should be applauded, as it hopefully will do away with assumptions, default values and indiscriminate use of safety factors.

5. MODIFICATION OF SOIL SCREENING VALUES TO SUIT A WATER QUALITY OBJECTIVE

- a) A soil screening value, which is based on a scientific acceptable risk level, should be based on scientific derived data. It **cannot be modified** to suit a specific objective but has to remain true to health to the environment and human health. It is bad science.
- b) Soil (land) is a unique media, unlike any other media, i.e. water. We can waste or contaminate waters, because waters do get replaced naturally, we can even replace or “make” the freshwater we need from an abundance of seawater. We cannot replace or make soils. If we do away with a soil due to for example contamination / pollution, then there will be a deficiency (the hole at Kimberley?), which cannot be filled by “making” more soils.

Therefore **it has to be a stand alone series of regulatory standards** (pp. 24) by which we are to make very sure that soils will always be available for use without adversely affecting any other life or media, irrespective of resource management approach and needs.

6. SOIL POLLUTION RISK VS ACTUAL RISK

Though soil pollution policies in North America and the European Union increasingly use risk-based standards, the construction and application of such standards are often deficient in taking account of actual risks. Standards refer to total concentrations of substances and not to **the biologically available amount**. A number of countries also neglect “background” exposure, and assumptions regarding routes of exposure to soil pollution can be very different and at variance with empirical data. Recent dose-effect studies are neglected in a number of cases. The application of standards does not take account of the overall risk of soil pollution but rather leads to the decision whether or not there is violation of at least one standard for a specified (group of) substance(s). Standards for soil pollutants are often based on the assumption that only effect addition can occur, whereas dose addition, antagonism and synergism, and indirect effects may in fact apply. (L. Reijnders, 2009)

Bioavailability referred to above must refer to bioavailability in the contaminated soil, as well as bioavailability once ingested. No reference is made in this work to bioavailability, which has to be accommodated.

7. ROLE OF MECHANISMS OF TOXICITY IN RISK ASSESSMENT

It is believed that scientific judgement, such as in or with soil screening levels to be adopted must be more scientific and specific, and that this could be done by for example the use of worst case scenarios or the use of the precautionary principle. This may specifically be important for those soil contaminants for which mode of action or mechanistic data is not available, but extrapolation of data has to be performed. This is very important for example in the application of a 10^{-6} or 10^{-4} risk of a particular hazard to man. It is believed that little justification exist for using a 10^{-5} or 10^{-6} risk due to all uncertainties and that a health risk of 10^{-4} would be appropriate. However, with regard to the present work, must the Department fully discuss and motivate the relevance of 10^{-4} or 10^{-5} or 10^{-6} risk used in this soil framework for the management of contaminated land.

8. MUTAGENICITY AT LOW DOSES AND LOW-DOSE CARCINOGENESIS STUDIES

To give some perspective to paragraph 7 referred to above, is the fact to the lack of low-dose carcinogenicity data in risk assessments. When there is no mechanistic model available, then extrapolation from high to low doses is used, which is described in the literature to be “fraught with uncertainties” (Demarini, USEPA, 2009). The facts are that only three low-dose carcinogenicity studies were performed to date: exposure of 4320 mice to 2-acetylaminofluorene, 4080 rats to N-nitrosodiethylamine and 40800 trout to dibenz (a,l) pyrene, and that therefore no carcinogenicity studies were ever performed by which one cancer per million could be detected without extrapolation. Demarini points out that analysis of the NTP rodent carcinogenicity base, coupled with mechanistic considerations, suggest that threshold effects are likely for many of the carcinogens, however without absolute proof.

The above sentiments is (again, because it is well known by toxicologists) discussed by Zeiger (2009) pointing out that because cancer is a multi-hit event, it is assumed that cancer induction by genotoxic chemicals is linear at low doses, and that there can be no safe doses of a genotoxic carcinogen. This has been shown over the past 30 years not to be true, supported by the biology of mutation induction, cancer initiation and progressing, as well as a number of low dose genetic studies. All this work indicate amongst others how careful interpretations for regulatory and health concerns should be amongst others a potential health risk of 10^{-5} or 10^{-6} to man.

