New Zealand Guidelines for Assessing and Managing

ASBESTOS IN SOIL

Produced in association with:

Australasian Land & Groundwater Association

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BRANZ

BRANZ is an independent and impartial research, testing and consulting organisation inspiring the building and construction industry to provide better buildings for New Zealanders. We achieve this by transforming insightful research into accessible actionable knowledge.

Our customers are located in New Zealand, Australia and around the world. We aim to provide them with innovative and value-for-money research-based solutions, helping to create a better built environment. Our work includes research, publications, seminar and training services, product appraisal, and materials and fire testing.

We have around 100 highly trained specialist staff located in Wellington. The main BRANZ site at Judgeford, Wellington, covers 5 hectares and contains laboratories, testing facilities and exposure sites to meet national and international standards.

ALGA

The Australasian Land & Groundwater Association (ALGA) was formed to provide a forum and identity for the Australasian contaminated land and groundwater industry and support the many professionals working in the field.

The core focus of ALGA is to support advances in the prevention, assessment and remediation of contaminated land and groundwater. ALGA is the peak body for contaminated land practitioners operating in Australasia.

ALGA established the New Zealand Asbestos Group early in 2016 as regulation and guidance within New Zealand on the management of asbestos was rapidly changing. The interest group is to provide a stand-alone forum for the wide variety of practitioners working within the asbestos management industry to work collectively on nationally consistent guidance to support regulation. It also provides a network forum for practitioners to discuss various issues within industry and provides a mechanism for collective industry advocacy focused on asbestos-related regulation.

FOREWORD

Our own experience of asbestos-contaminated soil at BRANZ was the reason behind the development of the *New Zealand Guidelines for Assessing and Managing Asbestos in Soil.*

We discovered that the asbestos-cement roof on our fire laboratory was shedding asbestos fibres and contaminating the surrounding soil. The asbestos contamination was then being mobilised from soil to air by the very innocent act of mowing the lawn. This opened a Pandora's Box for BRANZ. The lack of clear guidance in New Zealand and the confusion, uncertainty and concern for our people is still very front of mind when I think of what happened here.

At BRANZ, we pride ourselves on our health and safety processes. Seeking guidance on managing the asbestos risks alone was not something we could let pass without finding a solution for New Zealand industry or property owners. The Health and Safety at Work (Asbestos) Regulations 2016, which came into force on 4 April 2016, have made this work even more timely.

Experts from central and local government and industry – in particular, the ALGA New Zealand Asbestos Group team – have been instrumental in helping form the guidelines. The input from both local and international experts has been invaluable and adds significant weight to the guidelines.

The guidelines will be an invaluable document for all industry practitioners as well as home, property and business owners in understanding how to assess and manage asbestos-contaminated soil in New Zealand.

At BRANZ, we want to share our story, along with that of other New Zealand enterprises, to reassure others that this issue can be dealt with safely and successfully.

Chelydra Percy
Chief Executive
BRANZ

ABOUT THESE GUIDELINES

Asbestos is a health hazard driven by fibres in the air. *The New Zealand Guidelines for Assessing and Managing Asbestos in Soil* (the guidelines) takes New Zealand industry step by step through the process of identifying, assessing and managing asbestos in soil. The guidelines provide a practical approach for industry practitioners (consultants, contractors and regulators) that is specific to New Zealand – our soils, climate, lifestyle, history and regulations.

The purpose of the guidelines is to provide a methodology to ensure that management of asbestos in soil meets regulatory requirements and an acceptable level of managed risk. They follow an approach that is tailored to the remediation outcomes required for changes in land use and subdivision of asbestos-contaminated land under the Resource Management Act, but many aspects will be applicable in other cases of asbestos-contaminated land, such as continuing use as workplaces, schools or recreational land. The guidelines set conservative threshold values for determining asbestos contamination, and users should bear this in mind when applying them.

In publishing this first edition, BRANZ's intention is that the science and practice of the guidelines will be further developed over the next 2 years. The results of the further research work will be combined with industry and regulatory feedback on implementation, and the thresholds within the guidelines will be re-evaluated at the end of 2019.

The guidelines have been developed through engagement with WorkSafe New Zealand, Ministry for the Environment, Ministry for Business, Innovation and Employment, other key regulators and various industry stakeholders.

The guidelines align with these key New Zealand documents:

- Health and Safety at Work (Asbestos) Regulations 2016 (Asbestos Regulations)
- Approved Code of Practice: Management and Removal of Asbestos (ACOP)
- Resource Management (National Environmental Standard for Assessing and Managing Contaminants in Soil to Protect Human Health) Regulations 2011 (NES-CS)
- Contaminated Land Management Guidelines (CLMGs).

It should be noted that the NES-CS and some CLMGs may change before the next update of the guidelines.

Historically, WorkSafe New Zealand has actively supported the use of the Guidelines for the Assessment, Remediation and Management of Asbestos-Contaminated Sites in Western Australia (WA Guidelines). The guidelines have continued to leverage this internationally recognised guidance document.

The guidelines are split into these sections:

1. **Introduction**: The aims and objectives of the guidelines.
2. **Legal obligations and triggers**: Due to the nature of the asbestos risk, practitioners must always follow the Health and Safety at Work Act 2015 as soon as a site becomes a place of work. Asbestos in soil is also governed by the Resource Management Act 1991 within the contaminated land framework, in particular the NES-CS. These regulations have defined the nature and format of the guidelines.
3. **Understanding asbestos in soil**: The history and use of asbestos products in New Zealand, including photographs of asbestos-containing materials in soil. This section includes the specific characteristics, fate and behaviour of asbestos in soil.
4. **Preliminary site investigation**: Completing a preliminary investigation for a site or defined area of a site is a key requirement in establishing NES-CS compliance and assists in the design of detailed site investigation. The investigation assesses current and past land uses. It identifies potential contaminants of concern (which may include asbestos), their likely location and significance, pathways for migration and linkages between the

pollution and people who may be affected by it. The preliminary site investigation process presented largely follows the CLMGs and has been adapted for the specific requirements of asbestos.

5. **Detailed site investigation**: Practical guidance on methods and techniques to investigate asbestos-contaminated sites, leveraging the existing CLMGs. Methods of analysing asbestos in soils are described in detail, including field screening techniques. Tier 1 soil guideline values are presented for a number of generic land use scenarios and a framework for Tier 2 health risk assessment.
6. **Management and remediation**: Key remedial methods ranging from administrative procedures (such as planning controls) to engineering controls (such as capping) through elimination/removal of contamination posing a risk. Guidance is given on assessing remedial options, developing remedial strategies for the site, developing a remedial action plan and mitigation controls. This section also covers decontamination of plant, equipment and personnel following remediation and disposal of asbestos in soil.
7. **Site validation**: A key component of any contaminated land project and asbestos work is confirming that the asbestos clean-up goals are achieved and the site can be used as intended. This includes the required reporting, clearance certificates and management plans.
8. **Ongoing management**: Where residual asbestos remains on site, management plans should be included in the site's asbestos management plan as well as any institutional controls.
9. **More information**: Lists of key legislation and standards and links to New Zealand and overseas resources.
10. **Glossary**: There are many asbestos-specific terms throughout the guidelines. See the glossary at the back of the guidelines for definitions.

For workplaces:
For guidance specific to PCBUs and the workplace, refer to Asbestos in Soil – A Guide for PCBUs (www.branz.co.nz/asbestos), and for asbestos more generally, WorkSafe New Zealand's Approved Code of Practice: Management and Removal of Asbestos (November 2016) (www.worksafe.govt.nz/worksafe/asbestos).

For do-it-yourselfers:
The guidelines are not intended for do-it-yourselfers. However, the process and methodology can and should be used as guidance. For more information on removing asbestos from the home, refer to these Ministry of Health publications at www.moh.govt.nz:

- All About Asbestos
- Removing Asbestos from the Home.

CONTENTS

1. INTRODUCTION

'Asbestos' is the term for several fibrous minerals regulated under New Zealand law that are known to cause fatal or potentially fatal illnesses when inhaled. Asbestos does not present a known significant health risk in other situations. The symptoms of illness may not appear for 20 or more years after exposure.

Diseases known to be caused by asbestos include, but are not limited to:

- pleural disease – scarring of tissue on the outer lining of the lungs and internal chest wall
- asbestosis – lung inflammation leading to scar tissue
- mesothelioma – cancer of the lining of the lungs
- lung cancer – tumours form in the lungs
- laryngeal cancer – affecting the larynx (part of the throat)
- intestinal cancer
- ovarian cancer.

Once thought to be safe, asbestos-containing material (ACM) was widely used in several industries, including building and construction, because it was durable, fireproof and cost-effective. Asbestos-based products were prominent in New Zealand homes, offices, factories and other buildings from the 1920s to the mid-1980s. Importing crocidolite (blue) and amosite (brown) was prohibited from 1984. Chrysotile was banned from 1999, but importing ACM was only banned in New Zealand in October 2016. The mineral was manufactured into a wide variety of construction and industrial products, many of which remain in place today.

Less-careful waste management and building demolition practices in the past have resulted in asbestos contamination of soil, creating an ongoing problem for the building and health industries. This is a large commercial and emotive health issue for the New Zealand public and industry.

There are legal requirements and restrictions around investigating, assessing and managing occupational exposures to asbestos, particularly under the Health and Safety at Work (Asbestos) Regulations 2016 (Asbestos Regulations). However, these provide limited detail for addressing asbestos as a soil contaminant and dealing with contaminated land.

The guidelines therefore aim to provide practical guidance around assessing and managing sites that contain soil potentially contaminated with asbestos. The guidelines are targeted at all practitioners as well as those property owners, land managers or business owners seeking technical information on the topic.

The typical range of work undertaken for asbestos in soil projects is outlined in the flowchart in Figure 1. The flowchart steps through work from the initial stages of a project through the investigation and health risk assessment process, site management and remediation to work completion and verification. The flowchart sets the structure of the guidelines.

The flowchart also sets out the key regulatory controls that apply. Integrating the requirements of all the health and safety and environmental regulations has not been straightforward, and many jurisdictions have struggled with this.

The higher-risk licensed work administered by the Health and Safety at Work Act 2015 and associated Asbestos Regulations is shown in dark green in Figure 1.

1.1 Regulatory framework

Anyone with responsibility for assessing, managing or remediating land contaminated with asbestos in New Zealand should be familiar with the key regulations and guidance.

WorkSafe New Zealand and Ministry of Business, Innovation and Employment:

- Health and Safety at Work Act 2015
- Health and Safety at Work (Asbestos) Regulations 2016
- WorkSafe New Zealand Approved Code of Practice: Management and Removal of Asbestos (November 2016)
- Good Practice Guidelines: Conducting Asbestos Surveys (2016)

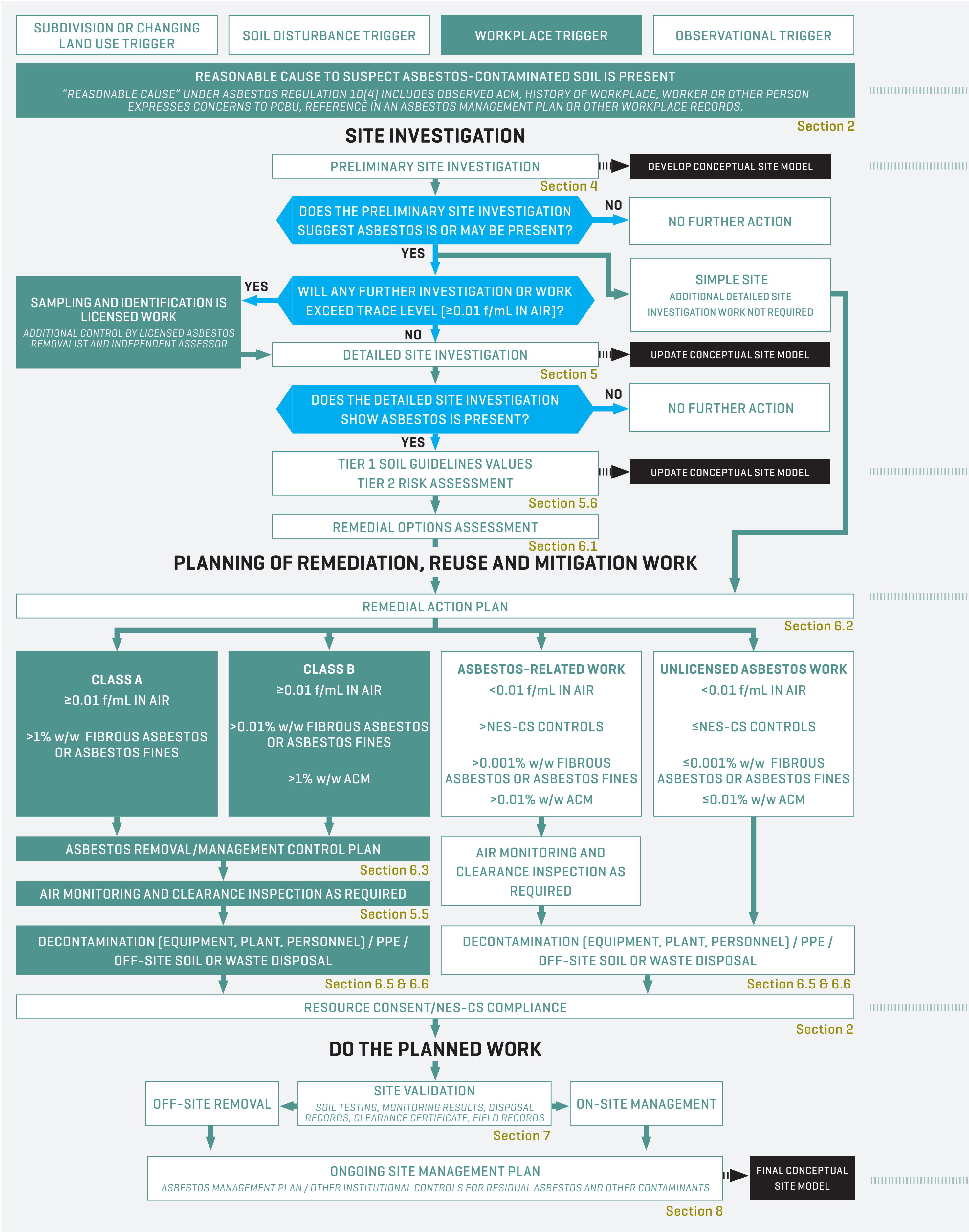


Figure 1. Decision flowchart for work involving asbestos in soil.

GUIDANCE AND CONTROLS	RESPONSIBILITY/SIGN-OFF
REGULATION 10(4)	PCBU
CLMG 1	COMPETENT PERSON/SQEP
Regulation 48	Comptent Person/SQEP
Regulation 4 & 9(2)	SQEP/Asbestos Assessor
CLMG 1	SQEP
	SQEP
CLMG 1 & 5	SQEP/ASBESTOS ASSESSOR
CLMG 2	SQEP
CLMG 1	SQEP
Class A: Regulation 46	Class A/Class B Asbestos Assessor/ SQEP/PCBU
Regulation 32 Class A: Regulation 43 ARW Regulation 51	Asbestos Assessor Independent Assessor
Class A: Regulation 39 & 52 Other: Regulation 40 & 53	PCBU/SQEP/ Asbestos Assessor
NES-CS	REGULATOR
CLMG 1, Regulation 41+42 Regulation 13+14	Class A: Independent Asbestos Assessor Other: Independent Competent Person Asbestos Assessor
CLMG 1	SQEP

- Building Act 2004
- New Zealand Building Code clause F1 *Hazardous agents on site*

Ministry for the Environment

- Resource Management Act 1991 (RMA)
- Resource Management (National Environmental Standard for Assessing and Managing Contaminants in Soil to Protect Human Health) Regulations 2011 (NES-CS)
- Users' Guide: National Environmental Standard for Assessing and Managing Contaminants in Soil to Protect Human Health
- Hazardous Activities and Industries List (HAIL) guidance
- Contaminated Land Management Guidelines (CLMGs):
  1. Reporting on Contaminated Sites in New Zealand
  2. Hierarchy and Application in New Zealand of Environmental Guidelines Values (Revised 2011)
  3. Risk Screening System
  4. Classification and Information Management Protocols
  5. Site Investigation and Analysis of Soils

Ministry of Health

- Health Act 1956

1.2 Specialist roles

Assessing, managing and remediating asbestos contamination requires specific expert skills, equipment and experience. These specialist roles are mentioned throughout the guidelines (and defined in the glossary):

- Person conducting a business or undertaking (PCBU).
- Suitably qualified and experienced practitioner (SQEP): Territorial authorities often hold lists of consultants/ practitioners they accept as being suitably qualified and experienced for working on contaminated sites. The SQEP should also be experienced in dealing with asbestos in soil.
- Competent person: Under the Asbestos Regulations, a competent person has acquired, through training and experience, the knowledge and experience of relevant asbestos removal industry practice. In the context of asbestos-contaminated soil, this will often be a SQEP.
- Licensed asbestos removalist (Class A or Class B).
- Independent asbestos assessor.
- Accredited testing laboratory.

The guidelines do not go into wider social responsibilities, such as communicating with staff or residents at the affected site and with neighbouring properties, beyond recommending full communication with stakeholders.


DANGER
ASBESTOS
CANCER AND LUNG DISEASE
HAZARD
KEEP OUT
AUTHORIZED
PERSONNEL ONLY
RESPIRATORS AND
PROTECTIVE CLOTHING
ARE REQUIRED IN
THIS AREA.

2. LEGAL OBLIGATIONS AND TRIGGERS

Significant legal obligations apply to anyone working with asbestos and controls that must be applied to contaminated sites. There are also documents that provide statements of good practice but that may not have the status of law. These should still be applied or considered to ensure compliance with the minimum safety duties under the Health and Safety at Work Act 2015 and Asbestos Regulations.

Any site with asbestos-contaminated soil is treated as a contaminated site under the RMA and NES-CS. Controls and processes can then be applied for compliance with both the RMA and the Health and Safety at Work Act 2015 to manage health risks associated with contaminated soil.

Depending on each site, the parties commissioning the investigations should be informed of their legal obligations and the minimum requirements under the regulatory framework. For do-it-yourself homeowners, the legal obligations are less extensive but the controls and processes remain the same.

In addition, the general requirements relating to the effects of hazardous substances/contaminants and materials (such as those in buildings) apply:

- Health and Safety at Work Act 2015 – controls for human health and safety when a site is a workplace.
- Resource Management Act 1991 – avoiding, remedying or mitigating any adverse effects of activities on the environment (including people and communities).
- Building Act 2004 – controls the design, construction, operation, use and demolition of buildings and structures
- Health Act 1956 – considers effects on public health.

2.1 Health and Safety at Work (Asbestos) Regulations 2016

The Asbestos Regulations are set up under the Health and Safety at Work Act 2015. These regulations primarily apply to workplaces, but any site becomes a workplace when a worker carries out work there as part of their employment.

The Asbestos Regulations prohibit a PCBU from directing or allowing a worker to carry out work involving asbestos or ACM in New Zealand (unless that work falls under an exception listed within regulation 7). They impose certain duties on a PCBU around managing the risks of work involving asbestos, ACM, asbestos removal and licensing. The seven parts to the Asbestos Regulations are:

1. Preliminary provisions and declaration of notifiable incidents
2. Work involving asbestos and ACM
3. Licensing, supervision and training of asbestos removalists
4. Class A licences and air monitoring
5. Asbestos-related work
6. Licensing of asbestos removalists and asbestos assessors
7. Miscellaneous provisions.

One of the objectives of the Asbestos Regulations is to regulate and set out the acceptable level of respirable asbestos fibres in the air. The more fibres in the air small enough to be inhaled, the greater the risk to health. This introduces the following terms:

- Trace level – an average concentration over any 8-hour period of less than 0.01 respirable asbestos fibres per millilitre of air (0.01 f/mL). If the proposed work is likely to exceed the acceptable trace level, the work is subject to licensed work controls as per the Asbestos Regulations.
- Airborne contamination standard – an average concentration over any 8-hour period of 0.1 respirable fibres per millilitre of air (0.1 f/mL).

The contamination standard cannot be exceeded at any workplace, except as defined by Part A of the ACOP.

The Asbestos Regulations impose specific obligations in relation to asbestos removal or asbestos-related work involving soil that is likely to lead to airborne contamination over the acceptable trace level when one or more of these conditions are met:

- Work involving more than 10 m² of non-friable ACM (sometimes referred to as bonded ACM).
- Work involving asbestos-containing dust associated with the removal of >10 m² of non-friable asbestos or ACM.
- Work involving friable asbestos.
- Work for which trace level is likely to be exceeded during or after assessment and/or remediation work.

Even if none of these conditions are met, the person commissioning asbestos removal work must ensure that the work is carried out by a competent person.

'Competent person' is a term used to describe a person with the knowledge, experience, skills and qualifications to carry out a particular task under the Asbestos Regulations. A competent person must determine whether soil does not contain ACM or friable asbestos in a quantity likely to lead to airborne contamination above trace level. If it does not, work involving asbestos-contaminated soil is permitted either as that work or asbestos removal work. This is subject to risk control measures being in place and that appropriate lines of evidence supporting that finding are kept. This is further outlined in the ACOP and the guidelines.

Regulation 3 of the Asbestos Regulations defines two types of asbestos work:

- Asbestos-related work means work involving asbestos (other than asbestos removal work to which Part 3 of the Asbestos Regulations applies) that is permitted under the exceptions set out in regulation 7(2), (3) and (4) of the Asbestos Regulations.
- Asbestos removal work means:
  a. except in Part 6 of the Asbestos Regulations, work involving the removal of asbestos, asbestos-contaminated soil or ACM; or
  b. in Part 6 of the Asbestos Regulations, Class A or Class B asbestos removal work.

Work involving asbestos in soil is classified into these categories:

- Unlicensed asbestos removal work
- Asbestos-related work
- Licensed asbestos removal work, divided into two categories:
  - Class A licensed asbestos work
  - Class B licensed asbestos work.

Class A and B removal work are defined in the glossary.

Asbestos-related work involving soil should be overseen by a person competent at managing asbestos in soil, i.e. a suitably qualified and experienced practitioner (SQEP).

If the trace level in air is likely to be exceeded while assessing or remediating the site, any work involving the removal of asbestos-contaminated soil must comply with the asbestos-removal obligations under the Asbestos Regulations. If asbestos is not completely removed, a workplace asbestos management plan is required (see section 8).

Refer to the Asbestos Regulations and ACOP for more information on health and safety considerations, processes and legal requirements during asbestos work.

2.2 Resource Management (National Environmental Standard for Assessing and Managing Contaminants in Soil to Protect Human Health) Regulations 2011

Referred to as the NES-CS, these regulations are set up under the Resource Management Act 1991.

The NES-CS is a national framework for planning controls and soil contaminant standards for managing public health risks around land use and development (including subdivision) and soil disturbance. It ensures that land potentially affected by contaminants in soil is appropriately identified and assessed before it is disturbed and/or developed. Resource consent requirements under the NES-CS are triggered for soil disturbance, change of use and subdivision on sites where there are or were activities/industries likely to cause contamination and listed on the Hazardous Activities and Industries List (HAIL) held by the Ministry for the Environment. The HAIL includes industrial processes such as chemical or fertiliser manufacture, sites, livestock dips and so on. Resource consent may be granted with conditions for the land to be remediated or managed to make it safe for human use. Asbestos in soil is captured under the NES-CS as a contaminant with the potential to impact human health. For more information, refer to www.mfe.govt.nz /land/hazardous-activities-and-industries-list-hail.

The NES-CS only applies to sites where contaminants, including asbestos, are present at concentrations above background levels. In New Zealand, asbestos in soil is generally considered to be a contaminant as it is typically a result of human activities rather than occurring naturally. However, it is a common contaminant on many developed properties. For example, on urban sites, there could be background (or ambient) concentrations of asbestos in soil that, while present and being a result of human activity, are unlikely to pose a human health risk. However, they could pose a commercial risk arising from conservative risk perceptions.

The HAIL is likely to identify sites that have possible asbestos in soil issues. Specifically, subcategory E1 of the HAIL is the "manufacture of asbestos products or sites containing asbestos known to be in a deteriorated condition".

Under the NES-CS, all site investigations should be completed in accordance with the CLMGs, which are administered by the Ministry for the Environment. The key CLMG documents are:

1. Reporting on Contaminated Sites in New Zealand
2. Hierarchy and Application in New Zealand of Environmental Guidelines Values (Revised 2011)
5. Site Investigation and Analysis of Soils.

Under the NES-CS, when any one or more of the following conditions applies to the disturbance of soil, resource consent is required:

- More than 25 m^3 of soil is disturbed per 500 m^2.
- More than 5 m^3 of soil is removed off site per 500 m^2.
- Changing land use or subdivision activities.
- A contaminant is above background concentration.

