Residential Property —
Soil Sampling and Analysis Plan

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Kāinga Ora
Homes and Communities

Contents

Acronyms

AFB	air force base
ACM	asbestos-containing materials
ATSDR	Agency for Toxic Substances and Disease Registry
bgl	below ground level
CCA	copper-chrome-arsenic
CLMG	Contaminated Land Management Guidelines
CoC	contaminates of concern
CSM	conceptual site model
DSI	Detailed Site Investigation
GM	geometric mean
HAIL	Hazardous Activities and Industries List
HSNO	Hazardous Substances and New Organisms Act 1996
ICP-MS	inductively coupled plasma-mass-spectrometry
LNAPL	light non-aqueous phase liquid
m	meter
MDL	maximum detection limit
MfE	Ministry for the Environment
mg/kg	milligram per kilogram
MoH	Ministry of Health
NES-CS	National Environmental Standard for Assessing and Managing Contaminants in Soil to Protect Human Health
NR	not recorded
PA	Permitted Activity
PSI	Preliminary Site Investigation
SAP	Sampling Analysis Plan
SCS	human health Soil Contaminant Standard
SOP	Standard Operating Procedure
SQEP	suitably qualified and experienced practitioner
TCLP	toxicity characteristic leaching procedure
TEL	tetra ethyl lead
UK	United Kingdom
USEPA	United States Environmental Protection Agency
UCL	Upper Confidence Limit
w/w	weight/weight

1 Introduction

1.1 Background and Context

Kāinga Ora – Homes and Communities (Kāinga Ora) has two key roles:

- Being a public housing landlord; and
- Working in partnership to enable, facilitate, and deliver housing and urban re-development projects.

Kāinga Ora, as a major landowner and developer, faces many challenges delivering its key functions and objectives. In the context of land development, Kāinga Ora has identified the need to manage environmental, human health, safety, cultural and heritage considerations associated with contaminated land during project scoping, construction, and longer-term management.

As a responsible landowner and landlord, Kāinga Ora needs to ensure these issues are appropriately managed in a consistent way across the country. At the same time Kāinga Ora needs to drive efficiency in the delivery of its national residential build programme, longer-term urban re-development projects, and management and maintenance of existing assets and land. Growing community awareness of contaminated land issues also requires Kāinga Ora to implement high operating standards and the need for increased accountability and transparency.

Kāinga Ora has a portfolio of approximately 65,000 residential properties and as part of its residential build programme, a significant number of these properties are being re-developed to high-density housing.

Pictorial conceptual site models (CSMs) for existing and re-developed Kāinga Ora properties are given in **Figure 1** and **Figure 2.** These pictorial CSMs show the types of contamination that could be present on Kāinga Ora properties.

Many of the original homes were built between the late 1950s and 1980s, comprise single-storey dwellings, and occupy relatively large residential sections (typically in the order of 500 m^2 to 1,000 m^2). These original homes were often constructed on agricultural land that surrounded towns/cities and so are not situated on legacy brownfield land that was contaminated from historic land uses.

Given the nature of the building materials used in the construction of the Kāinga Ora dwellings and allowing for 50 to 70 years of residential use, the soil around Kāinga Ora houses typically has elevated concentrations of some inorganic elements and, in some cases asbestos.

In some areas of the country the original development took place on horticultural land that was often subject to herbicide and pesticide use and so these properties are contaminated (typically at low concentrations) with chemicals used in the formulations. A small number of properties have been subject to contamination from other historic land uses and from contaminant migration from neighbouring properties. The sites that have been subject to historic brownfield activities and/or contaminant migration from neighbouring sites are listed on the Ministry for the Environment's (MfE) Hazardous Activities and Industries List (HAIL) (MfE, 2011a).

1.2 Sampling and Analysis Plan Background

To support Kāinga Ora's contaminated land management work during re-development, this Sampling Analysis Plan (SAP) has been prepared as an update to the Kāinga Ora Contaminated Land Management Policy and Framework - Generic Site Investigation Protocol issued in 2020 (Kāinga Ora, 2020). The SAP update has been driven in part by revisions to MfE's Contaminated Land Management Guidelines No.1. Reporting on Contaminated Land in New Zealand (CLMG #1 – MfE, 2021a) and No.5. Site Investigation and Analysis of Soils (CLMG #5 – MfE, 2021b) and investigation work Kāinga Ora has been undertaking to better understand the nature of contamination on its residential properties and the health risks posed by the contamination (Kāinga Ora Conceptual Site Model – Residential Properties, EHS Support, 2022).

Re-development of Kāinga Ora properties to high-density residential use is occurring on individual property lots (typically lot size up to approximately 1,000 m^2), clusters of property lots (several lots aggregated together – combined lot sizes in the order of 1,000 m^2 to 10,000 m^2), and super lots (aggregated property areas typically greater than 10,000 m^2). In many cases, all the near surface superficial soils (topsoil and underlying natural ground) are being excavated for foundation and pavement construction.

The re-development process requires Kāinga Ora to characterise the contamination on the properties for the reasons listed below:

- Long-term human health risks. While most of the contaminated soil is being stripped and removed from the Kāinga Ora sites, residual contamination may remain in place which will require long-term management to mitigate human health and environmental risks.
- Topsoil re-use. Soils being stripped from re-development sites may be re-used and so it is necessary to ensure residual contamination in re-used topsoil does not pose a long-term human health risk.
- Off-site disposal of excavated soils. Soils stripped from sites are often contaminated at varying concentrations and so it is necessary to ensure the soils are disposed of appropriately to suitably licensed faculties in a cost-effective manner.
- Regulatory Compliance. A combination of national and local regulations requires the contamination on properties to be characterised and controls put in place to manage environmental and human health risks (both short and long-term). In some situations, resource consents are required and/or permitted activity criteria need to be complied with.
- Contractor health and safety. Earthwork's contractors disturbing and handling excavated contaminated soils may require additional health and safety controls (over and above standard operating procedures) to address soil contamination issues, particularly with respect to asbestos in soil.

Because of the large number of Kāinga Ora residential properties being re-developed nationally, for the last 4-5 years, Kāinga Ora has focused on investigating, remediating, and documenting residual contamination in a consistent manner (as set out in the 2020 Kāinga Ora generic investigation protocol). This consistent approach has been taken, regardless of whether resource consents are required or not for the re-development work, to provide confidence to stakeholders that Kāinga Ora is managing its contaminated land issues proactively, in a logical manner and for ease of deployment/delivery nationally. The key elements of this consistent investigation approach comprised the following:

- A preliminary site investigation (PSI) is undertaken to establish if a HAIL activity has been undertaken on the site (or neighbouring site) and to assist in scoping intrusive investigation work.
- Adequately characterise the soil contamination spatially and with depth (to a typical maximum investigation depth of 0.5 m below ground level (bgl) through a detailed site investigation (DSI).
- Analyse the soil samples for key trace elements (arsenic, copper, lead, and zinc) and asbestos.
- Prove the depth of the contamination to background levels (assuming shallow topsoil or fill).

Where possible, investigate the site once (to avoid the need for multiple investigation mobilisations) and use the DSI information to validate the remedial earthworks (i.e., avoiding the need to collect remedial benchmark samples because the DSI has proved the residual contamination concentrations below the likely re-development excavation depth).

For this updated SAP, it is concluded (based on the data presented in the Kāinga Ora Conceptual Site Model – Residential Properties report (EHS Support, 2022) and discussed in **Section 5** of this report) that residential Kāinga Ora properties constructed on agricultural land (pasture or arable) from the late 1940s/early 1950s onwards are non-HAIL.

This updated SAP has therefore been developed as a generic methodology for contractors investigating non-HAIL Kāinga Ora residential re-development sites and has maintained (wherever possible) investigation principles that were presented in the original Kāinga Ora document. This SAP should be read in conjunction with the Kāinga Ora Conceptual Site Model – Residential Properties report (EHS Support, 2022) which provides a more in-depth assessment of contamination on Kāinga Ora residential properties.

1.3 Structure of this Report

The Kāinga Ora SAP is set out as follows:

Section 2 – Provides background information on contamination in urban soils, with a particular focus on lead and asbestos.

Section 3 – This section presents an overview of the nature and extent of soil contamination on Kāinga Ora residential sites based on a review of Kāinga Ora soil contamination data.

