REPORT
Thames-Coromandel District Council

Brightsmile Garden
Further investigation of ground contamination

Report prepared for:
THAMES-COROMANDEL DISTRICT COUNCIL

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1 Introduction

Thames-Coromandel District Council (TCDC) has engaged Tonkin & Taylor Ltd (T&T) to undertake further assessment of ground contamination at the Brightsmile Garden, Bella Street, Thames.

T&T has recently completed limited soil sampling for ground contamination with regard to land subsidence that has occurred at the site (T&T December 2011). This further report details the results of additional work undertaken to determine the contamination levels in near surface soils including in raised garden beds at the site. This assessment has been undertaken in accordance with our proposal dated 8th February 2012.

2 Background

Land subsidence occurred in the northeastern corner of the Brightsmile Garden in March 2011 (see Figure 1, Appendix A). The geotechnical aspects of the subsidence were investigated by T&T and a report was prepared which included options for further investigation and stabilisation of the void (T&T May 2011).

The history of the site was investigated as part of the 2011 geotechnical investigation. Available information shows that the site was involved in mining from the mid 1800s until the early 1900s. Land subsidence is known to have occurred at the site in the past.

The geotechnical investigation indicated that there is at least 2 m of fill material in the area of the subsidence. This material was described as comprising topsoil overlying soft to firm clayey silt with some cobbles/boulders and tree roots. The fill material is considered to be processed mine tailings, and/or unprocessed waste rock.

Further geotechnical investigations of the collapse were undertaken in February 2012. As a result, various remedial options were presented consisting of preparation of the void area followed by backfill with engineered or non-engineered fill.

Limited chemical testing of soil samples was undertaken in November 2011, and the topsoil and fill material in the vicinity of the subsidence were found to contain arsenic concentrations in excess of the new National Environmental Standards (NES) for residential and commercial land use (T&T Dec 2011). The results of the sampling raised questions regarding contamination potential throughout the remainder of the site. In particular, to assess the produce ingestion pathway given the site’s community use, through sampling of garden soils and garden produce as discussed below.

3 Work scope

The objective of this investigation is to further assess ground contamination across the property, with particular emphasis on the community garden areas, and to review the results with respect to future use of the site.
to the NES requirements as they pertain to subsidence and contamination remediation management options. The work scope to achieve this objective has included:

- Review of the NES with regard to appropriate guidelines for the current land use scenario and discussion regarding NES derivation and appropriate site-specific criteria.
- Review of New Zealand literature regarding the uptake of arsenic by plants to determine the most appropriate plants to sample for contamination.
- Collection of near surface soil samples from the garden areas.
- Collection of fruit and vegetable samples from the garden.
- Analysis of soil samples for arsenic and lead.
- Analysis of fruit and vegetable samples for arsenic and lead.
- Review of previous soil and vegetable data collected by the lease holder and provided by TCDC.
- Review of NZ food standards and derivation of produce acceptance criteria using NES methodology.
- Preparation of this report documenting the above and soil analysis results from previous work undertaken at the site by T&T.

4 Site setting

4.1 Site description

Brightsmile Garden is located at 239 Bella Street, Thames. The property covers an area of approximately 1,700 m² and is owned by TCDC. The location and layout of the site is indicated in Figure 1 (Appendix A).

The site is flat and current land uses include the growing of fruit trees, and root and leafy vegetables in raised garden beds. Most of the gardening activities occur in the southern half of the site where raised garden beds have been constructed. Walls of the raised garden beds are made from adobe cement and the beds are lined with weed matting. The leaseholders⁵ state that the soil in the raised beds was sourced from an organic farm, but that the beds have been topped up with site generated compost. The beds comprise 16 separate beds, forming two circular structures in the southern part of the site, and are raised approximately 200mm above the surrounding ground level. To the south of the raised beds fruit trees and vegetables are planted in containers, tyres and directly in the ground.

The northern half of the site is dominated by an open grass area with banana palms planted along the western and northern boundaries. A full inventory of plants observed at the site at the time of the site visits in February 2012 is provided in Appendix B.

The site appeared well grassed and the only significant areas of bare soil observed were inside the raised garden beds, and near the eastern boundary, where composting appears to have occurred at ground level.

A meeting was held with the leaseholders of the site and TCDC on 27 January 2012. The leaseholders note that the garden has become a focal point for the community and that it is used for passive recreation on a daily basis. Gardening activities typically occur once or twice a week with some regular garden users coming every week. The lease holders advised that most people would only get a small proportion of their total vegetable consumption from the site, however

⁵ Meeting onsite, 27th January 2012
some older garden users are thought to use it as their main source of vegetables. Excess produce is sometimes given to the local food bank.

4.2 Published geology

The published geology of the area indicates that the surface soils are alluvium, colluviums and fan deposits of the Tauranga Group (Edbrooke, 2001). These are underlain by andesite and dacite intrusives at depth. The andesite and dacite intrusives form the surface geology east of Thames as the Coromandel Ranges. As indicated above, fill soils occur at the site overlying the Tauranga group sediments.

Quartz veins in the volcanic rock near Thames have been mined for epithermal gold deposits since 1867. The gold deposits are accompanied by arsenic, cadmium, copper, lead, zinc, and some antimony. Arsenopyrite, FeAsS, is the dominant arsenic mineral in most arsenic-bearing natural occurrences. Arsenic comprises 46% by weight in Arsenopyrite.

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5 Land use planning

Regulatory control of contaminated sites is managed by the Thames Coromandel District Council and the Waikato Regional Council. The planning requirements with regard to contaminated land are detailed in this section.

5.1 Regional Plan

The Waikato Regional Plan (WRP) sets out objectives and policies for the management of discharges from contaminated land within the Waikato Region.

Contaminated land is defined in Variation 7 of the WRP as follows:

Contaminated land means land of 1 of the following kinds:
(a) if there is an applicable national environmental standard on contaminants in soil, the land is more contaminated than the standard allows; or
(b) if there is no applicable national environmental standard on contaminants in soil, the land has a hazardous substance in or on it that—
   i. has significant adverse effects on the environment; or
   ii. is reasonably likely to have significant adverse effects on the environment.

