Government of **Western Australia**
Department of **Health**

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

health.wa.gov.au

Preface

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

The Guidelines consider community expectations and concerns regarding the management of asbestos. They also conform with the National Strategic Plan for Asbestos Awareness and Management 2019-23, developed by the Australian Government Asbestos Safety and Eradication Agency. The national strategy promotes prioritised removal of asbestos. As such, remediation often occurs once there is confirmation that asbestos contaminated soils are present above screening criteria with detailed risk-based assessments occurring less often than for other soil contaminants.

In WA, the Department of Water and Environmental Regulation (DWER) is the primary regulator of contaminated sites and the CS Act administrator. However, DWER seeks advice from other agencies on asbestos-related issues due to the significance of asbestos exposure to human health and the broader legislative framework for asbestos regulation and control. These Guidelines are approved by DWER.

The intent of the Guidelines is to ensure that asbestos soil contamination is identified early and managed effectively.

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Contents

Tables

Figures

Appendices

Chapter 1

Introduction

In WA, the Department of Water and Environmental Regulation (DWER) administers the *Contaminated Sites Act 2003* (CS Act). DWER seeks Department of Health (DOH) advice on asbestos-related issues given the significance of asbestos exposure to human health

These Guidelines have the same status as the DWER Contaminated Sites Guidelines. They are to be used in conjunction with the Assessment and Management of Contaminated Sites (DWER, 2021) (external site) and the National Environmental Protection (Assessment of Site Contamination) Measure (ASC NEPM) ASC NEPM, Schedule B1, Section 4 Asbestos Materials in Soils (external site).

Any departure from these Guidelines should be fully justified with relevant information and evidence documented in site reports.

1.1 Scope of the guidance

These Guidelines apply to the identification, assessment, remediation and management of sites suspected or known to be contaminated with asbestos in Western Australia.

Contaminated is defined under the CS Act as:

In relation to land, water or a site, means having a substance present in or on that land, water or site at above background concentrations that presents, or has the potential to present, a risk of harm to human health, the environment or any environmental value.

1.2 Role of the Department of Health

There is provision in the CS Act for DOH to provide advice in matters relating to public health. As asbestos contamination is mainly a public health matter, the DOH is involved in establishing guidance around assessing and managing asbestos contaminated sites. In addition, the DOH has a broader role in administering public health legislation and in public health assessment.

The *Health (Asbestos) Regulations 1992* set out requirements for the handling, demolition and removal of asbestos associated with building structures for residential sites. Further information on the scope and application of these regulations is available from: https://ww2.health.wa.gov.au/Articles/A_E/About-asbestos.

1.3 Consultative process

Asbestos contaminated sites often attract significant stakeholder and community interest and concern. Appropriate public and stakeholder consultation is required throughout the stages of site investigation, remediation and management as described by Schedule B8 of the ASC NEPM (external site). This should include information provision and collection and complaint resolution. The extent of consultation will vary with the size, sensitivity and complexity of the site.

Consultation with stakeholders should be an interactive process where possible and not just an awareness-raising and information session. The need for adequate risk communication and understanding risk perception applies to asbestos, which can be an emotional issue and can become difficult to manage if an investigation becomes contentious.

Engage in proactive and effective community and stakeholder consultation and risk communication in accordance with Schedule B8 of the ASC NEPM.

1.4 Asbestos-containing materials

There is a history of production and widespread use of asbestos materials in WA. 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 was used in building products until 1987. A total ban on asbestos occurred in 2003, which included friction and industrial products.

The term ACM is used to describe any material known to contain commercial forms of asbestos in any bonded or non-bonded form. Asbestos has been historically used in the manufacture of a huge variety of products and materials, typically to give that material additional strength, durability or resistance to fire, heat, electricity, damp or mould. Examples of asbestos-containing materials are provided in Table 1.

Table 1 List of common asbestos-containing products

Automotive Parts brake pads; clutches; hood liners; gaskets; valves
Cement cement; cement pipes; cement wallboard; cement siding; tabletops
Construction Materials acoustical and decorative plaster; adhesives, putties, and mastics; compressed sheet packing; electrical panel partitions and wiring; fireproofing and prevention materials (e.g. curtains, blankets); gaskets; heating and electrical ducts; insulating board; joint compounds; millboard; pipe and equipment insulation; spray-on and blow-in insulation; taping compounds (thermal); textured paints and coatings; vinyl sheet flooring; linoleum backing paper and wall coverings
Laboratory Equipment Bunsen burners; ceramics; clamps; filters; fume hood; gloves; ovens and furnaces; sealants; tubes and sleeves
Textiles cloth; curtains; personal protective clothing; rope; felt; rugs; thermal paper products; yarn

A gallery of common products is available from: https://asbestosawareness.com.au/gallery-videos/ (external site).

ACM contain different types and quantities of asbestos fibre. It is important to describe the type/form, and condition of all ACM identified in the field so that it may be appropriately characterised and assessed.

The term asbestos contaminated materials can also refer to a range of materials known to contain asbestos other than by original design or manufacture, such as waste and soil mixed with ACM waste, repurposed or recycled materials found to contain asbestos.

1.5 Asbestos as a contaminant

Asbestos may be present in a range of forms, sizes and degrees of deterioration. For the purposes of these Guidelines, the asbestos associated with contamination is divided into the three distinct groups described below.

1.5.1 Bonded (non-friable) asbestos-containing material (bonded ACM)

The term bonded ACM refers to bonded (non-friable) asbestos-containing material where the asbestos fibre is bound by another material or is part of a matrix; for instance, asbestos cement sheeting or vinyl tile. Bonded ACM can include broken, weathered or fragmented material that retains its basic integrity.

Bonded ACM as asbestos cement sheeting in soil is the most common form of asbestos site contamination in WA as a result of:

- widespread use in a range of construction materials
- inadequate removal and disposal of asbestos products during building demolitions
- historical widespread use as uncharacterised fill material for site landscaping
- fly-tipping on vacant or development sites.

Figure 1 Asbestos cement fragments in soil.

Typically, broken bonded asbestos cement exists in larger fragments. Bonded ACM corresponds to material that is larger than 7mm x 7mm. This size is used as it approximates the thickness of broken asbestos cement sheeting as it is the most common form of soil contamination.

1.5.2 Fibrous asbestos (FA)

Fibrous asbestos is any material containing asbestos that is wholly or in part friable (can be broken or crumbled by hand pressure), including any previously non-friable asbestos asbestos-containing material that is in a severely degraded condition such that it can be broken or crumbled by hand pressure and original friable asbestos, such as pipe lagging and other loose-fill insulation and manufacturing waste.

Figure 2 Friable test – example of hand crumbled low density fibre board found in soil originally in a rectangular form (FA).

Fibrous asbestos also includes materials that have higher asbestos content with a propensity to become friable with use, e.g. low density asbestos fibre board and textile materials or fibres contained within a less durable bond, e.g. used gaskets and textile products. FA may be more difficult to visibly distinguish when coated in soil or mixed with other material. In some cases, FA that has mixed with soil is sampled and assessed as AF.

1.5.3 Asbestos fines (AF)

Asbestos fines relate to the size of asbestos contamination present (smaller than 7 mm x 7 mm) within a soil sample. It corresponds to, but is not the same as asbestos contaminated dust or debris (external site) (ACD) (Safe Work Australia) on surfaces. ACD on surfaces is more readily identified and managed. AF includes loose fibre bundles[1] of asbestos as well as small pieces of friable and non-friable material such as asbestos cement fragments mixed within the soil.

Figure 3 Visible amount of AF on from high-pressure cleaning of an asbestos cement roof.

Concentrated amounts of asbestos fines on the soil surface may be visually observed, as in Figure 3. However, low quantities of asbestos fines or lower concentrations will need to be identified analytically by a NATA accredited laboratory. Note that there are limitations associated with reliably quantifying low levels of asbestos fines in soil.

1.6 Naturally occurring asbestos (NOA)

Asbestos is a naturally occurring mineral and present in rocks and soils in parts of Western Australia. Undisturbed naturally occurring asbestos (NOA) is not considered to be 'above background concentrations' and therefore does not meet the definition of contamination under the CS Act. However, if disturbed and redistributed in the landscape, NOA may be considered as contamination and potentially subject to management under the CS Act. Exposure to NOA is most likely during geological sampling and mining operations. Management measures similar to those for friable asbestos usually apply. More information is available from the Department of Mines, Industry and Safety Regulation (external site) and the Guidance Note on Public Health Risk Management of Asbestiform Minerals Associated with Mining.

1.7 Human health risks

The health effects of asbestos are well understood and result from inhalation exposure to airborne (respirable) fibres. If deposited in the lungs, the fibres can initiate diseases that take many years to produce serious health effects. These effects include asbestosis, lung cancer and mesothelioma. The likelihood of asbestos-related disease is related to the concentration and duration of exposure to respirable asbestos fibres (f/mL.yr). Exposure thresholds have been suggested for both asbestosis and lung cancer. An exposure threshold has not been established for mesothelioma and it remains the main health outcome of concern with regard to lower or less frequent exposures.

The presence of undisturbed asbestos material in soil does not directly translate to an increased risk to health. The risk to health is dependent on the concentration of airborne respirable fibres that can be released or created from activities at the site and the frequency and duration of recipient exposure.

The relationship between the concentration of asbestos in a source material (such as asbestos contaminated soil) and the concentration of fibres in air that results when that source is disturbed is dependent on a wide range of variables and cannot be reliably estimated or predicted for any given type and concentration of asbestos in soil.

[1] Loose asbestos fibre bundles may be visible under low power stereo microscopy. This document makes a distinction between loose fibres and "respirable" fibre (see glossary).

As such, for human health risk assessment, direct measurement of airborne asbestos fibres is recommended to inform the exposure assessment (See Section 5.9).

There are many uncertainties related to understanding the exposure to airborne asbestos fibres. Complications for completing an exposure assessment include the:

- uncertainty associated with determining the degree, nature and extent of the asbestos impacts, especially respirable fibres
- concentration of respirable dust that may be released from different soils for different activities
- duration and frequency of exposure to airborne fibres from current and future activities in a contaminated area.

1.8 Asbestos eradication and control

In addition to human health risks, consideration is given in these Guidelines to community expectations and concerns about asbestos contamination and the national strategic plan (external site) on the prioritised removal and management of asbestos in the general environment.

1.9 Competency of practitioners

Competent persons are those with sufficient skills, knowledge and experience to undertake particular tasks. Competency is developed over time and gained by various means, such as education and training, professional development and experience.

Where necessary, specialist technical advice should be obtained (e.g. assessing naturally occurring asbestos and other fibrous minerals, undertaking detailed (Tier 2) health risk assessment, air quality monitoring, planning, and completing removal/remediation works).

General and specific industry training should include:

- an outline of all applicable legislation, codes of practice and Australia Standards that apply to asbestos, including workplace health and safety, public health and waste legislation
- an understanding of public health risks associated with exposure to asbestos
- a description of common materials that have historically been used and found at asbestos contaminated sites
- specific requirements for asbestos contaminated sites investigation, assessment and reporting requirements.

An asbestos investigation and remediation action plan should be supervised by someone with:

- continuous and relevant experience with asbestos in soil contamination
- relevant tertiary qualifications in environmental science, science or engineering
- additional training and experience related to asbestos, including identification and assessment of asbestos.

1.10 Worker risk assessment

Advice on work health and safety matters is the responsibility of WorkSafe Division, Department of Mines, Industry Regulation and Safety (DMIRS). Failure to manage asbestos, during demolition activities in accordance with work health and safety (WHS) legislative arrangements, is the origin of many asbestos contaminated sites and can be prevented by complying with removal requirements. Further information is available from: https://www.der.wa.gov.au/your-environment/contaminated-sites/61-contaminated-sites-guidelines (external site).

Safe systems of work must be implemented for all contaminated site work to prevent exposing workers to airborne asbestos and prevent further degradation or distribution of asbestos contamination. Worker risks should be assessed by a person competent in assessing workplace asbestos exposure risks, such as an occupational hygienist.

Safe systems of work should consider appropriate training and supervision of site workers and include the licensing requirements for removalists. DMIRS Information sheet – Asbestos contaminated soils (external site) provides additional information on the selection of licensed removalist.

Application of WHS legislation falls outside of the scope of this document, with further information available from DMIRS.

1.10.1 Additional resources – Department of Mines, Industry Regulation and Safety

- Removal Checklist – Non Friable Asbestos (external site)
- Asbestos removalists presentation (external site)
- Frequently asked questions (external site)

Chapter 2

Framework for response to asbestos contamination

Asbestos contaminated soil must be addressed at the earliest possible opportunity permitted by legislation. Understanding how asbestos is legislated, managed and controlled in Western Australia is important to effectively assess, remediate and manage asbestos contamination early and in compliance with the most relevant legislation.

Section 5.5 and Figure 2 of the Contaminated Sites Guidelines: Identification, reporting and classification of contaminated sites in Western Australia (2017) (external site) references alternate legislative processes for addressing asbestos contaminated soil impacts. Table 2 expands on this advice and outlines the various legislation, responsible agencies and associated codes of practices and guidance and how they may apply in various circumstances.

For example, asbestos contamination of soil related to the following activities may be addressed immediately through other legislation outlined in Table 2:

- incomplete removal and/or clean-up of soil directly following asbestos removal work
- broken and damaged sections of bonded materials from existing structures, such as fencing
- illegal dumping of bonded asbestos cement material with simple surface impact
- incident response (pollution) from contamination arising from a single incident, e.g. fire, high-pressure water hose cleaning of a roof.

Figure 4 Broken ACM sheeting.

2.1 Decision to report under the Contaminated Sites Act 2003

The decision on whether it is necessary to report a site (external site) must consider both:

- the information available, including initial site inspections on the likely type, quantity and distribution of asbestos-containing materials at the site
- other regulatory provisions in place for managing asbestos.

If in doubt, it is best to contact DWER and other relevant agencies to discuss the decision. The obligation to report falls on the owner, occupier, 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.

It is important to note that the CS Act allows new information to be submitted to DWER for (re)evaluation at any time. Even where a site has been previously reported and not classified, where information becomes available that asbestos-contaminated soils remain at a site, the site should again be reported to DWER.

2.2 Further guidance for common asbestos contamination scenarios

The information provided in the various chapters of these guidelines (e.g. soil sampling, characterisation of contamination and soil clean up) can be used to achieve compliance with other legislation.

Further advice on specific situations is outlined below

2.2.1 Small scale or limited surface impacts

Small scale or limited surface impact of bonded ACM can be more readily and practically assessed and managed using the Guidance Note on the Management of Small-Scale, Low-Risk Soil Asbestos Contamination – May 2009 (PDF 121KB) (under review).

2.2.2 Incident response

Specific guidance is available for responding to fires, storm damage and natural disasters and single incidents involving high pressure water equipment on roofs.

Table 2 Legislation framework

Source of asbestos	Legislation	Supporting Documents	Responsible Agency
Existing asbestos products			
Commercial / Industrial and other workplaces	*Occupational Health and Safety Regulations 1996*	Code of Practice for the Safe Removal of Asbestos [NOHSC:2002 (2005)] (external site) National code of practice for the management and control of asbestos in workplaces [NOHSC:2018 (2005)] (external site) Guidance note on the membrane filter method for estimating airborne asbestos fibres 2nd edition [NOHSC:3003(2005)] (external site) AS 4964: 2004 Method for the qualitative identification of asbestos in bulk samples	WorkSafe Division, DMIRS
Residential	*Health (Asbestos) Regulations 1992*	Guidance Note: Identification of Asbestos Containing Material (PDF 2.4MB) Guidance Note: Asbestos Cement Fences (PDF 1.3MB) Guidance Note: Asbestos Cement Roofs (PDF 1.13) Dust from DIY renovations (external site) Prohibited: Pressure Cleaning of Asbestos Cement Roofs 2010 (PDF 157KB) Hazards on your property after a bush fire (PDF 58KB) Guidance note on the management of fire damaged asbestos (PDF 687KB) Asbestos fire contamination leaflet (PDF 606KB) Contamination Free Mulch	DOH/Local Government Authority
New products	National Ban since 2003	Australian Border Force: Prohibited Goods (external site)	Border Force

Source of asbestos	Legislation	Supporting Documents	Responsible Agency
Mining and mineral extraction	*Mines Safety and Inspection Regulations 1995*	Management of fibrous minerals in Western Australian mining operations Second edition (external site) Guidance Note on Public Health Risk Management of Asbestiform Minerals Associated with Mining (external site)	Resources Safety, DMIRS
Pollution (large quantities) **Illegal dumping – minor**	*Environmental Protection Act 1986*		DWER Local Government Authority
Contamination of Land	*Contaminated Site Act 2003* *Contaminated Site Regulations 2006*	Contaminated sites guidelines (external site) Guidance note - Occupational safety and health management and contaminated sites work, 2005 (external site) NEPM, Schedule B2. Guideline on site characterisation (external site) Guidance Note on the Management of Small-Scale Low-Risk Soil Asbestos Contamination – May 2009 (PDF 121KB) (under review) Guidance Note on the Identification, Assessment and Management of Asbestos Contamination in Regional Public Areas – May 2011 (PDF 394KB) (under review) The Information Brochure for Owners and Occupiers (May 2009) (PDF 105KB) (under review) Public Health and Contamination of Soil by Asbestos Cement Material (PDF 321KB)	DWER WorkSafe Division, DMIRS
Recycled products and waste	*Environmental (Controlled Waste) Regulations* *The Waste Avoidance and Resource Recovery Levy Act 2007* *Landfill Waste Classification and Waste Definitions 1996* (as amended 2019)	Guidelines for managing asbestos at construction and demolition waste recycling facilities 2021 (external site)	DWER

2.2.3 Soil contamination related to removal and demolition activities

Planned removal work and demolition of structures should be closely monitored to ensure all asbestos material is removed in compliance with WHS Regulations. Controlled and compliant removal prevents both asbestos contamination of soil and the introduction of asbestos-containing materials into the recycling waste stream.

