Guidelines for the Assessment, Remediation and Management of Asbestos-Contaminated Sites in Western Australia

May 2009

Are these Guidelines relevant to you?

This document is primarily intended for contaminated sites regulators, auditors, and industry consultants. However, parts may be useful to others, including:

- Local Government Environmental Health Officers and site workers – **Appendix B – Management of Small-Scale Demolition Asbestos Contamination** and **Appendix C – Immediate Response Actions**
- Local government – **Section 5.3 Ongoing Management**
- Developers, owners, the public and local community members – **Key Management Messages** and **Chapter 1 – Introduction**

For occupational health issues, advice should be sought from WorkSafe, Department of Commerce on 1300 307 877. Detailed information is provided in the Commission for Occupational Safety and Health's guidance note *Occupational Safety and Health Management and Contaminated Site Work 2005*, to be found at:

www.commerce.wa.gov.au/WorkSafe/PDF/Guidance_notes/Contaminated_Sites.pdf

Additional asbestos information is available through the following Department of Health and Australian Safety and Compensation Commission sources:

www.public.health.wa.gov.au/2/867/2/asbestos.pm

www.safeworkaustralia.gov.au/NR/rdonlyres/1A198A7C-D0A7-40AD-964E-31673C695E92/0/AsbestosCode.pdf

Preface

This document has been prepared by the Western Australian (WA) Department of Health (DOH) to provide guidance for the investigation, remediation and management of asbestos-contaminated sites, and it is based on both Australian and international best practices tailored to Western Australian conditions. Asbestos is a major contamination issue in the State as a result of extensive past use.

The Guidelines include discussion on the character and toxicity of asbestos, its occurrence in Western Australia, investigation procedures and criteria appropriate for different environmental scenarios, and acceptable management strategies.

These Guidelines are likely to have the greatest application in urban situations but they are also suitable for rural settings and mining and industrial sites in country areas.

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These Guidelines are available electronically at:

www.public.health.wa.gov.au/2/656/2/contaminated sites.pm

Table of Contents

Figures

Tables

Key management messages

Background

In Western Australia (WA), asbestos was extensively used in building and other products into the 1980s. This legacy, combined with urban redevelopment and implementation of the *Contaminated Sites Act 2003* (CS Act), has resulted in asbestos-contaminated sites becoming an important human health risk and management issue.

Characteristics of Asbestos Contamination

Asbestos is a contaminant that differs from most others. In particular, its toxicology is such that it primarily affects humans rather than being a risk to the environment. Inhalation of asbestos fibres can produce a range of lung-associated diseases, including cancers, sometimes resulting from only low levels of exposure.

Asbestos usually occurs discretely in an impacted area and will not degrade over time to form less harmful materials (i.e., it is very persistent). It can migrate through physical disturbance and this is when its dangerous fibres can be released.

Contamination Criteria

The Department of Health (DOH) takes a risk-based and, where necessary, conservative approach to the uncertainties associated with protecting the public from asbestos-contaminated sites. As a result, the Guidelines employ the following four general contamination criteria:

- The investigation criterion or clean-up goal used by DOH is 0.001% asbestos in soil on a weight for weight basis (w/w) for free fibre-related materials including fibrous asbestos and free fibre itself;
- Depending on site use, DOH applies at least 10-fold higher criteria to asbestos-containing materials (ACM) in sound condition, such as commonly found asbestos cement fragments, since these pose much lower risks to human health;
- For remediation purposes, the top 10 cm of soil should also be made free of visible asbestos or ACM;
- The asbestos air-quality limit for protecting the public around contaminated sites is 0.01 fibres per millilitre (f/ml)(using the membrane filter method) as endorsed by the enHealth Council in *Management of asbestos in the non-occupational environment 2005* document (enHealth 2005).

More information about the risk basis for and applications of these soil and air criteria are provided in Sections 1.1.4 and 1.1.5, respectively.

Regulation

In WA the Department of Environment and Conservation (DEC) is the primary regulator of contaminated sites and also the administrator of the CS Act. However, DEC seeks WA DOH advice on all asbestos-related issues due to the significance of asbestos exposure to human health.

DEC has published extensive guidance on site contamination in its *Contaminated Sites Management Series* (CSMS), although information on asbestos is limited.

The main national regulatory guidance for asbestos-contaminated sites is enHealth 2005, although this document primarily provides general management principles.

DOH has developed these Guidelines to provide comprehensive practical guidance for environmental sites consultants and auditors on the assessment, remediation and management of asbestos-impacted sites in WA. The Guidelines are largely consistent with and build upon the enHealth 2005 and CSMS documents and **have the same regulatory status as the CSMS**.

Any significant departure from these Guidelines should be outlined in detail and fully justified in the appropriate site reports.

DOH and DEC recommend a staged approach to contaminated site investigation and management as per the CSMS, including for asbestos impacts. Figure 1 provides a generalised flow diagram of this process.

Site Investigation

Key elements of the first stage of the investigation, the Preliminary Site Investigation (PSI), are an investigation of records and anecdotal material and a site walkover looking for signs of contamination. Based on the PSI or other evidence, it may be necessary to report the site to DEC under the CS Act as a known or suspected contaminated site and to consider the need for a Detailed Site Investigation (DSI). A DSI and the associated extensive program of follow-on work may not be necessary if the contamination is confined to purely surface ACM (simple surface impact) or an in situ management approach is adopted.

The effectiveness of the PSI is critical to the subsequent management of the site. If asbestos contamination is missed and is then accidentally disseminated across the site through earth disturbance, a much larger area may require investigation and remediation. This would prove to be a protracted and costly exercise. **Appendix F – Case Study** demonstrates the results of an inadequate investigation.

When reporting the visual inspection results, it is critical that an inspector **comments specifically on the presence or absence of asbestos** material and on the inspection methodology.

Any DSI and asbestos sampling programs should be focussed and, where feasible, use ACM as a measure of total asbestos contamination. The sampling will help inform any health risk assessment and the selection of soil clean-up levels, if these are deemed necessary.

Management

Remediation options are preferred which minimise public risk, soil disturbance and also minimise the amounts of contaminated material that are removed to landfill.

Management of asbestos *in situ* is encouraged, which may include covering the contamination with clean fill and/or other protective or warning layers as well as registering a memorial on the site's certificate of title. A common alternative of complete removal of asbestos from a site often involves extensive and costly investigative and confirmatory sampling and is sometimes not effective. Also whenever a licensed asbestos removalist is used or a structure potentially containing asbestos is demolished, an environmental consultant should supervise the work to ensure site contamination does not occur through poor practices.

These Guidelines also provide a simplified investigation and management approach primarily for use by Local Government Environmental Health Officers in dealing with single residential lots possibly contaminated by asbestos dumping or poor demolition practices. This makes use of visual contamination indicators, site knowledge and basic remediation measures for what is usually a low risk situation. Details are provided in **Section 1.1.4** and **Appendix B**.

Consultation

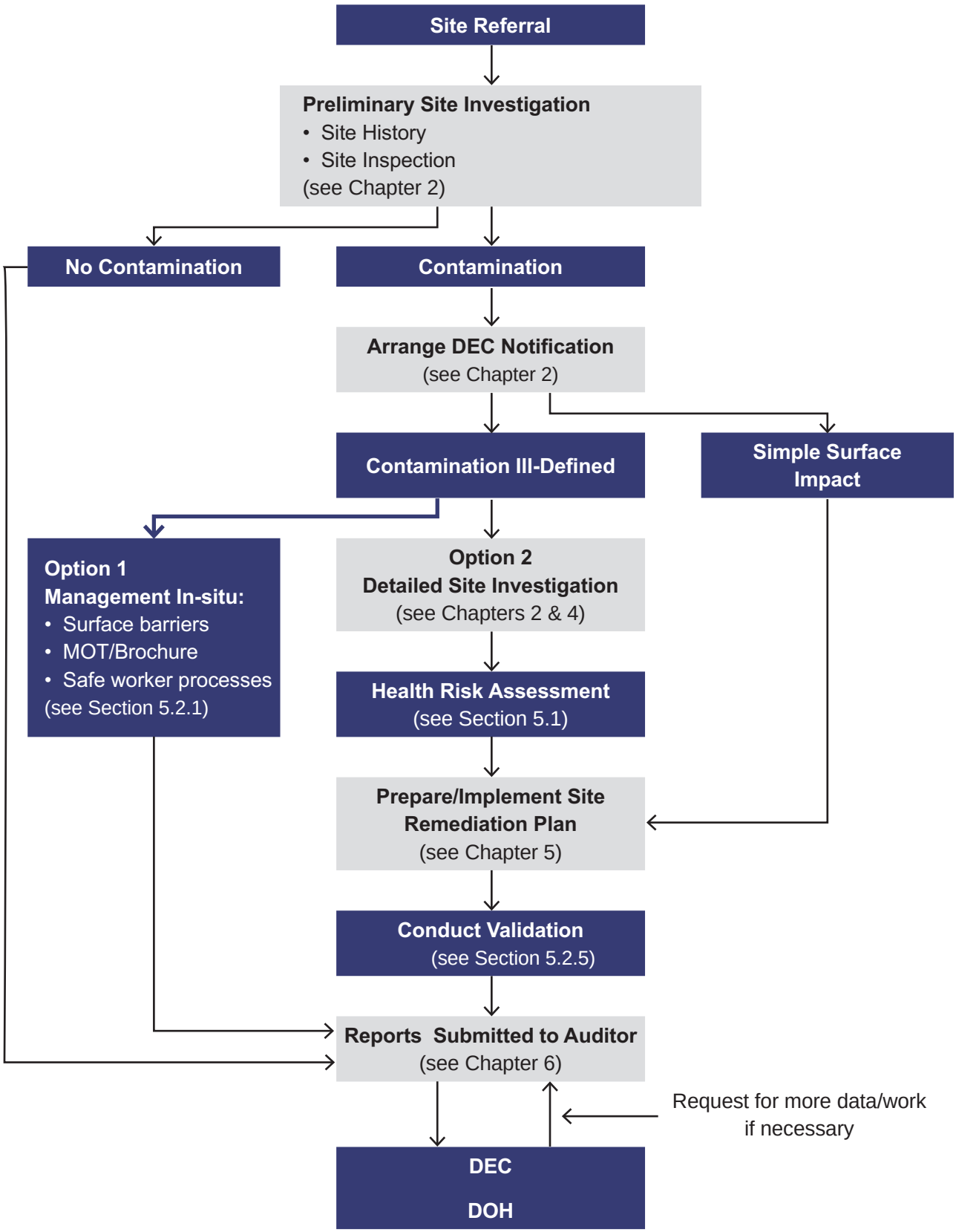
All reporting and enquiries associated with contaminated sites in WA should be addressed to DEC in the first instance (Telephone Hotline 1300 762 982). DEC will seek advice from or refer issues to DOH as necessary in regard to public health.

In more complex cases, DOH is available **via the accredited site auditor** (if any) to provide general advice on asbestos sampling and management proposals. Such an approach should include suitable documentation outlining the relevant contextual information and details of the proposed approach. DEC should be kept informed. For further information, contact the DOH Toxicology Branch on 08 93884999.

The proponent is also responsible for conducting public consultation during the whole investigative, management and development process, depending on the size, complexity and sensitivity (for instance if a child care centre is involved) of the undertaking. This should include information provision and collection and complaint resolution.

Figure 1 – Site Asbestos Investigation and Management Process*

* This schematic is primarily for consultants and auditors, applies where a formal process is required, and takes no account of other contaminants. Note an auditor may not always be involved with a site.



1. Introduction

In 2005 the enHealth Council published its *Management of asbestos in the non-occupational environment – 2005* (enHealth 2005) to provide a nationally consistent approach to managing this area of risk. This enHealth 2005 document provides important principles to build upon and tools to use for asbestos contaminated sites.

These current Guidelines take the enHealth process further by providing a consistent and comprehensive approach to the assessment, remediation and management of asbestos-contaminated sites in Western Australia. They consolidate and formalise existing DOH asbestos policies and take account of modern international scientific research and regulatory precedents.

The Guidelines should be used in conjunction with enHealth 2005 and the Department of Environment and Conservation (DEC) *Contaminated Sites Management Series* (CSMS). However, due to specific features of asbestos contamination, some guidance such **as sampling and validation procedures may differ from the general CSMS approach**.

1.1 Role of the Department of Health

DOH has a key role in the regulation and management of asbestos in Western Australia via the provision of expert health guidance and the administration of relevant asbestos legislation. For contaminated sites, the responsibility is primarily advisory, based on legislative requirements and administrative arrangements with DEC with respect to the *Contaminated Sites Act 2003* (CS Act). DEC relies on DOH advice in regard to asbestos contamination and risk to human health. These Guidelines are a joint publication of DOH and DEC and have **the same regulatory status as the CSMS**.

Any departure from these Guidelines should be fully justified and the application of the approach explained.

Relevant legislation administered by DOH includes the *Health (Asbestos) Regulations 1992*. This legislation imposes requirements for handling, demolition and removal of asbestos associated with building structures at a site. WorkSafe, Department of Commerce, is the licensing authority for such removals (see www.commerce.wa.gov.au/WorkSafe). Failure to manage asbestos, particularly during demolition activities, in accordance with the Regulations and existing guidance documents is the origin of many asbestos-contaminated sites.

1.2 Asbestos-Contaminated Sites and Health

The toxic effects of asbestos are well recognised and primarily result from the inhalation of free fibres. Due to its toxicology, transport and degradation properties, and its physical form, asbestos presents a unique contamination challenge. In addressing this, DOH takes a practical and risk-based approach wherever possible, and is conservative in situations of uncertainty.

1.2.1 Asbestos-Contaminated Sites in Western Australia

There is a history of production and widespread use of asbestos materials in Western Australia. Crocidolite asbestos, primarily used in asbestos-cement products, was extensively mined at Wittenoom until the mine ceased operation in 1966. Imported amosite asbestos was also used in these products until 1984, and chrysotile asbestos until 1987. Degradation and subsequent dissemination of asbestos materials has required many sites to be subject to contamination assessment and management in accordance with regulatory guidance. Adherence to these Guidelines will help avoid costly and unnecessary delays associated with such activities including for any redevelopment projects.

1.2.2 Nature of Asbestos Contamination

Contaminant asbestos can be in a range of forms, sizes and degrees of deterioration. For the purposes of these Guidelines, the asbestos associated with contamination is divided into three groups.