The objectives and policies in the WRP attempt to manage discharges from contaminated land to air and water so that they do not present a significant risk to human health, flora and fauna, and to provide an integrated approach to management by cross-referencing water and air quality management objectives set out in the WRP.

Objective 5.3.2 states that discharges from contaminated land shall be managed so that they:

- Do not present a significant risk to human health, flora and fauna.
- Do not adversely affect water quality or aquatic ecosystems and are consistent with the water management objectives set out in Section 3.1.2 of the WRP.
- Have no adverse effects on air quality that are inconsistent with the air quality objectives set out in Section 6.1.2 of the WRP; and
- Avoid significant adverse effects on Tangata Whenua values.

Policy 2 (Significant Risks) establishes a framework to assess the significance of risks associated with a particular site. This framework is based on factors such as:

- Numerical standards provided in relevant nationally recognised guidelines.
- Contaminant concentrations in soil.
- Site history and proposed future land use.
- Nature of receiving environment, and
- Archaeological sites and Tangata Whenua relationships.

Other policies in the WRP attempt to address high priority land uses and confirmed contaminated sites, and enable remediation of contaminated land.

The rules in the WRP specific to contaminated land involve the remediation of contaminated land as a permitted or controlled activity. However, if the site meets the definition of a contaminated

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8 In particular, Objective 3.1.2 of the WRP inter alia seeks to ensure that concentrations of contaminants leaching from land use activities and non-point source discharges to shallow groundwater and surface waters do not reach levels that present significant risks to human health or aquatic ecosystems.
site, and a discharge to the environment is occurring, a resource consent from Waikato Regional Council (WRC) may be required.

5.2 National Environmental Standard

The National Environmental Standard for Assessing and Managing Contaminants in Soil to Protect Human Health (NES) came into effect on 1 January 2012. The main objectives of the NES are to set out nationally consistent planning controls appropriate to district and city councils for assessing contaminants in soil and to provide a set of chemical specific soil contaminant thresholds (or soil contaminant standards (SCSs)) that define an adequate level of protection for human health for a range of differing land-uses in New Zealand. All territorial and unitary authorities are required to implement the NES on 1 January 2012.

The NES introduces new rules relating to specific activities on potentially contaminated sites. The provisions of the NES only apply where an activity covered by the NES is proposed, and the land meets the definitions provided in the NES. The legislation cannot be applied retrospectively.

6 Site investigation

6.1 Soil, fruit and vegetable sampling

The assessment of ground contamination at the site has included the collection of soil, fruit and vegetable samples from across the site.

Near surface soil samples were collected from the garden on 7 February 2012. Samples were collected from within the raised garden beds, as well as from in situ soil. The locations of the soil samples are indicated in Figure 1 (Appendix A). The samples were collected with a trowel that was decontaminated between samples using a phosphate free disinfectant and rinsed in deionised water prior to collection of each sample. The samples were collected using gloved hands and placed directly into plastic sampling bags. All samples were forwarded to Hill Laboratories under chain of custody documentation. Selected samples were analysed for contaminants of concern (arsenic and lead).

The produce samples were collected on 22 February 2012. Samples were collected from a range of leafy, root and tuber vegetables as well as fruit that were present at the time of sampling.

A literature review indicated that root and tuber vegetables were more likely to have significant arsenic (and other metal) uptake and . However, some leafy vegetables are exceptions to this general rule; specifically, lettuce, spinach and mustard greens. Fruits are not expected to have high uptake.

Samples were collected using gloved hands and placed directly into plastic sampling bags. All samples were forwarded to Hill Laboratories under chain of custody documentation. At the laboratory, the samples were washed with tap water to simulate preparation for cooking in a residential scenario, and analysed for arsenic and lead.

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10 Petra Angela Gulz, University of Munich PhD dissertation, 2002, Arsenic Uptake of Common Crop Plants from Contaminated Soils and Interaction with Phosphate
11 Sverdrup Corporation, 1995, Uptake of lead and arsenic by plants
6.2 Guideline values

6.2.1 Soil guideline values

The results of the soil analyses have been compared with the NES SCSs, guidelines for the protection of human health. Where no SCS exist, guideline values documents have been selected in accordance with the Ministry for the Environment hierarchy of guideline documents (MFE 2011) and accordingly for this project we have used the National Environment Protection Council (NEPC) Soil Investigation Levels.

Based on the usage of the site as described by the lease holders, the assessment criteria that have been selected are for a rural residential land use scenario. This land use scenario incorporates risks from ingestion of soil, dermal contact and produce consumption. The SCSs are determined using Soil Guideline Values (SGVs) which are developed for each of the exposure pathways (soil, dermal contact and produce consumption).

The rural residential land use scenario assumes more contact with the soil than the standard residential scenario assuming 25% produce is home grown (compared with 10% for a standard residential scenario). This land use scenario captures the contaminant pathways of concern for the site, i.e. produce consumption, accidental soil ingestion and dermal contact. However, the assumptions for the rural residential land use scenario may be more conservative than what is currently occurring at the site (i.e. overestimating people’s exposure).

The NES indicates that an applicable SGV can be derived using site-specific data or that a standard with greater assumed exposure can be adopted. To better determine site-specific parameters would require significantly more work (see Section 7.4 below); beyond the scope of the current phase of assessment at the site.

The soil analysis results have also been compared with published background concentrations of metals in the Auckland region (ARC 2001). There is little published information regarding natural background concentrations of metals in soils in the Coromandel area. TCDC has commissioned a study to determine the background levels of arsenic in Thames. The results of the study are not yet available, therefore the Auckland information has been provided for comparison. The Auckland document provides information regarding naturally occurring metal concentrations in soils of volcanic origin in the Auckland area. The concentrations are provided for information only and may not be representative of background concentrations in soils in the Thames area.

The NES SCS for arsenic has been selected based on risk calculations and comparison with background concentrations from across New Zealand. Specifically, the SCS has been set at 99th percentile concentration (17 mg/kg) for rural residential as the derived SCS (13 mg/kg) would have been below background for many sites.

