HAWKE'S BAY
REGIONAL COUNCIL

Soil Quality of Orchard and Vineyard Soils in Hawke's Bay

2014/2015

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Hawke's Bay Regional Council

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1 EXECUTIVE SUMMARY

Hawke's Bay Regional Council (HBRC) are responsible for monitoring the soil quality of Hawke's Bay region as part of their obligations for State of the Environment (SoE) reporting. HBRC reviewed their soil monitoring programme in 2006 (Pearson & Reid, 2006). This provided a framework on which to base a selection process for sites that represent Hawke's Bay based on land form, soil order, soil types and land use. It also prioritised the soil quality indicators to be used in this programme.

In 2009, the National Land Monitoring Forum (LMF) produced robust guidelines from which councils can produce nationally consistent land monitoring procedures and reporting. In accordance with the identified reporting requirements, HBRC have engaged LEI to assist with fieldwork and report on soil quality parameters. Information presented in this report examines the soil quality of orchards and vineyards in Hawke's Bay. Soil quality is assessed in accordance with the recommendations of Pearson and Reid (2006) and the LMF guidelines.

Typically, orchards and vineyards are long term tree and vine crops for human consumption. They tend to maintain the trees or vines in rows with access between, referred to here as inter-row. The land is intensively managed. Land used for orchards and vineyards usually but not always receives irrigation.

Sampling for soil quality monitoring for the orchard and vineyard occurred in May 2015. Sampling was timed to access recently harvested sites. Where possible sampling occurred prior to post harvest spray and fertilisation, although this was not always possible.

Eleven sites were sampled from orchard properties used for apples, kiwifruit or cherries. Three certified organic apple orchards were included. Five vineyard sites were sampled including three sites previously sampled in 2010. Results from the analysis of soil from each site enabled the following conclusions to be made:

- In general, soil quality in Hawke's Bay orchard and vineyard sites is acceptable.
- Soil fertility is expected to be appropriate for the orchard and vineyard crops grown, and will vary seasonally due to the cropping cycle. While every attempt to sample immediately following harvest was made, some variance may be expected due to post-harvest calcium ammonium nitrate (CAN) fertiliser applications at some sites.
- Soil aggregate stability is a concern for trafficked areas of orchard and vineyard sites, in particular those sites with Recent Soils, which are common for this land use.
- Aggregate stability, Olsen P and contaminant levels are considered to be the key issues for soil quality and sustainability of orchard and vineyard land use for Hawke's Bay.

Recommended actions coming from this report include:

- Managers of the properties sampled should be informed of the soil quality on their properties and where remedial activity is recommended, HBRC may provide advice on potential management strategies.
- Copper levels in soils of orchards and vineyards should continue to be monitored, and consideration of strategies to avoid accumulation in the soil should be considered.
- Areas subject to high traffic should be encouraged to be maintained in vegetative cover to avoid reduction in aggregate stability and loss of soil.
- The same sites should be resampled within 5 years and at ongoing intervals to develop a long term record of soil quality indicator performance over time.

2 INTRODUCTION

2.1 Purpose

This report provides Hawke's Bay Regional Council (HBRC) with an interpretive soil quality report based on laboratory and field data collected. This information is intended to contribute to the council's State of the Environment reporting obligations.

2.2 Background

HBRC is maintaining a database of soil condition from different land uses and soil types representative of Hawke's Bay region. This database began with the "500 Soils Project" co-funded with the Ministry for the Environment (MfE) during 1999 - 2000. The MfE ceased involvement in the project in 2001 with the understanding that regions would continue monitoring and at a future date the 500 Soils Project sites would be resampled.

HBRC reviewed their soil monitoring programme in 2006 (Pearson & Reid, 2006). This provided a framework on which to base a selection process for sites that represent Hawke's Bay based on land form, soil order, soil types and land use. It also prioritised the soil quality indicators. The current report focuses solely on orchard and vineyard soils.

In 2009, the National Land Monitoring Forum (LMF) produced robust guidelines from which councils can produce nationally consistent land monitoring procedures and reporting. In accordance with the identified reporting requirements, HBRC have engaged LEI to assist with fieldwork and report on soil quality parameters. This report evaluates the soil quality of land managed as orchards and vineyards in Hawke's Bay. Soil quality is assessed in accordance with the recommendations of Pearson and Reid (2006) and the LMF guidelines.

2.3 Scope

This report follows on from previous soil quality reports produced for extensive pastoralism (2011), intensive pastoralism (2013) and cropping (2014) in Hawke's Bay. For consistency, this report maintains a similar format and methodology for assessing soil quality as that used in the previous reports. The scope of this report is to describe the soil quality of land used for orchards and vineyards in the Hawkes Bay region. In particular, it details:

- Section 3: Discusses the soil quality monitoring framework;
- Section 4: Methods used to collect data;
- Section 5: Results from data collected with brief written interpretation;
- Section 6: Discussion;
- Section 7: Conclusion; and
- Section 8: Recommendations.

To enable the report to be a stand-alone document, which is able to be read without the previous reports, some information is repeated from previous reports – particularly as regards to the framework and methodology.

3 SOIL QUALITY AND LAND USE

3.1 Soil Quality Monitoring in Hawke's Bay

As previously reported (LEI, 2011, 2013 and 2014), soil quality and land use impacts on soil quality are important indicators of the state of the environment. A clear procedure for the investigation of soil quality in New Zealand has been established. This report uses guidelines prepared by the National Land Monitoring Forum (LMF, 2009) for the measurement and interpretation of soil quality. It is complimented by information from previous reports on soil quality for Hawke's Bay region, which have been reviewed and are referenced throughout this report.

3.2 Land Use Definition

The LMF guidelines provide a hierarchical land use classification. The land use categories are defined so that they can be aggregated back to the New Zealand Land Cover Database. Horticulture sites were sampled for this report, and these are further broken down to orchards and vineyards/berry-fruit. The terms orchard and vineyard are used in this report to distinguish between these land use types.

Typically, orchards and vineyards are long term tree and vine crops for human consumption. Trees or vines have access areas between the rows, referred to here as inter-row. The land is intensively managed. Land used for orcharding and vineyards usually, but not always, receives irrigation.

3.3 Soil Quality Indicators

Much investigation has been undertaken into the measurement of soil quality. In line with the recommendations of Pearson and Reid (2006), the adopted indicators for Hawke's Bay region follow the convention of the "500 Soils Project" (Sparling, *et al.*, 2001). The identified soil quality indicators are as follows:

Priority One: The Minimum Data Set

- Soil pH (soil acidity);
- Olsen P;
- Total carbon (C) and nitrogen (N);
- Anaerobically mineralisable N;
- Bulk density;
- Macroporosity; and
- Aggregate stability.

The Priority One indicators are considered to represent the minimum parameters to be measured in order to assess soil health. These indicators are the focus of the monitoring programme described in this report regarding the health of orchard and vineyard sites in Hawke's Bay.

Priority Two: Extra Measurements – Visual Soil Assessment (VSA; Shepard, 2000)

- % bare ground;
- % area of crusted soil and crust thickness;
- % area damaged soil surface; and
- Thickness of organic matter thatch.

Priority Two indicators provide a qualitative assessment of soil condition. These measurements can indicate if soil quality is degraded. However, the VSA is designed particularly for pasture and cropping situations where frequent disturbance of the soil (by animal traffic and grazing, by cultivation, etc) occurs. These activities are not typical in orchards and vineyards, and where they occur it is at a low intensity and frequency. Priority Two indicators have not been evaluated for the 2015 orchard and vineyard sites due to the reasons described above.

Priority Three: Extra Measurements

- Exchangeable cations and cation exchange capacity;
- Trace elements including arsenic (As), cadmium (Cd), chromium (Cr), copper (Cu), lead (Pb), mercury (Hg), nickel (Ni), zinc (Zn), uranium (U), fluorine (F);
- DDT; and
- Hot water extractable C.

Priority Three indicators provide information that supports interpretation of Priority One indicators and adds detail about fertility and trace element contamination. While Priority One indicators describe soil quality in general terms i.e. as relates to any land use, Priority Three indicators help to determine the soil quality as it relates to the specific site activity. Priority Three indicators have been evaluated for the 2015 orchard and vineyard sites.

3.4 Trace Element and Organochlorine Pesticide Monitoring

Trace element and organochlorine pesticide measurement corresponds to the Priority Three indicators. While not considered fundamental to the measurement of soil quality, they give important information about soil health on an individual property, and may identify sites where previous land use has had a detrimental effect on soil quality. If data from several properties exceeds guidelines for the trace elements of particular concern (As, Cd, Cr, Cu, Ni, Pb, Zn, Hg, U, F), it is recommended to pursue further investigation (Chapter 5: LMF, 2009). Organochlorines such as DDT and its metabolites are an indicator of land use impacts since they do not occur naturally. In addition, the presence of elevated levels of organochlorine pesticides and trace elements indicates a limitation to land uses on the site.

Trace elements and other materials of concern which have the highest potential to be elevated are Cd, U and fluoride. They are known to accumulate in the soil when superphosphate has been applied. Copper is used in anti-fungal treatments for food crops and is known to have detrimental effect on soil biota, and poses a risk if transported to the aquatic environment. Use of a range of Zn-containing products such as antibiotics and fungicides are also common practice on pastoral farms, particularly facial eczema preventative remedies (Kim & Taylor, 2009). While the sampling programme summarised in this report relates to orchard and vineyard sites, some are likely to have had a pastoral history or may include a grazed phase in their rotation and so have the potential for elevated zinc levels.

3.5 Historical State of Hawke's Bay Soils

Previous reports and the New Zealand Soil Health Report Card (NZSHRC; MfE, 2010) have identified the soil management challenges for Hawke's Bay (and all other regions) as:

- Poor aggregate stability (all land uses);
- Low macroporosity (intensive pasture);
- Low carbon reserves (cropping);
- General fertility (extensive pasture); and

- Phosphorus status (extensive pasture).

The above indicates that soil properties of concern were and are predominantly physical properties including for orchard and vineyard sites that are likely to be affected by frequent vehicle passes or lack of vegetative cover (bare ground) between (and sometimes on) rows.

In addition to the Priority 1 indicators, the incidence of elevated trace metals and organochlorine pesticides in pip-fruit orchards had been identified as a potential issue with the 2009 State of the Environment report (HBRC, 2009) stating:

"Some work on residual agrichemicals in old horticultural soils on the Heretaunga Plains was undertaken by MacAskill (2004).

The MacAskill survey found some issues in orchard soils because of historic use of organochlorines and heavy-metal based pesticides, particularly copper. Findings were consistent with studies elsewhere, for example work done by Auckland Regional Council (2002) on old horticultural soils in the Auckland area.

4 METHODOLOGY

4.1 Site Selection

The method for site selection follows the recommendation of LMF (2009) for determining if a site is representative of a land use type, and whether a site is suitable for establishment of long term monitoring. Pearson and Reid (2006) described locations which are considered to represent the range of soils and land use activities in the region. The sites identified by Pearson and Reid (2006) are considered to be aligned to the LMF (2009) recommendations and so where these sites could be accessed, they were sampled.

In order to confirm where sites were identified by Pearson and Reid, or determine locations for the establishment of new soil quality monitoring sites, HBRC utilised existing GIS soil and land use maps of the region. Overlays of land use and soil type were applied to property boundaries. To enable the detection of soil quality changes over time, sites that were visited in the 2007 study (Sparling, 2007) were given preference where detail for relocating those sites was known. Soil quality is not a static measure and so revisiting sites is important for the long term value of the soil quality monitoring programme. Vineyard sites were previously sampled in 2010 and have been resampled in this round. Orchards have not been sampled before.

For the soil types not previously sampled, and where information was insufficient to relocate a previously sampled site, HBRC identified a representative property for each soil type. An approach was made to the property owner followed by a land management history questionnaire.

Where the property was deemed to have met criteria for the establishment of a soil quality monitoring site (e.g. Section 5.1; Pearson and Reid, 2006), the site was selected for establishing a monitoring site.

4.2 Establishment of a Monitoring Site

Monitoring sites were established in accordance with LMF (2009) procedures and Section 5.2 of Pearson and Reid (2006). In brief, the site was located on land so that no part of the sampling transect was affected by tracks, fence lines, shelter belts, stock camps, water troughs, streams, drainage ditches, buildings, fire sites, erosion scars or other disturbed areas.

A 50 m transect was marked out and GPS co-ordinates were taken at 0 m, 25 m and 50 m. Soil pits were also excavated at these same co-ordinates along the transect. Soil was described to a depth of around 50 cm for two pits and to around 100 cm at one pit. Details of each site are given in Appendix A.

4.3 Observations on Site Selection and Site Establishment

Sampling for soil quality monitoring for the orchard and vineyard round occurred in May 2015. Sampling was timed to access recently harvested sites. Where possible sampling occurred prior to post harvest spray and fertilisation.

Location details of previously (vineyards, HBRC, 2010) sampled sites were not exact. However, sites were located within approximately one row and are considered comparable.

4.4 Sampling and Analysis

Soil sampling and analyses followed the guidelines prepared by the LMF (2009). The LMF guidelines are based on the protocols established by the 500 Soils Project (Hill *et al.*, 2003). A summary of the procedures for sampling and analysis are as follows.

Orchards and vineyard plantings are laid out in rows. Conditions and management differ between the "row" (containing trees/vines) and "inter-row" areas. Rows typically have irrigation drippers and are maintained in bare ground by use of herbicides or mechanical means. Inter-row areas typically are maintained in grass cover, and have a high number of vehicle passes. It is likely that fertiliser applications are different between the row and inter-row areas. The row and inter-row have been sampled separately, so that there are two sets of samples for each site.

4.4.1 Sampling for Soil Physical Indicators

For bulk density, porosity, macroporosity, field capacity and available water capacity, intact cores (10 cm diameter x 7.5 cm depth) were taken at three points along each transect. The sampling locations corresponded to the soil pits at 0 m, 25 m and 50 m.

For aggregate stability analysis, one composite sample per site was collected by digging three squares of soil from along the transect to 100 mm depth and placing them in a plastic container. Care was taken to avoid breaking up the soil clod.

4.4.2 Sampling for Soil Chemical and Microbiological Indicators

A foot corer with dimensions of 20 mm in diameter and 100 mm in length was used to obtain one soil core approximately every 2 m along the transect. The cores were combined to provide a composite sample for analysis. The composite sample was used for analysis of organic matter and soil nutrient levels.

The procedure above was repeated to provide a second composite sample. This second sample was used for analysis of trace elements and persistent organic contaminants.

Separate core samples were taken for microbial DNA testing for a separate (but related) joint project with the University of Auckland. These cores were also taken every 2m but bagged individually to avoide contamination.

4.4.3 Sample Handling and Transport

Samples were packed in sealed bags and placed in chilly bins, where necessary, and were refrigerated before being sent to the laboratory for analysis. The cores to be analysed for microbial DNA had to be frozen (rather than just refrigerated) as soon as possible. Intact cores for the physical analysis were stored and transported in padded crates.

Intact cores for soil physical indicators were sent to the Landcare Research Laboratory in Palmerston North for analysis. Composite samples for chemical analysis were sent to Hill Laboratories in Hamilton.

4.4.4 Sample Analysis

As indicated above, samples were sent to Hill Laboratories and analysed for:

- Basic soil test: pH, Olsen P, exchangeable cations, CEC, base saturation;
- Organic soil profile: Available N, anaerobically mineralisable N (AmN), organic matter, total C, total N, C/N ratio, AmN/N ratio;

- Heavy metal screen (for trace elements): As, Cd, Cr, Cu, Ni, Pb, Zn, Hg;
- Organochlorine pesticide screen;
- Total uranium (U); and
- Total fluoride (F-).

Analyses conducted at the Landcare Research laboratory were:

- Bulk density;
- Macroporosity;
- Particle density;
- Total porosity;
- Field capacity: soil moisture content when all macropores have drained;
- Available water capacity (AWC); and
- Aggregate stability.

4.5 Data Presentation

All data is expressed as received from Hills Laboratories. Where necessary, recalculation of data to different units was made to enable comparison to historical data, i.e. the analysing laboratories typically express results on a gravimetric basis (mass/mass basis), however for some parameters, as they relate to soil quality, it is considered more appropriate to compare them on a volumetric basis (mass/volume). Where historic data has been presented on a volumetric basis, the results presented in this report are given on both a gravimetric and a volumetric basis to enable comparison with historical data.

Available N data is received from the laboratory expressed per 150 mm of topsoil depth. Results given in the following sections have been adjusted to reflect the 100 mm depth that was sampled for this soil quality monitoring programme.

5 RESULTS

5.1 Soils and Sites

Eleven sites were sampled from orchard properties in Hawke's Bay. Five sites were sampled from vineyard properties. Table 1 lists the soil types at each sample site and the soil order/group to which they belong.

Of the 8 soil orders chosen to represent the region (Pearson & Reid, 2006), only 2 soil orders are represented in the orchard and vineyard soils of the region sampled for this study. The limited number of soil orders represented reflect that orcharding, in particular, is limited to landforms associated with the alluvial plains. While vines may be grown in a range of soils and landforms, the soil monitoring predominantly reflects the alluvial plains, and specifically the area known as the Gimblett Gravels.

Table 1: Soil Quality Monitoring Sites

Site No	Soil Type	Soil Order*	Crop
ORCH 1	Hastings silt loam	Recent	Apples
ORCH 2	Karamu silt loam	Recent	Apples
ORCH 3	Flaxmere sandy silt	Recent	Apples
ORCH 4	Pakowhai clayey silt	Recent	Apples
ORCH 5	Pakowhai clay loam	Recent	Apples
ORCH 6	Farndon silt loam	Recent	Apples
ORCH 7	Mangateretere clay loam	Recent	Kiwifruit
ORCH 8	Pakowhai silt loam	Recent	Apples (organic certification)
ORCH 9	Hastings silt loam	Recent	Apples (organic certification)
ORCH 10	Mangateretere clay loam	Recent	Apples (organic certification)
ORCH 11	Irongate silt loam	Recent	Cherries
VIN 1	Kaiapo clay loam	Recent	Grapes
VIN 2	Takapau silt loam	Brown	Grapes
VIN 4	Takapau silt loam	Brown	Grapes
VIN 5	Ngatarawa sandy loam	Recent	Grapes
VIN 6	Omahu sandy loam	Recent	Grapes

* New Zealand Soil Classification (Hewitt, 1992)

Soil profile and site descriptions are provided in Appendix A. Note the vineyard sites include three sites previously visited and two new sites. The site corresponding to VIN03 in the previous sampling round was unable to be accessed for this sampling round. Several of the sites received some form of irrigation. Irrigation, where present, was predominantly by drip type emitters or mini/micro-sprinklers that were located in the "row" zone.

5.2 Analysis Results

Soil chemistry, physical data, trace element levels and agrichemical contaminants are shown in Tables 2 to 4 below. Analysis results as received from the analysing laboratories are given in Appendix B.

Table 2: Soil chemical characteristics of Hawke's Bay orchard and vineyard sites sampled in 2015

Site	Position	Soil Type	pH	CEC	Total C		Total N		C/N	Olsen P	Base Saturation	Anaerobically Mineralisable N		Available N	K	Ca	Mg	Na
				me/100g	%	mg/cm³	%	mg/cm³	ratio	mg/L	%	µg/g	µg/cm³	mg/kg	me/100g			
ORCH 1	Inter-row	Hastings	6.6	24	3.8	45	0.39	4.7	9.6	39	84	111	133	85	1.04	16.8	2.17	0.09
	Row		6.6	23	3.0	35	0.3	3.5	10.2	72	85	62	73	54	1.92	15.1	2.49	0.11
ORCH 2	Inter-row	Karamu	6.3	19	2.8	37	0.3	4.0	9.4	**14**	71	77	103	68	1.18	10.6	1.82	0.06
	Row		6.0	17	2.2	29	0.23	3.0	9.7	25	69	46	60	45	1.36	8.6	1.51	0.09
ORCH 3	Inter-row	Flaxmere	6.5	16	2.2	31	0.21	3.0	10.3	**15**	77	60	85	59	0.27	10.5	1.30	0.11
	Row		5.8	18	2.3	30	0.25	3.3	9.2	70	71	65	85	63	1.24	9.3	1.91	0.14
ORCH 4	Inter-row	Pakowhai	6.8	29	4.5	51	0.42	4.7	10.6	**10**	82	122	138	93	1.50	20.2	2.41	0.10
	Row		6.7	23	3.2	37	0.32	3.7	10.0	21	82	60	70	51	1.62	14.9	2.70	0.10
ORCH 5	Inter-row	Pakowhai	6.8	24	4.1	51	0.4	5.0	10.4	**14**	85	117	147	96	1.51	16.1	2.36	0.07
	Row		7.0	19	2.5	31	0.26	3.2	9.6	35	88	56	69	49	1.48	12.7	2.12	0.08
ORCH 6	Inter-row	Farndon	6.7	18	2.3	29	0.25	3.2	9.0	76	81	68	86	63	1.08	11.8	1.29	0.12
	Row		6.3	16	2.0	27	0.24	3.2	8.3	**112**	75	63	84	61	1.53	9.2	1.34	0.11
ORCH 7	Inter-row	Mangateretere	6.6	29	4.7	51	0.43	4.7	10.7	42	85	131	142	107	1.50	19.3	3.57	0.14
	Row		6.7	25	4.1	45	0.4	4.4	10.1	62	85	96	106	79	1.61	16.1	3.59	0.13
ORCH 8	Inter-row	Pakowhai	6.8	26	3.9	47	0.4	4.8	9.9	**18**	88	115	139	93	1.34	19.5	2.24	0.13
	Row		7.0	24	3.4	34	0.34	3.4	10.0	44	90	72	73	61	1.54	17.7	2.23	0.10
ORCH 9	Inter-row	Hastings	6.7	32	5.2	56	0.49	5.3	10.6	26	81	141	153	104	1.62	20.5	3.20	0.10
	Row		6.7	29	4.4	45	0.44	4.5	10.0	43	83	96	99	76	2.22	18.6	3.01	0.09
ORCH 10	Inter-row	Mangateretere	6.6	30	4.5	52	0.45	5.2	9.9	30	88	168	194	137	1.43	22.3	2.64	0.09
	Row		6.7	27	4.5	45	0.44	4.4	10.3	60	86	125	125	100	1.52	19.2	2.41	0.10
ORCH 11	Inter-row	Irongate	6.3	26	4.4	62	0.4	5.6	11.0	40	77	144	203	121	1.35	16.4	2.19	0.10
	Row		5.9	23	3.6	41	0.36	4.1	10.0	63	68	111	127	92	1.59	11.7	2.28	0.09

Site	Position	Soil Type	pH	CEC	Total C		Total N		C/N	Olsen P	Base Saturation	Anaerobically Mineralisable N		Available N	K	Ca	Mg	Na
				me/100g	%	mg/cm³	%	mg/cm³	ratio	mg/L	%	µg/g	µg/cm³	mg/kg	me/100g			
VIN 1	Inter-row	Kaiapo	6.5	19	2.7	34	0.29	3.6	9.4	23	82	97	121	87	1.42	12.2	1.91	0.09
	Row		5.9	16	**1.7**	23	0.21	2.9	8.2	28	69	51	70	53	1.10	8.0	1.49	0.16
VIN 2	Inter-row	Takapau	5.9	27	7.1	62	0.71	6.2	10.1	**18**	55	127	112	99	1.77	11.3	1.90	0.11
	Row		6.7	23	5.4	44	0.5	4.1	11.0	**8**	71	76	62	63	1.64	11.6	2.83	0.34
VIN 4	Inter-row	Takapau	6.5	23	3.8	43	0.38	4.3	9.8	46	76	64	73	57	0.55	14.9	1.84	0.22
	Row		7.6	24	3.4	36	0.31	3.3	10.8	63	100	50	53	49	1.64	19.7	1.95	0.28
VIN 5	Inter-row	Ngatarawa	6.4	20	3.6	39	0.35	3.8	10.2	29	76	134	147	113	1.07	12.0	2.00	0.09
	Row		7.0	16	2.5	30	0.26	3.2	9.6	20	87	53	64	48	0.65	10.9	2.42	0.26
VIN 6	Inter-row	Omahu	6.8	15	2.7	NR	0.31	NR	9.0	26	84	74	NR	74	0.82	9.8	2.02	< 0.05
	Row		6.6	12	2.0	NR	0.21	NR	9.4	**12**	81	47	NR	51	0.43	7.5	1.59	0.09

* Items in bold fell outside the target range for that land use and soil order (Hill & Sparling, 2009)

Table 3: Soil physical characteristics of Hawke's Bay orchard and vineyard sites sampled in 2015

Site		Soil Type	Dry bulk density (g/ cm³)	Particle density (g/cm³)	Porosity (%)	Macro-porosity (%)	Field capacity (%)	AWC (%)	Aggregate Stability MWD (mm)
ORCH 1	Inter-row	Hastings	1.19	2.63	55	11	43	17	**1.46**
	Row		1.18	2.62	55	12	43	18	**1.88**
ORCH 2	Inter-row	Karamu	1.33	2.62	49	14	35	16	**1.23**
	Row		1.31	2.63	50	16	34	16	2.14
ORCH 3	Inter-row	Flaxmere	**1.42**	2.64	46	14	32	18	**1.28**
	Row		1.31	2.64	51	19	32	18	**1.61**
ORCH 4	Inter-row	Pakowhai	1.13	2.59	56	12	44	15	**1.53**
	Row		1.17	2.60	55	10	45	16	2.49
ORCH 5	Inter-row	Pakowhai	1.25	2.63	52	13	40	16	**1.36**
	Row		1.24	2.63	53	13	40	19	2.21
ORCH 6	Inter-row	Farndon	1.27	2.64	52	15	37	22	**1.23**
	Row		1.33	2.64	50	12	38	23	**1.61**
ORCH 7	Inter-row	Mangateretere	1.09	2.59	58	8	50	22	**0.97**
	Row		1.11	2.60	57	8	49	21	**1.81**
ORCH 8	Inter-row	Pakowhai	1.21	2.58	53	8	45	19	**0.94**
	Row		1.01	2.60	61	22	39	22	2.18
ORCH 9	Inter-row	Hastings	1.08	2.60	58	8	50	25	**1.20**
	Row		1.03	2.61	60	11	49	26	2.24
ORCH 10	Inter-row	Mangateretere	1.15	2.59	56	8	47	23	**1.73**
	Row		1.00	2.59	62	17	45	20	**1.90**
ORCH 11	Inter-row	Irongate	**1.41**	2.64	47	8	39	12	**1.33**
	Row		1.14	2.61	56	19	37	13	**1.83**
VIN 1	Inter-row	Kaiapo	1.25	2.63	53	16	36	18	**1.08**
	Row		1.38	2.64	48	14	33	14	**0.65**
VIN 2	Inter-row	Takapau	0.88	2.40	63	25	38	24	2.76
	Row		0.81	2.44	67	**30**	36	24	2.60

Site		Soil Type	Dry bulk density	Particle density	Porosity	Macro-porosity	Field capacity	AWC	Aggregate Stability
			(g/ cm³)	(g/cm³)	(%)	(%)	(%)	(%)	MWD (mm)
VIN 4	Inter-row	Takapau	1.14	2.51	55	20	35	15	**1.65**
	Row		1.07	2.53	58	25	33	17	**1.67**
VIN 5	Inter-row	Ngatarawa	1.09	2.54	57	26	31	19	**1.53**
	Row		1.22	2.56	52	21	32	17	**1.50**
VIN 6	Inter-row	Omahu	NR	NR	NR	NR	NR	NR	NR
	Row		NR	NR	NR	NR	NR	NR	NR

* Items in bold fell outside the target range for that land use and soil order (Hill & Sparling, 2009)
NR – no result (sample not able to be taken due to extremely gravelly topsoil).