The first is asbestos-containing material **(ACM)** which is in sound condition, although possibly broken or fragmented, and the asbestos is bound in a matrix; for instance, asbestos fencing or vinyl tiles. This is also restricted to material that cannot pass through a 7mm x 7mm sieve. This sieve size is selected because it approximates the thickness of common asbestos cement sheeting and for fragments to be smaller than this would involve extreme mechanical action probably also associated with asbestos fibre release. The smaller fragments are covered by the third category described below. ACM usually represents a low human health risk.

The second category is termed fibrous asbestos **(FA)** and encompasses friable asbestos material, such as severely weathered ACM, and asbestos in the form of loose fibrous material such as insulation products. Friable asbestos is defined here as asbestos material that is in a degraded condition such that it can be broken or crumbled by hand pressure. Both ACM and FA can often be detected visually.

The third group is called asbestos fines **(AF)**. It includes free fibres of asbestos, small fibre bundles and also ACM fragments that pass through a 7mm x 7mm sieve. Both FA and AF have the potential to generate or be associated with free asbestos fibres, which can pose a considerable inhalation risk if made airborne.

Asbestos-Containing Material (ACM)

ACM in soil is the most common form of asbestos site contamination in Western Australia due to: its historical widespread use as uncharacterised fill material for site landscaping; dumping of as debris on vacant or development sites; and inadequate removal and disposal of asbestos products during building demolitions. If identified before further dissemination or disturbance, the dumping and demolition usually only results in readily rectifiable surface contamination.

Fibrous Asbestos (FA) and Asbestos Fines (AF)

Sites are occasionally contaminated by asbestos fibrous material or free fibres, often as a result of mining, manufacture or distribution associated with asbestos products. Friable asbestos and very small fragments may arise respectively from severe weathering or damage associated with ACM contamination.

The identification and delineation of areas of AF contamination can be difficult because of poorer visual indicators than ACM and FA and also analytical limitations associated with low levels of free asbestos fibres in particular.

Naturally Occurring Asbestos (NOA)

Under the CS Act, in situ naturally occurring asbestos (NOA) is not considered contamination. However, due to the serious health concerns associated with asbestos, affected areas should be effectively managed in the short and long term. NOA is most likely encountered during geological sampling and mining operations. Management measures similar to those for free fibre usually apply, though DOH may require a site-specific approach.

1.2.3 Risks from Asbestos Contamination

Asbestos poses a human health risk through the inhalation of its fibres. If deposited in the lungs, the fibres can initiate diseases that take many years to produce major health effects. These effects include asbestosis, lung cancer and the normally rare cancer mesothelioma that affects certain chest membrane linings. These impacts tend to be the result of higher levels of exposure, most often occupational, but mesothelioma can also result from low level exposures.

The human health risk from asbestos-contaminated soil varies considerably depending on the form of asbestos, its quantity and its exposure situation. For instance, large amounts of free-fibre asbestos on the surface of a residential lot would be considerably more dangerous than asbestos incorporated in a cement pipe buried beneath a commercial property. This is because the fibre can more readily be disturbed and inhaled in that residential situation and exposure theoretically may be for 24 hours a day for a lifetime.

An additional complication is the uncertainty associated with determining the degree and nature of the asbestos contamination, and therefore also of the level of the resulting risk.

DOH has taken account of this variable, and often uncertain risk, in developing these Guidelines and applies more rigorous requirements in higher risk situations. DOH also bases its guidance and investigation criteria on the following practical positions, which are designed to manage human health risks now and into the future:

- Overall, the potential health impacts posed by different asbestos minerals, such as chrysotile and crocidolite, and fibre dimensions can be treated as equivalent;
- ACM may pose a future free-fibre risk through its degradation, and therefore potential release of asbestos fibres;
- The cancer risk from asbestos should be kept as low as practical and preferably no more than one occurrence in one million over a lifetime for the exposed population. Mesothelioma is used here as the most sensitive health impact of asbestos exposure.

1.2.4 Investigation Criteria and Clean-up Goals

DOH has historically applied a contamination criterion for asbestos in soil of 0.001% weight for weight (w/w) asbestos as cited in enHealth 2005. DOH has reviewed this criterion in light of extensive research by Swartjes and Tromp in The Netherlands (2008). This study resulted in The Netherlands introducing general regulatory investigation criteria of 0.01% w/w asbestos for fibrous asbestos and 0.1% w/w asbestos for non-friable ACM. The 0.01% criteria has the highest attendant risks but should keep asbestos air levels below 0.001 f/ml and probably around 0.0001 f/ml. Using WHO (2000) risk figures for mesothelioma, 0.0001 f/ml corresponds to a lifetime risk of 10^{-6} to 10^{-5} in the exposed human population, which are risks that are broadly acceptable to DOH.

DOH has used these Dutch figures divided by a factor of 10 to derive investigation criteria for WA, taking account of the greater dryness and dust-generating potential of local soils and the fact that DOH treats the mineralogical forms of asbestos as equivalent. The fibrous asbestos criterion applies to FA and AF due to their ability to generate asbestos fibre. DOH applies even higher criteria for the ACM, depending on site use. These mirror the National Environmental Protection Measure (NEPM) (1999) site uses and associated default exposure ratios. These criteria are summarised below.

Soil asbestos investigation criteria

0.001 % w/w asbestos for FA and AF	–	All site uses
0.01 % w/w asbestos for ACM	–	Residential use, day care centres, preschools, etc.
0.04 % w/w asbestos for ACM	–	Residential, minimal soil access
0.02 % w/w asbestos for ACM	–	Parks, public open spaces, playing fields, etc.
0.05 % w/w asbestos for ACM	–	Commercial/Industrial

The FA and AF criteria of 0.001% w/w remain fixed for all site uses because the means to determine concentration differences at this level of detection is difficult.

These generic investigative criteria can also be used as soil clean-up goals or site-specific goals can be developed if this is the chosen form of remediation. The site-specific goals may be higher than the investigative levels if any of a range of mitigating factors applies, such as the depth or form of contamination, binding or stabilising soil characteristics, or the nature of surface coverings.

For remediation of any contamination, the top 10 cm of soil should also be made completely free of visible asbestos, partly for risk reassurance purposes. This may be achieved by installing 10 cm of clean fill or in the case of ACM or FA contamination by several cycles of hand-picking and fine raking taking account of the procedure outlined in **Section 4.1.1 Hand-Picking (Emu-Bob)**. However, DOH would consider other means of managing that top 10 cm such as installing a long-term hardcover over it.

DOH allows for a more qualitative approach to be applied to small low-risk sites, specifically single residential lots with **ACM** contamination as a result of on-site demolition or dumping. Such sites should be assessed and managed in the first instance by Local Government Environmental Health Officers in conjunction with DOH so that more formal and demanding processes associated with the *Contaminated Sites Act 2003* (CS Act) may not be necessary.

The management process for such sites is fully described in Appendix B and may be summarised as follows for the different levels of contamination:

- ACM total sheet area < 10 cm^2 (i.e. 3 x 3 cm) and with little associated past soil disturbance – *very low risk* – **simply remove all visible ACM, including if practical after gently fine raking of soil to 10 cm depth to expose any covered ACM fragments**;
- ACM total sheet area > 10 cm^2, or ACM occurrences with significant soil disturbance, or buried asbestos fencing stumps – *low risk* – **consult DOH with the expectation of excavating the impacted and possibly all soil down to depth of likely ACM penetration. For larger quantities of ACM, the risk may be higher and the site may need to be reported to DEC under the CS Act**.

1.2.5 Air Quality Criteria

DOH recommends a 0.01 fibres per millilitre (f/ml) asbestos air quality limit to protect the public around contaminated sites, which is the limit of detection using the membrane filter method. This is the para-occupational limit endorsed in enHealth 2005, and remains the only practical limit and methodology in use.

Based on the WHO risk estimates outlined in **Section 1.1.4 Investigation Criteria and Clean-up Goals**, 0.01 f/ml of asbestos could result in an increased risk of 10^{-4} to 10^{-3} of an exposed person developing mesothelioma during their lifetime exposure. However, DOH applies this limit only in the context of site asbestos-disturbing activities which primarily occur during site remediation. Consequently, the period of exposure is likely to be at least 100-fold less than in a lifetime, resulting in reduced risks of 10^{-6} to 10^{-5}.

If asbestos-disturbing site activities may last more than 6 months, then more rigorous dust control measures and better sampling and lower air quality limits should be applied.

Nuisance dust monitoring may be also necessary and can be used to complement asbestos sampling, especially since it allows for more immediate responses to any failures in dust management measures. For nuisance dust, the National Environment Protection Measure (NEPM) 24-hour guidance goal of 50 µg/m^3 for PM10 (particulate matter with an equivalent aerodynamic diameter of 10 µm or less) should apply (NEPM 2003). Adherence to this limit can be used to help protect the community against asbestos exposure, if the soil asbestos fibre content is <0.1% w/w asbestos, as derived by DOH from the work by Addison et al 1988.

1.3 Assessment, Remediation and Management Process

The investigative and management process for asbestos-contaminated sites follows the same sequence and form as outlined for contaminants in general in the CSMS *Reporting on Site Assessments* (DEC, 2001).

The process commences with a Preliminary Site Investigation (PSI), which may lead to a more comprehensive Detailed Site Investigation (DSI). A Sampling and Analysis Program (SAP) will normally be prepared to support the investigations and also any validation sampling that occurs. Based on the investigations, a Site Management Plan (SMP) or in some cases an Asbestos Management Plan will need to be developed and then implemented. To ensure that this has been undertaken appropriately, the work will need to be verified in the form of a Site Management and Validation Report (SMVR).

DOH uses the above document titles for convenience of reference and because they are reasonably explicit. Other titles could also be used and possibly combined. In the case of the SMP, it is expected that it is included or prepared in conjunction with a Dust Management Plan (DMP). The SMP and/or SMVR may also need to include a commitment to and details of long–term future management of the site if asbestos remains *in situ* such as restrictions on land use/activities at a site.

All reports will need to be submitted for assessment by DEC, via an auditor if required by a planning condition or Regulation 31 of the *Contaminated Sites Regulations 2006*. DEC may refer asbestos or human health-related reports on to DOH with a request for advice. The auditor process and adherence to these Guidelines may make routine referrals to DOH less likely over time.

Environmental consultants employed to investigate and manage asbestos contamination should be supervised by a lead consultant with appropriate asbestos credentials. The lead consultant should normally have a minimum of 3 years continuous experience with asbestos soil contamination and relevant tertiary qualifications in environmental science, science or engineering.

1.4 Consultative Process

The proponent is responsible for undertaking appropriate public consultation throughout the site investigation, remediation, management and development process. An outline of the recommended communication process is provided in the *Contaminated Sites Management Series Guideline – Community Consultation* (DEC, 2006) and also in *Public health consultation: a guide for developers* (Synnott and Katscherian, 2007). The extent of consultation will vary with the size, sensitivity and complexity of the site, and stage of the development management process.

Consultation with stakeholders should be an interactive process where possible and not just an awareness-raising and information session. The need for this especially applies to asbestos, which can be an emotional issue and hard to manage both technically and if it gains a political dimension.

If necessary in more complex cases DOH is available **via the site auditor** to provide general advice on asbestos sampling and management proposals. Such an approach should include appropriate documentation outlining the relevant contextual information and details of the proposal. For further information, contact the Toxicology Branch on 93884999.

2. Preliminary Site Investigation

The Preliminary Site Investigation (PSI) is the initial stage of investigation and includes checking the site history, a visual site inspection and possibly preliminary sampling. It is important in determining the likely presence of contamination and in directing any subsequent investigation and management actions.

The key elements of a PSI are outlined in the CSMS *Reporting of Site Assessments* (DEC, 2001) and are augmented by asbestos-specific advice in these Guidelines.

Asbestos contamination needs to be identified early and properly handled, to ensure subsequent disturbance and dissemination does not occur across the site and result in costly delays and extra investigative and remediation effort.

Based on the PSI or other information, it may be necessary to report the site to DEC as potentially contaminated, as required by the CS Act. The obligation to report falls on the owner, the polluter and the contaminated sites auditor where appointed. However, others, such as an environmental consultant or Local Government officer, may also report the site. Detailed guidance is provided in the CSMS *Reporting of Known or Suspected Contaminated Sites* (DEC, 2006).

Reporting possible asbestos contamination would be expected if:

- There is FA or AF associated with a site's soil, based on analytical evidence or visual examination by someone with asbestos knowledge;
- ACM is present on site and is likely to penetrate below the soil surface, as identified by analysis or by someone with asbestos knowledge.

2.1 Site History Investigation

A site history or desktop investigation consists of compiling and assessing information from relevant records and interviews. This investigation should adhere to the normal DEC PSI process and include the following asbestos-related topics:

- An evaluation of records to determine the presence of asbestos associated with any remaining or demolished structures, including any asbestos material register or documentation demonstrating demolition in compliance with the *Health (Asbestos) Regulations 1992*;
- Analysis of aerial photographs where available to help identify past structures and possible disposal, burial and dumping activities;
- Information relating to the character and disposition of any fill material, especially which was derived from demolition waste.

Situations where asbestos contamination may occur include:

- Industrial land, e.g., asbestos-cement manufacturing facilities, former power stations, and rail and ship yards, especially workshops and depots;
- Waste disposal or dumping sites, e.g., building waste;
- Pre-1980s buildings or structures damaged by fire or storm;
- Land with fill or foundation material of unknown composition;
- Sites where buildings or structures have been constructed from ACM or where asbestos may have been used as insulation material, e.g., asbestos roofing, sheds, garages, reservoir roofs, water tanks, boilers;
- Sites where pre-1980s buildings or structures have been improperly demolished or renovated, or where relevant documentation is lacking;
- Disused services with ACM piping – e.g., water pipes, Telstra trenches or pits (usually within 1 metre of the surface).

2.2 Site Inspection

The initial site visual inspection or walkover provides the most important information on potential exposure to asbestos fibres and informs the design of appropriate control measures.

Inspections should be grid-based as far as practical in the first instance to detect any visible asbestos. The identified areas should then be surveyed in more detail along with suspect locations indicated as a result of the desktop study. enHealth 2005 *(Appendix V: Sample inspection and investigation form)* provides an asbestos visual inspection checklist. DOH recommends that such an approach be used to assist the systematic collection of relevant data.