6.2.2 Vegetation guideline values

The results of the fruit and vegetable sampling have been compared against current New Zealand Food Standards, and against BioGro standards for organic produce:

- Australia New Zealand Food Standards Code – Standard 1.4.1 – Contaminants and natural toxicants, 2011.

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12 Ministry for the Environment, 2011, Contaminated Land Management Guidelines No. 2 Hierarchy and Application in New Zealand of Environmental Guideline Values
13 National Environment Protection Council (NEPC), 1999, National Environment Protection Measure (NEPM)
14 Auckland Regional Council, October 2011, Background concentrations of inorganic elements in soils from the Auckland Region - Technical Publication No. 153
• BioGro New Zealand, Organic standards.

The fruit and vegetable sampling has also been compared against acceptance criteria developed using the methodology provided in the NES\textsuperscript{15} (presented in Appendix C).

6.3 Laboratory results

6.3.1 Soil samples - raised garden beds and insitu soil

The results of the soil analyses are presented in Appendix D and are summarised in Table 1 below.

<table>
<thead>
<tr>
<th></th>
<th>Arsenic</th>
<th>Lead</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Raised beds</td>
<td>In situ soil</td>
</tr>
<tr>
<td>No. of samples</td>
<td>8</td>
<td>17</td>
</tr>
<tr>
<td>Concentration range (mg/kg)</td>
<td>4 - 45</td>
<td>31 - 490</td>
</tr>
<tr>
<td>Guideline (SCS rural residential) (mg/kg)</td>
<td>17</td>
<td>160</td>
</tr>
<tr>
<td>No. of samples exceeding guideline</td>
<td>3 out of 8 (37.5%)</td>
<td>17 out of 17 (100%)</td>
</tr>
</tbody>
</table>

The results indicate numerous samples with concentrations above background, with elevated arsenic being more prevalent than lead.

The results show that three (3) of the eight (8) samples collected from within the raised garden beds exceed the SCS (rural residential land use scenario) for arsenic, and one (1) sample exceeded the SCS for lead. A maximum arsenic concentration of 45 mg/kg was recorded within the raised beds.

The insitu soil shows higher concentrations of arsenic, with all 16 samples from insitu soil exceeding the selected guideline. Four (4) samples also exceeded the guideline for lead. Samples collected from up to 1.0m below ground level during the November 2011 investigation in the vicinity of the subsidence indicated elevated arsenic concentrations.

The result of analysis of a soil sample taken from the site in 2007 was provided by the leaseholder. This sample is understood to be a composite sample of near surface material prior to the construction of the raised beds. This result is similar to the in situ soil results collected by T&T in February 2012 and shows elevated arsenic and lead concentrations, with arsenic exceeding the selected guideline level.

6.3.2 Fruit and vegetable samples

The results of the fruit and vegetable samples are presented in Appendix D and summarised in Table 2 below.

\textsuperscript{15} Ministry for the Environment, 2011, Methodology for deriving standards for contaminants in soil to protect human health
Table 2 – Summary of fruit and vegetable analysis results for arsenic and lead, February 2012

<table>
<thead>
<tr>
<th></th>
<th>Arsenic</th>
<th>Lead</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of samples</td>
<td>12&lt;sup&gt;a&lt;/sup&gt;</td>
<td>12&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Concentration range (mg/kg)</td>
<td>&lt;0.02 – 0.08</td>
<td>&lt;0.002 – 0.121</td>
</tr>
<tr>
<td>NZ food standard (mg/kg)</td>
<td>1.0</td>
<td>0.1&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>BioGro food standard (mg/kg)</td>
<td>0.1</td>
<td>0.02</td>
</tr>
<tr>
<td>Produce acceptance criteria (as derived in Appendix D using the NES methodology) (mg/kg)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Root vegetable</td>
<td>0.37</td>
<td>7.1</td>
</tr>
<tr>
<td>Tuber vegetable</td>
<td>0.034</td>
<td>2.4</td>
</tr>
<tr>
<td>Leafy vegetable</td>
<td>0.37</td>
<td>9</td>
</tr>
<tr>
<td>No. of samples exceeding guideline</td>
<td>0 out of 12</td>
<td>1 out of 12 exceed NZ standard 5 out of 12 exceed BioGro standard</td>
</tr>
</tbody>
</table>

<sup>a</sup> Includes two samples collected by the lease holder in 2010.

Standards for lead are provided for different plant groups. The stated standard is the most conservative value provided. See Appendix C for the applicable range of food standards for lead.

The results show that arsenic concentrations were below the analytical detection limit in eight (8) of the twelve (12) samples. All arsenic results were below the NZ and BioGro standards and the produce acceptance criteria (as derived in Appendix D using the NES methodology). Lead was present above the analytical detection limit in seven (7) of the twelve (12) samples. Lead exceeds the NZ standard in one sample (herbs) and exceeded the BioGro standard in five of the samples (silverbeet, herbs, parsley, kumara and rosemary). The elevated lead concentrations were recorded in plants grown in the raised beds as well as in the in situ soil, and included root and leafy vegetables. None of the fruit samples showed elevated concentrations of lead.

The results of two (2) vegetable samples analysed in 2010 were provided by the leaseholder. These results show similar arsenic concentrations to the samples collected by T&T, below the NZ and BioGro food standards and the derived produce acceptance criteria. However the herb sample indicates a lead concentration an order of magnitude higher than the T&T results, and also exceeds the NZ food and BioGro food standards.

6.3.3 Quality assurance

For quality assurance purposes two (2) duplicate soil samples were collected during the site investigation. Both samples were analysed for arsenic and lead. The results are presented in Appendix D.

Both RPD results fit within a normally accepted range of 30% to 50% and on this basis the results of the sampling are considered suitable for interpretation.
7 Discussion

7.1 Extent of contamination

Sampling and testing to date has indicated that arsenic and lead concentrations exceed NES SCSSs for rural residential land use. The exceedances extend to at least 1m depth in the vicinity of the subsidence. Geotechnical investigation has indicated that there is at least 2 m of fill material in the area of the subsidence. It is feasible that the fill extends across the site at a thickness of 2m, more or less.