Minor and/or localised asbestos contaminated dust and debris (ACD[2]) on structures and asbestos fines (AF) material in soil may be expected from the long term presence and use of structures made with asbestos-containing materials. Clean up and removal of minor AF contamination in soil and sediments (e.g. water tank sediment, soak wells receiving run-off from asbestos cement rooves, roof drip lines, damaged pipe insulation) will be required during removal works as it is for minor ACD. The removal of this material must be addressed in the asbestos removal control plan and comply with WHS Regulations and Codes of Practice.

Licensed asbestos removalists may seek assistance from a suitably qualified and experienced person to delineate soil impacts from structures in complex situations.

Where asbestos contamination is found in soil, care should be taken with site management practices during removal and demolition works to prevent the spread of any possible contamination.

Unrestricted asbestos removal licence holders have a legal obligation to include asbestos clearance inspections for any friable asbestos removal work.

The clearance inspection for friable removal work should be undertaken by an independent person[3] who:

- is independent of the removal business, is not involved in the asbestos removal work and does not have a real or perceived conflict of interest
- meets the competency requirements under the WHS legislation and Code of Practice for the Safe Removal of Asbestos [NOHSC:2002 (2005)]
- issues a clearance certificate.

It is recommended that verification of the removal of soil impacts is provided for all asbestos removal work.

DOH and DMIRS advise that a record of final clearance inspections is provided for all removal work. For non-friable asbestos removal, there is no requirement for an independent competent person to undertake the clearance inspection and provide a certificate. However, a final inspection can still be completed with a clearance report provided by either an independent person or the removalist themselves. In all cases, WA government agencies recommend that the owner/client inspects the removal work area as soon as possible after work is completed to ensure that all asbestos materials have been removed.

The person undertaking clearance inspections needs to make sure:

- they are satisfied asbestos is not visible in the removal area or its immediate surrounds
- a clearance certificate/report is issued before the area is re-occupied or before any further demolition or refurbishment work takes place

[2] asbestos contaminated dust or debris (ACD) is defined in Model Work Health and Safety Regulations (January 2019) as dust or debris that has settled within a workplace and is, or is assumed to be, contaminated with asbestos.
[3] May be a licensed asbestos assessor in proposed changes to legislation.

- the clearance certificate/report contains sufficient information regarding the outcomes of the clearance inspection, including the results of any air monitoring and laboratory analysis.

Clearance inspections may include some soil validation sampling, especially following removal of material that has been subject to task/activities that have the potential to generate asbestos fibres (e.g. use power tools, high-pressure cleaning equipment, excessive breakage, exposed ACM in poor condition, roof runoff collection points). The sampling requirements for clearance certificates/reports should be decided as part of the planning activities.

It is also suggested that all relevant records, including asbestos removal plans, clearance inspection reports, disposal receipts, be kept for a property/site and passed on to any new owners/occupiers.

2.2.4 Minor soil contamination found during land development and at construction sites

Asbestos containing debris in soil may be found within any previously developed land, including commercial and residential sites or where imported fill has been brought onto the site. These properties/sites may not have been properly cleaned up following removal or demolition of structures containing asbestos, particularly where impacts occurred before the introduction of the current legislative controls for asbestos removal and management.

For some sites, there may only be a small number of isolated, sparsely distributed fibre cement fragments arising from past incidental contamination or as residual fragments remaining following removal and demolition of buildings and structures. Where the total quantity and distribution is very low, these fragments may be removed under an established safe system of work for the site. In general, a small number of fragments can be carefully collected, secured in a labelled, heavy-duty plastic bag or wrapped in heavy-duty plastic (minimum 0.2 mm thickness) for transport and disposal to a licensed waste facility.

Specific procedures for handling small quantities of dispersed asbestos cement fragments and when and how to report hotspots and unexpected finds will need to be addressed through site-specific work health and safety procedures, site inductions and awareness training. Such procedures should include the decision making criteria for reporting more extensive contamination under the CS Act (Section 2.1).

The possibility of asbestos being present in underground structures, including infrastructure, buildings, footings and slabs, must be considered in cost estimates for land redevelopment projects. The discovery of asbestos impacts during excavation works can cause significant delays and cost overruns for redevelopment and become the subject of ongoing legal proceedings. **Case Study:** Trouble at the mill: Developer Glenvill sues Amcor over Alphington clean-up (external site).

2.2.5 Structures above and below ground

While still hazardous, asbestos that is ‘part of’ or ‘wholly contained’ within a building or other structure does not meet the definition of ‘contaminated’ and is not required to be reported under the CS Act. In these circumstances, other legislative controls apply.

Intact underground infrastructure on occupied commercial/industrial land, whether in live service or disused, e.g. asbestos cement pipes, may be managed through existing asbestos management programs required by WHS legislation, including the inclusion on organisational registers and/or prioritised removal programs. In determining whether disused or obsolete structures may be managed in situ or prioritised for removal, consideration should be given to the existing prioritised removal plan and whether the property owner or manager can manage the site in perpetuity, such as through institutional controls. Removal methods with minimum dissections and that prevent breakage are preferred.

Where land is being subdivided and redeveloped, a plan should be made to demolish and remove any remaining unrequired or disused above and below ground asbestos-containing structures, in accordance with WHS legislation and national policy for prioritised removal of asbestos.

For sites not subject to WHS legislation (e.g. residential development, road reserve), where the removal of disused/obsolete underground infrastructure is restricted, or a decision is made that the underground infrastructure is better left undisturbed, the land must be reported under the CS Act to ensure it is appropriately classified under the CS Act to inform future owner/occupiers of the presence of underground asbestos-containing materials.

Chapter 3

Assessment of asbestos contaminated sites

3.1 Overview

The WHS and health regulations described in Chapter 2 allow for immediate asbestos removal and soil clean-up of asbestos soil contamination associated with contemporaneous demolition of structures, recent illegal surface dumping and/or limited residual surface or low scale impacts. Where immediate removal is not possible due to the nature, extent or spread of contamination and there is a need for further assessment, a decision may be made to report the affected property as a contaminated site (Section 2.1). Once a site is reported, the investigation, assessment and management process is set out in the Contaminated Sites Guidelines (external site) and National Environmental Protection (Assessment of Site Contamination) Measure (ASC NEPM).

The key objective of an asbestos contaminated site investigation is to characterise the nature, quantity and extent of the asbestos in the soil in sufficient detail to inform remediation and/or management of the site for the protection of public health. As such, the scope of site investigations and the sampling and analysis plan must be aimed at:

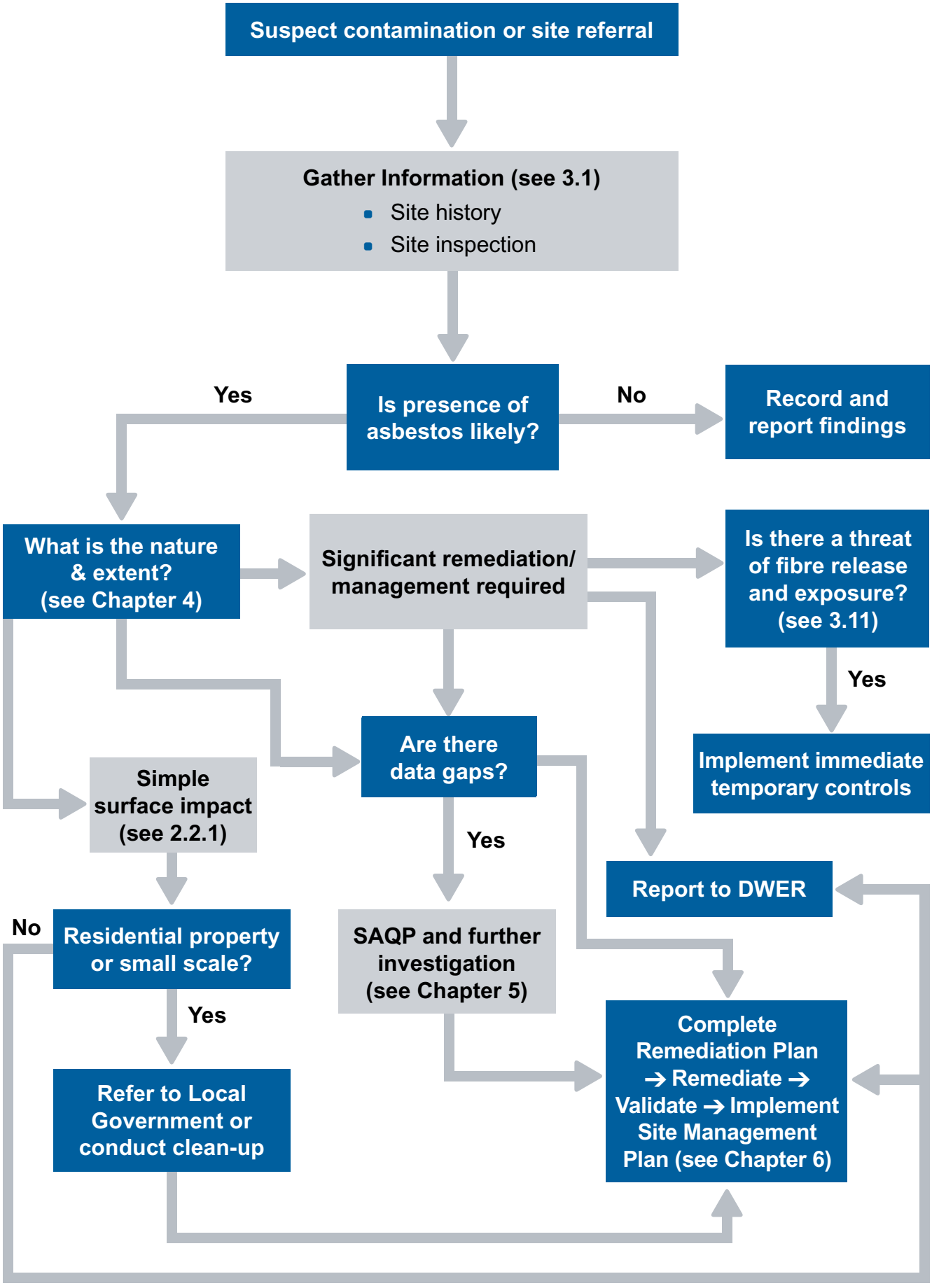
- addressing the data gaps regarding the nature, quantity, location and dispersion of asbestos contamination
- proposing feasible remedial options and developing a remediation plan/procedure for the preferred option
- establishing validation criteria for the removal or containment of sources of asbestos contamination.

Asbestos is a nationally controlled and regulated hazardous substance with restrictions on use, sale/supply, transport and disposal. As such, the decision for remedial action is often taken where contamination is found above screening levels (Tier 1 assessment) without undertaking further risk assessment.

The processes for further assessment (Tier 2 and 3) assessment and health risk assessment are described in the ASC NEPM Schedule B4 (external site). A health risk assessment may be completed and occur as part of a more detailed site investigation or as a separate activity/report. A health risk assessment may be undertaken to address real or perceived health risks associated with the site and can aid stakeholder communication and consultation.

Remediation options are preferred, which minimise the potential for release of airborne asbestos fibres and also minimise the volume of asbestos contaminated material handled, transported and disposed to landfill. Where feasible, containment and management in situ is supported.

Figure 5 Site investigation and management process



3.2 Site investigation process

Site investigations must be undertaken in accordance with the Contaminated sites guidelines: Assessment and management of contaminated sites, (DWER 2021) (external site).

The initial steps of an investigation undertaken for assessment and management of contaminated sites include:

- checking the site history
- systemic visual site inspection/walkover
- preliminary soil sampling.

These steps are important in determining the likely presence, type, condition, quantity, and distribution of suspect asbestos contamination, developing a conceptual site model, and directing any subsequent investigation and management actions.

Given the physical nature of asbestos contamination, particularly bonded ACM, much more information can be gathered at the early stage of an investigation than for other contaminants. Visual indicators and field sampling provide immediate results, and data gaps may be addressed as they arise. Results from sampling and field analysis can be used to implement pre-considered remediation and validation actions. For example, for an investigation area with simple surface bonded ACM impacts, it may be possible to concomitantly:

- complete the site investigation
- delineate the impacted area through successive surface sampling
- undertake multiple passes to record and remove the surface impact
- validate the impacted area as clear of visible bonded ACM on the final pass.

Early confirmation of the presence or potential for asbestos contamination has three main advantages:

1. Early consideration of possible remediation/management options.
2. Protection of site workers before more extensive site investigation works being undertaken.
3. Prevent the spread of contamination.

If asbestos contamination is missed and is then accidentally dispersed 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.

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.

The need for a more extensive investigation will depend on the conceptual site model (CSM) data gaps. (See Section 3.7). Further investigations may provide:

- greater accuracy in delineating the lateral and vertical extent of impacts to inform site remediation plan/procedures
- a better understanding of future land uses and activities that may lead to the release of airborne fibre and possible receptors, e.g. maintenance workers for underground services, trespassers, recreational activities, construction/site works.

Additional investigations may also be necessary where new evidence of contamination arises, such as:

- vandalism or degradation of structures containing asbestos on a reported site
- identifying new contaminated areas, e.g. following site excavations
- wind or storm damage
- cross-contamination by earthworks and movement of materials and stockpiles

Information from additional investigation may be used to update conceptual site models to include any changes in site conditions, surrounding environment and possible receptor exposures.

3.3 Site history

A site history or desktop investigation consists of compiling and assessing information from relevant records and interviews. This investigation should include:

- historical site use, including site buildings, structures and associated utilities which have the potential to contain asbestos
- an evaluation of records to determine the presence of asbestos in any remaining or demolished structures, including any:
  - asbestos register
  - demolition permits, asbestos removal plans and/or clearance certificates
  - site or building plans
  - previous environmental or geotechnical investigations identifying building or commercial/industrial waste
  - local authority records/permits
- Landgate (external site) records
- anecdotal information regarding the site history and use (sources include site owner/family members, neighbours, local government, historians)
- analysis of historical aerial photographs to identify past structures and possible disposal, burial and dumping activities
- information relating to the character and extent of any fill material, especially that which was derived from building waste
- the likelihood of unexpected discovery of building(s) and/or structure(s) that main contain asbestos that may be in the pathway of planned soil disturbance.

The above information should be reviewed to identify situations where asbestos contamination may be expected or suspected to be present, such as:

- 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-1990 buildings or structures damaged by fire or storm
- land with fill or foundation material of unknown composition
- commercial and residential sites where buildings or structures have been constructed using bonded 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-1990s buildings or structures have been improperly demolished or renovated, or where the relevant documentation is lacking
- disused services made from asbestos cement – e.g., water pipes, telecommunication trenches or pits.

Where a clearance certificate/report has been provided for site demolition and removal activities, it must be reviewed together with any available asbestos removal plans to ensure that soil contamination was addressed at the demolition/removal stage. A comprehensive clearance report and asbestos removal plan that addresses soil contamination issues may be relied upon if there is no further evidence of asbestos contamination from recent or past land uses.

3.4 Site inspection

More intensive initial site inspection/walkover is expected for asbestos contaminated sites, given the physical nature of the contaminant. Surface inspection methodology can include the early sampling of bonded ACM and other suspect materials (see Chapter 5 for sampling methodologies).

When reporting the site inspection/walkover results, it is critical that the report comments specifically on the presence or absence of asbestos material and the inspection methodology.

The inspection methodology should be based on set objectives developed from a conceptual site model (see Section 3.7). The site inspection methodology must be scoped and designed to adequately inform decision making for subsequent stages of investigation or management.