Table 4: Trace element and organochlorine pesticide levels of Hawke's Bay sites sampled in 2015

Site		Soil Type	Individual Tests		Heavy metals, screen As, Cd, Cr, Cu, Ni, Pb, Zn, Hg								Organochlorine pesticides	
			Total Recoverable Uranium	Fluoride	Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Zinc	Sum DDT/DDE/DDD	Dieldrin
			mg/kg											
ORCH 1	Inter-row	Hastings	0.92	360	8	0.17	18	65	22	0.10	15	123	0.40	< 0.010
	Row		0.94	430	8	0.20	18	65	21	0.14	15	157	0.67	< 0.010
ORCH 2	Inter-row	Karamu	0.69	350	**59**	0.15	15	**133**	181	0.69	12	125	**7.97**	< 0.010
	Row		0.69	350	**56**	0.11	15	**122**	174	0.74	14	117	**9.85**	< 0.010
ORCH 3	Inter-row	Flaxmere	0.89	350	4	0.15	14	18	12	< 0.10	11	67	0.00	< 0.010
	Row		0.78	340	4	0.20	28	20	14	< 0.10	11	91	0.00	< 0.010
ORCH 4	Inter-row	Pakowhai	1.19	420	7	0.12	18	20	22	< 0.10	16	78	0.11	< 0.010
	Row		1.32	450	8	0.19	18	18	25	< 0.10	15	88	0.25	< 0.010
ORCH 5	Inter-row	Pakowhai	0.86	420	7	0.20	17	**148**	22	< 0.10	14	128	0.34	< 0.010
	Row		0.89	450	7	0.16	17	**146**	24	< 0.10	15	108	**0.73**	< 0.010
ORCH 6	Inter-row	Farndon	0.71	320	5	0.19	15	25	19	< 0.10	14	88	0.02	< 0.010
	Row		0.67	350	4	0.16	15	27	19	< 0.10	12	89	0.05	< 0.010
ORCH 7	Inter-row	Mangateretere	0.96	410	5	0.21	15	24	21	< 0.10	13	82	0.05	< 0.010
	Row		1.12	430	7	0.38	16	23	19	< 0.10	13	89	0.10	< 0.010
ORCH 8	Inter-row	Pakowhai	1.12	380	10	0.17	19	46	26	< 0.10	18	94	0.15	< 0.010
	Row		1.20	490	9	0.15	18	45	25	< 0.10	16	92	0.19	< 0.010
ORCH 9	Inter-row	Hastings	1.15	420	**21**	0.18	17	**189**	22	< 0.10	15	96	0.01	< 0.010
	Row		1.19	460	**21**	0.16	18	**126**	22	< 0.10	15	93	0.04	< 0.010
ORCH 10	Inter-row	Mangateretere	1.00	310	9	0.29	16	30	20	< 0.10	16	80	0.00	< 0.010
	Row		0.93	420	8	0.14	16	38	20	< 0.10	14	85	0.00	< 0.010
ORCH 11	Inter-row	Irongate	1.20	**520**	8	0.52	18	**560**	25	< 0.10	15	**310**	0.22	< 0.010

Site		Soil Type	Individual Tests		Heavy metals, screen As, Cd, Cr, Cu, Ni, Pb, Zn, Hg								Organochlorine pesticides	
			Total Recoverable Uranium	Fluoride	Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Zinc	Sum DDT/DDE/DDD	Dieldrin
			mg/kg											
VIN 1	Row	Kaiapo	0.98	480	7	0.21	17	**370**	24	0.26	15	173	0.19	< 0.010
	Inter-row		0.70	290	4	0.13	16	51	13	< 0.10	12	60	0.05	< 0.010
	Row		0.69	330	4	0.12	15	56	14	< 0.10	11	68	0.13	0.018
VIN 2	Inter-row	Takapau	0.82	370	3	0.39	7	34	12	< 0.10	4	57	0.64	< 0.010
	Row		0.74	340	4	0.20	7	43	12	< 0.10	5	82	0.18	< 0.010
VIN 4	Inter-row	Takapau	0.91	330	3	0.26	9	13	11	< 0.10	8	56	0.13	< 0.010
	Row		1.00	250	4	0.35	10	15	11	< 0.10	7	68	0.16	< 0.010
VIN 5	Inter-row	Ngatarawa	0.69	270	2	0.21	9	11	10	< 0.10	6	52	0.00	< 0.010
	Row		0.88	290	4	0.29	11	16	11	< 0.10	7	72	0.00	< 0.010
VIN 6	Inter-row	Omahu	0.44	280	5	< 0.10	12	17	15	< 0.10	9	72	0.00	< 0.010
	Row		0.36	240	5	< 0.10	13	14	15	< 0.10	8	67	0.00	< 0.010

5.3 Priority One Indicators

The results from the soils analysed have been compared to the interpretative frameworks developed by the LMF expert panel (Hill & Sparling, 2009) (referred to in this report as the Framework). The Framework provides terms to categorise the results and target ranges or critical limits.

5.3.1 Soil pH

Soil pH results are shown in Figure 1. The target range for both orchard and vineyard soils is pH 5.0 to 7.6 for the soil groups sampled. All except one site were within the target range for soil pH. The Takapau soil (VIN04) row sample was at the upper boundary. The pH of orchard and vineyard soils sampled does not indicate soil pH is adversely affected by the land use.

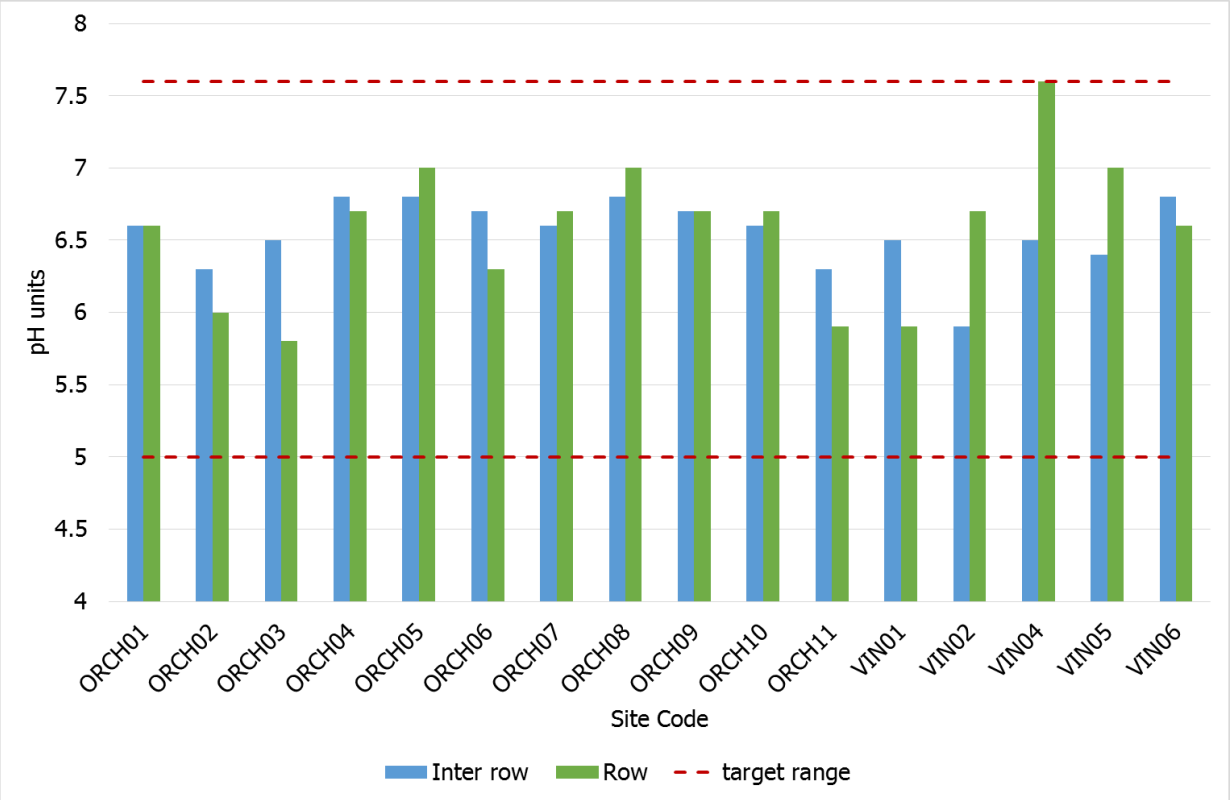

Figure 1: Soil pH for Hawke's Bay orchard and vineyard sites sampled in 2015

5.3.2 Soil Total Carbon

Soil total carbon results are shown in Figure 2. The target range for soils is dependent on the soil order. Of the soil orders represented by the sites sampled the target range is:

- Recent soils: >2%; and
- Brown, Gley soils: >2.5%. (only VIN02 & VIN04 were on these soils)

Only one sample (VIN01 row) was below the total carbon target range. Four additional sites were at the low end of the range (ORCH02, ORCH03, ORCH06 and VIN06). In general, total carbon was lower in the row samples. This is to be expected since the row is typically managed using herbicide, or cultivation (organic orchards). Both of these techniques reduce the

accumulation of biomass by avoiding the establishment of vegetation, and in the case of cultivation, encouraging the oxidation and loss of organic matter.

Sites with conventionally managed apples tended to have lower total carbon than organic management and alternative crops (kiwifruit and cherries).

The vineyard sites had variable levels of total carbon and it is expected that this is predominantly due to natural variations in the soils.

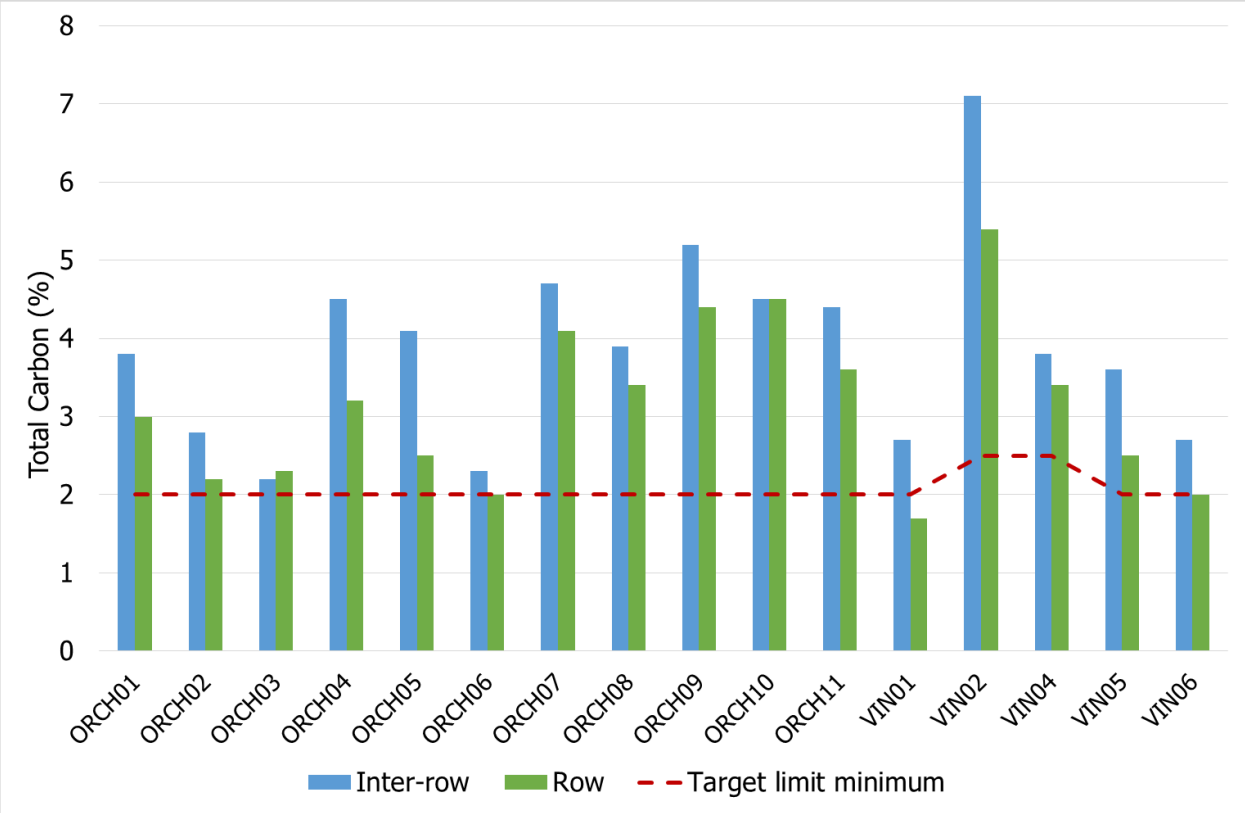

Figure 2: Soil total carbon for Hawke's Bay orchard and vineyard sites sampled in 2015

5.3.3 Soil Total Nitrogen

Soil total nitrogen results are shown for the orchard and vineyard soils in Figure 3. There is no target range for orchard and vineyard soils since the optimum level is dependent on the crop grown. The trends in total nitrogen concentrations follow the same pattern as for total carbon.

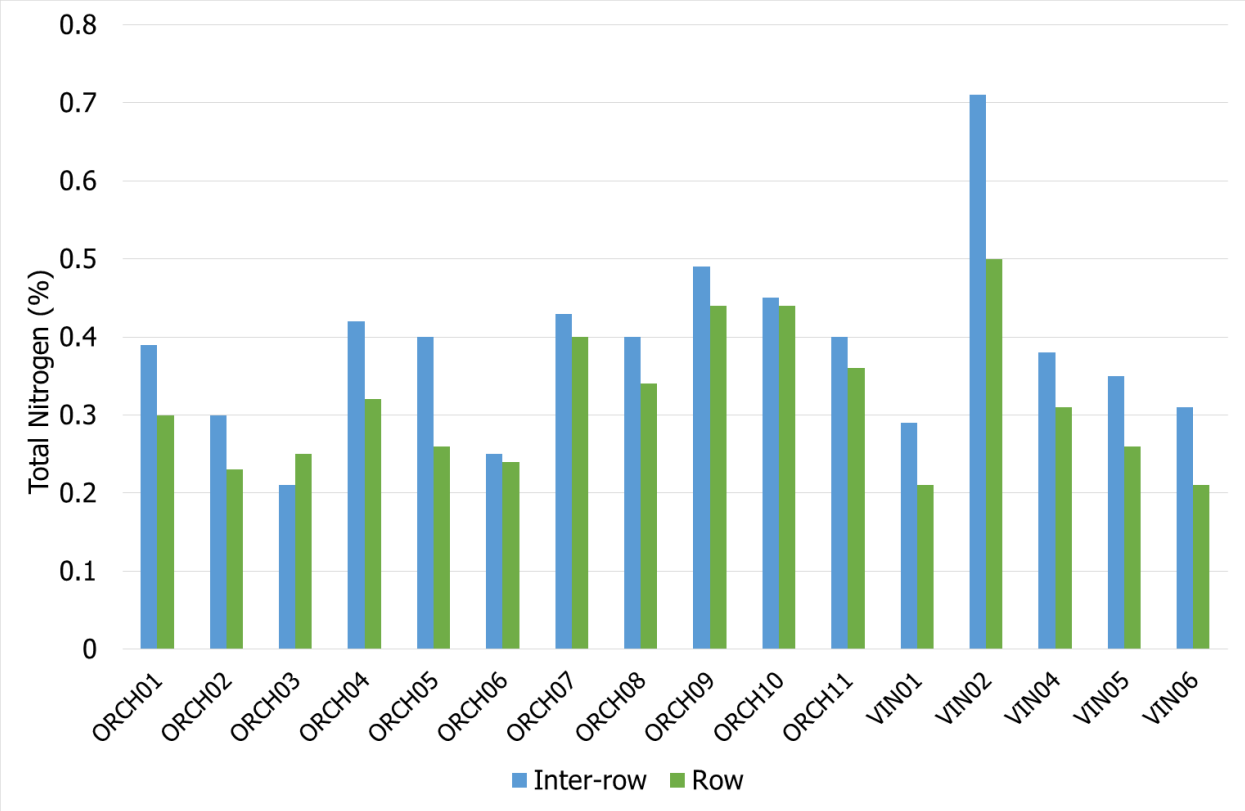

Figure 3: Soil total nitrogen for Hawke's Bay orchard and vineyard sites sampled in 2015

5.3.4 Anaerobically Mineralisable Nitrogen

Anaerobically mineralisable nitrogen (AmN) results for the orchard and vineyard soils are shown in Figure 4. All sites were within the target range for AmN and therefore the risk for N leaching is low. Fourteen of the sites had AmN values of less than 100 µg/g in the planted (row) zone, which may indicate a potential limitation for plant growth. However, as with cropping, application of mineral fertilizer means a high proportion of applied N is taken up by plants or leached and is therefore not stored in the soil which may account for these low readings.

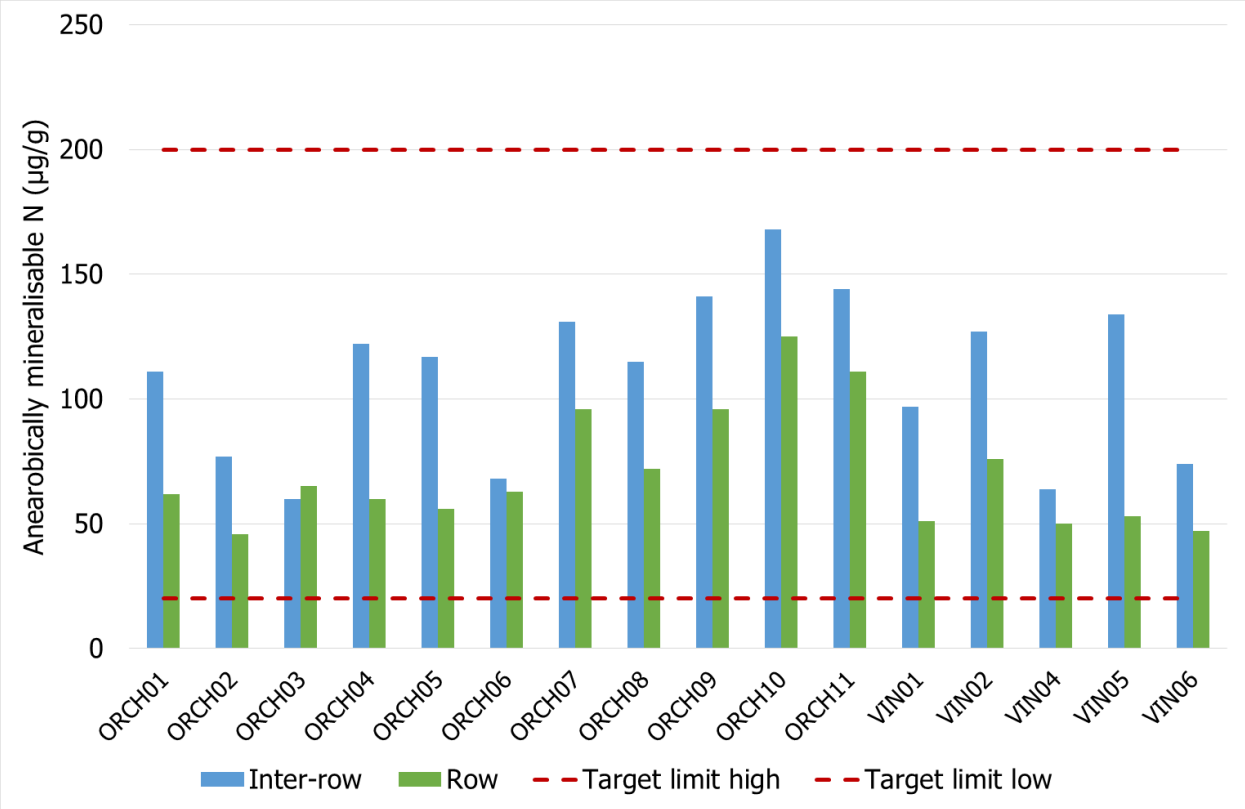

Figure 4: AmN for Hawke's Bay orchard and vineyard sites sampled in 2015

5.3.5 Available Nitrogen

When the anaerobically mineralisable N results are adjusted for each site's bulk density and expressed on a per hectare basis, the results can be expressed as Available N. Available N is shown in Figure 5 below for the orchard and vineyard sites. The available N follows the same trends as the AmN. This suggests that variations in land use management, e.g. the adoption of cultivation versus herbicide in the row areas, alter the nitrogen availability.

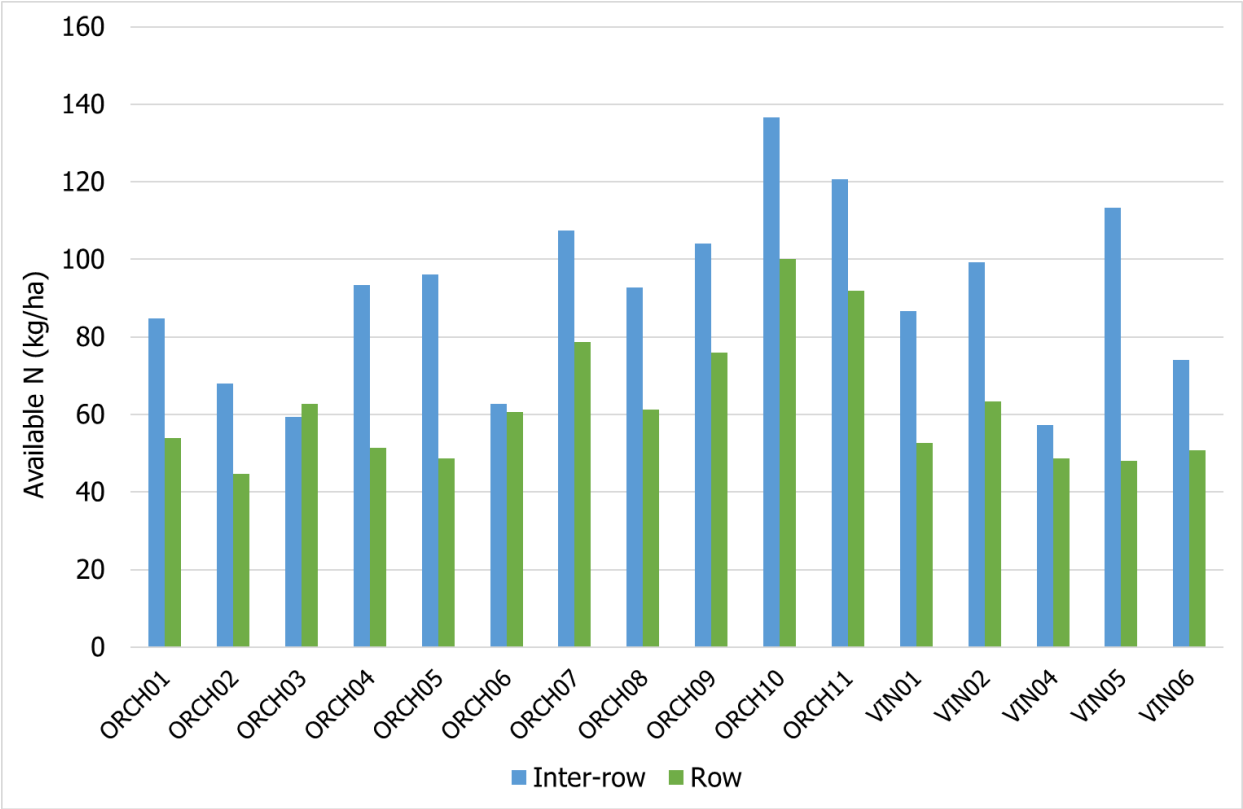

Figure 5: Available nitrogen for Hawke's Bay orchard and vineyard sites sampled in 2015

5.3.6 Olsen Phosphorus

Figure 6 shows the Olsen P results for the orchard and vineyard sites. The target range for the orchard and vineyard soils is 20 - 100 mg/L for the soil types represented. For the orchard sites, the row concentration is higher than the inter-row concentration of Olsen P. Row Olsen P for the orchards was above the lower limit for all orchard sites, however two sites (ORCH02 and ORCH04) were close to the lower limit. Only one site exceeded the upper limit (ORCH06). Site 6 was the only site to exceed the upper limit of Olsen P and may be due to post harvest fertilization.

Inter-row Olsen P levels at orchard sites were likely to be lower than row levels due to the distribution of fertilisers being focussed in the drip zone of the trees. Levels at sites ORCH02, ORCH03, ORCH04, ORCH05 and ORCH08 were below the target lower limit, representing around 45% of the orchard sites. Olsen P for site VIN02 was below the target levels, and VIN01, VIN05 and VIN06 were at the lower end of the range. The low level is likely due to crop specific fertiliser management.

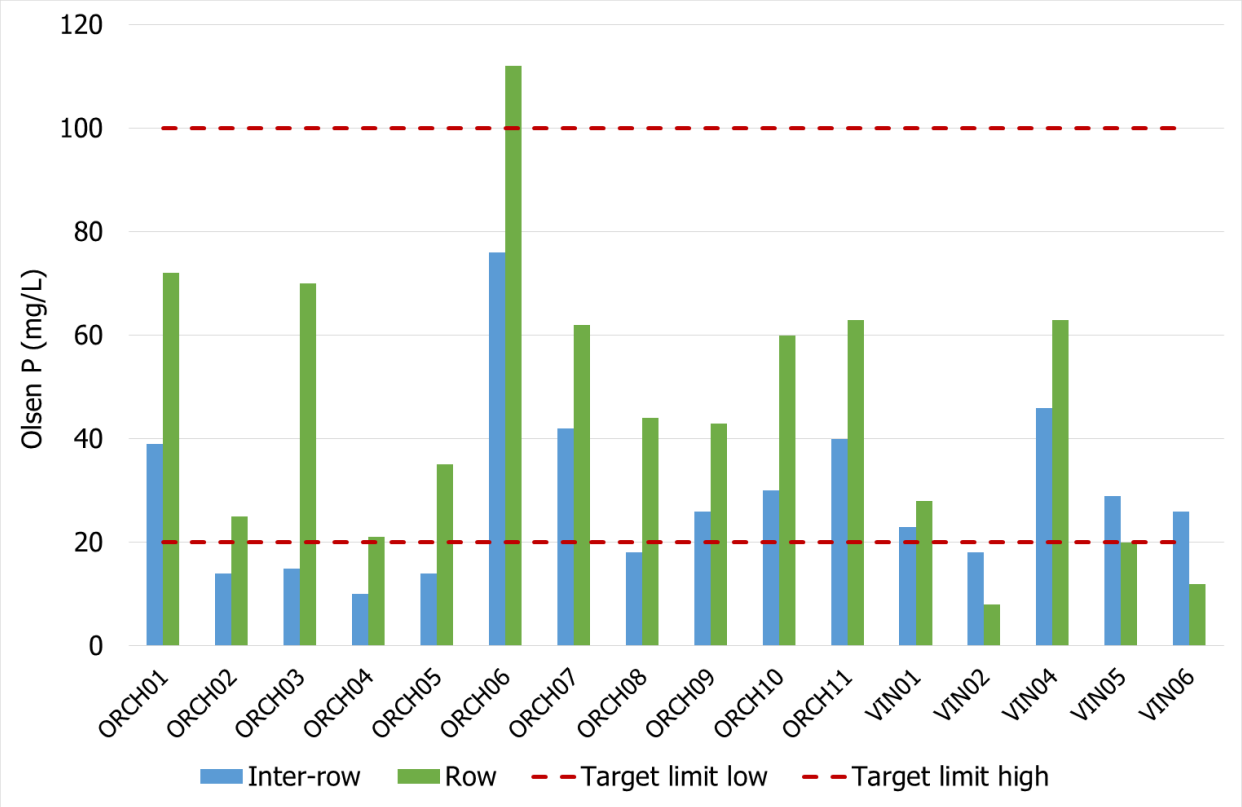

Figure 6: Olsen phosphorus for Hawke's Bay orchard and vineyard sites sampled in 2015

5.3.7 Carbon : Nitrogen Ratio

Figure 7 shows the C:N results for the orchard and vineyard sites. All the sites had a C:N ratio at a level that would favour mineralisation of nitrogen for plant uptake. Differences between the row and inter-row zones were not significant.