Section 4 – Provides an overview of Kāinga Ora compliance with the National Environmental Standard for Assessing and Managing Contaminants in Soil to Protect Human Health (NES-CS) in the context of re-development of Kāinga Ora sites.

Section 5 – This section presents generic CSM for non-HAIL Kāinga Ora residential property.

Section 6 – This section provides outline comments on soil disposal on Kāinga Ora re-development sites.

Section 7 – This section presents the generic SAP for intrusive investigation work being undertaken on Kāinga Ora non-HAIL residential sites.

This report has been prepared by EHS Support New Zealand Ltd on behalf of Kāinga Ora, the principal authors were Andrew Rumsby and Simon Hunt. Acknowledgement is given to Lisa Paton for the preparation of CSM schematics.

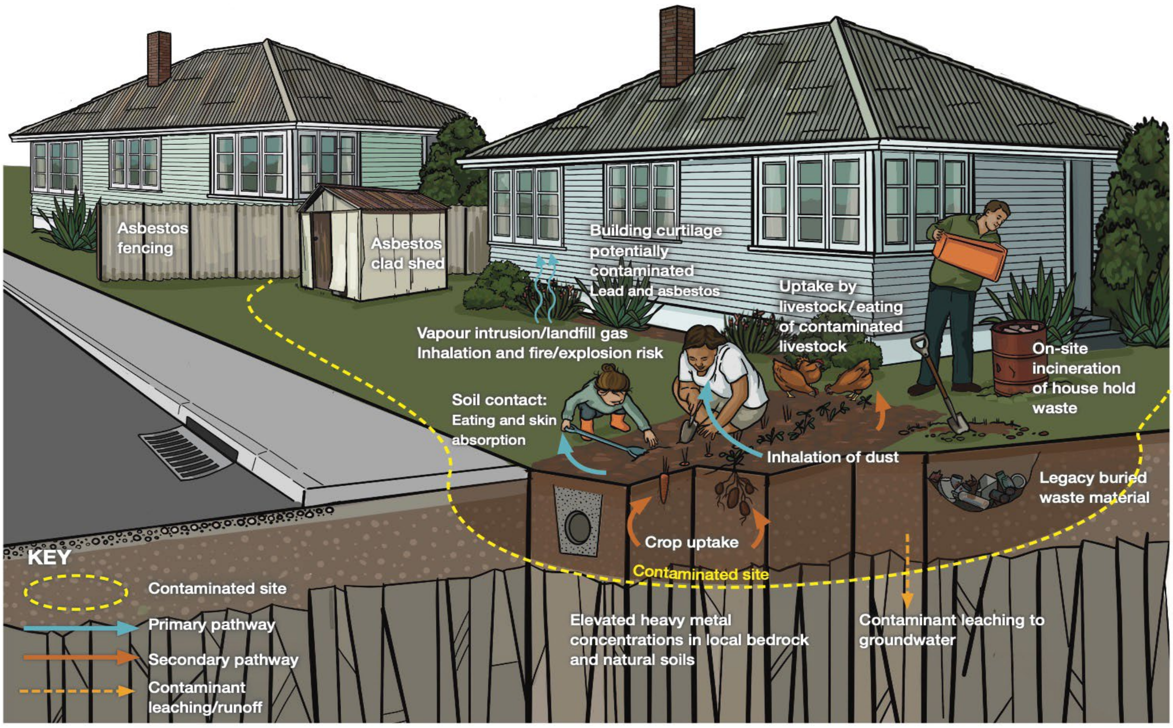

Figure 1 **Conceptual Site Model – Existing Kāinga Ora Residential Property**

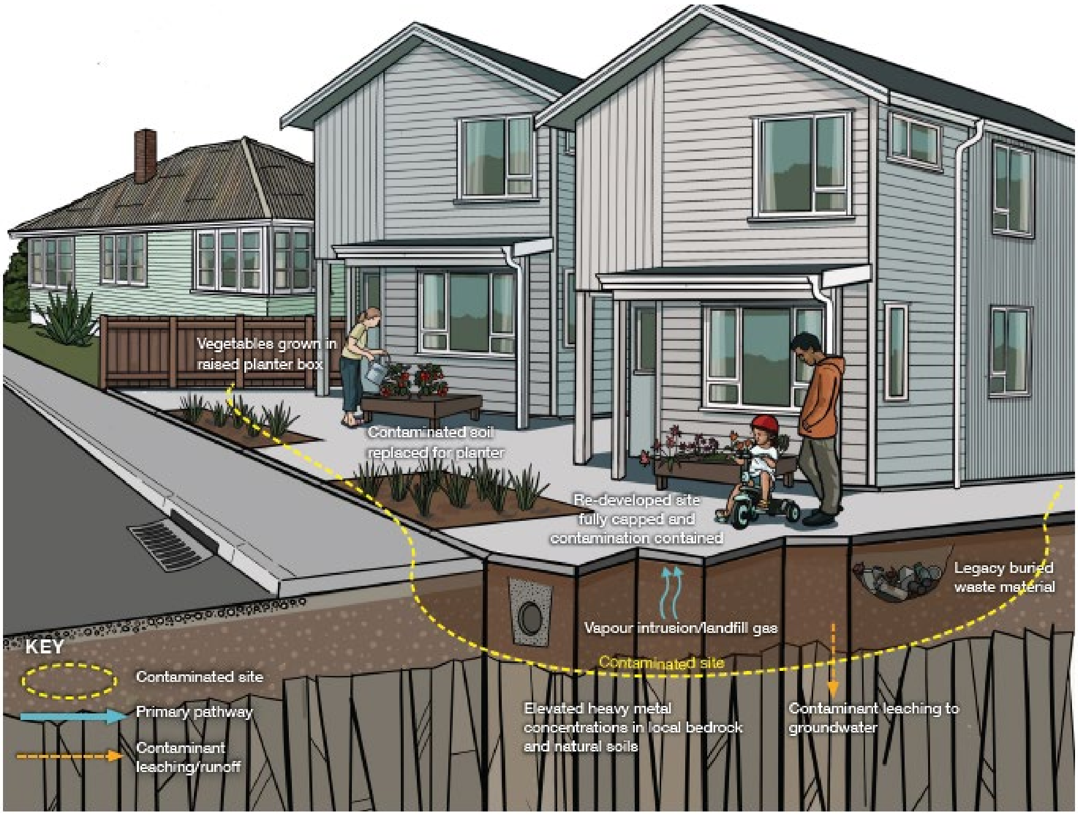

Figure 2 **Conceptual Site Model – Re-Developed Kāinga Ora Residential Property**

2 Background to Contaminants in Urban Soils

Urban residential soils have been shown to contain elevated concentrations of several inorganic elements compared to background soil concentrations (Meuser, 2010). The source of these inorganic elements can range from:

- Weathering and leaching of building products (i.e., copper-chrome-arsenic (CCA) treated timber, copper guttering and spouting, asbestos-containing materials (ACM), and galvanised roofing iron (zinc).
- Flaking and removal of lead-based paints.
- Deposition of fireplace ash or outdoor incineration of waste.
- Deposition of contaminated dust from industrial sources or vehicle emissions.
- Fertiliser and fungicide use which contain inorganic salts (particularly copper and zinc).
- Construction on historical fill materials or contaminated industrial sites (brownfield sites).

This section provides an overview of the likely contaminants of concern (CoC) to be encountered on Kāinga Ora residential sites. In particular, the section principally focuses on lead, and to a lesser extent asbestos, because these CoC are the most significant and widespread contaminants found on residential sites, both from a human health risk and soil disposal perspective. In addition, lead contamination around the dwelling(s) on a property is a “marker” contaminant, in that its spatial distribution and depth, typically indicates where other elevated CoC are likely to be recorded around the dwelling.

While most Kāinga Ora sites are not located on former historical industrial sites (brownfield sites), some have been built on former horticultural land. Consequently, these properties may have an elevated concentration of persistent organic pesticides in the near surface soil.

For most Kāinga Ora residential sites built between the late 1950s and 1980s, asbestos, copper, lead, and zinc are the key soil CoC’s principally derived from the building materials used in the construction of the dwellings. On some residential sites, elevated arsenic concentrations have been found in soils. Various sources exist for the arsenic contamination (CCA treated timber, disposal of fireplace ash, arsenic-containing paint pigments (i.e., Scheele's green and as a white paint extender), naturally elevated arsenic and use of arsenic-based pesticides (either lead arsenate pesticides for control of coddling moth or monomethyl arsenate weedkillers) in many cases the source has not been definitively established.