Permitted activity controls apply whether or not these conditions are met.

For land use for primary production, the resource consent requirements under the NES-CS only apply to soil disturbance affecting an existing or proposed residential use. Resource consent is also required under the NES-CS for a subdivision or a change of land use if there is a material risk that will create a risk to human health.

Resource consent may be required to authorise the removal and/or ongoing management of asbestos-contaminated soil under the provisions of the NES-CS and/or regional or unitary plan. The resource consent process formally records asbestos in soil matters on property files and other council records, such as HAIL registers and Land Information Memorandums (LIMs). This information is therefore available to a wider audience including potential purchasers or developers of sites.

If resource consent is required for the removal of asbestos contaminated soil, the documentation prepared to support asbestos in soil work under the provisions of the Asbestos Regulations should be enough to support resource consent requirements. Additional documentation prepared by a SQEP is likely to be required where the proposal for dealing with asbestos in soil is by methods other than removal. This includes encapsulation on site or other methods that require ongoing institutional controls and management, which would also be included in an asbestos management plan under the Asbestos Regulations.

As per the RMA section 76, district plans may also address issues around land use and the protection of human health. However, for soil contamination, the NES-CS prevails over district plan rules, except where those rules permit or restrict effects not dealt with in the NES-CS.

As per the RMA section 68, regional plans (and some parts of unitary plans) cover protection of the general environment, including ecosystems, habitats, communities and individuals that may be exposed to contaminants. Asbestos is not typically identified as a contaminant of concern to environmental health in regional plans. Therefore, consent for asbestos in soil-related effects is often not required under regional planning rules.

Resource consent requirements should always be discussed with the relevant territorial authority before any work involving asbestos in soil begins.

2.3 Building Act 2004

The Building Act 2004 is relevant because many New Zealand buildings were built with asbestos-containing materials between the 1920s and mid-1980s. Under the Asbestos Regulations, however, any building constructed before 2000 is assumed to contain asbestos.

Sitting under the Building Act 2004 is the New Zealand Building Code, where clause F1 *Hazardous agents on site* of that Code relates to identifying and remediating hazardous agents or other contamination of a building site. The functional requirement of the clause is that "buildings shall be constructed to avoid the likelihood of people within the building being adversely affected by hazardous agents or contaminants on the site".

With this very general wording, clause F1 and the Building Act 2004 are unlikely to trigger any activity relating to asbestos.

2.4 Health Act 1956

The Health Act 1956 gives the Ministry of Health the primary function of improving, promoting and protecting public health.

The Ministry of Health publishes The Management of Asbestos in the Non-occupational Environment – Guidelines for Public Health Units. The Health Act 1956 also requires people to avoid public health nuisances (which include dust from asbestos). Under the Health Act 1956, environmental health officers from the local authority have powers to abate nuisances and can do so without notice to the occupier. The Ministry of Health guidelines are directed at non-workplace exposure to asbestos in air and provide advice on:

- determinig the risk of an asbestos hazard
- managing and appropriately communicating the risk.

Further information for do-it-yourself homeowners is also available – see section 9.3.2 of the guidelines.

2.5 Triggers for assessing asbestos in soil

There are many triggers for considering whether possible asbestos contamination is present in soil. Five of these have been identified in Figure 1 and Table 1 as:

- subdivision
- changing land use
- soil disturbance
- known or reasonably likely exposure to respirable fibres in a workplace
- public observation of potentially unsafe asbestos practices.

Regardless of how the contamination or suspected contamination is identified, several laws require the property owner (PCBU) with management or control of the workplace to take action. Table 1 shows how the various laws intersect.

<table>
<tr><th>Legislation</th><th colspan="4">Key regulatory considerations</th><th>Contact</th></tr>
<tr><td rowspan="7">NES-CS</td><td colspan="2">Consent required</td><td colspan="2">Permitted activity</td><td rowspan="7">Local or regional authority
www.localcouncils.govt.nz</td></tr>
<tr><td colspan="2">Soil disturbance >25 m³ and/or off-site removal of >5 m³ of contaminated soil per 500 m² of a piece of land</td><td colspan="2">Soil disturbance <25 m³ and/or off-site removal of <5 m³ of contaminated soil per 500 m² of a piece of land</td></tr>
<tr><td colspan="4">HAIL assessment</td></tr>
<tr><td colspan="4">Contaminant concentrations above background</td></tr>
<tr><td colspan="4">Subdividing land or changing land use</td></tr>
<tr><td colspan="4">Suspicion and/or discovery of asbestos in soil within site work area</td></tr>
<tr></tr>
<tr><td rowspan="3">Asbestos Regulations</td><td colspan="3">Licensed asbestos work</td><td>Unlicensed</td><td rowspan="3">WorkSafe
www.worksafe.govt.nz/worksafe/information-guidance/guidance-by-hazard-type/asbestos

Other PCBUs</td></tr>
<tr><td>Class A friable asbestos</td><td colspan="2">Class B >10 m² non-friable ACM over the whole project for the site</td><td><10 m² of non-friable ACM over the whole project for the site</td></tr>
<tr><td colspan="4">Observation of a believed asbestos risk or unsafe practice at a workplace</td></tr>
<tr><td>Building Act 2004</td><td colspan="4">Refurbishment or demolition of a structure or plant constructed or installed before 1 January 2000</td><td rowspan="2">Local or regional authority
www.localcouncils.govt.nz</td></tr>
<tr><td>Health Act 1956</td><td colspan="4">Observation of a believed asbestos risk or unsafe practice to public health</td></tr>
</table>

Table 1. Current regulatory triggers for considering the possibility of asbestos contamination in soil.

Hardie's Fibrolite Factory, Penrose, Auckland. Whites Aviation Ltd.
Ref: WA-02425-G. Alexander Turnbull Library, Wellington, New Zealand.

3. UNDERSTANDING ASBESTOS IN SOIL

The most harmful asbestos fibres are very small and easily inhaled – typically less than 3 µm in width, greater than 5 µm in length and with a length-to-width ratio greater than 3:1. They are not visible to the human eye – as a comparison, an average human hair is over 2,000 times thicker.

Asbestos is very often mixed with other materials and rarely seen in its raw form, so it is difficult to identify it just from looking at it. Laboratory tests are required to confirm its presence.

Asbestos is the fibrous form of several silicate minerals belonging to the serpentine and amphibole groups of minerals. More information on the types of asbestos is available in section 2 of the ACOP.

The most common form of asbestos in soil is bonded ACM, which typically comprises asbestos in a bound matrix of cement or resin.

Fibrous asbestos (FA) and asbestos fines (AF – including free fibres of asbestos, fibrous asbestos, small fibre bundles and ACM fragments) are the biggest cause for concern. They are the most likely to generate respirable fibres that can lodge in the lungs and therefore have the greatest exposure potential.

3.1 History of asbestos use in New Zealand

Although natural asbestos is found in New Zealand (including Takaka, King Country, Fiordland and Dunedin), it was only mined on a small scale. Raw asbestos was mostly imported – from around 2,000 tonnes per year until the late 1940s to a peak in 1975 of 12,500 tonnes. It is estimated that around 200,000 tonnes of asbestos was imported altogether.

Asbestos-based products were widely used in New Zealand homes, offices, factories and other buildings from the 1920s to the mid-1980s. The mineral was manufactured into dozens of construction and industrial products (Figure 2). Asbestos-cement building products were manufactured in Penrose (Auckland) from 1938–1980s and in Riccarton (Christchurch) from 1943–1974. A Dunedin company also produced lagging materials containing asbestos. The use of asbestos in New Zealand building materials (in particular, roof and wall cladding, pipes and gutters) grew considerably in the 1960s and 1970s.

Pascoe, John Dobree, 1908-1972 Photographic albums, prints and negatives. Ref: 1/4-000378-F. Alexander Turnbull Library, Wellington, New Zealand.

Figure 2. Manufacturing asbestos fibrolite (ca 1940s).

After local manufacture of building materials containing asbestos ceased, their use significantly declined. Their importation into New Zealand was not fully banned until 1 October 2016.

A significant proportion of New Zealand houses built in the 1940s–1970s used asbestos-cement sheet or tile roofing, sheet or plank wall cladding, soffits and fencing. Its use was widespread in other types of buildings too. The asbestos content was typically 5–15% by weight. As well as being fire resistant, it was inexpensive, durable and easy to install.

Some of these materials are still in place 40–80 years later. They may appear to be in reasonable condition if they have been regularly painted but otherwise left undisturbed.

ACMs were also used widely in surface-applied finishes (for acoustic, decorative and fire-retardant purposes), thermal insulation and pipes, lagging and insulating plant and equipment in buildings and in subsurface infrastructure.

Figures 3 and 4 show where ACM is most commonly found in New Zealand houses and other buildings.

3.2 Identifying asbestos in soil

These are the most common forms of asbestos contamination in soil in New Zealand:

- ACM waste products used as imported fill – used from the 1930s–1970s in farm tracks, swamp infilling and so on, generally close to an asbestos factory.
- Dumping of ACM – from uncontrolled dumping of asbestos waste (such as fly-tipping) or from waste management, disposal or processing sites (such as scrap yards and landfills).
- Inadequate identification, removal, clearance and decontamination of ACM before building or structure demolition resulting in surface-contaminated soil. This may be found from a lack of asbestos survey information, evidence of fire, historical lack of guidance for building demolition or other reasons.
- Inadequate identification and removal of subsurface ACM – which can be found in water pipes, telephone and electrical conduits and so on.
- Rainwater and wind carrying fibres from degrading ACM cladding to the ground around a building. This may occur at sites where existing structures had or have significant areas of degrading asbestos roof or wall cladding.
- Damaged drains from roofs and guttering constructed from ACM.

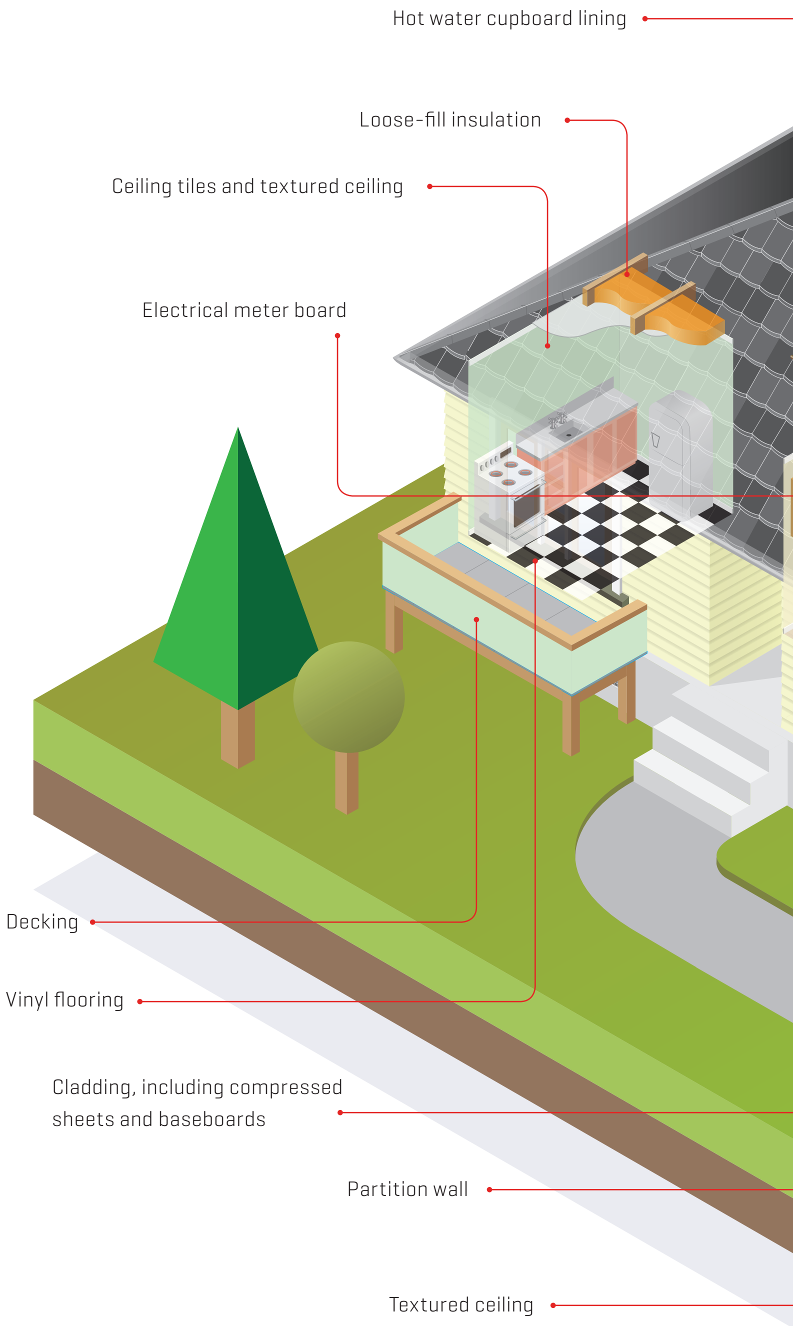
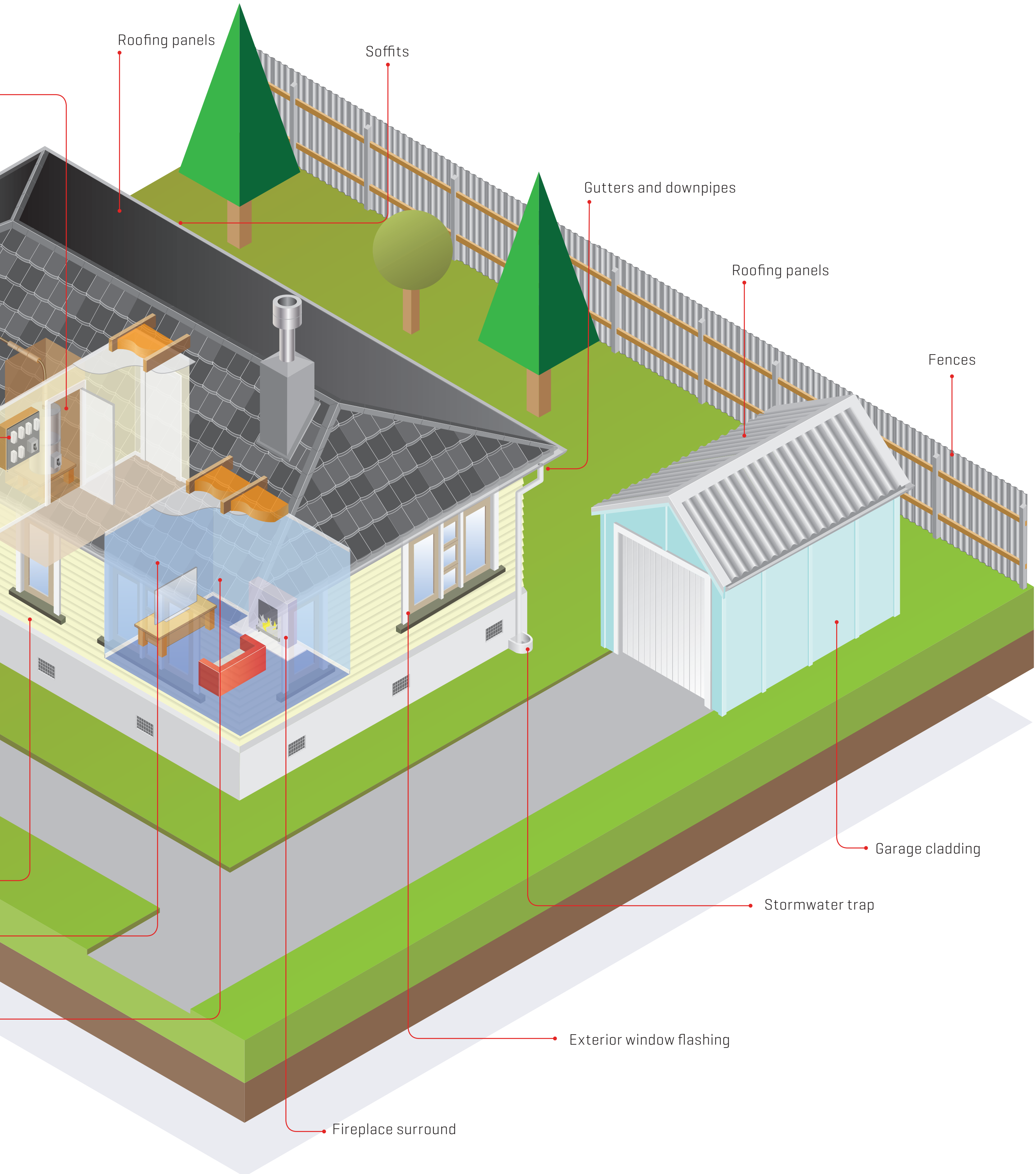


Figure 3. Commonly found asbestos in residential buildings.


Roofing panels
Soffits
Gutters and downpipes
Roofing panels
Fences
Garage cladding
Stormwater trap
Exterior window flashing
Fireplace surround

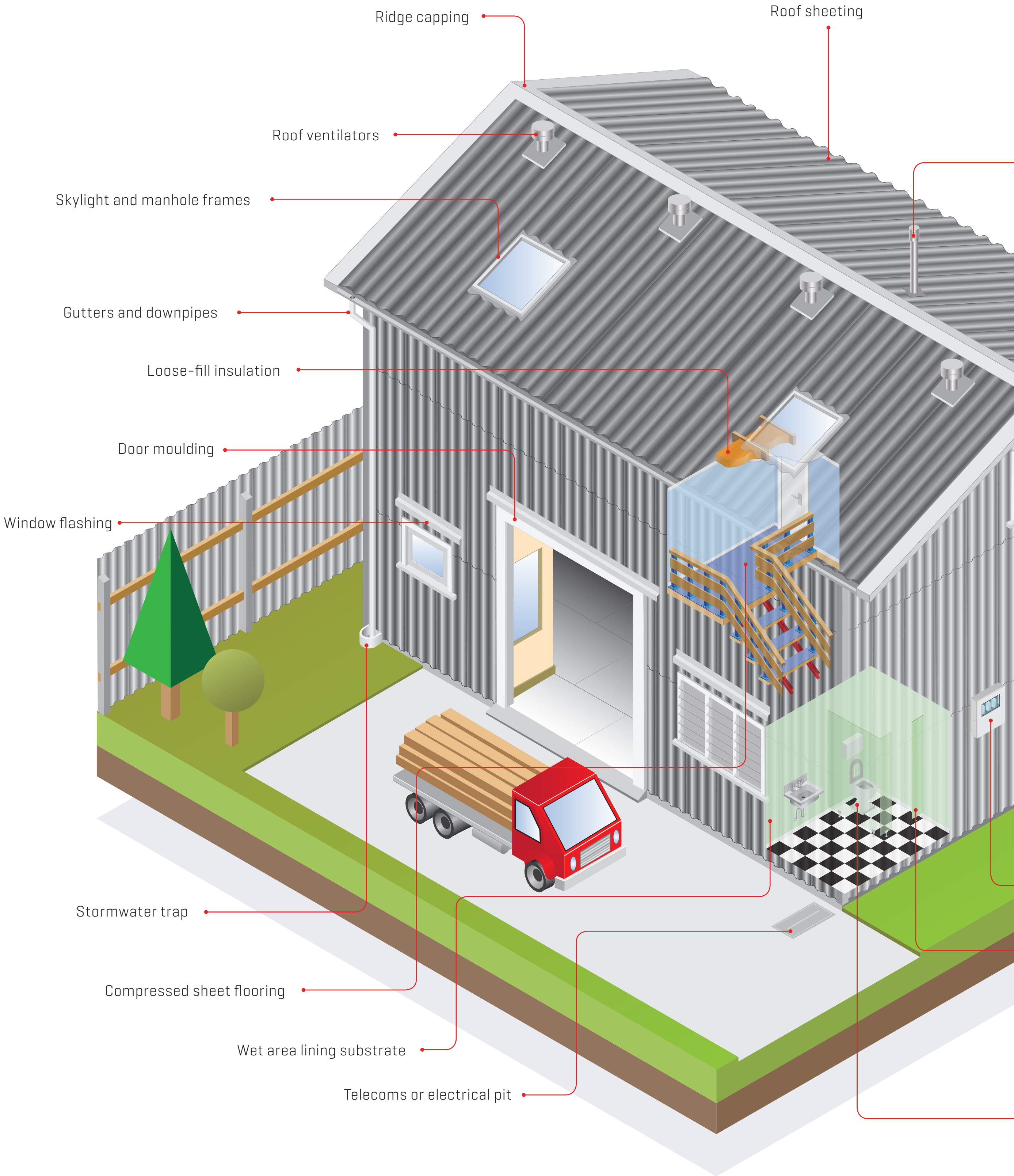


Figure 4. Commonly found asbestos in non-residential buildings.

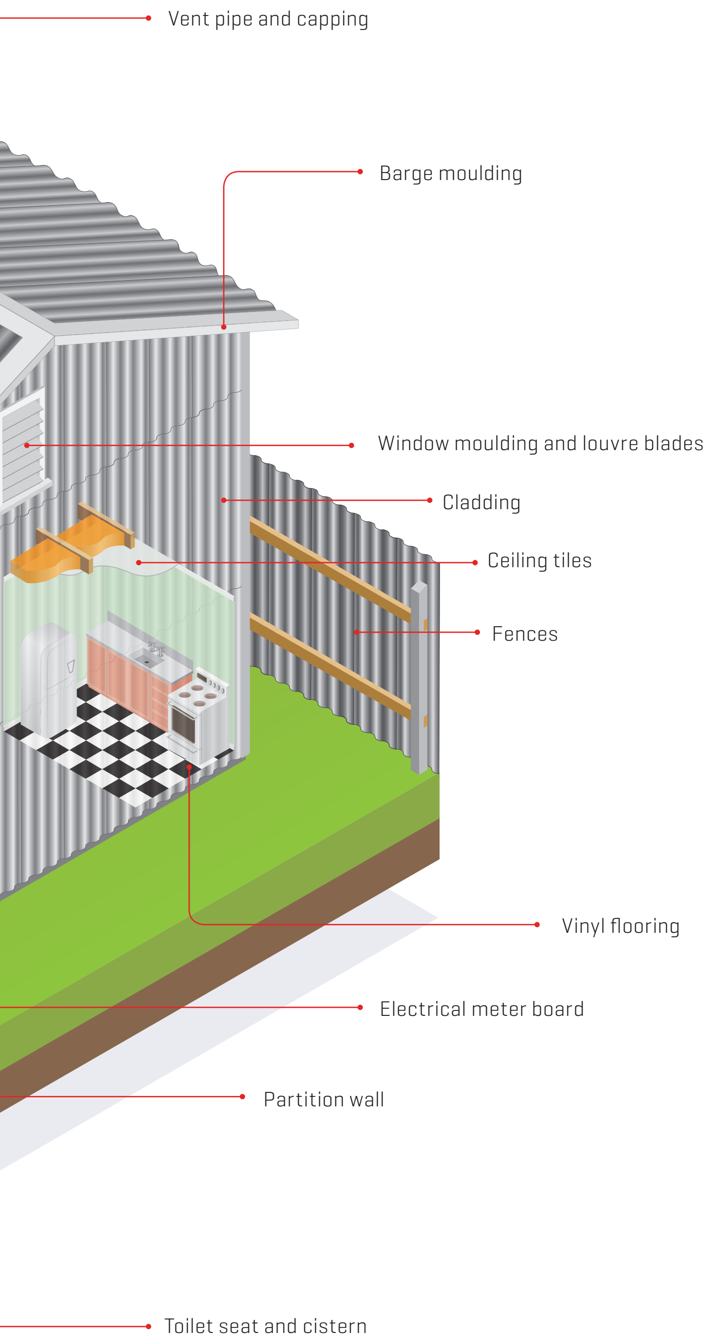


Figure 5. Tile and floor coverings containing asbestos in soil.

Reprinted with permission. Source: Nathanail, Jones, Ogden, & Robertson. (2014). CIRIA C733.

Figure 6. Insulating materials containing asbestos in soil.

Photo: Mike Mechaelis.

Figure 7. Asbestos-cement sheet and bonded ACM in soil.

Reprinted with permission. Source: Nathanail, Jones, Ogden, & Robertson. [2014]. CIRIA C733.

Figure 8. Decorative coatings containing asbestos in soil.

Photo: Gareth Oddy

Figure 9. Other asbestos-containing products in soil.

Photo: Paul Dahl

Figure 10. Landfill contaminated with a wide variety of asbestos-containing products as a result of dumping demolition waste.

Photo: Paul Dahl

Figure 11. Earthquake and general building demolition rubble.