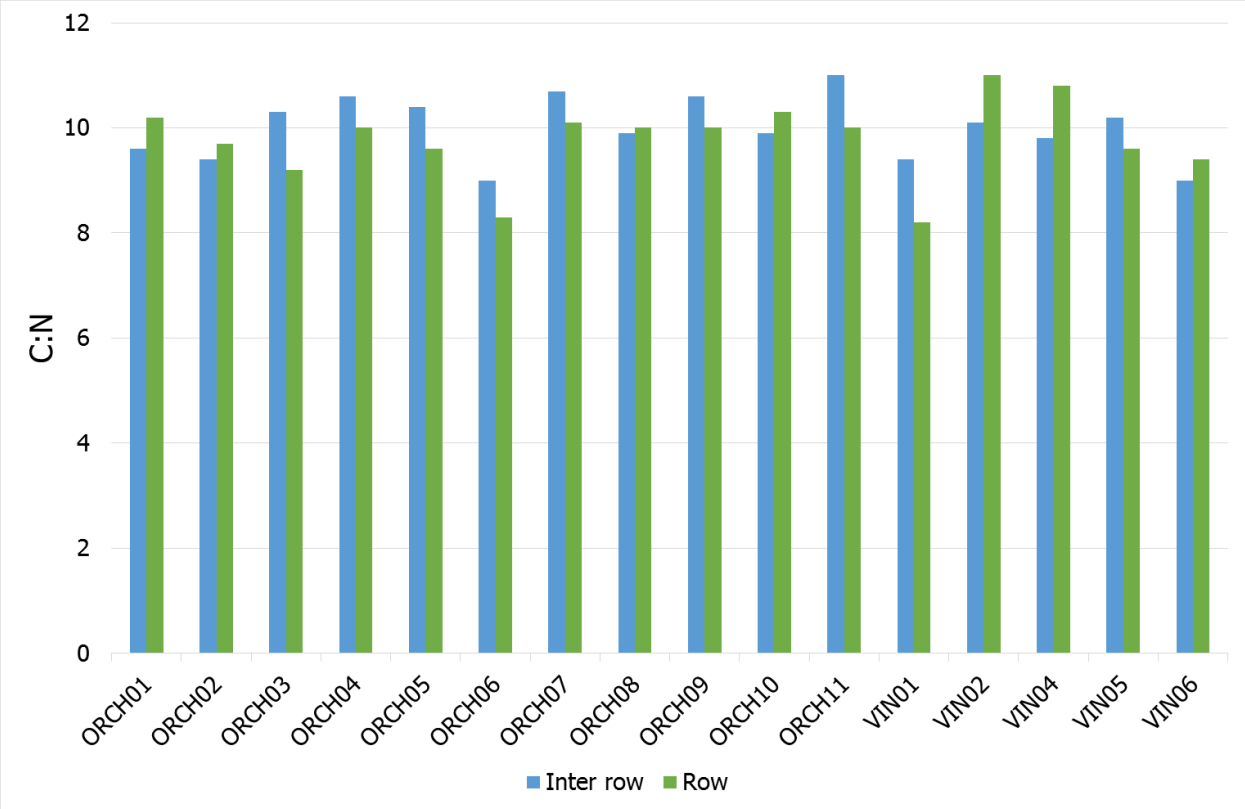

Figure 7: C:N for Hawke's Bay orchard and vineyard sites sampled in 2015

5.3.8 Bulk Density

Figure 8 shows the bulk density results for the orchard and vineyard sites. All sites were within the target range, with the exception of the inter row for ORCH03, which is marginally high. . High Bulk density at site ORCH03 is likely due to high traffic in the inter-row area, increasing the level of compaction.

The target range for soils is dependent on the soil order. Of the soil orders represented by the sites sampled the target range is:

- Recent soils: >0.7 g/cm^3 and below 1.4g/cm^3; and

Brown, Gley soils: >0.6 g/cm^3 and below 1.4g/cm^3 (only VIN02 & VIN04 were on these soils)

Figure 8: Bulk density for Hawke's Bay orchard and vineyard sites sampled in 2015

5.3.9 Macroporosity

Figure 9 shows the macroporosity results for the orchard and vineyard sites. All sites were within the target range, except site VIN02 which was marginally above the recommended upper limit. This may reflect the incidence of gravel in this soil resulting in a greater volume of larger pores.

The organic apple and the cherry orchards showed increased macroporosity in the row zone. For the organic apples this is likely due to regular cultivation of the row zone for pest and weed control. Higher macroporosity for sites VIN02, VIN03 and VIN04 are likely to reflect the high gravel content of these soils and correspondingly larger pore spaces.

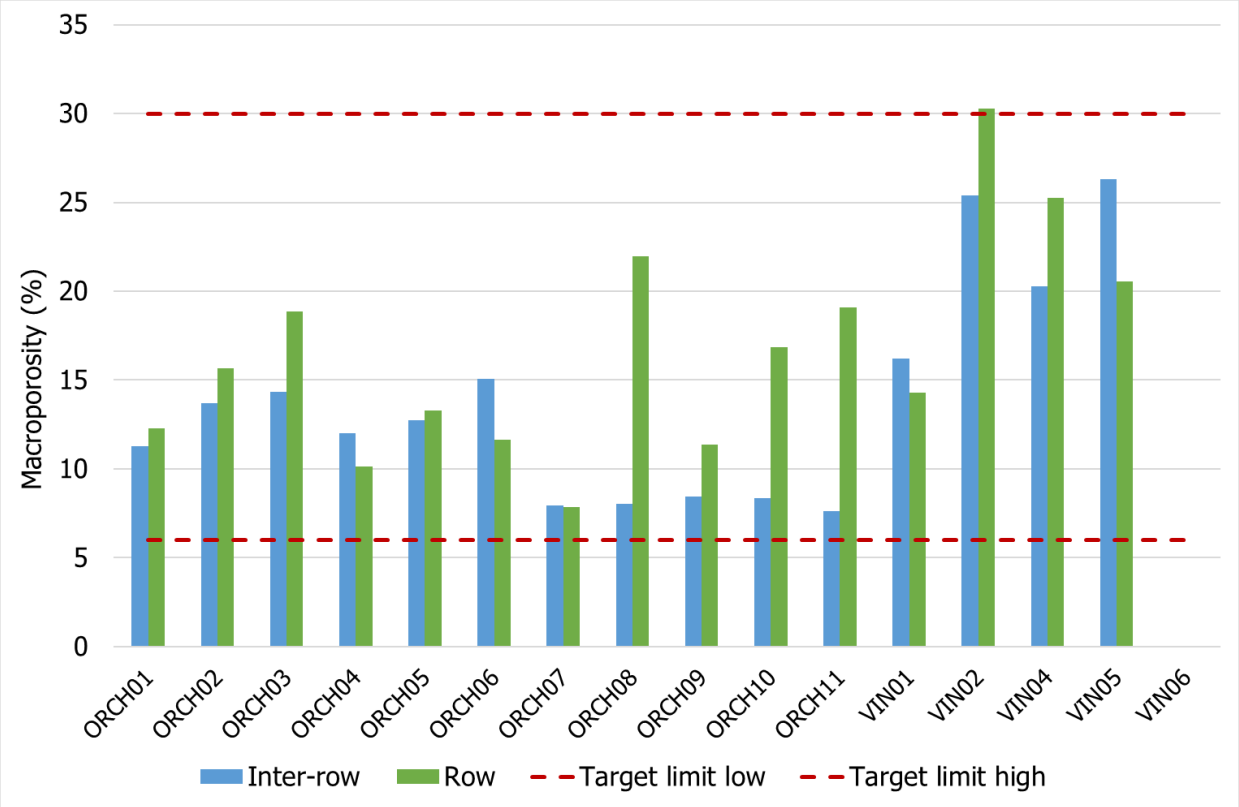

Figure 9: Macroporosity for Hawke's Bay orchard and vineyard sites sampled in 2015

5.3.10 Aggregate Stability

Figure 10 shows the aggregate stability results for the orchard and vineyard sites. There is no target range for aggregate stability, however it is considered that a value < 2 mm mean weight diameter (MWD) would influence both production and environmental factors (Sparling and Stevenson, 2008).

All but one of the inter-row sites fell below the 2 mm MWD threshold. Low MWD indicates poor aggregate stability and is often associated with areas exposed to high rates of vehicle trafficking.

Recent soils are prone to structural instability due to limited structural development and in the current sampling, recent soils represented 14 of the 16 sites. In all, 6 sites had measured MWD greater than 2 mm in the row zone, i.e. acceptable aggregate stability. The row zone is expected to be more stable than the inter-row, since disturbance of the row zone is less frequent under most management. Under organic management, the row zone is rotary hoed for pest and weed management, and therefore at greater risk of structural instability. No significant difference was noted between the organic and conventionally managed orchards.

The lowest aggregate stability was measured at the VIN01 site. Compared to the other vineyard sites, this site has finer grained and less well drained soil. Furthermore, the site has been subject to removal and replanting of vines as well as re-establishment of structural supports. Mechanical damage associated with recent replanting is likely to be the cause of the low aggregate stability.

The highest aggregate stability was measured at the VIN02 site which corresponds to a more resilient soil type than most other sites.

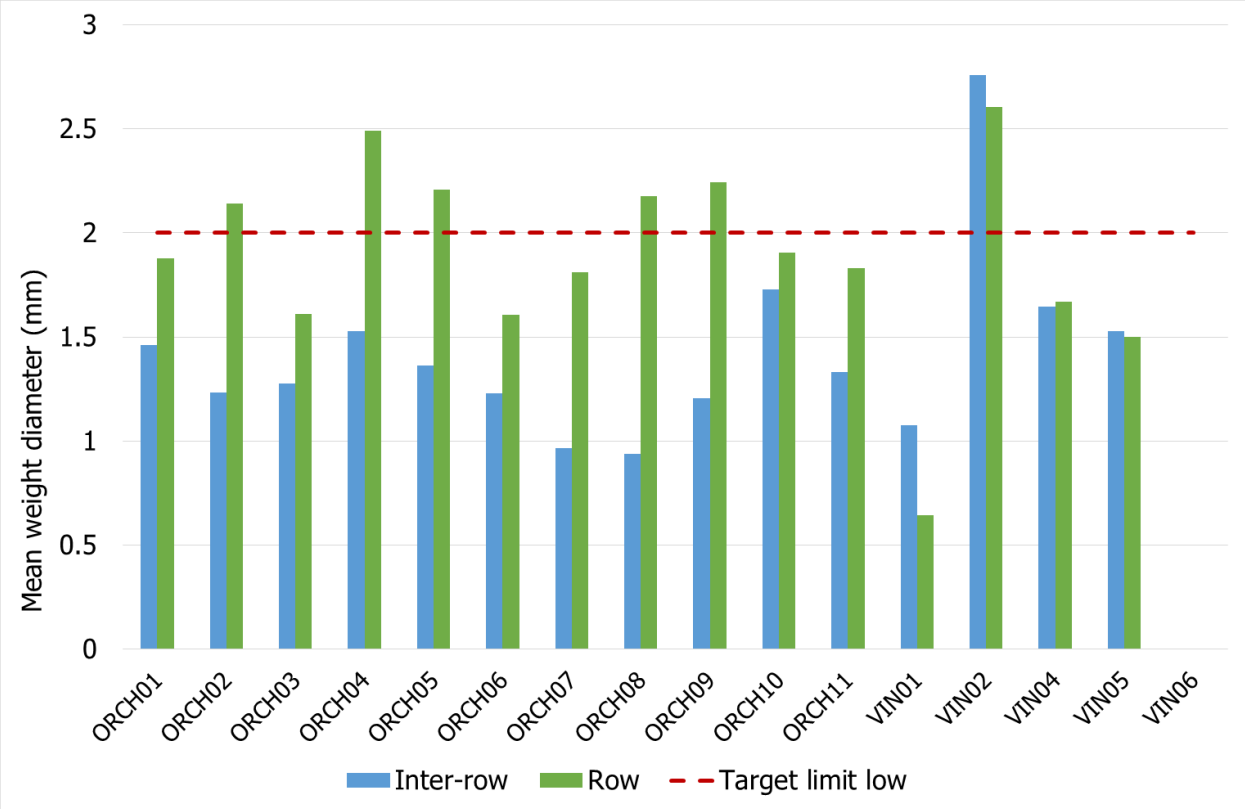

Figure 10: Aggregate stability for Hawke's Bay orchard and vineyard sites sampled in 2015

5.4 Priority Two Indicators

Priority Two indicators were not determined for this sampling round.

5.5 Priority Three Indicators

The results from the soils analysed are described as follows.

5.5.1 Organochlorine Pesticides

For most sites, all measured organochlorine pesticides were below detectable limits. Of the measured organochlorine pesticides, only DDT or its metabolites (DDD, DDE) or dieldrin were detected.

DDT/DDD/DDE was detected in soil at all except 4 sites. Figure 11 shows the sum of DDT, DDE and DDD (ΣDDT+DDE+DDD) for the orchard and vineyard sites. In the absence of a New Zealand guideline for the protection of soil health, the measured values were compared to the Canadian Council of Ministers of the Environment (CCME, 1999) guideline. The CCME guideline for soil quality for protection of environmental and human health is 0.7 mg/kg ΣDDT+DDE+DDD. Site ORCH02 exceeded the CCME guideline by greater than tenfold. Sites ORCH01 and ORCH05 were at the guideline limit in the row zone.

Dieldrin was detected at one site, being VIN01. Figure 12 shows the measured dieldrin for the orchard and vineyard soils. When compared to soil limits given in the biosolids guidelines (NZWWA and MfE, 2003) of 0.02 mg/kg, no site exceeded the guideline.

Historically, DDT and dieldrin were commonly used as pesticides. The elevated level of DDT at ORCH02 and the consistency between the row and inter-row zones may reflect the site's use for cropping prior to orcharding.

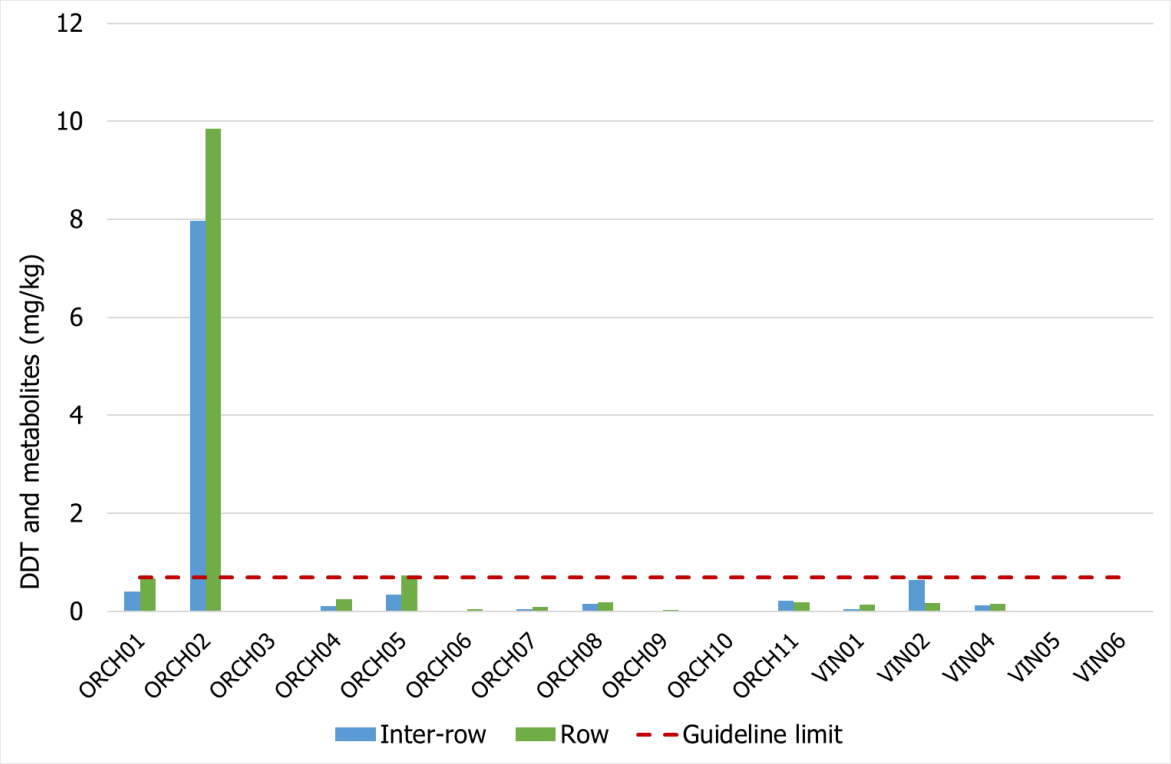

Figure 11: DDT and metabolites for Hawke's Bay orchard and vineyard sites sampled in 2015

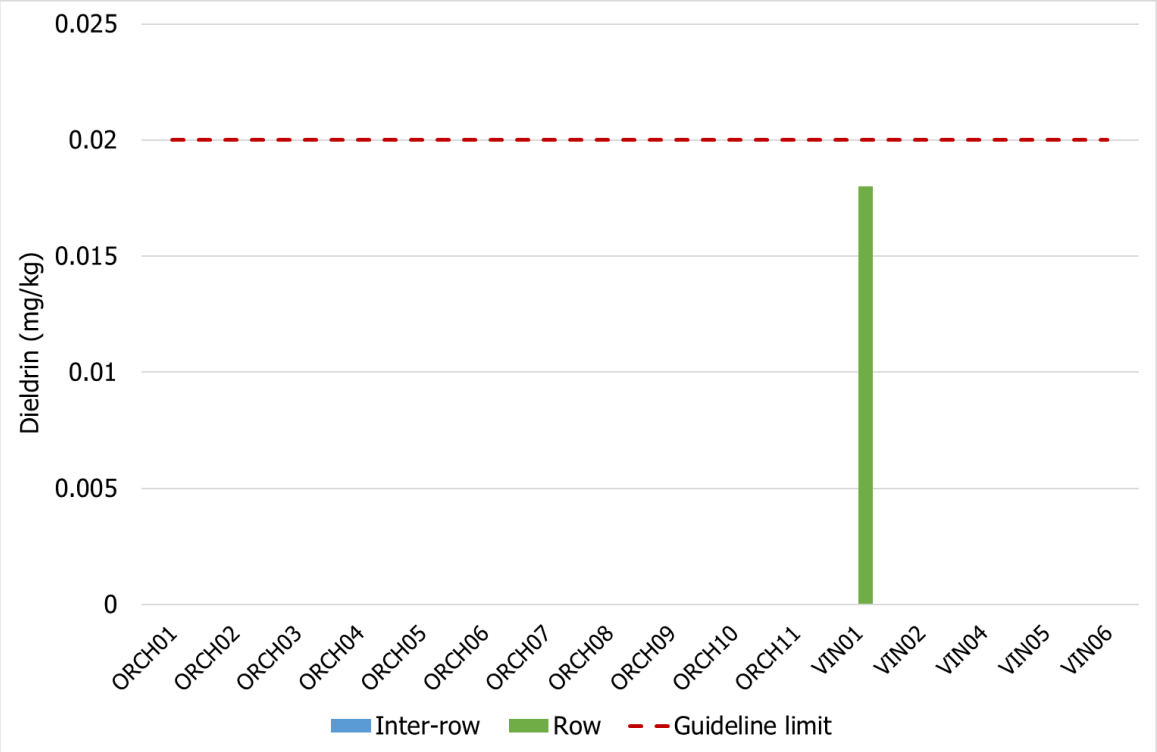

Figure 12: Dieldrin for Hawke's Bay orchard and vineyard sites sampled in 2015

5.5.2 Trace Elements

Measured levels of Cd, Cr, Pb and Ni were below levels corresponding to risk of environmental or human health at all sites (NZWWA & MfE, 2003).

ORCH11 returned fractionally elevated Hg (row) and Zn (inter-row) values. Site ORCH02 had elevated As at almost three times the guideline limit, while ORCH09 returned As values that marginally exceed the guideline values. Figure 13 shows As results for the orchard and vineyard sites.

Note: Orchard 02 showed several 'higher than guideline values' and has be resampled. The results of the extra testing appear as an addendum at the end of this report.

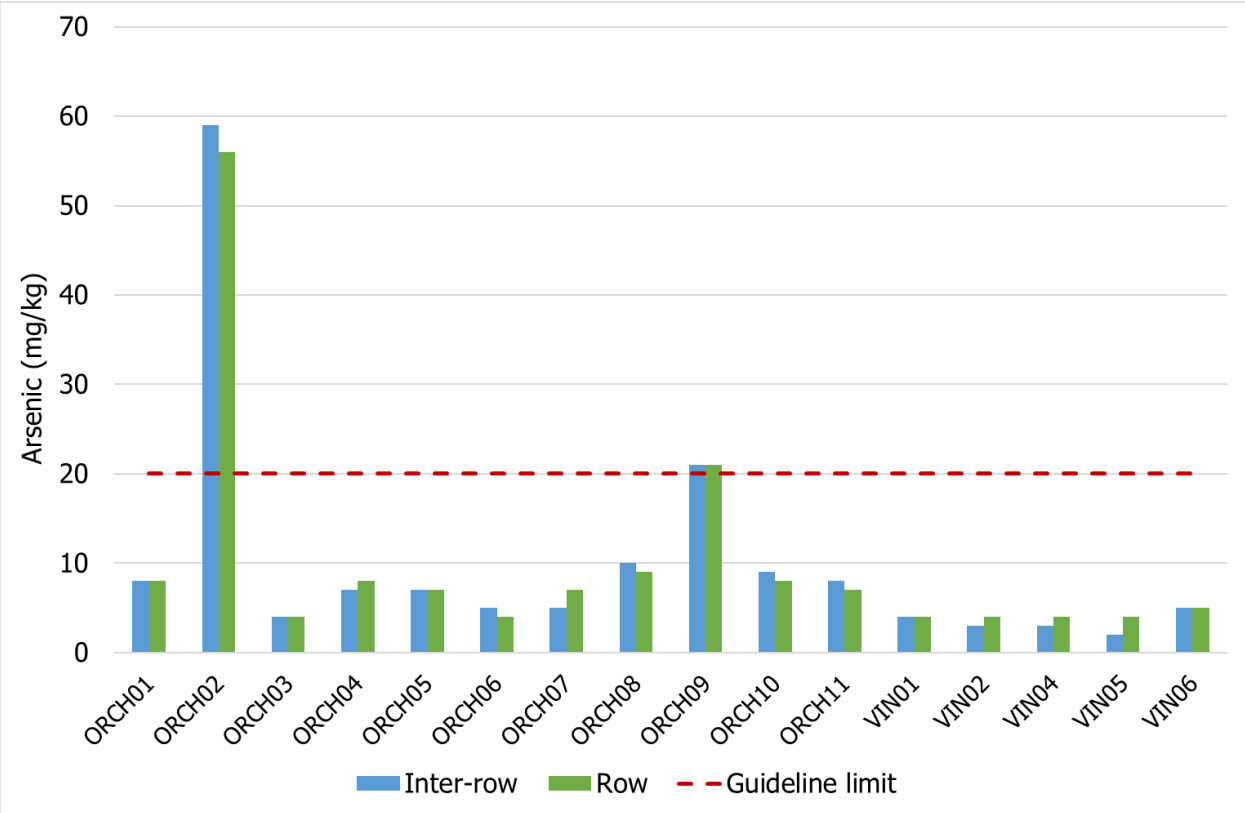

Figure 13: Arsenic for Hawke's Bay orchard and vineyard sites sampled in 2015

The presence of Cu in the soils of the orchard and vineyard sites is expected since Cu based fungicides are commonly used. Four sites returned Cu values above the guideline limits in both the row and inter-row zones. Sites ORCH02 and ORCH05 are conventionally managed apple orchards, site ORCH09 is an organically managed apple orchard and site ORCH11 is a cherry crop.

Elevated levels of Cu are a risk to soil biota and to the aquatic environment if leaching or run-off occurs.

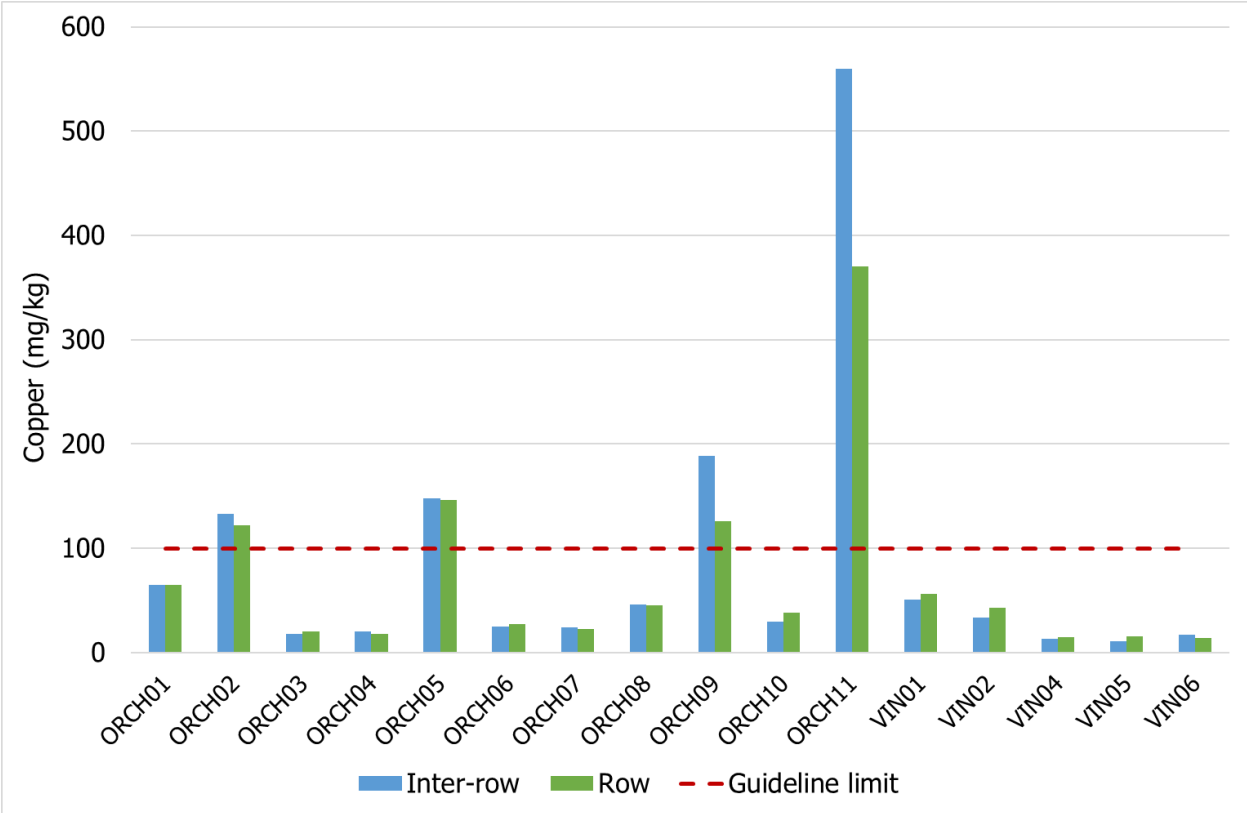

Figure 14: Copper for Hawke's Bay orchard and vineyard sites sampled in 2015

5.5.3 Fluoride (F-)

Measured F- varied from 240 - 520 mg/kg for the orchard and vineyard soils, which compares to the expected range for NZ soils of 200 - 500 mg/kg (FLRC, 2009).

As with P, high F, Cd and U results may reflect phosphate fertiliser addition. However there appears to be no clear correlation between the results for these four elements. Another potential 'natural' source of F is from volcanic ash. Hawke's Bay has been exposed to ash fall out from several volcanic eruptions in the past.

5.5.4 Uranium (U)

Measured U varied from 0.36 to 1.32 mg/kg. In general, levels are low and below the proposed Canadian soil limit of 23 mg/kg (CCME, 1999). Further information is required to determine a New Zealand limit (Taylor *et al.*, 2007).

5.6 Overall Soil Quality

The results from the soils analysed have been compared to LMF guidelines, which provides terms to categorise the results and target ranges or critical limits. The orchard and vineyard soils are considered against six priority 1 indicators of soil quality.

Seven sites met all soil quality targets for both the row and inter-row zones. When just the row was considered, 12 sites met all targets while 10 sites met all targets for the inter-row. Two sites had more than one target unmet. Figure 13 shows the proportion of priority 1 targets that were met at each site.