Chromium may also be elevated in soils around some residential properties due to the weathering of CCA treated wood. However, the human health soil contaminant standards (SCS – MfE, 2012) are much lower for arsenic than chromium and so soils identified as being impacted by chromium are typically identified for removal from site because of high arsenic (and sometimes copper) concentrations. Therefore, analysis of chromium in the soil is unnecessary. A discussion on the scheduling of soil testing for off-site disposal of excavated soils, particularly when dealing with volcanic soils which may contain elevated chromium (and nickel), is given in **Section 6**.

Meuser (2010) also identified that cadmium, nickel, and vanadium might be slightly elevated in some residential soils; they typically are not present in concentrations above background levels or levels of health concern (Meuser, 2010). Hence these elements are not considered as CoC's on Kāinga Ora sites.

Migration of ground gases and vapour onto a Kāinga Ora property may be an issue at some sites, particularly within 50 m of a Light Non-Aqueous Phase Liquid (LNAPL) plume or 200 m of a closed landfill. During the PSI process the SQEP needs to confirm if there is the potential that the site could be HAIL Category H.

Further discussion on the selection of analytes during the intrusive investigation work is given in **Sections 5** and **7.**

2.1 Asbestos in Soils

Asbestos-based products were used in New Zealand to construct residential homes from the 1920s to the mid-1980s (BRANZ, 2017). The BRANZ guideline indicates that many New Zealand houses built between the 1940s and the 1970s used ACMs within the roofing and cladding materials (BRANZ, 2017). Therefore, it is likely Kāinga Ora built houses during this period could contain ACM.

Kāinga Ora building materials have been reasonably well maintained/painted and so there is limited chance that physical weathering of the ACM has resulted in high levels of asbestos fibres being deposited in soils around dwellings and other structures. As with the lead paint, the nature of ACM building materials varies between properties, and so there is obviously a greater potential for asbestos in soil impacts to be recorded around properties that have used a significant amount of ACM in their construction. This situation typically occurs with asbestos roofing and guttering and where downpipes discharge to ground and not a reticulated stormwater system.

Building activities, such as the burial of ACM residues on-site, can result in the ACM impact beyond the building halo. Also, fires and demolition of buildings can also result in more widespread contamination on a residential property.

2.2 Lead

Lead is a toxic naturally occurring trace element which has been documented to cause neurological, renal, cardiovascular, haematological, immunological, reproductive, and developmental effects (ATSDR, 2020). Lead affects the developing brain and nervous system of young children, who are of greatest risk of ingesting lead contaminated dust and soil.

Historically, lead has been used on residential houses for several purposes, including leaded paints, lead-headed roofing nails, lead flashing, and roof covering. The use of lead-based paint, in particular, has resulted in elevating the concentration of lead in soil (Battelle Memorial Institue, 1998), (Brown, 2016), (Miekle, 1998), and (Ministry of Health, 2021).

The drip line (curtilage) area around a building can be the location of a localised elevation in lead concentrations from several different sources, including:

- Discharges from downpipes and leaky guttering during storm events of fine-grained dust deposited on the building roof.
- Leaching and weathering of lead-based products used in roofing materials (such as flashing and nail heads) or stabilising agent in PVC guttering/downpipes.
- The deterioration and improper removal of lead-based paints and primers from a building's roofing materials, exterior walls, and woodwork.

Since lead is a toxic and persistent environmental pollutant, the historical release of lead from a dwelling can be an ongoing health concern many years after the lead sources (paint or building products) has been removed from the building.

2.2.1 Lead-based Paints

Lead-based paint has been used from before the 1840s until 1983.

Regulations introduced in 1957 onwards successively reduced the lead concentration in paint to the current maximum level of 0.1% (weight/weight (w/w)). Lead-based paint used in New Zealand was originally manufactured in the United Kingdom (UK). However, during World War 1, the export of lead-based paints from the UK was banned. The UK's ban on exporting lead-based paints resulted in countries like Australia and New Zealand manufacturing their paints soon afterwards.

A summary of the evolution of lead-based paint regulations in New Zealand is outlined below:

- The UK introduced restrictions on lead in paint in 1926 (to approximately 5% w/w lead).
- Queensland, Australia restricted lead concentrations in paint to 5% w/w in 1922 for surfaces accessible to children.
- White lead (which could contain up to 50% lead by weight) was used as extensively a pigment of paint before 1945.
- New Zealand introduced restrictions through several import tariffs from 1957. Lead content in paint was also regulated under The Poisons Act 1960.
- The Toxic Substances Act 1979 banned the use of white lead in New Zealand paints.
- In 1983, the lead content in domestic/residential paint was restricted to 0.5% w/w.
- In 1993 the maximum allowable concentration in residential house paint was lower to 0.25% w/w.

Currently, lead in paint is regulated under the Group Standards for Surface and Coatings and Colourants, Hazardous Substances and New Organisms Act 1996 (HSNO), limiting lead to a maximum concentration of 0.1% lead.

Kennedy *et al.* (Kennedy, 1988) surveyed exterior house wall paint samples in Auckland suburbs in the 1980s and reported geometric mean (GM) concentrations by house age. Kennedy found that:

- Houses built before 1899 had a GM lead concentration above 10% w/w.
- Houses built between 1900 and 1959 had GM concentrations between 1 and 10 % w/w.
- Houses built between 1960 and 1979 had GM lead concentration at 0.1% w/w.
- Houses built 1980 and 1984 had a GM lead concentration of 0.003% w/w.

Therefore, houses built before the 1980s may have been painted with lead-based paints, which could generate elevated lead concentrations in soil (particularly within the drip line area of the dwelling). Residential houses built before 1957 could potentially have very high soil lead concentrations as the lead content in paint was significantly higher before tariffs and regulations controlled the amount of lead in paint.

2.2.2 Lead in New Zealand Residential Soils

Lead occurs naturally in soils, typically at concentrations from 2 to 65 mg/kg (Auckland Council, 2001). Background concentrations of lead do vary across the country with some soil types having lead concentrations of less than 25 mg/kg. However, anthropogenic activities such as vehicle emissions, lead paint on houses, lead arsenate pesticides, incineration of wastes, and air emissions from industrial activities have elevated the lead concentrations in urban soils (Mielke H. G., 2019).

Soil can be contaminated by leaded paint particles from deterioration or damage to exterior lead-based paintwork or improperly removing lead paint (Ministry of Health, 2021). The Ministry of Health (Ministry of Health, 2021) indicates that most soil contamination will occur within 1 to 2 metres of the building containing lead-based paints, whilst the USEPA/HUD indicates that the majority occurs within the dripline of the house. Dumping or burning of building debris contaminated by lead-based paint or disposal of ash from fires may also result in hotspots in urban gardens (Ministry of Health, 2021).

Several studies have found that around older houses (particularly pre-1960s), the concentration of lead in soil is much higher within the dripline of the house than in other locations within the section (Clickner, 1995) (Schwarz, 2012). Studies undertaken in New Zealand have found that older houses (pre-1950s) have a significantly higher lead concentration in soils (Ashrafzadeh, 2018).

A summary of several studies on urban/residential lead soil concentrations within New Zealand is presented in **Table 2-1**.

Table 2-1 Lead in New Zealand Residential Soil

Location	Geomean (mg/kg)	Range (mg/kg)	Reference
Christchurch (pre-1950s home)	282	NR	(Ashrafzadeh, 2018)
Christchurch (all houses)	137	22.6-2,615	(Ashrafzadeh, 2018)
Ashburton		Typical Range (300-600 mg/kg – maximum 5,946 mg/kg)	(Malloch Environmental Limited, 2018)
Dunedin	131.1	35-2,354	(Turnball, 2019)
Palmerston North	207.6	11.5-9,571	(Blunden, 2020)

Location	Geomean (mg/kg)	Range (mg/kg)	Reference
Lead Sunderland District (dripline 0-1 m)	NR	26-16,800	(Golder, 2013)
Lead-Sunderland District (non-dripline)	NR	16-1,100	(Golder, 2013)
Hobsonville AFB	NR	5.4-16,800	(PDP, 2013)
National	51.79	6.8-2,600	(PDP, 2021)
Table Notes: All soil lead values are reported in mg/kg (dry weight) unless indicated. AFB = air force base NR = not recorded Golder = Golder Associates New Zealand Ltd PDP = Pattle Delamore Partners Ltd			

3 Factors Affecting the Kāinga Ora Residential Conceptual Site Model

Kāinga Ora has actively been investigating residential re-development sites nationally for the last 5+ years and for the last 3-4 years, a significant amount of the investigation work has been undertaken by a small group of contractors who have used a similar investigation methodology.