Site inspection methods should be adopted to prevent further degradation or distribution of asbestos. This may include: restricted on-site use of vehicles and equipment; minimal disturbance of stockpiled or discarded materials; and the use of equipment and footwear scrub-down areas.

2.2.1 Visual Indicators

Most potential asbestos contamination will be identifiable if on the surface and in significant quantities. The main exception is free fibre which will be hard to identify unless in bulk. An experienced inspector is likely to identify asbestos as such, but confirmation of representative samples by analysis is appropriate if there is any uncertainty.

If the surface is heavily vegetated, then confidence in the visual inspection will be lessened. Some careful vegetation clearance may help to clarify the situation.

The inspection should also include any asbestos-containing structures, especially if in poor repair, footprints of demolished structures, and debris that has been dumped on the site, particularly demolition waste.

2.2.2 Characteristics of Contamination

The condition, quantities and location of the asbestos should be evaluated in general terms to inform initial remediation and management decisions. The following basic approach is generally appropriate:

- Where there is good historic information on the sources of the asbestos contamination, the estimated surface area of contamination can be considered equivalent to the visually delineated area of impact, and up to 1 m in all directions to account for uncertainty;
- The depth of contamination may be inferred from the desktop investigation, or later informed by targeted sampling. In either case, an additional 30 cm should be incorporated to account for uncertainty;
- The condition of ACM should be considered equivalent to the most degraded samples found in an area, noting that this may vary across different areas;
- Where significant amounts of free asbestos fibres may have been exposed over time, the immediate surrounding area should also be considered contaminated.

The need for additional measures should also be considered as outlined in **Appendix C – Immediate Response Actions** and **Appendix D – Contingency Plans**.

2.3 Sampling

Sampling during the PSI is not normally recommended, since either a management strategy may be adequately defined based on other PSI investigation findings or because it is evident that a detailed site investigation (DSI) will be necessary anyway. Limited PSI sampling may be appropriate for the following reasons:

- To confirm that asbestos is present, including as free fibre;
- To roughly delineate the contamination's lateral and vertical extent;
- To inform the Sampling and Analysis Plan for the Detailed Site Investigation;
- To obtain a preliminary idea of appropriate management options;
- For air sampling, to ascertain what additional site-control measures are warranted or if immediate response actions are required.

PSI sampling would most likely be surface hand-picking or targeted test pits. Any sampling should be based on a written plan which takes account of **Section 3.2 – Sampling and Analysis Program**. Information on common sampling methods for asbestos is provided in **Chapter 4 – Sampling, Monitoring and Analytical Methods**.

3. Detailed Site Investigation (DSI)

A DSI is an investigation which confirms and delineates potential or actual contamination through a comprehensive sampling program. The key elements of a DSI are outlined in the CSMS *Reporting of Site Assessments* (DEC, 2001).

A DSI is not usually required by DOH for management purposes, although this will depend on site-specific circumstances, especially the remediation approach proposed. A DSI should only be undertaken when delineation of asbestos impacts must be accurate, such as if:

- The remediation or management approach requires asbestos to be removed or relocated from an area;
- Asbestos contamination is due to friable or free-fibre generating material;
- Land uses are to be determined and delineated according to the extent and nature of asbestos contamination.

A DSI may also help resolve uncertain findings from the PSI, or to help assess the likely effectiveness of alternative remediation and management strategies.

A DSI is not necessary if the contamination is demonstrated to be ACM in limited quantities sitting on the soil surface (simple surface impact). Hand-picking as outlined in **Section 4.1.1** may be sufficient to manage this type of contamination.

A DSI should normally only be undertaken when the area of asbestos impact needs to be well delineated.

3.1 DSI Preparations

Any DSI should build upon the PSI and take account of any subsequent relevant site developments, such as:

- Any causes or evidence of further site contamination:
  - Vandalism or degradation of structures containing asbestos;
  - Removal of asbestos structures;
  - Identifying new contamination areas, e.g. following site excavations;
  - Cross-contamination by earthworks, transport of wastes, vehicular activity and wind or storm damage to asbestos materials.
- Changes in site conditions, surrounding environment and possible receptor exposures:
  - Adjacent developments or altered land usage;
  - Wind breaks, e.g., removal of nearby or site trees, fences or buildings;
  - Seasonal influence;
  - Performance of any Immediate Response Actions;
  - Community concerns, complaints and consultations;
  - Consultation undertaken with relevant stakeholders;
  - Any alterations to site development plans.

3.2 Sampling and Analysis Program

The DSI should incorporate a site Sampling and Analysis Program (SAP) determined by the contamination characteristics and intended future site uses. The SAP should comply with CSMS *Development of Sampling and Analysis Programs* (DEC, 2001). Asbestos specific sampling and monitoring methods are outlined in **Chapter 4 – Sampling, Monitoring and Analytical Methods**.

In developing a SAP, the following important principles should be applied. The DOH approach here and elsewhere in the Guidelines is to try to reduce the amount of sampling and to improve its practicability, while taking account of the special contamination features of asbestos.

3.2.1 ACM as Primary Measure of Asbestos Contamination

The recommended way to detect and measure soil asbestos contamination is by using ACM when present, unless FA and AF are also involved in significant concentrations. ACM is the most common type of asbestos contamination and, when exposed, can usually be readily detected visually and concentrations calculated. By "significant" FA and AF DOH means concentrations that might exceed 10% of the amount of asbestos as would be determined by using ACM alone. If AF arises from co-located ACM, DOH considers that this will not exceed 10% of the ACM even if the ACM is primarily very small pieces arising from severe mechanical action. An exception would be ACM damage resulting from power shaping tools, such as a circular saw.

If necessary or in doubt, sampling for ACM, FA and/or AF should occur and the findings compared against the relevant investigation criteria. The methodology for calculating asbestos concentrations is outlined in **Section 4.1.7**.

3.2.2 Avoiding Sampling Invalidation by Site Activities

Care is necessary during the DSI to ensure that sampling and monitoring results are not compromised due to poor site management practices, specifically:

- Sampling should follow removal of any asbestos material that may be actively generating asbestos free fibres, such as exposed ACM products in poor condition;
- Investigations should follow any planned demolition of asbestos-containing structures or buildings, or removal of asbestos from within them, unless the demolition is closely monitored and the associated removal site is professionally validated;
- All equipment operation, vehicle movements and dust during the sampling and monitoring regime need to be carefully managed.

3.2.3 A Focus on Judgmental Sampling

Judgmental sampling targets particular areas of a site based on known or likely contamination, which is the preferred approach. It depends heavily on a thorough PSI and should reflect the state of the site at that time. Judgmental sampling can help avoid unnecessary broad area sampling. Judgmental sampling may need to be augmented or substituted by grid sampling.

Grid sampling is most appropriate when asbestos contamination is widespread or may be present at unknown locations. If the contamination is buried then test pits in particular and/or boreholes are used for either the judgmental or grid-based regimes.

The following situations are especially relevant to judgmental sampling:

- If contamination 'hot spots' are identified by the PSI, a sampling strategy is required to confirm their extent, which if indicated to be sub-surface should include test pits and stratified sampling methods;
- The SAP provides for opportunistic (discretionary) sampling to be conducted as necessary, for example, when unexpected suspect asbestos products or unusual soil strata are encountered;
- Areas that will remain covered by hardstand do not require sampling. However, if asbestos is likely, its presence will be assumed unless sampling indicates otherwise. If sampling cannot readily meet the recommended density because of hardstands, targeted sampling in key locations is suitable to allow limited characterisation of sub-surface contamination;
- If structures containing asbestos have been removed, the former 'footprint' should be investigated, unless the removal was properly managed and documented. In addition to a visual inspection, sub-surface sampling should only be necessary if the structure was partially buried, for instance, asbestos fencing, or subsequent soil disturbance has occurred. Sampling below 30 cm depth is not generally warranted. Sampling should extend laterally up to 50 cm outside the footprint perimeter, and include soak-wells. A sampling interval of 5-10 m along and within the footprint perimeter is recommended, aligned with any adjacent grid sampling pattern;
- Disused sub-surface asbestos structures and products, such as former service trenches or piping, may be localised areas of potential contamination. If not properly documented, these should be delineated by sampling, although validation sampling would suffice if structure removal is undertaken.

3.2.4 Sampling Triggers and Densities

Greater sampling densities and sample volumes should generally be used for asbestos than those considered appropriate for other contaminants. This is because asbestos can occur widely, unpredictably and, as a discrete contaminant, asbestos can be hard to detect by conventional sampling regimes.

Where grid sampling is appropriate, the density should be some multiple (see Table 1) of the minimum density listed in CSMS *Development of Sampling and Analysis Programs (DEC, 2001) – Appendix C* (included in these Guidelines as Appendix A). The CSMS list was not designed for asbestos sampling but DOH's experience is that it can provide a suitable guide for asbestos sampling in conjunction with a multiplication factor (from 0.5 to 2) depending on the likelihood of contamination.

In the case of judgmental sampling, the density selected will be primarily at the investigator's discretion, but should equal or exceed that proposed for grid sampling in Table 1 for each level of asbestos likelihood. For localized higher risk contamination, a denser sampling regime should be used, such as for investigating asbestos fibres that may have been carried by rainwater into soil from large expanses of asbestos roofing.

Table 1 – Triggers and Types of Asbestos Investigations

Likelihood of Asbestos	Typical Scenarios	Investigation Regimen
Unlikely	– Grazing with no building history – Site with minimal pre-1987 history	Desktop/site walkover (DW) – No sampling without indicators
Possible	– Uncontrolled fill without mixed building waste – Undeveloped site adjacent to urban infill (& possible dumping)	DW. Judgmental &/or 0.5 x CSMS grid sampling for any buried material
Suspect	– Uncontrolled fill with mixed building waste – Soil linked to dumped ACM – Industry associated with asbestos – Demolished structure footprints	DW. Judgmental &/or 1 x CSMS grid sampling for any buried material, with at least 1 sample per final lot
Likely	– Some sub-surface asbestos found – Asbestos activities associated with soil disturbance – Landfill site	DW. Judgmental &/or 2 x CSMS grid sampling for any buried material, with at least 1 sample per final lot
Known	– Identified asbestos but not sufficiently delineated	DW. Judgmental at 2 x CSMS & at least 1 sample per final lot in delineation zone

The first three categories are primarily for asbestos screening purposes. They may if necessary be undertaken in full or in part at the PSI stage. The fourth category, 'Likely', may be for screening, confirmation or delineation purposes, depending on the circumstances. Sampling associated with the 'Known' contamination is likely to be used for confirmation and precise delineation. Depending on the findings, it may be necessary to adopt a more detailed sampling regime for subsequent work, which can build upon sample locations already used.

4. Sampling, Monitoring and Analytical Methods

If appropriate, a Sampling and Analysis Program (SAP) should be implemented as outlined in Section **3.2 Sampling and Analysis Program**, noting that ACM should be used as a contamination indicator where practical. The SAP should be based on these Guidelines and as far as possible on the CSMS *Development of Sampling and Analysis Programs* (DEC, 2001).

Large area and/or localised sampling methods can be used, depending on the type of contamination and purpose of the sampling. As will be discussed, some methods are not suitable for fibrous asbestos (FA) or asbestos fines (AF). Large area methods include hand-picking, tilling and screening. Localised sampling includes using test pits, trenches and bore holes. Sampling and management are not normally necessary for any asbestos deeper than 3 m since such soil is usually inaccessible to most activities.

The SAP should include a written protocol and procedures for the proposed sampling. The methods chosen should be demonstrated to be effective in previous investigations or trials. For instance, a tilling method should detect and allow collection of most asbestos contamination for its particular operational parameters.

An experienced asbestos investigator can determine which fragments clearly are asbestos (consistent with weight-of-evidence) and decide their condition. If identification is at all in doubt, the fragments should be assumed to be asbestos unless shown otherwise by laboratory analysis. Representative fragments can be used for visual identification and analysis. Analysis is recommended for fragment types that comprise the bulk of the suspect material.

Conclusions should be drawn in regard to fragment size distribution and relative proportions of asbestos collected for any successive sampling passes. For instance, if fragments are all very small, then there is a reasonable possibility that significant amounts may be missed and may in fact fall into the < 7 mm category and so be regarded as AF. For successive passes, if the amount found in each is quite large, (such as > 0.1 % w/w asbestos) and does not show a substantial sequential reduction, then the contamination may be such that its quantification and remediation cannot be achieved by the particular method.

Where asbestos contamination is found, its quantification should relate to that particular immediate grid area or volume. Care should be taken in any compilation of results not to permit averaging, which might result in inappropriate “dilution” of the calculated level of contamination. For instance, the level of contamination should not be determined across a whole large tilled area or one with an unreasonably large grid size, such as 40 x 40 m.

In locations where asbestos exceeds the relevant investigation criteria, delineation of the impact should follow unless it is taken to be widespread and managed appropriately or addressed by post-remediation validation. Any delineation sampling regimen will depend on the contamination circumstances but should ensure the impacted area is confidently captured, especially for higher asbestos concentrations and fibre-generating material.

If the contamination is associated with a layer of uncontrolled fill, then the whole extent of the fill may need to be considered impacted unless a strong argument or a more intensive sampling regime can demonstrate otherwise.

For naturally occurring asbestos, such as may be found on mining sites, the emphasis should be on sampling those areas where soil or rock disturbance and therefore potential human health risk may be likely, rather than delineating contamination zones.

4.1. Soil Sampling

4.1.1 Hand-picking (Emu-Bob)

Hand-picking primarily refers to the visual inspection of the soil surface and manual collection of ACM, as outlined in Table 2.

Table 2. Summary of Hand-picking Sampling Recommended Method

Process

- Can use a rake to sample down to a depth of 10 cm;
- Most suitable for ACM, and possibly for low levels of FA;
- Relevant where contamination is known or considered only to be on or near the soil surface and may be attributed to a defined event;
- Limited application for deeper contamination or if there is surface vegetation or debris. Raking may be difficult except in sand;
- Used to characterise the extent and level of contamination, whilst concurrently reducing its impact.