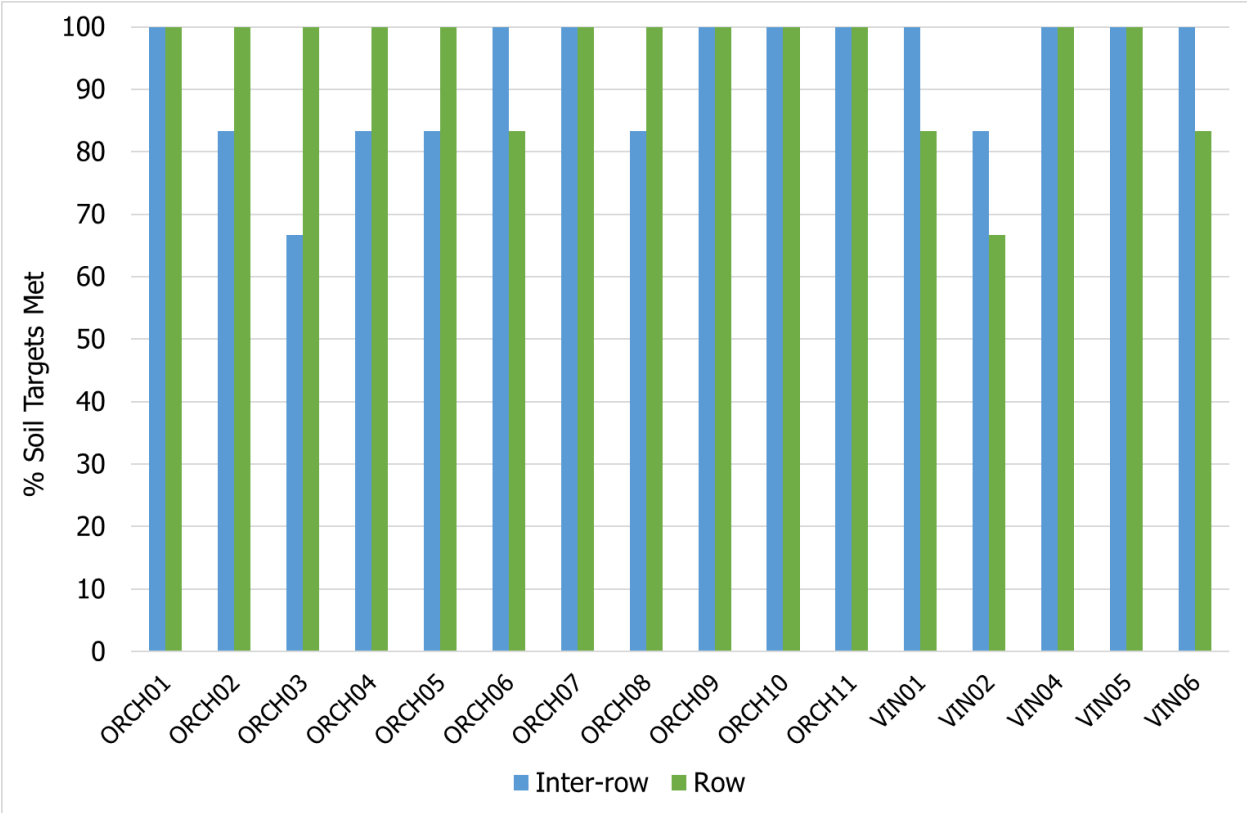

Figure 13: Proportion of priority 1 soil quality targets met for Hawke's Bay orchard and vineyard sites sampled in 2015

Soil quality indicators for which a target was not met were:

- Total carbon (VIN01 row);
- Olsen P (ORCH02 inter-row, ORCH03 inter-row, ORCH04 inter-row, ORCH05 inter-row, ORCH06 row, ORCH08 inter-row, VIN02 row, VIN02 inter-row, VIN06 row);
- Bulk density (ORCH03 row); and
- Macroporosity (VIN02 row).

Of interest for orchard and vineyard soils are the Priority 3 indicators as described in Section 5.5. In particular, Cu is considered to be an important parameter since it is in common use as a fungicide in both orchards and vineyards, under conventional and organic management. Elevated levels of Cu in 25% of the sites indicates that future monitoring of Cu is essential.

5.7 Changes in Soil Quality over Time

There are no orchard sites in this sampling round that can be directly compared to previous sampling rounds. However, Orchard 02 showed several 'higher than guideline values' and has be resampled. The results of the extra testing appear as an addendum at the end of this report. The vineyard sites VIN01 to VIN04 can be directly compared to sampling from 2010, while VIN05 and VIN06 are new sites. Table 5 gives a summary of previously reported results compared to the current (2015) round.

Table 5: Comparative soil sites from 2010 and 2015

		2015 results		2010 results		Difference %	
Site ID	**Parameter**	**Inter-row**	**Row**	**Inter-row**	**Row**	**Inter-row**	**Row**
VIN01	pH	6.5	5.9	6.5	6.2	0	-5
	Total C	2.7	1.7	2.7	1.8	0	-6
	AmN	97	51	97	28	0	45
	Olsen P	23	28	23	30	0	-7
	Bulk density	1.25	1.38	1.39	1.46	-11	-6
	Macroporosity	16	14	12	14	25	0
VIN02	pH	5.9	6.7	6.1	6.3	-3	6
	Total C	7.1	5.4	6.7	4.7	6	13
	AmN	127	76	123	39	3	49
	Olsen P	18	8	15	11	17	-38
	Bulk density	0.88	0.81	0.86	0.81	2	0
	Macroporosity	25	30	23	30	8	0
VIN04	pH	6.5	7.6	6.5	6.9	0	9
	Total C	3.8	3.4	3.7	3.5	3	-3
	AmN	64	50	60	59	6	-18
	Olsen P	46	63	45	48	2	24
	Bulk density	1.14	1.07	1.14	1.03	0	4
	Macroporosity	20	25	18	25	10	0

Due to the heterogeneous nature of soils, both spatially and seasonally, a change of greater than ±15% is needed to indicate a change in soil quality. For most re-sampled sites and parameters, the difference is less than 15%. For site VIN01 row, a 45% increase is noted in AmN. This is an improvement from the previous low measured result. For VIN01 inter-row, macroporosity has increased by 25% and is also an improvement.

For site VIN02 row, a 49% increase in AmN is an improvement in the soil from its previous low status.

For site VIN04 row, an 18% percent reduction in AmN and 24% increase in Olsen P are not considered to represent a change in soil quality. Changes in AmN for all sites are likely due to seasonal variation with the 2010 samples having been taken in spring, while 2015 samples were taken in autumn. Similarly, the Olsen P is likely to have been influenced by the stage of the growing season.

It is noted that VIN01 had the only measured Dieldrin of the sites (0.018 mg/kg), and this was measured at similar levels in 2010 (0.016 mg/kg). It should be noted that this level does not exceed the guideline limit.

In general, it is considered that no significant change in soil quality for the re-sampled sites has occurred between 2010 and 2015.

6 DISCUSSION

As outlined in Section 3.5, in previous soil quality monitoring, soils across all land uses were identified as having poor aggregate stability. From the current (2015) sampling round, it is considered that aggregate stability remains a concern for orchard and vineyard soils in Hawke's Bay. This indicates that soil properties of concern for orchard and vineyard sites are predominantly physical properties, likely to be impacted by frequent vehicle passes or lack of vegetative cover (bare ground).

In general, most soil quality indicators are met for most sites evaluated, suggesting that the quality of orchard and vineyard soils is acceptable. The exceptions to this relate to aggregate stability and Olsen P, which are discussed below.

Aggregate stability for orchard and vineyard soils is of concern. The analytical results are generally low, particularly in the inter-row zones. The high incidence of low MWD (see section 3.1.10) in inter-row zones indicates that soils used for orcharding are susceptible to soil structural damage from frequent traffic. Higher MWD, and therefore better aggregate stability for the same sites in the row zone may suggest that this is not limiting to the growth of the trees or vines. It should be noted that soils with poor aggregate stability are susceptible to sheet, rill and wind erosion.

Soils with better structure such as the Takapau silt loam (Brown Soil) tended to have better aggregate stability. Poor aggregate stability is slow to recover, but further damage can be minimised if vegetation in the inter-row is maintained and fertilisers which encourage biological activity are chosen.

Low Olsen P indicates limitations to plant growth which are likely to be addressed by planned fertiliser regimes. It is expected that fertility will vary throughout the cropping cycle. Further reductions in levels may impact on the ability of the soil to support a healthy biota, and therefore it is desirable to maintain the current levels.

Contaminant levels in the orchard and vineyard soils were predominantly undetectable, with the exception of DDT/DDD/DDE, which was measured at several sites, with one site exceeding the guideline limit. This is in line with previously reported observations (MacAskill, 2004). Two sites recorded values in excess of the guideline limit. For both DDT and As, it is possible that their elevated levels are due to historic land use practices but more detail will be required to determine this. The presence of Cu warrants continued monitoring as it is current practice to use Cu based fungicides, and therefore has potential for accumulation.

7 CONCLUSIONS

- In general, soil quality in Hawke's Bay orchard and vineyard sites is acceptable.
- Soil fertility is expected to be appropriate for the orchard and vineyard crops grown, and will vary seasonally due to the cropping cycle. While every attempt to sample immediately following harvest was made, some variance may be expected due to post-harvest fertiliser applications at some sites.
- Soil aggregate stability is a concern for trafficked areas on orchard and vineyard sites, in particular those sites with '*Recent Soils*', which are common for this land use.

8 RECOMMENDATIONS

- Managers of the properties sampled should be informed of the soil quality on their properties and where remedial activity is recommended, HBRC may provide advice on potential management strategies.
- Copper levels in soils of orchards and vineyards should continue to be monitored, and consideration of strategies to avoid accumulation in the soil should be considered.
- Areas subject to high traffic should be maintained in vegetative cover to avoid reduction in aggregate stability and, in turn, loss of soil.
- The same sites should be resampled within 5 years and at ongoing intervals to develop a long-term record of soil quality indicator performance over time for orchards and vineyards.

9 ADDENDUM: RESAMPLING OF ORCH 2

Soil quality monitoring of orchard and vineyard sites found very high levels of arsenic (As) and total DDT at site ORCH2 (Fig. 11 ,Fig.13). Levels of total As were almost three times the New Zealand *Water and Wastes Association (NZWWA) guideline* limit of 20 mg/kg. Total DDT levels were over ten times the *Canadian Council of Ministers of the Environment (CCME) guideline* value of 0.7 mg/kg.

To verify the high levels of As and DDT at site ORCH2, HBRC resampled the site and tested soil samples for heavy metals and organochlorine pesticides. The site was resampled along the original transect and an additional 2 transects (*Transect 1* and *Transect 2*) were sampled at a distance of 60 to 70 m apart (Fig.A). Both the planted row and inter-row areas were sampled at each sampling transect as per the methods outlined in section 4.

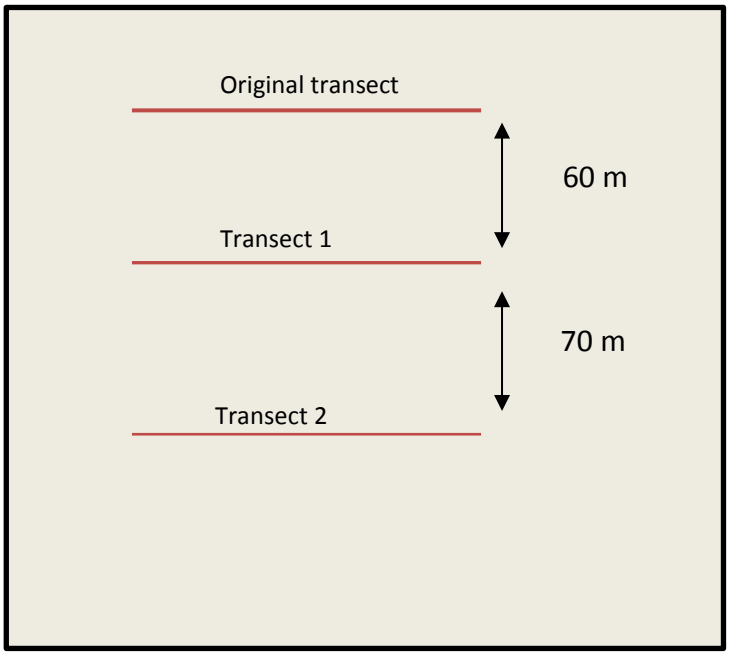

Figure A. A schematic of the sampling strategy used to resample site ORCH2. Transects were set up in the row and inter-row areas for each sampling zone to give a total of 6 transects.

Arsenic

Soil testing results indicate As levels are not as high as that of the original sampling in 2015, but still considerably higher than the guideline limit (Fig. B). All resampled and newly sampled transects had As levels that were at least twice the NZWWA guideline limit, suggesting that high levels of As are present at an elevated level throughout the orchard.

A likely reason for the elevated values for arsenic is that arsenic based pesticides and herbicides were widely used in the horticultural industry in New Zealand before being phased out in the 1970's. Lead arsenate (LA) was the most extensively used pesticide

and is known to remain in soils for a long time after application. When LA enters the soil profile it dissasociates into Pb and As. Elevated levels of Pb were also found (although well below NZWAA guidline values) which supports this theory. However, the persistence and availability of trace metals such as Pb and As to plants is highly dependent on soil properties such as pH and mineralogy.

A possible concern regarding high levels of As at site ORCH2 is its uptake by apple trees and accumulation in the fruit with subsequent consumption of the fruit by humans. Although As in LA-contaminated soils is phytoavailable and can be phytotoxic, plants do not in generally absorb appreciable amounts of As and convey it to edible plant tissues (Peryea, 1998). Testing of apple samples from this site found **no** detectable traces of heavy metals, which rules out human health risk from consumption of the apples.

Another concern could be that under the correct soil and environmental conditions, trace metals such as As could leach from soil into ground water. To aliviate this concern, HBRC also collected and tested ground water samples from nearby bores. All heavy metal concentrations were beneath detectable levels. HBRC will continue to monitor the site to ensure any changes in trace metal concentrations are detected.

The elevated levels of As at site ORCH2 will impact the suitability of the site in its current state for future residential development.

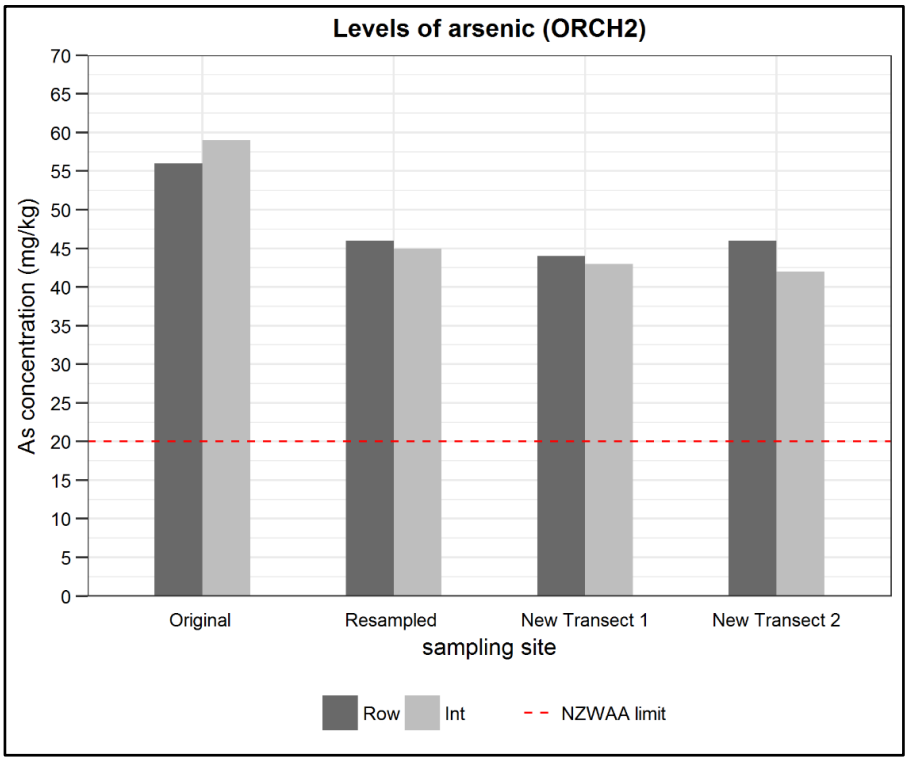

Figure B. Arsenic concentrations for sampled row and inter-row areas at each sampling transect.

DDT

DDT is an organochlorine pesticide that was widely used throughout New Zealand, before eventually being banned in 1989. DDT is a highly persistent chemical and can remain in

the soil environment for long periods. The main risk to human health is through ingestion of contaminated soil or consuming meat, eggs or vegetables raised on highly contaminated sites. Apple samples from this site were tested for a whole suite of organochlorine pesticides and DDT compounds were below detectable limits.

Both the retested and newly established transects had levels of DDT considerably lower than the levels measured in the original sampling (Figure C). The elevated levels found during the original sampling was likely due to a hotspot area which was not sampled during the second round of sampling. However, all recently sampled areas (resampled, new transect1 and new transect2) were above the CCME guideline level of 0.7 mg/kg. Surface runoff, volatilization, photolysis and biodegradation of DDT could have possibly contributed to the decreased level of DDT. Further monitoring is needed to understand the long-term change of DDT levels at this site.

The levels of DDT at site ORCH2 will impact the suitability of the site in its current state for future residential development.

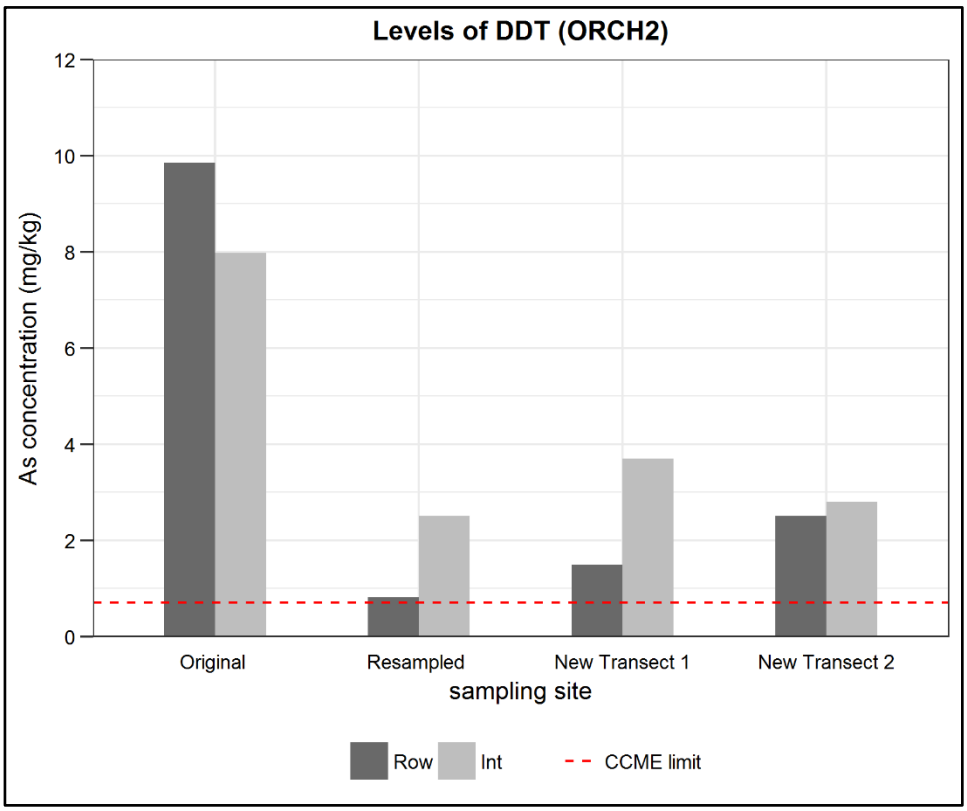

Figure C. DDT concentrations for sampled row and inter-row areas at each sampling transect.

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11 APPENDICES

Appendix A Soil Descriptions
Appendix B Laboratory Analysis Reports
Addendum Orchard 02 re-test results.

APPENDIX A

Soil Descriptions

Appendix A: Soil Descriptions

ORCH 1

Soil	Hastings
	silt loam
Transect length and direction	50 m
Classification	Mottled Orthic Recent soil
Land use	Orchard
Date sampled	11/05/2015
Land use history	Orchard for 20 years, cropping prior
Present vegetation	10yo apples with understory pasture
Slope degrees	0-3
Landform	Floodplain
Annual rain (mm)	800 mm
Elevation (m)	3
Parent material	Sedimentary and ash alluvium
Drainage	Poorly drained
Topsoil depth (cm)	20
Limiting horizon	None
Sampled by	KH/KB

Profile	Depth (cm)	Description
	0 - 5	Very dark greyish brown (10YR 3/2) silt loam; slightly sticky; moderately plastic; moderately pedal; fine polyhedral peds; weak soil strength; common medium roots; indistinct smooth boundary; slightly moist.
	5 - 20	Very dark greyish brown (10YR 3/2) silt loam; slightly sticky; moderately plastic; moderately pedal; fine polyhedral peds; weak soil strength; few fine roots; indistinct occluded boundary; slightly moist.
	20 - 45	Olive grey (5Y 5/2) clayey silt; common fine (7 YR 5/6) mottles; slightly sticky; moderately plastic; moderately pedal; fine polyhedral peds; weak soil strength; very few fine roots; distinct wavy boundary; slightly moist.
	45 - 75+	Light brownish grey (10YR 6/2) silt; common fine (7 YR 5/6) mottles; slightly sticky; moderately plastic; apedal massive; slightly firm soil strength; very few fine roots; dry.

ORCH 2

Soil	Karamu
	Silt loam
Transect length and direction	50 m
Classification	Typic Fluvial Recent
Land use	Orchard
Date sampled	11/05/2015
Land use history	Orchard for 50 years
Present vegetation	10yo Apples with pasture inter-row
Slope degrees	0-3
Landform	Floodplain
Annual rain (mm)	800 mm
Elevation (m)	3
Parent material	Sedimentary alluvium
Drainage	Well drained
Topsoil depth (cm)	26
Limiting horizon	None
Sampled by	KH/KB

Profile	Depth (cm)	Description
	0 - 26	Very dark grey (10YR 3/1) silt loam; non-sticky; moderately plastic; weakly pedal; medium polyhedral peds; firm soil strength; common fine roots; distinct irregular boundary; slightly moist.
	26 - 39	Olive (5Y 4/4) sandy loam; non-sticky; slightly plastic; apedal massive; medium blocky peds; slightly firm soil strength; common fine roots; indistinct wavy boundary; slightly moist.
	39 - 70	Olive (5Y 5/3) loamy sand; common fine (7 YR 5/6) mottles; non-sticky; slightly plastic; apedal massive; coarse blocky peds; firm soil strength; few fine roots; indistinct wavy boundary; slightly moist.
	70 - 77+	Olive (5Y 5/3) sandy loam; non-sticky; slightly plastic; apedal massive; coarse blocky peds; firm soil strength; few fine roots; slightly moist.

ORCH 3

Soil	Flaxmere
	Sandy silt
Transect length and direction	50 m
Classification	Mottled Fluvial Recent
Land use	Orchard
Date sampled	11/05/2015
Land use history	Orcharding
Present vegetation	11yo apples with inter-row pasture
Slope degrees	0-3
Landform	Floodplain
Annual rain (mm)	800
Elevation (m)	3
Parent material	Alluvium
Drainage	Imperfectly drained
Topsoil depth (cm)	33
Limiting horizon	None
Sampled by	KH/KB

Profile	Depth (cm)	Description
	0 - 33	Dark greyish brown (10YR 4/2) sandy silt; non-sticky; non-plastic; apedal earthy; weak soil strength; common fine and medium roots; indistinct smooth boundary; dry.
	33 - 47	Brown (10YR 5/3) silty sand; common medium (orange brown) mottles; non-sticky; non-plastic; apedal massive; weak soil strength; few fine and medium roots; indistinct smooth boundary; dry.
	47 - 63	Grey (10YR 5/1) sand; few medium (orange brown) mottles; non-sticky; non-plastic; apedal single grain; weak soil strength; few fine and medium roots; indistinct smooth boundary; dry.
	63 - 80	Light olive brown (2.5Y 5/3) loamy sand; common medium (orange brown) mottles; non-sticky; non-plastic; apedal single grain; weak soil strength; few fine and medium roots; indistinct smooth boundary; dry.
	80 - 85+	Light olive brown (2.5Y 5/3) fine sand; few medium (orange brown) mottles; non-sticky; non-plastic; apedal single grain; weak soil strength; few fine and medium roots; dry .

ORCH 4

Soil	Pakowhai
	Clayey silt
Transect length and direction	50 m
Classification	Mottled Fluvial Recent
Land use	Orchard
Date sampled	12/05/2015
Land use history	Apples since 1990's
Present vegetation	~20yo apples with inter-row pasture
Slope degrees	0-3
Landform	Floodplain
Annual rain (mm)	800
Elevation (m)	3
Parent material	Sedimentary alluvium
Drainage	Imperfectly drained
Topsoil depth (cm)	26
Limiting horizon	None
Sampled by	KH/KB

Profile	Depth (cm)	Description
	0 - 26	Dark greyish brown (10YR 4/2) clayey silt; very sticky; very plastic; apedal massive; slightly firm soil strength; common fine and medium roots; indistinct smooth boundary; moist.
	26 - 42	Very dark grey (10YR 3/1) clayey silt; few fine (7.5YR 5/6) mottles; very sticky; moderately plastic; apedal massive; slightly firm soil strength; few fine and medium roots; distinct occluded boundary; moist.
	42 - 85+	Dark greyish brown (2.5Y 4/2) non-gravelly silty clay; common fine (7.5YR 5/6) mottles; very sticky; moderately plastic; apedal massive; firm soil strength; few fine and medium roots; moist.

ORCH 5

Soil	Pakowhai
	Clay loam
Transect length and direction	50 m
Classification	Mottled Fluvial Recent
Land use	Orchard
Date sampled	12/05/2015
Land use history	Refer to Land Use Questionnaire
Present vegetation	Apples with inter-row pasture
Slope degrees	0-3
Landform	Floodplain
Annual rain (mm)	800
Elevation (m)	17
Parent material	Sedimentary alluvium
Drainage	Imperfectly drained
Topsoil depth (cm)	8
Limiting horizon	None
Sampled by	KH/KB

Profile	Depth (cm)	Description
	0 - 8	Very dark greyish brown (10YR 3/2) clay loam; very sticky; very plastic; weakly pedal; fine polyhedral peds; weak soil strength; many fine and medium roots; distinct smooth boundary; wet.
	8 - 30	Olive brown (2.5Y 4/4) clay loam; few fine (orange brown) mottles; very sticky; very plastic; weakly pedal; fine polyhedral peds; firm soil strength; few medium roots; indistinct smooth boundary; wet.
	30 - 40	Olive brown (2.5Y 4/3) clayey silt; few fine (orange brown) mottles; moderately sticky; moderately plastic; weakly pedal; fine polyhedral peds; firm soil strength; few medium roots; indistinct smooth boundary; wet.
	40 - 70	Light olive brown (2.5Y 5/3) silt loam; few fine (orange brown) mottles; moderately sticky; moderately plastic; weakly pedal; very fine polyhedral peds; slightly firm soil strength; few medium roots; indistinct smooth boundary; wet.
	70 - 100+	Very dark greyish brown (10YR 3/2) non-gravelly clayey silt; few fine (orange brown) mottles; moderately sticky; moderately plastic; weakly pedal; very fine polyhedral peds; slightly firm soil strength; few medium roots; wet.

ORCH 6

Soil	Farndon
	Silt loam
Transect length and direction	50 m
Classification	Mottled-saline Fluvial Recent
Land use	Orchard
Date sampled	12/05/2015
Land use history	Refer to Land Use Questionnaire
Present vegetation	Apples with inter-row pasture
Slope degrees	0-3
Landform	Uplifted estuarine area
Annual rain (mm)	800
Elevation (m)	1
Parent material	Lacustrine of sedimentary origin
Drainage	Moderately well drained
Topsoil depth (cm)	25
Limiting horizon	None
Sampled by	KH/KB

Profile	Depth (cm)	Description
	0 - 25	Dark yellowish brown (10YR 4/4) silt loam; slightly sticky; non-plastic; weakly pedal; fine polyhedral peds; weak soil strength; few fine and medium roots; distinct wavy boundary; slightly moist.
	25 - 36	Dark yellowish brown (10YR 3/6) sandy loam; slightly sticky; non-plastic; apedal single grain; weak soil strength; few fine and medium roots; distinct wavy boundary; slightly moist.
	36 - 59	Greyish brown (2.5Y 5/2) sandy loam; non-sticky; non-plastic; apedal massive breaking to single grain; weak soil strength; few fine and medium roots; distinct wavy boundary; slightly moist.
	59 - 67	Dark yellowish brown (10YR 4/4) sandy loam; few fine (orange brown) mottles; non-sticky; non-plastic; apedal massive breaking to single grain; weak soil strength; few fine and medium roots; distinct wavy boundary; slightly moist.
	67 - 90+	Greyish brown (2.5Y 5/2) non-gravelly sandy loam; non-sticky; non-plastic; apedal single grain; weak soil strength; few fine and medium roots; slightly moist.