The focus should be on judgmental investigation of areas that have (or are suspected of having) asbestos contaminated soils, e.g. waste deposits, former building footprints. Consider the following:

- site history (Section 3.3)
- areas that could reasonably be expected to be contaminated (e.g. building footprints)
- visible evidence of contamination
- the likely distribution and scale
- the likely depth of contamination
- hidden contamination (e.g. dense vegetation, buildings and structures, hardstand areas)
- soil type and physical properties.

The site inspection/walkover should include a description of:

- any remaining asbestos-containing structures, especially if in poor repair
- footprints of demolished structures (including fences, drains and soakwells)
- waste and debris on the surface of the site
- any uncontrolled fill (particularly if it contains building or industrial waste).

Site walkovers for finding surface asbestos occurrence and distribution should be grid-based to facilitate good coverage of the site and facilitate the logging of visible evidence of possible contamination. Areas with suspect or known asbestos contamination should then be surveyed and assessed in more detail (see Chapter 5).

Visual inspection reports need to include comments on the presence or absence of any suspect asbestos or other indicative findings and the inspection methodology. The decision-making parameters and methodology used for inspection, including any variations from these guidelines, should be justified and reported

EXAMPLE – SITE INVESTIGATIONS AND FINDING EVIDENCE OF ASBESTOS CONTAMINATION

All field technicians and contract workers working with AAA Enviro Consultancy Pty Ltd have completed in-house asbestos in soil training course and on the job mentoring program. Company procedures state that suspect asbestos contamination sources need to be recorded at every stage of any site investigation.

During the initial walkover at a commercial/industrial site, a field technician notes the location of suspect waste building waste materials on a map of the site. The site is divided into large grids, and a field notation is made of the densities of different type of debris as they walk over a grid area. Broken bricks, concrete, fibre-cement fragments and tiles are noted in particular grids. A number of test pits are made in the grid areas of observed contamination to consider the vertical extent of observed surface impacts. All test pits show that debris is found no deeper than 15 cm from the surface.

An investigation area is defined by the lead investigator based on the findings of the site walkover and site history. An SAQP is developed that includes dividing the investigation area in smaller 2 m x 2 m grids, collecting suspect debris for bulk identification to confirm the presence of asbestos, and soil cross raking and sampling to 15 cm. All suspect asbestos materials are separated, weighed and described. Several fragments of suspect asbestos contamination representing the variety of visual materials observed are sent for laboratory confirmation for the presence of asbestos.

The bore logs for ground water monitoring wells include a detailed description of the soil layers and the presence/absence of introduced fill. The logs specifically state that no fibre containing waste (insulation, textiles, fibre-cement) or building waste debris is observed. The lead investigator confirms there is no site history evidence of uncontrolled fill at the site and considers all the information from the walkover, more detailed surface investigations, bore logs and site history before finalising the CSM.

3.4.1 Visual indicators of contamination

If contamination is from broken asbestos cement sheeting or other bonded ACM, where the material retains its integrity, any co-located AF (smaller size fraction material) may be considered ‘trivial’ in proportion to the bulk bonded ACM source. In these circumstances, the investigation and remediation areas can be assessed and validated using bonded ACM as the primary measure of contamination.

The presence of other building or industrial waste material may suggest/provide evidence for the presence of asbestos contamination.

It may also be possible to visibly distinguish bulk FA in soil. However, FA mixed in soil may not be visible and may be best sampled as AF (see Chapter 5).

3.4.2 Laboratory confirmation of contamination

3.4.2.1 Suspect materials

Laboratory confirmation for suspect materials is important as the appearance of bonded ACM or FA in the ground is disguised through destruction and discolouration such that it may become difficult to identify.

It is possible to assume the presence of asbestos within a material based on knowledge of asbestos-containing products and the age and appearance of materials. The alternate assumption must not be made (that a suspect material does not contain asbestos). However, it is recommended that a NATA accredited laboratory always confirms the presence of asbestos in suspect materials.

Figure 6 Examples of known asbestos-containing materials – fibre rope seal, textile materials and weathered low density fibre board.

3.4.2.2 Asbestos Fines in soil

Laboratory confirmation for AF in soil would be indicated where asbestos contamination has been severely degraded or broken down, leading to a likely increased proportion of AF in soil.

For example, observation of unusually high numbers of very small sized debris that suggest the destruction of original source material or site history suggesting the destruction of material, including:

- evidence of pulverising, crushing, cutting, sawing, sanding, or other means of the breakdown of bonded ACM into fine material
- use of high-pressure cleaning of asbestos cement sheeting.
- damage by fire or other natural disasters
- severe weathering/deterioration (Figure 7).

Where FA is suspected to be present, it may be more readily broken down into fine material and mixed with soil, which will make it difficult to identify and quantify visually. As such, the delineation of contamination is likely to require soil sampling and laboratory analysis for FA as AF in soil (See Chapter 5).

Figure 7 Fire damaged asbestos cement flue.

Figure 8 FA in soil (photo courtesy of Aurora Environmental).

3.5 Sampling

Chapter 5 – Sampling, Monitoring and Analytical Methods, provides detailed information on sampling methodology and common analytical methods for assessing asbestos contamination.

3.6 Delineating extent of contamination

Delineating the extent of asbestos contamination is required to inform remedial options where asbestos is present at or above screening levels. Information to be considered for delineating the impact is provided below.

- Where there is good information on the origin of the asbestos contamination, the lateral investigation area can be considered to include the entire area likely to have been impacted, with confirmatory sampling extending slightly beyond the suspect area in all directions.
- The depth of contamination may be either be inferred from the desktop investigation or informed by targeted sampling.
- In both the above cases, the need to confirm the extent of contamination will depend on site-specific data requirements for possible remedial options and data gaps/uncertainty associated with the suspected area of impact.

3.7 Conceptual site model

A conceptual site model with illustrated source-pathway-receptors must be derived that includes all activities associated with the site, including existing and future uses. Possible receptors include:

- site remediation personnel
- earth moving and construction workers
- site visitors and trespassers
- future owners/occupiers
- adjacent residents or workers
- underground service maintenance workers.

Consideration should be given to any asbestos remaining in structures that will be subject to demolition or disturbance so that they can be handled in compliance with the WHS legislation and in such a way, they do not result in asbestos soil contamination.

The only exposure pathway of concern is inhalation of airborne respirable fibres. As such, consideration must be given to the potential for activities at the site to generate or release respirable fibres. While natural erosion forces may be considered, in most circumstances, these are unlikely to significantly contribute to an amount of exposure to respirable particulates within a recipient's breathing zone to a level or duration that increases disease risk.

For a simple assessment (Tier 1), a precautionary approach is taken that assumes an exposure pathway is complete where there are people at the site, and a recipient could interact with the asbestos contaminated material (e.g. recipients have access to the asbestos in soil either at the surface or from excavations). Tier 2 assessment may include a more comprehensive site-specific exposure assessment that includes the factors outlined in Section 3.11.

3.8 Screening levels for asbestos in soil

In establishing screening criteria, consideration has been given to the following principles and assumptions used for regulating and controlling asbestos at a National level:

- screening criteria do not distinguish between commercial asbestos mineral fibre types
- the reporting, assessment and management of asbestos contamination under the CS Act provides a mechanism to inform and protect persons from potential future exposure to asbestos-contamination
- fibres are more likely to be released from both FA and AF than from bonded ACM
- bonded ACM in soil is assumed to eventually (over a long period) degrade to asbestos fines as a result of damage or destruction over time
- exposure to asbestos, which has no evidence of a threshold level for mesothelioma risk, should be kept as low as reasonably practicable.

The criteria are summarised in Table 2 and remain the same as in previous Department of Health guidance. A background in establishing screening criteria is provided in Appendix One.

Table 3 Asbestos in soil screening levels

Site uses[4]	Soil asbestos screening criteria
All site uses – FA	10 mg/kg (0.001 %) w/w asbestos
All site uses – AF	10 mg/kg (0.001%) w/w asbestos
Residential A – bonded ACM	100 mg/kg (0.01 %) w/w asbestos
Residential B – bonded ACM	400 mg/kg (0.04 %) w/w asbestos
Recreational C – bonded ACM	200 mg/kg (0.02%) w/w asbestos
Commercial/Industrial D – bonded ACM	500 mg/kg (0.05%) w/w asbestos

3.8.1 Application of investigation and screening levels

The criteria for FA and AF remain fixed for all site uses as there is high uncertainty associated with quantifying asbestos concentrations below 0.01% w/w asbestos. As such, the sampling error and lack of analytical sensitivity in establishing concentration differences between 0.001% w/w and 0.01% w/w would make any adjustment at this order of magnitude meaningless. Example calculations for estimating asbestos in soil concentrations are provided in Appendix Two.

Inadequate sampling strategies rather than lack of accuracy in the adopted analytical methods characteristically limit the effective evaluation of sites contaminated by asbestos.

As for other contaminants, the results from soil analysis must be interpreted in the context of the information obtained from the broader site investigation and applying professional judgement on whether the criteria have been exceeded. More information is provided in Appendix B1 (external site), Section 3 of the ASC NEPM.

[4] Classification of site uses as per the ASC NEPM.

The use of statistics may be appropriate in some circumstances. However, justification for the use of statistics, along with a description of any limitations and assumptions and compliance with DWER Contaminated Sites Guidelines and ASC NEPM, must be provided.

The final decision regarding assessment against criteria should include multiple lines of evidence for which statistics may contribute but not be the sole decision-making parameter. If using statistical analysis, the following must be considered:

- where more than one distinct fill or soil stratum is impacted, separate determinations should be made for each section
- sampling strategy, including sample locations, sampling methods, and sampling density, is designed to find localised hot spots
- sampling strategy considers future subdivision plans with a sample distribution that includes each proposed lot
- where an individual sample result is equal to or greater than 0.1 % w/w asbestos soils, for any form of asbestos, the surrounding soils are subject to higher density sampling to confirm/delineate a hot spot and the impacted soils remediated.

For mixed waste materials (e.g. coarse aggregate material vs soil), a judgemental and semi-quantitative approach may be necessary to estimate the contamination concentration. The extent of the investigation and the sampling plan should consider the remediation options for the mixed waste materials present at a site. Where it is necessary to provide advice against criteria, professional judgement will be required. It is expected that sufficient justification is provided within reports to support any decisions made.

3.8.2. Surface contamination

In addition to meeting the criteria in Table 2, the accessible ground surface (as designated by site investigations or the 10 cm default) should be free of visible bonded ACM and FA at the end of the remedial site works (expected site clean-up criteria). There are two main objectives for remediating the soil surface to be visibly free of asbestos:

1. Minimises the potential for ready access to any contamination (such as isolated fragments), resulting in further deterioration or misuse.
2. Addresses aesthetic, public perception and other regulatory expectations specific to asbestos.

3.8.2.1 Accessible ground surface determined by site investigation

The accessible, readily disturbed surface layer should be differentiated from the underlying soils when describing the site's soil profile. The factors in defining the surface soil layer and the depth to which superficial asbestos contamination is observed or can be reasonably expected to be found are:

- activities undertaken at their site and their frequency (e.g. walking, driving, sports activities)
- the likely depth of soil disturbance from site activities
- any mitigating factors (e.g. ground cover, compaction, soil type and condition).

For example, shifting and sandy soils with no ground cover may have surface bonded ACM contamination extending beyond 10 cm depth that can be encountered when walking or playing in the sand.

Test pits or other sampling methods may be used to verify/justify the inspection/remediation depth of the surface impacted soils.

3.9 Derivation of site-specific clean up criteria

The screening criteria are often used as default soil clean up goals. Site-specific clean up goals can be developed if any of a range of mitigating factors apply, such as the depth or form of contamination, binding or stabilising soil characteristics, or the nature of surface coverings.

The derivation of site-specific clean-up criteria should be limited to those parameters that will not change character with time. For instance, surface cover is less useful as its extent and integrity can change, whereas contamination depth is less likely to change. In applying this approach, the adjustment of each parameter must be justified and supported by evidence.

The parameters that best lend themselves to the derivation of site-specific criteria are:

- soil character
- contamination depth
- contamination lateral spread
- analytical method.

If any of these parameters are demonstrated to be mitigating for a particular site, they can apply to any of the asbestos types present, i.e. bonded ACM, AF and FA. The only exception is the analytical method parameter, as it relates only to AF.

Soil character would be an addition to current investigation requirements, and additional sampling will have to be undertaken to confirm parameters and provide confidence in any proposed site-specific clean-up goals.

Additional information on how the above parameters can be considered in the derivation of clean-up goals is available in Appendix Three. These parameters are also important in exposure assessment (Section 3.11).

As asbestos is a banned and controlled hazardous substance/waste, the second objective of remediating asbestos contamination must be considered, which is to inform site owners, occupiers and users regarding the presence of asbestos and enable compliance with all legislation. If all mitigating factors are considered, the amount of bonded ACM, AF and FA that can remain in the soil at levels that do not increase public health risk may still be subject to control by other legislation. **As such, the derived site-specific screening clean up goals may not exceed the maximum level of 0.1% w/w asbestos in soil**. That is, for deriving site-specific criteria, even where all the mitigating factors apply, and the conceptual site model demonstrates that there is no unacceptable health risk, the maximum amount of material that can remain at a site without any form of remediation, control, or management is 0.1% w/w asbestos.

The derivation of site-specific clean-up goals will most likely be applicable in supporting sustainable, in situ remediation and management options.

Any adjusted site-specific goals must still be below 0.1% w/w asbestos content (Globally Harmonised System of Classification and Labelling of Chemicals (GHS)).

When considering regulatory requirements (and potential requirements for analytical testing) of soil being removed from a site, practitioners should first address whether the soil meets the definition of waste. (see Factsheet – Assessing whether material is waste (external site)). Material removed from site for disposal or re-use that meets the definition of waste will need to comply with the *Environmental Protection (Controlled Waste) Regulations 2004* and *Landfill Waste Classification and Waste Definitions 1996* (as amended 2019).

3.10 Air guidelines

A practical air quality control limit of 0.01 fibres per millilitre (f/mL) asbestos applies to all **removal work**, including around contaminated sites, as described by the Membrane Filter Method. [NOHSC:3003(2005) (MFM). (See Section 5.9.1)

It is important to note that the control limit **should not be used to evaluate recipient exposure risks**.

Exposure should always be minimised to as low as can be achieved by implementing effective dust control measures.

Personal sampling results for any site personnel should be below the occupational exposure standards (0.1 fibres/mL) or the site-specific action level adopted as part of the workplace risk assessment.

No ambient air guidelines have been set for asbestos. A cumulative exposure of 0.01 f/mL.yr is estimated to increase risk above 1 x 10^{-5} for mesothelioma for crocidolite and amosite fibres (Hodgson and Darnton, 2000). Exposure assessment would need to consider the duration of exposure and, potentially, the use of air monitoring reference methods that allow for a lower limit of detection.

Dust (particulate) monitoring may accompany other asbestos specific sampling during remediation activities for more immediate responses to any failures in dust management measures. The Air NEPM 24-hour guidance goal of 50 µg/m^3 for PM_{10} (particulate matter with an equivalent aerodynamic diameter of 10 µm or less) is often applied as an action level for total dust control.

3.11 Exposure assessment for public health

A quantitative or qualitative exposure assessment that assumes reasonable and probable worst-case exposure scenarios can be undertaken for asbestos contamination. Such an assessment can provide additional confidence in conclusions and recommendations, aid in health risk communication and/or provide support and justification for site-specific clean-up goals.

The magnitude of the asbestos contamination hazard depends on the potential for respirable fibres to be released from soil which is influenced by among other things:

- the type and condition of asbestos present
- the quantity/concentration of asbestos present in soil
- the depth and extent of contamination
- soil type and physical properties
- nature of surface coverings, including presence of vegetative cover
- soil moisture content.

Exposure assessment should consider reasonable worst-case seasonal variations for each of the above factors at each site. Also, the measurement of various parameters, e.g. soil moisture, can be included in the sampling plan.

It is also important to note that while the above factors are suitable for understanding the magnitude of the asbestos in soil hazard, the most significant contributing exposure factor will be the human activities/tasks that directly create and/or release dust and airborne fibres.

Exposure assessment should consider:

- future site uses
- the duration and frequency of dust-generating activities and likely levels of airborne (respirable fraction) particulates
- quantification or estimation of fibre in air concentrations during current and future site activities
- mitigation through proposed remediation and management measures.

Methods for completing an exposure assessment include:

- qualitative exposure assessment based on investigation and assessment of the site, activities undertaken, the potential for particulate/fibre release and expected air concentrations
- task/activity-based sampling for activities being undertaken at the site
- simulation of past or future tasks/activities likely to be undertaken at the site (may require additional approval from WorkSafe Division or the WorkSafe Commissioner).