9. INTERPRETATION OF SOIL INGESTION IN HUMAN RISK ASSESSMENT

Interpretation for regulatory and health concerns of the ingestion and hence risk assessment of the ingestion of contaminated soils in South Africa should be regarded as dubious at best. Many studies have been conducted by specifically Calabrese, Dominy and others on this phenomenon, and it is clear that this should be handled with caution for risk assessment purposes in South Africa. Amongst others difference has to be made between geophagy and accidental and incidental ingestion of soils, as well as ingestion rates, which varies between 17 mg/day (children) to 330 mg/day for a utility worker. It is to be remember that the USEPA soil screening guidance provides for **specifically residential land use risk-based soil concentrations**, which is certainly not the intention or exclusive intention of this proposed framework. We have previously discussed and referred to that the RSA soil screening values should be via primarily the ecosystem (ecotoxicological) exposure route and that incorporation of human health criteria, as a secondary exposure pathway could be included. Should the risk assessment for human health result in a more conservative value, then the merits for inclusion of such a value should be considered.

It is reported in the international literature that children consume considerable quantities of soil regardless of geography and socio-economic status (Dominy et al, 2004). It is also reported by the same author that clayish soils adsorbed about 30% of the **bioavailable** fraction of ingested chemical compounds. The conceptual approach for the RSA framework (pp. 24) to be “based on USEPA methodologies, human health exposure” and “activity patterns of increased risk of **residents** of informal settlements” is and can only be of relevance (similar to USEPA) when contaminated soils is to be considered for specifically residential use. Thus it remains a secondary exposure pathway if “all” soils in the RSA, which may contaminate groundwaters or surface waters, with regard to ecosystems, is considered.

10. IMMUNOTOXICITY OF SOIL CONTAMINANTS

It is the experience of OFT that the toxicological appraisal of most of the “old” well known chemicals such as metals, volatile and non-volatile organic compounds did not include immunotoxicity. Today the toxicological dossiers of new pharmaceutical, agricultural and some chemical industrial compounds include immunotoxicity risk assessments.

For all countries in the world (specifically Africa) where HIV/AIDS is a huge problem, immunotoxicity risk assessment must be part of health standards for human health. Thus, all standards including contaminated soil standards adopted from the international literature, or the toxicology adopted from the literature to set such standards, must be verified and assessed for immunotoxicity characteristics.

11. ASSUMPTION OF DAF 2000 VALUE

The total DAF assumption value of 2000 on page 35 and used in the calculations for protection of the ecosystem “health” on page 36, is not at all acceptable. This value has to be properly referenced and peer reviewed in South Africa and internationally. OFT therefore also please request the said references.

12. BEHAVIOUR OF METALS IN SOILS UNDER EQUILIBRIUM CONDITIONS

This topic, specifically with regard to partition coefficients, is reported (understandably) to be subject to “numerous sources of uncertainty”. It is reported that “within a population of soils, the natural variability in soil composition and composition of associated soil pore water are such as to result in variation of **K_d over orders of magnitude**, even for a single metal!”. It is therefore “desirable to national population of such natural media systems to obtain a frequency distribution of K_d ” and of cause must such collection be representative of the national population. It is then also reasoned that K_d values obtained from the literature “are almost certainly not representative of the true national frequency distribution of K_d ”. Thus, any K_d values not obtained from such a national population must not be used in any calculations such as proposed in the current framework.

13. INTERNATIONAL VARIATION IN GENERIC SOIL SCREENING VALUES

Soil screening values differ from country to country. The variation being one to four orders of magnitude (Provost, 2008). It is concluded in the literature that common generic values between countries is not appropriate and therefore a value for a compound in the RSA will have to be individually developed.

14. MASS-LIMIT ANALYSIS

It is recommended that simple-mass-balance models (entire mass of contamination in a source) leaches to groundwater be used. These models are applied all over the world, including the USEPA, Canada, Europe, etc. The models are conservative and appropriate.