ORCH 7

Soil	Mangateretere
	Clay loam
Transect length and direction	50 m
Classification	Argillic Perch-gley Pallic
Land use	Orchard
Date sampled	12/05/2015
Land use history	Refer to Land Use Questionnaire
Present vegetation	Kiwifruit with long (20 cm) pasture inter-row
Slope degrees	0-3
Landform	Floodplain
Annual rain (mm)	800
Elevation (m)	3
Parent material	Sedimentary alluvium
Drainage	Poorly drained
Topsoil depth (cm)	9
Limiting horizon	Pan
Sampled by	KH/KB

Profile	Depth (cm)	Description
	0 - 9	Very dark grey (10YR 3/1) silt loam; slightly sticky; slightly plastic; weakly pedal; fine polyhedral peds; weak soil strength; common fine and medium roots; indistinct wavy boundary; wet.
	9 - 22	Dark greyish brown (2.5Y 4/2) clay loam; few fine (10YR 4/6) mottles; slightly sticky; slightly plastic; weakly pedal; fine polyhedral peds; slightly firm soil strength; common fine and medium roots; indistinct smooth boundary; wet.
	22 - 48	Greyish brown (2.5Y 5/2) y silty clay; common fine (10YR 4/6) mottles; very sticky; moderately plastic; apedal massive breaking to fine nut and crumb; slightly firm soil strength; few fine and medium roots; abrupt smooth boundary; wet.
	48 - 60	Dark grey (2.5Y 4/1) clayey silt; moderately sticky; moderately plastic; apedal massive breaking to fine nut and crumb; slightly firm soil strength; very few fine and medium roots; indistinct smooth boundary; wet.
	60 - 80+	Greyish brown (2.5Y 5/2) silty clay; common fine (10YR 4/6) mottles; moderately sticky; moderately plastic; apedal massive breaking to fine nut and crumb; firm soil strength; very few fine roots; wet.

ORCH 8

Soil	Pakowhai
	Silt loam
Transect length and direction	50 m
Classification	Mottled Fluvial Recent
Land use	Orchard
Date sampled	13/05/2015
Land use history	Refer to Land Use Questionnaire
Present vegetation	Apples with inter-row pasture (Organic certification)
Slope degrees	0-3
Landform	Floodplain
Annual rain (mm)	800
Elevation (m)	3
Parent material	Sedimentary alluvium
Drainage	Imperfectly drained
Topsoil depth (cm)	28
Limiting horizon	None
Sampled by	KH/KB

Profile	Depth (cm)	Description
	0 - 28	Dark yellowish brown (10YR 3/4) silt loam; non-sticky; slightly plastic; weakly pedal; fine polyhedral peds; slightly firm soil strength; few medium roots; diffuse smooth boundary; slightly moist.
	28 - 42	Olive brown (2.5Y 4/3) fine sand; few fine mottles; non-sticky; non-plastic; apedal single grain; weak soil strength; few medium roots; distinct smooth boundary; slightly moist.
	42 - 60	Very dark grey (10YR 3/1) clay loam; very sticky; very plastic; moderately pedal; fine polyhedral peds; slightly firm soil strength; few medium roots; diffuse smooth boundary; slightly moist.
	60 - 90+	Dark grey (2.5Y 4/1) clay; many fine (7.5YR 4/6) mottles; very sticky; very plastic; apedal massive breaking to blocky; firm soil strength; few medium roots; slightly moist.

ORCH 9

Soil	Hastings
	Silt loam
Transect length and direction	50 m
Classification	Mottled Orthic Recent soil
Land use	Orchard
Date sampled	13/05/2015
Land use history	Refer to Land Use Questionnaire
Present vegetation	Apples with pasture inter-row (organic certification)
Slope degrees	0-3
Landform	Floodplain
Annual rain (mm)	800 mm
Elevation (m)	3
Parent material	Sedimentary and ash alluvium
Drainage	Poorly drained
Topsoil depth (cm)	24
Limiting horizon	None
Sampled by	KH/KB

Profile	Depth (cm)	Description
	0 - 24	Very dark greyish brown (10YR 3/2) silt loam; slightly sticky; moderately plastic; weakly pedal; fine polyhedral peds; slightly firm soil strength; many medium roots; diffuse smooth boundary; slightly moist.
	24 - 48	Pale olive (5Y 6/3) clayey silt; common medium (bright orange) mottles; slightly sticky; slightly plastic; weakly pedal; fine polyhedral peds; firm soil strength; few medium roots; diffuse smooth boundary; slightly moist.
	48 - 72	Greyish brown (2.5Y 5/2) clayey silt; many medium (bright orange) mottles; slightly sticky; very plastic; apedal massive breaking to blocky; peds; slightly firm soil strength; few medium to coarse roots; diffuse smooth boundary; slightly moist.
	72 - 95+	Dark greyish brown (10YR 4/2) silty clay; abundant medium (bright orange) mottles; very sticky; very plastic; weakly pedal; fine polyhedral peds; slightly firm soil strength; few to coarse roots; slightly moist.

ORCH 10

Soil	Mangateretere
	Clay loam
Transect length and direction	50 m
Classification	Argillic Perch-gley Pallic
Land use	Orchard
Date sampled	13/05/2015
Land use history	Refer to Land Use Questionnaire
Present vegetation	Apples with pasture inter-row (Organic certification)
Slope degrees	0-3
Landform	Floodplain
Annual rain (mm)	800
Elevation (m)	3
Parent material	Sedimentary alluvium
Drainage	Poorly drained
Topsoil depth (cm)	24
Limiting horizon	Pan
Sampled by	KH/KB

Profile	Depth (cm)	Description
	0 - 24	Very dark grey (10YR 3/1) silt loam; slightly sticky; slightly plastic; weakly pedal; fine polyhedral peds; weak soil strength; common fine and medium roots; indistinct wavy boundary; wet.
	24 - 45	Greyish brown (2.5Y 5/2) silty clay; few fine (10YR 4/6) mottles; very sticky; moderately plastic; apedal massive breaking to fine nut and crumb; slightly firm soil strength; few fine and medium roots; indistinct smooth boundary; wet.
	45 - 70+	Dark grey (2.5Y 4/1) silty clay; common fine (10YR 4/6) mottles; moderately sticky; moderately plastic; apedal massive breaking to fine nut and crumbs; slightly firm soil strength; very few fine and medium roots; wet.

ORCH 11

Soil	Irongate
	Silt loam
Transect length and direction	50 m
Classification	Typic Recent Gley
Land use	Orchard
Date sampled	13/05/2015
Land use history	Refer to Land Use Questionnaire
Present vegetation	Cherry trees with bird covers over entire block. Inter-row pasture
Slope degrees	0-3
Landform	River terrace
Annual rain (mm)	800
Elevation (m)	3
Parent material	Sedimentary alluvium
Drainage	Poorly drained
Topsoil depth (cm)	3
Limiting horizon	None
Sampled by	KH/KB

Profile	Depth (cm)	Description
	0 - 3	Very dark grey (10YR 3/1) silt loam; non-sticky; non-plastic; weakly pedal; fine polyhedral peds; weak soil strength; many fine and medium roots; distinct smooth boundary; slightly moist.
	3 - 17	Dark greyish brown (2.5Y 4/2) silt loam; few fine (10YR 4/6) mottles; non-sticky; non-plastic; apedal massive; very firm soil strength; few fine and medium roots; indistinct smooth boundary; slightly moist.
	17 - 84+	Dark greyish brown (2.5Y 4/2) non-gravelly silt loam; few fine (10YR 4/6) mottles; non-sticky; non-plastic; apedal massive; slightly firm soil strength; few fine and medium roots; slightly moist.

VIN 1

Soil	Kaiapo
	Clay loam
Transect length and direction	50 m
Classification	Typic Orthic Gley
Land use	Vineyard
Date sampled	18/05/2015
Land use history	Refer to Land Use Questionnaire
Present vegetation	Grape vines with inter-row pasture
Slope degrees	0-3
Landform	Floodplain
Annual rain (mm)	800
Elevation (m)	12
Parent material	Sedimentary alluvium
Drainage	Poorly drained
Topsoil depth (cm)	26
Limiting horizon	None
Sampled by	KH/KB

Profile	Depth (cm)	Description
	0 - 26	Very dark greyish brown (10YR 3/2) clay loam; slightly sticky; moderately plastic; weakly pedal; fine polyhedral peds; many fine roots; distinct occluded boundary; slightly moist.
	26 - 50	Greyish brown (2.5Y 5/2) clayey silt; few fine (10YR 4/6) mottles; slightly sticky; very plastic; weakly pedal; fine polyhedral peds; common fine roots; indistinct wavy boundary; slightly moist.
	50 - 80+	Light olive brown (2.5Y 5/3) clayey silt; very few fine (10YR 4/6) mottles; slightly sticky; moderately plastic; apedal massive; few fine roots; slightly moist.

VIN 2

Soil	Takapau
	Silt loam
Transect length and direction	50 m
Classification	Typic Allophanic Brown
Land use	Vineyard
Date sampled	14/05/2015
Land use history	Refer to Land Use Questionnaire
Present vegetation	Grape vines with inter-row pasture
Slope degrees	0-3
Landform	Floodplain
Annual rain (mm)	800
Elevation (m)	12
Parent material	Alluvial outwash including greywacke and rhyolitic ash
Drainage	Well drained
Topsoil depth (cm)	20
Limiting horizon	None
Sampled by	KH/KB

Profile	Depth (cm)	Description
	0 - 20	Very dark grey (10YR 3/1) slightly gravelly silt loam; non-sticky; slightly plastic; apedal earthy; many fine and medium roots; distinct wavy boundary; slightly moist.
	20 - 52	Dark yellowish brown (10YR 4/4) slightly gravelly silt loam; non-sticky; slightly plastic; apedal earthy; many fine and medium roots; distinct occluded boundary; slightly moist.
	52 - 70+	Dark yellowish brown (10YR 4/4) very gravelly silt loam; non-sticky; slightly plastic; apedal earthy; many fine and medium roots; slightly moist.

VIN 4

Soil	Takapau
	Silt loam
Transect length and direction	50 m
Classification	Typic Allophanic Brown
Land use	Vineyard
Date sampled	14/05/2015
Land use history	Refer to Land Use Questionnaire
Present vegetation	Grape vines with inter-row pasture
Slope degrees	0-3
Landform	Floodplain
Annual rain (mm)	800
Elevation (m)	12
Parent material	Alluvial outwash including greywacke and rhyolitic ash
Drainage	Well drained
Topsoil depth (cm)	20
Limiting horizon	None
Sampled by	KH/KB

Profile	Depth (cm)	Description
	0 - 20	Very dark grey (10YR 3/1) slightly gravelly silt loam; non-sticky; non-plastic; apedal earthy; many fine roots; distinct wavy boundary; dry.
	20 - 32	Dark yellowish brown (10YR 4/4) slightly gravelly silt loam; non-sticky; slightly plastic; apedal earthy; common fine roots; indistinct wavy boundary; dry.
	32 - 70+	Dark yellowish brown (10YR 4/4) very gravelly silt loam; non-sticky; slightly plastic; apedal earthy; many fine roots; dry.

VIN 5

Soil	Ngatarawa
	Sandy loam
Transect length and direction	50 m
Classification	Weathered Fluvial Recent
Land use	Vineyard
Date sampled	18/05/2015
Land use history	Refer to Land Use Questionnaire
Present vegetation	Grape vines with inter-row pasture
Slope degrees	0-3
Landform	Floodplain
Annual rain (mm)	800
Elevation (m)	12
Parent material	Greywacke alluvium
Drainage	Well drained
Topsoil depth (cm)	18
Limiting horizon	None
Sampled by	KH/KB

Profile	Depth (cm)	Description
	0 - 18	Very dark grey (10YR 3/1) slightly gravelly sandy loam; slightly sticky; slightly plastic; apedal earthy; weak soil strength; many fine roots; distinct occluded boundary; dry.
	18 - 20	Yellowish brown (10YR 5/4) slightly gravelly sandy loam; non-sticky; slightly plastic; apedal earthy; weak soil strength; common fine roots; indistinct wavy boundary; dry.
	20 - 63+	Yellowish brown (10YR 5/4) very gravelly loamy sand; non-sticky; slightly plastic; apedal earthy; weak soil strength; common fine roots; dry.

VIN 6

Soil	Omahu
	Sandy loam
Transect length and direction	50 m
Classification	Fluvial Recent Soil
Land use	Vineyard
Date sampled	18/05/2015
Land use history	Refer to Land Use Questionnaire
Present vegetation	Grape vines with inter-row pasture
Slope degrees	0-3
Landform	Floodplain
Annual rain (mm)	800
Elevation (m)	12
Parent material	Greywacke alluvium
Drainage	Well drained
Topsoil depth (cm)	18
Limiting horizon	None
Sampled by	KH/KB

Profile	Depth (cm)	Description
	0 - 10	Very dark greyish brown (10YR 3/2) very gravelly sandy loam; apedal single grain; profuse fine and medium roots; indistinct wavy boundary; dry.
	10 - 60+	Dark greyish brown (10YR 4/2) extremely gravelly sandy; apedal single grain; many fine and medium roots; dry.

APPENDIX B

Analysis Reports

Hill Laboratories
BETTER TESTING **BETTER RESULTS**

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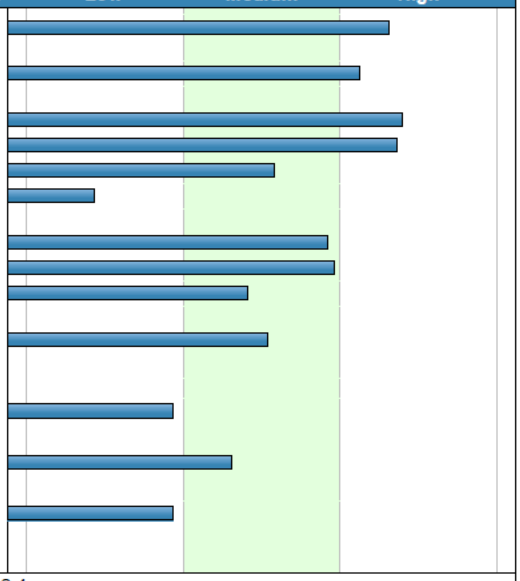
ANALYSIS REPORT

Client:	Hawkes Bay Regional Council	**Lab No:**	1428574	shpv1
Address:	Private Bag 6006 NAPIER 4142	**Date Registered:**	20-May-2015	
		Date Reported:	22-May-2015	
		Quote No:	45047	
		Order No:	340-202	
		Client Reference:	Lynch 340-202	
Phone:	06 835 9200	**Submitted By:**	B Lynch	

Sample Name: ORCH01-I-Agri2015 Hastings **Lab Number:** 1428574.1
Sample Type: SOIL General, Outdoor (S10)

Analysis		Level Found	Medium Range
pH	pH Units	6.6	5.8 - 6.3
Olsen Phosphorus	mg/L	39	20 - 30
Potassium	me/100g	1.04	0.50 - 0.80
Calcium	me/100g	16.8	6.0 - 12.0
Magnesium	me/100g	2.17	1.00 - 3.00
Sodium	me/100g	0.09	0.20 - 0.50
CEC	me/100g	24	12 - 25
Total Base Saturation	%	84	50 - 85
Volume Weight	g/mL	0.76	0.60 - 1.00
Available Nitrogen (15cm Depth)*	kg/ha	127	100 - 150
Anaerobically Mineralisable N*	µg/g	111	
Organic Matter*	%	6.5	7.0 - 17.0
Total Carbon*	%	3.8	
Total Nitrogen*	%	0.39	0.30 - 0.60
C/N Ratio*		9.6	
Anaerobically Mineralisable N/Total N Ratio*	%	2.8	3.0 - 5.0
Soil Sample Depth*	mm	0-100	



Base Saturation %	K 4.3	Ca 70	Mg 9.0	Na 0.4
MAF Units	K 16	Ca 16	Mg 37	Na 3

The above nutrient graph compares the levels found with reference interpretation levels. NOTE: It is important that the correct sample type be assigned, and that the recommended sampling procedure has been followed. R J Hill Laboratories Limited does not accept any responsibility for the resulting use of this information. IANZ Accreditation does not apply to comments and interpretations, i.e. the 'Range Levels' and subsequent graphs.

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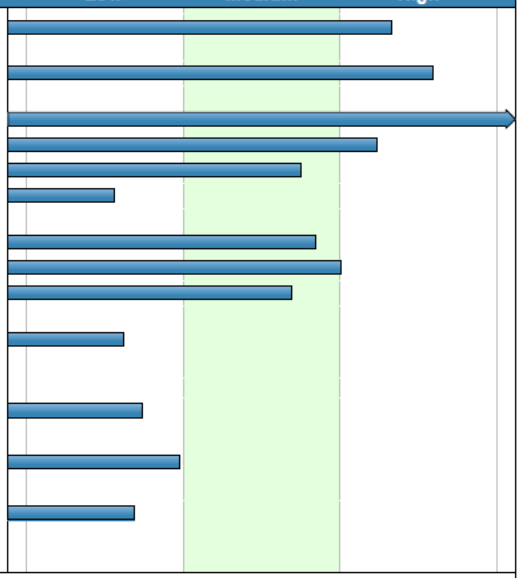
		Date Reported:	22-May-2015
		Quote No:	45047
		Order No:	340-202
		Client Reference:	Lynch 340-202
Phone:	06 835 9200	**Submitted By:**	B Lynch

Sample Name: ORCH01-R-Agri2015 Hastings **Lab Number:** 1428574.2
Sample Type: SOIL General, Outdoor (S10)

Analysis		Level Found	Medium Range
pH	pH Units	6.6	5.8 - 6.3
Olsen Phosphorus	mg/L	72	20 - 30
Potassium	me/100g	1.92	0.50 - 0.80
Calcium	me/100g	15.1	6.0 - 12.0
Magnesium	me/100g	2.49	1.00 - 3.00
Sodium	me/100g	0.11	0.20 - 0.50
CEC	me/100g	23	12 - 25
Total Base Saturation	%	85	50 - 85
Volume Weight	g/mL	0.88	0.60 - 1.00
Available Nitrogen (15cm Depth)*	kg/ha	81	100 - 150
Anaerobically Mineralisable N*	µg/g	62	
Organic Matter*	%	5.2	7.0 - 17.0
Total Carbon*	%	3.0	
Total Nitrogen*	%	0.30	0.30 - 0.60
C/N Ratio*		10.2	
Anaerobically Mineralisable N/Total N Ratio*	%	2.1	3.0 - 5.0
Soil Sample Depth*	mm	0-100	



Base Saturation %	K 8.3	Ca 66	Mg 10.8	Na 0.5
MAF Units	K 34	Ca 17	Mg 49	Na 4

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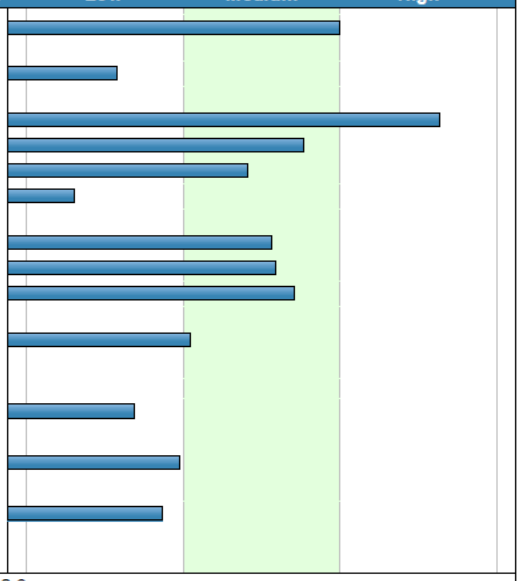
		Date Reported:	22-May-2015	
		Quote No:	45047	
		Order No:	340-202	
		Client Reference:	Lynch 340-202	
Phone:	06 835 9200	**Submitted By:**	B Lynch	

Sample Name: ORCH02-I-Agri2015 Karamu **Lab Number:** 1428574.3
Sample Type: SOIL General, Outdoor (S10)

Analysis		Level Found	Medium Range
pH	pH Units	6.3	5.8 - 6.3
Olsen Phosphorus	mg/L	14	20 - 30
Potassium	me/100g	1.18	0.50 - 0.80
Calcium	me/100g	10.6	6.0 - 12.0
Magnesium	me/100g	1.82	1.00 - 3.00
Sodium	me/100g	0.06	0.20 - 0.50
CEC	me/100g	19	12 - 25
Total Base Saturation	%	71	50 - 85
Volume Weight	g/mL	0.88	0.60 - 1.00
Available Nitrogen (15cm Depth)*	kg/ha	102	100 - 150
Anaerobically Mineralisable N*	µg/g	77	
Organic Matter*	%	4.8	7.0 - 17.0
Total Carbon*	%	2.8	
Total Nitrogen*	%	0.30	0.30 - 0.60
C/N Ratio*		9.4	
Anaerobically Mineralisable N/Total N Ratio*	%	2.6	3.0 - 5.0
Soil Sample Depth*	mm	0-100	



Base Saturation %	K 6.1	Ca 55	Mg 9.4	Na 0.3
MAF Units	K 21	Ca 12	Mg 36	Na 2

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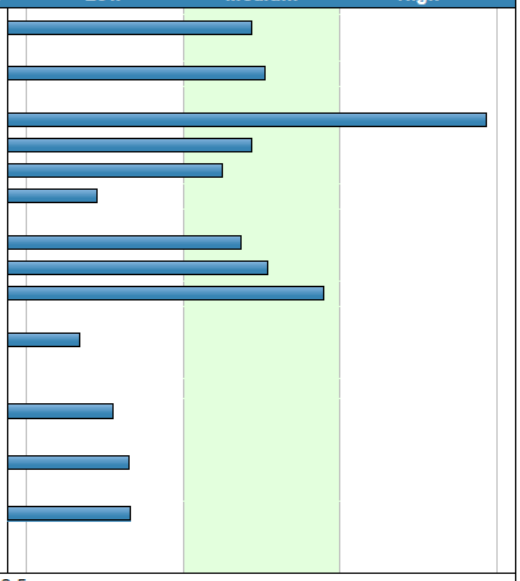
		Date Reported:	22-May-2015	
		Quote No:	45047	
		Order No:	340-202	
		Client Reference:	Lynch 340-202	
Phone:	06 835 9200	**Submitted By:**	B Lynch	

Sample Name: ORCH02-R-Agri2015 Karamu **Lab Number:** 1428574.4
Sample Type: SOIL General, Outdoor (S10)

Analysis		Level Found	Medium Range
pH	pH Units	6.0	5.8 - 6.3
Olsen Phosphorus	mg/L	25	20 - 30
Potassium	me/100g	1.36	0.50 - 0.80
Calcium	me/100g	8.6	6.0 - 12.0
Magnesium	me/100g	1.51	1.00 - 3.00
Sodium	me/100g	0.09	0.20 - 0.50
CEC	me/100g	17	12 - 25
Total Base Saturation	%	69	50 - 85
Volume Weight	g/mL	0.96	0.60 - 1.00
Available Nitrogen (15cm Depth)*	kg/ha	67	100 - 150
Anaerobically Mineralisable N*	µg/g	46	
Organic Matter*	%	3.9	7.0 - 17.0
Total Carbon*	%	2.2	
Total Nitrogen*	%	0.23	0.30 - 0.60
C/N Ratio*		9.7	
Anaerobically Mineralisable N/Total N Ratio*	%	2.0	3.0 - 5.0
Soil Sample Depth*	mm	0-100	



Base Saturation %	K 8.1	Ca 51	Mg 9.0	Na 0.5
MAF Units	K 27	Ca 10	Mg 33	Na 4

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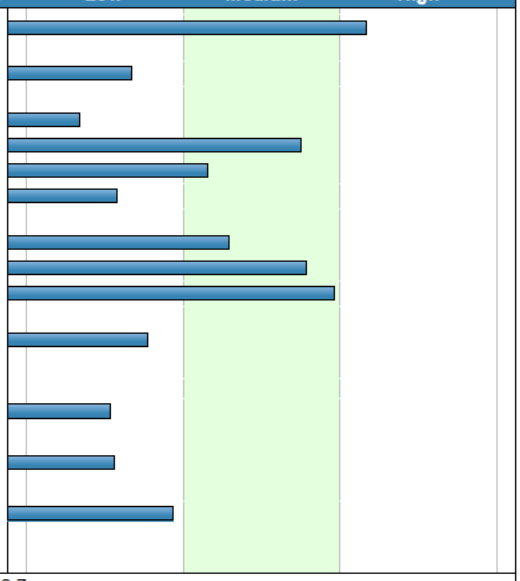
		Quote No:	45047	
		Order No:	340-202	
		Client Reference:	Lynch 340-202	
Phone:	06 835 9200	**Submitted By:**	B Lynch	

Sample Name: ORCH03-I-Agri2015 Flaxmere **Lab Number:** 1428574.5
Sample Type: SOIL General, Outdoor (S10)

Analysis		Level Found	Medium Range
pH	pH Units	6.5	5.8 - 6.3
Olsen Phosphorus	mg/L	15	20 - 30
Potassium	me/100g	0.27	0.50 - 0.80
Calcium	me/100g	10.5	6.0 - 12.0
Magnesium	me/100g	1.30	1.00 - 3.00
Sodium	me/100g	0.11	0.20 - 0.50
CEC	me/100g	16	12 - 25
Total Base Saturation	%	77	50 - 85
Volume Weight	g/mL	0.99	0.60 - 1.00
Available Nitrogen (15cm Depth)*	kg/ha	89	100 - 150
Anaerobically Mineralisable N*	µg/g	60	
Organic Matter*	%	3.8	7.0 - 17.0
Total Carbon*	%	2.2	
Total Nitrogen*	%	0.21	0.30 - 0.60
C/N Ratio*		10.3	
Anaerobically Mineralisable N/Total N Ratio*	%	2.8	3.0 - 5.0
Soil Sample Depth*	mm	0-100	



Base Saturation %	K 1.7	Ca 67	Mg 8.3	Na 0.7
MAF Units	K 5	Ca 13	Mg 29	Na 5

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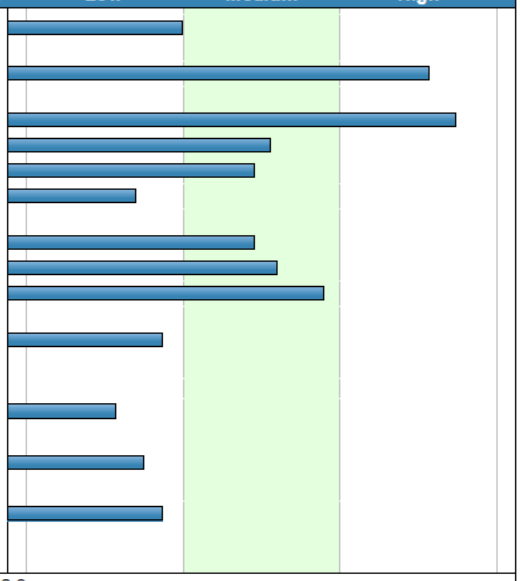
Address:	Private Bag 6006 NAPIER 4142	**Date Registered:**	20-May-2015	
		Date Reported:	22-May-2015	
		Quote No:	45047	
		Order No:	340-202	
		Client Reference:	Lynch 340-202	
Phone:	06 835 9200	**Submitted By:**	B Lynch	

Sample Name: ORCH03-R-Agri2015 Flaxmere **Lab Number:** 1428574.6
Sample Type: SOIL General, Outdoor (S10)