It is not easy to estimate exposure for all uses of a site confidently. The feasibility of undertaking monitoring during exposure assessment should be carefully considered (See Section 5.9.2). However, in some circumstances, such as to demonstrate support for sustainable options for in situ remediation or to provide health risk information on possible past exposures, it may be justified.

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 air monitoring results, the exposure assessment should be reviewed, and the CSM updated.

Chapter 4

Characterisation of contamination

Characterisation should clearly summarise the evidence of contamination at a site with regard to the distribution within the surface layer and fill, nature and extent of the contamination and any remaining uncertainties. The discussion should consider trends across the investigated area, including variability and change in asbestos type and condition. Where there are several sources of impact, these should be identified and discussed separately. Occasional or isolated/sporadic occurrences of asbestos contamination found either below screening criteria or removed during works should also be included in any report.

Characterisation will inform:

- the CSM and the degree to which an individual or group may be exposed to airborne asbestos fibres
- proposed remediation options
- legislative requirements required for compliance with legislation on the handling, removal and disposal of asbestos (See Chapter 2).

Detailed characterisation minimises project delays and costs and facilitates both:

- the planning of effective and compliant remediation
- long term management solutions to prevent or minimise disturbance of materials

For Tier 1 assessment, the soil contamination concentrations should be directly compared against the soil screening levels. If exceedances occur, a precautionary approach can be taken to remediate the site using screening levels as the clean-up goal as a means of minimising lifetime exposure risk. Conclusions or categorisation of risks based on a Tier 1 assessment should be adequately explained. In many cases, a Tier 1 assessment only informs the presence/magnitude of the hazard rather than the risk to health.

In some cases, minor contamination of the surface layer, such as the presence of isolated asbestos cement fragments or other bonded ACM, may be encountered at a site. Even where these sites are not reported under the Contaminated Sites Act 2003, any surface contamination must still be managed as small scale or limited impact contamination in compliance with good practice and legislative requirements and Guidance Note on the Management of Small-Scale Low-Risk Soil Asbestos Contamination – May 2009 (PDF 121KB) (under review).

The precautionary approach to remedial action at a Tier 1 level of assessment and to remediate any amount of visible surface contamination is consistent with national policy and other State legislation requiring the control, removal and disposal of asbestos. Consequently, results presented as being below screening criteria for site classification need to be based on rigorous and well justified investigative work, but there will still be a need to remove isolated/sporadic amounts of visible contamination in compliance with OSH or Health legislation (See Chapter 2).

A Tier 2 or 3 site assessment, including the development of site-specific clean-up goals (See Section 3.9), can be undertaken and will need to include more comprehensive discussion on the site-specific exposure scenario(s) (See Section 3.11).

The final assessment against criteria will depend on the CSM and the data quality objectives and the relevance of findings, including interpreting sample results.

In high exposure risk circumstances, the need for immediate exposure control measures should also be considered as per **Immediate Response Actions and Contingency Plans (to be updated).**

The report should also comment on the limitations and uncertainties associated with the site investigation process.

It is important that the overall evaluation process be transparent, logical and reliable. Where the local community or other stakeholders raise concerns, consideration should be given to addressing and effectively communicating health risks. Note that interested stakeholders may read any investigation reports; therefore, all statements regarding health risks must be well supported.

Chapter 5

Sampling and analysis

5.1 Sampling and analysis quality plan

A sampling and analysis quality plan (SAQP) should be developed based on data quality objectives influenced by site-specific variables and project-specific data gaps and goals. The sampling and analysis plan should comply with the *Assessment and Management of Contaminated Sites (DWER, 2021)* and the ASC NEPM.

The SAQP should include a written protocol and procedures for the proposed sampling. Standard reference methods and procedures may be included as an appendix to the investigation report. The methodology should comply with the Contaminated Sites Guidelines and be demonstrated to be effective in previous investigations or trials.

When designing the SAQP, the following key questions should be addressed:

- What is the sampling intended to demonstrate?
- What is the current conceptual site model (CSM) or hypothesis, and how will data be used to verify, disprove or modify the site model?
- How will data gathered be used to make management or remedial decisions?
- What confidence level is necessary to aid in decision-making?
- Will the investigation meet the data quality objectives?

The SAQP should attempt to anticipate any likely constraints or limitations (e.g. access, vegetation, hard standings, buried structures) that may affect the accuracy and completeness of data and develop strategies to compensate and mitigate for these constraints and limitations in advance.

All contaminated sites SAQPs should allow for additional, discretionary asbestos contamination sampling to be conducted where it is possible that suspect material may be encountered during other contaminated sites works, even where asbestos in soil contamination has not been previously identified. For example, consideration should be given to the potential for construction waste to be buried on-site.

As results from field analysis are immediately available, allowance can be made in the SAQP to undertaken additional confirmatory or delineation sampling rather than return for subsequent investigations. Decision criteria for additional sampling may be outlined in the SAQP.

Sampling is required for both the site investigation (e.g. to delineate the impacted area to inform a remediation plan) and to validate remedial work against pre-determined objectives. Any delineation sampling will depend on the contamination circumstances but should ensure the impacted area is confidently captured, especially for areas of higher asbestos concentrations and fibrous asbestos.

The sampling strategy should be aimed at addressing data gaps and meeting the objectives of the site investigation. An investigation to confirm the extent of asbestos cement debris from a damaged structure may entail a less rigorous sampling program than an investigation required to confirm the various forms and quantity of asbestos contamination suspected to be mixed through uncontrolled fill brought to a site.

If the asbestos contamination is associated with a layer of uncontrolled fill, where feasible, the whole extent of the fill may be considered impacted and subject to remediation (e.g. containment). Supporting evidence and/or an intensive sampling regime must be provided to demonstrate otherwise, i.e. that suspect uncontrolled fill is not contaminated.

Consideration should always be given to the need for air quality monitoring data to assess whether airborne fibres are present.

5.2 Sampling approaches

Targeted judgmental sampling targets particular sampling locations based on known or likely asbestos contamination or to address data gaps. Judgemental sampling depends heavily on a thorough site inspection that properly identifies the targeted investigation area and relevant, representative sampling locations.

Grid sampling (for example, using 4 m x 4 m grid) is likely to be indicated when asbestos contamination is known to be widespread (e.g. cutting and filling are known to have occurred, mixing asbestos contamination through site soils) or where there are data gaps from site investigations and it can be reasonably suspected that contamination may be present at unknown locations (e.g. historical uncontrolled fill).

If the contamination is buried, then **test pits or trenching** are useful methods for identifying contamination and can be used in conjunction with judgmental or grid-based sampling.

The following situations are examples of judgmental sampling:

- “hot spots” are identified by the earlier stages of site investigation, and additional sampling is undertaken at the edges of the hot spot area to confirm the lateral extent
- sampling locations targeted within the former building ‘footprint’ of removed building structures known or suspected to contain asbestos building products
- adjacent to a below-ground service to delineate contamination from damaged asbestos-containing, below-ground infrastructure.

For pre-1990[5] buildings that have been removed, sampling within the footprint area may include targeted AF sampling locations corresponding to soils within soak wells and roof rainwater run-off locations, especially for former large commercial buildings with a large expanse of asbestos cement roofing.

5.3 Sampling triggers and densities

The sampling strategy selected will be primarily at the investigator’s discretion, with justification for any minimum number of sampling points considered for a particular site. For sampling strategies that include grid sampling for locating hot spots, the density should be some multiple (see Table 4) of the sampling density shown in Table 5.

The first three “likelihood” categories primarily apply to the low or uncertain likelihood of contamination. The fourth and fifth category, ‘Likely’ and “Known”, apply where characterisation of contamination (e.g. screening, confirming or delineating) is required.

[5] While manufacturing of many building products containing asbestos ended earlier, using 1990 provides a buffer for use of stock and construction time.

Therefore, sampling locations and density will be based on the nature of the contamination and the precision of lateral delineation required for any proposed remediation options. That is, sampling density will be influenced by evidence of contamination and data requirements for characterisation or remediation. The selected sampling densities and sample volumes for asbestos may be higher than for other contaminants, as asbestos contamination can be widespread and heterogeneous. However, for bonded ACM and FA, it is feasible (easier and inexpensive) to fill data gaps through successive field analysis from immediately available results.

Table 4 Sampling densities

Likelihood of asbestos	Example Scenarios	Sampling density
Unlikely	– grazing land with no building history – site developed after 1990	– no sampling required without evidence of contamination
Possible	– uncontrolled fill without building waste – undeveloped site (possible dumping)	– sampling of uncontrolled fill at 0.5 sampling points in Table 5.
Suspect	– uncontrolled fill with building waste – dumped waste material – demolished structure footprints (pre-1987)	– sampling points as per Table 5 for uncontrolled fill with at least 1 sample per final lot for subdivisions – every 5 – 10 m for building footprint – hot spot sampling for dumped material
Likely	– industry associated with asbestos – some isolated asbestos found – landfill present	– double the sampling points in Table 5 across surface and depth.
Known	– asbestos has been identified and needs further delineation	– judgmental graduated targeted sampling for linear extent and depth

Table 5 Minimum sampling points required for detection of circular hot spots using a systematic sampling pattern at 95% confidence level (AS 4485.1)

Investigation area ha (m2)	Number of sampling points	Equivalent sampling density (points/ha)	Diameter of hotspot that can be detected with 95% confidence	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.
3. Judgmental sampling is preferred to grid-based where possible.

5.4 Surface sampling

These Guidelines require that all visible surface contamination is removed even where contamination levels are below the screening criteria.

Accessibility of the site surface should be addressed in the SAQP. The surface should include the readily accessible and disturbed surface layer, which may vary depending on the soil type, seasonal vegetation cover and compaction of the soil surface (default of 10 cm depth).

Table 6 describes the surface sampling method compatible with concomitant removal and validation processes (See Section 6.8 for validation requirements) from handpicking to remove asbestos material.

5.5 Sampling of bonded asbestos-containing material and fibrous asbestos

These guidelines and the ASC NEPM (1999) acknowledge that larger-sized fragments and quantities of bonded ACM and FA are likely to be visibly distinguishable in soil. Where site conditions are conducive, visible bonded ACM and FA may be used as the primary measure of contamination.

Suspect products/materials (e.g. fibre-cement sheeting, textiles, lagging) should be identified along with a description of the type of asbestos (bonded ACM vs FA). It is important to note that the appearance of the product/material may be disguised when mixed in with soil or other waste materials. As such, testing of suspect materials for asbestos fibre identification (NATA accredited laboratory for asbestos mineral fibre identification in bulk samples by PLM) is an important step in site investigations to confirm and characterise asbestos contamination in mixed materials and soils. A representative sample of each different type of suspect material should be collected. Once positive asbestos identification results are available, all material similar in appearance can be assumed to contain asbestos. The alternative assumption that any similar material does not contain asbestos cannot be made. Laboratory confirmation must be provided for deciding a material does not contain asbestos.

Great care needs to be taken to manage associated fibre release when sampling FA. The sampling methods used should minimise disturbance. Note that sieving is not recommended for quantifying FA.

Most reported asbestos in soil contamination is from fibre cement fragments. Field analysis allows information to be collected on the fragment size, distribution and relative proportions of fragments collected for any consecutive sampling passes. Field reports should document the locations, numbers and mass of fragment samples collected. The use of small grid patterns across an investigation area facilitates the notation and characterisation of surface contamination. Photographs are also highly recommended.

The presence of building and construction waste or industrial plant and equipment waste (e.g. gaskets, seals, pipe lagging, fibre ropes) from a time before the national ban on asbestos would be sufficient evidence that asbestos contamination is probable. The presence and relative quantity and distribution of associated waste material should be reported.

5.6 Sampling of asbestos fines contamination

AF are distinguished by their size and may include small fragments of bonded ACM, asbestos contaminated dust and debris from structures or loose fibre bundles that have become mixed with soil. Observation and estimation of AF in a soil sample is completed by a NATA accredited laboratory (Appendix Four).

Since these Guidelines were introduced in 2009, many sites have been reported with contamination from bonded asbestos cement fragments in reasonably sound condition. Sampling results support previous assumptions that AF contamination associated with broken, bonded asbestos cement fragments is minor.

AF sampling is necessary where there is information available that the AF portion is a non-trivial portion of the asbestos in soil contamination. For example,

- many smaller sized fragments are present suggestive of bonded ACM having been crushed or pulverised
- bonded ACM is known to have been subject to crushing or breakdown through the use of powered tools or equipment or from fire, for instance.

These impacted soils/areas should be regarded as potentially contaminated with AF, with a separate AF sample collected to estimate the concentration of asbestos in soil.

The nature of contamination may allow AF to be assumed to be present (e.g. probable AF contamination of soils around FA material) with sampling and analysis used to delineate the outer boundaries of the impacted area for remediation and provide validation following clean up. Where localised high concentration of AF is present, it may also be visibly discernible from the surrounding soil, and sampling can again be targeted to delineate the impacted soils and validate sampling following clean up.

To investigate AF, **separate, targeted and representative** samples of the suspect AF in soil should be collected. That is, AF sample collection should not be from a tampered with or mixed sample or diluted from a larger sample (e.g. collected from a sieved 10L sample).

Sample size should be determined based on data quality objectives. A sample of 500 mL (or approximately 1 kg) is generally sufficient to undertake quantitative estimates of the % w/w AF by conventional gravimetric methods by separating and weighing the <7mm fragments, fibre bundles and other asbestos debris observed within the known dry weight of soil.

5.6.1 Low concentration sample analysis

The soil sample size may be varied for specific data objectives. That is, the soil sample size should be selected based on the most appropriate sampling and analytical methodology required to meet those objectives (e.g. confirmation of fibre bundles or fibres present in soil may require a collection of a smaller, representative sample in the field which is preferable to laboratory sub sampling).

While there is currently no nationally adopted reference method to reliably quantify fibres, AS4964 provides a qualitative method that can identify asbestos fibres in soil, which may provide important supporting information for a site investigation. This has a practical limit of detection of 0.01 to 0.1%.

International reference methods may also be considered to estimate respirable asbestos fibres within soil samples in Tier 2 assessments. Further information is provided in Appendix Four.

5.7 Sample collection

This section outlines various methods that can be adopted in an SAQP for different investigation areas or assessment purposes or to provide supporting data for validating remedial works.

5.7.1 Bonded asbestos-containing material in surface soils

Surface asbestos cement fragments and other bonded ACM may be collected by hand (emu-bob) picking. Handpicking refers to the pick-up, collection and weighing of any visible asbestos-containing material across an impacted surface layer. Handpicking may be used to sample and concurrently remediate surface impacts. Table 6 describes the process and reporting of handpicking to remove asbestos material.

For loose soils, surface inspection and handpicking may include raking to ensure that the full depth of the surface layer is observed. The design of the rake (e.g. tine length and spacing) should be small enough that the bonded ACM debris present at the site does cannot pass through. Where this is not possible (i.e. debris is too small to be collected by the rake), the soil could be screened.

Where asbestos contamination is found, its quantification should relate to that particular immediate impacted surface layer. Care should be taken to prevent averaging and “dilution” of the calculated level of contamination. For instance, the level of contamination should not be quantified across a large raked or tilled area or large-sized grid area that contains both contaminated and uncontaminated soils.

Where raking across the surface is impractical or limited by dense vegetation, shallow surface trenching/sampling may be used that targets the cross-section of the impacted surface layer. Care must be taken when collecting the required sampling volume to avoid diluting the sample with uncontaminated layers. See Figure 9.