Implementation

- Locations and weights of asbestos material should be recorded;
- Rake teeth should be $\leq$ 7 mm spaced apart and > 10 cm long;
- At least 2 passes of picking (and of raking if appropriate) made with 90^{o} direction change between each and using a grid pattern;
- Material should not be further damaged or buried by the process;
- % contamination may be calculated as per Section 4.1.7, using 1 cm as soil depth for hand-picking or using the rake teeth length as appropriate;
- Final visual inspection of the area should not detect surface ACM.

4.1.2 Tilling

Tilling refers to a process of mechanically turning over surface soils to facilitate the presentation and collection of asbestos fragments. The process and its implementation are outlined in Table 3.

Table 3. Summary of Tilling Sampling Recommended Method

Process

- Most suitable for ACM, not for fibre-generating materials;
- Generally conducted across the entire zone of suspected impact;
- Relevant for contamination within top 30 cm of soil;
- Limited application for deeper contamination or if there is surface vegetation or debris;
- Used to characterise the extent and level of contamination, whilst concurrently reducing ACM impact.

Implementation

- Usually preceded by hand-picking;
- Locations and weights of asbestos material should be recorded;
- Soils should be pre-wet to the tilling depth, and the dust controlled;
- Rotor blades should present ACM optimally for 1 or 2 spotters closely following depending on speed, till breadth and contamination level;
- At least 2 passes with 90^{o} direction change using a grid pattern;
- Material should not be further damaged or buried from the process;
- Evaluated areas normally cannot be considered representative of other locations;
- Percentage contamination may be calculated as per **Section 4.1.7**, using an estimate of the average impact depth as well as the area involved;
- Final visual inspection of the area should not detect surface ACM.

4.1.3 Screening

The term ‘screening’ is applied to both the small-scale separation of ACM fragments from localised soil samples and the large-scale treatment of an area to detect and quantify asbestos contamination, with concomitant remediation. This Section deals with large-scale mechanical screening. The process and its implementation are outlined in Table 4.

Table 4. Summary of Screening Sampling Recommended Method

Process

- Most suitable for minor ACM impact, not for fibre-generating materials;
- Other sampling methods are preferable because of potential dust/fibre generation;
- Generally conducted across the entire zone of suspected impact;
- Relevant for larger volumes of reasonably accessible and delineated contamination;
- Used to effectively characterise the extent and level of contamination, whilst concurrently reducing ACM impact.

Implementation

- May be preceded by hand-picking if appropriate;
- Oversized ACM may be removed by 'screening down' from larger mesh sizes to the final screening mesh;
- Final mesh size of ≤ 7 mm is recommended. Anything larger will require validation sampling as outlined in Section 4.3;
- ACM weights/concentrations should be closely correlated to locations or stockpiles to allow re-sampling or segregation if required;
- Impacted soil should not be mixed with other soil in a way that might compromise the concentration calculations;
- Soils should be pre-wet and procedure subject to strong dust/fibre control and monitoring measures as outlined in a Dust Management Plan;
- Evaluated areas normally cannot be considered representative of other locations;
- Percentage contamination may be calculated as per Section 4.1.7, using the weight of ACM found for a particular strata, area or volume;
- Final visual inspection of the stockpile surface should not detect ACM.

Alternatives to mechanical screening that do not require extensive dust management are often available and are preferred.

4.1.4 Test Pits and Trenching

If asbestos extends below surface soils (>30cm), then sampling by test pits and trenches (TPs) are most common and effective, especially if contamination distribution is uncertain. DOH recommends use of TPs instead of boreholes (BHs) because buried ACM and FA can be more readily identified, differing strata distinguished and there is more sampling flexibility. Specified large sample sizes should be used for both methods with reliance put on visual methods of asbestos detection and concentration calculation wherever possible. The process and its implementation are outlined in Table 5.

Table 5. Summary of Test Pit/Trenching Sampling Recommended Method

Process

- Suitable for all asbestos types, but especially ACM, and FA if fibre disturbance is manageable;
- Relevant if contamination is buried and of unknown location and depth.

Implementation

- Sampling should be conducted to 30 cm below the likely lower limit of potential contamination unless this is greater than 3 m;
- Suspect asbestos material or construction debris should be targeted and all sample locations noted;
- Precautions are necessary to protect workers and public from wall collapse or hole hazards, and potential fibre release from excavation/sampling.

ACM and FA

- At least one 10 L sample from each relevant stratum (or per 1 m depth) of one wall, and discretionary samples from other suspect spots;
- Sample screened manually on-site through a $\leq$ 7 mm sieve or spread out for inspection on a contrasting colour material (recommended for FA);
- Identified ACM and FA weighed to calculate asbestos soil concentration for individual samples as per Section 4.1.7.

AF

- At least one wetted 500 ml sample from each relevant stratum or 1 m depth (if thick) of one wall, and discretionary samples from other suspect spots;
- May be done with ACM/FA sampling, albeit at another wall position;
- Whole sample submitted for laboratory analysis as per Section 4.1.8.

4.1.5 Bore Samples

Although TPs are recommended, bore hole (BHs) sampling may be appropriate where physical obstructions may limit soil access or generation of asbestos contaminated dust is a potential problem. The sample taking and assessment is similar to that for TPs. The process and its implementation are outlined in Table 6.

Table 6. Summary of Bore Sampling Recommended Method

Process

- Suitable for all asbestos types;
- Relevant if contamination is buried and of unknown location and depth.

Implementation

- Sampling should be conducted to 30 cm below the likely lower limit of potential contamination unless this is greater than 3 m;
- Suspect asbestos material or construction debris should be targeted and all sample locations/ depths noted.

ACM and FA

- Corer diameter should be at least 15 cm;
- At least one 10 L sample if practical from each relevant stratum (or per 1 m depth) of core. Cross-strata samples are permissible provided that asbestos detections are further investigated;
- Sample screened manually on-site through a ≤ 7 mm sieve or spread out for inspection on a contrasting colour material (recommended for FA);
- Identified ACM and FA weighed to calculate asbestos soil concentration for individual samples as per **Section 4.1.7**.

AF

- At least one wetted 500 ml sample from each relevant stratum (or per 1 m depth);
- May be done with ACM/FA sampling;
- Whole sample submitted for laboratory analysis as per **Section 4.1.8**.

4.1.6 Stockpile Sampling

Soil stockpiles intended for use on-site and of unknown quality should be assessed for asbestos contamination. DOH adopts a conservative approach to stockpile assessment and use because of associated uncertainties and risks.

If the stockpiles originated on the site from areas not likely to be contaminated, for instance, no indication of building activity or waste, the assessment can consist of a close visual examination and hand-picking over the whole stockpile surface. If any asbestos is found or the soil came from asbestos suspect areas on site, then the stockpiles should normally be considered contaminated. These stockpiles and any imported soil, aggregate or crushed material of unknown quality should not be used as “clean” fill without further investigation and management if necessary.

The sampling regime outlined in Table 7 can be used to assess better the level and nature of contamination. This is designed to be consistent with the sampling density included in Table 1 for an area likely to be contaminated.

Table 7. Summary of Stockpile Sampling Recommended Method

Process

- Suitable for all asbestos types;
- Confidence in results is not as high as with other sampling procedures.

Implementation

- Sampling should be spread over the whole stockpile surface at a minimum rate of 14 locations per 1000 m^3;
- If soil is subject to a conveyor process (not recommended for FA or AF) then a minimum of 1 sample should be taken per 70 m^3 of material;
- Suspect asbestos material or construction debris should be targeted and all sample locations noted.

ACM and FA

- At least one 10L sample from each location;
- Sample screened manually on-site through a $\leq$ 7 mm sieve or spread out inspection on a contrasting colour fabric (recommended for FA);
- Identified ACM and FA weighed to calculate asbestos soil concentration for **individual** samples as per **Section 4.1.7**.

AF

- At least one wetted 500 ml sample from each location;
- May be done with ACM/FA sampling, albeit at another spot;
- Whole sample submitted for laboratory analysis as per **Section 4.1.8**.

For ACM, if the contamination is below the investigation criteria then the stockpile may be used on the site as non-contaminated fill, subject to suitable controls. Controls should include closely monitoring the installation process for asbestos and visual inspection and hand-pick sampling of the new soil surface and also the stockpile footprint. It may also be appropriate to undertake test pit sampling of the installed material. Depending on the results, it may be necessary to remediate the installed soil and stockpile footprint.

If any free fibre or FA is found in the stockpile, it would not normally be useable as “clean” fill and would be regarded as contaminated unless extensive sampling demonstrates otherwise.

4.1.7 Determining Soil Asbestos Concentrations

Determining asbestos concentration in soil can be difficult and sometimes not possible because of its discrete and heterogeneous occurrence and the different physical forms it can take. Most common and easy to deal with is ACM contamination, particularly due to its ease of visual detection. As indicated in **Section 3.2.1**, ACM is a recommended measure for total asbestos contamination where FA and AF are not likely to be significant. Using the sampling procedures previously outlined,

asbestos concentrations can be calculated based on the weight of ACM for a given weight of soil using the method described below. If ACM weight is estimated rather than measured, such as by using ACM sheet area, then confidence in the results is reduced.

Depending on what is known of the site history and nature of the investigative methods, the confidence in the calculation and extent of application will vary. In particular, “emu-bob” and tilling surveys may provide less confidence and apply to only certain delineated areas, compared to large volume screening. **Emphasis should be placed on a weight-of-evidence approach**.

As the nature of asbestos contamination can vary greatly, the investigative method and consequent contamination calculation should take account of those particular circumstances. Some important considerations include:

- Asbestos concentrations in soil should be determined for relevant impacted strata. Inclusion of non-impacted soils in calculations dilutes samples which is not acceptable. Therefore:
  - ACM weight should not be averaged across the mass of soil at the site, within a whole remediation zone or across a total bore sample volume;
  - Determinations of asbestos concentration should not be made using samples collected from soil stockpiles, unless all soils comprising the stockpile are sourced from the same strata;
  - Where more than one distinct soil strata are impacted by asbestos, separate asbestos concentration estimates should be made for each.

Asbestos concentrations in soil should be determined for relevant impacted strata. Averaging asbestos levels across all soils at a site is not appropriate.

Calculations

enHealth 2005 (page 27) outlines how the concentration of asbestos in soil attributable to ACM contamination may be estimated:

$$\%\ Soil\ Asbestos = \frac{\%\ Asbestos\ Content \times ACM\ (kg)}{Soil\ Volume\ (L) \times Soil\ Density\ (kg/L)}$$

where it was assumed that:

% Asbestos Content (within asbestos cement materials) = 15%

Soil Density (for Perth sandy soils) = 1.65 kg/L

This is considered a suitable approach for all ACM contaminated sites because:

- ACM products in Australia typically contain 10 – 15% asbestos by weight;
- Soil densities are typically greater than 1.5 kg/L (1500 kg/m^3).

More representative results for ACM asbestos concentration in soil can be calculated if the values of the contributing parameters are measured rather than being assumed. This is the recommended approach, although care should be taken to ensure transparency in the methods adopted.

When FA is present and needs to be quantified, a similar visual bulk assessment approach can be used, although the 15% assumption may not necessarily apply. Greater care needs be taken to manage associated fibre release, and free fibre should be assumed to be present in the soil. If FA derives from co-located ACM, it may be necessary to regard the ACM as FA if site conditions are conducive to such degradation. FA may be treated as a surrogate for AF contamination where FA lends itself to quantification and is likely to be the greater contaminant.

As yet, there is no validated method of reliably estimating the concentration of free asbestos fibres in soil, although this may be possible with larger AF material. Soil contamination by free asbestos fibres should therefore be simply determined according to the presence or absence of fibres, in accordance with guidance provided in **Section 4.1.8**. Care should be taken in interpreting the results of AF sampling because of detection limitations and the relatively small size of samples. A weight-of-evidence approach should therefore be used.

Some sites may contain combinations of different forms of asbestos contamination, each at significant levels. In those cases or if in doubt, the respective investigation criteria and concentration calculation methods should be applied.

4.1.8 Analytical Procedures

Appendix II of enHealth 2005 discusses the analytical methods available for the assessment of free asbestos fibres and fine asbestos material.

It is important to note that inadequate sampling strategies, rather than lack of accuracy in the adopted analytical methods, characteristically limit the effective evaluation of sites contaminated by asbestos.

For asbestos analysis, phase-contrast microscopy (PCM) or polarised-light microscopy (PLM) as asbestos identification methods are appropriate for most investigations. Although alternative electron microscopy techniques are more precise, PCM/PLM has the advantage of being readily available and significantly cheaper. This allows for greater sampling densities and, where practicable, for effective on-site assessment.

Soil asbestos analysis should comply with Australian *Standard Method for the Qualitative Identification of asbestos in bulk samples* (AS4964–2004) or be demonstrated to be able to achieve the equivalent level of results to this Australian Standard. AS4964–2004 provides for a tiered approach to detecting the presence of asbestos in soil samples. If asbestos is not found in the coarser filtering, processing and filtrate examination stages, a trace analysis is required of the residue. This is at the margins of the technique's sensitivity. The examination at least of a 500 ml sample may improve the likelihood of identifying asbestos material that cannot pass through the required 2 mm sieve. The residue material from the sieving may need to be subject to sub-sampling procedures before subsequent stages of fine material analysis, including trace analysis.

AS4964 provides guidance in regard to reporting the presence or not of asbestos. Of the options available, DOH considers that **any asbestos detected should be reported as such** regardless of its respirable status. This is particularly pertinent to any trace analysis, and the laboratory analysis should be reported in the following form:

State the method's limit of detection;

- Indicate if asbestos was detected or not detected, regardless of its form;
- If detected indicate the type of asbestos and provide a factual description;
- If practical estimate the concentration of any asbestos;
- State whether the analysis report is consistent with these Guidelines or not.

4.2 Air Quality Monitoring

Air quality monitoring (AQM) for asbestos fibre, dust and other contaminant emissions should be considered during the DSI, remediation and site development processes. Asbestos fibre and dust (as a surrogate for asbestos fibre) are of particular interest.

DOH considers that if best practice is used to control generation of dusts, atmospheric sampling for asbestos fibres adds little value to the evaluation or management of asbestos risks. However, asbestos air sampling can help provide confidence in those control measures, can be used to allay community concerns in sensitive situations and may also be necessary for occupational purposes. If required for public health reasons, then para-occupational sampling is considered the most practical method to measure airborne asbestos at contaminated sites. Suitable guidance on relevant sampling and assessment strategies is provided by enHealth 2005 (Appendix II, page 49). DOH also supports the enHealth advice that "dust levels should remain sufficiently low for measured asbestos concentrations to be below the practical lower detection limit of 0.01 f/mL".