Analysis		Level Found	Medium Range
pH	pH Units	5.8	5.8 - 6.3
Olsen Phosphorus	mg/L	70	20 - 30
Potassium	me/100g	1.24	0.50 - 0.80
Calcium	me/100g	9.3	6.0 - 12.0
Magnesium	me/100g	1.91	1.00 - 3.00
Sodium	me/100g	0.14	0.20 - 0.50
CEC	me/100g	18	12 - 25
Total Base Saturation	%	71	50 - 85
Volume Weight	g/mL	0.96	0.60 - 1.00
Available Nitrogen (15cm Depth)*	kg/ha	94	100 - 150
Anaerobically Mineralisable N*	µg/g	65	
Organic Matter*	%	4.0	7.0 - 17.0
Total Carbon*	%	2.3	
Total Nitrogen*	%	0.25	0.30 - 0.60
C/N Ratio*		9.2	
Anaerobically Mineralisable N/Total N Ratio*	%	2.6	3.0 - 5.0
Soil Sample Depth*	mm	0-100	



Base Saturation %	K 7.0	Ca 52	Mg 10.7	Na 0.8
MAF Units	K 24	Ca 11	Mg 41	Na 6

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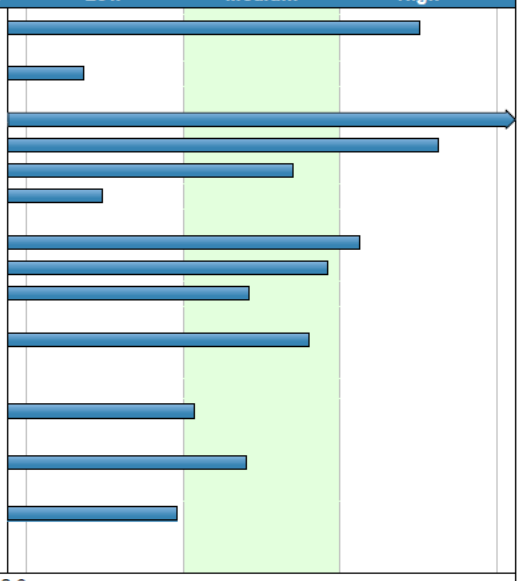
		Quote No:	45047	
		Order No:	340-202	
		Client Reference:	Lynch 340-202	
Phone:	06 835 9200	**Submitted By:**	B Lynch	

Sample Name: ORCH04-I-Agri2015 Pakowhai **Lab Number:** 1428574.7
Sample Type: SOIL General, Outdoor (S10)

Analysis		Level Found	Medium Range
pH	pH Units	6.8	5.8 - 6.3
Olsen Phosphorus	mg/L	10	20 - 30
Potassium	me/100g	1.50	0.50 - 0.80
Calcium	me/100g	20.2	6.0 - 12.0
Magnesium	me/100g	2.41	1.00 - 3.00
Sodium	me/100g	0.10	0.20 - 0.50
CEC	me/100g	29	12 - 25
Total Base Saturation	%	82	50 - 85
Volume Weight	g/mL	0.77	0.60 - 1.00
Available Nitrogen (15cm Depth)*	kg/ha	140	100 - 150
Anaerobically Mineralisable N*	µg/g	122	
Organic Matter*	%	7.7	7.0 - 17.0
Total Carbon*	%	4.5	
Total Nitrogen*	%	0.42	0.30 - 0.60
C/N Ratio*		10.6	
Anaerobically Mineralisable N/Total N Ratio*	%	2.9	3.0 - 5.0
Soil Sample Depth*	mm	0-100	



Base Saturation %	K 5.1	Ca 69	Mg 8.2	Na 0.3
MAF Units	K 24	Ca 19	Mg 41	Na 3

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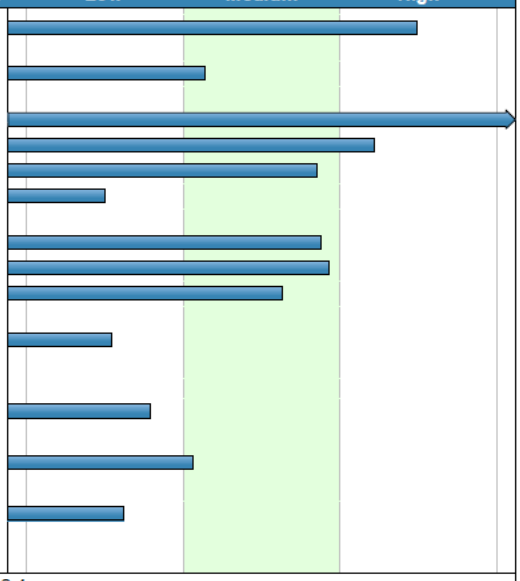
		Date Reported:	22-May-2015	
		Quote No:	45047	
		Order No:	340-202	
		Client Reference:	Lynch 340-202	
Phone:	06 835 9200	**Submitted By:**	B Lynch	

Sample Name: ORCH04-R-Agri2015 Pakowhai **Lab Number:** 1428574.8
Sample Type: SOIL General, Outdoor (S10)

Analysis		Level Found	Medium Range
pH	pH Units	6.7	5.8 - 6.3
Olsen Phosphorus	mg/L	21	20 - 30
Potassium	me/100g	1.62	0.50 - 0.80
Calcium	me/100g	14.9	6.0 - 12.0
Magnesium	me/100g	2.70	1.00 - 3.00
Sodium	me/100g	0.10	0.20 - 0.50
CEC	me/100g	23	12 - 25
Total Base Saturation	%	82	50 - 85
Volume Weight	g/mL	0.85	0.60 - 1.00
Available Nitrogen (15cm Depth)*	kg/ha	77	100 - 150
Anaerobically Mineralisable N*	µg/g	60	
Organic Matter*	%	5.5	7.0 - 17.0
Total Carbon*	%	3.2	
Total Nitrogen*	%	0.32	0.30 - 0.60
C/N Ratio*		10.0	
Anaerobically Mineralisable N/Total N Ratio*	%	1.9	3.0 - 5.0
Soil Sample Depth*	mm	0-100	



Base Saturation %	K 6.9	Ca 64	Mg 11.5	Na 0.4
MAF Units	K 28	Ca 16	Mg 52	Na 4

The above nutrient graph compares the levels found with reference interpretation levels. NOTE: It is important that the correct sample type be assigned, and that the recommended sampling procedure has been followed. R J Hill Laboratories Limited does not accept any responsibility for the resulting use of this information. IANZ Accreditation does not apply to comments and interpretations, i.e. the 'Range Levels' and subsequent graphs.

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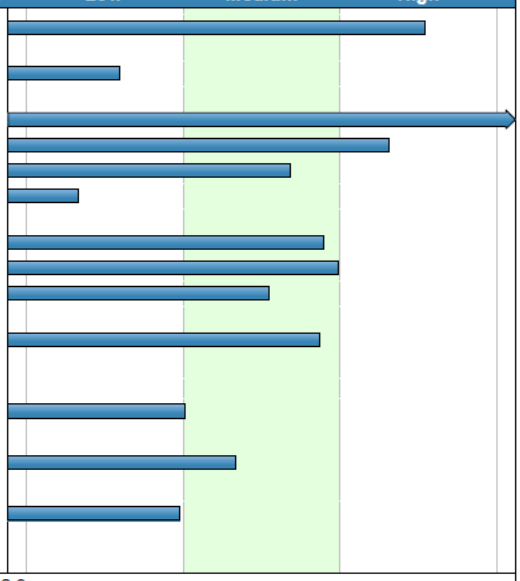
ANALYSIS REPORT

Client:	Hawkes Bay Regional Council	**Lab No:**	1428574	shpv1
Address:	Private Bag 6006 NAPIER 4142	**Date Registered:**	20-May-2015	
		Date Reported:	22-May-2015	
		Quote No:	45047	
		Order No:	340-202	
		Client Reference:	Lynch 340-202	
Phone:	06 835 9200	**Submitted By:**	B Lynch	

Sample Name: ORCH05-I-Agri2015 Omarunui **Lab Number:** 1428574.9
Sample Type: SOIL General, Outdoor (S10)

Analysis		Level Found	Medium Range
pH	pH Units	6.8	5.8 - 6.3
Olsen Phosphorus	mg/L	14	20 - 30
Potassium	me/100g	1.51	0.50 - 0.80
Calcium	me/100g	16.1	6.0 - 12.0
Magnesium	me/100g	2.36	1.00 - 3.00
Sodium	me/100g	0.07	0.20 - 0.50
CEC	me/100g	24	12 - 25
Total Base Saturation	%	85	50 - 85
Volume Weight	g/mL	0.82	0.60 - 1.00
Available Nitrogen (15cm Depth)*	kg/ha	144	100 - 150
Anaerobically Mineralisable N*	µg/g	117	
Organic Matter*	%	7.1	7.0 - 17.0
Total Carbon*	%	4.1	
Total Nitrogen*	%	0.40	0.30 - 0.60
C/N Ratio*		10.4	
Anaerobically Mineralisable N/Total N Ratio*	%	2.9	3.0 - 5.0
Soil Sample Depth*	mm	0-100	



Base Saturation %	K 6.4	Ca 68	Mg 10.0	Na 0.3
MAF Units	K 25	Ca 16	Mg 44	Na 2

The above nutrient graph compares the levels found with reference interpretation levels. NOTE: It is important that the correct sample type be assigned, and that the recommended sampling procedure has been followed. R J Hill Laboratories Limited does not accept any responsibility for the resulting use of this information. IANZ Accreditation does not apply to comments and interpretations, i.e. the 'Range Levels' and subsequent graphs.

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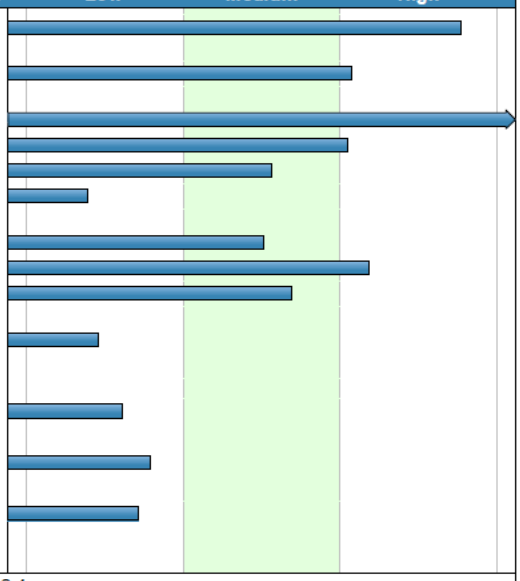
		Quote No:	45047	
		Order No:	340-202	
		Client Reference:	Lynch 340-202	
Phone:	06 835 9200	**Submitted By:**	B Lynch	

Sample Name: ORCH05-R-Agri2015 Omarunui **Lab Number:** 1428574.10
Sample Type: SOIL General, Outdoor (S10)

Analysis		Level Found	Medium Range
pH	pH Units	7.0	5.8 - 6.3
Olsen Phosphorus	mg/L	35	20 - 30
Potassium	me/100g	1.48	0.50 - 0.80
Calcium	me/100g	12.7	6.0 - 12.0
Magnesium	me/100g	2.12	1.00 - 3.00
Sodium	me/100g	0.08	0.20 - 0.50
CEC	me/100g	19	12 - 25
Total Base Saturation	%	88	50 - 85
Volume Weight	g/mL	0.88	0.60 - 1.00
Available Nitrogen (15cm Depth)*	kg/ha	73	100 - 150
Anaerobically Mineralisable N*	µg/g	56	
Organic Matter*	%	4.3	7.0 - 17.0
Total Carbon*	%	2.5	
Total Nitrogen*	%	0.26	0.30 - 0.60
C/N Ratio*		9.6	
Anaerobically Mineralisable N/Total N Ratio*	%	2.2	3.0 - 5.0
Soil Sample Depth*	mm	0-100	



Base Saturation %	K 7.9	Ca 68	Mg 11.4	Na 0.4
MAF Units	K 27	Ca 14	Mg 42	Na 3

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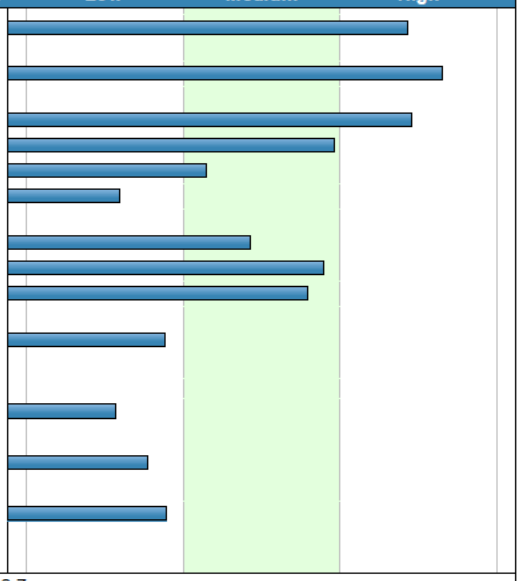
		Order No:	340-202	
		Client Reference:	Lynch 340-202	
Phone:	06 835 9200	**Submitted By:**	B Lynch	

Sample Name: ORCH06-I-Agri2015 Farndon **Lab Number:** 1428574.11
Sample Type: SOIL General, Outdoor (S10)

Analysis		Level Found	Medium Range
pH	pH Units	6.7	5.8 - 6.3
Olsen Phosphorus	mg/L	76	20 - 30
Potassium	me/100g	1.08	0.50 - 0.80
Calcium	me/100g	11.8	6.0 - 12.0
Magnesium	me/100g	1.29	1.00 - 3.00
Sodium	me/100g	0.12	0.20 - 0.50
CEC	me/100g	18	12 - 25
Total Base Saturation	%	81	50 - 85
Volume Weight	g/mL	0.92	0.60 - 1.00
Available Nitrogen (15cm Depth)*	kg/ha	94	100 - 150
Anaerobically Mineralisable N*	µg/g	68	
Organic Matter*	%	4.0	7.0 - 17.0
Total Carbon*	%	2.3	
Total Nitrogen*	%	0.25	0.30 - 0.60
C/N Ratio*		9.0	
Anaerobically Mineralisable N/Total N Ratio*	%	2.7	3.0 - 5.0
Soil Sample Depth*	mm	0-100	



Base Saturation %	K 6.1	Ca 67	Mg 7.4	Na 0.7
MAF Units	K 20	Ca 14	Mg 27	Na 5

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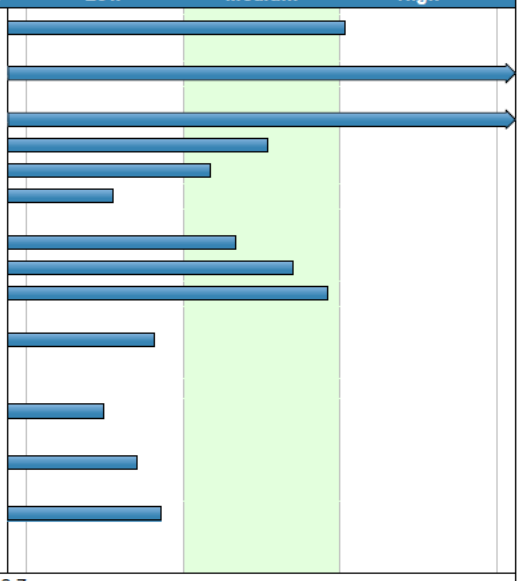
		Order No:	340-202	
		Client Reference:	Lynch 340-202	
Phone:	06 835 9200	**Submitted By:**	B Lynch	

Sample Name: ORCH06-R-Agri2015 **Lab Number:** 1428574.12
Sample Type: SOIL General, Outdoor (S10)

Analysis		Level Found	Medium Range
pH	pH Units	6.3	5.8 - 6.3
Olsen Phosphorus	mg/L	112	20 - 30
Potassium	me/100g	1.53	0.50 - 0.80
Calcium	me/100g	9.2	6.0 - 12.0
Magnesium	me/100g	1.34	1.00 - 3.00
Sodium	me/100g	0.11	0.20 - 0.50
CEC	me/100g	16	12 - 25
Total Base Saturation	%	75	50 - 85
Volume Weight	g/mL	0.97	0.60 - 1.00
Available Nitrogen (15cm Depth)*	kg/ha	91	100 - 150
Anaerobically Mineralisable N*	µg/g	63	
Organic Matter*	%	3.5	7.0 - 17.0
Total Carbon*	%	2.0	
Total Nitrogen*	%	0.24	0.30 - 0.60
C/N Ratio*		8.3	
Anaerobically Mineralisable N/Total N Ratio*	%	2.6	3.0 - 5.0
Soil Sample Depth*	mm	0-100	



Base Saturation %	K 9.3	Ca 56	Mg 8.2	Na 0.7
MAF Units	K 30	Ca 11	Mg 29	Na 5

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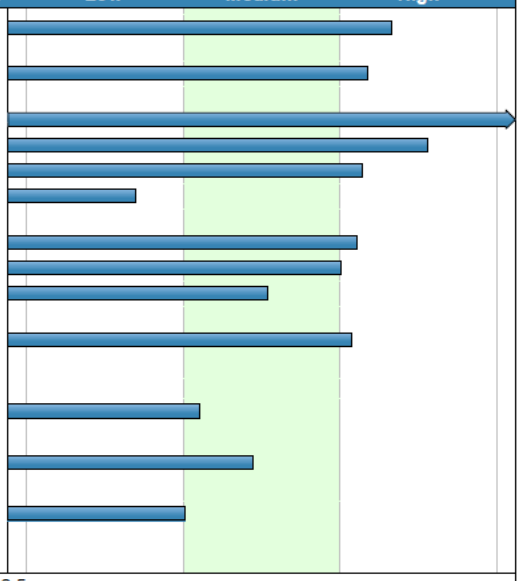
Phone:	06 835 9200	**Submitted By:**	B Lynch	

Sample Name: ORCH07-I-Agri2015 Mangateretere **Lab Number:** 1428574.13
Sample Type: SOIL General, Outdoor (S10)

Analysis		Level Found	Medium Range
pH	pH Units	6.6	5.8 - 6.3
Olsen Phosphorus	mg/L	42	20 - 30
Potassium	me/100g	1.50	0.50 - 0.80
Calcium	me/100g	19.3	6.0 - 12.0
Magnesium	me/100g	3.57	1.00 - 3.00
Sodium	me/100g	0.14	0.20 - 0.50
CEC	me/100g	29	12 - 25
Total Base Saturation	%	85	50 - 85
Volume Weight	g/mL	0.82	0.60 - 1.00
Available Nitrogen (15cm Depth)*	kg/ha	161	100 - 150
Anaerobically Mineralisable N*	µg/g	131	
Organic Matter*	%	8.0	7.0 - 17.0
Total Carbon*	%	4.7	
Total Nitrogen*	%	0.43	0.30 - 0.60
C/N Ratio*		10.7	
Anaerobically Mineralisable N/Total N Ratio*	%	3.0	3.0 - 5.0
Soil Sample Depth*	mm	0-100	



Base Saturation %	K 5.2	Ca 67	Mg 12.4	Na 0.5
MAF Units	K 25	Ca 20	Mg 66	Na 5

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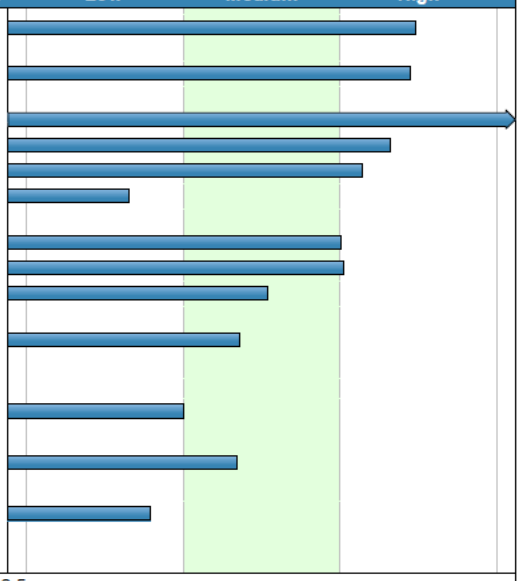
		Order No:	340-202	
		Client Reference:	Lynch 340-202	
Phone:	06 835 9200	**Submitted By:**	B Lynch	

Sample Name: ORCH07-R-Agri2015 **Lab Number:** 1428574.14
Sample Type: SOIL General, Outdoor (S10)

Analysis		Level Found	Medium Range
pH	pH Units	6.7	5.8 - 6.3
Olsen Phosphorus	mg/L	62	20 - 30
Potassium	me/100g	1.61	0.50 - 0.80
Calcium	me/100g	16.1	6.0 - 12.0
Magnesium	me/100g	3.59	1.00 - 3.00
Sodium	me/100g	0.13	0.20 - 0.50
CEC	me/100g	25	12 - 25
Total Base Saturation	%	85	50 - 85
Volume Weight	g/mL	0.82	0.60 - 1.00
Available Nitrogen (15cm Depth)*	kg/ha	118	100 - 150
Anaerobically Mineralisable N*	µg/g	96	
Organic Matter*	%	7.0	7.0 - 17.0
Total Carbon*	%	4.1	
Total Nitrogen*	%	0.40	0.30 - 0.60
C/N Ratio*		10.1	
Anaerobically Mineralisable N/Total N Ratio*	%	2.4	3.0 - 5.0
Soil Sample Depth*	mm	0-100	



Base Saturation %	K 6.4	Ca 64	Mg 14.3	Na 0.5
MAF Units	K 27	Ca 16	Mg 66	Na 5

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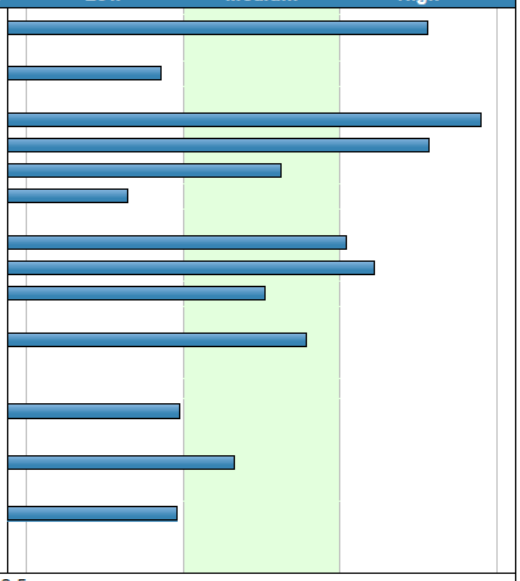
		Order No:	340-202	
		Client Reference:	Lynch 340-202	
Phone:	06 835 9200	**Submitted By:**	B Lynch	

Sample Name: ORCH08-I-Agri2015 Pakowhai **Lab Number:** 1428574.15
Sample Type: SOIL General, Outdoor (S10)

Analysis		Level Found	Medium Range
pH	pH Units	6.8	5.8 - 6.3
Olsen Phosphorus	mg/L	18	20 - 30
Potassium	me/100g	1.34	0.50 - 0.80
Calcium	me/100g	19.5	6.0 - 12.0
Magnesium	me/100g	2.24	1.00 - 3.00
Sodium	me/100g	0.13	0.20 - 0.50
CEC	me/100g	26	12 - 25
Total Base Saturation	%	88	50 - 85
Volume Weight	g/mL	0.81	0.60 - 1.00
Available Nitrogen (15cm Depth)*	kg/ha	139	100 - 150
Anaerobically Mineralisable N*	µg/g	115	
Organic Matter*	%	6.8	7.0 - 17.0
Total Carbon*	%	3.9	
Total Nitrogen*	%	0.40	0.30 - 0.60
C/N Ratio*		9.9	
Anaerobically Mineralisable N/Total N Ratio*	%	2.9	3.0 - 5.0
Soil Sample Depth*	mm	0-100	



Base Saturation %	K 5.1	Ca 74	Mg 8.5	Na 0.5
MAF Units	K 22	Ca 20	Mg 41	Na 5

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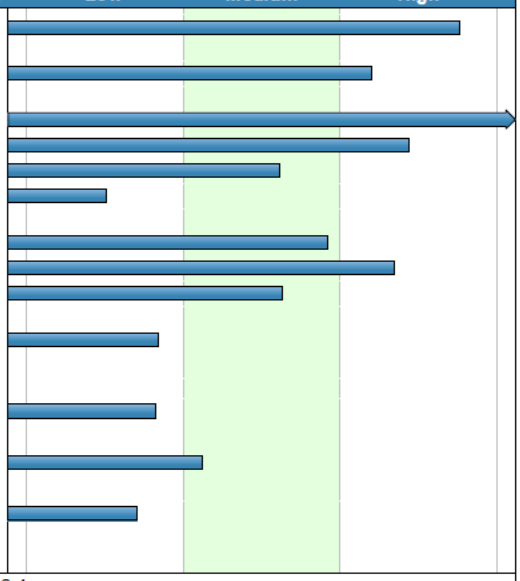
		Client Reference:	Lynch 340-202	
Phone:	06 835 9200	**Submitted By:**	B Lynch	

Sample Name: ORCH08-R-Agri2015 **Lab Number:** 1428574.16
Sample Type: SOIL General, Outdoor (S10)

Analysis		Level Found	Medium Range
pH	pH Units	7.0	5.8 - 6.3
Olsen Phosphorus	mg/L	44	20 - 30
Potassium	me/100g	1.54	0.50 - 0.80
Calcium	me/100g	17.7	6.0 - 12.0
Magnesium	me/100g	2.23	1.00 - 3.00
Sodium	me/100g	0.10	0.20 - 0.50
CEC	me/100g	24	12 - 25
Total Base Saturation	%	90	50 - 85
Volume Weight	g/mL	0.85	0.60 - 1.00
Available Nitrogen (15cm Depth)*	kg/ha	92	100 - 150
Anaerobically Mineralisable N*	µg/g	72	
Organic Matter*	%	5.8	7.0 - 17.0
Total Carbon*	%	3.4	
Total Nitrogen*	%	0.34	0.30 - 0.60
C/N Ratio*		10.0	
Anaerobically Mineralisable N/Total N Ratio*	%	2.1	3.0 - 5.0
Soil Sample Depth*	mm	0-100	



Base Saturation %	K 6.4	Ca 74	Mg 9.3	Na 0.4
MAF Units	K 27	Ca 19	Mg 43	Na 4

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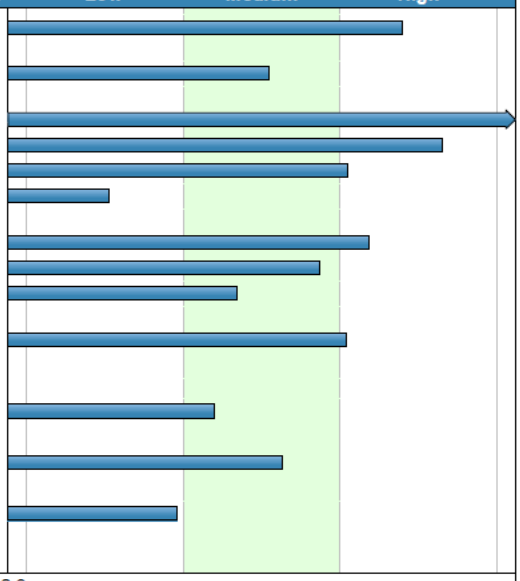
		Client Reference:	Lynch 340-202	
Phone:	06 835 9200	**Submitted By:**	B Lynch	

Sample Name: ORCH09-I-Agri2015 Hastings **Lab Number:** 1428574.17
Sample Type: SOIL General, Outdoor (S10)

Analysis		Level Found	Medium Range
pH	pH Units	6.7	5.8 - 6.3
Olsen Phosphorus	mg/L	26	20 - 30
Potassium	me/100g	1.62	0.50 - 0.80
Calcium	me/100g	20.5	6.0 - 12.0
Magnesium	me/100g	3.20	1.00 - 3.00
Sodium	me/100g	0.10	0.20 - 0.50
CEC	me/100g	32	12 - 25
Total Base Saturation	%	81	50 - 85
Volume Weight	g/mL	0.74	0.60 - 1.00
Available Nitrogen (15cm Depth)*	kg/ha	156	100 - 150
Anaerobically Mineralisable N*	µg/g	141	
Organic Matter*	%	8.9	7.0 - 17.0
Total Carbon*	%	5.2	
Total Nitrogen*	%	0.49	0.30 - 0.60
C/N Ratio*		10.6	
Anaerobically Mineralisable N/Total N Ratio*	%	2.9	3.0 - 5.0
Soil Sample Depth*	mm	0-100	



Base Saturation %	K 5.1	Ca 65	Mg 10.2	Na 0.3
MAF Units	K 25	Ca 19	Mg 53	Na 4

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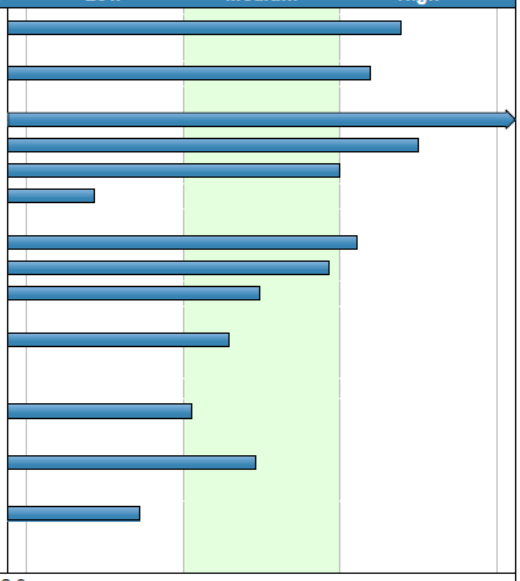
Phone:	06 835 9200	**Submitted By:**	B Lynch	

Sample Name: ORCH09-R-Agri2015 **Lab Number:** 1428574.18
Sample Type: SOIL General, Outdoor (S10)

Analysis		Level Found	Medium Range
pH	pH Units	6.7	5.8 - 6.3
Olsen Phosphorus	mg/L	43	20 - 30
Potassium	me/100g	2.22	0.50 - 0.80
Calcium	me/100g	18.6	6.0 - 12.0
Magnesium	me/100g	3.01	1.00 - 3.00
Sodium	me/100g	0.09	0.20 - 0.50
CEC	me/100g	29	12 - 25
Total Base Saturation	%	83	50 - 85
Volume Weight	g/mL	0.79	0.60 - 1.00
Available Nitrogen (15cm Depth)*	kg/ha	114	100 - 150
Anaerobically Mineralisable N*	µg/g	96	
Organic Matter*	%	7.5	7.0 - 17.0
Total Carbon*	%	4.4	
Total Nitrogen*	%	0.44	0.30 - 0.60
C/N Ratio*		10.0	
Anaerobically Mineralisable N/Total N Ratio*	%	2.2	3.0 - 5.0
Soil Sample Depth*	mm	0-100	



Base Saturation %	K 7.7	Ca 64	Mg 10.4	Na 0.3
MAF Units	K 36	Ca 18	Mg 54	Na 3

The above nutrient graph compares the levels found with reference interpretation levels. NOTE: It is important that the correct sample type be assigned, and that the recommended sampling procedure has been followed. R J Hill Laboratories Limited does not accept any responsibility for the resulting use of this information. IANZ Accreditation does not apply to comments and interpretations, i.e. the 'Range Levels' and subsequent graphs.