Asbestos itself is very stable and will remain in the soil indefinitely, although many common forms of ACM may slowly degrade (particularly in acid-rich soils) if left in soil or made ground. This may lead to more asbestos fibres being released over time. Examples of asbestos contamination in soil are shown in Figures 5–11).

3.3 Asbestos behaviour and characteristics in the ground

Unlike other common contaminants, the risks associated with asbestos-contaminated soil result from the potential to release airborne fibres. However, asbestos in soil typically:

- is inert
- does not degrade quickly, depending on how it is bonded and specific soil conditions
- is not readily mobilised into the air
- once buried, is immobile – it does not migrate other than through erosion, physical movement or airborne migration
- is not evenly distributed – there is often no pattern to its location
- is the result of human activity rather than naturally occurring and is widespread as ACM, particularly in urban environments
- does not impact groundwater
- does not affect plant or animal life.

Depending on the nature of the site, sediment in the stormwater system and at the point of discharge to a surface water course (or similar) may be contaminated with asbestos.

Asbestos pipes were (and still are) often used to supply potable water. However, testing of asbestos fibres in drinking water does not need to be undertaken unless a health issue has been identified.

Several studies have evaluated the potential for airborne concentrations of asbestos fibres from various types and degrees of asbestos-contaminated soil. The two sloping trend lines in Figure 12 indicate the connection between different amounts of friable asbestos in the soil and in the air. The lower blue line describes field measurements, while the upper red line describes the laboratory-simulated, theoretical worst-case measurements. The graph also shows results for field measurements of bound asbestos.

International field tests found that:

- soil containing bonded ACM concentrations of <1% weight for weight (w/w) produces little to no airborne fibres
- for friable asbestos, higher soil concentrations generate higher airborne fibre concentrations – airborne fibre concentrations ranged from around 0.0001 f/mL at 0.01% w/w up to around 0.05 f/mL at over 1% w/w

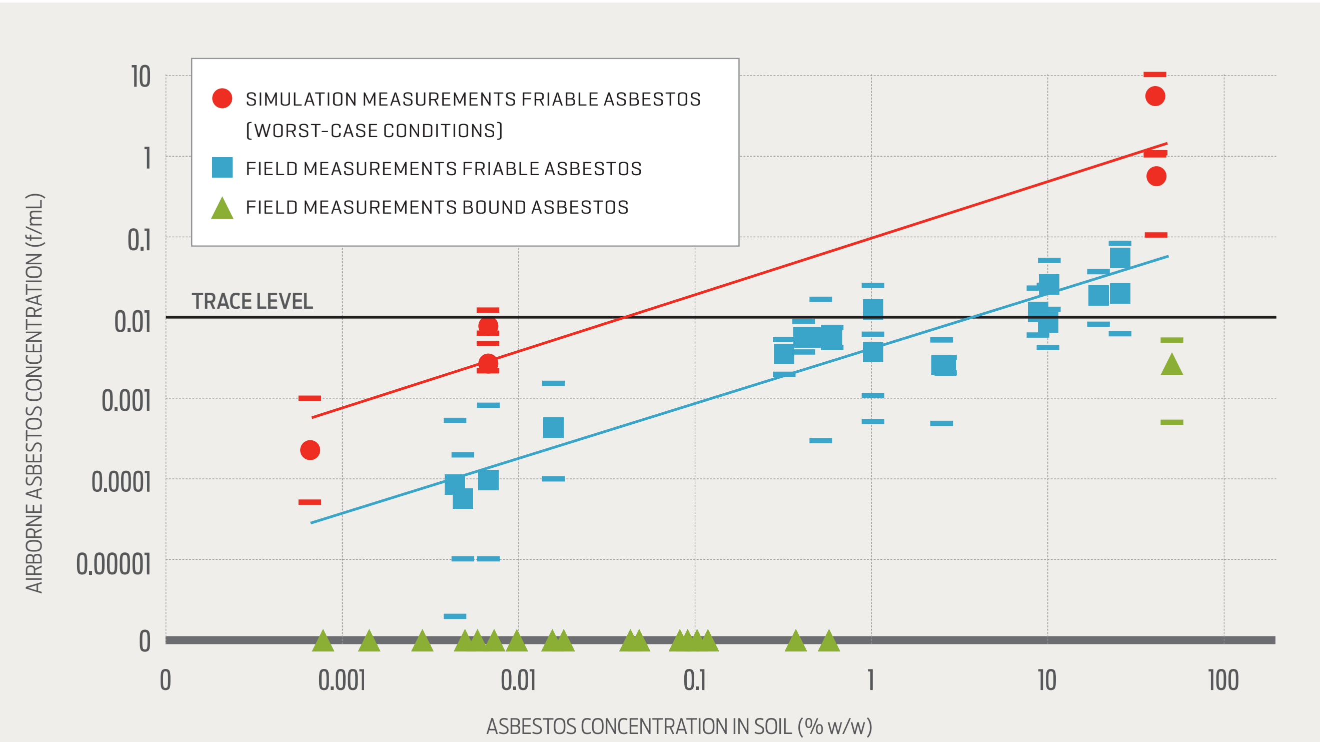


Figure 12. Asbestos fibre release in simulated and field measurements.

Swartjes & Tromp, 2008, reprinted and adapted with permission of Taylor and Francis, LLC (http://www.tandfonline.com).

- the variability in the data is high – for example, the highest airborne concentration measured at 0.01% w/w exceeds the lowest measurement at 1% w/w
- in general, worst-case laboratory simulations predict higher airborne concentrations than are seen in field measurements, meaning laboratory-simulated results generally overstate the predicted airborne concentration.

Current analytical evidence, available studies and experience in New Zealand suggest that significant visible quantities of non-friable ACM, such as asbestos cement products, would need to be present in the soil to result in airborne asbestos concentrations over the trace level of 0.01 f/mL.

The release of airborne asbestos fibres from three natural soils (sandy, silty and clay) generally produces different airborne fibre concentrations, with the sandy soil producing higher concentrations than silty and clay soils.

Soil acidity may also be important. The more acidic the soil, the more likely that bonding compounds in ACM will degrade and lead to an increase of asbestos fibre release into air over time.

The amount of asbestos fibres in air is not driven by the soil conditions alone. Other factors such as those described in Figure 13 also need to be considered.

The New Zealand Soil Classification System is useful for describing the physical, chemical and structural types of soil and predicting how asbestos behaves in soil. This includes:

- soil type
- soil moisture/water content
- surface cover.

3.3.1 Soil type

Basic maps show areas of different soil types across New Zealand. However, even the most intricate soil or geological maps cannot describe the soil at a specific site in detail and so this information is gained through a detailed site investigation.

Soils found during a contaminated land investigation must be logged with standard descriptions, such as those of the New Zealand Geotechnical Society (Figure 14). Key descriptions include grain size(s) for the differing geological units and relative moisture content of the soil (dry, moist and wet).

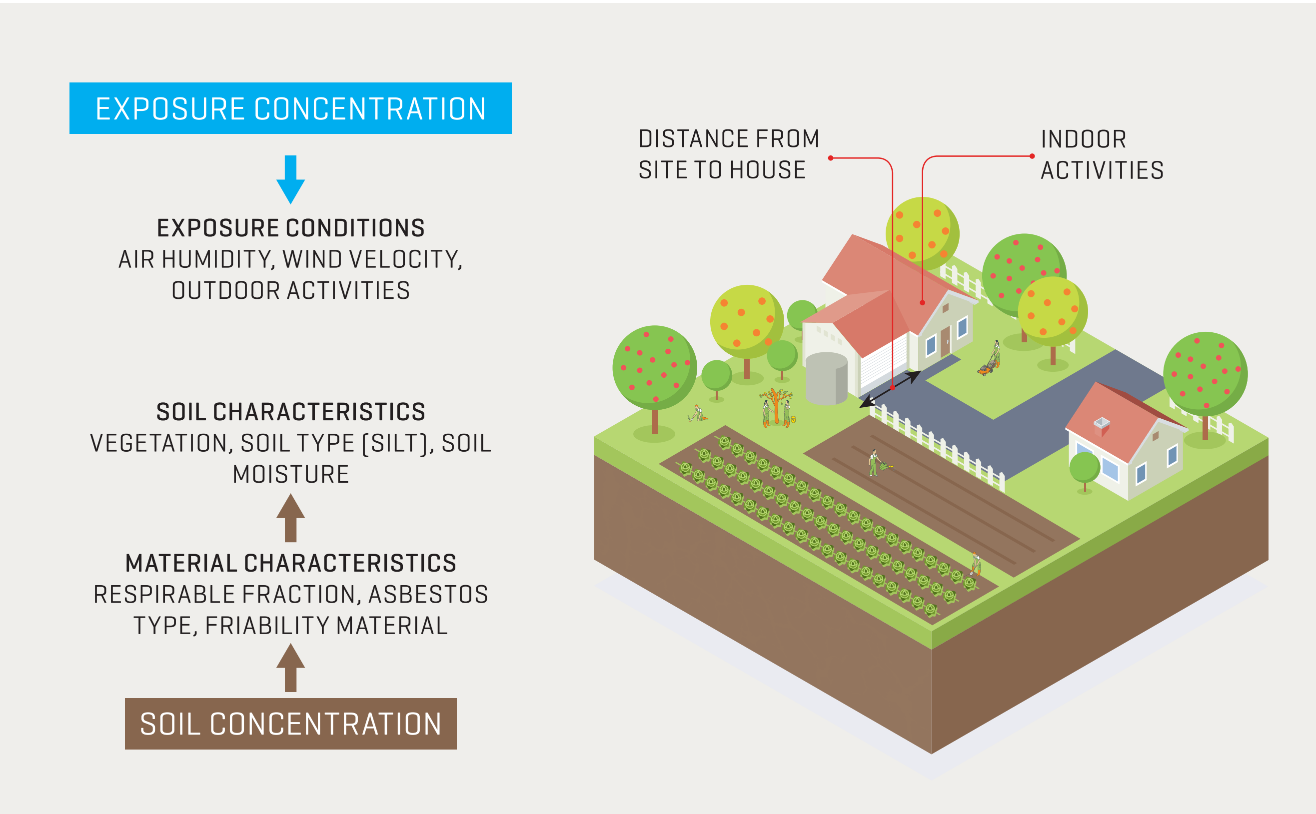


Figure 13. Risk factors linking the concentration of asbestos in soil and human exposure concentrations.

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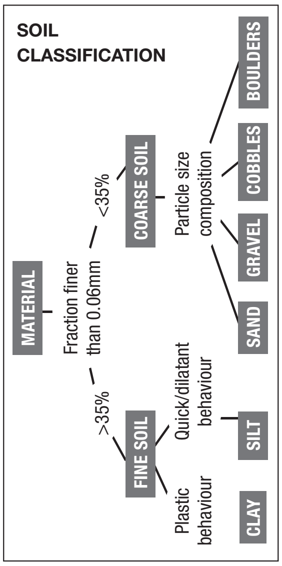
SOIL > field guide sheet

FIELD DESCRIPTION OF SOIL

SEQUENCE OF TERMS – fraction – colour – structure – strength – moisture – bedding – plasticity – sensitivity – additional

GRAIN SIZE CRITERIA

TYPE	COARSE								FINE		ORGANIC
	Boulders	Cobbles	Gravel			Sand			Silt	Clay	Organic Soil
			coarse	medium	fine	coarse	medium	fine			
Size Range (mm)	200	60	20	6	2	0.6	0.2	0.06	0.002		
Graphic Symbol											



PROPORTIONAL TERMS DEFINITION (COARSE SOILS)

Fraction	Term	% of Soil Mass	Example
Major	(….) [UPPER CASE]	≥ 50 [major constituent]	GRAVEL
Subordinate	(….) y [lower case]	20 – 50	Sandy
Minor	with some … with minor …	12 – 20 5 – 12	with some sand with minor sand
	with trace of (or slightly)…	< 5	with trace of sand (slightly sandy)

DENSITY INDEX (RELATIVE DENSITY) TERMS

Descriptive Term	Density Index (R_D)	SPT "N" value (blows / 300 mm)	Dynamic Cone (blows / 100 mm)
Very dense	> 85	> 50	> 17
Dense	65 – 85	30 – 50	7 – 17
Medium dense	35 – 65	10 – 30	3 – 7
Loose	15 – 35	4 – 10	1 – 3
Very loose	< 15	< 4	0 – 2

Note: • No correlation is implied between Standard Penetration Test (SPT) and Dynamic Cone Test values.
• SPT "N" values are uncorrected. • Dynamic Cone Penetrometer (Scala)

CONSISTENCY TERMS FOR COHESIVE SOILS

Descriptive Term	Undrained Shear Strength (kPa)	Diagnostic Features
Very soft	< 12	Easily exudes between fingers when squeezed
Soft	12 – 25	Easily indented by fingers
Firm	25 – 50	Indented by strong finger pressure and can be indented by thumb pressure
Stiff	50 – 100	Cannot be indented by thumb pressure
Very stiff	100 – 200	Can be indented by thumb nail
Hard	200 – 500	Difficult to indent by thumb nail

ORGANIC SOILS/ DESCRIPTORS

Term	Description
Topsoil	Surficial organic soil layer that may contain living matter. However topsoil may occur at greater depth, having been buried by geological processes or man-made fill, and should then be termed a buried topsoil.
Organic clay, silt or sand	Contains finely divided organic matter; may have distinctive smell; may stain; may oxidise rapidly. Describe as for inorganic soils.
Peat	Consists predominantly of plant remains. ***Firm***: Fibres already compressed together ***Spongy***: Very compressible and open stucture ***Plastic***: Can be moulded in hand and smears in fingers ***Fibrous***: Plant remains recognisable and retain some strength ***Amorphous***: No recognisable plant remains
Roolets	Fine, partly decomposed roots, normally found in the upper part of a soil profile or in a redeposited soil (e.g. colluvium or fill)
Carbonaceous	Discrete particles of hardened (carbonised) plant material.

PLASTICITY (CLAYS & SILTS)

Term	Description
High plasticity	Can be moulded or deformed over a wide range of moisture contents without cracking or showing any tendency to volume change
Low plasticity	When moulded can be crumbled in the fingers; may show quick or dilatant behaviour

MOISTURE CONDITION

Condition	Description	Granular Soils	Cohesive Soils
Dry	Looks and feels dry	Run freely through hands	Hard, powdery or friable
Moist	Feels cool, darkened in colour	Tend to cohere	Weakened by moisture, but no free water on hands when remoulding
Wet			Weakened by moisture, free water forms on hands when handling
Saturated	Feels cool, darkened in colour and free water is present on the sample		

GRADING (GRAVELS & SANDS)

Term	Description	
Well graded	Good representation of all particle sizes from largest to smallest	
Poorly graded	Limited representation of grain sizes - further divided into:	
	Uniformly graded	Most particles about the same size
	Gap graded	Absence of one or more intermediate sizes

NZ GEOTECHNICAL SOCIETY INC

This field sheet has been taken from and should be used and read with reference to the document FIELD DESCRIPTION OF SOIL AND ROCK. Guideline For the Field Classification and Description of Soil and Rock for Engineering Purposes. NZ Geotechnical Society Inc, December 2005. **www.nzgeotechsoc.org.nz**

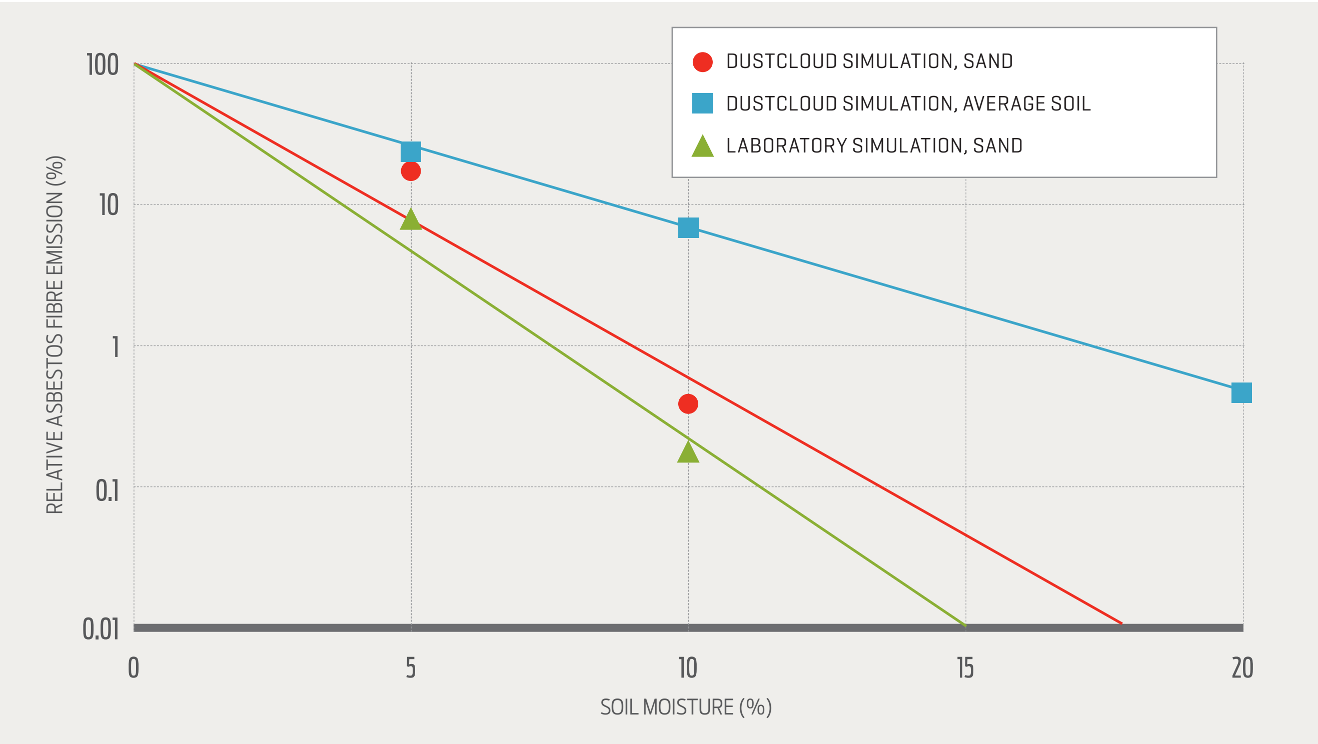
compiled by KATE WILLIAMS **design** KARRYN MUSCHAMP

Figure 14. New Zealand Geotechnical Society field guide sheet for soil.

As Figure 14 shows, soil can be broadly characterised as dry, moist, wet or saturated, although this is likely to change over time.

Soil moisture content is one of the most important factors dictating the release of airborne asbestos fibres. Minor increases in moisture content significantly reduce the release of asbestos fibres (Figure 15). At 0% moisture in the soil, research has found that concentrations of airborne asbestos exceeding occupational control limits (in this case, >0.1 f/mL) could be generated from soil containing as little as 0.001% asbestos w/w. Adding just 5% moisture reduces airborne asbestos by 80–95%.

These findings support damping down as a mitigation measure to control occupational exposures to airborne asbestos (see section 6.4) and significantly contribute to the health risk assessment (see section 5.6).



Swartjes & Tromp, 2008, reprinted and adapted with permission of Taylor and Francis, LLC (http://www.tandfonline.com).

Figure 15 . Asbestos fibre release in soils with differing moisture/water content.

4. PRELIMINARY SITE INVESTIGATION

The Ministry for the Environment has produced guidance on conducting and reporting on preliminary site investigations (PSIs) and detailed site investigations (DSIs) for contaminants in soil.

This guidance includes:

- CLMG 1: Reporting on Contaminated Sites in New Zealand
- CLMG 5: Site Investigation and Analysis of Soils
- Users' Guide: National Environmental Standard for Assessing and Managing Contaminants in Soil to Protect Human Health.

Practitioners should be familiar with these and other internationally recognised standards and guidance, such as the WA Guidelines. This section does not repeat those but gives additional guidance on key issues when undertaking a site investigation when asbestos in soil could be present.

Contaminated site assessments are generally undertaken in a phased manner, evolving as more information is found. There is typically a PSI first, followed by a DSI where necessary. Other detailed work may then be required, depending on the site.

A robust conceptual site model should be started early. This is a system diagram and/or written description (often a table) showing where contamination is and how it could be released and transported to those who may be affected by it. It can be supported by maps and drawings. In simple terms, it tells what is going on at the site and helps to inform everyone involved in the work. It helps to guide initial investigation work, and it is added to as more information is found. The conceptual site model is dynamic, and development is iterative based on investigation findings.

After initial development of the conceptual site model, appropriate management options can be developed. The scope of the site investigation work will be controlled by the aims of the investigation. In some instances, it may be appropriate to tailor the site investigations to areas of a site that are being developed rather than the whole site – particularly on large properties.

Asbestos may not be the only contaminant of concern at a site. Site investigations must establish whether other contaminants of concern are present on a site or are likely to be.

A PSI gathers information on present and past uses of a site or a defined area of a site. It aims to identify contaminants of concern, their likely location and significance and pathways for migration within the site or off site, including pathways where contamination might reach people. This will provide the information to develop a preliminary conceptual site model.

PSIs are undertaken for a variety of reasons, including:

- compliance with the NES-CS, such as a change in land use, property subdivision or soil disturbance
- due diligence
- remedial and excavation planning
- scoping a DSI.

CLMG 1 presents the recommended content of a PSI report, particularly with respect to compliance with the NES-CS. It also serves as a useful prompt to ensure that all appropriate lines of evidence and data sources are assessed.

The PSI may include a site inspection and is a key source of information for assessing potential asbestos soil contamination. A site inspection is required in certain circumstances – see sections 4.3 and 4.5. The decision to undertake a site inspection will depend on project requirements and judgement of the SQEP signing off the PSI report.

4.1 Desktop information sources

Key desktop information sources for a PSI include:

- asbestos-related documentation (if available) – asbestos management plans, registers (a crucial reference if one exists), site or building survey reports (may include

air testing, swab testing, material and/or soil testing), removal reports and records
- historical reports and aerial photographs
- site layout plans, building plans and records
- council databases and records
- historical society records, newspaper articles, historical photographs, titles
- fire service records.

A more comprehensive summary is given in CLMG 5. Various international guidance such as the WA Guidelines (see section 9.4) and the UK Industry Profiles (see section 9.5) provide lists of possible background data sources and types of industries that are likely to have used asbestos and asbestos products.

It is important not to restrict the review of documentation on a site. Depending on the activities on neighbouring properties, an asbestos source elsewhere may have migrated to and/or deposited on the site. This could be through stormwater run-off, roof or building cleaning activities, fire in buildings constructed with ACM or infilling encroaching on a site from neighbouring property.

4.2 Asbestos, preliminary site investigations and NES-CS compliance

When assessing the risks posed by sites potentially contaminated with asbestos as well as determining compliance with the NES-CS, the assessment of asbestos contamination should be no different to sites with other contaminants. The one exception is the need to address the potential health risk(s) from the potential release of airborne asbestos fibres.

Key sites for possible asbestos-contaminated soil include:
- industrial land – asbestos-cement manufacturing, thermal power stations, rail and ship yards, especially workshops and depots
- waste disposal or dump sites that have received demolition waste
- pre-2000 buildings and structures damaged by storm or fire
- sites and properties that have used ACM or where asbestos may have been used for insulation material – asbestos roofing, sheds, garages, water tanks and so on
- land with fill or foundation material of unknown composition
- sites where pre-2000 buildings or structures have been improperly demolished or renovated or where documentation is lacking
- disused services with ACM piping – water pipes and so on.

As detailed in CLMG 1, under the NES-CS, a PSI is required in these situations:
- To establish whether or not the site is or has been on the HAIL of property types likely to be at higher risk. This means it is more likely than not that an activity or industry in the HAIL is being or has been undertaken – regulation 5(7) or 6(3).
- If the site is HAIL and the activity is a change of use or subdivision, to show the activity is permitted (as per the NES-CS). This involves demonstrating it is highly unlikely that there will be a risk to human health in the particular circumstances and proposed use or subdivision – regulation 8(4).

The HAIL captures potential asbestos contamination under industry-specific categories A to G (because of asbestos use and asbestos soil contamination/infilling). It also involves categories H and I because of potential migration/release of asbestos onto a subject site from air or waterborne migration. This could be from building fires, waterblasting of roofing and stormwater run-off.

Asbestos is specifically dealt with under category E(1) – asbestos product manufacture, including sites with buildings containing asbestos products known to be in a deteriorated condition. The last part of this phrase is not well defined. Assume that this applies to all sites or properties that have used asbestos-containing building products, provided it can be shown that the building materials have been or are in a deteriorated condition.