Air sampling results **should not be used** to conclude that there has been no asbestos fibre release from soils or to justify use of less stringent site management measures, because the sampling methodology is not sufficiently accurate or representative for these purposes.

4.2.1 Air Monitoring Principles

The following sections outline when various AQM methods may be relevant to the site investigation and management process. In addition, the following issues should be born in mind:

- The purpose of any air sampling should be clearly identified;
- The AQM strategy should be developed by a person suitably experienced in asbestos sampling and exposure assessment;
- Monitoring for asbestos fibres is not useful in real time for informing management decisions about the effectiveness of controls during asbestos disturbance due to analytical delays;
- The membrane filter method is the only recognised and standardised measurement technique regularly employed across Australia for the determination of airborne asbestos fibre. It provides a useful estimate of personal exposure to airborne asbestos fibres;
- Electron microscope techniques are preferred for low-level exposure situations in which the fibre size and identification are important;

- Although transmission electron microscopy (TEM) is best suited to distinguish asbestos from non-asbestos fibres, it examines a much smaller area of the collecting filter than scanning electron microscopy (SEM) or phase contrast microscopy (PCM). TEM results are therefore less reproducible and have greater uncertainty;
- PCM is simple and inexpensive. The simplicity of the method allows for analysis to be performed on-site;
- The resolution of PCM is poor and may miss many small fibres that are observed using other techniques. It also does not always distinguish asbestos from non-asbestos fibres. PCM can result in a significant underestimation and sometimes overestimation of the asbestos fibre concentration in air;
- Asbestos sampling filters may become overloaded with dust in unfavourable conditions and can become unusable. They should be reported as such and not as 'nil' or 'no asbestos detected';
- The AQM arrangements should be modified if necessary in response to relevant changes in site conditions, activities and monitoring results.

4.2.2 Personal Monitoring

Personal monitoring of asbestos in air to determine and help minimise potential workplace exposure is an occupational health and safety issue. The WorkSafe Division, Department of Commerce should therefore be consulted prior to the implementation of any personal monitoring regime.

Personal monitoring is appropriate where significant levels of airborne asbestos fibres are possible, as may be associated with the following conditions:

- Free asbestos fibre contamination is present or is likely to exist within the soil and may be exposed during the course of site works;
- Site works will require extensive ground-disturbing activities in asbestos-impacted areas, including tilling and mechanical screening;
- Asbestos contamination is present at the soil surface and significant vehicle or machinery traffic across the site is anticipated.

Personal monitoring results are also useful where there is uncertainty regarding the suitability or effectiveness of adopted site management measures and may also help allay community concerns. However, once representative data has been obtained, ongoing monitoring efforts may prove of little value.

4.2.3 Para-occupational Sampling

Para-occupational sampling for asbestos can help demonstrate that past site activities are unlikely to have increased risks to adjacent site users. The value of such sampling can depend on:

- Stakeholder values and perceptions;
- Constraints on available site management methods;
- The nature of adjacent land-uses and potential receptors; e.g., a primary school versus an industrial facility;
- Community interest and/or complaints;
- Performance history.

The relative importance of these factors should be discussed within reports if para-occupational sampling is used as an investigation or management tool.

4.2.4 Dust Monitoring

Dust provides a useful site surrogate measure to evaluate the potential generation and distribution of airborne fibres for the following reasons:

- It allows for continuous and portable monitoring that is capable of informing managers during the course of asbestos disturbance, control or removal;
- Dust monitoring is a normal management practice during soil disturbing activities at a contaminated site, and provides a useful visual indicator;
- Dust monitoring methods are well known, readily employed and require no specific expertise in asbestos;
- Portable dust monitoring equipment allows for assessment to be maintained in unpredictable or frequently changing wind conditions;
- The capacity of some monitoring methods to automatically record dust concentrations allows for rapid and transparent reporting of results to stakeholders, notably regulators and local communities;
- Results are easily interpreted and useful for demonstrating improvements in site management practices than data provided by asbestos fibre sampling.

Dust monitoring equipment should demonstrate that dust levels are kept as low as reasonably possible. Tapered Element Oscillating Microbalance (TEOM) (or equivalent) equipment is preferred to provide continuous and accurate perimeter air monitoring for community protection. Portable dust monitoring can be used in all active areas to demonstrate the effectiveness of dust management during site works. The site manager should be kept informed of conditions breaching pre-defined dust levels used as triggers for control actions.

For comprehensive assessment, DOH recommends that dust monitoring stations be established along the site perimeter at ‘background’, up-wind and down-wind locations, taking account of local irregular site features, to provide comparison between results. Where there is a well defined diurnal variation in the dominant wind direction (for instance, sea and land breezes), monitoring stations should be situated along the key axes. For lengthy earthmoving or remediation work, monitoring stations may need to be relocated with seasonal shifts in meteorological conditions. Portable dust monitoring equipment, such as hand-held dust trackers, should be repositioned as wind conditions change throughout the day and relocated as works progress across the site. Generally, regional meteorological data will be sufficient to determine locations of dust monitoring equipment. For this, a detailed log of atypical meteorological conditions may be useful for evaluating sampling results.

Site perimeter monitoring should be conducted to ensure compliance with the NEPM ambient air 24 hour PM10 goal of 50 µg/m^3 with no exceedances.

4.3 Validation

The best form of 'validation' for an asbestos-contaminated site is to evaluate and report the suitability of site management practices throughout the course of a project. The more comprehensive that site investigation and remediation practices are demonstrated to be, the greater confidence that stakeholders will have that the risks of exposure to asbestos have been minimised. The type of supporting documentation required is outlined in **Chapter 6. Reporting**.

Validation will be necessary for remediation works primarily related to excavations and large scale soil screening where the mesh size is greater than 7 mm. Hand-picking, tilling and fine screening (≤ 7 mm mesh) remediation of ACM should not require validation if conducted in accordance with these Guidelines. Guidance on validation sampling procedures is provided in Table 8.

Table 8. Summary of Validation Sampling Recommended Method

Process

- Suspect asbestos material or construction debris should be targeted.

Excavation

- Suitable for all asbestos types;
- Similar process to TP sample taking and assessment. See Table 5.

Screened Material

- Suitable for ACM;
- Similar process to stockpile sample taking and assessment. See Table 7;
- Mesh size used will have to be justified.

Implementation

Excavation

- At least 1 sample from each wall per 5 m length of strata of interest (or per 1 m depth); additional discretionary samples if necessary;
- Floor should be visually inspected and if suspect may need to be sampled at twice the minimum density outlined in the CSMS.

Screened Material

- Sampling should be over the whole stockpile surface at a minimum rate of 14 locations per 1000 m^3;
- If the soil is subject to a feeding or conveyer belt process then a minimum of 1 sample should be taken per 70 m^3 of material.

4.4 Interpretation of Results

Given the nature and varied sources of asbestos contamination, it is often difficult to differentiate between impacted and non-impacted soils and to determine the level of contamination. Due to these difficulties and based on national and international precedents, DOH takes a conservative approach to asbestos investigations and interpretation as well as to the whole asbestos management process. Consequently, results presented will have to be based on rigorous and justified investigative work, especially if not following DOH preferred procedures, and care is necessary in extrapolating results and demonstrating their reliability.

Important points to consider include:

- Interpretation of results should be informed by a comprehensive desk top study;
- If asbestos is found at or above the investigation criteria, the immediate area and possibly comparable soils should be investigated and if necessary remediated;
- In the case of fibre, a few minor detects may sometimes be construed as incidental or background, especially if contamination is not suggested by site history.

4.5 Quality Assurance/Quality Control

The SAP should include measures to ensure the quality and reproducibility of all sampling methods used at the site, noting challenges associated with asbestos due to its heterogeneous and discrete occurrence and its range of forms. Quality assurance and quality control (QA/QC) practices should be consistent with guidance provided by the *Contaminated Sites Management Series – Development of Sampling and Analysis Programs*, which also provides information on the development of Data Quality Objectives (DQO) and on quality control samples.

Relevant considerations particular to asbestos include:

- As per **Section 1.3**, investigators should have adequate asbestos experience to ensure the quality of recommended visual detection and quantitation methodologies;
- Sampling and analytical procedures should be justified as to their appropriateness and effectiveness, for instance soil tilling;
- Analytical methods should be consistent and allow results to be reproducible within and between laboratories. Importantly, fibre-counting criteria should be consistent for all sample analyses;
- National Association of Testing Authorities (NATA) asbestos accreditation is a standard QA/QC requirement;
- Wherever there is analytical uncertainty regarding whether fibres in a sample are asbestos, the fibres should be assumed to be asbestos. Re-sampling should be considered to clarify the presence of asbestos at a site;
- Until an alternative method to identify asbestos in bulk materials (including soil) is developed and validated, the use of the Australian Standard *Method for the Qualitative Identification of asbestos in bulk samples* (AS4964-2004) is recommended.

5. Risk Assessment, Remediation and Management

5.1 Human Health Risk Assessment

The primary reference in undertaking a Human Health Risk Assessment (HHRA) is CSMS *The Use of Risk Assessment in Contaminated Site Assessment and Management: Guidance on the Overall Approach (DEC, 2006)*.

Risk assessment should start early in the investigation and management process to guide subsequent actions and to help ensure that on-site personnel and the local community are protected during and as a result of a development. Immediate hazard or contamination control measures may sometimes be necessary, as outlined in **Appendix C – Immediate Response Actions and Appendix D – Contingency Plans**.

DOH, like DEC, recommends a staged approach for risk assessment, involving:

- Tier 1: screening risk assessment;
- Tier 2: intermediate (simple) risk assessment;
- Tier 3: detailed (site-specific) risk assessment.

Tier 1 includes development of a conceptual site model (CSM) which captures information related to the contamination exposure pathways to receptors, and thus help determine where risk occurs. The CSM is a graphical depiction of these linkages which derives from and should be accompanied by the following information.

5.1.1 Characterising the Contamination

Of primary interest are PSI and any DSI information on asbestos distribution, concentration and condition, especially relating to fibre generating potential.

As noted in the Introduction, DOH did not take account of the different types of mineral asbestos and fibre dimensions in developing its asbestos-in-soil investigation trigger criteria. However, such information may be useful if site-specific clean-up criteria are to be developed.

As well as contamination per se, it is also important to identify any asbestos in structures which will be subject to demolition or disturbance so that they can be handled appropriately.

5.1.2 Determining Exposure Scenarios

Potential exposure should include all activities associated with the site at present and during its remediation and long-term management. Possible receptors include: site remediation and development personnel, the local community, site visitors, future owners and occupiers, and service workers in the longer term.

For asbestos, the primary exposure concern will be any human activities with the potential to generate the release of airborne asbestos fibre. However, natural forces should also be considered, including wind and water erosion. At this stage, the evaluation will be largely theoretical, because there is unlikely to be any air monitoring data. However, if results of monitoring during the DSI or relevant activities on similar sites are available, they should be fully utilised.

5.1.3 Assessing Risk

For the Tier 1 assessment, the contamination concentrations are compared against the soil asbestos investigation criteria levels in **Section 1.2.4**. If these levels are not exceeded and the investigation has been in accordance with these Guidelines, then no contamination management actions will be required. The CSMS *Assessment Levels for Soil Sediment and Water* (DEC, 2003) provides general guidance in this regard.

If exceedances occur, the associated soil asbestos criteria can be used as clean-up goals or other appropriate forms of remediation undertaken as outlined later in this Chapter.

If the investigation criteria are not considered strictly applicable to the site due to the fact that their underlying assumptions do not apply or mitigating factors are operating, then it is possible for site-specific clean-up goals to be developed (Tier 2 or 3) or a case to be made that no clean-up is necessary. This will probably require more extensive information on the nature of contamination and exposure scenarios. For instance, the potential risk might be less by virtue of the depth and type of contamination, the nature of surface coverings, the soil conditions or the form of future site use.

If non-generic clean-up criteria are employed or remediation approaches adopted which are not consistent with these Guidelines, then a strong supporting case, possibly as a HHRA should be made. It should be noted that the confident estimation of human risks associated with asbestos soil contamination is difficult. This is because it is difficult to translate soil concentrations of various forms of asbestos into quantified air levels and then into potential human health impacts. Confidence in any estimates is also lessened due to difficulties in measuring the soil levels of a heterogeneous and discrete contaminant such as asbestos.

In most circumstances it is not possible to undertake a quantitative HHRA for asbestos on a site, and therefore a semi-quantitative or qualitative assessment may have to suffice. As a consequence, the HHRA may need to assume reasonable worst case scenarios in its determinations to provide additional confidence to the degree of protection afforded by the results. The approach and references used by DOH in developing its asbestos investigation criteria, **Section 1.2.4**, may be a useful basis for estimating a site's risk, taking account of site-specific circumstances.

The risk to affected parties should be assessed taking account of the asbestos-contamination profile, the exposure scenarios, the level of relevant activities, the proposed remediation and control measures, and the final use of the site. This may partly be an iterative process because the emerging risk will drive and then be moderated by the nature and effectiveness of the management measures.

Any assessment results produced should be explained; for instance, the basis or the meaning of a "low" risk statement should be provided.

The assessment should also comment on the uncertainties associated with the process, such as confidence in the calculated level of contamination.

It is also important that the overall process be transparent, logical and reliable. In those cases where there are particular concerns from the local community or other stakeholders, consideration should be given to managing the perceived, as well as the real, risks associated with the site.

If the elements of the risk determination change during the subsequent site operations, such as by uncovering unexpected additional asbestos material or as indicated by the results of air monitoring, the risk assessment should be reviewed and any appropriate actions implemented, for instance, as outlined in **Appendix D – Contingency Plans**.

DOH considers that the health risks posed by an appropriately managed site, whereby the asbestos remains *in situ* subject to controls, are likely to be negligible and often preferable to removing the asbestos containing materials from the site.

5.2 Site Remediation

If adequate asbestos-contamination investigations and risk assessments have taken place, it should be possible to narrow down the most likely remediation options and to select one or a combination of them.

In undertaking the selection process, it is important that all options are considered and the preferred one should be supported by strong argument when compared with the others. Although cost, time, convenience and future owner perception will be important considerations, the arguments presented for selection should be primarily stated in terms of public and worker protection.