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ANALYSIS REPORT

Client:	Hawkes Bay Regional Council	**Lab No:**	1428574	shpv1
Address:	Private Bag 6006 NAPIER 4142	**Date Registered:**	20-May-2015	
		Date Reported:	22-May-2015	
		Quote No:	45047	
		Order No:	340-202	
		Client Reference:	Lynch 340-202	
Phone:	06 835 9200	**Submitted By:**	B Lynch	

Analyst's Comments

Samples 1-18 Comment:
The medium range guidelines shown in the histogram report relate to sampling protocols as per Hill Laboratories' crop guides and are based on reference values where these are published. Results for samples collected to different depths than those described in the crop guide should be interpreted with caution.
For pastoral soils, the medium ranges are specific for a 75mm sample depth, but if a 150mm sampling depth is used the nutrient levels measured may appear low against these ranges, as nutrients are typically more concentrated in the top of the soil profile. These soil profile differences are altered upon cultivation or contouring.

Samples 1-18 Comment:
The Available Nitrogen (kg/ha) test above assumes the sample is taken to a 15 cm depth. If the depth is 7.5 cm, then the result reported above should be divided by two.
To calculate Available Nitrogen (as kgN/ha) for other sample depths use the reported Anaerobic Mineralisable Nitrogen (AMN) result in the following equation:
AN (kg/ha) = AMN (µg/g) x VW (g/ml) x sample depth (cm) x 0.1
Note that the AN and AMN results reported include the readily available Mineral N (NH4-N and NO3-N) fraction, which is typically quite low.

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.

Sample Type: Soil

Test	Method Description	Default Detection Limit	Sample No
Sample Registration*	Samples were registered according to instructions received.	-	1-18
Soil Prep (Dry & Grind)*	Air dried at 35 - 40°C overnight (residual moisture typically 4%) and crushed to pass through a 2mm screen.	-	1-18
pH	1:2 (v/v) soil:water slurry followed by potentiometric determination of pH.	0.1 pH Units	1-18
Olsen Phosphorus	Olsen extraction followed by Molybdenum Blue colorimetry.	1 mg/L	1-18
Potassium (MAF)	1M Neutral ammonium acetate extraction followed by ICP-OES.	1 MAF units	1-18
Calcium (MAF)	1M Neutral ammonium acetate extraction followed by ICP-OES.	1 MAF units	1-18
Magnesium (MAF)	1M Neutral ammonium acetate extraction followed by ICP-OES.	1 MAF units	1-18
Sodium (MAF)	1M Neutral ammonium acetate extraction followed by ICP-OES.	2 MAF units	1-18
Available Nitrogen*	Determined by NIR, calibration based on Available N by Anaerobic incubation followed by extraction using 2M KCl followed by Berthelot colorimetry. (Calculation based on 15cm depth sample).	1 mg/L	1-18
Anaerobically Mineralisable N*	As for Available Nitrogen but reported as µg/g.	5 µg/g	1-18
Organic Matter*	Organic Matter is 1.72 x Total Carbon.	0.2 %	1-18
Total Carbon*	Determined by NIR, calibration based on Total Carbon by Dumas combustion.	0.1 %	1-18
Total Nitrogen*	Determined by NIR, calibration based on Total N by Dumas combustion.	0.04 %	1-18
Potassium	1M Neutral ammonium acetate extraction followed by ICP-OES.	0.01 me/100g	1-18
Calcium	1M Neutral ammonium acetate extraction followed by ICP-OES.	0.5 me/100g	1-18
Magnesium	1M Neutral ammonium acetate extraction followed by ICP-OES.	0.04 me/100g	1-18
Sodium	1M Neutral ammonium acetate extraction followed by ICP-OES.	0.05 me/100g	1-18

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		Client Reference:	Lynch 340-202	
Phone:	06 835 9200	**Submitted By:**	B Lynch	

Sample Type: Soil

Test	Method Description	Default Detection Limit	Sample No
Potassium (Sat)	1M Neutral ammonium acetate extraction followed by ICP-OES.	0.1 %BS	1-18
Calcium (Sat)	1M Neutral ammonium acetate extraction followed by ICP-OES.	1 %BS	1-18
Magnesium (Sat)	1M Neutral ammonium acetate extraction followed by ICP-OES.	0.2 %BS	1-18
Sodium (Sat)	1M Neutral ammonium acetate extraction followed by ICP-OES.	0.1 %BS	1-18
CEC	Summation of extractable cations (K, Ca, Mg, Na) and extractable acidity. May be overestimated if soil contains high levels of soluble salts or carbonates.	2 me/100g	1-18
Total Base Saturation	Calculated from Extractable Cations and Cation Exchange Capacity.	5 %	1-18
Volume Weight	The weight/volume ratio of dried, ground soil.	0.01 g/mL	1-18

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.

Andrew Whitmore BSc (Tech)
Technologist - Agriculture Division

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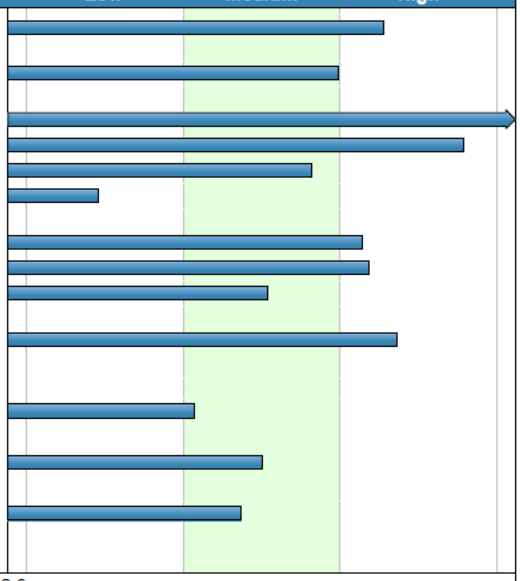
ANALYSIS REPORT

Client:	Hawkes Bay Regional Council	**Lab No:**	1428684 shpv1
Address:	Private Bag 6006 NAPIER 4142	**Date Registered:**	20-May-2015
		Date Reported:	22-May-2015
		Quote No:	45047
		Order No:	340-202
		Client Reference:	Lynch 340-202
Phone:	06 835 9200	**Submitted By:**	B Lynch

Sample Name: ORCH10-I-Agri2015 **Lab Number:** 1428684.1
Sample Type: SOIL General, Outdoor (S10)

Analysis		Level Found	Medium Range
pH	pH Units	6.6	5.8 - 6.3
Olsen Phosphorus	mg/L	30	20 - 30
Potassium	me/100g	1.43	0.50 - 0.80
Calcium	me/100g	22.3	6.0 - 12.0
Magnesium	me/100g	2.64	1.00 - 3.00
Sodium	me/100g	0.09	0.20 - 0.50
CEC	me/100g	30	12 - 25
Total Base Saturation	%	88	50 - 85
Volume Weight	g/mL	0.81	0.60 - 1.00
Available Nitrogen (15cm Depth)*	kg/ha	205	100 - 150
Anaerobically Mineralisable N*	µg/g	168	
Organic Matter*	%	7.7	7.0 - 17.0
Total Carbon*	%	4.5	
Total Nitrogen*	%	0.45	0.30 - 0.60
C/N Ratio*		9.9	
Anaerobically Mineralisable N/Total N Ratio*	%	3.7	3.0 - 5.0
Soil Sample Depth*	mm	0-100	



Base Saturation %	K 4.8	Ca 74	Mg 8.8	Na 0.3
MAF Units	K 24	Ca 23	Mg 48	Na 3

The above nutrient graph compares the levels found with reference interpretation levels. NOTE: It is important that the correct sample type be assigned, and that the recommended sampling procedure has been followed. R J Hill Laboratories Limited does not accept any responsibility for the resulting use of this information. IANZ Accreditation does not apply to comments and interpretations, i.e. the 'Range Levels' and subsequent graphs.

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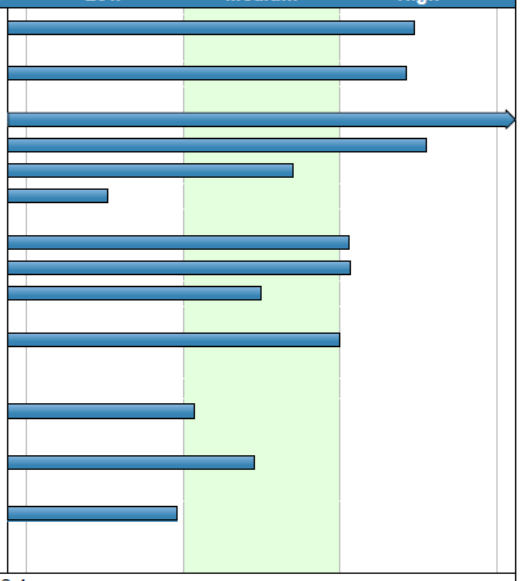
		Order No:	340-202	
		Client Reference:	Lynch 340-202	
Phone:	06 835 9200	**Submitted By:**	B Lynch	

Sample Name: ORCH10-R-Agri2015 **Lab Number:** 1428684.2
Sample Type: SOIL General, Outdoor (S10)

Analysis		Level Found	Medium Range
pH	pH Units	6.7	5.8 - 6.3
Olsen Phosphorus	mg/L	60	20 - 30
Potassium	me/100g	1.52	0.50 - 0.80
Calcium	me/100g	19.2	6.0 - 12.0
Magnesium	me/100g	2.41	1.00 - 3.00
Sodium	me/100g	0.10	0.20 - 0.50
CEC	me/100g	27	12 - 25
Total Base Saturation	%	86	50 - 85
Volume Weight	g/mL	0.80	0.60 - 1.00
Available Nitrogen (15cm Depth)*	kg/ha	150	100 - 150
Anaerobically Mineralisable N*	µg/g	125	
Organic Matter*	%	7.7	7.0 - 17.0
Total Carbon*	%	4.5	
Total Nitrogen*	%	0.44	0.30 - 0.60
C/N Ratio*		10.3	
Anaerobically Mineralisable N/Total N Ratio*	%	2.9	3.0 - 5.0
Soil Sample Depth*	mm	0-100	



Base Saturation %	K 5.6	Ca 71	Mg 8.9	Na 0.4
MAF Units	K 25	Ca 19	Mg 43	Na 4

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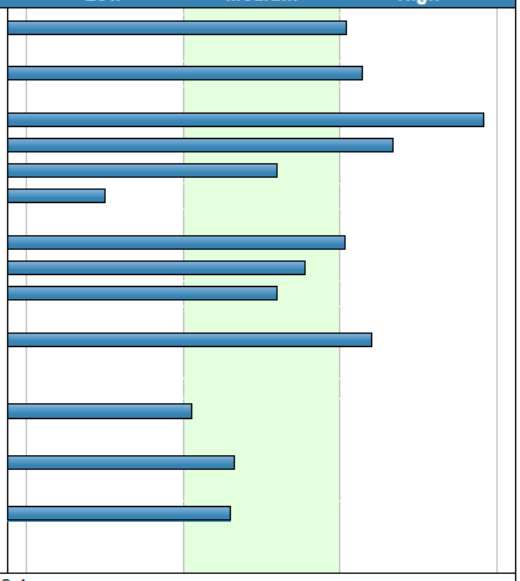
		Client Reference:	Lynch 340-202	
Phone:	06 835 9200	**Submitted By:**	B Lynch	

Sample Name: ORCH11-I-Agri2015 **Lab Number:** 1428684.3
Sample Type: SOIL General, Outdoor (S10)

Analysis		Level Found	Medium Range
pH	pH Units	6.3	5.8 - 6.3
Olsen Phosphorus	mg/L	40	20 - 30
Potassium	me/100g	1.35	0.50 - 0.80
Calcium	me/100g	16.4	6.0 - 12.0
Magnesium	me/100g	2.19	1.00 - 3.00
Sodium	me/100g	0.10	0.20 - 0.50
CEC	me/100g	26	12 - 25
Total Base Saturation	%	77	50 - 85
Volume Weight	g/mL	0.84	0.60 - 1.00
Available Nitrogen (15cm Depth)*	kg/ha	181	100 - 150
Anaerobically Mineralisable N*	µg/g	144	
Organic Matter*	%	7.5	7.0 - 17.0
Total Carbon*	%	4.4	
Total Nitrogen*	%	0.40	0.30 - 0.60
C/N Ratio*		11.0	
Anaerobically Mineralisable N/Total N Ratio*	%	3.6	3.0 - 5.0
Soil Sample Depth*	mm	0-100	



Base Saturation %	K 5.2	Ca 63	Mg 8.4	Na 0.4
MAF Units	K 23	Ca 17	Mg 41	Na 4

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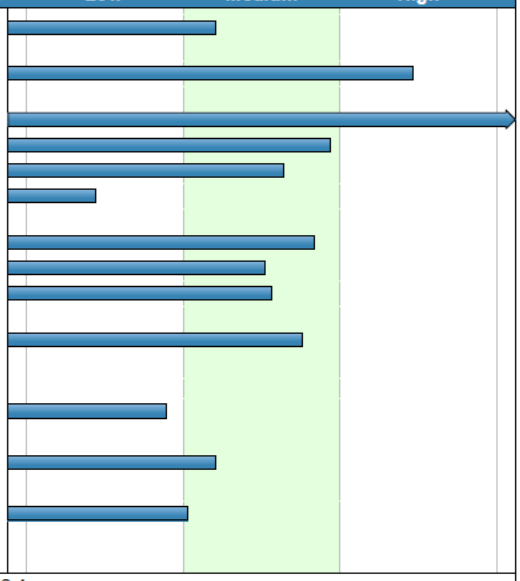
		Quote No:	45047	
		Order No:	340-202	
		Client Reference:	Lynch 340-202	
Phone:	06 835 9200	**Submitted By:**	B Lynch	

Sample Name: ORCH11-R-Agri2015 **Lab Number:** 1428684.4
Sample Type: SOIL General, Outdoor (S10)

Analysis		Level Found	Medium Range
pH	pH Units	5.9	5.8 - 6.3
Olsen Phosphorus	mg/L	63	20 - 30
Potassium	me/100g	1.59	0.50 - 0.80
Calcium	me/100g	11.7	6.0 - 12.0
Magnesium	me/100g	2.28	1.00 - 3.00
Sodium	me/100g	0.09	0.20 - 0.50
CEC	me/100g	23	12 - 25
Total Base Saturation	%	68	50 - 85
Volume Weight	g/mL	0.83	0.60 - 1.00
Available Nitrogen (15cm Depth)*	kg/ha	138	100 - 150
Anaerobically Mineralisable N*	µg/g	111	
Organic Matter*	%	6.3	7.0 - 17.0
Total Carbon*	%	3.6	
Total Nitrogen*	%	0.36	0.30 - 0.60
C/N Ratio*		10.0	
Anaerobically Mineralisable N/Total N Ratio*	%	3.1	3.0 - 5.0
Soil Sample Depth*	mm	0-100	



Base Saturation %	K 6.9	Ca 51	Mg 10.0	Na 0.4
MAF Units	K 27	Ca 12	Mg 42	Na 3

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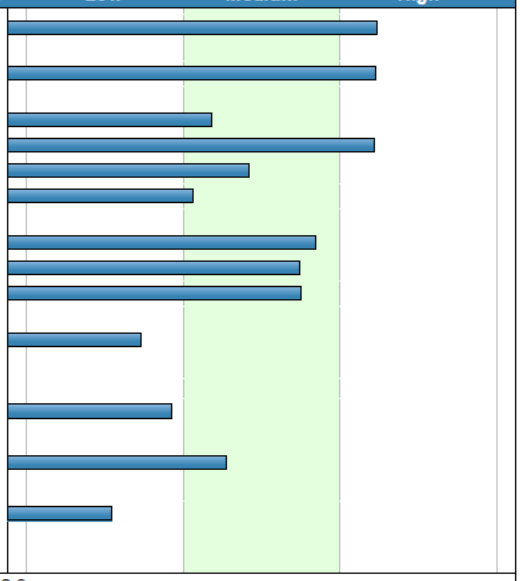
		Client Reference:	Lynch 340-202	
Phone:	06 835 9200	**Submitted By:**	B Lynch	

Sample Name: VIN04-I-Agri2015 **Lab Number:** 1428684.5
Sample Type: SOIL General, Outdoor (S10)

Analysis		Level Found	Medium Range
pH	pH Units	6.5	5.8 - 6.3
Olsen Phosphorus	mg/L	46	20 - 30
Potassium	me/100g	0.55	0.50 - 0.80
Calcium	me/100g	14.9	6.0 - 12.0
Magnesium	me/100g	1.84	1.00 - 3.00
Sodium	me/100g	0.22	0.20 - 0.50
CEC	me/100g	23	12 - 25
Total Base Saturation	%	76	50 - 85
Volume Weight	g/mL	0.90	0.60 - 1.00
Available Nitrogen (15cm Depth)*	kg/ha	86	100 - 150
Anaerobically Mineralisable N*	µg/g	64	
Organic Matter*	%	6.5	7.0 - 17.0
Total Carbon*	%	3.8	
Total Nitrogen*	%	0.38	0.30 - 0.60
C/N Ratio*		9.8	
Anaerobically Mineralisable N/Total N Ratio*	%	1.7	3.0 - 5.0
Soil Sample Depth*	mm	0-100	



Base Saturation %	K 2.4	Ca 65	Mg 8.0	Na 0.9
MAF Units	K 10	Ca 17	Mg 37	Na 9

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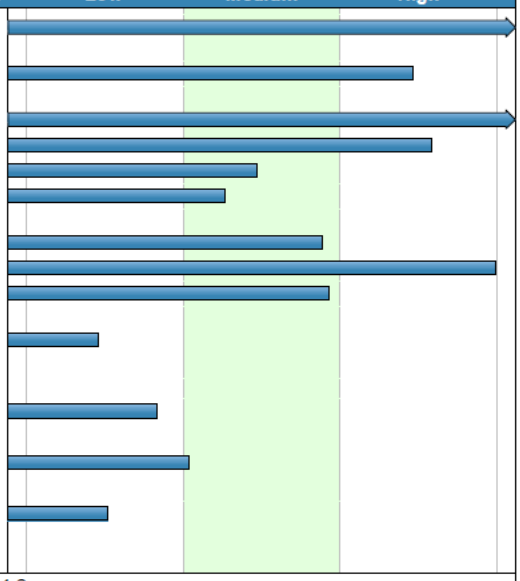
		Client Reference:	Lynch 340-202	
Phone:	06 835 9200	**Submitted By:**	B Lynch	

Sample Name: VIN04-R-Agri2015 **Lab Number:** 1428684.6
Sample Type: SOIL General, Outdoor (S10)

Analysis		Level Found	Medium Range
pH	pH Units	7.6	5.8 - 6.3
Olsen Phosphorus	mg/L	63	20 - 30
Potassium	me/100g	1.64	0.50 - 0.80
Calcium	me/100g	19.7	6.0 - 12.0
Magnesium	me/100g	1.95	1.00 - 3.00
Sodium	me/100g	0.28	0.20 - 0.50
CEC	me/100g	24	12 - 25
Total Base Saturation	%	100	50 - 85
Volume Weight	g/mL	0.97	0.60 - 1.00
Available Nitrogen (15cm Depth)*	kg/ha	73	100 - 150
Anaerobically Mineralisable N*	µg/g	50	
Organic Matter*	%	5.8	7.0 - 17.0
Total Carbon*	%	3.4	
Total Nitrogen*	%	0.31	0.30 - 0.60
C/N Ratio*		10.8	
Anaerobically Mineralisable N/Total N Ratio*	%	1.6	3.0 - 5.0
Soil Sample Depth*	mm	0-100	



Base Saturation %	K 7.0	Ca 84	Mg 8.3	Na 1.2
MAF Units	K 33	Ca 24	Mg 43	Na 13

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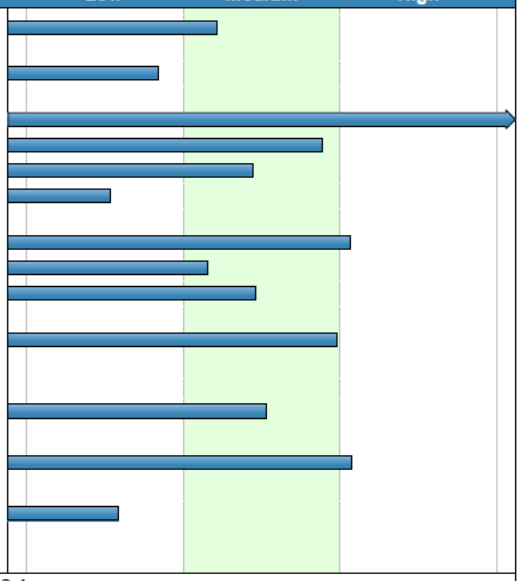
		Client Reference:	Lynch 340-202	
Phone:	06 835 9200	**Submitted By:**	B Lynch	

Sample Name: VIN02-I-Agri2015 **Lab Number:** 1428684.7
Sample Type: SOIL General, Outdoor (S10)

Analysis		Level Found	Medium Range
pH	pH Units	5.9	5.8 - 6.3
Olsen Phosphorus	mg/L	18	20 - 30
Potassium	me/100g	1.77	0.50 - 0.80
Calcium	me/100g	11.3	6.0 - 12.0
Magnesium	me/100g	1.90	1.00 - 3.00
Sodium	me/100g	0.11	0.20 - 0.50
CEC	me/100g	27	12 - 25
Total Base Saturation	%	55	50 - 85
Volume Weight	g/mL	0.78	0.60 - 1.00
Available Nitrogen (15cm Depth)*	kg/ha	149	100 - 150
Anaerobically Mineralisable N*	µg/g	127	
Organic Matter*	%	12.3	7.0 - 17.0
Total Carbon*	%	7.1	
Total Nitrogen*	%	0.71	0.30 - 0.60
C/N Ratio*		10.1	
Anaerobically Mineralisable N/Total N Ratio*	%	1.8	3.0 - 5.0
Soil Sample Depth*	mm	0-100	



Base Saturation %	K 6.5	Ca 42	Mg 7.0	Na 0.4
MAF Units	K 28	Ca 11	Mg 33	Na 4

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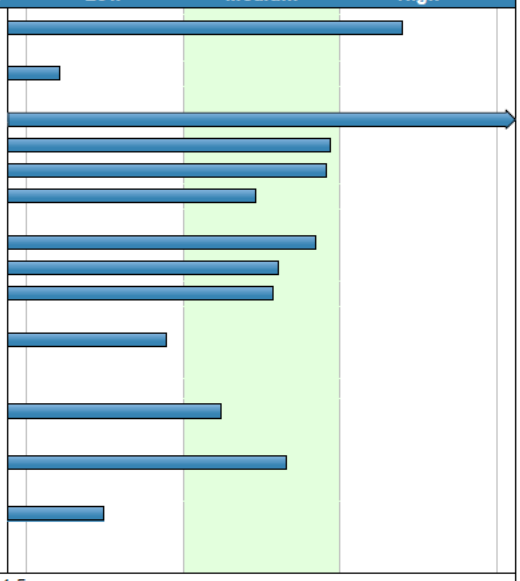
		Order No:	340-202	
		Client Reference:	Lynch 340-202	
Phone:	06 835 9200	**Submitted By:**	B Lynch	

Sample Name: VIN02-R-Agri2015 **Lab Number:** 1428684.8
Sample Type: SOIL General, Outdoor (S10)

Analysis		Level Found	Medium Range
pH	pH Units	6.7	5.8 - 6.3
Olsen Phosphorus	mg/L	8	20 - 30
Potassium	me/100g	1.64	0.50 - 0.80
Calcium	me/100g	11.6	6.0 - 12.0
Magnesium	me/100g	2.83	1.00 - 3.00
Sodium	me/100g	0.34	0.20 - 0.50
CEC	me/100g	23	12 - 25
Total Base Saturation	%	71	50 - 85
Volume Weight	g/mL	0.83	0.60 - 1.00
Available Nitrogen (15cm Depth)*	kg/ha	95	100 - 150
Anaerobically Mineralisable N*	µg/g	76	
Organic Matter*	%	9.4	7.0 - 17.0
Total Carbon*	%	5.4	
Total Nitrogen*	%	0.50	0.30 - 0.60
C/N Ratio*		11.0	
Anaerobically Mineralisable N/Total N Ratio*	%	1.5	3.0 - 5.0
Soil Sample Depth*	mm	0-100	



Base Saturation %	K 7.1	Ca 50	Mg 12.3	Na 1.5
MAF Units	K 28	Ca 12	Mg 53	Na 13

The above nutrient graph compares the levels found with reference interpretation levels. NOTE: It is important that the correct sample type be assigned, and that the recommended sampling procedure has been followed. R J Hill Laboratories Limited does not accept any responsibility for the resulting use of this information. IANZ Accreditation does not apply to comments and interpretations, i.e. the 'Range Levels' and subsequent graphs.