Kāinga Ora residential soil contamination data has been collated into a comprehensive database that has been used to provide insight into the nature of the contamination on Kāinga Ora sites. A discussion on this data and the findings are presented in the Kāinga Ora Conceptual Site Model – Residential Properties report (EHS Support, 2022). A summary of the key findings from this study and the issues that informed development of the SAP is given below. This section discusses the following issues:

1. Age of Kāinga Ora housing stock, nature of their use, and external factors.
2. Contaminants of concern.
3. Contamination impact within the dwelling dripline and extent.
4. Contamination depth.
5. Impact from vehicle emissions (principally within the front yard areas).

3.1 General Considerations

The vast majority of the Kāinga Ora housing stock dates from post 2nd World War and from the late 1950s onwards. Based on the discussion presented in **Section 2,** the paint used in the construction and maintenance of these legacy Kāinga Ora dwellings would have had a relatively low lead concentration (in the order of 1% w/w). This potentially contrasts with older residential buildings that exist across much of New Zealand, dating from the late 19th Century and early 20th Century, which would have used paint with significantly higher lead concentrations.

Kāinga Ora dwellings have been routinely maintained over their operational life (unlike private ownership, which often is variable) and so this activity would limit the likelihood of the release of lead paint and asbestos from the building fabric and generation of contaminated soil. It must be acknowledged that variable historic maintenance practices may have contributed to elevated lead and asbestos concentrations on select Kāinga Ora properties.

3.2 Site Wide and Dripline Contamination Data

A summary of soil lead concentrations on Kāinga Ora residential properties is shown in **Table 3-1**. The data presented is for residential properties developed between the 1950s and 1980s for the surface soils across the whole of the property and data for surface soils at the edge of the dripline (1 m from the dwelling). The soil samples were all collected between ground level and 0.1 m bgl.

Table 3-1 Analysis of Lead in Urban Surficial Soils (0-0.1m bgl) around Kāinga Ora Properties

Descriptive statistics	Concentration of Soil Lead (all samples) (mg/kg)	Concentration of Soil Lead within 1 m of Dwelling (mg/kg)
Minimum	6.8	7.4
Maximum	5,200	5,200
Mean	128.8	262.1
Geometric Mean	60.3	111.9
95% UCL of mean (95% Chebsyshev UCL)	171.6	394.8
Standard Derivation	242.3	555.6
25 Percentile	28	47
Median	49	86
75 Percentile	104	230
90 percentiles	250	568
95 percentiles	440	695
99 percentiles	1,193	3,508
Percentage of results above 210 mg/kg	10.6%	22%
Table Notes: All soil lead values are reported in mg/kg (dry weight) unless indicated.		

A bullet point summary of the Kāinga Ora data[1] is given below:

- The all-soil sample data indicates that the lead in soils on Kāinga Ora properties tends to be elevated above background for lead (typical background in New Zealand is less than 40 to 65 mg/kg).
- The average (GM) and 50 % percentile lead concentration is slightly higher than the typical background concentration[2]. However, the 95% Upper Confidence Limit (UCL) of the mean indicates that Kāinga Ora residential soils will be above background levels.
- Higher lead concentrations were recorded within the dripline area (i.e., within 1 m of the dwelling).

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[1] Based upon 1,049 datapoints from 228 properties across the country.

[2] This appears to be the influence of one outlier datapoint of 31,300 mg/kg, if this datapoint is excluded from the dataset the geometric mean of the data is 54 mg/kg and the 95% Upper confidence limit of the mean for the dataset is 181.7 mg/kg.

- Approximately 10% of the all-soils data exceeded the NES-CS Residential Soil Contaminant Standard (SCS) (10% homegrown produce) of 210 mg/kg, while just over 20% of the dripline data exceeded this SCS.

3.3 Depth of Lead Contamination

The Ministry of Health (2021) indicates that after the deposition of lead particles onto the soil surface, the particulate matter binds with the soil matrix and limits lead mobility to less than 5 cm of soil depth. However, it notes that the extent of lead-soil binding depends on soil type, organic content, and soil pH.

The USEPA recommends that lead soil samples should be collected from 0.15 m (6 inches) depth but does not need to extend more than 0.6 m (24 inches) (USEPA, 2003). The USEPA recommendation indicates that lead paint contamination should be relatively shallow.

Jack Blunden investigated the vertical distribution of lead in residential soils in Palmerston North in 2020 (Blunden, 2020). This study found that the concentration of lead in soil decreased with depth, however soil lead concentrations could still exceed the NES-CS SCS for residential lead (10% homegrown produce) of 210 mg/kg at a depth of 0.2 m. However, at a depth greater than 0.2 m below the ground surface Blunden found that the soil lead concentrations were less than the 210 mg/kg (Blunden, 2020). The properties investigated by Blunden were not Kāinga Ora properties, rather they comprised private residential dwellings built between 1900s to 1950s. Therefore, the concentration of lead in soils are likely to be higher than observed on Kāinga Ora properties.

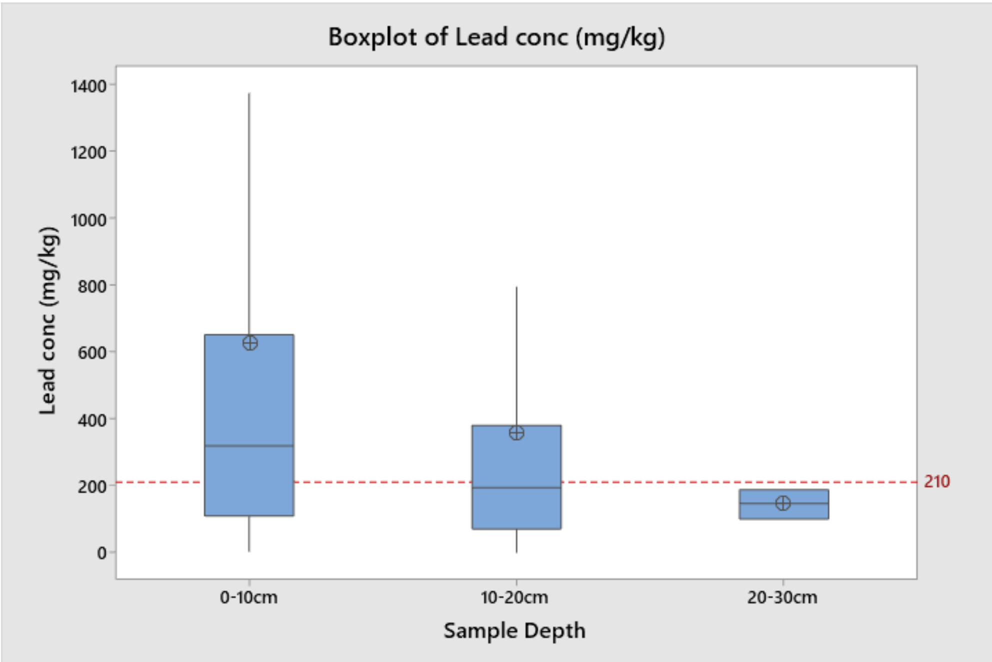

Figure 3 Box plot of Soil Lead Concentrations from Residential Properties in Palmerston North (from (Blunden, 2020)).

Kāinga Ora has undertaken a similar study for soils collected from its properties. **Figure 4** shows the vertical distribution of soil lead at sample locations where surficial soil exceeded 65 mg/kg (i.e., above likely maximum background concentrations). Samples used to generate the data in **Figure 4** were collected from 36 Kāinga Ora properties from Auckland, Waikato, Taranaki, Manawatū, Wellington, Marlborough, and Nelson-Tasman districts. **Figure 4** shows the average soil lead concentration at various depths. A summary of the data used to generate these figures is presented in **Table 3-3.**

An initial sampling depth of between 0.075 m and 0.1 m was selected as CLMG#5 states the upper 0.075 m represents the depth of soil that people are typically exposed to in their day-to-day activities (Ministry for the Environment, 2021b).