The presence of other contaminants may affect the approach taken to or the timing of asbestos remediation. The following considerations may be important:

- Do other contaminants present an immediate threat to health or the environment?
- Will the proposed asbestos remediation option mobilise or compromise the other contaminants or vice versa?
- Is a single option or combination of remediation options available that will treat both asbestos and the other contaminants?

The main remediation options include: management *in situ*, treatment on-site, and removal of the contaminated soil from the site. Consideration should also be given to changing the final intended use, in order to manage the risk better.

The main options are discussed in the following sections, and relate primarily to ACM unless FA or AF is specifically referred to. The proponent is free to propose other remediation measures through suitable argument and/or precedent.

Important considerations for the DOH in assessing the acceptability of any remediation proposal consists of:

- minimisation of public risk;
- minimisation of contaminated soil disturbance;
- minimisation of contaminated material/soil moved to landfill.

Care should be taken in using any licensed or other asbestos removalists associated with the cleaning up or development of a site. Often their emphasis will be on managing the occupational and environmental risks at the time of the removal, with little consideration to remnant soil asbestos. Such activity unless closely supervised can lead to the generation and spread of asbestos contamination, especially if subsequent soil disturbance occurs.

5.2.1 Management In situ

Predisposing conditions

- Asbestos is buried reasonably deeply, for example > 1.5 m;
- Distribution of asbestos is difficult to determine;
- Proponent does not wish to characterise the asbestos contamination;
- Asbestos contamination covers a large area, for example > 2000 m^2;
- Contamination includes significant FA or AF;
- Site will largely be covered by hardstand;
- Site is to be covered by clean fill for geotechnical or other purposes;
- Likely associated requirement for a Memorial on Title (MOT) is not a concern.

In situ management primarily involves the isolation of the contaminated area with barriers and covers so that it cannot be readily disturbed and therefore will not generate airborne fibres. Potentially affected parties should be informed of the contamination and the arrangements in place to protect them, including through a MOT, as discussed in **Section 5.3**. Other in situ management measures not described in these Guidelines are possible, such as cement injection stabilisation, which effectively encapsulates the asbestos material.

DOH considers that a MOT associated with remediated sites is likely to become a common occurrence and should not be regarded from a human health risk perspective as a less acceptable outcome.

The barrier or cover is usually a layer of clean fill (sand or soil). This fill should be demonstrated to be free of contamination. Nominally, the depth of the clean fill should be at least 1 m for public open spaces and at least 0.5 m for all other uses, such as residential or commercial activities. The greater depth for the public space is because of: the potential for deeper below-ground activity associated with such areas, such as irrigation systems and service trenches; the potential lower awareness of the presence of the contamination; and the increased practicability of having such deep covers.

The 0.5 m cover may need to be increased to avoid contamination disturbance by subsequent installation of sub-surface utilities below 0.5 m, unless any contamination excavated is properly managed and not mixed in with material used for backfilling.

For ACM contamination in bushland parks or nature reserves and where the area will be minimally disturbed and subject to closer management, the cover may be 0.1 m of organic mulch. For instance, mulch has been used in isolated or low-use areas of bushland where surface dumping of ACM has occurred. However, any visible ACM should be removed first and the mulch cover maintained in a proactive manner. This usually requires an asbestos management plan for the area.

If impacted soil is or will be covered by more than 3 m of clean fill, then that area will not normally be deemed asbestos contaminated and will not require a MOT for asbestos purposes.

Contamination associated with high concentrations of free asbestos fibre, for instance > 10% w/w asbestos in hotspots, may require a greater depth of clean fill depending on site circumstances.

For covers of less than 3 m, additional management measures as well as a MOT would also be expected. Measures might include: a geo-textile barrier, an ongoing site management plan (OSMP), and a vegetation cover. If all of these additional measures are used, then it may be argued that the depth of clean fill may be reduced, including for practical reasons contaminated areas immediately next to lower level existing road infrastructure. The presence of a hardstand is also a strong reason to have a reduced depth of clean fill in that specific area.

The geo-textile barrier provides a warning of the presence of underlying soil contamination. It is normally necessary for all site uses except in bushland situations, areas of permanent hardstand, or public open spaces (unless there is heavy contamination i.e., ACM >1 % asbestos w/w; FA, AF >0.1 % asbestos w/w). Specialised or improvised geo-textile fabrics may be used, meeting the following conditions:

- Water permeable;
- High visibility;
- Rot-proof and chemically inert;
- High tensile strength;
- Coverage of contaminated area and 0.5 m beyond boundary if practical;
- Parallel sheets to be fixed together or overlap by 20 cm.

The OSMP is a recommended element whenever a covering barrier is employed. This provides additional assurance that the protective measures will be maintained and that potentially affected parties will be kept informed of possible risks. A full description of the OSMP is provided later in **Section 5.3**.

A vegetative barrier can be very useful in protecting the clean fill cover from erosion and also from some forms of human disturbance. In certain cases, the site may involve ongoing corporate or communal management which will control what happens with the vegetative barrier, including its maintenance.

Consideration of the in situ remediation measure should take account of the following factors:

Advantages

- Minimal disturbance of soil and therefore minimal dust generation;
- Minimisation of the amount of sampling necessary;
- Potentially lower costs, time delays and greater confidence of outcomes.

Disadvantages

- Asbestos remains on the site and will need to be properly managed;
- Level of the site may need to be raised;
- MOT will be necessary, except for clean fill covers > 3 m, which could adversely affect purchaser perceptions.

5.2.2 Treatment On-site

Predisposing conditions

- Asbestos is not buried deeply, for example, < 1 m;
- Asbestos contamination covers a large area, e.g., > 0.2 hectares, for some methods;
- Extent of contamination is well delineated;
- Contamination is not by asbestos free-fibres;
- Need to avoid an MOT is important;
- Adjacent properties are at some distance and/or are non-residential or do not involve sensitive receptors, such as child care centres.

Treatment on-site is taken here to mean undertaking some physical treatment or manipulation of the contaminated soil on-site, specifically ACM hand-picking (possibly FA), tilling, screening or excavation of the affected soil and burial on-site (all asbestos). For the first three methods, any ACM collected should be consolidated, properly packaged and disposed of at an approved landfill.

An important outcome of the remediation is that the top 10 cm of soil should be free of all visible asbestos.

Hand-picking

Guidance on hand-picking or “emu-bob” of surface ACM is provided in **Section 4.1.1**. This technique can sometimes be used to remediate as well as to estimate the level of contamination associated with surface soils. Remediation would be possible if the soil can be made free of ACM. This may be only possible if it is proven that the ACM is confined to surface soils, for instance, no deeper than 10 cm, and that this has been substantially removed. Evidence of the depth of penetration may come from sampling and/or the desktop study.

Hand-picking may be used with care to remove FA material which is on the surface although additional work should be undertaken to assess and manage likely asbestos free-fibres associated with it.

The ACM removal process would involve at least three passes over the area collecting surface and sub-surface ACM with a manual or mechanical rake capable of probing to 10 cm. The spacing between the rake teeth should be at most 7 mm. The picking and raking should be done on a grid basis and the ACM recovered weighed and its source location noted. If a pass across the impacted area results in no ACM being found then the soil can be considered effectively free of ACM. Raking may only be effective with very sandy soils.

For either of these methods to work properly, it may be necessary to remove any covering vegetation, whilst ensuring that the vegetation is clean of ACM before disposal. Prior to vegetation clearing, consideration should be given as to the need for a Clearing Permit to be obtained from the DEC under the *Environmental Protection (Clearing of Native Vegetation) Regulations 2004*.

Tilling

Tilling using mechanical means may be an acceptable remediation methodology, for instance, when the ACM contamination is demonstrated to be not more than 30 cm deep. The desktop study and sampling may help to determine this. A detailed description of the process for surface ACM is provided in **Section 4.1.2**.

Tilling may be used in together with hand-picking and will require initial removal of surface vegetation. A grid approach should again be used with a similar spotting, locating, weighing and calculation approach used as outlined for hand-picking. Again, the top 10 cm of soil must be free of ACM.

Screening

If undertaken properly, screening can be an effective remediation tool for ACM which provides considerable confidence that the processed soil achieves the required standard of cleanness. The process is detailed in **Section 4.1.3**.

A screen of effective final mesh size of less than or equal to 7 x 7 mm should be used to ensure that fragments of ACM panels do not pass through lengthways. Based on the amount of ACM retrieved for a given volume of soil screened, the percentage of asbestos w/w can be calculated. If the levels of small fragments are high, some sampling of the resulting stockpiles may be appropriate (see **Section 4.4**) to ensure that the screening is effective.

If the 7 mm mesh size is impractical to use because of soil or other conditions, then a coarser mesh size may be used, but this will need to be done in conjunction with sampling of the screened stockpiles (see Section 4.3). The top 10 cm of screened installed soil must be free of ACM.

Air quality management and monitoring are particularly important for screening procedures because they have the potential to release considerable amounts of dust and possibly free asbestos fibre.

Consideration of the above on-site treatment options should take account of the following factors:

Advantages

- No contaminated soil needs to be moved off-site for disposal;
- MOT is avoided ;
- Sampling can be combined with remediation;
- Risk is removed and no more management is required.

Disadvantages

- Usually not suitable for high levels of contamination;
- May not be suitable if there is considerable additional demolition debris;
- May not be suitable for compacted soils or soils with high clay content;
- In some cases, has potential to generate considerable dust which requires management and monitoring to ensure there are no off-site impacts.

Excavation and On-Site Burial

On some sites, the on-site relocation and re-burial of asbestos-contaminated soil may be an option. The burial site is usually in an already asbestos-contaminated area of the site. This can lessen the risks and costs associated with say taking the material off-site and disposing of it. Sites which have a public open space, internal roadways or bitumen car parks may be suitable for this purpose as those areas may be used for the internment. The reburied asbestos would still have to be properly managed in accordance with **Section 5.2.1**.

The boundaries of the area from which excavated soil was taken should include an extra 1 m laterally and an additional 30 cm depth to account for any uncertainty in the contamination delineation and removal process. The exposed excavation surfaces will need to be validated in regard to asbestos contamination as outlined in **Section 4.4**. Consequently, only the burial site may need to have a MOT.

5.2.3 Removal Off-Site

Predisposing conditions

- Asbestos is not buried deeply, for example it is within the top 1 m;
- Extent of contamination is well delineated;
- Asbestos contamination covers a relatively small area;
- Excavations will be required as part of site development;
- Contamination includes significant exposed asbestos free–fibres generating material;
- It is important to avoid a MOT.

Since DOH considers minimising public risk, soil disturbance and off-site disposal as priorities, this remediation method should be considered only when all other options are unsuitable. However, “dig and dump” has been widely practiced and in certain cases may be appropriate, for instance, when unexpected “hotspots” are found during site development.

For excavation of any asbestos contaminated soil, it is recommended that an extra 1 m should be removed in all directions beyond the measured lateral boundary of the contaminated area and an additional 30 cm depth also be removed. The surfaces exposed by the excavation will need to be validated in regard to asbestos contamination as outlined in **Section 4.3 Validation**. Excavated contaminated material should be disposed of at a suitable landfill.

Consideration of removal off-site should take account of the following factors:

Advantages

- Potential risk is removed from the site and no more management is required;
- MOT is not required.

Disadvantages

- Relocation of contaminant and occupation of landfill space;
- Potential to generate considerable dust and possibly asbestos free-fibres which require management and monitoring to ensure there are no off-site impacts;
- High cost.

5.2.4 Air Quality Management

Some of the investigative procedures and especially the remediation measures have the potential to generate significant amounts of dust including free asbestos fibre. Possible dust-generating activities include the mechanical screening of soil and major earth excavations and vehicle movement. The generation of dust should be minimised and meet national air quality standards.

A Dust Management Plan (DMP) should be developed and implemented. Its level of detail and extent will depend on the nature of contamination and the type and magnitude of earth-disturbing activities. A DMP should include sections on: control measures, air quality standards, personnel protection and training, a monitoring program, and action levels and responses.

As indicated in **Section 4.2 Air Quality Monitoring**, effective dust management can be used as a surrogate for managing airborne asbestos fibre as well. It is important that where asbestos fibre may be present any wetting should be with an agent specifically designed to suppress the release of that fibre.

Dust control measures that may need to be instigated include:

- Treatment of soil with wetting agent before disturbing it;
- Using dust suppressants or covers on soil stockpiles;
- Installing wind barriers;
- Using sheltered areas wherever possible;
- Monitoring meteorological conditions and modifying or stopping work when they are adverse;
- Regulating the speed of vehicles;
- Minimising access to contaminated areas, especially by vehicles;
- Implementing a community dust complaint and response system.

Section 4.2 Air Quality Monitoring also provides a detailed description of appropriate asbestos and dust air monitoring arrangements, including meeting national asbestos fibre and nuisance dust limits.

5.2.5 Validation

Following remediation, the adequacy of the work and sometimes the air-quality management will need to be assessed by the consultant. The soil validation will depend on the remediation approach adopted and the form of asbestos.

For excavated areas involving ACM, FA or AF, the procedure should be followed as outlined in **Section 4.3**.

Where remediation is by hand-picking or tilling consistent with **Section 5.2.2 Treatment On-Site**, no validation is necessary since the procedure itself is self-verifying. In the case of screening, validation may be necessary, as outlined in Section 4.3.

In situations where air sampling is conducted, the results should be assessed as soon as is practicable and corrective control or monitoring actions taken as necessary. Guidance is provided in regard to procedures and air quality limits in **Section 4.2 Air Quality Monitoring**.

5.3 Ongoing Management

Ongoing management refers to proper control and communication of information about asbestos remaining on-site. As such, it is most relevant to remediation measures of ***Management In situ*** and on-site burial.

A management plan will need to be developed and implemented on a long-term basis. This should be included in the Site Management and Validation Plan that also outlines the remediation and validation measures.

The following elements should be considered in such a plan:

- Arrangements to check the integrity of the covering barrier of the contaminated area if there is any possibility of it being disrupted, for instance if the barrier is in the form of a vegetative cover;
- Arrangements for personnel associated with any future work on the site to be warned and guided in regard to the impacted area, including safe working practices and repairing any damage to the barrier;
- Development of an information brochure for existing or prospective owners and occupiers of the site. A relevant template is provided in **Appendix F – Generic Asbestos Soil Contamination Factsheet**;
- Arrangements for the local shire if possible or other responsible entity to make the brochure available in perpetuity and to assist with the disposal of ACM if it is found.