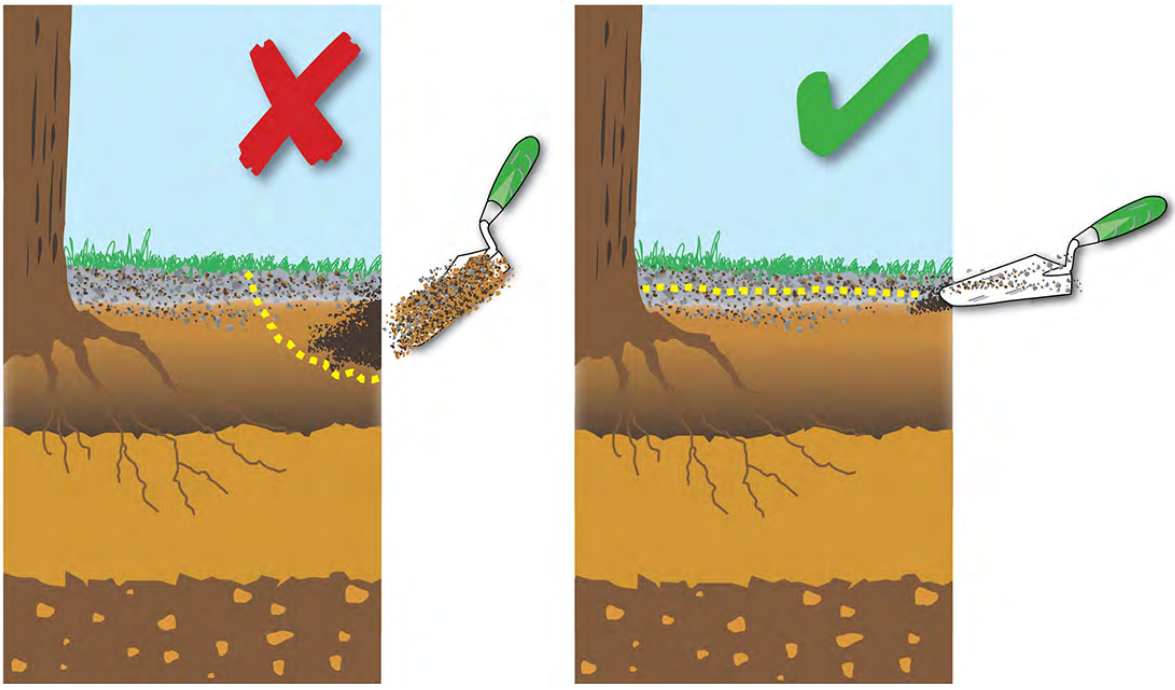


Figure 9 Collecting a representative and targeted surface sample.

A shallow 10L sample of impacted surface soils can be collected to estimate asbestos concentration as per the test pitting method Section 5.7.2.

Tilling (Table 7) refers to mechanically turning over surface soils to facilitate the presentation and collection of asbestos cement fragments. However, it is rarely used as it is generally difficult to implement and validate effectively. It is included here for completeness, but its use must be well justified by site-specific conditions.

Table 6 Summary of handpicking sampling method

Process

- Collect material from the soil surface, using a rake in sandy soils to uncover material in the accessible surface layer.
- The use of small grid sections facilitates notation and calculation of asbestos contamination.
- Most suitable for asbestos cement sheeting fragments or other well bonded ACM.
- Relevant where contamination is known or considered to be only on the soil surface (i.e. attributed to a defined event such as a building asbestos removal or dumping).
- Has limited application for contamination at depth or there is surface vegetation or debris.
- Used to characterise the extent and level of contamination and to validate surface clean up.

Implementation

- Record and report location and numbers of fragments, weights and description of collected asbestos material.
- Rakes should be selected, or purpose made, with tines of the smallest usable width and appropriate to reach the depth of surface soils being investigated.
- At least two passes of picking (and raking if appropriate) made with a 90º direction change between each and using a manageable grid pattern (based on level of contamination and soil characteristics).
- Material should not be further damaged or buried by the process.
- To validate concomitant removal, the final raked (3rd or more) pass and confirmatory lead inspector/auditor visual inspection of the area should not detect surface impacts.

Table 7 Summary of tilling sampling method

Process

- Suitable for asbestos cement sheeting fragments or other well bonded ACM.
- Generally conducted for large areas of impact across the entire area of suspected impact.
- Relevant for surface investigation and remediation of sandy soils - limited application for other soil types, deeper contamination or when there is substantial surface vegetation or debris.
- Used to characterise the extent and level of contamination while concurrently reducing bonded ACM impact.

Implementation

- Should be preceded by the removal of obvious larger pieces of bonded ACM to avoid breakage.
- Report and record the location and weights of asbestos material.
- Soils should be pre-wet to the tilling depth, dust control measures implemented, and personal and control monitoring undertaken during works.
- May require consultation with WorkSafe Division, DMIRS.
- Rows of tines (preferably non-rotary) should be spaced and designed to optimally reveal bonded ACM with 1 or 2 spotters walking behind tines at a controlled speed.
- Material should not be further damaged or buried from the process.
- At least two passes with 90º direction change using a grid pattern.
- Evaluated areas normally cannot be considered representative of other locations.
- Level of contamination may be calculated as per Appendix Two using an estimate of the average tilled depth and area for each grid.
- Final visual inspection of the area should not detect surface bonded ACM.

5.7.2 Test pitting and trenching

Sampling by test pits and trenching is the most common and effective sampling method for identifying and delineating bonded ACM and FA contamination below surface soils.

The excavation of soils allows differing strata to be identified and provides more confidence in sampling results.

Table 8 Summary of test pit and trenching sampling methods

Process

- Suitable for all asbestos types, but especially visible bonded ACM and FA (where fibre disturbance is manageable).
- Relevant if contamination is buried and of unknown location, distribution and depth.

Implementation

- Sampling should be conducted to below the likely lower limit of potential contamination or to virgin soils.
- Suspect asbestos material or building debris should be targeted, and all sample locations noted.
- The excavation should be such that the sidewall can be examined to assist sample targeting.
- Precautions are necessary to protect workers and the public from wall collapse or hole hazards and potential fibre release from excavation/sampling.

Bonded ACM and FA

- At least one 10 L or 20 kg sample from each relevant stratum (or per 1 m depth) of one wall and discretionary samples from other suspect spots.
- Sample screened manually through a ≤ 7 mm sieve or spread out for inspection on a contrasting colour material (recommended for suspect FA to minimise disturbance).
- Identified bonded ACM and FA weighed to calculate asbestos soil concentration for individual samples as per Appendix Two.

AF

- At least one targeted, wetted 500 mL or 1 kg sample from each representative strata or section of waste material and discretionary samples from other suspect spots.
- May be done in the same representative location as bonded ACM/FA sampling, either taken first (before screening) or at another wall position.
- Whole sample submitted for laboratory analysis.

5.7.3 Mechanical screening of bonded asbestos-containing material in soils

Mechanical screening is only suitable for separating bonded ACM from the soil. It can be used to quantify and remediate bonded ACM contamination in sandy soils concomitantly. It is most appropriate for low-level impacts. Mechanical screening may be subject to other local government or DWER approval.

Alternatives to mechanical screening that do not require extensive dust management are available and preferred where sensitive receptors are located nearby.

The sampling method is outlined in Table 9.

Table 9 Summary of mechanical screening validation sampling

Process

- Most suitable for low levels of asbestos cement fragments and other well-bonded materials.
- Mechanical screening is generally conducted across the entire area of suspected impact.
- Relevant for larger volumes of reasonably accessible and delineated contamination.
- Used to effectively confirm and characterise the extent and level of contamination whilst concurrently reducing bonded ACM impact.

Implementation

- Should be preceded by surface handpicking and/or separate and removing large material and concentrated hot spots.
- May follow a process of 'screening down' from larger mesh sizes to the final screening mesh size.
- Mesh sizes > 7mm x 7mm require validation sampling (screening process to include a "spotter" able to identify asbestos and include a minimum of 1 sample per 70 m3 from the conveyor).
- Impacted soil should not be mixed with other soil in a way that might compromise the concentration calculations (i.e. dilution is not permitted).
- Soils should be pre-wet with continued dust suppression and air quality monitoring outlined in a detailed Dust Management Plan that includes community and stakeholder consultation, where appropriate.
- The level of contamination may be calculated as per Appendix Two using the weight of asbestos found for particular strata, area or volume.
- Final visual inspection of the stockpile surface should be clear of contamination.

5.7.4 Bore samples

Test pits and trenches are recommended over borehole sampling for bonded ACM. Borehole sampling may be useful to prevent exposure to field workers where the main origin of contamination is loose FA (e.g. insulation, asbestos manufacturing waste). For FA contamination, borehole sampling may be suitable to provide data on material profile, distribution and depth to assist in the delineation of contamination

Where borehole sampling is considered for bonded ACM, it must be supported by appropriate data quality objectives as this method is unlikely to provide sufficient information regarding contamination levels of bonded ACM.

Consideration should be given to ensuring an appropriate sample size is collected, which should be addressed as part of the SAQP data quality objectives.

The process and its implementation are outlined in Table 10.

Table 10 Summary of bore sampling method

Process

- Most suitable for buried FA (e.g. buried loose-fill insulation or industrial waste).
- Relevant if contamination is buried and of unknown location, distribution and depth.

Implementation

- Sampling should be conducted to below the likely lower limit of potential contamination where the vertical delineation is required.
- Suspect soils should be targeted, and all sample locations/ depths noted.
- A larger corer diameter (e.g. 15 mm) should be selected.
- For FA samples, a split tube core sample is recommended, both to reduce potential exposure to personnel examining the sample and to better identify contamination within different soil strata. For suspect FA contamination, it is recommended that the entire core sample is submitted to the laboratory to be examined under controlled conditions and to allow sub-sampling of soil layers and separation and identification of suspect material.

5.7.5 Stockpile sampling

Soils should always be assessed in situ before any site works or material movement is undertaken.

In some circumstances, retrospective assessment of fresh stockpiles is required following evidence of asbestos contamination. Stockpiles may also need to be assessed against landfill classification criteria to:

- confirm stockpiles are not contaminated and acceptable for re-use
- confirm stockpiles are not classifiable as asbestos “special” waste.

DOH adopts a conservative approach to retrospective stockpile assessment of suspect contamination because of increased uncertainty from the mixing of soils. Investigations of stockpiles should consider the likely contaminants, whether bonded ACM, AF or FA is likely to be present and is subject to sampling criteria in Table 11.

If there is a high degree of confidence that the stockpile is contaminated with bonded asbestos cement fragments only and the material has not been subjected to crushing processes, then sampling for bonded ACM would be sufficient.

Where AF is suspected to be present, separate AF samples should be collected from soils suspected to be contaminated. For example, for stockpile materials that have been through any crushing processes, AF sampling is to be included. Further information is available in the Guidelines for management of asbestos at construction and demolition waste recycling facilities (external site) (Department of Environment and Conservation, DWER, 2021).

Stockpiles deemed to be from areas assessed as not contaminated (or for which there is no evidence or suspicion of contamination) can be subject to a close visual examination over the whole stockpile surface with further observation during material movement to confirm that there are no indicators of asbestos contamination or other commonly co-located waste (e.g. building waste).

Remediated stockpiles for reuse at the same site must comply with the site-specific clean up goals and the requirement to have the surface cover layer free of visible contamination. Soil stockpiles intended for re-use at an **alternate** site should meet the stricter requirements for "uncontaminated fill" as per the thresholds in Table 6 of the waste classification criteria (external site).

Table 11 Summary of stockpile sampling method

Process

- Suitable for all asbestos types
- Confidence in results can be improved with adequate information on the history and origin of the stockpile material and its potential to be contaminated with asbestos.

Implementation

- Visually inspect the entire surface of the stockpile and note the materials observed.
- Sampling should be evenly spread through the stockpile. Collect three samples for all stockpiles less than 75 m^3, with an extra sample for every additional 25 m^3.
- Suspect asbestos material or construction debris should be targeted, and all sample locations noted.

Bonded ACM and FA

- At least one 10L sample from each location screened with a sieve capable of capturing ≥ 7mm x 7mm fragments or spread out for inspection on a contrasting colour fabric (recommended for suspect presence of FA).
- Identified bonded ACM and FA weighed to calculate asbestos soil concentration.

AF

- At least one wetted 500mL or 1kg sample from each location.
- Taken within the same impacted soil layer but separate spot from the 10L sample.
- Whole sample submitted for laboratory analysis.

5.8 Laboratory analysis

5.8.1 Identification of asbestos mineral fibres

Identification of asbestos mineral fibres should be undertaken in accordance with a relevant, validated method.

AS4964–2004 Method for the qualitative identification of asbestos in bulk samples is commonly used to identify asbestos in soil samples. NATA accredited laboratories can also seek accreditation for in house methods that support the (pre-)analysis of AF samples as described in Appendix Four. Other reference methods may be considered (See Appendix Four).

5.8.2 Estimating asbestos fines concentration

The same principles are used to estimate the concentration of AF in soil samples as for bonded ACM. This method provides an estimate of total AF concentration in soil (w/w).

This method allows the soil sample to be examined under laboratory-controlled conditions and can utilise stereo microscopy to identify suspect AF. The laboratory examines the entire sample and can separate, weigh and positively identify any suspect material or debris or fibrous matter found within the various size fractions, such as sub 10 mm, +7 mm, 7 mm to 2 mm and sub 2 mm.

For the estimate of concentration to be meaningful, it is important to ensure that samples submitted for analysis are representative of the asbestos contamination and not seeded with incidental finds nor diluted with uncontaminated soils (see Figure 10).

Note that where a larger fraction +2mm material is present in a soil sample, it will be the main contributor to the concentration measurement. It may be important, such as in Tier 2 or Tier 3 assessments, to have detailed observations of the AF fraction. It may also be relevant to submit a smaller, representative soil sample volume, particularly where this improves the collection of a discrete, targeted and representative area of contamination. Any variations or decisions regarding sample size should be justified by the sampling plan and data quality objectives and discussed with the laboratory undertaking the analysis.

Identifying respirable asbestos fibres in soil samples may provide important supportive information for characterising the asbestos contamination. Discretion must be used for comparing AS 4964 trace analysis results against assessment criteria. However, results may provide important qualitative data relevant to exposure assessment.

It is important to note that the laboratory sees a very small, targeted sample of soil. The origin and distribution of AF material within the investigation area may be unknown to the analyst. As such, analysts do not have the information necessary to advise whether the observed AF represents site contamination and whether the contamination should be characterised as friable, non-friable or minor contamination for legislative control or management.

There are several reference methods available internationally that can be accredited for use in Australia. These can be utilised where additional confirmatory analysis is required, such as for higher Tier assessments. Further information for laboratories is provided in Appendix Four.

5.9 Air quality monitoring

5.9.1 Air monitoring principles

The purpose of any air sampling should be clearly identified. The sampling strategy should be developed by a suitably qualified and experienced person (e.g. occupational hygienist).

The Guidance Note on the Membrane Filter Method for Estimating Airborne Asbestos Fibres NOHSC:3003 (2005) (MFM) is regularly employed for control monitoring at contaminated sites. Where real-time monitoring is required to determine the effectiveness of dust controls measures during asbestos work, a direct reading dust measurement may be used to supplement airborne fibre monitoring (see Section 5.9.3).

Control monitoring is used to confirm that control measures have effectively prevented the release of fibres during remediation or site works. Where best practice dust control measures are used, it is expected that a sampling plan will be in place that outlines the number and position of samples and that the action level is the limit of reporting of 0.01 f/mL.

Personal air monitoring provides an index or estimate of exposure to respirable fibres in air. The air monitoring program must consider the need for exposure monitoring of workers undertaking tasks that may expose them to elevated levels of particulate emissions (including sample collection and remediation works). Personal monitoring of asbestos in air to assess and control workplace exposure is an occupational health and safety issue; however, results may also be used in site investigation reports to show that controls have been effective in minimising fibre release and, in effect, protecting public health. The WorkSafe Division, DMIRS, is the lead agency with regard to employee exposure.

5.9.2 Air monitoring for public health exposure assessment

A specific sampling plan should be considered for exposure assessment undertaken as part of the contaminated sites assessments, i.e. in Tier 2 or 3 assessments where more information is required to characterise exposure risks consider monitoring during activities that have the potential to release fibres. Undertaking simulated activities (activity-based sampling) for exposure assessment may require approval from DMIRS. (See Section 3.9.1).

In low-level exposure settings, the MFM may significantly underestimate and sometimes overestimate the fibre concentration in air. For example, fibre counts may include other background fibres present in the environment (organic and other mineral fibres), and MCE filters may also contribute to the fibre count. In addition to ensuring that field blank filters (which are a requirement) are included for all sampling events, a methodology that allows a lower limit of reporting (LOR) should be considered. The analytical sensitivity of MFM may be improved for individual samples and/or relevant international methods can be used that allow a lower LOR and identification of fibre type. Laboratories may seek NATA accreditation for relevant methods.

Exposure assessments have been completed in Western Australia based on a modification of *ISO 14966:2002 Ambient air — Determination of numerical concentration of inorganic fibrous particles — Scanning electron microscopy method* which has a limit of reporting of 0.002 f/mL.

Air sampling results taken during periods of no activity or when effective remediation controls are in place should not be used to conclude that there has been no asbestos fibre release from soils or to justify the use of less stringent site management measures.

5.9.3 Dust/Particulate monitoring

Dust monitoring does provide a useful surrogate for assessing the effectiveness of overall dust control measures at a site for the following reasons:

- real-time dust sampling can be undertaken with alarms/action levels set that provide immediate feedback regarding the effectiveness of dust control measures or changes in conditions that may lead to elevated dust levels
- dust monitoring is commonly used, well known and does not require specific asbestos monitoring expertise
- results are immediately available and easy to interpret, and data logging provides evidence that adequate dust management has been employed during the entire period of remedial/site works.