Key lines of evidence to consider:
- Is ACM present or suspected to be present based on relevant factors such as age, composition, industry, evidence of demolition, location, interviews and so on?
- What is the condition (level of deterioration) of the external building fabric (which may or may not include ACM)? Is it intact and well maintained, detached, damaged and fragmented, or somewhere in between? There may still be a problem even if old cladding has been removed.
- Can you see evidence of suspected external ACM such as cladding, roofing, guttering and so on?
- Are there existing or historical asbestos building surveys available? If there is no survey information, the SQEP should assume there is asbestos in the structure if it was constructed before 2000.

Given that the information obtained for a PSI is mostly general and not about specific quantities of contaminants, take a conservative approach when assessing the potential human health risk. This will mean considering multiple lines of evidence. However, the approach and response need to be proportional to the risk.

4.3 Site inspection

When desktop information shows the presence of asbestos contamination in soil is likely, it is essential that a competent practitioner makes a site inspection. Photographs and location co-ordinates should be taken to document what can be seen. A site inspection will also allow contaminant linkages that were not obvious from the desktop information to be better understood.

The site inspection should consider the following as a minimum:

- Where possible (and depending on the competence of the practitioner), whether or not asbestos building products were used in the external building fabric and may have contaminated the soil. For a PSI, it is not necessary to consider the internal building fabric.
- Evidence of asbestos labelling on any buildings or structures – potentially on entranceways and/or the asbestos product itself.
- Evidence of any previously demolished buildings on site or any significant exterior refurbishment.
- Evidence of infilling or landfilling with potential asbestos wastes.
- Inspection of near-surface exposed soil for the presence/absence of asbestos, notably ACM fragments.
- Assessment of whether migration of asbestos fibres or fragments from neighbouring properties onto the subject site is possible or has occurred.

To assist with the site inspection, Table 2 shows a prompt sheet. Depending on the nature and objectives of the PSI, a competent practitioner making a site inspection could also use the Material Assessment Algorithm from the Good Practice Guidelines: Conducting Asbestos Surveys (2016). This is used to characterise the nature of the building materials and their likelihood of releasing asbestos fibres and contaminating the soil. It is important to state whether the building fabric has been proven to contain asbestos or not.

4.4 Conceptual site model

The results from the PSI will enable the initial development of a conceptual site model to support the decision-making process for the DSI and ongoing site management, including developing an asbestos management plan.

This model is a written and/or diagrammatic summary of the environmental processes at the site and surrounding area. It also describes the ways contamination at a site may reach communities or individuals or anything that may potentially be affected. A schematic geological cross-section showing an asbestos conceptual site model is shown in Figure 16. Further guidance on developing a conceptual site model can be found in CLMG 5.

The conceptual site model should describe three essential elements:

- **Sources** – known and potential sources of contamination (a site could be contaminated solely by asbestos, or there could also be other contaminants of concern).
- **Pathways** – all likely and complete exposure pathways by which people (occupants of the site, neighbours, site workers) could be exposed to contaminants, under current or known future land uses. It is important to remember that the only relevant exposure pathway for asbestos is airborne fibres.
- **Receptors** – this term mostly refers to people who may be exposed to asbestos.

The written section of the conceptual site model should explain the level of uncertainty associated with the conceptual site model's various elements. Similarly, if a diagrammatic representation is being used (such as a geological cross-section), the areas of uncertainty need to be identified.

Asbestos-contaminated soil is typically found near the surface in the top 0.5 m of soil, unless asbestos waste (or soil) has been buried and/or asbestos-contaminated fill has been brought to the site. The conceptual site model must try to explain the different ways and sources by which the soil came to be contaminated with asbestos.

4.5 Preliminary site investigation reporting

CLMG 1 sets out the recommended content of a typical PSI report. In many cases, several contaminants of concern could be present at a site. Therefore, the report may include a stand-alone section detailing asbestos-related issues. That may relate to soil contamination and/or presence and condition of asbestos-containing building or other products that could have been or are contributing to asbestos-contaminated soil.

Where a PSI report indicates there is likely to be asbestos in soil, several lines of evidence may be required to justify this conclusion. This avoids unnecessarily and negatively impacting a site due to conservative assumptions about the presence of asbestos when there is no strong evidence to suggest its presence.

The PSI report should describe the limits and uncertainty of the investigation, noting areas that have not been fully addressed. These steps will assist in the preparation of the report on asbestos:

- The PSI report should be signed off by a SQEP experienced in dealing with asbestos in soil. However, simple PSIs may be undertaken and signed off by a PCBU/competent person.
- If it concludes that:
  - the site is unlikely to pose a human health risk from asbestos in soil in relation to the NES-CS and/or
  - a DSI is not required to characterise asbestos in soil issues before starting work

  these conclusions must be supported by a site inspection.
- If there has been a site inspection, the PSI report should contain a photographic record of it.
- Where necessary, confirm certain building and/or subsurface infrastructure asbestos management-related impacts on soil. The SQEP may need to seek advice from an asbestos surveyor.

If the PSI report concludes that there is no evidence to suggest the presence of asbestos in soil, this model wording could be used:

> No positive evidence has been identified to suggest that asbestos from historical buildings/infrastructure or

On-site buildings	
Building age (construction before 1 January 2000)	
Building use and associated external infrastructures (asbestos pipework, etc.)	
Exterior fabric (including description on the quality, condition and maintenance of the building fabric)	Cladding
	Roofing
	Gutters and downpipes (and if asbestos present, where they drain to)
Fences, outhouses and ancillary buildings potentially constructed from asbestos products	
Evidence of asbestos waste disposed of underneath or adjacent to buildings	
Existing asbestos register or ACM	
Below-ground and above-ground services (supplemented by desktop study)	
Below-ground services – water supply pipelines, stormwater drains and so on	
Below-ground services boxed within asbestos sheeting	
Above-ground services – wrapped/insulated pipework	
On-site activities	
Former building likely to be constructed before 2000 – evidence of building footprints, old foundations and so on	
Evidence of demolition of previous structures that potentially contained asbestos	
Fire within buildings that potentially contained asbestos	
Landfilling activities – evidence of asbestos wastes having been used for infilling	
Off-site activities	
Surface water run-off from neighbouring properties that may be contaminated with asbestos – run-off from adjacent roofing, overland flow, drainage into swales and so on	
Infilling on a neighbouring site encroaching on the subject site	
Building fires on site and on neighbouring properties that may have contained asbestos	

Table 2. Asbestos in soil preliminary site inspection prompt sheet.

> uncontrolled fill is present on the site, based on the PSI undertaken. This is subject to the following limitations …

Depending on the aims and findings of the report, it could be useful to record that PCBUs have a general duty to advise that unexpected finds or accidental discoveries could arise once earthworks begin. This could be old pipework or buried construction and demolition waste that would not ordinarily be apparent from a PSI. This could extend to advising that workers are educated to identify unexpected finds (such as through awareness training) and referring to WorkSafe New Zealand guidance and addressing any such unexpected or accidental discoveries.

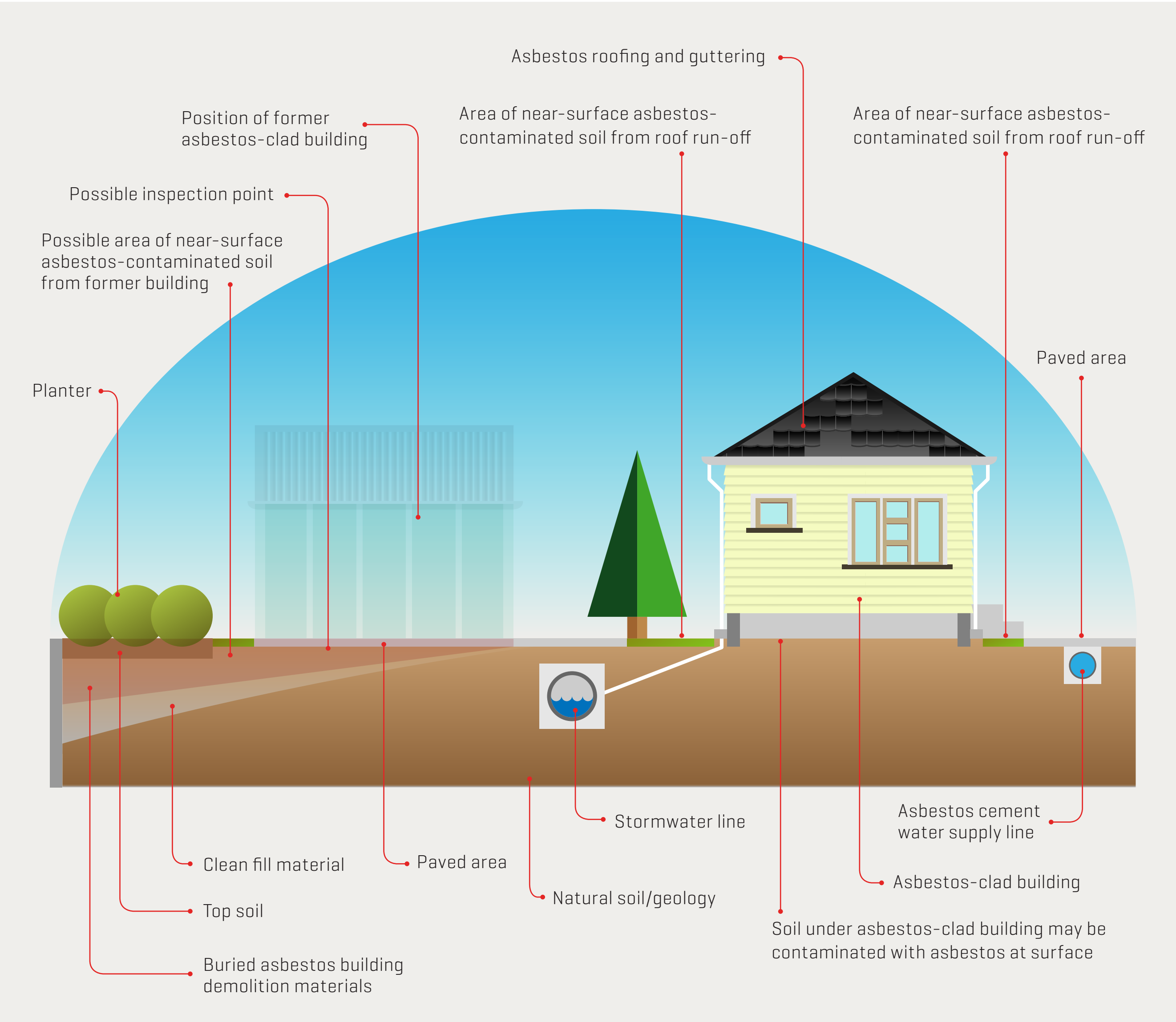


Figure 16. Example of schematic geological cross-section conceptual site model.

CASE STUDY

PROCESS

Earthworks for stream diversion and embankment construction at the SH29 Hairini Link, Tauranga, identified an area of buried construction waste including suspected ACM in the form of degraded fibre-cement sheeting and vinyl fragments.

Despite historical investigations, the ACM identification was unexpected. The principal contractor temporarily covered suspected contamination areas with high-density polyethylene (HDPE) liner. The New Zealand Transport Agency (NZTA), Tauranga City Council, Bay of Plenty Regional Council and WorkSafe New Zealand were promptly notified.

A formal preliminary site investigation was not undertaken during the initial resource consent process, and geotechnical investigations were limited within the vicinity of the buried waste.

A SQEP conducted a detailed site investigation to delineate the extent of asbestos in soil. Historical aerial photography reviewed as part of the investigation identified that the contaminated site was located in an area of historical land reclamation overlying estuarine deposits on the margins of Tauranga Harbour. Ground investigations confirmed that 3 m of reworked natural ash and alluvium was placed over the former ground surface. This was capped by 1.5 m of construction waste containing damaged and burnt building materials. Laboratory testing confirmed that the shallow soil asbestos contamination could be attributed to this construction waste.

Subsequent risk assessment concluded that the risk to end users was low given the contaminated material was to be below the design embankment. However, due to the nature of ongoing ground disturbance work, the asbestos risk remained significant to the health of site workers and to the public for the project duration. Topographic and environmental constraints meant that limited space was available for temporary or permanent retention of the waste. As such, an encapsulation solution was deemed unsuitable.

In total, 3,185 m^3 of contaminated soil was removed by a licensed asbestos removalist, under supervision of a SQEP. Members of the public were notified through letters and media releases before work started. The worksite was secured to prevent unauthorised access. An independent assessor monitored air quality and dust hazard during excavation and soil removal work, and a sprinkler system dampened the soil as a control mechanism.

Following visual confirmation that waste had been removed, the base and sides of excavations were sampled to validate the work. This was done for the benefit of future site management and to confirm that the risk was sufficiently low to allow construction activity to continue. The site validation results confirmed the bulk of asbestos-contaminated soil had been removed. A small amount of residual waste could not be removed due to stability constraints from adjacent infrastructure. Geotextile sheeting was laid to make clear residual risk areas and surveyed for inclusion within as-built drawings. A 300 mm drainage blanket was also placed to stop residual waste being moved by future earthworks. To manage these residual risks for the duration of the project and beyond, an asbestos and ongoing site management plan was prepared.

Effective planning and collaboration meant the remedial work was completed without incident or further delay. However, had a preliminary site investigation been completed early in the process, a well planned risk mitigation and remedial action plan could have been prepared within the project design, programme and budget.


DANGER
ASBESTOS IN THIS AREA
CANCER AND LUNG DISEASE HAZARD
RESPIRATORS AND PROTECTIVE CLOTHING
ARE REQUIRED IN THIS AREA

5. DETAILED SITE INVESTIGATION

The principal aim of a detailed site investigation (DSI) should be to establish the nature, extent and degree of contamination at a site or area within a site. The key elements of a contaminated soil DSI and the content of a report are found in CLMG 5 and CLMG 1, respectively.

DSIs are undertaken for a number of reasons including:

- supporting human health risk assessment – Tier 1 and Tier 2
- remedial planning/scoping
- due diligence
- demonstrating compliance with the NES-CS
- benchmarking surface soils before building demolition
- post-remediation verification
- other land disturbance site activities (construction/earthworks), subdivision or land use changes.

The aims and objectives of each investigation will vary depending on project-specific requirements. Because of the complexities posed by asbestos soil contamination, it is important that the SQEP verifying the investigation work is experienced in dealing with asbestos in soil issues.

A DSI for asbestos-contaminated soils may not be required. It must be demonstrated (through a PSI or documented site inspection, depending on site conditions) that:

- the contamination includes ACM in good condition (no signs of degradation)
- the ACM is in small quantities sitting on the surface (with no evidence of soil disturbance/infilling)
- the ACM is going to be removed/managed by hand picking/raking.

Similarly, depending on the management approach for the estos-contaminated soil (such as capping with permanent cover), a comprehensive DSI may not be required. It is still necessary to determine how far the asbestos is spread over the site. This applies particularly when dealing with ACM in good condition.

Asbestos is typically found in the upper 0.5 m of the soil unless asbestos materials/soils have been buried or imported to site as fill. If there are other contaminants of concern, they are likely to have different characteristics that may require a different investigative approach (sampling depth, sample containers and so on).

5.1 Planning the detailed site investigation

The scope of the DSI will be guided by the findings of the PSI and preliminary conceptual site model. Gaps/uncertainties may have been identified during the preliminary work that can be addressed through additional PSI work and/or during the DSI. This may require the DSI to be undertaken in several phases.

Developing the soil sampling strategy and setting data quality objectives are key elements of the DSI planning phase. This may be documented ahead of the DSI in a sample analysis and quality plan. CLMG 5 and the WA Guidelines give examples and advice on sampling strategies and considerations including:

- contamination source(s) and mechanism of contamination
- objectives of the investigation
- preliminary conceptual site model and current/future site use
- spatial distribution of the soil sample locations and number of samples
- use of field screening techniques
- laboratory testing requirements
- quality assurance/quality control requirements.

Examples of soil sampling strategies are shown in Figure 17.

Consider a grid sampling approach for widespread contamination where the PSI did not find historical information where buried contamination is suspected but location is unknown or where earthworks have redistributed the contamination. CLMG 5 provides advice on grid sampling densities for soil contamination hot spots, such as that in Appendix A.

Key situations where judgemental soil sampling may be appropriate (modified from the WA Guidelines):

- If suspected asbestos contamination hot spots are identified during the PSI.
- If sampling cannot readily meet the recommended sampling density because of hardstand areas, judgemental sampling in key locations is suitable to allow limited characterisation of subsurface contamination.
- If structures containing asbestos have been removed and/or demolished, the former building footprint may need to be investigated. Undertake a visual/near-surface assessment of contamination impacts (down to a depth of about <0.2 m) within the building footprint area. A subsurface/deeper investigation should only be undertaken if a structure was partially buried (foundations, fences, etc. extending >0.2 m depth) or the soil has been disturbed (potentially burying asbestos contamination). Use a judgemental grid sampling interval of 5–10 m along and within the footprint perimeter of the building(s) and extending about 0.5 m beyond the edge of the building(s).
- Disused subsurface asbestos structures and products (such as service trenches containing asbestos piping) may create localised areas of contamination. If not properly removed/documented, these should be delineated by sampling. Previous sampling would suffice if the structure has been removed (depending on the quality of the validation work).

In general, sampling densities are likely to be greater than those used for other contaminants. This is principally because, unlike some other contaminants, asbestos is not evenly distributed in soil and there is typically no pattern or trend on where it is located. Sampling densities/approach may vary for different layers or types of soil. For example, a site may include multiple types/layers of contaminated material. Trenching may also be an appropriate assessment method.

Table 3 presents an overview of soil sampling densities and is adapted from an approach in the WA Guidelines and other sources. Where grid sampling is used, the density should be some multiple (as set out in Table 3) of the sampling density for a given site area presented in Appendix A and the likelihood of asbestos contamination being present.

For judgemental sampling, the SQEP should decide on the sampling density, but it should equal or exceed the sampling density given in Table 3. For more localised and higher-risk/concentration areas, such as areas contaminated by asbestos fibres from stormwater run-off, use a denser sampling regime.

The first three categories in Table 3 (unlikely, possible and suspected) are primarily for screening for asbestos in soil, and further investigation work may be needed if detected. The fourth and fifth categories (likely and known) are more focused on confirmation or delineation, depending on the circumstances. Judgemental sampling of known contamination is likely to be used for delineation. The practitioner undertaking the investigation should be mindful of possible differences in asbestos contamination with different soil layers. Depending on the findings, it may be necessary to adopt a more detailed sampling regime for subsequent DSI work, which can build on sample locations already used.

Prior to field work commencing and where uncertainties of historical activities and underground services are present, it may be advantageous to use ground-penetrating radar to better plan the investigation. The ground-penetrating radar can be good for detecting non-ferrous materials, such as asbestos cement pipes, which are difficult to identify using other methods.

A key safety issue is whether friable asbestos is likely to be present and could release fibres in air at concentrations greater than trace level (0.01 f/mL). If the investigation work is likely to generate trace levels of fibre in air, the work needs to be overseen by a licensed asbestos removalist and independent licensed assessor (see Figure 1).

Investigations generating trace levels in air are likely to be rare but may occur where friable asbestos is suspected/known to have been placed as fill at a site. Most investigations are unlikely to generate trace levels in air, particularly if mitigation controls are adopted (such as dampening trial pitting work with water or surfactants).

5.2 Sampling methodology

The methods used to investigate asbestos in soil are no different to those used with other contaminants. However, there may be limitations to conventional investigation techniques because of:

- the nature of asbestos-contaminated soil (fragments of ACM and presence of fibrous asbestos/asbestos fines contamination)
- the fact that asbestos is not evenly distributed in soil and there is typically no pattern or trend on where it is located
- the volume of soil required for testing
- possible health and safety issues during investigation.

Likelihood of asbestos contamination	Typical scenarios/land uses	Investigation approach
Sampling rationale: soil sampling initial screen for asbestos in soil (may require further DSI work to fully define the nature and extent of contamination)		
Unlikely	• Grazing, farming or greenfield site with no building history. • Site with minimal pre-2000 history.	PSI site inspection – using a systematic grid. No soil sampling required, unless visual asbestos contamination noted.
Possible	• Uncontrolled fill placed at site without mixed building waste. • Undeveloped site adjacent to a site that has been subject to infilling and/or dumping of fill.	PSI site inspection – using a systematic grid. Judgemental or grid sampling for surface and buried asbestos material. Soil sampling at half Appendix A sample grid density for a given site area.
Suspected	• Soil or fill materials associated with dumped ACM. • Site history or land use associated with handling, manufacture or storage of asbestos or ACM. • Pre-2000 buildings/structures and/or demolished buildings/ structures.	PSI site inspection – using a systematic grid. Judgemental or grid sampling for surface and buried asbestos material. Soil sampling at Appendix A sample grid density for a given site area.
Sampling rationale: confirmation and/or delineation for asbestos in soil (depending on site conditions, may require sampling of separate geological layers)		
Likely	• Uncontrolled fill with known building waste and/or landfill site. • Some visible subsurface asbestos material found.	PSI site inspection – using a systematic grid. Judgemental or grid sampling for surface and buried asbestos material. Soil sampling at twice Appendix A sample grid density for a given site area.
Known	• Identified asbestos-contaminated soil but not sufficiently delineated	PSI site inspection – using a systematic grid. Judgemental sampling for surface and/or buried asbestos material identified during previous DSI. Soil sampling at twice Appendix A sample grid density for a given site area. If soil or fill has been disturbed or bladed during earthworks, grid sampling will be required.

Table 3. Triggers and types of asbestos investigation.

Table 4 summarises investigation methods for asbestos-contaminated sites and outlines the advantages and disadvantages of each. Avoid boreholes and hand auger holes unless no other sampling method is possible. They only expose a small area/volume of the underlying soil layers and types and reduce the opportunity to establish whether asbestos could be present. Asbestos-contaminated soil is typically found near the surface. Therefore, shallow hand-excavated and/or machine-excavated pits and trenches typically provide more reliable information than the other methods to determine whether asbestos is present and its extent.

Traditional intrusive investigation work may be combined with or undertaken separately to tilling/raking surveys that are often used across large areas of exposed surface soil (such as during an earthworks stripping operation).

5.2.1 Primary measurement of asbestos contamination

Determining asbestos concentrations in soil can be difficult and sometimes not possible. This can be due to it not being evenly distributed, there being no clear pattern to its location and the different physical forms it can take. Practitioners should use the PSI to identify what type of asbestos could be present and use this to guide the method(s) used to analyse soil samples. If the PSI suggests an industrial/commercial site where friable asbestos is likely to have been used, asbestos fines and fibrous asbestos may be present and should be tested.

ACM is the most common type of asbestos contamination and recommended measure for total asbestos contamination (because it can be more easily seen) where asbestos fines/fibrous asbestos are not likely to be significant. Asbestos in soil concentrations can be calculated based on the weight of ACM for a given weight of soil using the method described below.

Fibrous asbestos often comes from insulation material or damaged asbestos insulation board tipped at a site and/or following building demolition. Asbestos fines also frequently come from dust/debris from a building fire, cutting and sanding of ACM materials or high-pressure cleaning of ACM roofs and cladding.

If asbestos fines and fibrous asbestos arise from ACM in the same location, the guidelines currently consider that the asbestos fines/fibrous asbestos concentrations will not exceed 10% w/w of the ACM concentration. This is even if the ACM is mostly very small pieces/fragments. Exceptions would be known ACM damage resulting from power tools (such as

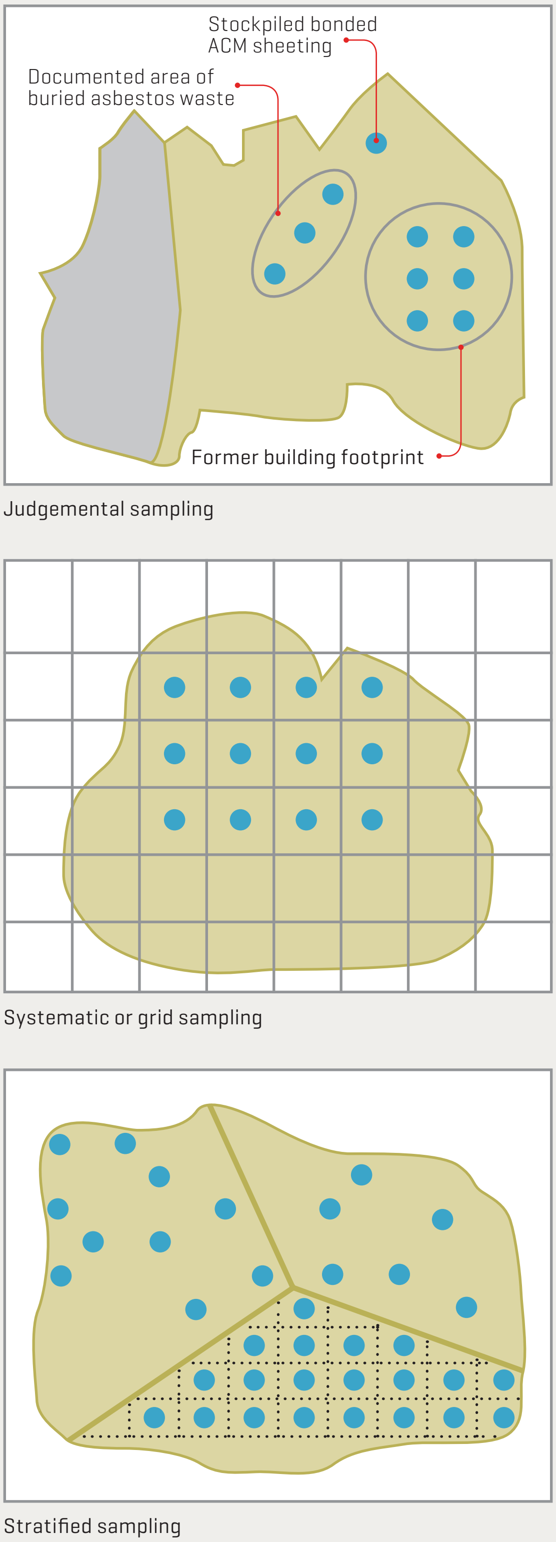


Figure 17. Sampling patterns as per CLMG 5 (dots represent sampling locations).