The information brochure should include details of: risks associated with asbestos; site history and current circumstances; management arrangements; personal actions that may be appropriate, and from where additional information may be obtained.

Where ACM remains on the site and is managed, the land will be classified accordingly by DEC and a memorial put on the title. The classification will be “Remediated for restricted use”. The restricted use would consist of a warning that asbestos remains on site below ground and that precautions should be taken not to disturb it. If disturbance is unavoidable then it should be done in a safe manner.

6. Reporting

All asbestos-related reports should be presented primarily as outlined in the DEC guidance document *Contaminated Sites Management Series – Reporting of Site Assessments – 2001*. The reports should also reflect the guidance provided in relevant chapters of these Guidelines as well as the following information:

- Each report should outline the relevant training and experience of at least the supervising environmental consultant;
- If an approach varies from these Guidelines, it should be fully detailed and justified, including by providing information on precedents;
- All reports should be as comprehensive as possible in regard to information, process and decisions, to avoid misinterpretation;
- Each report should be normally a “stand-alone” and should not rely on other documents for contextual information or for interpretation;
- Each report should investigate, outline and take account of any changes to site-associated conditions that might affect the management process;
- Where asbestos is not the only contaminant, any reporting relating to it should be clearly identified and preferably discretely handled. This may deserve a specific report such as an Asbestos Management plan;
- For the PSI visual inspection it is critical to **comment specifically on the presence or absence of asbestos** material and on the inspection method;
- If a DSI is conducted, its report should include a statement as to why it was necessary as part of the remediation and management process;
- If a site is subject to a Mandatory Auditors Report, that report should comment on the compliance with these Guidelines of the relevant site investigation and management activities;
- The Site Remediation and Validation Report should include documentation arising from the disposal of removed asbestos or asbestos containing material at a suitable landfill;
- Incorporate photographs in reports since asbestos is often identified visually.

6.1 Soil Investigations

Of particular interest to DOH are details of the process and rationale associated with site sampling, analysis and validation, and how the results are interpreted. This needs to be clear and comprehensive especially for sites that are complicated or lack good historical information. The full raw data, including soil logs and laboratory results should be provided in appendices. Tables and diagrams should be used to help summarise and interpret the data. Any asbestos concentration calculations should be made explicit.

Reporting of Hand-picking Sampling

As hand-picking relies heavily on visual identification of ACM and FA, reporting may benefit from the annotation of summary information on a suitable site inspection diagram. Useful information may include:

- Average and range of fragment sizes;
- Locations where samples of suspect ACM were taken for analysis;
- Locations where photographs were taken including direction of the shot.

Reporting of Screening or Tilling Sampling

For these types of sampling, a site diagram should be provided denoting on a grid basis the investigation area(s), the direction of each pass, the collected weight of asbestos, and calculated soil asbestos concentrations, all on a per pas basis. In the case of screening, the effective screen mesh size should be stated, and the results for the different strata should be differentiated.

The discussion of results should include trends observed across the sequence of investigation passes, including variability and change in asbestos concentrations, and delineation of areas where asbestos contamination is more pronounced.

Reporting of Sampling – Soil Bores, Test Pits and Trenches

This type of sampling may often also involve discretionary and follow-up sampling. The different types of sampling should all be differentiated and a rationale provided as to why and where they occurred. The following components should be considered for inclusion in the site investigation diagram:

- Depth of strata sampled for asbestos;
- Soil asbestos concentrations at each position for each strata sampled;
- Size of sample screening mesh used;
- Highlighted locations if free asbestos fibres are identified.

6.2 Air Quality Monitoring

Reporting elements for air-quality monitoring should make use of the recommendations in enHealth 2005 pages 50–51 and also include:

- Rationale for air-quality monitoring conducted and any corrective action levels adopted;
- Monitoring positions should be shown;
- Tabulated or graphical presentation of results for each monitoring location, highlighting any exceedances of adopted corrective action levels;
- Discussion should provide an evaluation of potential causes of exceedances, the prevailing meteorological conditions and the effectiveness of corrective actions implemented;
- Statement of the potential exposure of human receptors to asbestos fibres and of the adequacy of site management measures implemented.

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Glossary

AQM	Air-quality monitoring
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.
Asbestos Removalist (Licensed)	A removalist registered, licensed or otherwise authorised, under Western Australian State legislation to perform asbestos removal and maintenance work.
Clean Fill	Material of certified quality and not having harmful environmental or health effects. Consists of rocks, sand or soil from the excavation of undisturbed material or derived from an acceptable source.
CS Act	Contaminated Sites Act – 2003.
CSMS	DEC Contaminated Sites Management Series.
DEC	Department of Environment and Conservation (WA).
DOH	Department of Health (WA).
DSI	Detailed Site Investigation.
“Emu-Bob” or “Emu-Pick”	The manual collection or hand-picking usually of ACM fragments using a systematic process of visual inspection across the surface of a site.
Exposure Pathway	The course a chemical or physical agent takes from a source to an exposed organism. An exposure pathway describes a unique mechanism by which an individual or population is exposed to chemicals or physical agents at or originating from a site.
f/mL	Fibres per millilitre.
Fibril	The smallest discrete constituent which can be physically separated from a bundle of asbestos, representing a single microscopic or sub-microscopic crystal.
Fibrous Asbestos (FA)	Friable asbestos material, such as severely weathered ACM, and asbestos in the form of loose fibrous material such as insulation products.
Free Fibres	Mineral asbestos fibres or asbestos fibres released from ACM or other asbestos sources due to deterioration, demolition or disturbance.

Friable Material	Material which is crumbled or reduced to powder by hand. Asbestos in this form is especially hazardous due to potential for fibres to become airborne.
Hardstand Area	An area that is covered by impervious construction material such as asphalt, concrete or brick.
Hazard	The capacity of an agent to produce a particular type of adverse health or environmental effect, (e.g., asbestos to cause mesothelioma).
Health Risk Assessment	The process of estimating the potential impact of a chemical, biological, physical or social agent on a specified human population system under a specific set of conditions and for a certain time-frame.
IRAs	Immediate Response Actions
Management (cf. Remediation)	Used in regard to (potentially) asbestos-contaminated sites to define those actions taken to mitigate potential negative effects on human health, or where asbestos contamination remains on-site and measures for continuing oversight and control have been implemented. This is to allow distinction from sites where full remediation has been effected and no further actions are required.
Memorial on Title (MOT)	A statement registered on the site certificate of title by the Registrar of Titles, Landgate, documenting information relevant to the status of site contamination and relevant restrictions on site use. For further information, refer to Section 5 of DEC (2006) *Contaminated Sites Management Series – Site Classification Scheme*.
NATA	National Association of Testing Authorities
NEPM	National Environment Protection Measure
NOA	Naturally Occurring Asbestos
Para-occupational Sampling	Para-occupational samples are those *static samples* taken as an indicator of the effectiveness of control techniques.
PM10	Particulate matter with an equivalent aerodynamic diameter of 10 µm or less
Polarised Light Microscopy (PLM)	Polarised light microscopy with dispersion staining which allows simple optical characterisation of asbestos fibres to 0.2 µm.
PSI	Preliminary Site Investigation
Remediation (cf. Management)	Used in regard to (potentially) asbestos-contaminated sites to define those actions taken to eliminate, remove or suitably reduce asbestos to concentrations below relevant cleanup criteria in soil. This is to allow distinction from sites where on-going management and awareness of residual asbestos contamination is required.
Risk	The probability that, in a certain timeframe, an adverse outcome will occur in a person, group of people, plants, animals and/or ecology of a specified area that is exposed to a particular dose or concentration of a hazardous agent.

SAP	Sampling and Analysis Plan
Sensitive Receptor	Any individual who may be at greater risk than the general public of suffering detrimental effects from exposure to asbestos. Land-uses such as schools and residences where such individuals are located may also be considered sensitive receptors.
Static Samples	Samples taken at fixed locations, usually 1-2 m above ground level.
Structure	Includes *inter alia* any industrial plant, edifice, wall, chimney, or fence.
Transmission Electron Microscopy (TEM)	Transmission electron microscopy uses a beam of highly energetic electrons to examine objects very closely, on a fine scale. TEM allows individual asbestos fibres and fibre structures to be distinguished from other fibres.
Uncontrolled Fill	Any form of fill material located on site, whether resulting from waste disposal, land-scaping practices, or other process, for which the composition cannot be reliably ascertained. This includes construction and demolition material, ‘inert’ waste, and municipal waste.
Validation	The process of demonstrating that an investigation area has been delineated or remediated successfully.

Appendix A

Contaminated Sites Management Series – Development of Sampling and Analysis Programs (2001) – Appendix C.[1]

Minimum Sampling Points Required for Site Characterisation Based on Detection of Circular Hot Spots Using Systematic GRID Sampling Pattern

This table has been modified from *Contaminated Sites Sampling Design Guidelines* (NSW EPA, 1995)

Area of the Site AND/OR Excavations ha (m^2)	Number of Sampling Points Recommended	Equivalent Sampling Density (POINTS/ha)	DIAMETER OF THE HOTSPOT THAT CAN BE DETECTED WITH 95% CONFIDENCE(m)	grid size (m)
0.05 (500)	5	100.0	11.8	9.5
0.1 (1000)	6	60.0	15.2	12.9
0.2 (2000)	7	35.0	19.9	16.9
0.3 (3000)	9	30.0	21.5	18.2
0.4 (4000)	11	27.5	22.5	19.1
0.5 (5000)	13	26.0	23.1	19.6
0.6 (6000)	15	25.0	23.6	20
0.7 (7000)	17	24.3	23.9	20.3
0.8 (8000)	19	23.8	24.2	20.5
0.9 (9000)	20	22.2	25.0	21.2
1.0 (10 000)	21	21.0	25.7	21.8
1.5 (15 000)	25	16.7	28.9	24.5
2.0 (20 000)	30	15.0	30.5	25.4
2.5 (25 000)	35	14.0	31.5	26.7
3.0 (30 000)	40	13.3	32.4	27.4
3.5 (35 000)	45	12.9	32.9	27.9
4.0 (40 000)	50	12.5	33.4	28.3
4.5 (45 000)	52	11.6	34.6	29.3
5.0 (50 000)	55	11.0	35.6	30.1

Notes: **1. The provision in this table of the number of sampling points does not imply that minimum sampling is good practice for a given site. The investigator should be prepared to justify the appropriateness of applying this table or any other sampling rationale.**

2. No guidance is provided for sites larger than five hectares (50 000 m^2). Such sites are usually subdivided into smaller areas for more effective sampling.

[1] DOH note – Judgmental sampling is preferred to grid-based where possible.

Appendix B

Management of Small-Scale Low-Risk Soil Asbestos Contamination

Purpose

This document provides guidance on the assessment and management of single residential blocks which have soil asbestos contamination resulting from poor demolition practices or dumping. It is intended to be primarily used by Local Government Environmental Health Officers (LG EHOs), in consultation as necessary with the Department of Health (DOH).

Background

Asbestos building products were widely used in Western Australia (WA) from the 1940s to the 1980s, and many of the buildings and structures involved are now being demolished for infill developments. If the demolition is not properly conducted, then asbestos debris will often remain on site or be dumped on other sites. This can pose a risk or community concern that LG EHOs are frequently called upon to resolve.

The main legislation in WA relating to contaminated sites is the *Contaminated Sites Act 2003* (CS Act), administered by the Department of Environment and Conservation (DEC). For asbestos contamination issues, DEC relies on advice from the DOH and its *Guidelines for the Assessment, Remediation and Management of Asbestos Contaminated Sites in Western Australia (DOH, 2009)*. LG EHOs and DOH may also make use of the *Health (Asbestos) Regulations 1992* to help regulate asbestos removals, including the disposal of asbestos spoil.

The full application of the legislation and the Guidelines, which can be expensive and protracted, is not warranted in certain low-risk situations where acceptable simpler regulatory measures may be sufficient. Soil asbestos contamination resulting from poor demolition practices or dumping on a single residential block are often low-risk situations where the following regulatory process is recommended. However, with DOH agreement, the approach may also be suitable for other low-risk applications such as for commercial sites or several or more residential blocks.

Simple Site Assessment and Management Process

This process is for asbestos-containing materials (ACM) where the asbestos is bound in a matrix such as cement (bonded asbestos), and there is little free fibre present. The ACM would mainly appear as fragments, pieces or sheets. Asbestos in these forms is not likely to release appreciable amounts of free asbestos fibre, which presents the main risk from asbestos through inhalation.

The general sequence of steps is to:

- halt potential contaminating or contamination disturbing activities at a site;
- identify the presence of asbestos;
- assess the extent of contamination and select a clean-up option;
- provide notice of what is required;
- monitor and validate the clean-up.

At various stages, it may be necessary to inform other agencies such as WorkSafe.

Contamination Prevention

Any incorrect handling or disturbance of ACM on a site should be halted as soon as possible by available regulatory means if necessary, possibly in conjunction with WorkSafe. The activity may be posing a real-time risk to adjacent properties or site personnel, or may be scattering and burying ACM which may pose a future risk.

Asbestos Identification

The LG EHO may be able to identify ACM based on experience, but confirmation is recommended by submitting representative ACM pieces for laboratory analysis. If in doubt, assume it is asbestos.

Site Assessment and Management Selection

The site assessment will primarily depend on a visual inspection. Other useful information includes: building license records; demolition applications; asbestos removal plans; asbestos disposal receipts; and often interviews with site personnel, the owner or neighbours. Important topics include: age and condition of building or structures; the likely amount of asbestos in them; the method of demolition and safeguards; and details of earth-disturbing activity.

The "walkover" should be systematic and preferably on a grid basis. For instance, a 4 m by 4 m area might be inspected, taking note of the total sheet area of ACM found. Small location flags may be helpful. It is then possible to determine the average ACM total sheet area per m^2 of surface, for each grid area. As an example, 3 x 1 cm^2, 1 x 6 cm^2 and 1 x 20 cm^2 ACM pieces found in that grid would equate to a total of 29 cm^2 divided by 16 (the grid area) which equals about 2 cm^2 of ACM per m^2.