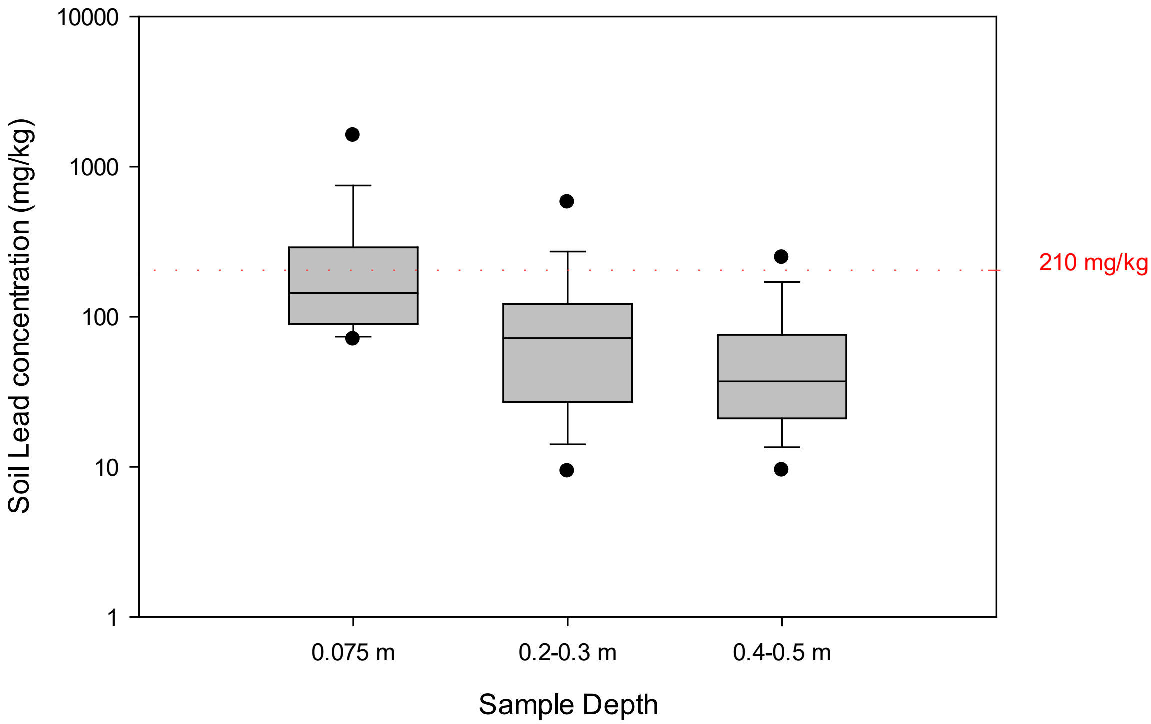

Figure 4 **Box Plot of Kāinga Ora Soil Lead Concentrations versus Depth**

The data collected by Kāinga Ora shows that the highest soil lead concentrations are found within 0.075 m bgl of the soil profile. Concentrations of soil lead decrease with depth and are below NES-CS low density residential SCS of 210 mg/kg at most sites at depths of 0.2 m to 0.3 m bgl (**Figure 4** and **Table 3-2**). However, at some sites, soil-lead concentrations can exceed NES-CS low density residential SCS of 210 mg/kg at 0.5 m bgl.

Table 3-2 Analysis of Soil Concentrations around Kāinga Ora Properties (built between 1950 to 1980s)

Descriptive Statistics	Soil Sample Depth		
	0-0.075 m bgl	0.2-0.3 m bgl	0.4-0.5 m bgl
Minimum	34	3.1	3.9
Maximum	3,600	1,500	560
Mean	336	131	70.8
Geometric Mean	187.8	64.19	41.5
95% UCL of mean (95% Chebyshev UCL)	534.8	209.2	117.7
Standard Derivation	533.4	209.6	98.1
25 Percentile	89.50	27	21
Median	144	72	37
75 Percentile	290	122	76
90 percentiles	728	264	145
95 percentiles	1,472	546	240
Percentage of results above 210 mg/kg	35.8%	12.4%	7.2%
Table Notes: All soil lead values are reported in mg/kg (dry weight) unless indicated.			

3.4 Distance of Lead Soil from the Dwelling

The USEPA defines the size of a typical building contaminant halo zone to be within the dripline of the building (0.15 to 0.75 m from the exterior wall of a building) (USEPA, 2003). The Ministry of Health states that typically lead-based paint hazard generates hotspots 1 or 2 metres away from the exterior wall (Ministry of Health, 2021).

To better understand the size of a typical lead halo zone around dwellings, Kāinga Ora undertook sampling around various properties in several different locations across New Zealand to define the extent of the lead halo around dwellings. A summary of this sampling programme results is presented in **Table 3-3**.

Table 3-3 Kāinga Ora Lead Halo Analysis

Descriptive Statistics	Distance from Exterior Wall	
	1 m	2 m
Minimum	68	38
Maximum	3,300	110
Mean	519.9	64.55
Geometric Mean	233.1	62.37
95% UCL of mean (95% Chebyshev UCL)	1,292	89
Standard Derivation	867.4	18.61
25 Percentile	87.5	54.5
Median	154	61
75 Percentile	471.3	71
90 percentiles	943	77
95 percentiles	2,785	93.5
Percentage of results above 210 mg/kg	45.8%	0%
Table Notes: All soil lead values are reported in mg/kg (dry weight) unless indicated.		

The soils data presented is where the dripline data exceeded 65 mg/kg (maximum background) and so the soils are deemed to be impacted by lead paint.

Based on the data presented in **Table 3-3**, the extent of the typical lead halo around a dwelling is between 1 m to 2 m from the exterior wall.

3.5 Distance of Lead Soil from Roadways

Tetra ethyl lead (TEL) was added to gasoline (petrol) in the United States in 1920s to prevent knocking in automotive engines (Ngiagu 1990). By 1970s approximately 720 billion litres of leaded gasoline were being sold each year (Ngiagu 1990) and by the time leaded fuel had been phased out by 1990 over 10 million tonnes of lead had been discharged into the environment by motor vehicle emissions (Mielke 1998). As noted above, vehicle emissions are often cited as a source of lead impact on properties that front onto roadways.

TEL was phased out in most New Zealand fuels in 1996 and since then roadside soil lead concentrations have decreased (Wilson, 2008). Work undertaken by Ward et al in the 1970s showed a dramatic decrease of soil lead concentrations within a few metres of the road (Ward, 1979).

Kāinga Ora soil data collected from the front yards area of properties is presented in **Table 3-4.** Over 80% of soils collected from the front yard areas of Kāinga Ora properties had soil lead concentrations below background levels and only 1.2% of all soil samples collected from the front yard areas that exceeded the NES low density residential SCS of 210 mg/kg. There is no evidence that roadside vehicle emissions or diffuse contamination from vehicle (tyre/brake wear contaminants – zinc and copper) are having a significant impact on soil quality on Kāinga Ora properties.

Table 3-4 Kāinga Ora Soil Lead Concentrations within Front Yard Area (based upon 840 samples collected from 228 properties nationwide)

Descriptive Statistics	Soil Lead Concentrations (mg/kg dry weight)
Minimum	6.8
Maximum	840
Mean	54.5
Geometric Mean	39.25
95% UCL of mean (95% Chebyshev UCL)	73.05
Standard Derivation	70.58
25 Percentile	25
Median	34
75 Percentile	54.5
90 percentiles	95.2
95 percentiles	163.9
Percentage of results above 210 mg/kg	1.2%
Table Notes: All soil lead values are reported in mg/kg (dry weight) unless indicated.	

4 Compliance with the NES-CS and SAP Development

4.1 HAIL Classification of Kāinga Ora Residential Re-development Properties

The NES-CS and supporting documents (notably the HAIL (MfE, 2011a), the Methodology for Deriving Standards for Contaminants in Soil to Protect Human Health (MfE, 2011b), the User's Guide-NES-CS (Ministry for the Environment, 2012a), and CLMG #5 (Ministry for the Environment, 2021)), are silent on how residential properties, in particular re-development on residential properties, should be managed within the context of the regulation.