Sampling method	Asbestos considerations
Tilling/raking/hand-picking surveys	• Can be used to assess near-surface impact raking surveys (up to 0.05 m depth, depending on soil type) and tilling (up to 0.3 m depth) across a large area. • Most suited to surface ACM contamination and non-fibre-generating asbestos. • Limited by soil type – suited to dry granular soils. • Very limited application for deeper contamination and/or if there is cover (vegetation/pavement). • May mix contaminated/non-contaminated soil layers. • Health and safety considerations, particularly dust generation. • Hand picking is often done together with tilling/raking.
Hand-excavated pits/trenches	• Small hand-excavated pits can be used to collect good-quality samples from shallow depth (typically up to 0.5–1 m) and inspect the soil. • Limited contamination footprint on site. • Suitable for limited-access sites. • Limited risk of asbestos dispersal (depending on the condition and extent/nature of asbestos contamination).
Hand auger	• Can be used to collect very limited/small volume samples and limited inspection of the soil. Typically able to investigate soil up to 2–3 m depth depending on soil type. • Provides a very poor indicator of soil conditions for asbestos and should only be considered as a last resort. • Suitable for limited-access sites only. • Limited contamination footprint on site. • Can be used to investigate hardstand areas. • Limited risk of asbestos dispersal.
Mechanically excavated test pits and trenches	• Ideal for full examination of soil profile and collection of high-volume samples. Typically able to investigate soil to a depth of about 3–4 m depending on soil type. • Very effective investigation technique. • Impact on site, unable to investigate hardstand areas, reinstatement issues. • In extreme situations (where friable asbestos is present), risk of asbestos dispersal.
Dynamic sampling with a geoprobe or similar	• Ideal for deep soil sampling where thick layers of fill are present. • Depending on fill composition, this sampling technique may not be able to penetrate fill layers. • Limited ability to collect high-volume samples and inspection of the soil profile. • Soil sample collected/retained in a plastic sheath. • Very effective investigation technique for deep soil samples and/or determining deep geology. • Limited damage to the site, can investigate hardstand areas, no major reinstatement issues. • Limited risk of asbestos dispersal provided retrieved samples are handled safely. • A higher sampling density may be necessary compared with test pits/trenches.
Mechanical auger drilling	• Ideal for deep soil sampling where thick layers of fill are present, although this sampling technique may not be able to penetrate all fill layers. • Limited ability to collect high-volume samples and inspection of the soil profile. • Soil returned to surface on auger flights and/or collected disturbed/undisturbed samples. • Very effective investigation technique to collect deep soil and/or determine deep geology. • Limited damage to the site, can investigate hardstand areas, no major reinstatement issues. • Limited risk of asbestos dispersal. • A higher sampling density may be necessary compared with test pits/trenches.

Table 4. Soil sampling methodologies.

a circular saw cutting ACM sheet), during demolition work or ACM damage from fire. Asbestos fines and fibrous asbestos concentrations are generally considered to be significant where the concentrations exceed 10% w/w of the amount of asbestos as would be determined by using ACM alone.

5.3 Soil sampling

Soils found during an investigation should be described/logged in accordance with the standard methods presented in section 3, in particular, noting soil texture and moisture content. Where possible, document:

- the presence/absence of visible asbestos contamination
- the nature/form of any asbestos contamination visible (type of ACM, fibrous asbestos, asbestos fines, bundles of fibres visible and so on)
- the condition of ACM – is it friable, intact?
- the depth/location of asbestos within the observed soil layers.

Photographs of soil contaminated with asbestos and associated descriptions are shown in section 3.2.

Samples collected for field screening and/or laboratory testing need to be collected from separate geological layers. Soil samples across geological types and layers (fill materials/natural ground) must not be mixed together or averaged.

5.3.1 Field screening of bonded ACM

Contamination may be largely ACM in reasonable/good condition – for example, bonded ACM not severely deteriorated or damaged and considered unlikely to release fibres. In this case, field screening to quantify the asbestos concentration in soil can be undertaken by calculating a given weight of ACM within a given weight of soil. This is best achieved by collecting a minimum 10 L sample of the asbestos-contaminated soil layer. ACM fragments can be hand picked from the sample spread on a tarpaulin/garbage bag (or similar) with contrasting colour. The WA Guidelines also suggest field sieving, which could be used at sites with dry friable soils. Both field screening methods require robust health and safety measures to protect workers.

Once the weight of ACM has been determined, use the estimated asbestos concentration in the ACM to calculate the percentage weight of asbestos. While this varies for different ACM products, asbestos cement roofing is reported to contain about 10–15% asbestos. The field screening concentration will not be able to be directly compared to laboratory-derived ACM concentrations because of differences inherent in the estimation process. In addition, the field screening results will be expressed as wet weight concentrations. Take care when comparing the results against dry weight concentrations determined in the laboratory and the risk criteria.

Key issues to consider when sampling and analysing for asbestos in soils (using both field screening and laboratory techniques) include the following:

- ACM weight should be used for the sample being analysed. It should not be averaged across the mass of soil at the site, within a whole remediation zone and/or across a total bore sample volume.
- Establishing the concentration of asbestos in soil stockpiles is difficult unless all soils forming the stockpile were sourced from the same layer or soil type. If the soil stockpile is a mix from different layers and soil types, use a conservative sampling regime to estimate the asbestos in soil concentration. For example, this could be 14 samples per 1,000 m^3 of stockpiled material. There is more stockpile sampling guidance in the WA Guidelines.
- Where there is asbestos contamination in more than one distinct soil layer or soil type, separate asbestos concentration estimates should be made for each layer.
- Focus on a line-of-evidence approach for determining the concentration of asbestos in soil. The nature of asbestos contamination can vary greatly, so the investigative method and concentration calculation should be site-specific.
- Field screening using sieving is better on dry/friable soils rather than coarse gravel/fill and cohesive soils, which are more suited to visual assessment.
- With field screening, consider health and safety issues associated with airborne fibre release, particularly generation of trace level in air (Figure 1). This may require an independent licensed assessor to develop an asbestos work plan for the sampling event and monitor the workers being potentially exposed to asbestos fibres in air.

Where the asbestos contamination lies near the surface and the soil can be tilled/raked, an estimate of the bonded ACM/asbestos in soil contamination concentration can be made using the field screening method. This approach only applies to certain delineated areas and has less confidence compared to grid sampling large areas and laboratory analysis.

Complete field sheets with each sieve test and include in the DSI report, ideally with photographs of the soil sample.

A sample calculation (based on enHealth 2005 – see section 9.4) for estimating the asbestos in bonded ACM within soil is:

$$\% \text{ soil asbestos} = \frac{\% \text{ asbestos content} \times \text{ACM (kg)}}{\text{soil volume (L)} \times \text{soil density (kg/L)}}$$

The assumed percentage of asbestos in asbestos-cement materials is often between 5% and 15%. Soil density can range from 0.9 kg/L (dry, loose, stockpiled topsoil) to 2 kg/L (saturated clay).

ACM asbestos concentration in soil can be measured more accurately if the values of the different criteria (such as soil density and asbestos content of ACM) are measured rather than being assumed.

If fibrous asbestos comes from friable/degraded ACM in the same location and site conditions suggest widespread degradation, it may be necessary to regard the ACM as fibrous asbestos.

As yet, there is no validated method of reliably estimating the concentration of free asbestos fibres in soil, although this may be possible with larger asbestos fines material. Soil contamination by free asbestos fibres should therefore be simply determined according to the presence or absence of fibres. Take care interpreting the results of asbestos fines sampling because of detection limitations and the relatively small size of samples. Follow a line-of-evidence approach.

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

The approach depends on the data quality objectives for the DSI and ongoing site management. Where field screening is the dominant asbestos in soil quantification method, 10% of the field screening sample should be analysed in a laboratory for ACM, asbestos fines and fibrous asbestos. Given that there is no pattern to the distribution of asbestos in soil, duplicate samples for quality assurance/quality control laboratory analysis are not recommended.

5.3.2 Soil samples collected for laboratory analysis

Ideally, place soil samples collected for laboratory analysis into laboratory-supplied containers. Any samples collected must be representative of the soils found in the geological layer being sampled. There should be no mixing of samples from different geological layers or compositing from samples.

For laboratory samples, the soil should be in as-found condition. This means the samples must not have been subject to field screening and must not be used for analysis of other contaminants. Double-bag large pieces of ACM collected for weighing/laboratory analysis in strong/durable polythene bags (typically >200 μm). They should be clearly labelled with corresponding sample numbers of asbestos material placed in laboratory-supplied containers from the same soil layer.

5.4 Laboratory soil analysis methods

Analysis of suspected asbestos in soil samples must be conducted by laboratories accredited to AS 4964-2004 *Method for the qualitative identification of asbestos in bulk samples*. AS 4964-2004 is the testing standard for Australia and New Zealand in relation to asbestos.

Laboratories will also be accredited to international standard NZS ISO/IEC 17025:2005 *General requirements for the competence of testing and calibration laboratories*.

The accreditation process maintains consistency between laboratories and offers public confidence that samples are being analysed by suitably trained personnel.

5.4.1 Sample preparation

To enable comparison of the laboratory results against the Tier 1 soil guideline values (see section 5.6.1), laboratories need a larger sample size than that specified by AS 4964-2004. As a minimum, a 500 mL unsieved sample is required. The entire sample must be prepared for analysis. Subsampling must not be performed on the sample by the laboratory before sample preparation and can only be performed on the <2 mm fraction. Any sample submitted for bulk asbestos identification testing must be a separate sample to that used for other analyses.

Following AS 4964-2004, the entire sample is prepared for analysis, and the sample is dried before being sieved. If there is excessive organic material in the sample, it can be ashed at 400°C (±30°C) to aid preparation and analysis.

Once dried (and ashed), the sample is sieved through a 10 mm sieve and a 2 mm sieve (as directed by AS 4964-2004). To reduce the risk of sample cross-contamination, a perforated steel sieve is specified over a wire mesh sieve.

The >10 mm fraction and the <10 mm, >2 mm fraction are analysed in their entirety. Subsampling of the <2 mm fraction can be carried out providing homogenisation and subsampling procedures have been developed in the laboratory.

For further information on valid subsampling techniques, three international standards are quoted in AS 4964-2004.

For example, BS 1377-1:1990 *Methods of test for soils for civil engineering purposes. General requirements and sample preparation* details a cone and quartering technique that is suitable for subsampling the <2 mm fraction.

5.4.2 Analysis

Analysis is performed as described in AS 4964-2004, with asbestos fibres and ACM removed from each fraction. (For more about asbestos content in ACM, see HSG264 in section 9.5.) The material removed must be separated according to its asbestos content. It is the laboratory's responsibility to determine how this is done. Before identification of the fibres, the material is weighed to 5 decimal places, unless there is a large amount of ACM, which can be weighed to 2 decimal places. Due to the complexities of analysing soil samples this way, laboratories should consider limiting the number of samples that each analyst evaluates in a shift. Typical analysis time should be in the region of 40–60 minutes per sample, depending on the ratio of material that is greater than or less than 2 mm. In some cases, where the sample is mostly <2 mm, the analysis time will be shorter.

ACM, friable asbestos and asbestos fines

The material removed from the >10 mm fraction can either be ACM or friable asbestos. The material is weighed, and the asbestos content is calculated. The laboratory can report fibrous asbestos in the >10 mm fraction and asbestos fines in the <10 mm fraction.

Any and all asbestos material found in the <10 mm fraction is classified as fibrous asbestos or asbestos fines. This can be in the form of fragments of ACM or fine loose fibres. As some of the material may be up to 10 mm in size, it may be possible to determine the type of ACM present and therefore its asbestos content. Smaller fragments may have to be assigned a higher percentage of asbestos, as the binding matrix may have been degraded. The analyst will use their judgement.

5.4.3 Reporting

The defined limit of detection in AS 4964-2004 (where a sample can be reported as 'no asbestos detected') is 0.01% w/w. Laboratories accredited under AS 4964-2004 and NZS ISO/IEC 17025:2005 are only accredited to this limit. Any asbestos concentrations reported below 0.01% w/w must be marked as an unaccredited result on the laboratory report.

In addition to the standard information (such as laboratory name, client name and sample identification), a report should include:

- asbestos type(s) present
- received weight of sample
- dry weight of sample
- percentage of asbestos present as ACM*
- percentage of asbestos present as fibrous asbestos*
- percentage of asbestos present as asbestos fines*
- combined percentage of asbestos present as fibrous asbestos and asbestos fines.*

The asbestos percentage calculations are measured on a weight-for-weight (w/w) basis, using the sample's dry weight. The laboratory may report other data, such as:

- ashed weight of sample (if ashing is performed)
- weight of >10 mm fraction
- weight of <10 mm, >2 mm fraction
- weight of <2 mm fraction
- weight of <2 mm subsample
- weight of asbestos as ACM
- weight of asbestos as fibrous asbestos
- calculated weight of asbestos as asbestos fines*

* These are unaccredited activities and must be marked as such on the report.

5.4.4 Method limitations

Because of the limit of detection accredited of 0.01% w/w, care must be taken with results that calculate the percentage to less than this. The finer, respirable fibres are unable to be detected effectively using this methodology.

To help practitioners assess potential respirable fibre risk, a method has been developed that combines the AS 4964-2004 method with a fibre counting method currently used in the United Kingdom. This combined method assists in the calculation of asbestos fines to give a better understanding of the risk of respirable fibres in soil.

The combined analysis takes a portion of the soil from the <2 mm sieved fraction to create the suspension and subsequent filter preparation. The filter is then prepared for analysis by clearing with acetone vapour and trace. The fibres are assessed using modified counting rules (described in EIC:SCA 2015 – see section 9.5).

The combined method can calculate the asbestos percentage to a higher degree of accuracy and provides a limit of measure beyond 0.001% w/w. There are currently no New Zealand laboratories that have the accreditation to perform this methodology, therefore it must be marked as unaccredited in any report.

5.5 Air monitoring

Air quality monitoring for asbestos fibre, dust and other contaminant emissions must be carried out during Class A removal work by an independent assessor. It must also be carried out where there is uncertainty if the 0.01 f/mL trace level in air is likely to be exceeded. It is not required under the Asbestos Regulations for Class B or unlicensed asbestos removal work but is recommended. For more information on when air monitoring is required, refer to Part H section 30 of the ACOP.

5.5.1 Field sampling requirements

International Accreditation New Zealand (IANZ) provides accreditation for the analysis of the filters in the laboratory. It does not currently provide accreditation for the work completed in the field. Therefore, staff and third parties conducting asbestos air monitoring are outside a laboratory's accreditation and should meet the following minimum requirements to monitor work involved with asbestos in soil:

- Each third-party staff member will have received and passed a formal training programme, including recording evidence of practical (field-based) and theoretical training. Training could follow, for example, NZQA Unit Standard 29768 Conduct asbestos assessment associated with removal.
- Training must include understanding of equipment calibration requirements, flow rates, selection of appropriate pump locations, method limitations, volume and concentration requirements as per NOHSC:3003 (see section 9.4).
- Include the name of the staff or third party (both individual and company) on each test report.
- Include a note in the test reports stating that trained staff or third parties did the volume measurement and are responsible for the measurement.

Should the field work phase of the test not be carried out by personnel meeting the above requirements, the certified laboratory should note this limitation.

Due to the limitations within NOHSC:3003, volumes should aim to not exceed 550 L (but not be less than 480 L). This reduces the potential for reporting inaccuracies in the detectable concentration and calculation.

5.5.2 Air monitoring principles

Various air quality monitoring methods may be relevant to the site investigation and management process. These are the key considerations:

- Clearly identify the purpose of any air sampling.
- The air monitoring strategy should be developed by a person suitably experienced in asbestos sampling and exposure assessment (a WorkSafe licensed asbestos assessor).
- Input from a qualified occupational hygienist may be helpful, particularly on complicated projects.

Real-time asbestos monitoring would be useful as an additional layer of evidence when undertaking monitoring on sensitive projects, but there are currently no recognised or accredited methods available for this.

The membrane filter method is currently the most economical accredited measurement technique in New Zealand for estimating the concentration of airborne asbestos fibres. This uses the phase contrast microscopy (PCM) technique and provides a useful estimate of personal exposure. However, this method cannot distinguish between asbestos fibres and non-asbestos fibres.

Electron microscope techniques are preferred for low-level exposure situations where the fibre size and definitive fibre matrix composition are important. enHealth 2005 has noted that "results obtained by air sampling in non-occupational environments are almost invariably below the detection limit of the membrane filter method, especially when samples are taken at times when the asbestos is not being disturbed" (see section 9.4).

The asbestos air monitoring concentration of 0.01 f/mL is the lowest level of detection using PCM. The World Health Organisation (WHO) estimates an exposure of 0.01 f/mL of asbestos could result in an increased cancer risk of 10^{-4} to 10^{-3} of an exposed person's lifetime exposure. As exposure to asbestos during contaminated site work is generally during work hours, this limit is considered acceptable for worker exposure.

5.5.3 Limit of detection in air

Air monitoring for occupational environments is covered under the ACOP. It requires a detection limit of 0.01 f/mL of air to be achieved over an equivalent 8-hour time-weighted average using the membrane filter method together with microscopy.

For non-occupational scenarios and activity-based sampling, alternative monitoring and analytical methods may be necessary to achieve a sufficient detection limit to a lower order of magnitude (<0.001 f/mL). However, no certified method is currently available using PCM to this level.

There are certifiable methods that provide a means of both positive determination and fibre composition. They also provide a certifiable means of achieving a detection limit lower than 0.01 f/mL in air using electron microscopes. These methods include the following:

- ISO 10312:1995 *Ambient air – Determination of asbestos fibres – Direct transfer transmission electron microscopy method* (TEM). This method can be combined with phase contrast microscopy equivalency (PCME) analysis to determine the respirable fraction of asbestos fibres.
- NIOSH Method 7402: *Asbestos by TEM*. This can also be combined with PCME using NIOSH Method 7400: *Asbestos and other fibers by PCM* to determine the respirable fraction of asbestos fibres (TEM).
- ISO 14966:2002 *Ambient air – Determination of numerical concentrations of inorganic fibrous particles – Scanning electron microscopy method* (SEM).

Further points to note:
- In some circumstances, electron microscopy methods may not achieve any better detection limit than through PCM, due to matrix interference or filter overloading.
- SEM may require a different filter media, and it is therefore important to check with the laboratory before starting any air monitoring work if SEM is to be used.
- TEM meeting the ASTM method requires a 0.45 µm filter, although a modified method is available using 0.80 µm filter media.

Analysis should be completed using an accredited method such as IANZ, National Association of Testing Authorities (NATA) or other internationally recognised accredited methods.

5.5.4 Developing an air monitoring plan

An air monitoring plan should be completed with input from a competent person – this may be in the form of a SQEP, industrial hygienist or licensed asbestos assessor. It is important to determine the number of monitors needed, locations, duration, frequency, wind direction and prevailing weather conditions.

Measuring airborne fibre levels can confirm the airborne contamination standard has not been exceeded and show whether control measures are effective. There is a difference between air monitoring and quality control monitoring for asbestos removal or encapsulation work. Both relate to safeguarding the health of individuals, but quality control monitoring places the emphasis on confirming that the job has been completed to a satisfactory standard.

For occupational environments (including construction sites), refer to the ACOP (Part H section 30). Routine or selective personal (exposure) monitoring may more accurately quantify worker exposure. This involves the placement of an air monitor filter cowl within the breathing zone of a worker (no more than 300 mm from the worker's mouth).

The National Occupational Health and Safety Commission in Australia has recommended that "the total sample duration (for exposure monitoring) should aim at collecting a sample that is representative of the period in question, usually an entire shift" (NOHSC:3003 – see section 9.4).

Static air monitoring during asbestos-related work should be a minimum of 4 hours. At a rate of 2 litres per minute, this ensures the minimum volume requirement of 480 L is met (see section 5.5.1) and the period measured is representative of the shift.

Aim to obtain and distribute results within 12–18 hours after collecting the samples and submitting to the laboratory (the following morning) where reasonably practicable. Under the Asbestos Regulations, all air monitoring results must be made available to occupants of the site and other relevant stakeholders.

5.5.5 Activity-based sampling

The principal risk from asbestos in soil comes from the contaminated soil being disturbed and airborne asbestos fibres being inhaled. To assess the potential risk associated with earthworks or using a site with asbestos-contaminated soil, an activity-based sampling trial can be designed and implemented to simulate intended site activities. Activity-based sampling is the process of undertaking air sampling for asbestos fibres while conducting a physical activity such as excavating, loading and transporting material that may lead to fibres being released into the air. The technique is usually designed for high-asbestos content soils.

Any use of activity-based sampling in New Zealand would need to be permitted under the Asbestos Regulations and subject to the requirements for asbestos-related work. Several overseas bodies, including the United States Environmental Protection Agency (US EPA), provide guidance on the management of asbestos-contaminated sites. The US EPA has published a standard operating procedure for activity-based sampling for asbestos.

The SQEP should determine whether activity-based sampling is needed and the scope and nature of the programme needed to provide additional certainty around exposure.

Activity-based sampling should take place at the location of the proposed activity and with representative soil samples to assess the risks to humans. It should take account of the following:
- The activity – it should be representative of current and future land use of the site or of some proposed specific

activity that has been implicated in the release of asbestos fibres.

- Soil moisture content – wet soil conditions inhibit asbestos becoming airborne.
- People the contamination may reach – occupational exposure samples should be collected in a representative manner. For example, sampling should be conducted using personal air sampling pumps if workers will be directly exposed to the soil.
- Wind direction – sampling should be conducted both upwind and downwind of the activity as well as via personal air sampling pumps.

When reviewing results of air sampling data, use the sampling duration and flow rate of the sampling pumps to calculate the likely exposure over a set period of time (a time-weighted average).

Results of activity-based sampling studies may be used to determine the most appropriate controls for exposure during a removal to assist in developing an asbestos removal control plan (see section 6.3). The most common use of activity-based sampling is for determining the suitability of a site for long-term use based on results of specific types of simulated activities.

5.6 Risk assessment

The guidelines follow the general approach of the NES-CS management framework. They use the conservative Tier 1 soil guideline values for given land use scenarios and an approach to generate Tier 2 site-specific soil guideline values for the protection of human health. For NES-CS purposes, the Tier 1 soil guideline values should be considered applicable standards for asbestos in soils under regulation 7(4)(b), by reference to CLMG 2.

Risk assessment of contaminated land means considering the extent and source(s) of contamination, pathways and exposure (pollutant linkage) to the inhalation of asbestos fibres. Results from the PSIs and DSIs, in particular, soil sampling and field screening/laboratory testing work, are compared against the Tier 1 soil guideline values or used to derive site-specific Tier 2 values. (Further guidance on the interpretation of soil contamination levels and comparison to health risk screening values is given in CLMG 5.)

The two-tiered human health risk assessment framework is defined as follows:

- **Tier 1 values**: conservative predefined soil guideline values that are considered protective for a set of generic land use scenarios. Tier 1 values can be used as screening criteria above which either mitigation should be employed to manage the risk(s) or a Tier 2 assessment be undertaken to better quantify the risk.
- **Tier 2 methodology**: sets out site-specific information needed to modify the generic assumptions behind Tier 1 soil guideline values. Site-specific human health values can be found using the framework below.