Compiled by:



Dr H O Fourie
TOXICOLOGIST

Date: 4 May 2010

6 May 2010

Attention: Mr Stranton Narain
Deputy Director: Waste Management
Department of Environmental Affairs
Private Bag X447
Pretoria

Dear Stranton

Framework for the Management of Contaminated Land – Reply to Stakeholder Review Comments from Ockie Fourie Toxicologists

1. Human Health being the starting point for development of soil screening values

We accept the fundamental importance of water resource protection in the Framework. We do not advocate the paramouncy of any particular environmental media above any other.

The South African Constitution entrenches the right to an environment that is not harmful to human health or well being. It is therefore fair and reasonable that human health concerns are given prominence in the Framework.

2. Approach based on USEPA Methodology

The basic concepts and source equations used in the Framework have developed from the source-pathway-receptor model which was developed by a number of international administrations. The generic exposure parameters used to derive soil screening values have been adapted to South African population groups and reflect activity patterns that do not conform to equations in use by the USEPA. The exposure parameters used are generally conservative. At present we have no definitive study to suggest that drinking intake of water and average body weight are substantially different in South Africa from elsewhere in the world.

3. Toxicity Assessment

The critical comments on the indiscriminate use of toxicological data are valid and during the research for the Framework we have encountered many examples in the advisories developed by different countries, where scientific assumptions on data sources are not transparent. It is however important to note that the variances between different countries in deriving simple generic screening levels for contaminated land are usually related to choice of receptors and exposure pattern assumptions rather than differences in the toxicological database.

It is clearly stated that water resource protection end points are derived from existing published sources with DWAF Water Quality Guidelines (1996) as the default point of reference. We have also noted where aesthetic considerations were used as a basis for drinking water quality.

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4. USA National Academy of Science

The comment is noted. We have noted that there has been a substantial increase in research and policy development in many administrations in the last two years and anticipate revisions to a number of important sources that may have to be reflected eventually in the South African Framework. We have advised that the technical components of the Framework be reviewed and updated on a regular basis.

5. Modification of Soil Screening Values to suit a water quality objective

The concept that soil is a stand alone media that falls outside the realms of a needs-based or resource management approach is a facile argument that does not address the intention of human health and environmental protection required by the Waste Act. It fails to point out that South Africa's water quality standards are based on water use.

6. Soil Pollution Risk vs Actual Risk

We agree that standards for soil pollution in many countries have been applied only as compliance criteria for triggering regulatory intervention and actual risk and the complexity associated with contaminant mixtures and realistic exposure scenarios are rarely evaluated. The Framework is tiered so that Site Specific Risk Assessment can be applied and thus there is a mechanism for dealing with complex situations, although uncertainty in our knowledge base will always be a limiting factor. It is important to note that the proponent of a Site Assessment Report must make clear whether the assumptions used to derive soil screening values in the Framework are valid for the site in question.

The developing understanding of bioavailability in risk assessment is an important consideration that should eventually be accommodated for in the Framework. At present there is still considerable uncertainty for a number of important contaminants that prevents us from addressing these factors adequately at a generic screening level. It is however a concept that specialists in contaminated land are aware of and do apply in site specific risk assessment.

7. Role of Mechanisms of Toxicity in Risk Assessment

We agree that the 10^{-6} risk adopted by certain administrations has been coloured by policy decisions on how to manage uncertainties inherited from early work in this field. The decision on the target risk factor is a political one as much as a scientific one. In the Framework the 10^{-5} risk level is adopted simply due to the fact that it is already in use in both the South African Drinking Water Guidelines and the WHO Water Quality Standards, which can be end-points for compliance. Further debate on this issue is thus of academic interest.

8. Mutagenicity at low doses and low dose carcinogenesis studies

We agree with the comments and it is acknowledged this is an issue and there is a international trend towards 'benchmarking', and an emerging body of data suggesting that certain carcinogens may have a 'threshold' or frequency based response.

9. Interpretation of Soil Ingestion in Human Risk Assessment

The direct exposure pathway of soil ingestion is relevant to residential sites in South Africa so therefore is considered to be a key part of the risk paradigm. The reviewer has an interesting but misguided view of a risk assessment process that follows a hierarchy of risks so that the ecosystem exposure route is promoted to a position of primacy. This approach has not been followed internationally and previous attempts to follow a similar strategy in the classification of hazard waste components for disposal to landfill in South Africa has now been abandoned.