It should be acknowledged that the NES-CS SCSs are health risk screening criteria, and that exceedance of these criteria does not necessarily indicate a health risk exists. Rather, an exceedance of an SCS (from a health risk assessment perspective) should prompt additional investigation work to understand whether a potential risk exists.

The MfE HAIL does not directly list residential properties. Rather, practitioners often use the following categories to classify residential properties as being on the HAIL:

1. Category E. Mineral Extraction, Refining and Reprocessing, Storage and Use. E.1 Asbestos product manufacture or disposal including sites with buildings containing asbestos products known to be in a deteriorated condition; and/or

2. Category I. Any other land that has been subject to the intentional or accidental release of a hazardous in sufficient quantity that it could be a risk to human health or the environment.

Consequently, there is significant confusion nationally on whether re-development on residential properties is captured by the NES-CS. The following discussion presents Kāinga Ora's interpretation of compliance with the NES-CS and supporting documents.

As stated above, Kāinga Ora properties typically date from the late 1950s onwards, have been relatively well maintained, and have been managed by Kāinga Ora and its legacy organisations. The nature and distribution of contamination on Kāinga Ora properties will be different to older residential properties and to a certain extent different to private residential properties of a similar age/vintage to the Kāinga Ora properties. Therefore, this discussion and interpretation of compliance with the NES-CS is particular to Kāinga Ora re-development sites.

Because Kāinga Ora properties have been and are relatively well maintained, ACM building products on these properties will generally not be in a deteriorated condition. As such, HAIL Category E would not apply to Kāinga Ora properties except in very extreme cases which would be identified during the site visit/inspection stage of the PSI/DSI process.

As noted above, HAIL Category I requires the contamination "to be in sufficient quantity that it could be a risk to human health". However, the Kāinga Ora contamination database and human health risk assessment work outlined in the EHS Support 2022 report suggests that Category I should not necessarily be applied to Kāinga Ora properties as there is insufficient evidence to conclude that soil contaminant concentrations (notably lead) are present in sufficient quantities that could be a risk to human health. This determination is based on the following reasons:

1. The Kāinga Ora database assessment work described above clearly demonstrates it is more likely than not (in term of compliance with Regulation 7 (c)) that Kāinga Ora properties with residential houses built after the 1950s will have soil lead concentrations outside the halo areas that are significantly less than NES-CS low density residential SCS of 210 mg/kg.
2. While more elevated (albeit localised) contaminant concentrations (notably lead) are recorded within the halo area. The Ministry of Health (in their document The Environmental Case Management of Lead-exposed Persons, MoH, 2021) suggest that for soil lead levels in the range of 1,000 to 3,000 mg/kg, that soil removal is probably not indicated (*required)* and that other measures (such as covering or behaviour modification) may suffice to manage risks to children. The Kāinga Ora 95th percentile lead concentration for lead within the halo areas fall below this value (695 mg/kg – **Table 3-1**).

Based on the above discussion, unless the PSI undertaken on a Kāinga Ora re-development property clearly shows the site to have been subject to a HAIL activity (such as historic horticultural use (HAIL Category A), significant use of level raising fill (not just subgrade for original house/pavement construction) (HAIL Category G), or land that has been subject to the migration of contamination (HAIL Category H) then the property would be classed as non-HAIL.

The above interpretation may not be accepted by all regulators and so when applying for resource consent(s) for a Kāinga Ora re-development project it may be necessary to apply for an NES-CS consent where the regulator is unwilling to accept/acknowledge the above interpretation. Revisions to the NES-CS, the HAIL and other supporting documents in the future may add further clarity to this interpretation.

4.2 Compliance with CLMG's #1 and #5

For the last 4-5 years Kāinga Ora has progressively deployed the use a standardised intrusive investigation approach on non-HAIL Kāinga Ora sites (Kāinga Ora, 2020) with the key aims to minimise the investigation effort (particularly multiple investigation mobilisations) and to avoid the need (where possible) to undertake benchmark soil sampling/testing on completion of remedial earthworks.

CLMG's #1 and #5 have recently been revised and while the discussion above indicates that the NES-CS does not necessarily apply to Kāinga Ora non-HAIL re-development sites, it is necessary for Kāinga Ora to follow national guidance where appropriate and investigate sites in a defensible and transparent manner that ensure acceptance of the investigation data to meet the investigation objectives set out in **Section 7**.

The key issues the revised SAP needs to address with respect to the CLMG #1 and #5 updates are listed below (in summary form):

- Sampling and investigation objectives must be defined.
- A CSM must be developed for the investigation.
- Sampling design needs to ensure sufficient data is collected that is fit for purpose and satisfies investigation objectives.
- Two soil sampling approaches are presented – 1) targeted/judgmental sampling or 2) probability-based/systematic.
- Targeted sampling informed by a well-developed CSM, not statistically based.
- Systematic sampling needs to be probability based and use statistical considerations.
- Contamination hotspots need to be delineated.
- Field composite sampling should not be used.
- Justification for number of soil samples selected.

5 Kāinga Ora Generic Residential Property CSM

Based on the information provided in **Sections 2** and **3**, the following section presents the generic CSM for an existing Kāinga Ora residential property (non-HAIL site) that could undergo re-development. The generic CSM set presented is a "probability" generated model based on the statistics derived from the Kāinga Ora contamination database. The CSM for an existing Kāinga Ora residential property is shown pictorially in **Figure 1.**

The CSM described below is used in **Section 7** to define the intrusive investigation methodology for the SAP.

5.1 Contaminant Distribution Kāinga Ora Properties

On an existing Kāinga Ora residential property the following contaminant distribution should be expected (based on the Kāinga Ora data described/presented in the previous sections).

1. The dwelling comprises the contamination "hot spot" on the Kāinga Ora property. In particular, the dripline/curtilage area around the dwelling is the soil hot spot area because concentrations very occasionally occur within this area that could be an order of magnitude above the NES-CS low density residential SCS of 210 mg/kg. As noted in **Section 3**, this contaminated halo will likely extend some 1 m to 2 m from the dwelling. To be conservative it should be assumed the dripline/curtilage area extends 2 m from the dwelling and to a depth of 0.3 m. If other significant structures exist on a property, there could other drip line/halo impacts.

2. Differences in cladding and roofing materials used in the construction of Kāinga Ora dwellings has an influence on the nature and concentration of contaminants within the halo area. Therefore, the contaminant concentrations within the dripline/curtilage will likely vary in concentration. It should not be automatically assumed that the soils within the dripline/curtilage area are heavily contaminated.

3. The contaminant concentrations within the area of the site outside of the dripline/curtilage area will vary and will range from background concentrations (i.e., uncontaminated) to slightly elevated concentrations. Elevated dripline/halo contaminant concentrations (in the order of the hot spot concentration described in Item 1 above) are not routinely recorded within the remainder of the Kāinga Ora property.

4. Anthropogenic contamination within the remainder of the Kāinga Ora property will have principally arisen from surface contamination (through multiple sources), the soil contamination is typically at low concentrations, but has been shown to extend to depths of 0.2 m to 0.3 m bgl. It would be the exception to encounter soil contamination at depths of 0.5 m bgl (particularly on a non-HAIL residential site).

5. It is acknowledged that materials may have been buried on the site (particularly during construction), buried materials could comprise a burn-pit (or similar) that has been covered, asbestos cement sheet etc. Contamination caused by these types of residential activities tend to occupy a very small area (diameters less than 2 m) and to detect such an area would require a grid size between 1 m to 3 m which is not economically viable (or practicable). Managing this type of contamination is best dealt with through the accidental discovery protocols within the remedial action plan/remedial work instruction.

5.2 Contaminants of Concern

The following trace elements are deemed the CoC on Kāinga Ora residential sites and should be analysed as part of the intrusive investigation work.

- Arsenic, copper, lead, and zinc.
- Asbestos is the other key CoC and should be assessed as part of the PSI site walkover/inspection (inspecting the buildings and ground surface) and during the intrusive investigation work. Select collected soil samples should be analysed for asbestos in soil.