If there is just a "hotspot" of contamination, e.g., many pieces of ACM in a localised area, then a smaller grid size may have to be used. If there are just a few large ACM pieces sitting cleanly on the surface, then just their managed removal would be adequate, without resorting to calculations.

Actions will normally depend on the estimated level of contamination per m^2 of surface as follows:

- ACM total sheet area < 10 cm^2 (e.g. 3 x 3 cm) and with little associated past soil disturbance – *very low risk* – **simply remove all visible ACM, including if practical after gently fine raking of wetted soil to 10 cm depth to expose ACM fragments**;
- ACM total sheet area > 10 cm^2, or ACM occurrences with significant soil disturbance, or buried asbestos fencing stumps – *low risk* – **consult DOH with the expectation of excavating the impacted and possibly all soil down to depth of likely ACM penetration**.
- **For larger quantities of ACM, the risk may be higher and the site may need to be reported to DEC under the CS Act.**

Reporting and Communication

The LG EHO should document the process (including photographs) and notify the owner in writing as to what is required. This may take the form of a notice issued pursuant of the *Health (Asbestos) Regulations 1992*.

Clean-up Management

The LG EHO or an independent auditor should observe the clean-up, check the final surface for contamination and inspect disposal documentation. If inadequate, then another remediation round or higher level of action may be necessary.

During any removal of asbestos soil contamination, the material should be handled carefully and management measures instituted to minimise the release of asbestos fibres, and thus protect site personnel and the public.

As a minimum, gloves and P1/P2 dust masks should be worn and ACM double wrapped in heavy plastic (0.2 mm thick). If soil is to be excavated, then the following additional measures are recommended: dust suppression methods such as spraying with a suitable wetting agent; securing the site and erecting warning signs; informing neighbours about activities; and covering transported impacted soil. All contaminated material must be disposed of at an approved landfill site.

If the responsible party is not willing to implement the appropriate actions then it may be necessary to report the site to the DEC under the CS Act and take other actions as deemed necessary, including managing any real or perceived risks in the meantime. Any report to the DEC should include details of the contamination, including location, cause, character and photographic evidence if possible and be on the Contaminated Site **Form 1** (Report of a Known or Suspected Contaminated Site), available at:

www.dec.wa.gov.au/contaminatedsites

Once reported to DEC, the site will be normally assessed within the statutory prescribed timeframe of 45 days and classified according to its contamination status. This will likely legally require the owner to investigate or remediate the site and a memorial will be placed on the Certificate of Title where necessary.

Contact Information

For information on asbestos-contaminated soil issues contact the Toxicology Branch on 9388 4984 or for asbestos demolition advice contact Applied Environmental Health Branch on 9388 4965.

Appendix C

Immediate Response Actions (IRAs)

EnHealth 2005 identifies the need for immediate remedial action wherever 'it is demonstrated that there is potential for people to inhale airborne asbestos fibres'. DOH supports this position and recommends generic and site-specific IRAs, which are most relevant for free asbestos fibre, fibrous asbestos and degraded asbestos containing material, especially on or near the soil surface.

Generic IRAs

The following actions should occur for any site where airborne asbestos fibres have potential to be generated:

- Areas where fibre contamination is considered likely are to be isolated and secured from unnecessary access – this includes members of the public and any non-essential workers;
- Appropriate signage warning of asbestos is required across the site and at site access points (see enHealth 2005);
- Notification of potential asbestos contamination and any intended site works is to be provided to nearby landholders or occupants;
- A contact officer responsible for handling enquiries and potential complaints is to be designated;
- A sealant, temporary cover or encapsulation can be applied to degraded ACM or remnant asbestos building material in soil that cannot be immediately removed;
- Dust suppressants should be applied across relevant impacted areas which may be disturbed by wind or site activities;
- Site drainage may be improved or altered to prevent potential water erosion;
- Wind fencing may be erected to reduce the potential for dust generation.

Situation-Specific IRAs

The following IRAs should be enacted when specific site conditions are identified during the initial visual inspection or as situations are encountered during the progress of site works:

- Where the nature of contamination and existing or probable site conditions indicate a likely risk of public exposure to asbestos fibres, consultation with DOH is necessary;
- Any activities that result in the movement of dust beyond site boundaries should immediately cease and the dust control measures reviewed;
- Where soil excavations encounter previously unidentified asbestos contamination, activities should cease, the extent of the soil impact be delineated and management implemented prior to the re-commencement of works;
- A cover or dust suppressant material, such as hydro-mulch, should be applied to any excavated soil stockpiles suspected to be contaminated by asbestos.

A suitably experienced site manager should be present during all site activities to determine whether the IRAs listed above are required.

If there is doubt regarding whether or not exposure to asbestos fibres may occur, conservative IRAs should be adopted as an interim measure.

Appendix D

Contingency Plans

During any investigation and remediation program, there should be clear procedures for the identification, isolation, reporting and management of asbestos in unanticipated locations and forms. These contingency measures may make use of relevant IRAs **(Appendix C)** and opportunistic sampling methods.

The contingency plans should be outlined in appropriate reports, such as the Sampling and Analysis Program, and cover all stages of the investigation and management process especially if fibre-generating materials may be present and earth disturbing activities occurring. These plans may need to be amended over time based upon actual site experience.

In general terms, aspects that should be addressed by site contingency plans include:

- Designation of responsibility for on-site management and response;
- Methods for notification and reporting of potential site issues;
- Trigger conditions and response actions (IRAs);
- Consultation and communication;
- Validation of response.

Contingency plans should include worker training in regard to the identification, reporting and precautions involving asbestos finds noting that if asbestos is not properly managed it may disperse and thus cross-contaminate large portions of the site.

Consistent implementation of contingency plans should be demonstrated such as through the use of site-activity logs.

Appendix E

Information Brochure for Owners and Occupiers of (include address details)[2]

Presence of Managed Asbestos Materials in Soil at Depth

Purpose

This brochure provides information for prospective or current owners or occupiers of a site with residual asbestos which is managed in accordance with the *Contaminated Sites Act 2003* (CS Act). It does not address other managed contaminants that may be present.

Introduction

The Site refers to *(include address details)*. The Site has been classified by the Department of Environment and Conservation (DEC) as *Remediated for Restricted Use* due to the potential occurrence of asbestos material in a buried layer of soil across the Site. This has resulted in memorials being placed on the respective Certificates of Title and the Site being registered on the DEC's Contaminated Sites database with restrictions relating to the excavation of impacted soils on the Site.

Background

Historically, the Site has been used for *(outline activities)*.

During the redevelopment of the Site its contamination status had to be assessed as required by *(planning conditions)* and in accordance with the CS Act. The assessment incorporated a desktop study, a review of the historical use of the Site, soil and groundwater investigations as well as a soil asbestos survey.

Asbestos contamination was found in the form of *(indicate type)* in *(indicate location/depths)* at a concentration that required clean-up or management so as to ensure that it does not present a significant human health risk. The asbestos contamination likely resulted from *(indicate cause)*. *(Indicate any initial remediation efforts)*.

Asbestos Health Effects

Asbestos is a naturally occurring mineral fibre which due to its excellent heat and sound insulation was widely used in building products between the 1940s and 1980s. Such materials include cement sheeting and fencing, drainage pipes, roofing, guttering and flexible building boards. Its use was completely banned in 2003.

Asbestos fibres if released into the air produce the main health effects through inhalation. These effects can include asbestosis, lung cancer and mesothelioma, and generally only result from higher exposure over a long period of time, for instance, in some workplaces.

[2] This template is adapted from a work done by Richard Noble Co. It should be tailored to a particular Site by replacing text in bracketed italics or as necessary with Site-specific information.

The nature of the asbestos contamination on the site is such that risk is considered *low*. However, to increase health and safety at the Site and to meet regulatory requirements, management measures have been put in place.

Site Management

In accordance with Department of Health (DOH) and Department of Environment and Conservation (DEC) guidance, the contaminated soil has been covered by a non-degradable, *(colour)* geo-textile fabric and above this a minimum of *(500)* mm of clean engineered fill. This brochure forms part of a Site Management Plan developed for the Site in regard to the remnant asbestos.

On-going Management

Any contractors employed by the owner/occupiers of the Site should be made aware of the potential occurrence of asbestos below the warning layer. Any soil excavated from below that level must be treated as contaminated by asbestos, and not mixed with the clean fill. Any separate fragments found should be securely sealed with strong tape in heavy duty (0.2 mm thick) polyethylene bags to not more than half capacity. In both cases the material should be disposed of to a licensed asbestos facility in accordance with the DEC Controlled Waste Regulations. Alternatively, contact the *(name of City or Town and phone number)* for advice on removal, disposal and transport of asbestos waste materials.

A list of the current licensed asbestos facilities can be obtained from DEC and is contained in *Fact Sheet: Asbestos – Disposal of Material Containing Asbestos – 2007* available at:

www.dec.wa.gov.au/pollution-prevention/controlled-wastes/publications.html.

The facility operator must be informed on arrival that the waste contains asbestos.

Further Information

Further information about the Site's investigation, remediation and management may be available from the developer, *(name and phone number)*, or the *(name of City or Town and phone number)*.

Advice concerning the possible health risks of asbestos may be obtained from the Environmental Health Directorate of the Department of Health (Ph: 9388 4999). General information on asbestos can be obtained from the following website:

www.public.health.wa.gov.au/2/867/2/asbestos.pm

Appendix F

Case Study: Investigating and Remediating an Asbestos Contaminated Site in Perth

Background

Land located in Perth (the Site) was being redeveloped as several residential sub-divisions and a designated public open space. Many of the 100 residential blocks had sale commitments made before the environmental clearance.

The developer employed an environmental consultant to investigate the Site to meet a contamination condition of the Western Australian Planning Commission. The consultant identified a number of contamination issues, with the most important being asbestos. Residual asbestos-containing material (ACM) fragments were present as a result of poor demolition of asbestos structures and also waste material dumping on what had been a rural residential site. The consultant delineated the extent of asbestos impact and the developer arranged for its excavation to a depth of 400 mm. The excavated material was placed in a borrow pit in a section of the site designated as public open space. The pit infill was then covered with a geo-textile fabric and back filled with sand to 600 mm thick. The original soil from the borrow pit was used to infill the excavated impacted areas.

A reinvestigation of the excavated areas found additional ACM in and under the soil surface in locations adjacent to those initially delineated. Consequently, the same remediation strategy was employed with a second borrow pit.

A subsequent total site walkover by developer personnel found yet more ACM shards in small amounts broadly across the Site. The developer determined that this was of low risk and that it could be managed by putting a memorial on the Certificate of Title warning new owners to take care.

Developer sought confirmation as to the acceptability of the approach from the Department of Health (DOH). The request consisted of largely unsubstantiated summary information. DOH advised that the development would have to be subject to a full investigation and management process through the Contaminated Sites Branch of the Department of Environment and Conservation.

Main Lessons to this Stage

- Do not sell blocks that are still subject to conditions unknown to the buyers whose clearance may be potentially protracted, costly and sensitive;
- Ensure that asbestos impacts are fully investigated and very well delineated;
- Ensure that the investigation is fully documented and this is provided to regulators to assist their decisions;
- If asbestos contamination may be widespread and ill-defined, and timeframes are tight, management in situ is a particularly effective option.

Regulatory Dialogue

The developer subsequently engaged another consultant who submitted a short sampling and analysis plan (SAP) to DOH designed to demonstrate that the asbestos was below the existing DOH criteria for contamination of 0.001% weight for weight asbestos of soil. The plan proposed the sampling of 10% of the site's total residential area where select house lots would be chosen from four different areas distinguished by their association or not with the cycles of remediation. The issue of free asbestos fibres was not addressed, but DOH determined that it was unlikely to be a risk given the site circumstances.

Areas designated for sampling would be tilled to a maximum depth of 400 mm, followed by visual inspection of the tilled area for ACM. Asbestos that was uncovered would be collected and weighed and the average percentage by weight of asbestos would be estimated for each selected areas. DOH does not normally tell consultants what should be in a specific site SAP but will identify deficiencies. In this case DOH replied that it could not support this proposal given the ongoing lack of investigative documentation, uncertainty as to the extent of contamination and the limited and unsubstantiated proposed SAP. DOH indicated that much more comprehensive investigation and management plans should be provided or that the ongoing presence of asbestos be accepted and managed on-site.

The consultant then submitted a management strategy which assumed asbestos contamination across the entire site, which would be remediated by having a landscaper screen the top 100mm of soil in the front and gardens of residential blocks after the houses had been erected. The developer had the ability to do this as these were house and land packages. DOH would not support the remediation because screening is a higher risk remediation process, it was to be undertaken by landscapers not asbestos specialists, it did not remediate deep enough and it had the potential to contaminate the buildings and possibly occupied houses nearby.

The following management package was finally agreed for all residential areas:

Remediation Measures

- Remediation to occur across the Site before issue of titles and construction;
- Personnel with the expertise and equipment should undertake clean up activities, e.g., use of landscapers was inappropriate for this purpose;
- ACM handpicking was to occur followed by installation of surface covers;
- Non-hardstand areas were to have a geo-textile warning barrier and above it a 500 mm minimum of clean fill (certified) cover;
- A 300 mm minimum thickness was permitted if lot levels had to be graded from the house pad down to the same level as existing kerbs and footpaths;
- The geo-textile membrane would be of a type that does not impede the free drainage capabilities of soils;
- A dust management plan was to be implemented including dust suppression measures, monitoring and work protection.

Communication

- Prospective buyers were to receive an explanatory letter and a brochure and construction contractors details of safe working procedures in regard to the remnant asbestos contamination;
- The placement of a memorial on the Certificate of Title to warn about the potential presence of asbestos.

The local Shire extended some of these requirements, in consultation with the DOH. For instance the 500 mm clean fill cover was to apply across the whole residential development including the access roads. The Shire also undertook to provide the brochure to new prospective owners in perpetuity.

The whole process from the initial discovery of the ACM to the construction signoff by the Shire took 2 years, with considerable consumer concern.

Final Messages

- To avoid delays and costs, it is important make proposals and take actions that go beyond the adequate rather than trying to get away with less;
- DOH will not do the consultants' work for them and normally will not get into a prolonged iterative process of proposal and response;
- Keep key stakeholders informed in an accurate and balanced way, such as prospective buyers and Local Government;
- The developer should always try to work with the consultant to resolve contamination issues and not unilaterally undertake such work themselves. If replacing a consultant, relevant documentation should be retained.