It is likely that lead and arsenic levels throughout fill at the site are similar to those encountered in the sampling to date given that is likely all from a similar source. Deeper sampling would be required to confirm that levels are similar. Deeper samples or sampling on adjacent land would be required to establish whether levels are similar in native soils beneath the fill and in the underlying volcanic rock (encountered at 5m depth beneath the area of subsidence).

7.2 Permitted activities under the NES

Levels of contaminants identified in a number of the samples tested to date are above the NES SCSSs for rural residential land use. Furthermore, testing indicated levels above the SCSSs for commercial/industrial outdoor worker (unpaved) land use.

The NES applies at the property in the event of sampling, disturbing, subdividing or changing the land use. However, these activities can be permitted, i.e. not requiring resource consent, provided a number of conditions are met. For activities that do not meet the conditions, a resource consent from TCDC would be required, as discussed in Section 3.2 below.

7.2.1 Subsidence/contamination remediation works

The NES SCSS were developed by MfE considering long-term exposure to soils. For works required to carry out investigation and/or earthworks associated with subsidence remediation and/or contamination remediation, exposures would be short-term and as such the level of risk is considered to be much lower. However, to meet permitted activity criteria, subsidence remediation and/or contamination remediation works must meet the following requirements:

- Section 8 clause 3 (a) “....controls to minimise the exposure of humans to mobilised contaminants must be in place when the activity begins...effective while the activity is done...etc...”;
- Section 8 clause 3 (b) “…the soil must be reinstated to an erosion-resistant state within 1 month after serving the purpose for which the activity is done..”;
- Section 8 clause 3 (c)), “the volume of the disturbance of the soil of the piece of land must be no more than 25 m$^3$ per 500 m$^2$ (based on site area of 1,628m$^2$, the allowable volume to disturb would be 81m$^3$);
- Section 8 clause 3 (e) “....soil taken away in the course of the activity must be disposed of to a facility authorised to receive soil of that kind..”; and
- Section 8 clause (f) “…the duration of the activity must be no longer than 2 months...

Management Plans have been provided to meet these requirements$^{16}$and$^{17}$.

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$^{16}$T&T, March 2012, Health and Safety Plan, Contaminated Soils, Brightsmile Gardens, 239 Bella Street, Thames

$^{17}$T&T, March 2012, Earthworks Management Plan, Contaminated Soils, Brightsmile Gardens, 239 Bella Street, Thames
If materials are required to be taken offsite, volumes greater than 5m$^3$ per 500m$^2$ (~16m$^3$ based on site area of 1628m$^2$) would require resource consent.

7.2.2 Sampling

Similar requirements exist for sampling, except that soil must not be removed except as samples and the integrity of the structure containing the contaminated materials must not be compromised. Given the site conditions, sampling is considered achievable as a permitted activity.

7.2.3 Subdividing or changing land use

For subdividing or changing the land use to be a permitted activity, a preliminary site investigation (PSI) must state that it is unlikely there will be risk to human health. Given the findings to date, this is not feasible for the site. On this basis, any subdivision or change of land use would require resource consent.

7.3 Activities requiring consent under the NES

Remediation activities, either to address the land subsidence or to manage contamination, that disturb more than 81m$^3$, remove more than 16m$^3$ or do not meet other permitted activity conditions will require resource consent (see Section 7.2.1). The consent would be restricted discretionary or discretionary depending on whether the proposed activity meets the conditions set out in Section 10 of the NES.

As soil concentrations are not below the NES SCSs relevant to the land use, remediation would not be a controlled activity (see Section 9 of the NES).

7.4 Activities requiring consent under the WRC contaminated land rules

Given the levels of arsenic and lead encountered in the sampling to date, the site is likely to be considered to meet the WRC definition of a contaminated site. The WRC rules indicate that if a discharge to the environment is occurring, a resource consent may be required. Establishing whether a discharge is occurring should consider the results of the forthcoming background level investigation and further assessment of deeper soils (see Section 7.1 above).

7.5 Ongoing site use

Discussion regarding site risks is presented below based on the results of the assessment and review of the NES SCSs and pathway-specific SGVs. Section 7.6 provides some discussion on the NES derivation of the SCS relevant to this project.

7.5.1 Summary

The details of our comments in regards to ongoing site use are presented below. However, in summary:

- at present there do not appear to be produce ingestion risks given the overall levels measured in the produce samples and lower levels of contaminants found in soil in the raised garden beds.
- Nevertheless, the soils are indicated to pose an (accidental) ingestion risk throughout the site.
• Evaluation of site-specific criteria may not be warranted given that contaminant levels exceed NES SCSs for all of the land use scenarios considered including those with low soils contact.

7.5.2 Produce ingestion

For the most part, the results of fruit and vegetable testing indicate contaminants of concern (lead and arsenic) are not elevated and are not above the Food Standards criteria or the NES derived produce standards. Lead results in some produce are higher and exceed standards.

Furthermore, soil samples collected from the raised beds indicate that arsenic concentrations do not exceed the NES produce ingestion specific criteria for soil (34 mg/kg). Only one (1) lead result exceeds the NES produce ingestion specific criteria for soil (471 mg/kg).

To ascertain whether a risk would occur if there was increased consumption of produce at the site (i.e. above the 25% assumed in the NES soil and produce criteria), a sensitivity analysis was carried out. Up to 100% site produce consumption was considered (see Appendix C) and compared against the results of the produce testing. The analysis indicated that based on the NES methodology and assumptions, the concentrations of lead and arsenic found in fruit and vegetables would not cause unacceptable risks.

On the basis of the produce analysis results, overall, the fruit and vegetables grown at the site do not appear to present an unacceptable risk to human health. However, sampling has been limited to generally summer seasonal produce. Available literature indicates root and tuber vegetables will have higher potential for absorbing contaminants.

A more complete understanding of produce ingestion risks would require additional sampling throughout the year including more root and tuber produce sampling.

7.5.3 Accidental soil ingestion

Although lead and arsenic concentrations in raised garden bed soils are lower than elsewhere at the site and are generally below the NES produce ingestion specific criteria for soil, the levels still exceed the ingestion route specific SGVs (252 mg/kg and 21 mg/kg, respectively) indicating that site soils pose an unacceptable ingestion risk.