Dust monitoring equipment should demonstrate that particulate levels are kept as low as reasonably possible. The site dust management plan will need to identify triggers used for control actions. Dust monitoring should be considered as an adjunct, not as a substitute for fibre monitoring.

Equipment should be located along the site perimeter at “background” upwind and downwind locations, taking into account local site features and topography. Where there is a well-defined diurnal and seasonal variation in the dominant wind direction, monitoring stations should be located along the key axes. Generally, regional meteorological data will be sufficient to aid the planning of fixed dust monitoring stations, and portable devices may be repositioned depending on daily conditions. For fixed stations (e.g. Tapered Element Oscillating Microbalance), a detailed log of atypical meteorological conditions may be useful for interpreting results or addressing complaints.

Dust/particulate control monitoring cannot be used as a surrogate for asbestos exposure monitoring.

5.10 Quality assurance/Quality control

Quality assurance and quality control (QA/QC) practices should be consistent with guidance provided by the NEPM, which also provides information on the development of Data Quality Objectives (DQO) and on quality control samples.

Relevant considerations particular to asbestos include:

- investigators should have adequate asbestos experience and breadth of knowledge to ensure the quality of recommended visual detection and quantitation methodologies
- sampling and analytical procedures should be justified as to their appropriateness and effectiveness
- GHS labelling and safe sample packaging and transport requirements are to be met
- 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
- Australian Standard Method for the Qualitative Identification of asbestos in bulk samples (AS4964-2004) or relevant, validated international method can be used to identify asbestos in bulk materials (including soil).

Figure 10 Buried waste FA found during site works.

The use of duplicates during sampling for asbestos is not a mandatory requirement. However, there may be situations, for instance, the potential for legal challenge, where a duplicate or triplicate sample may be useful. In such a case, it may be a division of a single asbestos material sample (e.g. division of a suspect ACM fragment) rather than an attempt to collect equivalent samples.

Chapter 6

Site remediation

6.1 Approach

Remediation options that minimise the potential for exposure to airborne asbestos fibres and also minimise the amounts of contaminated material that are removed to landfill are preferred. Complete excavation and removal will remove the potential for any future exposure and does not require any ongoing management. However, the feasibility of safe removal, transport and disposal and sustainability of landfills should be considered in decision making.

Note that the *Environmental (Controlled Waste) Regulations* **must be complied with** for any movement of asbestos contaminated soils outside of the reported site boundary (i.e. controlled waste transport and disposal). This requirement also applies to large redevelopment sites that involve more than one land parcel.

The main remediation options include management in situ, treatment on-site, and removal of the contaminated soil from the site. Consideration may also be given to changing the final intended use or redesign of development plans (e.g. locations of building, hard surfaces and open spaces) to better manage the risk in perpetuity.

Containment of asbestos contamination eliminates the exposure pathway. Remediation involving minimal disturbance, such as containment and management in situ, is often preferable to large scale handling, removal and transport of asbestos contaminated soils.

All feasible options for remediation must be considered and presented to the site owner/occupier. Options may include a combination of methods. The preferred option should be supported by strong argument when compared with the others. Although cost, time, sustainability, convenience and future owner perception will be important considerations, the arguments presented for selection should be primarily stated in terms of public health and worker protection.

Most options presented relate primarily to bonded ACM unless FA or AF is specifically referred to. The proponent is free to propose other remediation measures through reasonable argument and/or precedent.

Compliance with WHS legislation, equipment operation and decontamination, vehicle movements and dust control during sampling and monitoring regime and remediation activities must be carefully managed.

Early stakeholder engagement in remediation options is expected. Where, following remediation, the control of the land will pass on to a new owner or entity (e.g. local government) to manage, these parties and individuals must be included in the decision making process. Where on-site containment and management of the contamination at the site will be required in perpetuity, consideration must be given to preventing disturbance of contamination during routine maintenance work.

In addition, site remediation activities will need to comply with any other licences or approvals required by State and local government (e.g. mechanical screening activities).

For example, for treatment of large volumes of soil, there may be a requirement under the *Environmental Protection Act 1986* (EP Act) to obtain a works approval, pollution prevention licence or licence amendment to undertaken clean-up. Such requirements should be identified in any remediation action plan.

Management options that are available for the remediation of reported contaminated sites are not implicitly endorsed or approved for other situations (e.g. illegal surface dumping, asbestos removal work, treatment of waste, sale or supply of asbestos contaminated products) where prevention or removal of asbestos contamination is a priority.

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

- minimisation of contaminated soil disturbance
- minimisation of contaminated material/soil moved to landfill
- minimisation of risks associated with transportation
- written agreement from parties with responsibilities for temporary, interim or perpetual site management.

The object of any remediation strategy and site management approach is to:

- prevent and protect individuals and communities from exposure that could lead to asbestos-related diseases
- provide information to individuals and communities about WHS and public health risks.

6.2 Presence of other contamination

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 to treat both asbestos and the other contaminants?

For contamination contained on-site, the restrictions on use will include the requirement for procedures to be in place for any excavation work beyond the clean surface layer. A site management plan must also be implemented for the following circumstances:

- containment in public open spaces (parks, ovals and playgrounds) at less than 1 m depth
- containment for all other uses, including residential, commercial, natural bushland/reserve, at less than 0.5 m depth

6.3 Site management plan

Site management plan (SMP) refers to the plan for proper control of any asbestos contamination remaining at the site and the communication of relevant information to site owners/occupiers, users and persons who may encounter asbestos contaminated material as part of future site works.

The management plan must include probable exposure scenarios for the relevant land use(s) whereby asbestos fibres may become airborne and pose a human health risk.

Site management strategies should aim to alert future workers or site users to asbestos and protect them from exposure to airborne fibres during activities that may disturb the contamination.

For commercial sites, depending on organisational arrangements, the location and extent of remaining contamination and how it may impact future site workers, it may be relevant to integrate the SMP into existing asbestos registers and asbestos management programs.

6.3.1 Restrictions on use

Where bonded ACM remains on the site and is managed, the land will be classified accordingly (external site). The final classification is likely to be 'remediated for restricted use' or 'contaminated – restricted use'. The 'restrictions on use' would relate to informing site users that asbestos remains on-site and any precautions required to prevent exposure.

Potentially affected parties, including current and known future users, should be informed of the contamination and the arrangements in place to protect them, including through the Basic Summary of Records and the SMP. All parties who are subject to its implementation and those who have roles and responsibilities allocated by the SMP should be involved in the decision making for on-site containment provisions (see Section 6.4).

Note that:

- on-site containment options must be designed such that there is minimal impact on routine activities at the site, such as landscaping, maintenance or gardening works.
- a site that has only implemented interim containment measures may retain a classification for requiring remediation until the long term measures have been confirmed to be in place.

6.3.2 Elements of a site management plan

A site management plan developed and implemented on a long-term basis must consider the following elements:

- agreement from all parties involved regarding the remediation plan and management arrangements proposed for the site
- agreed timeline for implementing long-term management solutions to ensure interim measures are not extended beyond their ability to prevent future exposure.
- description of the nature, degree, quantity and location of asbestos contamination remaining at the site
- description of engineering or institutional controls for any asbestos contamination remaining in situ
- authorisation arrangements for any ground disturbance/site works
- WHS provisions for workers
- integration with any existing corporate asbestos management plans used by the organisation and with any:
  - authorisation/permit to work process
  - existing procedures associated with inspection of cover materials (e.g. turf management)

- proof of arrangements to maintain 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, scheduling surface inspections (e.g. regular schedule and/or following periods of heavy rainfall)
- surface water runoff that may erode cover, particularly after heavy rainfall
- a safe system of work for anyone undertaking future work (including regular inspections)
- and repairing any damage to the barrier
- development of an information and communication strategy for existing or prospective owners, occupiers and users of the site
- where needed, procedures for how to deal with asbestos that may be encountered by various persons using or working at the site
- the periodic review and audit of management provisions and stakeholder engagement to ensure in perpetuity management of the asbestos contamination.

The stakeholder communication/training should include details of:

- results of site investigations
- restrictions on-site use to protect from exposure
- any responsibilities they hold with regard to the management arrangements
- where additional information may be obtained.

6.4 Containment and long term management

Effective long term containment with a restricted use classification is a sustainable outcome. Containment primarily involves the isolation of the contaminated area with barriers and covers so that it cannot be readily disturbed. The cover usually includes a layer of clean soil. This fill should be demonstrated to be free of contamination, and some form of visible barrier (e.g. contrasting/coloured geotextile fabric, crushed rock layer) can be included to identify and prevent mixing of the clean and contaminated soil layers. Long term management measures, including containment and a memorial on the certificate of title (CoT), would be expected for any asbestos-containing material remaining at the site.

The advantages of on-site containment include:

- minimal disturbance of asbestos contaminated soil
- minimisation of sampling and investigative works required with potentially lower costs, time delays and greater confidence of outcomes.

The disadvantages include:

- asbestos will need to be properly managed in perpetuity
- level of the site may need to be raised
- the site will remain classified with an associated memorial on the CoT, which could adversely affect purchaser perceptions

The feasibility of site containment and management should consider:

- the depth of the asbestos contaminated material and its likely future disturbance
- the CSM and potential for exposure to identified receptors (e.g. routine maintenance workers)

- distribution and coverage of asbestos contamination and the ability to effectively and practically delineate, treat and/or remove the contamination
- the risk and controls required for removing high concentrations of FA or AF and whether these can be managed
- the final use, design and layout of the site, including the location of hardstand covers, building or other hard surfaces
- the site works required, including whether the site is to be covered by clean fill for geotechnical or other purposes
- likely associated requirement for an MOT and the necessity for a future site owner/ manager (e.g. local government authority) to effectively implement an SMP

Other management measures not described in these Guidelines are possible, such as cement injection stabilisation, which effectively encapsulates the asbestos material.

6.4.1 Excavation and re-burial

Consultation with DWER is recommended for on-site re-burial. The excavation and re-burial of asbestos contaminated soil within an engineered containment cell may be a feasible and preferred option for some sites. The containment cell must be within the asbestos contaminated area or at least within the boundary of the reported site. An important advantage of this approach is that it can provide for the location of the containment cell to be delineated by an Interest Only Deposited Plan (see contaminated sites guidelines (external site) for more information), with remaining areas of the site free of restrictions. For example, a redevelopment site may situate a containment cell under buildings or hardstands or within an area of a redevelopment that is controlled by an entity that can apply institutional controls on a site, allowing more vulnerable parts of the site (i.e. sensitive land use or low integrity cover) to be decontaminated with no restrictions on site use.

Another advantage of using an engineered on-site containment cell is that it eliminates risks and costs associated with taking the material off-site and disposing of it at a licensed waste facility and allows limited licensed asbestos waste facility space to be reserved for asbestos waste arising from the removal of asbestos-containing building products.

The boundaries of the area from which excavated contaminated soil is taken should include consideration of additional lateral and vertical excavation to account for any uncertainty in the contamination delineation during site investigations and site excavations works and/or the sides and base of the excavation be validated as uncontaminated.

6.4.2 Design elements

The depth of the clean cover should be sufficient to prevent access to and disturbance of any buried asbestos-containing material. The depth of required fill should consider:

- current and future site use
- the integrity of the final top surface cover (e.g. hardstand, gravel, turf)
- potential for damage/erosion of the cover through human activity, surface water movement or other causes
- ability to inspect/maintain cover over the long term
- safe access to below-ground infrastructure, including irrigation systems and underground service.

The need for surface water drainage also needs to be assessed and included in the remediation plan.

As DOH considers, the deeper the contamination the lower the potential for extended current or future contact with the contamination; greater than 1 m of clean cover will require classification and restriction on excavation. However, under most site-use scenarios is unlikely to require active ongoing management control (e.g. SMP). A restriction on use will be applied that will require implementing appropriate controls if and when future contact with the material occurs. An SMP for the site is required where disturbance of the contamination is probable during normal use or maintenance related to current and future site uses.

Where possible, the depth of cover should be sufficient to address any access to or future installation of utility and underground services. Alternatively, underground services may be isolated from other buried contaminated material with a marker layer and backfilled with clean fill. The planning, size and design of buried services and/or service trenches should accommodate future maintenance or installation of additional services (e.g. allow sufficient clean area for additional services and/or room for re-excavation of trenches adjacent to buried services).

Contamination associated with high concentrations of fibrous asbestos may require a greater depth of clean fill or more frequent inspection of cover, depending on site circumstances.

Remediation Plans and long term management measures must be agreed to and endorsed in writing by the entity that will have control of the site.

6.4.2.1 Separation and/or isolation of the contaminated soil

A geotextile barrier provides a warning of the presence of soil contamination. Where possible, the barrier should be a contrasting colour to the surrounding soils. Specialised or improvised geotextile fabrics may be used, meeting the following conditions:

- water permeable
- high visibility
- rot-proof and chemically inert
- high tensile strength
- coverage of the contaminated area and at least 0.5 m beyond boundary if practical
- parallel sheets and adjoining sheets to be fixed together or overlap by at least 20 cm.

Alternate means of visibly identifying and separating fill may be used, e.g. a layer of crushed rock between clean soils and asbestos contaminated soils. An SMP is a recommended element whenever containment is employed; this ensures that the protective measures will be maintained and that potentially affected parties will be kept informed of possible risks.

The means of isolating and visibly identifying the layers of soils must be well documented in any SMP and specific procedures developed for any site works. The expected lifespan of geotextile barriers should also be included in the long-term management plan.

A dense vegetative barrier, such as turf, can be very useful in protecting the clean fill cover from erosion and 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.

6.5 Treatment on site

Treatment on site is taken here to mean undertaking some physical treatment or manipulating the contaminated soil at the site, specifically removing surface contamination or mechanical screening of excavated soils.

6.5.1 Removal of surface contamination

Surface remediation is possible where the collection of bonded ACM results in removing the contamination present at the site. It must be confirmed that the impacts are confined to the surface soils, and that surface remediation will be sufficient to achieve site clean-up goals. Evidence of the depth of surface penetration will be required (see Chapter 3).

Figure 11 Hot spot of bonded asbestos cement fragments.

For the collection of surface contamination to be effective, it may be necessary to remove any covering vegetation. The removed vegetation must be clean of bonded ACM before disposal or disposed as asbestos waste. Before vegetation clearing, consideration should be given to the need for a Clearing Permit to be obtained from DWER under the Environmental Protection (Clearing of Native Vegetation) Regulations 2004.

Guidance on surface sampling is provided in Section 5.7.1. This technique can be used to concurrently remediate and estimate the level of contamination associated with surface soils. The remediation of surface contamination must be adequately validated. At least two passes (and then as many as required) must be completed until a final validation pass results in no visible bonded ACM being found. 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 remediation cannot be achieved by this method.

For compact or clay soils, collection or emu picking may be an option where the bonded ACM is confirmed to be only on the top surface (i.e. site investigations confirm that the contamination does not penetrate the surface soil layer above the screening criteria).

Surface scraping vs raking can be more effective where surface “hot spots” of small fragments may be present.

Very small fragments may be evidence that the material has been crushed, smashed or pulverised and collection of a soil surface scrape of the visible material and immediately surrounding surface soils would remove and eliminate any potential AF impacts that may have occurred from any in situ breakage.

Some types of FA material located on the surface may also be readily collected and removed, although additional work should be undertaken to assess and manage any associated AF.

6.5.2 Tilling

Tilling using mechanical means may be an acceptable methodology for remediation of loose, sandy soils. Tilling can be used to reveal bonded ACM contamination that is no deeper than the tines. The desktop study and sampling may help to support such an approach. Tilling is expected to be used together with hand-picking and will require the initial removal of surface vegetation. A grid approach should be used with a spotting, separation, weighing and calculation approach used as outlined for hand-picking (Section 5.7). Dust management measures must be in place.

The readily disturbed and accessible ground surface must be free of visible asbestos for the site to be considered remediated.

6.5.3 Screening

Mechanical screening is most suitable for the removal of low-level asbestos cement fragment impact in sandy soils. If undertaken with the appropriate controls, mechanical screening can be an effective tool for separating bonded ACM from soil and limit the material being disposed to landfill.

The process must include a comprehensive dust management plan (including air sampling) and community consultation. A screen of effective final mesh size of less than or equal to 7 mm x 7 mm should be used to ensure that fragments of bonded ACM panels do not pass through lengthways. The percentage of asbestos w/w can be calculated by calculating the weight of bonded ACM retrieved for a given weight of soil screened. If there are small fragments present and/or (more commonly) a larger screening size is used, sampling of the resulting stockpiles will be required to confirm that screening is effective.

Dust management and air quality monitoring are particularly important during screening procedures because they can release considerable amounts of dust and possibly asbestos fibres.