5.6.1 Tier 1 values

The Tier 1 values are considered conservative and appropriate for most scenarios. The results of the Tier 1 assessment will indicate whether the site does not pose a human health risk or whether further assessment or development of a remediation or management strategy is needed.

The Tier 1 soil guideline values come from the approach set out in the WA Guidelines with some slight variation in the soil depth requirements to meet New Zealand conditions.

The WA Guidelines were based on Dutch field and simulation trials (Swartjes & Tromp, 2008). These indicated that a soil concentration of 0.01% w/w for fibrous asbestos and asbestos fines should keep asbestos fibre levels in air below 0.001 f/mL in most situations. This corresponds to an increased lifetime cancer risk of 10^{-5} to 10^{-6} for the exposed human population from airborne asbestos fibres using WHO risk figures for mesothelioma. On this basis, the Netherlands applies an investigation level of 0.01% w/w for fibrous asbestos and 0.1% w/w for non-friable asbestos (i.e. bonded ACM in sound condition) in soil.

The WA Guidelines and Schedule B1 of the Australian National Environment Protection (Assessment of Site Contamination) Measure (see section 9.4) adopted a more conservative approach (increasing the levels by a factor of 10). This was to allow for drier, dustier Australian soil with greater airborne fibre-generating potential compared to the Netherlands. Because soil with low soil moisture/water content may also be found in some locations in New Zealand, the same conservative adjustment has also been adopted in the guidelines. Based on these assumptions, the Tier 1 soil guideline values are considered conservative. They yield less than the New Zealand accepted increased cancer risk for non-threshold compounds of one additional cancer per 100,000 people (10^{-5} risk level – as detailed in the Ministry for the Environment's Methodology for Deriving Standards for Contaminants in Soil to Protect Human Health – see 9.1.4).

Table 5 presents the adopted soil guideline values for a Tier 1 human health risk assessment.

CASE STUDY

SAMPLING AND CONTROLS

Asbestos-cement roof and wall cladding on the BRANZ fire laboratory was removed in 2014. This triggered testing of the adjacent grass, garden and gravel areas for asbestos contamination.

Asbestos fibres were found at various locations in the ground surrounding the fire laboratory at varying concentrations and at depths of up to 120 mm. Judgemental sampling determined by the preliminary site investigation was undertaken in locations identified as likely to have asbestos contamination as well as randomly throughout other locations on the site (Figure 18).

The asbestos contamination of the grounds was primarily caused through loose asbestos fibres being transported in roof water run-off from the ACM roof, walls, gutters and downpipes and into the soil. One of the highest concentrations of asbestos contamination on the site was found where grass clippings were piled, indicating that lawnmowing was collecting asbestos from surface lawn areas.

An interim site control mechanism was put in place to get a better understanding of the workplace health and safety risks. Protective equipment and activity-based monitoring equipment was worn by the lawnmowing operator and while handling grass clippings. This enabled understanding of exposure from actual activities on the site.

The activity-based sampling also included mitigation controls such as the lawnmowing operator using disposable coveralls and a mask and closing all windows and doors to surrounding office buildings. This also involved keeping an asbestos register and implementing ongoing health monitoring.

Other than lawnmowing, no work on the grounds took place until there was a clear picture of the risks and a remedial action plan was agreed and implemented.

Figure 18. Sampling plan.

Consideration must be given to requirements for ongoing management where integrity of the cap may be disturbed in the future. See section 6.1.3 for more information on in situ management.

All concentrations are in weight-for-weight (w/w) dry weight. These soil guideline values hold the status of soil contaminant standards under clause 7 of the NES-CS by reference to CLMG 2. Any site with concentrations of >0.001% w/w fibrous asbestos and/or asbestos fines and/or between 0.05% and 0.01% w/w ACM (depending on land use) will require further assessment. It will also require completion of a Tier 2 human health risk assessment or use of mitigation to manage risk(s). This is required to

Form of asbestos	**Soil guideline values for asbestos (w/w)**			
	Residential[1]	High-density residential[2]	Recreational[3]	Commercial and industrial[4]
ACM (bonded)	0.01%	0.04%	0.02%	0.05%
FA and/or AF[5]	0.001%			
All forms of asbestos – surface	No visible asbestos on surface soil[6]			
Capping requirements for residual contamination above selected soil guideline value				
Depth[7] – Hard cap	No depth limitation, no controls – except for long-term management			
Depth[7] – Soft cap	≥0.5 m			≥0.2 m

Notes:

1. **Residential**: Single dwelling site with garden and/or accessible soil. Also includes daycare centres, preschools, primary and secondary schools and rural residential.
2. **High-density residential**: Urban residential site with limited exposed soil/soil contact, including small gardens. Applicable to urban townhouses, flats and ground-floor apartments with small ornamental gardens but not high-rise apartments (with very low opportunity for soil contact).
3. **Recreational**: Public and private green areas and sports and recreation reserves. Includes playing fields, suburban reserves where children play frequently and school playing fields.
4. **Commercial and industrial:** Includes accessible soils within retail, office, factory and industrial sites. Many commercial and industrial properties are well paved with concrete pavement and buildings that will adequately cover/cap any contaminated soils.
5. **FA and/or AF:** Where free fibre is present at concentrations at or below 0.001% w/w, a proportion of these samples should be analysed using the laboratory analysis method described in section 5.4.4 (≥10% of samples). This is due to limitations in the AS 4964-2004 and WA Guidelines 500 ml sample method for free fibre (see section 5.4 for more information).
6. **Surface:** Effective options include raking/tilling the top 100 mm of asbestos-contaminated soil (or to clean soil/fill if shallower to avoid contaminating clean material at depth) and hand picking to remove visible asbestos and ACM fragments or covering with a soft cap of virgin natural material (VNM) 100 mm thick delineated by a permeable geotextile marker layer or hard cap. Near-surface fragments of ACM can become exposed in soft soils such as sandy pumiceous soils after periods of rain.
7. **Depth:** Capping is used where contamination levels exceed soil guideline values. Considerations of depth need to incorporate the type and likelihood of future disturbance activities at the site and site capping requirements (see section 6.1). Ideally, any capping layer should be delineated by a permeable geotextile marker layer between the cap and underlying asbestos/contaminated material. Institutional controls must be used to manage long-term risks, particularly where the cap may be disturbed (see section 7). Two forms of capping are typically used:
    a. Hard cap comprises surfaces that are difficult to penetrate and isolate the asbestos contamination, such as tar seal or concrete driveway cover. This would typically not include pavers or decking due to maintenance and coverage factors.
    b. Soft cap consists of a layer(s) of material which either comprise virgin natural material or soils that meet the asbestos residential soil guideline value from an on-site source. Use of on-site soils may require resource consent.

Table 5. Soil guideline values for asbestos in New Zealand.

demonstrate an acceptable risk or implementation of management controls, mitigation or remediation to manage the potential human health risks. Depending on the preferred management option, an asbestos removal control plan and remedial action plan may be required where contaminated soil is going to be removed (see section 6). An ongoing site management plan, attached to the site's asbestos register, may also be required for residual asbestos-contaminated soil left in situ (see section 8.2).

Where asbestos in soil concentrations are below the Tier 1 values and residual contamination is being left in situ at greater than 0.001% w/w, develop an ongoing site management plan to control exposure from any future soil disturbance activities.

5.6.2 Tier 2 methodology

A Tier 2 human health risk assessment involves a more detailed assessment of the nature and extent of contamination and consideration of the factors affecting potential release of asbestos fibres into the air. These factors can be highly variable from site to site. A Tier 2 site-specific human health risk assessment is often carried out where the Tier 1 soil guideline values are considered too conservative. This depends on the current and future/intended land use of a site or part of a site.

The standard Tier 2 approach recommended for the guidelines is set out in Schedule B4 of the National Australian Environmental Protection (Assessment of Site Contamination) Measures 1999. Refer also to section 9 of the Methodology for Deriving Standards for Contaminants in Soil to Protect Human Health. A Tier 2 human health risk assessment must be signed off by a SQEP competent in asbestos health risk assessments. It must be based on PSI and DSI work undertaken to an appropriate standard.

To develop site-specific Tier 2 values that adequately consider exposure risk, the assessment must take into account the following:

- **Depth of contamination**: Asbestos that is exposed at the surface or may be in the future poses a risk, while buried asbestos tends not to pose a risk unless disturbed. This should be correlated against the planned use of the site and finished ground levels if earthworks are being undertaken.
- **Asbestos physical form or condition**: The exposure potential of friable asbestos is much greater than bound asbestos, and conforming free fibres pose a greater risk.
- **Asbestos physico-chemical nature**: Evidence suggests that amphibole asbestos poses significantly more risk than chrysotile/serpentine asbestos, although all asbestos fibre types can cause asbestos-related disease. Additionally, serpentile fibres adhere to water (hydrophilic), while amphibole fibres repel water (hydrophobic).
- **Matrix type**: It is easier to release asbestos fibres to air from coarser soils than from finer or siltier clay soils.
- **Soil moisture content**: Fibres are more likely to be released to air from dry soils than wet soils (Figure 15). This is also influenced/controlled by seasonal climatic variation.
- **Land use**: Because asbestos only poses a risk when released into respirable air, the risk is related to the frequency and extent of disturbance. Few soils will release asbestos fibres from wind action alone, especially with the presence of impermeable barriers and/or landscaping.
- **Duration of exposure**: The primary risk seems to come from the total (cumulative) exposure to asbestos rather than the concentration of asbestos. This means that prolonged exposure to lower-level concentrations of asbestos may result in the same risk as a shorter exposure to a high concentration of asbestos. Consider the site-specific exposure scenarios (current and future). Refer to CIRIA C733 for more information – see section 9.5.
- **Exposure frequency**: If a younger person is exposed to asbestos, they carry the resulting lung burden for a longer period. This probably increases the probability of contracting an asbestos-related disease some time during their life. Also, the younger the person when exposed, the younger they will be when they reach a time since exposure when the disease might be expected to develop. Refer to CIRIA C733 Tables 14.1 and 14.2 for appropriate risk factors based on age of exposure.

A Tier 2 risk assessment must follow a line-of-evidence approach. It should assume a reasonable worst-case scenario based on site-specific data. This may include activity-based sampling and use of general atmospheric dust as a surrogate for likely airborne asbestos fibre. When determining risk, consider whether human exposure of the site is occupational/voluntary (8 hours/day, 5 days/week) or environmental/non-voluntary (24 hours/day, 7 days/week for 70 years).

Any adjustments for soil moisture must be based on research (Figure 15) and an understanding of local field/site data, including annual/seasonal rainfall and soil moisture estimates. This is particularly where soil moisture levels may drop below 10% (see section 3.3.2, including Figure 16).

Irrespective of development of any site-specific Tier 2 criteria, to maintain confidence in the asbestos management process, asbestos (cement fragments or other materials) should not be visible on the exposed soil surface. This includes allowing for the depth to the contamination for rain and minor surface erosion exposing near-surface fragments – see Table 5.

6. MANAGEMENT AND REMEDIATION

6.1 Management and remediation process

Management and/or remediation is an action or a set of actions to mitigate the risks from a contaminated site. Management and remediation can include:

- administrative procedures such as a plan controlling land use activities or notation on a title for a parcel of land limiting a certain land use
- engineering controls such as capping
- elimination/removal of contamination posing the risk.

Develop a plan step by step, working through it several times before implementing remedial work to ensure the most appropriate remedial option is selected.

Key steps to take are:

- strategic remedial planning
- defining remedial objectives and drivers
- remedial technology/options assessment
- remedial design.

In consultation with stakeholders, the PCBU responsible for remediation of a site (which may be the landowner, responsible party/polluter or developer) develops an overarching strategy for the remedial works. This is based on defined remedial objectives and drivers, which could include regulatory controls, clean-up requirements set out in a sale and purchase agreement or timeframe constraints set by stakeholders. This process enables an assessment of remedial options that addresses long-term objectives to mitigate the risks as well as short-term risks (safety, environment and social) associated with undertaking the remedial work. This is particularly important when physical work is being performed.

The chosen remedial option needs to be designed and then documented in a remedial action plan. Where contaminated soil is being excavated, this plan may require work to be overseen by a licensed asbestos removalist. They will generate an asbestos removal control plan as part of the overall remedial action plan (see Figure 1).

Depending on the nature and complexity of the site, documents may be prepared to support remediation and mitigation that also fulfil regulatory requirements:

- Remedial options assessment is the process used to determine the most appropriate remedial option or mitigation method for the site.
- The remedial action plan details the methodology being used to undertake or execute the remedial works. It details the processes and procedures to manage health, environmental and safety risks during the programme of work. A remedial action plan may be a requirement of resource consent.
- An asbestos removal control plan is needed to fulfil the requirements of the Asbestos Regulations, specifically in accordance with the ACOP. It must address practical issues associated with the removal of asbestos in soil and management of health and safety risks. The asbestos removal control plan can form an addendum to the remedial action plan.
- An asbestos management plan forms part of the ongoing site management plan and states how long-term risks associated with managing residual asbestos-contaminated soil will be managed.

Documentation prepared to manage the risks associated with remediation must follow the standard approach presented in the CLMGs, particularly if contaminants in addition to asbestos are present.

6.1.1 Strategic remedial planning

Considering certain issues will help develop the remedial approach and help identify constraints that may impact the success of the project. These include:

- defining what the end vision is for the project or property being remediated
- understanding budgetary constraints, cash flow issues and project timelines
- recognising that stakeholders may influence the remedial approach and so their views need to be considered, particularly if they are consultees within a resource consent application process

- considering current and likely future land uses
- determining the nature of the asbestos contamination and presence of other contaminants of concern
- establishing a conceptual site model – this critical step assists in selecting the most appropriate option, and the conceptual site model review process enables data gaps and project uncertainties to be identified
- determining preliminary clean-up levels to define the likely extent of remediation.

6.1.2 Remedial drivers and objectives

Many remedial drivers can influence or control the outcome(s) for the site:

- Regulatory requirements may dictate conditions of consent or the level to which a site should be cleaned up or resource consent requirements.
- Legal and contractual requirements may be set in a sale and purchase agreement or as part of the make-good requirements (or similar) in a property lease.
- People or communities affected or potentially affected by contaminated soil, either on the subject site or neighbouring site, may influence the remedial option selected.

There is a need to clearly define the remedial objectives (performance objectives) that are used to verify that the remedial work has been successfully completed. These are typically set out in the remedial action plan but may also be detailed in a resource consent or legal contract. Remedial performance objectives could include the following:

- Verification of area and depth of contaminated soil remediated or removed. This is typically achieved through physical measurement, such as surveying.
- Validation soil sampling following completion of remedial excavation work. Given the lack of a pattern to asbestos distribution in soil, if excavation was aiming to achieve complete removal of contaminated soil, this may require detailed lateral and vertical sampling. This is also dependent on the type and extent of contamination and remediation objectives.
- Visual inspection of a contaminated area (perhaps in conjunction with tilling or raking) to verify that there are no ACM fragments close to the surface.
- Air monitoring during remedial excavation works.

6.1.3 Asbestos in soil remedial options

Given the nature of the contamination, remedial options available are generally limited. Depending on the scale and nature of a project, it is likely that a range of remedial options may be used. Typical options include the following.

In situ management

Several in situ management options are available, and most contaminated sites are likely to use one or a number as they provide cost-effective and risk-based solutions. It may be acceptable to leave asbestos-contaminated soil in place provided the risks are appropriately managed and institutional controls are implemented.

All in situ management options are likely to require institutional controls to manage the long-term risks of leaving the asbestos contamination in place. These could include notation on a LIM report or ongoing site management plan. It will require development of an ongoing site management plan and details of the residual contamination included with a site's asbestos register.

In situ management includes the following:

- Surface removal – using picking, raking and/or tilling to remove near surface visible asbestos impact (generally limited to non-friable/bonded ACM contaminated soils). This option requires an assessment of human health risk (using Tier 1 guideline values or Tier 2 site specific risk assessment) to manage the residual contamination risk.

- Capping – using either hard or soft capping placed over contaminated soils to manage risk.
  - Hard capping comprises surfaces that are difficult to penetrate and isolate the asbestos contamination, such as tar seal or concrete driveway cover. This would typically not include pavers or decking due to maintenance and coverage factors. When placing hard capping, it is prudent that a membrane or similar be placed under the concrete/tar seal. This prevents the capping itself from becoming contaminated – it may have to be removed in the future – and clearly marks out the residual asbestos in soil. A sand blinding/hard core layer (or similar) may also have to be placed under the hard cap as a foundation.
  - Soft capping consists of a layer(s) of material that either comprises VNM or soils that meet the asbestos residential guideline value from an on-site source. A permeable geotextile break layer needs to be installed between the cap and underlying impacted soil. The minimum thickness of soft capping to be used for the Tier 1 generic land uses are given in Table 5. When using on-site soils that meet the asbestos residential guideline values, care needs to be exercised to avoid generating asbestos fibre in air during soil excavation and placement. This activity may require a resource consent.
  - Temporary capping using a tarpaulin (or similar) can be used to minimise airborne exposure from exposed

soils during a remedial project, before placement of capping (see case study on long-term remedial planning) and/or excavation.

Further advice and guidance on capping design can be found in CIRIA 1996: Remedial Methods for Contaminated Land. Volume VI. Containment and Hydraulic Measures. Special Publication 106.

- Temporary on-site surface treatment – such as polymer coatings. This is a valid method for temporarily binding the surface layer until material can be remediated. This can last up to 1 year, provided access to the surface is restricted.

- Containment cell – placement of asbestos-contaminated soil in a containment cell or similar within the confines of the site. This could be within the landscaping or under roadways for lower-risk asbestos-contaminated soil (much the same as capping and for soil containing non-friable/bonded ACM) and more secure repositories for friable asbestos material. This activity is likely to require a resource consent.

Complete excavation and off-site disposal

Complete removal of asbestos-contaminated soil will negate the need for long-term institutional controls, such as a long-term management plan or inclusion in the asbestos register (or similar). However, during excavation and removal of soil, it will be necessary to manage the potential short-term risks to site workers and neighbours associated with possible release of asbestos fibres and dust. As detailed in Figure 1, depending on the nature and concentration of the asbestos in soil and volume being removed, it will be necessary to apply for an NES-CS consent for the earthworks. It will also be necessary to involve licensed removalists. Generic methods/options to manage the risks associated with excavation work and development of an asbestos removal control plan are given in section 6.3.

Soil contaminated with asbestos will need to be disposed of to a suitably licensed facility (see section 6.6.2).

6.1.4 Remedial options assessment

The scale and nature of the contaminated site dictates/influences the remedial options available and the process of selecting the best option. The remedial strategy for the site combined with the remedial drivers and objectives assist the decisions to select the remedial or mitigation approach.

Various international regulatory authorities/agencies (such as the US EPA) have developed sophisticated ranking systems to select the most appropriate remediation for highly complex sites with a mixture of contaminants. For smaller contaminated sites with a single contaminant (such as asbestos in soil on a residential site), the selection process is much simpler.

When applying for resource consent for remedial works, the Resource Management Act requires the applicant to consider alternatives (see section 2). The remedial option selection process helps fulfil this requirement.

6.1.5 Remedial design

Depending on the nature of the remedial work and how it is being contracted, some form of design will be needed. The design documentation may vary from a simple site plan showing where soil needs to be removed and to what depth to a more sophisticated document for more complex sites. In most instances, this will be included within the remedial action plan and/or asbestos removal control plan.

The remedial design will enable the SQEP and contractors to agree that the right level of work has been undertaken. It also enables the completed work to be verified.

6.2 Remedial action plan

The overarching document detailing the remedial work is the remedial action plan and is signed off by a SQEP competent in managing asbestos in soil projects. This plan is also likely to be a requirement of any resource consent obtained for the work. It should also be prepared even if the work is being undertaken as a permitted activity.

The content of a remedial action plan is set out in CLMG 1 and should address the following:

- The context, including applicable regulations and the consents needed to undertake the remedial works.
- Site description and a summary of the PSI and DSI work undertaken to establish the contaminants of concern.
- Remedial goals and objectives, in particular, reference to health risk assessment and the intended clean-up/management approach.
- Detailed remedial management methodology (this may also be addressed in the asbestos removal control plan). Where excavation and/or encapsulation of contaminated soil is being proposed, the document should include:
  - area and depths of excavation
  - location and methods for soil encapsulation and capping
  - methods to mitigate dust/asbestos fibre generation
  - off-site disposal (location, transport plan and authorisations)
  - soil stockpiling and management.

- Methods to assess the effectiveness of the remedial effort, in particular, the remedial verification process (this may also be addressed in the asbestos removal control plan).
- Unexpected contamination discovery protocols, including the safety considerations for these such as appropriate training.
- Methods to manage human health and environmental risks during the works.

6.3 Asbestos removal control plan

An asbestos removal (or management) control plan may also need to be developed for any licensed asbestos removal work to confirm the requirements under the Asbestos Regulations. This typically forms an addendum to the remedial action plan. The purpose of the asbestos removal control plan is to identify and document specific control measures to ensure workers and other people are not put at risk when carrying out asbestos removal work. They are required only for licensed asbestos removal work but can be drafted and used to help plan unlicensed asbestos removal work and asbestos-related work. Each asbestos removal control plan must address the site-specific requirements.

If the remedial project triggers the need for the work to be overseen by a licensed asbestos removalist, they are required to prepare the plan under regulation 32 of the Asbestos Regulations. WorkSafe must be notified 5 days before starting licensed asbestos removal work, as per regulation 34 of the Asbestos Regulations.

The plan needs to be completed for any asbestos in soil remedial project that involves disturbance and/or removal of soil off site by a licensed removalist. However, for unlicensed asbestos work that involves remediation of soil solely contaminated with asbestos and does not require a licence or resource consent, an asbestos removal control plan may not be required.

Appendix H of the ACOP has a template for an asbestos removal control plan. The template is a starting point, and consideration should be given to the different types, complexities and magnitudes of asbestos work.

Additional information in an asbestos removal control plan or asbestos-related work plan for unlicensed work may include:

- whether the soil guideline value and/or trace level in air is likely to be exceeded
- the competent person(s) who undertook the above assessment
- the competent person(s) engaged to undertake air monitoring
- contingency measures in the event trace level in air is exceeded
- contingency measures on discovery of significant asbestos contamination or friable asbestos
- accidental discovery protocols.

Further details for a Class A and B asbestos removal control plan, other than those items noted above, include:

- names of the nominated supervisor(s)
- relevant training or certification held by all staff proposed for the removal works
- details of the WorkSafe notification
- specialist equipment or methods to be employed including WorkSafe approvals, if applicable
- expected clearance inspection methods, including:
  - the licensed asbestos assessor or competent person undertaking the inspection
  - the competent person statement of qualifications
  - aims of the inspection (for example, <0.001% w/w asbestos in soil or asbestos-free top 100 cm)
  - proposed clearance surface/soil testing or air monitoring, if applicable.

6.4 Mitigation controls

The key objective during all asbestos work is to complete the work as safely as is reasonably practicable and to minimise personal exposure to airborne asbestos. If there is uncertainty as to whether the airborne trace level for asbestos is likely to be exceeded, consult a SQEP or licensed asbestos assessor. In this situation, regulation 51 of the Asbestos Regulations requires that air monitoring of the work area is conducted where asbestos-related work is being undertaken.

Splitting the site into clean and dirty/hot zones is a key method used to isolate asbestos work areas from non-asbestos work areas. The dirty/hot zone is where the physical remedial/removal work to address asbestos-contaminated soil is done and needs the most control. A clean zone is where activities can be undertaken with little to no health and safety control and is typically located in non-contaminated areas of the site.

Based on the four broad categories of work described in Figure 1, Table 6 summarises the key mitigation controls required for each work category. The controls follow the general hierarchy of risk controls set out in the Health and Safety at Work Act 2015. A mix of controls is likely to be required for all remedial projects, regardless of complexity, consistent with Part C section 14 of the ACOP.

Most projects use a combination of controls to manage potential health and safety hazards. Practitioners must

Scenario	PPE	Respiratory protective equipment (RPE)*	Dust/asbestos fibre suppression	Decontamination facilities
Class A: friable >1% w/w FA and/or AF in soil	Disposable coveralls rated type 5, category 3, nitrile gloves, steel toe capped gumboots or safety footwear with disposable overshoes.	Full-face P3 respirator with particulate filter. Consider increasing to power-assisted if required.	Water and asbestos-encapsulating polymer emulsion product applied before starting work and during as required. Consider adding a surfactant to water for amphibole fibres (brown and blue).	Basic disposable wet decontamination tent or trailer. Consider powered and plumbed decontamination unit if project scale warrants.
Class B: non-friable >0.01% w/w FA and/or AF in soil >1% w/w ACM		Half-face P3 respirator with particulate filter. Consider increasing to full-face if friable ACM present.		Basic disposable decontamination tent and foot wash.
Asbestos-related work >0.001% w/w FA and/or AF in soil >0.01% w/w ACM		Disposable P2 dust mask.	Water via localised points. Addition of surfactants and polymers where the location is sensitive (such as adjacent to busy centres, schools). Temporary cover of contaminated area awaiting remediation.	
Unlicensed asbestos work ≤0.001% w/w FA and/or AF in soil ≤0.01% w/w ACM	No asbestos-specific PPE if air monitoring confirms asbestos below 0.01 f/ml.	No asbestos-specific RPE if SQEP confirms unlikely to exceed trace levels in air monitoring (0.01 f/ml) and/or if air monitoring confirms asbestos below 0.01 f/ml.		Foot wash and used PPE collection area.