6 Excavated Soil Disposal

Soils excavated on Kāinga Ora sites during re-development are likely to require off-site disposal at appropriately licensed waste disposal facilities. Across New Zealand, the availability and waste acceptance criteria for clean fill, managed fill and landfill sites varies. Therefore, it will be necessary, as part of scoping the intrusive investigation on a re-development site, to have knowledge of the local waste acceptance criteria for disposal sites when scheduling the laboratory testing of soils and scoping remedial work.

Clean fill waste acceptance criteria for contaminated soils are generally based on local background concentrations, and therefore the concentration of trace elements (such as arsenic, copper, lead, or zinc) that may be acceptable for disposal as clean fill varies areas across the country. Background soil concentrations are available for most regions within New Zealand, however contractors undertaking contaminated land assessment work for Kāinga Ora need to be mindful that in some regions (such as Northland and the Bay of Plenty) do not necessarily have documented background data.

As noted above, the key CoC on Kāinga Ora re-development sites comprise arsenic, copper, lead, zinc, and asbestos. This suite of determinants should be adequate to negotiate the disposal of soils excavated on Kāinga Ora sites into local waste disposal sites. Where elevated concentrations of trace elements are recorded (such as lead or zinc) that are above local landfill acceptance criteria, it may be necessary to schedule toxicity characteristic leaching procedure (TCLP) testing on select trace elements (as required).

In certain parts of the country volcanic soils are prevalent which often results in elevated soil concentrations of chromium and nickel. The PSI should establish whether the study site comprises volcanic soils and this information should be used (wherever possible) in the negotiation of the off-site disposal of excavated soils rather than relying on laboratory testing (as these trace elements are not CoC).

Asbestos contaminated soil cannot be disposed of to clean fill (based on current definitions). Therefore, it is important to appropriately report on the possible presence, extent, and concentration of asbestos contaminated soil on Kāinga Ora sites to avoid incurring excessive disposal costs and to manage health and safety issues. The waste acceptance criteria and health and safety controls required for the transportation and disposal of asbestos contaminated soil to managed fill and landfill disposal varies around the country. WasteMINZ is in the process of developing guidance (with WorkSafe approval) on the transportation and disposal of low concentration asbestos contaminated soil (notably <0.01% w/w fibrous asbestos or asbestos fines and <1% asbestos containing material). This guidance is likely to require robust documentation (lines of evidence) within the PSI/DSI to verify whether asbestos contaminated soils are present and if present it is likely to be a requirement to have documentation in place and approval for the transportation of asbestos contaminated soil to the disposal site (i.e., some form of signed waste manifest).

7 Investigation Methodology

The generic investigation methodology outlined below (SAP) is for standard Kāinga Ora residential sites with no identified HAIL activity associated with the piece of land. Because each Kāinga Ora residential property (which typically occupies an area of 500 m^2 to 1,000 m^2) has its own unique site history it is necessary for each single lot site to be considered on its own merits (i.e., a stand-alone CSM).

This SAP has therefore been developed for either single lot sites or a cluster of sites (up to an aggregated area of 10,000 m^2). This SAP is not appropriate for super lot investigations (i.e., cluster of sites greater than 10,000 m^2 in area).

The SAP is based on the assumptions used to inform the generic Kāinga Ora residential non-HAIL CSM. The CSM should be considered as a "probability" based model (given it is based on statistics presented in this document) and so two of the aims of the SAP and DSI are to verify the generic CSM and address variations in the model (as required) during the PSI/DSI process.

7.1 Sampling Plan

A targeted sampling approach is the preferred sampling method on Kāinga Ora sites and this decision is based upon:

1. The generic CSM presented in this SAP and presented in the Kāinga Ora Conceptual Site Model – Residential Properties report (EHS Support, 2022).
2. Visual observations made by the suitably qualified and experienced practitioner (SQEP or SQEP delegate) during the PSI review of aerial photographs (and other associated information) and during the site walkover inspection.
3. Observations made by the SQEP/SQEP delegate while undertaking the DSI.

A targeted sampling investigation is being used on Kāinga Ora single lot and a cluster of sites because:

- The location of the house and the potential halo associated with asbestos and lead are known. There may also be other buildings/structures within the property that also have a halo impact.
- Position of driveways, sheds, garages, houses, patios, footpaths, and irregularly shaped properties makes it difficult to apply/use a regular sampling grid without distorting the sampling grid. This would result in the grid potentially not detecting the size circular hotspot that it was designed to detect (as per the grid sampling requirements of CLMG #5).
- The size of the halo contamination hotspot cannot be estimated to calculate an appropriate grid spacing and any grid spacing selected could not be justified in accordance with the requirements of CLMG#5 Section 4.2.3 (particularly considering the grid size selection section on page 45 and page 46 which warns against selecting a grid size purely based on property size).
- While the layout of Kāinga Ora properties is often similar within a neighbourhood, when aggregated together to form a cluster of sites irregular patterns of buildings/structures and

driveways occur. Therefore, each property and house are different and so the soil sampling plan must be particular to an individual property. The grid sampling approach is not an effective way to investigate these properties, particularly an aggregated cluster of properties.

- Contaminated areas outside of building halo caused by residential activities (such as incineration of waste, waste disposal, burying rubbish, home vehicle repairs and hobby activities) tend to be very small (typical diameters less than 2 m – due to the size of the activity). To detect such a hotspot would require a grid size between 1 to 3 m, which would result in over 200 samples per 500 m^2 residential lot. This number of samples is not economically viable and is not proportional to the risk posed.

To assist contractors/consultants undertaking a DSI on a Kāinga Ora property a schematic of the anticipated/generic sampling plan is presented in **Attachment A**. The generic sampling plan needs to be verified (and adjusted accordingly) throughout the PSI process, before commencing the DSI, and during the DSI.

7.2 Sampling Density

For a single residential lot 1,000 m^2 or less, Kāinga Ora requires a minimum of six targeted sample locations per residential lot[3]. This sampling density applies to sites where the soils are being excavated for off-site disposal or the topsoil is being scheduled for re-use. Ideally two of these sample locations should be located in the front yard area (depending on site layout) and a minimum of two samples locations should be located the back yard (depending on site layout). The other two sample locations should be used to verify the generic CSM, such as addressing halo width issues or halo impact associated with other on-site structures etc. An example of the generic layout of soil sample locations is given in the sampling plan presented in **Attachment A**.

Should a single lot site occupy an area larger than 1,000 m^2 (unless the site area greater than 1,000 m^2 is formed by driveway), then the targeted sampling density should be increased by one sample location per additional 100 m^2 of section.

The curtilage area of the main dwelling is not to be sampled, with the assumption that the soils within the drip line/halo are contaminated above background concentrations and (to be conservative) require disposal at landfill.

The exact number of samples and the area of the investigation should be stated within the main report.

[3] On a small residential lot (less than 600 m^2) buildings, footpaths, driveways etc. means that the typical amount of soil available for sampling is likely to be less than 250-300 m^2. Once the halo area around the house has been removed there is likely to be less than 200 m^2 of soil to be sampled.

Where a cluster of sites is being proposed, the sampling density for the cluster will be the sum of the sample locations for amalgamated lots (i.e., nominally 6 sample locations per lot, and so for a 3-lot cluster this would equate to 18 targeted sample locations).

In addition to the minimum number of samples recommended above, additional soil samples may be required to be collected if additional hotspot(s) or HAIL activity is identified in the PSI and site walkover. The number of additional samples required to characterise the hotspot will depend on the likely size and nature of the contamination. Therefore, if the PSI/site walkover does identify a HAIL activity, then CLMG #5 (MfE, 2021b) should be consulted to determine the number of samples required for the investigation.

7.3 Sample Depth

Soil samples outside of the dwelling dripline/curtilage should be collected at the following depth intervals:

- Surficial samples (0-0.1 m bgl).
- 0.2-0.3 m bgl.
- 0.4-0.5 m bgl.

For any given single property lot, three of the targeted soil sample locations should be progressed to 0.5 m depth (as directed by the SQEP/SQEP delegate). All other sample locations should be progressed to 0.3 m depth, unless fill materials are identified at the site (in the investigation holes) in which case all the holes should be progressed to 0.5 m depth. The presence of significant thicknesses of fill materials are not anticipated by the non-HAIL Kāinga Ora CSM and if shown to be present additional DSI work may be required to validate the generic CSM.