Using rural residential land use SCSs, contaminant exposure through soil and produce ingestion may be overestimated at the site given the community garden use (see discussion in Section 6.2.1). However, the levels of arsenic encountered to date (averaging at 83 mg/kg) exceed the SCSs for all of the NES land use scenarios provided in the methodology including high-density residential and recreation which assume much lower soil contact. On this basis, development of site-specific criteria for community garden scenario may not provide benefit to evaluation of the site. And on this basis, the soils would pose an ingestion risk even with lower exposure.

7.6 Derivation of NES SCS for arsenic

Background levels of arsenic in natural and fill soils in Thames are likely to be high, given the history of mining and natural occurrence of arsenic in gold ore deposits (see Section 4.2 above). TCDC has recently commissioned a study to determine the background levels of arsenic in Thames. The results of the study are not yet available. Any remedial planning for the site should be considered in the context of background levels of arsenic and lead.

As discussed in Section 6.2.1, in determining a rural residential land use SCS, MfE have used the 99th percentile of NZ-wide background concentrations (17 mg/kg) because the risk-based SCS (13 mg/kg) was lower. This use of background differs from other metals where background intake is subtracted in the derivation of the SCSs.
Although there is some evidence to suggest that lead and arsenic may not be 100% bioavailable, as assumed in recent NEPM guidance, discussion provided in the NES Methodology document\textsuperscript{18} indicates a lack of confidence in applying the results of overseas studies to NZ soils. The result is that lead and arsenic and other metals are assumed to be 100% bioavailable in the derivation of the SCSs. Given the discussion provided in the NES document, justification of any deviation from 100% bioavailability in derivation of site-specific criteria would be difficult and require extensive and detailed testing.

8 Conclusions

The results of the soil sampling from the Brightsmile Garden indicate that lead and arsenic concentrations in surface and near-surface soils are elevated, and exceed NES SCS for a rural residential land use scenario. The concentrations also exceed SCS for other land use scenarios considered by the NES including recreation and high-density residential. On this basis, it is likely that arsenic and lead concentrations would exceed site-specific criteria, if developed.

Contaminant concentrations in the raised beds where gardening activities are focussed are lower. Review of the NES pathway-specific criteria indicate that, while the contaminant concentrations in the raised garden soils pose a soil ingestion risk, overall they would not pose a produce ingestion risk.

Produce (fruit and vegetable) samples tested for lead and arsenic were lower than adopted food criteria, except for some lead results which exceed the BioGro standards. Further sampling would be required throughout the year to better determine risks as available literature indicates root vegetables (winter crops) may absorb higher contaminant concentrations.

Limited remediation works could be carried out to address the land subsidence at the site without the need for a resource consent under the NES. Works exceeding volume limits (81m\textsuperscript{3} for onsite earthworks and 16m\textsuperscript{3} offsite disposal) or failing to meet other requirements would require resource consent from TCDC regulatory section under the NES. Similarly, subdivision or change in land use would also require resource consent.

Elevated arsenic and lead have been encountered to 1m depth in the area of land subsidence in sampling carried out in 2011. It is likely that the arsenic and lead concentrations encountered are similar throughout fill materials (found to be 2m thick in the area of the subsidence). Further sampling at depth would be required to determine the extent of the fill and whether native soils beneath the fill have elevated arsenic and lead. The results of the further testing would be required to understand whether a discharge consent under the regional plan is required.

Any remedial planning to address contamination at the site should be considered in the context of further delineation investigation and the results of a forthcoming TCDC study into background levels of arsenic and lead in Thames.

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\textsuperscript{18} Ministry for the Environment, 2011, \textit{Methodology for deriving standards for contaminants in soil to protect human health}
9 Applicability

This report has been prepared for the benefit of Thames-Coromandel District Council with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose without our prior review and agreement.

Recommendations and options in this report are based on data laboratory results from near surface soil samples and vegetation samples. The nature and continuity of contaminant concentrations away from the sampled locations are inferred but it must be appreciated that actual conditions could vary from the assumed model.

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Authorised for Tonkin & Taylor Ltd by:

Gerard Bird
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Appendix A: Figures

- Figure 1 – Site plan and sample location plan
Appendix B: Site plant inventory
<table>
<thead>
<tr>
<th>Category</th>
<th>Plants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eastern circular raised beds</td>
<td>Courgettes, Kumara, Marigolds, Parsley, Pumpkin, Silverbeet, Sweetcorn, Tomatoes</td>
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<tr>
<td>Western circular raised beds</td>
<td>Beans, Beetroot, Broccoli, Celery, Courgettes, Kumara, Marigolds, Silverbeet, Strawberries, Tomatoes, Water melon</td>
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<td>Raised beds near western gate</td>
<td>Basil, Chillies, Chives, Courgetts, Herbs, Parsley, Sunflowers, Thyme</td>
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<td>Other parts of site</td>
<td>Apples/peaches?, Bananas, Beans, Feijoas, Herbs, Oranges, Passionfruit, Pawpaw and tropical fruit, Rosemary</td>
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</table>
Appendix C: Produce acceptance criteria based on NES methodology
PRODUCE ACCEPTANCE CRITERIA BASED ON NES METHODOLOGY

This worksheet calculates acceptance criteria for produce grown in contaminated soil using Ministry for the Environment NES guidelines.

References

Units

| μg | mg | 1000 |

Parameters

All parameters from NES, as referenced above.