The suitability of screening should take account of the following factors:

- Advantages
  - screened soil can be validated for re-use as uncontaminated fill, reducing the amount of soil to be moved off-site for disposal as “special waste”
  - potentially avoid a ‘restricted use’ classification with associated memorial on CoT
  - sampling can be combined with remediation;
  - hazard is eliminated.
- Disadvantages
  - less cost-effective for high levels of contamination or low volumes of asbestos contaminated soils
  - not suitable for crushed building and demolition debris
  - not suitable for compacted soils or soils with high clay content
  - in some cases, it has the potential to generate considerable dust, which requires consideration of and consultation with nearby receptors and monitoring to ensure there are no off-site impacts
  - may require additional controls (e.g. enclosure) where a sufficient buffer from sensitive receptors is unavailable.

6.6 Removal off-site

Removal off-site is a feasible option for asbestos contamination that is not much combined or mixed with other materials (e.g. soil or other waste), is not buried deeply and/or relatively confined, and the extent of contamination is evident and well delineated.

In some circumstances, removal is preferable or more feasible to containment or treatment options, for example, where:

- there are site constraints to asbestos contamination being contained or treated at the site
- there may be issues with or lack of stakeholder agreement in managing contamination in perpetuity
- excavations as part of land development allow for the opportunistic removal of contaminated soils
- unexpected “hotspots” are found during site works.
- Contamination is present within stockpiled material that has been brought on-site.

Removal off-site is an option where it is important to avoid a ‘restricted use’ classification, such as for residential land redevelopment.

For the excavation of any asbestos contaminated soil, it is recommended that additional material is removed in all directions beyond the measured lateral boundary of the contaminated area. The additional amount to be removed should be informed by the site investigation and may consider:

- removal of all introduced material down to the natural soil profile
- validation that the surfaces exposed by the excavation following removal of asbestos are not contaminated as outlined in Section 6.8.

Excavated contaminated material must be transported and disposed in accordance with the *Environmental (Controlled Waste) Regulations 2004*.

6.7 Remediation action plan

Some of the remediation measures can generate significant amounts of dust, including airborne asbestos fibre.

Possible dust-generating activities include the mechanical screening of soil and major earth excavations, and vehicle movement. Effective dust management controls are required, and air quality monitoring must be included.

A Remediation Action Plan (RAP) (see Contaminated Sites Guidelines (external site) and CRC CARE National Remediation Framework (external site)) should be developed and implemented for all activities undertaken at a site. The level of detail will depend on the nature and extent of the contamination and the type and magnitude of disturbing activities.

A RAP should include sections on dust control measures, air quality monitoring, personnel protection and training, and action levels and responses.

Available dust control measures include but are not limited to:

- wetting with an agent specifically designed to suppress the release of particulates/fibres
- using dust suppressants or covers on soil stockpiles
- installing wind barriers of a suitable height
- using sheltered areas wherever possible
- full enclosure structures around dust-generating activities
- monitoring meteorological conditions and modifying or stopping work when they are adverse
- regulating the activities at a site and/or speed of vehicles
- restricting or minimising access to contaminated areas, especially by vehicles
- implementing a community dust complaint and response system.

All persons involved in remediation works must be adequately trained. The site-specific training must include:

- asbestos awareness training
- understanding of the nature and extent of site-specific asbestos contamination
- controls and notifications to be followed
- how to prevent exposure to contamination, including
  - dust control measures
  - handling and disposal procedures
  - selection and use of personal protective equipment and clothing
  - personal and equipment decontamination procedures
  - emergency procedures.

6.8 Validation sampling

Validation will be necessary for remediation works. For all validation activities, no matter how simple or complex, the evaluation and reporting of a remediation methodology must be adequately recorded throughout the course of a project.

Any validation sampling should be based on the recommended sampling methods in Chapter 5. Validation to verify completion of remedial activities should be determined as part of the RAP. For example, the validation of excavated asbestos-contamination where boundaries of the waste or fill can be readily distinguished can be based on removing material until natural soils are revealed, or another change in a condition indicative of non-impacted soil is evident. The decision parameters and confirmation of remediation must be recorded.

Chapter 7

Auditing and reporting

All asbestos-related reports should be presented primarily as outlined in the Contaminated Sites Guidelines. The reports should also reflect the additional guidance provided in these Guidelines. Any Mandatory or Voluntary Auditors Report should comment on the compliance with these Guidelines of the relevant site investigation and management activities

The following items must be included in reports. Note that this is not a comprehensive auditing checklist but rather an outline of the information often omitted from reports.

7.1 General requirements

- Each report should outline the asbestos specific training, work history and experience of at least the person supervising the investigation (not a full CV). Field personnel need to demonstrate that they have been adequately trained to identify the range of asbestos-containing materials present in soils and how to assess their condition. Field analytical methods should be performed by appropriately skilled personnel (ASC NEPM, 1999).
- All reports should be as comprehensive as possible regarding information, process, and decisions to avoid misinterpretation.
- Each report must include a conceptual site model. The sampling and validation methodology must be detailed and justified, including providing information on precedents of any validation of methods used.
- Each report should normally be “stand-alone” and should not rely on other documents for contextual information or interpretation.
- Each report should outline any changes to site-associated conditions that might affect site management.
- Where asbestos is not the only contaminant, any reporting relating to it should be clearly identified. A specific plan and/or site-specific procedure for managing asbestos contamination (separate to other contaminants) may be required that incorporates control of all sources of asbestos at a location and complies with WHS legislation
- The report should include photographs of field investigation, remediation and validation inspections
- Derivation and justification for any site-specific clean up goals must be included.

7.2 Soil investigations

The details of the process and rationale associated with site investigations, walkover inspections, site sampling, analysis and validation, and how the results are interpreted must be reported.

The investigation methodology needs to be clear and comprehensive, especially for sites that are complicated or lack good historical information.

All samples taken are to be representative of the asbestos contamination to the extent practical. Soil samples for AF analysis are collected from undisturbed, representative soils (i.e. collectedly separately from field samples).

The report should:

- include the full raw data, including soil logs, sample volumes and weights and laboratory results (may be provided in appendices)
- incorporate tables and diagrams to help summarise and interpret the data
- include sampling methodology
- show asbestos concentration calculations or provide an example of how calculations against criteria have been made.

7.2.1 Reporting of site inspection findings

For the initial inspection/walkover, it is critical to comment specifically **on the presence or absence of asbestos material and the inspection method**, such as:

- the depth to which site-specific surface impacts were investigated/remediated
- the methodology used (e.g. raking, trenching or test pits) to confirm the depth of surface impacts
- inclusion of analytical reporting of suspect materials, including materials tested and found not to be asbestos-containing.

Reports will benefit from the annotation of summary information on suitable site inspection figures.

Useful information may include:

- the various types and forms of asbestos contamination encountered
- average and range of sizes observed
- locations where samples of suspect material were taken for either identification or soil (AF) analysis, including on a plan or aerial photograph
- locations where photographs were taken, including the direction of the shot.

The site inspection/walkover should include a description of:

- any remaining asbestos-containing structures, especially if in poor repair
- footprints of demolished structures (including fences, drains and soakwells)
- waste and debris on the surface of the site
- any uncontrolled fill (particularly if it contains building or industrial waste).

7.2.2 Reporting of tilling/raking or screening sampling

For these types of sampling, a site figure or diagram should be provided denoting on a grid basis the investigation area(s), the direction of each pass, the description, number of fragments and collected weight of asbestos for each grid, and calculated soil asbestos concentrations, all on a per pass 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.

7.2.3 Reporting of soil bores, test pits and trenches

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 stratum sampled
- sampling screening size.

7.3 Site characterisation

Comment is provided regarding the asbestos contamination at the site and the confirmation or applicability of assumptions such as:

- asbestos content of asbestos-containing materials found to be present
- soil density used when converting the volume of samples to weight
- sample results are representative of soil impacts to a referenced area or soil stratum.

Limitations and uncertainties have been acknowledged and discussed.

Site investigation reports should explicitly state whether asbestos contamination is evident at a site (for each location it is found) above or below the screening criteria with a description of:

- the location, nature, condition and origin of asbestos contamination
- the lateral and vertical extent of contamination
- a quantitative estimate of the contamination and its distribution in soil
- the consideration of any uncertainties, assumptions or limitations
- the conceptual site model.

7.4 Air quality monitoring

Reporting elements for air quality monitoring, in all instances, should include:

- the rationale for air quality monitoring conducted and site-specific action levels
- reference methods
- the date and time of the sampling
- the names of the people conducting the sampling and analysis
- sampling instrument used and accessories
- flow rates, pre and post flow checks
- any deviations from standard protocols/reference method
- static sampling locations
- the activities and location of any person wearing a sampling device
- relevant information on engineering controls, weather conditions and protective clothing and equipment.
- any exceedances of action levels;

The following information must be included:

- calibration certificates for sampling equipment used (e.g. air sampling pumps, field calibrator)
- flow rates and sampling times for air samples

- analytical reports – both NATA accredited reports, and relevant additional/supplementary laboratory reported data

The information may be provided within the main report or in appendices (such as laboratory reports and field records). However, a summary cross-referencing the relevant information would be of benefit.

The discussion on air quality monitoring should evaluate potential causes of exceedances, the prevailing meteorological conditions and the effectiveness of corrective actions implemented and include a statement of the potential exposure of on-site and off-site human receptors to asbestos fibres and the adequacy of site management measures implemented.

7.5 Material tracking and disposal

The validation reporting should include documentation arising from the disposal of removed asbestos or asbestos-containing material at a suitable landfill (e.g. material tracking and disposal receipts).

Compliance with the Environmental (Controlled Waste) Regulation 2004 must also be confirmed. Complete documentation of the remediation works needs to be available in the final report, including:

- description of all field operations or daily logs
- containment areas
- maps showing excavation profiles
- maps showing the location of asbestos contamination left in situ
- on-site and off-site vehicle/load tracking information that includes information on the load and its destination (source location, volume, description of contents and contaminants, specific destination location)
- disposal weights and receipts.

7.6 Site management plan

In the case of an SMP, evidence (e.g. signed acceptance by persons holding current positions of the assigned roles and responsibilities within the SMP) will need to be included that the responsible party (and any nominated responsible persons) will manage the site into perpetuity.

For contamination contained on-site, the restrictions on use will include the requirement for procedures to be in place for any excavation work beyond the clean surface layer. A site management plan must also be implemented for the following circumstances:

- containment in public open spaces (parks, ovals and playgrounds) at less than 1 m depth
- containment for all other uses, including residential, commercial, natural bushland/reserve, at less than 0.5 m depth

7.7 Auditor final inspection

The Auditor may use their discretion as to whether the presence of incidental and infrequent occurrence of fragments that may have resurfaced after remedial works are complete, i.e. when the surface soils are disturbed or following heavy rains, complies with the intent to have the surficial surface free from visible asbestos. A more stringent criterion of asbestos-free surfaces should be applied to sensitive site uses.

Chapter 8

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Chapter 9

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 Fines (AF)	Includes all asbestos or asbestos-containing materials, including loose fibre bundles and fragments of non-friable material that are smaller than 7 mm x 7 mm.
Asbestos Removalist (Licensed)	A removalist registered, licensed or otherwise authorised under Western Australian State legislation to perform asbestos removal and maintenance work.
Bonded Asbestos-containing Material (ACM)	Materials that contain asbestos in an inert bound matrix such as cement or resin. Related to bonded, non-friable material greater than 7 mm x 7 mm.
Brownfield Site	Any previously developed land that is not currently in use, whether contaminated or not.
CS Act	Contaminated Sites Act 2003
DOH	Department of Health (WA)
DSI	Detailed Site Investigation
DWER	Department of Water and Environmental Regulation
“emu-Bob”or “emu-Pick”	The manual collection or hand-picking usually of visible fragments or pieces of suspect materials using a systematic process of visual inspection across the surface of a site.
Exposure Pathway	The way a recipient comes into contact with a chemical or physical hazard. There are three basic exposure pathways: inhalation, ingestion, or direct contact.
f/mL	Fibres per millilitre.
f/mL-year	An exposure concentration equivalent to years of exposure used in exposure risk models (e.g. 25 f/mL-year is equivalent to 25 years at 1 fibre/ml, 10 years at 2.5 fibres/mL). Generally based on “occupational” hours of exposure during the year (40hrs x 48 weeks).

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)	Fibrous asbestos refers to asbestos products or materials that are friable (loose insulation) or have become severely degraded or damaged such that they are partly or completely friable.
Field Analysis	Sampling and analysis that is carried out at a site, rather than in a laboratory or office
Friable	Material which is crumbled or reduced to powder by hand pressure. Asbestos in this form is especially hazardous due to the 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 human 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 under a specific set of conditions and for a certain time frame.
Loose Fibre bundles	Mineral fibres that are not part of a matrix or otherwise in a bonded form. May originate from bonded ACM or other asbestos products and be liberated due to deterioration, fire or disturbance (e.g. settled dust from using power tools).
NATA	National Association of Testing Authorities
NEPM	National Environment Protection Measure
NOA	The natural geological occurrence of asbestiform minerals found in association with geological deposits including rock, sediment or soil.
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

Respirable fibre	A particle with a diameter less than 3 µm and length greater than 5 µm and with a length to width ratio of greater than 3:1 as defined by the International Agency for Research on Cancer.
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.
SAQP	Sampling and Analysis Quality Plan
Screening	The term 'screening' is applied to both the small-scale separation of bonded ACM from localised soil samples by sieving, as described in Table 8 and to the large-scale mechanical screening of soil from a contaminated area as described in Table 9
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. Therefore, anywhere people live is considered a 'sensitive receptor' by default.
Structure	Includes inter alia any industrial plant, edifice, wall, chimney, or fence.
Uncontrolled Fill	Any form of fill material located on-site, whether resulting from waste disposal, landscaping practices, or other processes, for which the composition cannot be reliably ascertained. This includes construction and demolition material, 'inert' waste, and municipal waste.
Visible/visual	Refers to visible observations made during site inspections and field sampling. The verb "examine" is used in this document to refer to laboratory observations by eye.

Appendix One:

Background information on the development of screening criteria

DOH established screening criteria in 2009 mainly based on international research by Swartjes and Tromp in The Netherlands (2008).

The determination of asbestos in soil has some differences with chemical contaminants, such as:

- fibres are physical structures of various sizes and dimensions, rather than a chemical molecule
- the available analytical methods provide semi-quantitative (estimate of) concentrations and depend on adequate representative sampling and consideration of other supporting information to characterise contamination
- concentration in soil does not consider the potential for release of airborne fibres, and there is a poor correlation between the two;

Asbestos is a banned and controlled substance, and contaminated sites management must consider other legislation (see Section 2.1) that applies to the handling, removal and disposal of asbestos contaminated soils, e.g. restriction on sale and supply, notification, labelling. This is a consideration for any remediation objective. The basis for the screening criteria is two-fold.

1. For all asbestos types, the concentration of 100 mg/kg or 0.01% w/w asbestos in soil is expected to keep outdoor airborne fibre levels below 0.001 f/mL and probably around 0.0001 f/mL.

DOH applied this criterion to the less hazardous bonded ACM, depending on on-site use. These mirror the Assessment of Contaminated Sites (ASC) National Environmental Protection Measure (NEPM) (1999) site uses and associated default exposure ratios.

A lower criterion has been applied to both FA and AF as activity and disturbance may result in the suspension of smaller particles from FA and AF in air. The 100mg/kg was divided by a factor of 10 to account for greater dryness and dust-generating potential of local soils and the fact that current exposure standards (external site) treat the mineralogical forms of asbestos as equivalent.

Note: For low concentration exposures (cumulative exposure of less than 0.01 f/mL.yr), the risk of mesothelioma, the most applicable health outcome from crocidolite fibre (the most potent fibre), is low. There are generally accepted quantitative estimates of disease, extrapolated from dose-response relationships established for higher occupational exposures. These are those presented by WHO (2000) and Hodgson and Darnton (2000). The estimates suggest that asbestos exposure below 0.0002 f/mL.yr is likely to be less than the lifetime risk of 1×10^{-5} and possibly less than 1×10^{-6} (WHO 2000 and Hodgson and Darnton, 2000). These are lifetime cancer risks estimates that are broadly acceptable for environmental contaminant hazards.

Appendix Two:

Determining soil asbestos concentrations and interpreting results

The confidence in the calculation and extent of the application will vary based on site-specific information on the nature of the contamination, the quantity and distribution, the investigative method used, the sensitivity of the analytical method and calculation assumptions.

Estimating asbestos concentration in soil with a high level of confidence is difficult because of its discrete and heterogeneous occurrence and the different physical forms it can take. Sampling asbestos in soil provides an estimate of contamination that can assist in characterising the site.

Ultimately, a professional judgement that considers all relevant parameters is relied upon to determine if the screening criteria has been exceeded.