*Refer to Part C section 14 of the ACOP and AS/NZS 1715:2009 for more information on RPE selection.

Table 6. Primary mitigation control requirements for work involving asbestos.

always be mindful of the hierarchy of controls (eliminating, substituting, isolating, engineering, administrative, PPE), with the first step being to eliminate the risk or hazard so far as is reasonably practicable.

6.4.1 Engineering controls

Dust/asbestos fibre suppression may not be required at all times, especially during rainfall and when high moisture content soils are being excavated. A method of applying a dust/asbestos fibre suppressant should be available on site at all times and be commensurate with the size of the site and scale of the soil disturbance. The suppressant type and application method should be outlined in the remedial action plan. When suppressants are used, the asbestos and soil matrix should be thoroughly wet before its disturbance activity starts and will need sufficient time to penetrate the soil and asbestos contamination. The volume and frequency of wetting will depend on the soil type and weather conditions during earthworks.

Steps should be taken to eliminate the hazards via engineering (and administrative) controls. Many of the engineering controls will be informed by the asbestos removalist and will be site-specific. These may include:

- water misting units stationed around the perimeter of the remedial area
- spraying exposed soil with encapsulating polymer emulsion sprays (typically only required for significant fibrous asbestos contamination in soil)
- fencing with 200 µm polythene lining to prevent airborne asbestos leaving the remedial area
- 200 µm heavy-gauge polythene barrier placed over the remedial area when earthworks are not in progress
- installation of sumps and stormwater barriers to contain run-off
- installation of clean pads for earthwork machinery to operate on rather than directly on contaminated soil
- installation of wheel-wash facilities for earthwork machinery
- manual removal of the worst-contaminated ACM areas
- erection of a decontamination unit.

Adding water to asbestos-contaminated soil has been proven to greatly reduce the potential for airborne asbestos (see section 3). As water is essential for suppressing dust and the generation of airborne asbestos fibres during soil remediation projects, a large, consistent and reliable source of water should be available at the site. Water should be applied to dampen the area only and prevent the visible generation of dust. With amphibole fibres (brown and blue) that have an affinity for water, a surfactant added to the water may assist in fibre suppression.

Water should be applied as a low-pressure fine mist. A series of sprinklers positioned on the ground in the remedial area is often used as it does not require supervision. For larger remedial projects, misting sprays positioned on fencing around the remedial area may be preferred. Timing devices on sprinklers could be used on sites unattended for a significant length of time (weekends, holidays) during drier/windier weather.

Buildings immediately surrounding the remedial zone should be protected to prevent contamination by asbestos-containing dust during soil disturbance. If the remedial work is being undertaken close to buildings that may be difficult to decontaminate, measures should be taken to protect the buildings from dust. This is often completed by erecting 3-metre high chain link fencing with polythene sheeting attached on the inside of the fence. The plastic should cover the full height of the fence. The fence should be strong enough to handle any likely wind.

6.4.2 Administrative controls

Administrative controls may include one or more of:

- an asbestos removal control plan developed in accordance with the Asbestos Regulations (see section 6.3)
- health and safety documentation including job safety analyses for each task and the hazard mitigation controls required for each task
- appropriate signage to prevent unauthorised access, mark out the asbestos remediation zone and outline the personal protective equipment requirements for each zone
- risk identification register and sign-in and sign-out registers at each entry point
- air monitoring to ensure controls are adequate
- training and induction for all site workers.

If best-practice controls are used to control dust generated during remediation, atmospheric sampling for asbestos fibres adds little value in evaluating or managing risks. However, asbestos air sampling can be effective in providing confidence in the control measures employed. Regardless, it is mandatory where friable asbestos is being removed under the Asbestos Regulations.

If required by the Ministry of Health, static air sampling is the most practical method to measure airborne asbestos at contaminated sites. Further guidance on sampling and assessment strategies is provided by enHealth 2005 – see section 9.4.

Use of personal protective equipment, including respirators, disposable overalls and so on, is one of the key controls that must be implemented during a site investigation or remedial earthworks to minimise exposure. This practice follows the Asbestos Regulations and the ACOP. Exactly what is required will be site-specific,

Photo: Gareth Oddy

Figure 19. Fire-damaged sites often contain significant volumes of ACM debris.

selected on advice from a SQEP and/or licensed asbestos assessor or removalist. Additional factors such as length and nature of the site work, work-related factors, facial characteristics, medical fitness and comfort may also need to be considered. There are numerous guidelines and standards that describe the selection of respirators, which should be consulted in conjunction with Part C section 14 of the ACOP. These include:

- AS/NZS 1715:2009 *Selection, use and maintenance of respiratory protective equipment*
- AS/NZS 1716: 2012 *Respiratory protective devices*
- Respiratory Protective Equipment at Work (HSG53)
- Asbestos: The Licensed Contractors' Guide (HSG247).

There are two main types of respirator – air-purifying (which filters the air breathed) and supplied air (where the air comes from a tank). The majority of asbestos soil contamination assessments and remedial work will only require air-purifying respirators. This is due to the sites being external, the asbestos content typically being low and the reasonable distance of the asbestos disturbance to the exposed worker. Supplied-air respirators are not considered further in the guidelines – they are unlikely to be required except where significant friable asbestos waste is being excavated.

6.5 Decontamination

Decontamination refers to cleaning equipment, machinery and personnel that were in the contaminated zone and are likely to have come into contact with asbestos-contaminated soil and/or airborne asbestos.

Photo: Gareth Oddy

Figure 20. Machinery operating on an asbestos-contaminated site.

During the DSI and/or remediation of asbestos-contaminated sites, there is a potential to mobilise asbestos fibres from the ground into the air. If not controlled, these asbestos fibres may contaminate personnel, their clothing and vehicles and surfaces on and adjacent to the site.

The level of decontamination required will reflect the risk from asbestos-contaminated soil at each site. This will be determined by the DSI and should allow for contingency if higher-risk situations could exist during a remedial project. Decontamination should occur each time something moves from the asbestos removal or remedial zone through a transition zone and into a clean zone.

The asbestos removal control plan should detail where the decontamination zone is in relation to each remedial zone. It should also detail the decontamination procedures to be adopted, including the proposed equipment and how workers should pass through the decontamination zone. Signage on site should also direct workers, approved visitors and contractors through the decontamination zone.

As a minimum, a disposable decontamination unit should be erected as the entry and exit point(s) for personnel working in the removal or remedial zone. The decontamination unit should be positioned so that it cannot be accidentally bypassed by those exiting the remedial zone and should, if possible, exit into a clean uncontaminated zone.

Remedial projects that extend beyond 5 days or 100 person working hours should consider using a more permanent decontamination unit. This ensures that the integrity of the disposable unit does not become compromised with longer use. The comfort of the workers and ease of self-decontamination would also be improved with a purpose-built trailer or container unit. This may form part of the PCBU's duty to ensure the provision of adequate facilities for personal decontamination under the Asbestos Regulations.

Part C section 17 of the ACOP provides the minimum decontamination methods for vehicles and personnel required to meet legal obligations. Personal decontamination must be conducted on all sites by all personnel who enter the asbestos remedial zone or participate in soil sampling.

6.5.1 Vehicle decontamination

Where vehicles enter the asbestos remedial zone, assess the vehicle for the presence of asbestos and decontaminate as necessary. The assessment should include a thorough systematic visual assessment of the vehicle and controlled

Scenario	Vehicle assessment before demobilisation from site	Vehicle assessment completed by	Vehicle (truck) protection	Truck/excavator air conditioning
Class A: friable >1% w/w FA and/or AF in soil	Visual plus swab samples, air sampling should be undertaken inside the cab.	Independent assessor or independent competent person.*	200 µm heavy-gauge polythene wrapped soil/lined trays and truck covered.	HEPA filter system fitted for all occupied vehicles, filter replaced or clean down with HEPA vacuum cleaner post work.
Class B: non-friable >0.01% w/w FA and/or AF in soil >1% w/w ACM	Visual (plus swab samples if friable ACM is elsewhere on site – lagging, insulation, etc).	Independent assessor or independent competent person.*		HEPA filter system fitted for all occupied vehicles where friable ACM on site (lagging, insulation, etc).
Asbestos-related work >0.001% w/w FA and/or AF in soil >0.01% w/w ACM	Visual assessment.	Competent person or SQEP.	Truck lining/soil wrapping depends on the receiving landfill. All trucks should be covered.	Standard air conditioning.
Unlicensed asbestos work ≤0.001% w/w FA and/or AF in soil ≤0.01% w/w ACM				

*An independent competent person must meet the requirements of regulation 41(3) under the Asbestos Regulations.

Table 7. Vehicle decontamination requirements.

Photo: Gareth Oddy

Figure 21. Asbestos roof cladding waste.

Photo: Gareth Oddy

Figure 22. Asbestos-contaminated soil packed and sealed in skips ready for transportation.

removal of any visible debris and soil. Attention should be paid to the tracks and bucket of excavators where dirt accumulates.

For Class A and licensed removal sites where friable and/or large volumes of ACM are present on site, swabs are recommended to be taken from the vehicle. These should be assessed before it leaves the remedial zone. Assessment and clearance of the vehicles by a licensed asbestos assessor should be completed before demobilising all plant. Air sampling should be undertaken inside the cab, where reasonably practicable, with the ventilation system running for Class A sites. Table 7 provides a summary of the recommended vehicle decontamination controls.

Once the surface of the vehicle has been assessed, the cab and air conditioning and ventilation system should be assessed (if used). Air conditioning filters should be replaced on Class A sites and potentially Class B sites at the end of the remedial work. The air intake filters to the engine may also need to be replaced depending upon the length of time on site, the result of air monitoring and the type of asbestos. Replace all filters if air monitoring detects airborne concentrations above trace level at any time on site. Dispose of contaminated filters as asbestos waste. Decontaminate the vehicle in a designated area on hardstanding, a ≥200 μm thick plastic liner or a sacrificial gravel pad.

Clean the inside of the cab with wet-wipes. For Class A projects, place a small-capacity negative-pressure unit inside the cab with the engine and the ventilation switched on. This should dislodge any fibres from the system and capture them on the negative pressure unit filter.

6.6 Disposal of asbestos waste

Asbestos waste includes any disposable protective equipment or respirators and any polythene sheeting or other protective materials that have been used on a known or presumed asbestos-contaminated site. Asbestos waste could also refer to asbestos-contaminated soil that is generated during a site investigation or remedial work and is unable to be left in situ. Once disturbed and excavated, it becomes the responsibility of the asbestos removalist and SQEP to ensure it is handled appropriately and disposed of to an approved waste facility as soon as practicable.

6.6.1 Transportation of waste

For soil remediation projects, the most common waste container is the truck used to transport the soil to landfill. The benefits are reduced handling and reduced agitation and disturbance of soil. On small sites, sites that are difficult to access or those beneath existing buildings, smaller loads may require an alternative approach. Options include waste skips, vehicle trays and asbestos waste bags, drums or bins in good condition – as per Part C section 18 of the ACOP. Sites that are difficult to access may require a crane to load and lift skips.

Asbestos-contaminated soil should be transported from site and disposed of as soon as possible. The Asbestos Regulations do not permit temporary storage at an unapproved location such as a trucking yard. Avoid stockpiling asbestos-contaminated soil on site where possible. Where soil is stockpiled, it should be covered with 200 μm plastic sheeting.

The Land Transport Rule Dangerous Goods 2005 classifies asbestos (chrysotile, amosite and crocidolite) as a Class 9 miscellaneous dangerous substance. This only applies to transport of raw asbestos, however, and not to asbestos-contaminated soils. Therefore, there is no dangerous goods rule that applies to the transport of asbestos in soil.

For more information, refer to the WasteMINZ document Draft Good Practice Guidelines to Manage the Collection, Receipt, Transport and Disposal of Asbestos Waste.

6.6.2 Asbestos disposal sites

Asbestos-contaminated soil and waste must be disposed of at approved/consented landfills across the country. Check the current status of approved asbestos disposal recipients on the WorkSafe website.

A suitable disposal facility should be identified and consulted at the project planning stage before generating asbestos waste. Discuss the amount, contamination concentrations, type of asbestos waste and any special transportation requirements the landfill may have around accepting waste.

6.6.3 Waste tracking

All asbestos waste and asbestos-contaminated soil removed from site should be tracked using industry standard Ministry for the Environment waste transfer forms – see section 9.3.1. The waste transfer form is taken with the waste, from the source to its disposal location.

The three main stages that should be controlled to ensure the waste is handled appropriately and reaches its intended disposal destination are:

- the source site
- the transporter
- the disposal destination.

At each step, the waste consignment and waste manifest should be transferred to the next PCBU and the manifest signed by the recipient. Once the asbestos waste is disposed of, the signed form should be returned to the originating PCBU, with copies to the SQEP and asbestos removalist for inclusion in a soil validation report.

An adapted waste transfer form with recommended information is shown in Figure 23.

An online waste-tracking system has been made available by the Ministry for the Environment (www.wastetrack.co.nz). WasteTRACK is designed to consolidate manifest, facility and carrier data. This enables:

- safe transportation of wastes to an approved treatment/disposal facility
- independent verification that waste has been disposed of appropriately

SERIAL NUMBER			
HAZARDOUS WASTE GENERATOR DETAILS			
SITE OWNER/CLIENT NAME		ANZSIC CODE	
POSTAL ADDRESS		SUBURB/CITY	
STREET ADDRESS		SUBURB/CITY	
CONTACT NAME	PHONE NUMBER	FAX NUMBER	EMAIL ADDRESS
SQEP		CONTACT	
LICENSED ASBESTOS REMOVALIST		CONTACT	
HAZARDOUS WASTE DETAILS			
WASTE DESCRIPTION		QUANTITY (M^3/TONNES)	
FORM OF CONTAINED HAZARDOUS WASTE SOLID SOIL LIKE LIQUID GAS POWDER PASTE ASBESTOS			
DANGEROUS GOOD	CONTAINER TYPE	NUMBER OF CONTAINERS	
L-CODE	W-CODE	D/R CODE	
HAZARDOUS WASTE TRANSPORTER DETAILS			
NAME OF ORGANISATION		VEHICLE REGISTRATION NUMBER	
POSTAL ADDRESS		SUBURB/CITY	
STREET ADDRESS		SUBURB/CITY	
CONTACT NAME	PHONE NUMBER	FAX NUMBER	EMAIL ADDRESS
HAZARDOUS WASTE TRANSPORTER DETAILS			
NAME OF ORGANISATION			
POSTAL ADDRESS		SUBURB/CITY	
STREET ADDRESS		SUBURB/CITY	
CONTACT NAME	PHONE NUMBER	FAX NUMBER	EMAIL ADDRESS
SIGNATURES			
WASTE GENERATOR	WASTE TRANSPORTER	WASTE RECIPIENT	
DATE	DATE	DATE	
SIGNATURE	SIGNATURE	SIGNATURE	

Adapted from the Ministry for the Environment hazardous waste transfer form.

Figure 23. Example hazardous waste transfer form.

- prevention of unauthorised discharge into the natural environment through monitoring and tracking
- central and local government to identify priority waste management issues
- an even and competitive system for broader waste management organisations
- increased industry and community awareness of the proper treatment of hazardous waste.

6.7 Asbestos-cement pipes

Asbestos-containing cement pipes were used throughout New Zealand for supply of reticulated water and in other network systems (such as stormwater) from the 1950s to the early 1980s.

There is no evidence of asbestos-related disease occurring from the use of asbestos pipes supplying potable water.

When asbestos pipes are left in situ and undisturbed, the chance of asbestos fibres becoming airborne is small, and they are generally considered to be low risk. However, they should still be considered a hazardous material and, whenever practicable, should not be moved unless necessary. When renewing asbestos-cement pipes, it has been common practice to leave the old pipe in the ground. The guidelines do not provide definitive recommendations around the methods and controls used to repair or replace these pipes – this depends on the site. However, when work on or around asbestos-cement pipes is necessary, good practice must be followed:

- All workers must be appropriately trained in the use of personal protective equipment, asbestos health risks and legislative requirements. A health and safety plan and work method statement should support the work to demonstrate adequacy of controls, policies and the risk mitigation framework used to prevent exposure to asbestos.
- Consider engaging professionals to guide the process and oversee controls and methodology (depending on the site-specific requirements) such as:
  - licensed asbestos removalist
  - independent licensed assessor
  - SQEP familiar with the methodology.
- Depending on site-specific requirements, air, soil and water monitoring should be carried out to assess concentrations of asbestos fibres.
- When purging a line, residue from within the pipes created from cutting or drilling should be filtered (to 5 μm) before discharge.
- The PCBU(s) in control of/undertaking the work must comply with all WorkSafe requirements, including the ACOP, as well as territorial authorities and regulators. This must include management of residual ACM and waste disposal. Where an alternative methodology is developed, this must be approved by local and regional council regulators/territorial authorities before starting work.
- Consider recording any residual asbestos-containing cement pipes at www.beforeudig.co.nz, showing areas where fractured ACM may remain in situ. This will enable future disturbance activities to mitigate any risks associated with fractured asbestos.
- Where pipes are on private property, notify the owner of the proposed course of action. Any residual ACM remaining in situ should be recorded on the ongoing site management plan for that property.
- Before any high-energy methods are proposed, confirm the presence of nearby underground infrastructure using www.beforeudig.co.nz. Avoid it if likely to create a disturbance.

Guidance should be sought from the Water New Zealand Good Practice Guide: National Asbestos Cement Pressure Pipe Manual (see section 9.3.4).

CASE STUDY

REMEDIATION METHODS

The Patea Freezing Works was closed and abandoned in the early 1980s. The industrial site in South Taranaki contained gradually decaying buildings, some damaged from a fire in 2008 (Figure 24). The site was recently remediated for agricultural use.

Asbestos had been used for lagging around hot water pipes and boilers, and asbestos-containing fibre-cement cladding and roofing had been widely used throughout the buildings. The site had been vacant for over 25 years, with fire (as well as general decay and other physical damage) during that time. Widespread distribution of asbestos across the site was identified.

A number of short-term and long-term solutions were put forward as potential remedial options, with a primary objective of minimising waste to landfill. As a short-term risk management measure, a liquid polymer membrane (AW95) was sprayed on to the fire-damaged structures and surrounding ground to minimise the potential for loose asbestos fibres to become airborne. The polymer membrane was effective at temporarily encapsulating and bonding the asbestos. However, the membrane had an effective lifespan of approximately 12 months, primarily due to degradation from ultraviolet sunlight.

Once begun, the site's $3.6 million remediation took about a year and was complicated through finding unexpected amounts of asbestos under some of the structures. Remedial solutions included the following:

- On-site screening. This was an innovative approach developed to separate asbestos fragments from otherwise uncontaminated soil. The asbestos-contaminated material was carefully separated from

Photo: David Dangerfield

Figure 24. Aerial view of Patea Freezing Works site.

soil using a uniquely redesigned 7 mm power screen (Figure 25). Rotary screening and other aggressive remedial options were ruled out through a full SWOT analysis (Figure 26). To reduce risk to workers and public health, the screening was conducted in damp conditions where there was minimal wind, with additional air monitoring throughout the screening programme.

- Off-site disposal of ACM building demolition waste and material containing friable asbestos, asbestos fines or other contaminants.
- On-site encapsulation of large amounts of fill material containing asbestos, asbestos drains, inaccessible bunkers and reservoirs. The remaining areas were sealed with ongoing institutional controls to ensure these areas were not disturbed during future site development works. An ongoing site management plan was developed to monitor this.
- Recycling of scrap metal and timber.
- Crushing of concrete (verified as not asbestos-contaminated) for on-site reuse.
- Ongoing monitoring and management.

The power screen technology was regarded as a successful remedial method due to successfully avoiding the need to dispose of treated material off site to landfill.

Photo: David Dangerfield

Figure 25. Screening of ACM at Patea Freezing Works site.

This innovative method is highly case specific, and conservative treatability trials and site characterisation investigations are warranted to ensure the technology is proven before its wider implementation. It is considered appropriate for remote and low land-use sensitivity scenarios (such as open space reuse), provided the appropriate treatability trials and controlled deployment, together with independent oversight, are implemented.

STRENGTHS	WEAKNESSES
1. SUSTAINABLE APPROACH 2. SIGNIFICANT FINANCIAL SAVINGS TO STAKEHOLDERS 3. SOIL EASILY SCREENED	1. VALIDATION TURNAROUND 2. SITE FOOTPRINT NEEDED 3. ADDITIONAL SITE SUPERVISION 4. HIGHER LEVEL OF SEGREGATION
OPPORTUNITIES	**THREATS**
1. LANDFILL SPACE SAVING 2. RETENTION OF FERTILE TOPSOIL 3. LITTLE ONGOING MANAGEMENT 4. ATTRACTIVE ALTERNATIVE TO ON-SITE/OFF-SITE DISPOSAL	1. EQUIPMENT SELECTION 2. CONTRACTOR APPRECIATION 3. PROXIMITY OF RESIDENTS 4. OTHER CONTAMINANTS 5. TRIAL VOLUME MUST BE REPRESENTATIVE 6. REMOTE SITE 7. MECHANICAL CREATION OF FA AND AF (<7MM)

Figure 26. SWOT analysis for Patea Freezing Works site.

7. SITE VALIDATION

The purpose of the site validation report is to document the site conditions following remediation and/or mitigation.

Validation will vary significantly depending on the nature of the work undertaken, ranging from simple to complex projects:

- **Simple**: Confirming that an area of asbestos-contaminated soil has been covered with hard cap to mitigate the risk, with no validation sampling.
- **Complex**: Detailing complex remedial work undertaken to address asbestos in soil impacts and other soil and groundwater contaminants, with validation sampling confirming the required level of soil remediation has been achieved.

Regardless of the complexity of the project, the nature of the remedial and/or mitigation work must be well documented. Future site users need to know the extent of residual contamination and the details of any physical work (such as capping) installed to mitigate long-term risks. The report should detail mitigation undertaken during the remedial work to protect site workers and neighbouring properties. The report should also verify that all wastes generated and contaminated soil removed from site have been appropriately disposed of. This information should include transportation manifests and tip dockets from the disposal facility. Where some asbestos contamination remains on site after the remedial effort, the site validation report may be used to support development of an asbestos management plan and ongoing site management plan (see section 8.2).

A summary of the requirements for a site validation report are given in CLMG 1. In many situations, a remediation action plan will have been prepared as part of resource consent application requirements. The site validation report may have been prepared to fulfil a resource consent condition. It demonstrates that the remedial work has been carried out to specification or that an appropriate level of remediation has been undertaken. This is a requirement in particular circumstances under regulation 10(3)(d) of the NES-CS.

7.1 Report content

The scale and content of the site validation report will depend on the nature of the site and the remedial goals/objectives. A detailed description of the likely content of a report is given in CLMG 1. However, the content a report for asbestos is likely to include is shown in Table 8.

7.2 Clearance certificate

Clearance inspections must be conducted by an independent assessor after Class A licensed asbestos removal work and by a competent person after Class B licensed asbestos removal work (Part G section 28 of the ACOP and required under regulation 41 of the Asbestos Regulations).

A clearance certificate will be issued under regulation 42 of the Asbestos Regulations when the asbestos work zone and surrounding area is sufficiently decontaminated. The clearance/validation process should be carried out in four stages:

- **Site condition and remediation completeness** – the independent assessor reviews the asbestos remedial action plan and checks any decontamination facilities and procedures.
- **Visual inspection of the remediated area** – looking at the completeness of the asbestos-contaminated soil remediation and the presence of any visible asbestos-containing dust or fine settle dust on surrounding buildings.
- **Clearance air monitoring** – air monitoring where dust disturbance will occur. The results must show airborne asbestos does not exceed trace level.
- **Final assessment** – dismantle and remove the decontamination facilities for final assessment.

Once the independent clearance inspection confirms the area is safe for reoccupation, a certificate stating this should be provided. This includes all test results and should be appended to the site validation report.