Body weight for an adult

BW_a := 70kg

Body weight for a child

BW_c := 13kg

Target hazard

HI := 1

Exposure duration for an adult (lifestyle block)

ED_a := 24yr

Exposure duration for a child

ED_c := 6yr

Exposure frequency

EF := 350day·yr^-1

Averaging time for nontreshold compounds

AT_nt := 75·yr

Averaging time for threshold compounds for children

AT_tc := ED_c

Averaging time for threshold compounds for adult

AT_ta := ED_a
Reference health standard (RHS) for arsenic, assessed as non-threshold

\[
\text{RHS}_{\text{arsenic}} := 0.0086 \mu g \text{ kg}^{-1} \text{ day}^{-1}
\]

Background intake for arsenic

\[
\text{BI}_{\text{arsenic}} := 0 \mu g \text{ kg}^{-1} \text{ day}^{-1}
\]

RHS for lead, assessed as threshold

\[
\text{RHS}_{\text{lead}} := 0.0019 \text{ mg kg}^{-1} \text{ day}^{-1}
\]

Background intake for lead

\[
\begin{align*}
\text{BI}_{\text{childlead}} & := 0.00097 \text{ mg kg}^{-1} \text{ day}^{-1} \\
\text{BI}_{\text{adultlead}} & := 0.00041 \text{ mg kg}^{-1} \text{ day}^{-1}
\end{align*}
\]

Percentage of produce ingested from the site

\[
\text{P}_g := 0.25
\]

Produce ingestion rate for an adult

\[
\text{IP}_a := 0.0322 \text{ kg day}^{-1}
\]

Produce ingestion rate for a child

\[
\text{IP}_c := 0.0105 \text{ kg day}^{-1}
\]

Percentage of produce types in diet

\[
\begin{align*}
\text{P}_{\text{root}} & := 0.1 \\
\text{P}_{\text{tuber}} & := 0.6 \\
\text{P}_{\text{leafy}} & := 0.3
\end{align*}
\]

Bioconcentration factors

\[
\begin{align*}
\text{BCF}_{\text{Asroot}} & := 0.011 \\
\text{BCF}_{\text{Asstuber}} & := 0.001 \\
\text{BCF}_{\text{Asleafy}} & := 0.011 \\
\text{BCF}_{\text{Proot}} & := 0.015 \\
\text{BCF}_{\text{Ptuber}} & := 0.005 \\
\text{BCF}_{\text{Pleafy}} & := 0.019
\end{align*}
\]

Soil loading factor

\[
\text{SL}_{\text{root}} := 0
\]
Equations

Age adjusted produce ingestion rate
(for non-threshold only)

\[ IP_{adj} := IP_c \frac{ED_c}{BW_c} + IP_a \frac{ED_a}{BW_a} \]

\[ IP_{adj} = 0.0159 \text{ kg yr}^{-1} \text{ day}^{-1} \]

Soil guideline values as determined by MfE:

\[
SGV_{NTproduce} \left( RHS, BI, BCF_{root}, BCF_{tuber}, BCF_{leafy}, AT, P_g \right) :=
\frac{IP_{adj} \cdot P_g \cdot EF \cdot \left( BCF_{root} + SL_{root} \right) \cdot P_{root} + \left( BCF_{tuber} + SL_{tuber} \right) \cdot P_{tuber} + \left( BCF_{leafy} + SL_{leafy} \right) \cdot P_{leafy}}{(RHS - BI) \cdot AT} \]

\[ SGV_{NTproduce} \left( RHS_{arsenic}, BI_{arsenic}, BCF_{Asroot}, BCF_{Astuber}, BCF_{Asleafy}, AT_{nt}, P_g \right) = 34 \text{ mg kg}^{-1} \quad \text{Matches pathway specific SGV} \]

\[
SGV_{Tproduce} \left( RHS, BI, BCF_{root}, BCF_{tuber}, BCF_{leafy}, AT, ED, BW, IP \right) :=
\frac{IP \cdot P_g \cdot EF \cdot ED \cdot \left( BCF_{root} + SL_{root} \right) \cdot P_{root} + \left( BCF_{tuber} + SL_{tuber} \right) \cdot P_{tuber} + \left( BCF_{leafy} + SL_{leafy} \right) \cdot P_{leafy}}{(RHS - BI) \cdot AT \cdot BW} \]

\[ SGV_{Tproduce} \left( RHS_{lead}, B_{childlead}, BCF_{Proot}, BCF_{Ptuber}, BCF_{Pleafy}, AT_{tc}, ED_c, BW_c, IP_c \right) = 471 \text{ mg kg}^{-1} \quad \text{Matches pathway specific SGV} \]

The allowable produce concentration is based on the soil guideline value and the bioconcentration factor (see page 62 of guidance).

\[ C_p(BCF, C_s) := BCF \cdot C_s \]

For arsenic:

Root guideline value

\[ C_p(BCF_{Asroot}, SGV_{NTproduce} \left( RHS_{arsenic}, BI_{arsenic}, BCF_{Asroot}, BCF_{Astuber}, BCF_{Asleafy}, AT_{nt}, P_g \right)) = 0.37 \text{ mg kg}^{-1} \]
Substituting this back into the SGV equation provides a check when compared to the allowable dosage (RHS). For arsenic:

\[
IP_{adj} \cdot Pg \cdot EF = \frac{\left(0.37 \text{ mg kg}^{-1}\right)_{\text{proot}} + \left(0.034 \text{ mg kg}^{-1}\right)_{\text{ptuber}} + \left(0.37 \text{ mg kg}^{-1}\right)_{\text{pleafy}}}{AT_{nt}} = 0.0085 \text{ g kg}^{-1} \text{ day}^{-1}
\]

\[
0.0085 \times 0.0086 = 0.000071 \text{ g kg}^{-1} \text{ day}^{-1}
\]

For lead:

\[
Bl_{\text{childlead}} + IP_{c} \cdot Pg \cdot EF \cdot ED_{c} = \frac{\left(7.1 \text{ mg kg}^{-1}\right)_{\text{proot}} + \left(2.4 \text{ mg kg}^{-1}\right)_{\text{ptuber}} + \left(9.0 \text{ mg kg}^{-1}\right)_{\text{pleafy}}}{AT_{tc} \cdot BW_{c}} = 1.91 \text{ g kg}^{-1} \text{ day}^{-1}
\]

\[
1.91 \times 1.90 = 1.90 \text{ g kg}^{-1} \text{ day}^{-1}
\]

The following charts provide an understanding of the sensitivity of the produce criteria with respect to fraction of produce consumed from site.
Root produce acceptance criteria for arsenic based on fraction consumed from site