We advocate a more holistic approach that can be applied to the broadest range of pathways and receptors.

10. Immunotoxicity of Soil Contaminants

We agree that this issue requires further consideration particularly for community health situations where immune suppression could be affected by contaminant exposure, and is a subject that requires a significant research effort. No methodology has yet been developed to adequately address these impacts. We would however concur with previous comments by the reviewer that the conservative nature of many of the reference dose assumptions and uncertainty factors applied in human health protection would tend to minimise the effects of immunotoxicity.

11. Assumption of DAF 2000 values

Note the following references from the Framework :

New Jersey DEP (2008) *Guidance for the Determination of the Dilution-Attenuation Factor for the Impact to Ground Water Pathway*.

CSIRO (2009) *The Australian Methodology to derive Ecological Investigation Levels in Contaminated Soils* .CSIRO Land and Water Sciences Report 43/09.

We agree that further specific research in South Africa could inform this decision further. However as DAF values are site specific parameters the default parameter can be revised by site specific risk assessment if the pathway exists and is sensitive.

12. Behaviour of metals in soils under equilibrium conditions

The K_d values used in the Framework are considered fair and reasonable assumptions for purposes of site screening. It is acknowledged that these values are controlled by a number of chemical soil processes that may vary from site to site.

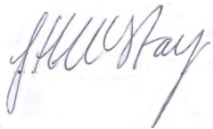
13. International Variation in Generic Soil Screening Values

Agreed. It was recognised that simple adoption of another country's soil screening values would not address South African needs, and that adaptation of international methods and the development of a uniquely South African approach would be the preferred option for the Framework.

14. Mass-Limit Analysis

The mass-balance flux models for leaching to groundwater are preferred and appropriate for water resource protection. This is however only one of many environmental exposure pathways relevant in the risk assessment of contaminated land. It also implies the presence and completeness of a pathway that may not exist for a specific site. Given the comments from the reviewer on the variability of K_d and DAF factors it is clear that model assumptions may deviate from reality. The likely output is a model dependant value that could either over or underestimate risk.

Yours sincerely,

A handwritten signature in blue ink, appearing to read 'J McStay', written over a light blue rectangular background.

Dr Jon McStay
Director
WSP Environmental (Pty) Ltd

Appendix F Frequently Asked Questions (excerpt from policy position presentation given at 2nd National Workshop on 31 March 2010)

FREQUENTLY ASKED QUESTIONS

- What is the DEA policy on the legal status of existing remediation projects?
  - Remediation projects with written authorisation in the form of directives, licenses, directions or letters issued by National or Provincial offices of DEA or DWA prior to 3 July 2009 can continue with the activity as long as the terms and conditions of the authorisations are being met.

FREQUENTLY ASKED QUESTIONS

- What is the DEA policy on the legal status of existing remediation projects?
  - Notification of contaminated land is a requirement of the Waste Act. This includes existing projects where contaminated land is being remediated. Therefore written notification of the activity and written proof of authorisation (where applicable) must be forwarded to the competent authority.

FREQUENTLY ASKED QUESTIONS

- What is the Point of Entry for authorisation of a Remediation Activity?
  - DEA will be the Point of Entry for the authorisation of Remediation Projects, but clean-up projects must also be registered with other relevant government departments, particularly Department of Water Affairs (DWA), in order to comply with sections 19 and 20 of the National Water Act (No. 36 of 1998).
  - Institutional arrangements between DEA and DWA will be made to facilitate the registration of current and future remediation activities.

FREQUENTLY ASKED QUESTIONS

- What is a Remediation Order?
  - The Remediation Order is an instruction to remediate.

FREQUENTLY ASKED QUESTIONS

- How is the 'Duty of Care' Defined for Remediation?
  - The Duty of Care is defined in NEMA. So the general requirements and responsibilities already exist.
  - The Duty of Care provision does not exempt the proponent of an emergency clean-up from notification or compliance with the 'Framework'.