Background information	• Summary of the project and intended long-term site use • Reference to the remedial action plan and asbestos removal control plan • Reference to supporting preliminary site investigation and detailed site investigation work • Details of resource consents that have been obtained to enable the remedial work to be undertaken
Remedial goals	• Summary of remedial goals • Soil acceptance criteria • Particular physical remedial work that was to be performed
Remedial/management work undertaken	• Summary of the remedial/management work actually undertaken • Reference to remedial action plan and asbestos removal control plan • Any deviation from the remedial action plan and its impact (if any) on the remedial outcome • Information on dates the work was undertaken • Volumes of contaminants removed
Validation work undertaken	• Details of the validation work undertaken as initially detailed in the remedial action plan • Any variation in the work from that intended • Validation sampling and/or surveying to verify removal has been successful across the required area and to the required depth • Sampling density and depths as detailed in the remedial action plan
Validation sampling undertaken	• Summary of the validation sampling undertaken • Site inspections made during the course of the work • Associated laboratory results or inspection results • Site plans/photographs clearly showing where sampling was undertaken • Site plans/photographs clearly showing where soil impact was removed
Control work undertaken	• Details of control work undertaken to manage asbestos risk during the remedial work • Methods to minimise generation of asbestos fibres during excavation work • Air monitoring (including results, particularly non-compliances) • Methods and results from equipment and personnel decontamination
Assessment of validation results	• An assessment of the validation sampling/testing results to demonstrate that the risk to human health is as intended or otherwise acceptable
Testing details	• Details of testing or certifications for engineered remedial solutions (i.e. installation of capping materials at surface or at depth) • As-built details for capping materials (or similar) confirming the area capped, depth and cap construction • Site inspection records and/or photographs showing thickness of capping layer at edges of cap or within test pits
Documentary evidence	• Documentary evidence to show that any disposal of contaminated materials has been undertaken in accordance with the remedial action plan , consents and the asbestos removal control plan
Assessment of results versus goals	• Assessment of the remedial/mitigation work against the remedial goals • Long-term management and monitoring requirements

Table 8. Site validation report content.


DANGER
ASBESTOS
CANCER AND LUNG DISEASE HAZARD
AUTHORIZED PERSONNEL ONLY

8. ONGOING MANAGEMENT

In some cases, asbestos-contaminated soil may remain on site as part of the remedial action plan or full clean-up may not be possible, practicable or desired by the property owner. In this situation, a PCBU with management or control of the workplace must ensure that a written plan is prepared. This will be an asbestos management plan, which could form part of a broader ongoing site management plan (long-term management plan) addressing other contaminants or hazards on the site.

8.1 Asbestos management plan

The Asbestos Regulations state that an asbestos management plan should include the following information:

- Any identified asbestos, ACM and asbestos-contaminated soil (including dates, location, type, condition and any analysis results) – this should be linked to the hazards register on site.
- Managing asbestos, including:
  - decisions and reasons for decisions about how the asbestos is managed, such as safe work procedures and control measures
  - the schedule for monitoring condition
  - procedures for accidental discovery protocols and emergency procedures
  - record-keeping requirements.
- All information about the workers carrying out asbestos work, including information and training responsibilities.
- The identities of every person with responsibilities under the asbestos management plan and what their responsibilities are.
- The workers carrying out work involving asbestos, including the training and information that is or will be provided, worker roles and responsibilities and health monitoring that is or will be conducted. Health monitoring details should be available on request.
- Key contact information – internally and externally.

Additional information that may be useful:

- A timetable for managing asbestos exposure risks (such as priorities and dates for remediation, reviews, circumstances and activities that could affect the timing of action).
- The procedures for reviewing and revising the asbestos management plan and asbestos documentation, including a timetable. Regulation 14 of the Asbestos Regulations requires a review at least every 5 years or if further asbestos is identified, removed, disturbed or remediated.
- Up-to-date occupational exposure standards, air monitoring procedures and safe work practices.
- Consenting requirements.
- An asbestos register.

The asbestos management plan is a requirement under regulation 13 of the Asbestos Regulations, and detailed guidance is provided in Part B section 9 of the ACOP. Under regulation 10 of the Asbestos Regulations, all workplaces where there is a reasonable likelihood of exposure and respirable fibres must have an asbestos management plan in place by 4 April 2018 if asbestos or ACM is identified at the workplace .

These actions are not required for homes that are not a workplace, although it is considered good practice.

8.2 Ongoing site management plan

An ongoing site management plan should be prepared by the SQEP to control future activities where remaining asbestos and other residual contaminants exist that do not require immediate remedial action.

As described in CLMG 1, specific content includes:

- contextual information
- allocation of responsibilities

- document control
- applicable regulations
- identified sources of asbestos (and other contaminants of concern)
- site control procedures, access, locations and isolation of work areas, transportation routes, location of clean areas, location of site facilities
- health and safety protection measures
- environmental management procedures
- monitoring requirements
- accidental discovery protocol
- key contact information
- monitoring locations
- trigger values or conditions requiring action
- action to be taken when trigger values or conditions are met
- reporting requirements.

Refer to CLMG 1 for the purpose and sample content requirements of an ongoing site management plan.

8.3 Final conceptual site model

A final update of the conceptual site model is also necessary to deliver the final site model, which can be used to determine risks associated with the site during future soil disturbances.

CASE STUDY

LONG-TERM REMEDIAL PLANNING

ACM was identified in building materials during a limited building inspection undertaken to support relocation of a number of buildings. Soil sampling was undertaken to provide an initial assessment of the presence of asbestos in soil.

The objectives of the initial assessment were to:

- document baseline soil quality before disturbance of known and potential ACM during building removal
- identify whether specific management controls were required to mitigate the risk to worker exposure from lifting and relocating the buildings.

The preliminary soil sampling indicated an uneven distribution of asbestos in soil. Asbestos was not detected in some areas and exceeded the soil guideline values for asbestos fines and fibrous asbestos in others. Further investigations were commissioned following building removal to work out exactly how widely the asbestos was distributed and inform decisions regarding remediation and ongoing management. The site investigations did not identify the presence of ACM within the shallow soil profile although the presence of ACM debris was noted by the laboratory. This suggested the soil contamination was attributable to weathering of building materials and contamination at the surface rather than associated with burial.

The presence of asbestos in soil exceeding the soil guideline values required that the asbestos removal control plan for the building ACM removal works had to

Photo: Golder Associates [NZ] Ltd

Figure 27. Temporary cover of contaminated soil.

account for the exposure of workers during relocation. The approved plan included the requirement to place groundsheeting on exposed areas during the building works and for workers to wear appropriate protective and respiratory equipment.

Given the presence of asbestos fines/fibrous asbestos at concentrations exceeding the applicable soil guideline values, it was agreed to remediate the asbestos-contaminated soil as part of re-establishment works following building removal. There were time constraints on the project. Multiple stakeholders agreed to remediate the asbestos in soil to a standard that did not pose an ongoing risk to use of the site and would require minimal maintenance in the long term. A simple Tier 2 assessment of health risk was performed and supported long-term management by inclusion of any residual asbestos-contaminated soil on the property's asbestos register.

The agreed remedial approach involved the removal of the top 100 mm of asbestos-contaminated soil, followed by re-establishment of the area for recreational use. Given project time constraints and to account for variability in the vertical distribution of asbestos fines/fibrous asbestos, an additional level of protection was provided. This was through the placement of geotextile matting following removal of the contaminated soil. The geotextile layer was installed to provide a break layer as part of ongoing management control for the site for any residual contamination remaining below the excavation depth.

Given the absence of ACM but presence of asbestos fines/fibrous asbestos above guideline values and the volume of soil requiring remediation, the work was undertaken by the equivalent of a Class A licence holder. An appropriate asbestos removal control plan was developed. The work was undertaken without an NES-CS consent because of the volume of soil being removed from site relative to the area of the property. However, the controls used to manage health, safety and environmental risks during the works were no different to those should a consent have been obtained. In addition to the Class A licence holder being retained by the project contractor, the project included daily air monitoring. This was undertaken by a fully independent licensed asbestos assessor (not engaged by the removal contractor). There was also oversight by a SQEP to ensure the requirements of the remedial action plan were being implemented.

Photo: Golder Associates (NZ) Ltd

Figure 28. Temporary cover of contaminated soil.

9. MORE INFORMATION

9.1 Legislation

Building Act 2004
http://legislation.govt.nz/act/public/2004/0072/latest/DLM306036.html

Health Act 1956
http://www.legislation.govt.nz/act/public/1956/0065/latest/DLM305840.html

Health and Safety at Work (Asbestos) Regulations 2016
http://www.legislation.govt.nz/regulation/public/2016/0015/19.0/DLM6729706.html

Health and Safety at Work Act 2015
http://legislation.govt.nz/act/public/2015/0070/37.0/DLM5976660.html

Resource Management (National Environmental Standard for Assessing and Managing Contaminants in Soil to Protect Human Health) Regulations 2011
http://www.legislation.govt.nz/regulation/public/2011/0361/latest/DLM4052228.html

Resource Management Act 1991
http://www.legislation.govt.nz/act/public/1991/0069/latest/DLM230265.html

9.2 Standards

AS 4964-2004 *Method for the qualitative identification of asbestos in bulk samples*

AS/NZS 1715:2009 *Selection, use and maintenance of respiratory protective equipment*

AS/NZS 1716: 2012 *Respiratory protective devices*

BS 1377-1:1990 *Methods of test for soils for civil engineering purposes. General requirements and sample preparation*

NIOSH Method 7402: *Asbestos by TEM*

NZS ISO/IEC 17025:2005 *General requirements for the competence of testing and calibration laboratories*

ISO 10312:1995 *Ambient air – Determination of asbestos fibres – Direct transfer transmission electron microscopy method*

ISO 14966 *Ambient air – Determination of numerical concentration of inorganic fibrous particles – Scanning electron microscopy method*

9.3 New Zealand resources

9.3.1 Ministry for the Environment

Contaminated Land Management Guidelines

- Reporting on Contaminated Sites in New Zealand (CLMG 1)
  http://www.mfe.govt.nz/publications/land-hazards/contaminated-land-management-guidelines-no-1-reporting-contaminated-sites
- Hierarchy and Application in New Zealand of Environmental Guidelines Values (CLMG 2)
  http://www.mfe.govt.nz/publications/land-hazards/contaminated-land-management-guidelines-no-2-hierarchy-and-application-new
- Risk Screening System (CLMG 3)
  http://www.mfe.govt.nz/publications/hazards-land/contaminated-land-management-guidelines-no-3-risk-screening-system
- Classification and Information Management Protocols (CLMG 4)
  http://www.mfe.govt.nz/publications/land-hazards/contaminated-land-management-guidelines-no-4-classification-and
- Site Investigation and Analysis of Soils (CLMG 5)
  http://www.mfe.govt.nz/publications/land-hazards/contaminated-land-management-guidelines-no-5-site-investigation-and

Hazardous Waste Transfer Form
http://www.mfe.govt.nz/sites/default/files/publications/waste/haz-waste-guide-mod1-jun02/hazardous-waste-transfer-form.pdf

WasteTRACK
http://www.wastetrack.co.nz/

Methodology for Deriving Standards for Contaminants in Soil to Protect Human Health
http://www.mfe.govt.nz/sites/default/files/methodology-for-deriving-standards-for-contaminants-in-soil.pdf

Users' Guide: National Environmental Standard for Assessing and Managing Contaminants in Soil to Protect Human Health
http://www.mfe.govt.nz/sites/default/files/guide-nes-for-assessing-managing-contaminants-in-soil.pdf

9.3.2 Ministry of Health

All About Asbestos
http://www.moh.govt.nz

Removing Asbestos from the Home
http://www.moh.govt.nz

The Management of Asbestos in the Non-Occupational Environment: Guidelines for Public Health Units
http://www.health.govt.nz/system/files/documents/publications/management-asbestos-in-non-occupational-environment-sep16.pdf

9.3.3 Office of the Prime Minister's Chief Science Advisor and Royal Society of New Zealand

Asbestos Exposure in New Zealand: Review of the Scientific Evidence of Non-occupational Health Risks
http://www.pmcsa.org.nz/wp-content/uploads/Asbestos-exposure-in-New-Zealand_9April15.pdf

9.3.4 WasteMINZ

WasteMINZ. (2017). Draft Good Practice Guidelines to Manage the Collection, Receipt, Transport and Disposal of Asbestos Waste.

9.3.5 Water New Zealand

Water New Zealand Good Practice Guideline: National Asbestos Cement Pressure Pipe Manual

- Volume 1 – User Guide
  https://www.waternz.org.nz/Attachment?Action=Download&Attachment_id=2113
- Volume 2 – Technical/Supporting Data
  https://www.waternz.org.nz/Attachment?Action=Download&Attachment_id=2088

9.3.6 WorkSafe New Zealand

Approved Code of Practice: Management and Removal of Asbestos (ACOP)
http://construction.worksafe.govt.nz/assets/guides/asbestos-acop/removal-of-asbestos-acop.pdf

Asbestos and Other Occupational Lung Diseases in New Zealand – 2013 Annual Report
http://www.worksafe.govt.nz/worksafe/information-guidance/all-guidance-items/asbestos-registers-national-annual-reports/asbestos-annual-report-2013.pdf

Good Practice Guidelines: Conducting Asbestos Surveys
http://construction.worksafe.govt.nz/assets/guides/conducting-asbestos-surveys/conducting-asbestos-surveys.pdf

9.4 Australian resources

Guidance Note on the Membrane Filter Method for Estimating Airborne Asbestos Fibres (NOHSC:3003)
https://www.safeworkaustralia.gov.au/system/files/documents/1702/guidancenote_membranefiltermethodforestimatingairborneasbestosfibres_2ndedition_nohsc3003-2005_pdf.pdf

Guidelines for the Assessment, Remediation and Management of Asbestos-Contaminated Sites in Western Australia (WA Guidelines)
http://ww2.health.wa.gov.au/~/media/Files/Corporate/general%20documents/Asbestos/PDF/Guidelines-Asbestos-Contaminated%20Sites-May2009.ashx

Management of Asbestos in the Non-Occupational Environment (enHealth 2005)
http://content.webarchive.nla.gov.au/gov/wayback/20080727052532/http:/www.health.gov.au/internet/main/publishing.nsf/Content/FB262D7C35664103CA257420001F2D74/$File/asbestos.pdf

National Environmental Protection (Assessment of Site Contamination) Measures 1999
http://www.nepc.gov.au/nepms/assessment-site-contamination

9.5 UK resources

Asbestos in Soil and Made Ground: A Guide to Understanding and Managing Risks (CIRIA C733)

Asbestos: The Licensed Contractors' Guide (HSG247)

Asbestos: The Survey Guide (HSG264)

Department of Environment (DoE) Industry Profiles

Respiratory Protective Equipment at Work (HSG53)

The Determination of Asbestos in Soil and Associated Material (EIC:SCA 2015)

10. GLOSSARY

accredited testing laboratory	A laboratory accredited by International Accreditation New Zealand (IANZ) or any other accreditation regime recognised by WorkSafe New Zealand to test for the presence of asbestos. In New Zealand, the Asbestos Regulations state that only accredited laboratories can do this testing. For accredited testing laboratories, refer to IANZ (www.ianz.govt.nz/directory/) or WorkSafe New Zealand.(www.worksafe.govt.nz/worksafe/information-guidance/guidance-by-hazard-type/asbestos/working-with-asbestos/laboratory-accreditation-process).
ACD	Asbestos-contaminated dust, meaning dust or debris that has settled and is or is assumed to be contaminated with asbestos. In the guidelines, FA/AF is used in its place.
ACM	Any material or item that, by its design, contains asbestos (typically comprising bonded cement board). The concentration of ACM in soil can either be quantified using an IANZ accredited laboratory or in the field using less-reliable field techniques.
ACOP	Approved Code of Practice: Management and Removal of Asbestos.
AF	Asbestos fines. Includes free fibres of asbestos, fibrous asbestos, small fibre bundles and also ACM fragments that pass through a 7 x 7 mm sieve for field screening and 10 x 10 mm sieve in the laboratory. The measurement of AF in soil is completed by an IANZ accredited laboratory.
airborne contamination standard	An average concentration over any 8-hour period of 0.1 respirable fibres per millilitre of air.
ALGA	Australasian Land and Groundwater Association (ALGA) Ltd.
background concentrations	The naturally occurring, ambient concentrations of substances in the local area of the site.
bonded ACM	Where asbestos is bound in a matrix such as cement and there is minimal free fibre present.
Class A	Removal work involving asbestos that requires a Class A licensed asbestos removalist, such as work specified in regulation 54(1) and (2) of the Asbestos Regulations, involving friable asbestos.
Class B	Removal work involving asbestos that requires a Class B licensed asbestos removalist, such as work specific in regulation 56(1) and (2) of the Asbestos Regulations, involving removal of more than 10 m² of non-friable asbestos or ACM.
CLMGs	Contaminated Land Management Guidelines.

competent person	Under the Asbestos Regulations, a competent person is a person who has acquired, through training and experience, the knowledge and skills of relevant asbestos removal industry practice including through holding one of the qualifications listed by WorkSafe New Zealand. A competent person may only conduct air monitoring and clearance inspections in relation to non-friable asbestos projects. For a SQEP to act as a competent person, they must meet criteria under regulation 3(1) of the Asbestos Regulations.
conceptual site model (CSM)	A system diagram of the site and any contamination. It shows current conditions, the distribution of contamination and how it might be released and transported to those who may be affected by it. It can be supported by maps and drawings. In simple terms, it tells you what is going on at the site and helps to inform everyone involved in the work. It helps to guide initial investigation work, and it is added to as more information is found. A CSM is a "diagrammatic or tabular representation of the characteristics of the site, [that] shows the possible relationships between contaminants, pathways and receptors as well as relevant uncertainties" (CIRIA C733).
detailed site investigation (DSI)	Detailed site investigation as defined in regulation 3 of the NES-CS as: "an investigation that: a. is done by a suitably qualified and experienced practitioner; and b. is done in accordance with the current edition of Contaminated Land Management Guidelines No. 5 – Site Investigation and Analysis of Soils, Wellington, Ministry for the Environment; and c. is reported on in accordance with the current edition of Contaminated Land Management Guidelines No. 1 – Reporting on Contaminated Sites in New Zealand, Wellington, Ministry for the Environment; and d. results in a report that is certified by the practitioner. A detailed site investigation involves intrusive techniques to collect field data and soil samples for analytical testing to determine the concentrations of contaminants of concern."
f/mL	Fibres per millilitre of air.
FA	Fibrous asbestos, as per the WA Guidelines, is "friable asbestos material, such as severely weathered ACM, and asbestos in the form of loose fibrous material such as insulation products". FA can be detected visually, but to quantify the concentration of FA in soil, an accredited laboratory should be used.
fibre	Typically, a respirable fibre is less than 3 μm in width, greater than 5 μm in length and has a length-to-width aspect ratio greater than 3:1.
friable	Asbestos that is in a powder form or able to be crumbled, pulverised or reduced to a powder form by hand pressure when dry (textile material, gaskets and asbestos insulation board is likely to be found in a friable condition). Non-friable asbestos can become friable with age and if handled incorrectly.

HAIL	Hazardous Activities and Industries List, administered by the Ministry for the Environment. This is a compilation of activities and industries that could be considered to cause land contamination resulting from hazardous substance use, storage or disposal. www.mfe.govt.nz/land/hazardous-activities-and-industries-list-hail
independent licensed assessor	Under the Asbestos Regulations, an independent licensed asbestos assessor is a person who is licensed by WorkSafe New Zealand to conduct air monitoring and clearance inspections for friable and non-friable asbestos projects. For asbestos in soil, the role of an independent assessor is to provide support to high-risk remedial projects (involving friable asbestos), undertake air monitoring and provide clearance on Class A removal work under regulation 41 of the Asbestos Regulations.
licensed asbestos removalist	Under the Asbestos Regulations, this is a PCBU with a Class A or Class B licence for asbestos removal. It should be noted that, for asbestos-contaminated soil, work should be completed in collaboration with a SQEP.
LIM	Land Information Memorandum.
mesothelioma	Cancer of the lining of the lungs.
NES-CS	Resource Management (National Environmental Standard for Assessing and Managing Contaminants in Soil to Protect Human Health) Regulations 2011.
non-friable	As per the ACOP: "in relation to asbestos or ACM, means not friable (and, for the purposes of this definition, asbestos and ACM include material containing asbestos fibres reinforced with a bonding compound".
PCBU	Person conducting a business or undertaking. In most cases, a PCBU will be an organisation such as a company, although it can be an individual. If they conduct an undertaking, they may be a PCBU, regardless of their legal structure.
PPE	Personal protective equipment, which includes face masks, respirators, eye protection, disposable coveralls and so on.
preliminary site investigation (PSI)	Preliminary site investigation as defined in regulation 3 of the NES-CS, as: "an investigation that: a. is done by a SQEP; and b. is reported on in accordance with the current edition of CLMG 1; and c. results in a report that is certified by the practitioner. A PSI is often referred to as a desktop study because it does not usually involve sampling and analysis of the soil. The main objectives of a PSI are to gather information about a piece of land to determine whether it may potentially be contaminated, to assess the suitability of the land for its current or intended land use and to design a DSI (if required)."
reasonably practicable	As per the ACOP: "means actions that are (or were at a particular time) reasonably able to be done to ensure health and safety. In deciding what actions to take, the PCBU must consider the hazards and associated risk, how serious the harm could be, what a person knows or ought to know about the risk and ways of controlling it, what measures exist to control the risk, and how available and suitable the controls are".

receptor	A person or other organism or ecological system that may be harmed by asbestos. Receptors can include remediation workers, site occupiers, site visitors and people living close by.
respirable asbestos fibre	The Asbestos Regulations define this as a particle of asbestos that is up to 3 μm in width and is greater than 5 μm in length and has a length-to-width ratio greater than 3:1. These fibres are small enough to penetrate into the area of the lung where they can be extremely harmful.
SQEP	Suitably qualified and experienced practitioner. A term found in the NES-CS (but not defined there). Depending on the nature and level of work, a SQEP is required to have relevant tertiary education and professional experience relating to the assessment and management of asbestos-contaminated land, with competence in managing asbestos in soil. If a SQEP is to act as a competent person, they must meet criteria under regulation 3(1) of the Asbestos Regulations.
simple site	PSI demonstrates asbestos contamination confined to surface ACM in good condition and in limited quantities over a defined area (such as a former building footprint). No excavation of soil required, any visual asbestos contamination is removed by hand, impacted area capped (as the preferred remedial method) and long-term management using institutional controls.
trace level	An average concentration over any 8-hour period of less than 0.01 respirable asbestos fibres per millilitre of air.
unlicensed	Work involving asbestos that does not require a licensed asbestos removalist.
virgin natural material (VNM)	Natural material (such as clay, gravel, sand soil or rock fines) that have been excavated or quarried from areas that are not contaminated with manufactured chemicals or with processed residues as a result of industrial, commercial, mining or agricultural activities.
WA Guidelines	Guidelines for the Assessment, Remediation and Management of Asbestos-Contaminated Sites in Western Australia. http://ww2.health.wa.gov.au/~/media/Files/Corporate/general%20documents/Asbestos/PDF/Guidelines-Asbestos-Contaminated%20Sites-May2009.ashx

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12. APPENDIX A

Minimum sampling points required for site characterisation based on detection of circular hot spots using a systematic grid sampling pattern.

Area of the site and/or excavations (m^2)	Number of sampling points recommended	Equivalent sampling density (points/ha)	Diameter of the hot spot that can be detected with 95% confidence (m)	Grid size (m)
500	5	100.0	11.8	10
1,000	6	60.0	15.2	12.9
2,000	7	35.0	19.9	16.9
3,000	9	30.0	21.5	18.2
4,000	11	27.5	22.5	19.1
5,000	13	26.0	23.1	19.6
6,000	15	25.0	23.6	20.0
7,000	17	24.3	23.9	20.3
8,000	19	23.8	24.2	20.5
9,000	20	22.2	25.0	21.2
10,000	21	21.0	25.7	21.8
15,000	25	16.7	28.9	24.5
20,000	30	15.0	30.5	25.4
25,000	35	14.0	31.5	26.7
30,000	40	13.3	32.4	27.4
35,000	45	12.9	32.9	27.9
40,000	50	12.5	33.4	28.3
45,000	52	11.6	34.6	29.3
50,000	55	11.0	35.6	30.1

Source: Guidelines for the Assessment, Remediation and Management of Asbestos-Contaminated Sites in Western Australia – May 2009.
http://ww2.health.wa.gov.au/~/media/Files/Corporate/general%20documents/Asbestos/PDF/Guidelines-Asbestos-Contaminated%20Sites-May2009.ashx

Notes:

1. The provision in this table of the number of sampling points does not imply that a 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 50,000 m^2.

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