![Graph showing root produce acceptance criteria for arsenic vs. fraction of produce consumed from site. The graph includes a red line for root acceptance criteria (mg/kg) and a dashed blue line for beetroot sample result (mg/kg) - detection limit.](image-url)
Leafy produce acceptance criteria for arsenic based on fraction consumed from site

Leafy produce acceptance criteria for arsenic (mg/kg)

Fraction of produce consumed from site

- Leafy acceptance criteria (mg/kg)
- Rosemary sample result (mg/kg)
Tuber produce acceptance criteria for arsenic based on fraction consumed from site

- Tuber acceptance criteria (mg/kg)
- Kumara sample result (mg/kg)
Appendix D: Summary of soil and vegetation analysis results
### Brightsminle Garden - Produce results

<table>
<thead>
<tr>
<th>Source</th>
<th>Date</th>
<th>Sample name</th>
<th>Sample type</th>
<th>Plant type</th>
<th>Sample location</th>
<th>lab number</th>
<th>Arsenic</th>
<th>Lead</th>
<th>Mercury</th>
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<tr>
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<td>20/07/2010</td>
<td>Fresh silverbeet</td>
<td>Silverbeet</td>
<td>Leafy</td>
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<td>Herbs</td>
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<td>T&amp;T</td>
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<td>V1</td>
<td>Silverbeet</td>
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<td>&lt; 0.02</td>
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</tbody>
</table>

### Standards

- **Produce contaminant value derived using NES methodology**
  - Root vegetable: 0.37, 7.1, -
  - Tuber vegetable: 0.034, 2.4, -
  - Leafy vegetable: 0.37, 9, -

- **Australia New Zealand Food Standards Code - 1.4.1. Maximum levels of metals in food**
  - Cereals: 1.0, -
  - Fruit and vegetables (excluding brassicas): -0.1, -
  - Cereals, pulses and legumes: -0.2, -
  - Brassicas: -0.3, -

- **BioGro standard for food and water**
  - Fruit/vegetable?: 0.1, 0.02
  - Soil: 20, 100, 1
  - Compost: 20, 250, 1
  - Water: 20, 45, 0.4

### QA results

<table>
<thead>
<tr>
<th>Date</th>
<th>Sample name</th>
<th>Sample location</th>
<th>lab number</th>
<th>Arsenic</th>
<th>Lead</th>
<th>Mercury</th>
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<tbody>
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<td>22/02/2012</td>
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<td>RPD (%)</td>
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<td>RPD (%)</td>
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Yellow highlighted cells indicate an exceedence of a BioGro organic standard
Orange highlighted cells indicate an exceedence of a New Zealand food standard
## Brightsmile Garden - Soil quality results

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<th>Sample No.</th>
<th>Lab No.</th>
<th>Soil type</th>
<th>Date sampled</th>
<th>Sample location</th>
<th>Sample depth m below ground level</th>
<th>Arsenic mg/kg</th>
<th>Cadmium mg/kg</th>
<th>Chromium mg/kg</th>
<th>Copper mg/kg</th>
<th>Lead mg/kg</th>
<th>Mercury mg/kg</th>
<th>Nickel mg/kg</th>
<th>Zinc mg/kg</th>
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<tr>
<td>HA1-0.5</td>
<td>957185.13</td>
<td>Fill</td>
<td>28/11/2011</td>
<td>Mine shaft collapse</td>
<td>1.0</td>
<td>93</td>
<td>0.23</td>
<td>12</td>
<td>13</td>
<td>&lt; 0.10</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cambrian</td>
<td>SE101298</td>
<td>Topsoil</td>
<td>12/10/2007</td>
<td>In situ soil</td>
<td>61.25</td>
<td>1.53</td>
<td>15.2</td>
<td>138.04</td>
<td>1.5</td>
<td>12.68</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Potential background concentrations

**Residential land use guidelines**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>17</td>
<td>0.8</td>
<td>290</td>
<td>160</td>
<td>200</td>
<td>600</td>
<td>7000</td>
<td>500</td>
<td></td>
</tr>
</tbody>
</table>

### QA results

<table>
<thead>
<tr>
<th>Sample No.</th>
<th>Lab No.</th>
<th>Soil type</th>
<th>Date sampled</th>
<th>Sample location</th>
<th>Arsenic mg/kg</th>
<th>Lead mg/kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>S102</td>
<td>975979.2</td>
<td>Topsoil</td>
<td>7/02/2012</td>
<td>Raised bed - western</td>
<td>45</td>
<td>750</td>
</tr>
<tr>
<td>S102a</td>
<td>975979.3</td>
<td>Topsoil</td>
<td>7/02/2012</td>
<td>Raised bed - western</td>
<td>52</td>
<td>970</td>
</tr>
<tr>
<td>RPD (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>14.4</td>
<td>25.58</td>
</tr>
</tbody>
</table>

Notes:

- NL = calculated guideline is >10,000 mg/kg, therefore the analyte is considered to be Not Limiting
- Guidelines for chromium are based on Chromium VI guidelines
- Guidelines for cyanide are based on complexed cyanide guidelines
- Highlighted cells indicate an exceedence of the selected residential guideline

### Guideline references:

- Auckland Regional Council, October 2011, Background concentrations of inorganic elements in soils from the Auckland Region - Technical Publication No. 153
### ANALYSIS REPORT

Client: Tonkin & Taylor  
Contact: Joanne Ferry  
C/- Tonkin & Taylor  
PO Box 9544  
HAMILTON 3240

Lab No: 975979  
Date Registered: 09-Feb-2012  
Date Reported: 13-Feb-2012  
Quote No: 27866.001  
Order No: 27866.001  
Client Reference:  
Submitted By: Chris Bailey

#### Sample Type: Soil

<table>
<thead>
<tr>
<th>Sample Name</th>
<th>Lab Number</th>
<th>Total Recoverable Arsenic</th>
<th>Total Recoverable Lead</th>
</tr>
</thead>
<tbody>
<tr>
<td>S101</td>
<td>975979.1</td>
<td>9</td>
<td>37</td>
</tr>
<tr>
<td>S102</td>
<td>975979.2</td>
<td>45</td>
<td>750</td>
</tr>
<tr>
<td>S102A</td>
<td>975979.3</td>
<td>52</td>
<td>970</td>
</tr>
<tr>
<td>S103</td>
<td>975979.4</td>
<td>14</td>
<td>83</td>
</tr>
<tr>
<td>S104</td>
<td>975979.5</td>
<td>4</td>
<td>22</td>
</tr>
</tbody>
</table>

#### SUMMARY OF METHODS

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively clean matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis.