7.4 Soil Sample Collection

Soil samples shall be collected in accordance with the Kāinga Ora Standard Operating Procure for Sampling Near Surface Contaminated Soils (SOP-01 - Kāinga Ora, 2022). Changes in the investigation methodology from this SAP and the SOP must be documented in the DSI report. A justification for the change must be provided.

7.5 Media to be Sampled and Analytical Regime

Only soil samples need to be analysed as part of the Kāinga Ora non-HAIL DSI.

As noted in **Section 5.2**, the trace element CoC are arsenic, copper, lead, and zinc. All soil samples collected at surface will be tested for these parameters and the depth samples should be tested progressively (with depth) until background concentrations have been achieved/recorded.

Select sample should be analysed for asbestos in soil, initially testing select surface samples for asbestos presence/absence testing and if a detect is recorded, then follow up semi-quantitative testing should be undertaken. The determination of whether a soil sample should be analysed for asbestos shall be determined by the environmental consultant based upon visual observation of the soils and observation undertaken during the site walkover (i.e., condition and cladding type present on structures on the site and the potential for fill material).

The test methods and detection limits are specified in **Table 7-1**.

Table 7-1 Analytical Regime, Sample Containers and Hold Times for Soil Samples

Parameters	Test method and method detection limit	Sample Container	Hold Times
Inorganic elements	USEPA 200.2 (ICP-MS). MDL ≤1 mg/kg.	Polyethylene or glass container or polythene bag.	90 days
Asbestos Presence/Absence	AS 4964-2004. MDL ≤0.01 % w/w.		Indefinite
Asbestos Semi-Quantitative	AS 4964-2004 and New Zealand Guidelines for Assessing and Managing Asbestos in Soil (BRANZ, November 2017). MDL ACM, Fibrous Asbestos and Asbestos Fines ≤0.001 % w/w.		

All surface samples collected shall be able to be tested for trace elements and select surface samples asbestos (initially PA and then if need be semi-quantitative testing). The volume of sample collected at all depths shall be adequate to enable TCLP testing to be undertaken if needed.

7.6 Quality Assurance/Quality Control

A copy of the laboratory QA/QC report should be obtained as part of the DSI QA/QC program.

No additional QA/QC samples need to be collected in the field (such as duplicates). Laboratory QA/QC reports can provide information on duplicate sampling analysis. Rinsate samples do not need to be collected as part of the standard decontamination methods outlined in the SOP.

7.6.1 Accuracy

Laboratory QA/QC report data will be evaluated to ensure that matrix spiked samples are within 50% to 130% for all trace elements.

7.6.2 Precision

Precision should be calculated using the formula below:

$$RPD = \frac{X_2 - X_1}{\left(\frac{X_2 + X_1}{2}\right)} x\ 100$$

The data quality will be assessed using the criteria in **Table 7-2**.

Table 7-2 Data Quality Criteria for Evaluating Precision of Soil Quality Data

%RPD	Precision is Considered
Less than 35%	Excellent
35-68%	Moderate precision is considered excellent if data is within ten times the method detection limit
68-95%	Poor - precision is considered moderate if data is within ten times the method detection limit
Greater than 95%	Unacceptable- precision is considered acceptable if data is within five times the method detection limit

Laboratory QA/QC report data will be evaluated to ensure that matrix spiked are within 50 to 130% for all inorganic elements.

7.6.3 Accuracy

Laboratory QA/QC report data should be evaluated to ensure that laboratory matrix spikes are within 50% to 130% for all inorganic elements.

7.6.4 Representativeness and Comparability

Representativeness of the sample results will be assured by:

- Using IANZ accredited laboratories within the approved holding times.
- Analysis of soil using analytical methodology specified in CLMG#5 (Ministry for the Environment, 2021b) and the BRANZ guidelines (BRANZ, 2017).
- Use of trained and experience field staff.
- Using Kāinga Ora Soil Sampling Standard Operating Procedure which is based upon national and international standards/guidance.
- Use of laboratory supplied sample containers which are suitable for the contaminants of concern.
- Decontamination sample collection equipment between sampling sites using appropriate decontamination procedures.
- Regular changes of nitrile gloves.

7.6.5 Completeness

Completeness check verifies that:

- Sampling documentation has been completed as required by the SOP.
- The field notes accurately reflect work carried out, including any observations and conditions at the time of sampling that may help interpret the data, and any alterations made to the sampling and analysis plan.
- Accurate labelling of sample containers with a unique sample identifier, the date sampled, and the time sampled.
- The chain of custody forms was accurately completed before dispatching the samples to the laboratory.

7.6.6 Sensitivity

The sensitivity check ensures that the correct analytical detection has been chosen for the analysis:

- Ensuring that the analytical method detection limit is where possible more than ten times lower than the soil guideline value appropriate for the site current and future use, as well as being lower than the waste acceptance criteria for the disposal facility accepting the soil (note for clean fill this may be many times lower than the NES SCS).
- Ensuring verification is received back from the laboratory that the samples have been received and the requirements understood.

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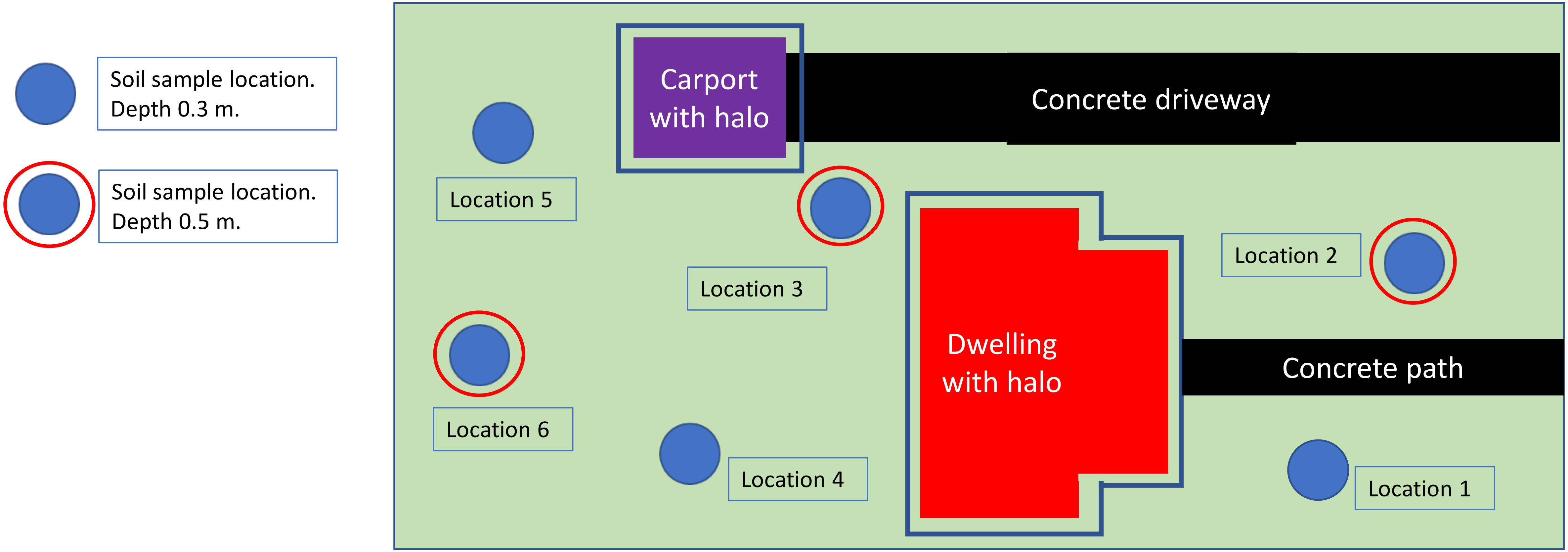
Attachment A – Generic Soil Sampling Plan

Generic Soil Sampling Plan



Kāinga Ora
Homes and Communities

Foot Notes:

1. Suggested soil sample locations shown – locations need to be confirmed by the SQEP before commencing work.
2. Six sample locations applied to non-HAIL residential sites <1,000 m^2 in area.
3. HALO testing during the DSI or post demolition may be required – confirm with Kāinga Ora Project Manager.
4. Other variations to DSI scope – confirm with Kāinga Ora Project Manager.