Asbestos concentrations can be calculated based on the weight of asbestos for a given weight of soil using the method described below. The asbestos weight portion of the bonded ACM can be estimated, such as by using manufacturing information or laboratory estimates of asbestos proportion.

Some important considerations for calculating asbestos concentration for site characterisation include:

- where more than one distinct stratum is impacted by asbestos, separate asbestos concentration estimates should be made for each stratum
- asbestos concentrations must be reported with reference to the sampled strata.
- weight by weight concentrations should be specific to the representative sampled material and should not be calculated for areas or sample volumes with distinctly different types and concentrations of asbestos contamination; however, the type, quantity and distribution of asbestos contamination through the observed impacted areas should be described as completely as possible
- the applied soil density should be confirmed to be applicable (with comment made within the report as to the suitability for using an assumed density for soil found at the site) or preferably use calibrated field scales to weigh the 10L sample and use a measured weight for calculations where practical to do so, and soil is dry.

Generally accepted assumptions:

- soil weight may be directly measured in the field or calculated. **Sandy soil** density (1.65 kg/L) may be used as a default in WA; therefore, a 10L soil sample can be estimated to weigh 16.5 kg
- the content of asbestos in bonded ACM from **asbestos cement sheeting** may be assumed to be 15%, but for any other products, the asbestos content must be decided based on **either manufacturing information for the specific product or suitable estimates of concentration provided by a NATA accredited (for bulk samples and soils) laboratory**.[6]

[6] While the NATA accreditation may not relate specifically to such work, the results can be provided in a non-NATA endorsed report.

- % FA will need to be estimated depending on the origin of the FA, manufacturing information about the original product and the degree of friability.

Confidence in the calculated results is improved using measured rather than assumed variables (e.g. soil weight, asbestos content); this is the preferred approach. Care should be taken in ensuring transparency for any methods adopted.

For AF, it is possible to estimate the mass of loose asbestos fibres observed under a low power stereo microscope using AS 4964 Section 8.2.3 (m). The ability of a laboratory to report a concentration of asbestos in soil will depend on the sample size, level of contamination, the representativeness and homogeneity of the sample, and sampling and analytical limitations.

It is important to remember that a sample result provides an estimate of contamination.

Whenever unquantifiable asbestos fibres are found in a laboratory sample (e.g. trace analysis results), the investigation report must interpret the results based on other site information, the data quality objectives and the site conceptual site model.

Interpretation of analytical data must be provided. Discussion on results should include information on the impact area represented by the sample and how the sample results relate to the assessment criteria. Similar to other contaminants, decision making against criteria should be based on all the information available from the site investigation rather than on individual sample results. In some cases, statistical interpretation of data in accordance with the ASC NEMP and DWER guidelines may be useful but should be well justified.

In the case of AF, a few low-level concentration detects may sometimes be construed as trivial, incidental or background, especially if contamination is not suggested by site history or the main contamination contributing to the source of fibre has been removed. The context and use of a conceptual site model that reflects the relevant exposure scenarios and the frequency and occurrence of other positive and negative results should be considered.

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 and, where applicable, combined.

The concentration of asbestos in soil may be calculated as below:

Equation 1:

$$\text{mg/kg} = \frac{\text{proportion of asbestos x weight of bonded ACM or AF or FA (mg)}}{\text{Soil weight (kg)}}$$

Equation 2:

$$\%\ (\text{w/w})\ \text{asbestos} = \frac{\text{proportion (expressed as \%) of asbestos x weight of bonded ACM or AF or FA (kg)}}{\text{Soil weight (kg)}}$$

Note Equation 2 is simplified to remove conversion required for percent values and could otherwise be written as.

$$\%\ (\text{w/w})\ \text{asbestos} = \frac{(\%\text{asbestos}/100)\ \text{in bonded ACM x weight of bonded ACM or AF or FA (kg)}}{\text{Soil weight (kg)}} \times 100$$

Table 13 Example calculations

Example calculations
Example 1 AF in Soil: A 2.5 g piece of asbestos cement and a 500 mg piece of woven textile material (assumed to be 100% asbestos content) have been found in 1kg of soil. $\text{mg/kg} = \frac{(0.15 \times 2500\text{mg}) + (1 \times 500\text{ mg})}{1\text{ kg}}$ mg/kg = 875 mg/kg asbestos **Example 2 Bonded ACM in soil:** Two fragments of asbestos cement sheeting have been found in a 10 L sample of soil. One fragment weighs 100 g and the other weighs 50 g. Total weight of asbestos cement fragments is 150 g (0.15kg). $\text{\% (w/w) asbestos} = \frac{15\% \times 0.15\text{ kg}}{16\text{ kg}}$ = 0.14 % (kg/kg) asbestos

Appendix Three:

Site-specific clean up goals

This appendix should be read in conjunction with Section 3.9.2 and provides more detailed information on parameters that may be considered in the derivation of site-specific clean up goals.

Soil character and mineralogy

Soil character and mineralogy are considered together because they were combined to derive screening levels, namely:

- division of Dutch figures by a factor of 10 in consideration of the greater dryness and dust-generating potential of local WA soils
- equivalent toxicity applied to the different mineralogical forms of asbestos.

The basis for the soil character mitigating potential for asbestos fibre release is primarily related to moisture content and also the presence of clay or silt. When present at sufficient levels, clay and silt have been shown by Addison (1998) and separately by Tromp and Swartjes to reduce the fibre releasability by factors of 10 or more depending on their order of magnitude.

The Friability of a material relates to how easily it is broken up and how readily fibres will be released into the air. Generally speaking, the more friable the material is, the more likely it will release airborne fibres when handled or disturbed. However, in the soil, the same material may be wetted (depending on soil moisture content) and coated with the soil reducing the tendency to release asbestos fibres.

The sandy and often dry soils of many WA urban centres, especially on the coast, do not meet these conditions and hence the basis for applying an adjustment factor in the derivation of the screening criteria.

If it can be demonstrated that soil will maintain the moisture content of 10% or more into perpetuity and there is substantial clay/silt content for the area impacted by asbestos, then this soil mitigation feature will be considered to be met. A soil moisture probe capable of reporting within ± 5% would be sufficient. The moisture content may be difficult to prove in the longer term, especially with projected climate changes, but features such as substantial year-round rainfall or depth of contamination may be of assistance.

For clay/silt content, this feature will be deemed to be achieved if the impacted soil can be classified as Fine Grain Soils – Silts and Clays under the AS 1726:2019 (more than 35% of soil, excluding oversize fraction, is less than 0.075mm).

Regarding the mineral form of asbestos, amphiboles, particularly crocidolite, have been reported to have higher potency for mesothelioma. For many contaminated sites, mixed fibre types are found. The practicality of demonstrating that only chrysotile is present is likely to limit the usefulness of this modifying factor, hence why it was excluded in the derivation of screening levels.

For consideration of moisture content and soil type separately to asbestos type, contact DOH.

Moisture, clay content and asbestos type (predominantly chrysotile) may allow for adjusting the screening criteria by x10 where such conditions are a permanent feature of the site.

Contamination depth

If contamination is prevented from coming into contact with people, such as by surface barriers or depth, then it presents a decreased potential for exposure. However, the longevity of a surface barrier may be difficult to guarantee, and even buried contamination may result in exposure if subsequently disturbed.

Contamination from below 1 m is less likely to be disturbed and still more so with increasing depth. If such material is disturbed by deep digging or excavation, any associated exposure may be short-lived as an infrequent activity with the material being reinstated or taken off-site for disposal subject to waste disposal regulations. Also, the deeper the contamination, the greater the likelihood that dilution during excavation will reduce exposure potential. For instance, a contamination layer that begins 2 metres deep and is 0.6 m thick may be diluted by nearly fourfold by the time it was dug up, assuming no additional dilution by the lateral spread. However, consideration needs to be given to plausible future excavations at the site that may undermine assumptions regarding dilution.

Site-specific clean up goals may be able to apply a modifying factor for increasing contamination depth. Modifying factors can be applied in consultation with DOH.

Extent of Contamination

The extent of asbestos contamination as a proportion of the total used area represents a parameter for mitigating risk. Consideration for this factor is already included as part of the ASC NEPM.

The total quantity of the contamination may also be a mitigating condition but is less easy to use and may not offer sufficient conservatism where human activities may be difficult to predict and may occur within a hot spot area. In addition, for localised hot spots and other limited area contamination situations, it may be more feasible and expedient to remove and dispose of the contamination.

The location, size, concentration and spread of contamination can be considered against the likely disturbance through discrete tasks/activities, proximity to and time spent in the area of contamination during the task/activities.

An example of limited contamination where this parameter might apply is in relation to soil impacts limited to an undisturbed narrow drip line along an un-guttered residential asbestos roof.

Supporting sampling

Derivation of the site clean-up levels requires adequate data on the parameters being modified. As such, there would be a need for supporting sampling and analysis beyond the standard expectations.

For instance, location and concentration-related mitigating factors will require a higher sampling rate to be confident of the patterns being used as a basis for clean-up variation, e.g. lateral and vertical distribution and concentration range.

Separately, if soil parameters are being used, then specific sampling and analysis of soil properties, including moisture content, will need to be done and shown to be widespread to support the proposal.

Analytical methods

The derivation of the screening level for AF was fixed for all site uses because of the difficulty quantifying fine material (especially loose fibre and fibre bundle concentrations). In other words, accurate quantification between 0.01% and 0.001% asbestos (weight/weight) is not feasible.

Since the first publication of the Guidelines in 2009, international methodologies have emerged that offer greater sensitivity and have been accepted for use by DOH (See Chapter 5). If these or other sufficiently sensitive DOH accepted analytical methods are employed, it is feasible that the screening criteria for AF can be varied to reflect the type of site use (ASC NEPM (1999).

Where other mitigation factors for a particular site are being applied for AF, there may be greater scope for considering site use exposure ratios for site uses as the clean-up levels will start from a higher quantifiable concentration.

Other factors

Other factors that have not been used in deriving screening values but could be considered in developing sustainable remediation options or deriving site-specific clean-up goals, if they appear to mitigate risk, include:

- rainfall patterns and level
- wind erosion potential
- soil physical properties
- surface cover, noting that this may vary with time
- soil chemistry (which may be stabilising rather than conducive to bonding breakdown)
- exposure assessment with air sampling data
- the physical form of the asbestos
- asbestos fibre characteristics
- the total mass of asbestos
- site isolation.

In using such factors, it is important not to exclude other factors that might have more of a risk increasing role, such as the asbestos being present as pure crocidolite fibre.

It is also worth noting that the original basis for developing the screening criteria assumed a 70-year exposure, and the current ASC NEPM applies 30-35 years. The average time for the development of mesothelioma is 40 years, and so late-life exposure will not have an opportunity to manifest as this disease.

Appendix Four:

Laboratory analysis

The current *AS4964–2004 Method for the qualitative identification of asbestos in bulk samples* provides a staged approach to detecting asbestos in soil samples. The information below can be used to develop in house procedures consistent with these Guidelines and the staged approach in AS4964 for pre-analysis of AF samples and sample preparation for trace analysis.

A larger 500 ml sample is submitted to assist in the quantification of AF (all material less than 7 mm x 7 mm) found in the preliminary steps of analysis, which cannot be effectively observed in the field and which is best examined in a controlled environment by a NATA accredited laboratory (see Table 14).

Samples submitted for AF in soil analysis are intended to be representative samples and should not be diluted through improper sampling techniques. It is accepted that the larger sample may result in the less than 2 mm material being reduced before subsequent stages analysis. Where it is expected that the form of asbestos contamination is predominately less than 2 mm, submission of a smaller field collected representative sample may be more relevant. Any variations or advice regarding sample size can be discussed between the client and the laboratory.

It is important to note that the laboratory sees a very small sample of material where the origin of AF may be unknown to the analyst. As such, analysts do not have the information necessary, unless provided by the sampler, to determine whether the origin of any AF should be managed as friable or non-friable or minor contamination of dust and debris.

Bonded ACM and FA (>7 mm) may be described based on appearance. (e.g. fraying woven asbestos). The size of material or debris found in AF may be insufficient to accurately identify the potential source of the debris (i.e. the identity of the source commercial product). Therefore, the laboratory may only be able to provide a limited description.

The supporting site investigation information may sometimes be provided to the laboratory to assist describe the sources of AF in the soil sample.

The DOH has requested that for contaminated site assessments, the presence of all forms of asbestos is reported, even where it is below the detection limit and non-respirable, as this information provides supporting information to site assessments.

Where these Guidelines recommendations inadvertently conflict with Australian Standards or in-house NATA accreditation requirements, laboratories should approach DOH to discuss and help resolve these differences.

The limit of reporting is determined by the laboratory. Where the presence of asbestos is detected using AS 4964 the value of 0.001%w/w asbestos should be assumed to be exceeded.

Limitations of PLM should also be considered, such as for analysis of fibres that are:

- of small diameter
- occluded by interfering materials in the sample matrix
- of a fibre type not able to be identified by the method.

The use of alternate methods may be acceptable to DOH, following consultation on their suitability, that may provide supporting information regarding the presence and relative quantities/contribution of asbestos fibres in a sample in Tier 2 and 3 assessments. Examples of international methods are:

- ASTM D7521
- ISO methods
- Quantification of Asbestos in Soil: Methods for the Examination of Waters and Associated Materials (Standing Committee of Analysts, 2017, "Draft") or the IOM Technical Report: Release of dispersed fibres from soils (Addison et al., 1988).

Table 14 Examination of samples

Further information regarding examination soil samples by the laboratory (aligned with steps in AS 4964-2004, 8.2.3)

1. Record the dry weight of the submitted soil sample.
2. Screen the entire sample through a 10 mm sieve.
3. Examine the +10 mm matter by eye or magnifying glass/stereo microscope
4. Options for providing separate information on +7 mm material
   a. Screen the entire sample through a 7 mm sieve as an intermediate step
   b. Examine the -10 mm fraction and report the separated and weighed +7 mm suspect material found in Step 5 separately to the -7 mm material.
5. Separate and weigh all suspect material, including small fragments of bonded material and other fibrous matter, for identification by PLM and DS – note appearance, size and estimated asbestos content.
6. Screen through a 2 mm sieve.
7. Spread out and examine the entire, or a number of sub samples (to be determined by in-house procedures), of the - 2mm fraction using a combination of low and high power stereomicroscopy.
8. Extract any suspect -2mm material for later identification by PLM DS, noting appearance and dimensions (weigh if possible).
9. Conduct a trace analysis on (a reduced) -2mm fraction.

For split tube core samples, open tube and examine each layer and separate suspect layers for more detailed analysis, i.e. more time should be spent examining those layers[7]. Each layer may require separate treatment, including sieving through 10 and 2 mm sieves, in effect allowing for individual sample results for each strata layer.

AS 4964 requires all fibrous matter to be weighed or measured and allows for the estimate of weight to occur based on the appearance and dimension of the matter found or knowledge of the identified asbestos-containing product found and likely asbestos content (see AS 4964, Section 8.2.3 (m)). For small pieces of bonded materials with fibres still retained in the substrate, it may be possible to assign a portion of the weight as asbestos (e.g. 15% asbestos for an asbestos cement fragment).

[7] Use appropriate safety precautions.

The proportion of asbestos content attributed to fibrous matter should be conservatively determined. Where little of the parent bonding material remains, 100% of the weight of the material can be apportioned as asbestos fibre.

It is important, especially for Tier 2 assessment, for all the supporting information gathered during analysis to be provided (i.e. information on the appearance, size and asbestos content of materials identified as asbestos). If possible, such a detailed report should differentiate between empirical and estimated values, including weights and dimensions.

The laboratory can provide NATA accredited reports that include a description and results of identification by PLM-DS of the separated asbestos found in the soil sample. Results of trace analysis on a laboratory reduced soil (sub)sample can also be provided as per AS4964, being:

- no asbestos detected by polarized light microscopy, including dispersion staining
- trace [fibre type] asbestos detected by polarized light microscopy, including dispersion staining
- [fibre type] asbestos detected by polarized light microscopy, including dispersion staining.

For these Guidelines, laboratories may assist the client with a summary of findings that clarifies:

- the total dry weight of the submitted soil sample
- a description of each confirmed asbestos “fibrous matter” found in the sample, its dimensions and the measured or estimated weight, which can also be categorised into:
  - +7mm bonded ACM
  - +7mm FA material
  - -7mm AF
- the estimated asbestos weight of the fibrous matter in the sample can be expressed as a percentage of the total dry weight of the sample (% asbestos (w/w) in soil) separately for the above categories.

The “trace analysis” results provide useful information, especially for Tier 2 assessment, but are subject to interpretation prior to comparison with screening criteria.

This document can be made available in alternative formats on request for a person with disability.

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