<table>
<thead>
<tr>
<th>Sample Type: Soil</th>
<th>Test</th>
<th>Method Description</th>
<th>Default Detection Limit</th>
<th>Samples</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Environmental Solids Sample Preparation</td>
<td>Air dried at 35°C and sieved, &lt;2mm fraction. Used for sample preparation. May contain a residual moisture content of 2-5%.</td>
<td>-</td>
<td>1-8, 11, 13-15, 17-22</td>
</tr>
<tr>
<td></td>
<td>Total Recoverable digestion</td>
<td>Nitric / hydrochloric acid digestion. US EPA 200.2.</td>
<td>-</td>
<td>1-8, 11, 13-15, 17-22</td>
</tr>
<tr>
<td></td>
<td>Total Recoverable Arsenic</td>
<td>Dried sample, sieved as specified (if required). Nitric/Hydrochloric acid digestion, ICP-MS, screen level. US EPA 200.2.</td>
<td>2 mg/kg dry wt</td>
<td>1-8, 11, 13-15, 17-22</td>
</tr>
<tr>
<td></td>
<td>Total Recoverable Lead</td>
<td>Dried sample, sieved as specified (if required). Nitric/Hydrochloric acid digestion, ICP-MS, screen level. US EPA 200.2.</td>
<td>0.4 mg/kg dry wt</td>
<td>1-8, 11, 13-15, 17-22</td>
</tr>
</tbody>
</table>
These samples were collected by yourselves (or your agent) and analysed as received at the laboratory.

Samples are held at the laboratory after reporting for a length of time depending on the preservation used and the stability of the analytes being tested. Once the storage period is completed the samples are discarded unless otherwise advised by the client.

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Martin Cowell - BSc (Chem)
Client Services Manager - Environmental Division
**Sample Type:** Nuts, Fruits and Vegetables and Derived Products

<table>
<thead>
<tr>
<th>Sample Name:</th>
<th>V1 22-Feb-2012</th>
<th>V1a 22-Feb-2012</th>
<th>V3 22-Feb-2012</th>
<th>V4 22-Feb-2012</th>
<th>V4a 22-Feb-2012</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lab Number:</td>
<td>980164.1</td>
<td>980164.2</td>
<td>980164.4</td>
<td>980164.5</td>
<td>980164.6</td>
</tr>
<tr>
<td>Arsenic</td>
<td>&lt; 0.02</td>
<td>&lt; 0.02</td>
<td>&lt; 0.02</td>
<td>&lt; 0.02</td>
<td>&lt; 0.02</td>
</tr>
<tr>
<td>Lead</td>
<td>0.020</td>
<td>0.014</td>
<td>0.008</td>
<td>0.014</td>
<td>0.012</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sample Name:</th>
<th>V5 22-Feb-2012</th>
<th>V6 22-Feb-2012</th>
<th>V8 22-Feb-2012</th>
<th>V9 22-Feb-2012</th>
<th>V10 22-Feb-2012</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lab Number:</td>
<td>980164.7</td>
<td>980164.8</td>
<td>980164.10</td>
<td>980164.11</td>
<td>980164.12</td>
</tr>
<tr>
<td>Arsenic</td>
<td>&lt; 0.02</td>
<td>0.02</td>
<td>&lt; 0.02</td>
<td>&lt; 0.02</td>
<td>&lt; 0.02</td>
</tr>
<tr>
<td>Lead</td>
<td>&lt; 0.002</td>
<td>0.029</td>
<td>&lt; 0.002</td>
<td>&lt; 0.002</td>
<td>0.005</td>
</tr>
</tbody>
</table>

**Sample Type:** Sauces, Herbs, Spice and Condiments

<table>
<thead>
<tr>
<th>Sample Name:</th>
<th>V2 22-Feb-2012</th>
<th>V7 22-Feb-2012</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lab Number:</td>
<td>980164.3</td>
<td>980164.9</td>
</tr>
<tr>
<td>Arsenic</td>
<td>&lt; 0.02</td>
<td>0.08</td>
</tr>
<tr>
<td>Lead</td>
<td>0.024</td>
<td>0.028</td>
</tr>
</tbody>
</table>

**SUMMARY OF METHODS**

The following tables gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively clean matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis.

**Sample Type:** Nuts, Fruits and Vegetables and Derived Products

<table>
<thead>
<tr>
<th>Test</th>
<th>Method Description</th>
<th>Default Detection Limit</th>
<th>Samples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Homogenise</td>
<td>Mincing, chopping, or blending of sample to form homogenous sample fraction. Analysis performed at Hill Laboratories - Food &amp; Bioanalytical Division, Waikato Innovation Park, Ruakura Lane, Hamilton.</td>
<td>-</td>
<td>1-12</td>
</tr>
<tr>
<td>Biological Materials Digestion</td>
<td>Nitric and hydrochloric acid micro digestion, 85°C for 1 hour. Analysis performed at Hill Laboratories - Food &amp; Bioanalytical Division, Waikato Innovation Park, Ruakura Lane, Hamilton.</td>
<td>-</td>
<td>1-12</td>
</tr>
<tr>
<td>Arsenic</td>
<td>Biological materials digestion, ICP-MS.</td>
<td>0.02 mg/kg as rcvd</td>
<td>1-12</td>
</tr>
<tr>
<td>Lead</td>
<td>Biological materials digestion, ICP-MS.</td>
<td>0.002 mg/kg as rcvd</td>
<td>1-12</td>
</tr>
</tbody>
</table>

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Mark Bryant, NZCS (Chemistry)
Senior Technologist - Food & Bioanalytical Division