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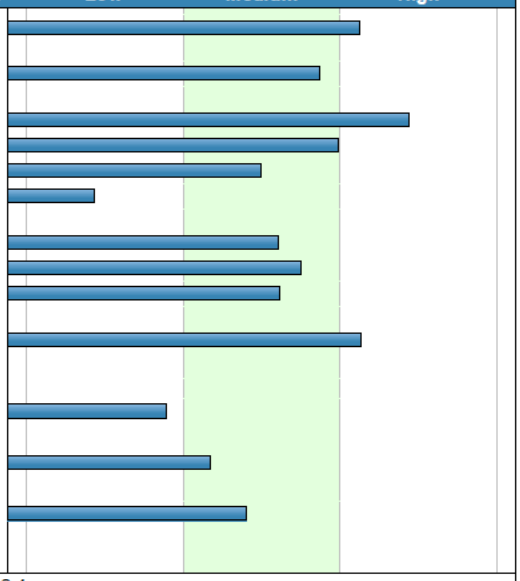
ANALYSIS REPORT

Client:	Hawkes Bay Regional Council	**Lab No:**	1428684	shpv1
Address:	Private Bag 6006 NAPIER 4142	**Date Registered:**	20-May-2015	
		Date Reported:	22-May-2015	
		Quote No:	45047	
		Order No:	340-202	
		Client Reference:	Lynch 340-202	
Phone:	06 835 9200	**Submitted By:**	B Lynch	

Sample Name: VIN05-I-Agri2015 **Lab Number:** 1428684.9
Sample Type: SOIL General, Outdoor (S10)

Analysis		Level Found	Medium Range
pH	pH Units	6.4	5.8 - 6.3
Olsen Phosphorus	mg/L	29	20 - 30
Potassium	me/100g	1.07	0.50 - 0.80
Calcium	me/100g	12.0	6.0 - 12.0
Magnesium	me/100g	2.00	1.00 - 3.00
Sodium	me/100g	0.09	0.20 - 0.50
CEC	me/100g	20	12 - 25
Total Base Saturation	%	76	50 - 85
Volume Weight	g/mL	0.85	0.60 - 1.00
Available Nitrogen (15cm Depth)*	kg/ha	170	100 - 150
Anaerobically Mineralisable N*	µg/g	134	
Organic Matter*	%	6.2	7.0 - 17.0
Total Carbon*	%	3.6	
Total Nitrogen*	%	0.35	0.30 - 0.60
C/N Ratio*		10.2	
Anaerobically Mineralisable N/Total N Ratio*	%	3.8	3.0 - 5.0
Soil Sample Depth*	mm	0-100	



Base Saturation %	K 5.4	Ca 60	Mg 10.1	Na 0.4
MAF Units	K 19	Ca 13	Mg 38	Na 3

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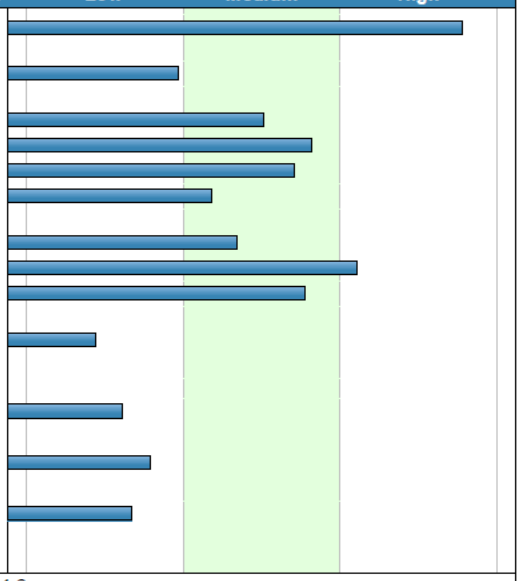
ANALYSIS REPORT

Client:	Hawkes Bay Regional Council	**Lab No:**	1428684	shpv1
Address:	Private Bag 6006 NAPIER 4142	**Date Registered:**	20-May-2015	
		Date Reported:	22-May-2015	
		Quote No:	45047	
		Order No:	340-202	
		Client Reference:	Lynch 340-202	
Phone:	06 835 9200	**Submitted By:**	B Lynch	

Sample Name: VIN05-R-Agri2015 **Lab Number:** 1428684.10
Sample Type: SOIL General, Outdoor (S10)

Analysis		Level Found	Medium Range
pH	pH Units	7.0	5.8 - 6.3
Olsen Phosphorus	mg/L	20	20 - 30
Potassium	me/100g	0.65	0.50 - 0.80
Calcium	me/100g	10.9	6.0 - 12.0
Magnesium	me/100g	2.42	1.00 - 3.00
Sodium	me/100g	0.26	0.20 - 0.50
CEC	me/100g	16	12 - 25
Total Base Saturation	%	87	50 - 85
Volume Weight	g/mL	0.91	0.60 - 1.00
Available Nitrogen (15cm Depth)*	kg/ha	72	100 - 150
Anaerobically Mineralisable N*	µg/g	53	
Organic Matter*	%	4.3	7.0 - 17.0
Total Carbon*	%	2.5	
Total Nitrogen*	%	0.26	0.30 - 0.60
C/N Ratio*		9.6	
Anaerobically Mineralisable N/Total N Ratio*	%	2.1	3.0 - 5.0
Soil Sample Depth*	mm	0-100	



Base Saturation %	K 4.0	Ca 66	Mg 14.7	Na 1.6
MAF Units	K 12	Ca 12	Mg 50	Na 11

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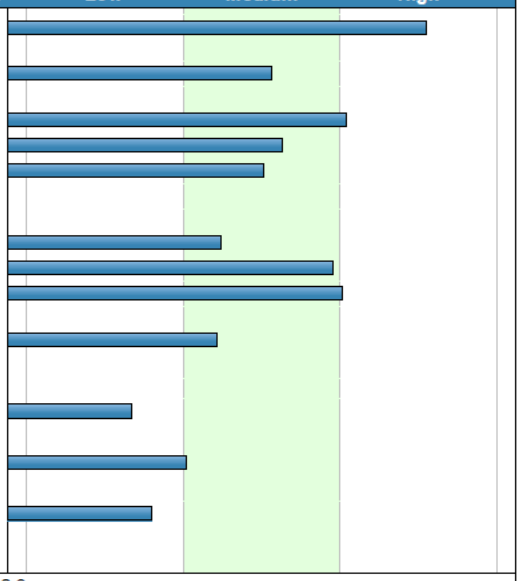
ANALYSIS REPORT

Client:	Hawkes Bay Regional Council	**Lab No:**	1428684	shpv1
Address:	Private Bag 6006 NAPIER 4142	**Date Registered:**	20-May-2015	
		Date Reported:	22-May-2015	
		Quote No:	45047	
		Order No:	340-202	
		Client Reference:	Lynch 340-202	
Phone:	06 835 9200	**Submitted By:**	B Lynch	

Sample Name: VIN06-I-Agri2015 **Lab Number:** 1428684.11
Sample Type: SOIL General, Outdoor (S10)

Analysis		Level Found	Medium Range
pH	pH Units	6.8	5.8 - 6.3
Olsen Phosphorus	mg/L	26	20 - 30
Potassium	me/100g	0.82	0.50 - 0.80
Calcium	me/100g	9.8	6.0 - 12.0
Magnesium	me/100g	2.02	1.00 - 3.00
Sodium	me/100g	< 0.05	0.20 - 0.50
CEC	me/100g	15	12 - 25
Total Base Saturation	%	84	50 - 85
Volume Weight	g/mL	1.00	0.60 - 1.00
Available Nitrogen (15cm Depth)*	kg/ha	111	100 - 150
Anaerobically Mineralisable N*	µg/g	74	
Organic Matter*	%	4.7	7.0 - 17.0
Total Carbon*	%	2.7	
Total Nitrogen*	%	0.31	0.30 - 0.60
C/N Ratio*		9.0	
Anaerobically Mineralisable N/Total N Ratio*	%	2.4	3.0 - 5.0
Soil Sample Depth*	mm	0-100	



Base Saturation %	K 5.4	Ca 64	Mg 13.4	Na 0.3
MAF Units	K 17	Ca 12	Mg 46	Na < 2

The above nutrient graph compares the levels found with reference interpretation levels. NOTE: It is important that the correct sample type be assigned, and that the recommended sampling procedure has been followed. R J Hill Laboratories Limited does not accept any responsibility for the resulting use of this information. IANZ Accreditation does not apply to comments and interpretations, i.e. the 'Range Levels' and subsequent graphs.

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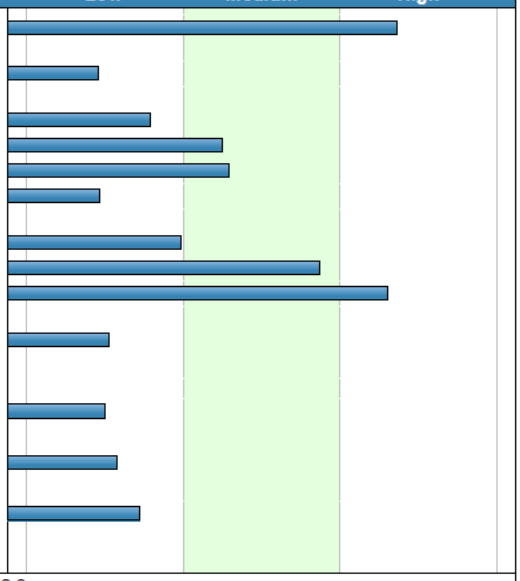
Address:	Private Bag 6006 NAPIER 4142	**Date Registered:**	20-May-2015	
		Date Reported:	22-May-2015	
		Quote No:	45047	
		Order No:	340-202	
		Client Reference:	Lynch 340-202	
Phone:	06 835 9200	**Submitted By:**	B Lynch	

Sample Name: VIN06-R-Agri2015 **Lab Number:** 1428684.12
Sample Type: SOIL General, Outdoor (S10)

Analysis		Level Found	Medium Range
pH	pH Units	6.6	5.8 - 6.3
Olsen Phosphorus	mg/L	12	20 - 30
Potassium	me/100g	0.43	0.50 - 0.80
Calcium	me/100g	7.5	6.0 - 12.0
Magnesium	me/100g	1.59	1.00 - 3.00
Sodium	me/100g	0.09	0.20 - 0.50
CEC	me/100g	12	12 - 25
Total Base Saturation	%	81	50 - 85
Volume Weight	g/mL	1.08	0.60 - 1.00
Available Nitrogen (15cm Depth)*	kg/ha	76	100 - 150
Anaerobically Mineralisable N*	µg/g	47	
Organic Matter*	%	3.5	7.0 - 17.0
Total Carbon*	%	2.0	
Total Nitrogen*	%	0.21	0.30 - 0.60
C/N Ratio*		9.4	
Anaerobically Mineralisable N/Total N Ratio*	%	2.2	3.0 - 5.0
Soil Sample Depth*	mm	0-100	



Base Saturation %	K 3.6	Ca 63	Mg 13.3	Na 0.8
MAF Units	K 9	Ca 10	Mg 39	Na 5

The above nutrient graph compares the levels found with reference interpretation levels. NOTE: It is important that the correct sample type be assigned, and that the recommended sampling procedure has been followed. R J Hill Laboratories Limited does not accept any responsibility for the resulting use of this information. IANZ Accreditation does not apply to comments and interpretations, i.e. the 'Range Levels' and subsequent graphs.

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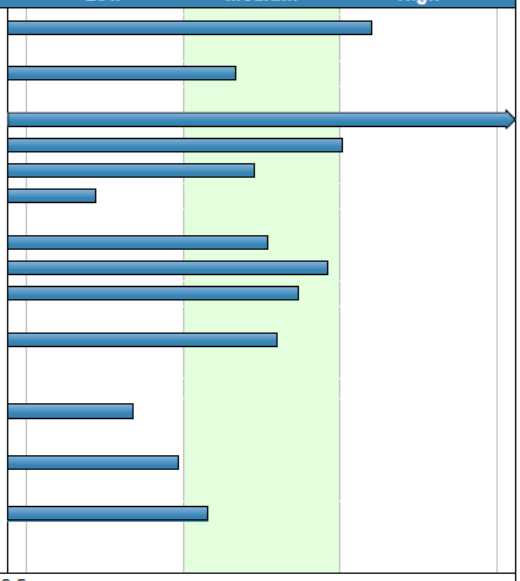
		Date Reported:	22-May-2015	
		Quote No:	45047	
		Order No:	340-202	
		Client Reference:	Lynch 340-202	
Phone:	06 835 9200	**Submitted By:**	B Lynch	

Sample Name: VIN01-I-Agri2015 **Lab Number:** 1428684.13
Sample Type: SOIL General, Outdoor (S10)

Analysis		Level Found	Medium Range
pH	pH Units	6.5	5.8 - 6.3
Olsen Phosphorus	mg/L	23	20 - 30
Potassium	me/100g	1.42	0.50 - 0.80
Calcium	me/100g	12.2	6.0 - 12.0
Magnesium	me/100g	1.91	1.00 - 3.00
Sodium	me/100g	0.09	0.20 - 0.50
CEC	me/100g	19	12 - 25
Total Base Saturation	%	82	50 - 85
Volume Weight	g/mL	0.89	0.60 - 1.00
Available Nitrogen (15cm Depth)*	kg/ha	130	100 - 150
Anaerobically Mineralisable N*	µg/g	97	
Organic Matter*	%	4.7	7.0 - 17.0
Total Carbon*	%	2.7	
Total Nitrogen*	%	0.29	0.30 - 0.60
C/N Ratio*		9.4	
Anaerobically Mineralisable N/Total N Ratio*	%	3.3	3.0 - 5.0
Soil Sample Depth*	mm	0-100	



Base Saturation %	K 7.5	Ca 64	Mg 10.1	Na 0.5
MAF Units	K 26	Ca 14	Mg 38	Na 4

The above nutrient graph compares the levels found with reference interpretation levels. NOTE: It is important that the correct sample type be assigned, and that the recommended sampling procedure has been followed. R J Hill Laboratories Limited does not accept any responsibility for the resulting use of this information. IANZ Accreditation does not apply to comments and interpretations, i.e. the 'Range Levels' and subsequent graphs.

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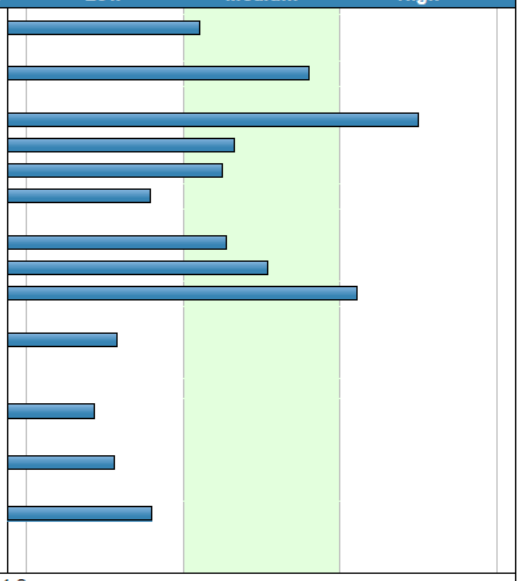
Client:	Hawkes Bay Regional Council	**Lab No:**	1428684	shpv1
Address:	Private Bag 6006 NAPIER 4142	**Date Registered:**	20-May-2015	
		Date Reported:	22-May-2015	
		Quote No:	45047	
		Order No:	340-202	
		Client Reference:	Lynch 340-202	
Phone:	06 835 9200	**Submitted By:**	B Lynch	

Sample Name: VIN01-R-Agri2015 **Lab Number:** 1428684.14
Sample Type: SOIL General, Outdoor (S10)

Analysis		Level Found	Medium Range
pH	pH Units	5.9	5.8 - 6.3
Olsen Phosphorus	mg/L	28	20 - 30
Potassium	me/100g	1.10	0.50 - 0.80
Calcium	me/100g	8.0	6.0 - 12.0
Magnesium	me/100g	1.49	1.00 - 3.00
Sodium	me/100g	0.16	0.20 - 0.50
CEC	me/100g	16	12 - 25
Total Base Saturation	%	69	50 - 85
Volume Weight	g/mL	1.03	0.60 - 1.00
Available Nitrogen (15cm Depth)*	kg/ha	79	100 - 150
Anaerobically Mineralisable N*	µg/g	51	
Organic Matter*	%	3.0	7.0 - 17.0
Total Carbon*	%	1.7	
Total Nitrogen*	%	0.21	0.30 - 0.60
C/N Ratio*		8.2	
Anaerobically Mineralisable N/Total N Ratio*	%	2.4	3.0 - 5.0
Soil Sample Depth*	mm	0-100	



Base Saturation %	K 7.1	Ca 51	Mg 9.6	Na 1.0
MAF Units	K 23	Ca 10	Mg 35	Na 7

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		Quote No:	45047	
		Order No:	340-202	
		Client Reference:	Lynch 340-202	
Phone:	06 835 9200	**Submitted By:**	B Lynch	

Analyst's Comments

Samples 1-14 Comment:
The medium range guidelines shown in the histogram report relate to sampling protocols as per Hill Laboratories' crop guides and are based on reference values where these are published. Results for samples collected to different depths than those described in the crop guide should be interpreted with caution.
For pastoral soils, the medium ranges are specific for a 75mm sample depth, but if a 150mm sampling depth is used the nutrient levels measured may appear low against these ranges, as nutrients are typically more concentrated in the top of the soil profile. These soil profile differences are altered upon cultivation or contouring.

Samples 1-14 Comment:
The Available Nitrogen (kg/ha) test above assumes the sample is taken to a 15 cm depth. If the depth is 7.5 cm, then the result reported above should be divided by two.
To calculate Available Nitrogen (as kgN/ha) for other sample depths use the reported Anaerobic Mineralisable Nitrogen (AMN) result in the following equation:
AN (kg/ha) = AMN (µg/g) x VW (g/ml) x sample depth (cm) x 0.1
Note that the AN and AMN results reported include the readily available Mineral N (NH4-N and NO3-N) fraction, which is typically quite low.

Sample 12 Comment:
The low CEC level found in this soil indicates that it can only retain cation nutrients (potassium, calcium, magnesium and sodium) at low levels. The normal ranges and the derived histograms are based on a typical soil with a CEC level between 12 and 25 me/100g. The % base saturation data for each element provides an alternative presentation that may be more appropriate for soils with atypical CEC values. Normal %BS levels, as a general guide, are: K 2%-5%, Ca 50%-75%, Mg 5%-15%, Na 1%-2%.

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.

Sample Type: Soil

Test	Method Description	Default Detection Limit	Sample No
Sample Registration*	Samples were registered according to instructions received.	-	1-14
Soil Prep (Dry & Grind)*	Air dried at 35 - 40°C overnight (residual moisture typically 4%) and crushed to pass through a 2mm screen.	-	1-14
pH	1:2 (v/v) soil:water slurry followed by potentiometric determination of pH.	0.1 pH Units	1-14
Olsen Phosphorus	Olsen extraction followed by Molybdenum Blue colorimetry.	1 mg/L	1-14
Potassium (MAF)	1M Neutral ammonium acetate extraction followed by ICP-OES.	1 MAF units	1-14
Calcium (MAF)	1M Neutral ammonium acetate extraction followed by ICP-OES.	1 MAF units	1-14
Magnesium (MAF)	1M Neutral ammonium acetate extraction followed by ICP-OES.	1 MAF units	1-14
Sodium (MAF)	1M Neutral ammonium acetate extraction followed by ICP-OES.	2 MAF units	1-14
Available Nitrogen*	Determined by NIR, calibration based on Available N by Anaerobic incubation followed by extraction using 2M KCl followed by Berthelot colorimetry. (Calculation based on 15cm depth sample).	1 mg/L	1-14
Anaerobically Mineralisable N*	As for Available Nitrogen but reported as µg/g.	5 µg/g	1-14
Organic Matter*	Organic Matter is 1.72 x Total Carbon.	0.2 %	1-14
Total Carbon*	Determined by NIR, calibration based on Total Carbon by Dumas combustion.	0.1 %	1-14

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		Date Reported:	22-May-2015	
		Quote No:	45047	
		Order No:	340-202	
		Client Reference:	Lynch 340-202	
Phone:	06 835 9200	**Submitted By:**	B Lynch	

Sample Type: Soil

Test	Method Description	Default Detection Limit	Sample No
Total Nitrogen*	Determined by NIR, calibration based on Total N by Dumas combustion.	0.04 %	1-14
Potassium	1M Neutral ammonium acetate extraction followed by ICP-OES.	0.01 me/100g	1-14
Calcium	1M Neutral ammonium acetate extraction followed by ICP-OES.	0.5 me/100g	1-14
Magnesium	1M Neutral ammonium acetate extraction followed by ICP-OES.	0.04 me/100g	1-14
Sodium	1M Neutral ammonium acetate extraction followed by ICP-OES.	0.05 me/100g	1-14
Potassium (Sat)	1M Neutral ammonium acetate extraction followed by ICP-OES.	0.1 %BS	1-14
Calcium (Sat)	1M Neutral ammonium acetate extraction followed by ICP-OES.	1 %BS	1-14
Magnesium (Sat)	1M Neutral ammonium acetate extraction followed by ICP-OES.	0.2 %BS	1-14
Sodium (Sat)	1M Neutral ammonium acetate extraction followed by ICP-OES.	0.1 %BS	1-14
CEC	Summation of extractable cations (K, Ca, Mg, Na) and extractable acidity. May be overestimated if soil contains high levels of soluble salts or carbonates.	2 me/100g	1-14
Total Base Saturation	Calculated from Extractable Cations and Cation Exchange Capacity.	5 %	1-14
Volume Weight	The weight/volume ratio of dried, ground soil.	0.01 g/mL	1-14

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.

Andrew Whitmore BSc (Tech)
Technologist - Agriculture Division

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ANALYSIS REPORT

Client:	Hawkes Bay Regional Council	**Lab No:**	1428245	SPv1
Contact:	B Lynch	**Date Registered:**	20-May-2015	
	C/- Hawkes Bay Regional Council	**Date Reported:**	12-Jun-2015	
	Private Bag 6006	**Quote No:**	45046	
	NAPIER 4142	**Order No:**	340-202	
		Client Reference:	Lynch 340-202	
		Submitted By:	B Lynch	

Sample Type: Soil

Sample Name:		ORCH01-I-Env2015 11-May-2015	ORCH01-R-Env2015 11-May-2015	ORCH02-I-Env2015 11-May-2015	ORCH02-R-Env2015 11-May-2015	ORCH03-I-Env2015 11-May-2015
Lab Number:		1428245.1	1428245.2	1428245.3	1428245.4	1428245.5
Individual Tests						
Total Recoverable Uranium	mg/kg dry wt	0.92	0.94	0.69	0.69	0.89
Fluoride*	mg/kg dry wt	360	430	350	350	350
Heavy metals, screen As,Cd,Cr,Cu,Ni,Pb,Zn,Hg						
Total Recoverable Arsenic	mg/kg dry wt	8	8	59	56	4
Total Recoverable Cadmium	mg/kg dry wt	0.17	0.20	0.15	0.11	0.15
Total Recoverable Chromium	mg/kg dry wt	18	18	15	15	14
Total Recoverable Copper	mg/kg dry wt	65	65	133	122	18
Total Recoverable Lead	mg/kg dry wt	22	21	181	174	12.4
Total Recoverable Mercury	mg/kg dry wt	0.10	0.14	0.69	0.74	< 0.10
Total Recoverable Nickel	mg/kg dry wt	15	15	12	14	11
Total Recoverable Zinc	mg/kg dry wt	123	157	125	117	67
Organochlorine Pesticides Screening in Soil						
Aldrin	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
alpha-BHC	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
beta-BHC	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
delta-BHC	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
gamma-BHC (Lindane)	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
cis-Chlordane	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
trans-Chlordane	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Total Chlordane [(cis+trans)* 100/42]	mg/kg dry wt	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04
2,4'-DDD	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
4,4'-DDD	mg/kg dry wt	0.011	0.012	0.107	0.071	< 0.010
2,4'-DDE	mg/kg dry wt	< 0.010	< 0.010	0.020	0.029	< 0.010
4,4'-DDE	mg/kg dry wt	0.24	0.41	3.8	4.6	< 0.010
2,4'-DDT	mg/kg dry wt	< 0.010	< 0.010	0.142	0.25	< 0.010
4,4'-DDT	mg/kg dry wt	0.149	0.25	3.9	4.9	< 0.010
Dieldrin	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Endosulfan I	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Endosulfan II	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Endosulfan sulphate	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Endrin	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Endrin aldehyde	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Endrin ketone	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Heptachlor	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Heptachlor epoxide	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Hexachlorobenzene	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Methoxychlor	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010

Sample Type: Soil						
	Sample Name:	ORCH01-I-Env2015 11-May-2015	ORCH01-R-Env2015 11-May-2015	ORCH02-I-Env2015 11-May-2015	ORCH02-R-Env2015 11-May-2015	ORCH03-I-Env2015 11-May-2015
	Lab Number:	1428245.1	1428245.2	1428245.3	1428245.4	1428245.5

	Sample Name:	ORCH03-R-Env2015 11-May-2015	ORCH04-I-Env2015 12-May-2015	ORCH04-R-Env2015 12-May-2015	ORCH05-I-Env2015 12-May-2015	ORCH05-R-Env2015 12-May-2015
	Lab Number:	1428245.6	1428245.7	1428245.8	1428245.9	1428245.10
Individual Tests						
Total Recoverable Uranium	mg/kg dry wt	0.78	1.19	1.32	0.86	0.89
Fluoride*	mg/kg dry wt	340	420	450	420	450
Heavy metals, screen As,Cd,Cr,Cu,Ni,Pb,Zn,Hg						
Total Recoverable Arsenic	mg/kg dry wt	4	7	8	7	7
Total Recoverable Cadmium	mg/kg dry wt	0.20	0.12	0.19	0.20	0.16
Total Recoverable Chromium	mg/kg dry wt	28	18	18	17	17
Total Recoverable Copper	mg/kg dry wt	20	20	18	148	146
Total Recoverable Lead	mg/kg dry wt	13.7	22	25	22	24
Total Recoverable Mercury	mg/kg dry wt	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Total Recoverable Nickel	mg/kg dry wt	11	16	15	14	15
Total Recoverable Zinc	mg/kg dry wt	91	78	88	128	108
Organochlorine Pesticides Screening in Soil						
Aldrin	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
alpha-BHC	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
beta-BHC	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
delta-BHC	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
gamma-BHC (Lindane)	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
cis-Chlordane	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
trans-Chlordane	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Total Chlordane [(cis+trans)* 100/42]	mg/kg dry wt	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04
2,4'-DDD	mg/kg dry wt	< 0.010	< 0.010	< 0.010	0.015	0.036
4,4'-DDD	mg/kg dry wt	< 0.010	< 0.010	< 0.010	0.041	0.062
2,4'-DDE	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
4,4'-DDE	mg/kg dry wt	< 0.010	0.054	0.096	0.162	0.32
2,4'-DDT	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	0.011
4,4'-DDT	mg/kg dry wt	< 0.010	0.053	0.157	0.123	0.30
Dieldrin	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Endosulfan I	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Endosulfan II	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Endosulfan sulphate	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Endrin	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Endrin aldehyde	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Endrin ketone	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Heptachlor	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Heptachlor epoxide	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Hexachlorobenzene	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Methoxychlor	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010

	Sample Name:	ORCH06-I-Env2015 12-May-2015	ORCH06-R-Env2015 12-May-2015	ORCH07-I-Env2015 12-May-2015	ORCH07-R-Env2015 12-May-2015	ORCH08-I-Env2015 13-May-2015
	Lab Number:	1428245.11	1428245.12	1428245.13	1428245.14	1428245.15
Individual Tests						
Total Recoverable Uranium	mg/kg dry wt	0.71	0.67	0.96	1.12	1.12
Fluoride*	mg/kg dry wt	320	350	410	430	380
Heavy metals, screen As,Cd,Cr,Cu,Ni,Pb,Zn,Hg						
Total Recoverable Arsenic	mg/kg dry wt	5	4	5	7	10
Total Recoverable Cadmium	mg/kg dry wt	0.19	0.16	0.21	0.38	0.17
Total Recoverable Chromium	mg/kg dry wt	15	15	15	16	19
Total Recoverable Copper	mg/kg dry wt	25	27	24	23	46
Total Recoverable Lead	mg/kg dry wt	18.8	19.1	21	18.9	26
Total Recoverable Mercury	mg/kg dry wt	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Total Recoverable Nickel	mg/kg dry wt	14	12	13	13	18

Sample Type: Soil						
	Sample Name:	ORCH06-I-Env2015 12-May-2015	ORCH06-R-Env2015 12-May-2015	ORCH07-I-Env2015 12-May-2015	ORCH07-R-Env2015 12-May-2015	ORCH08-I-Env2015 13-May-2015
	Lab Number:	1428245.11	1428245.12	1428245.13	1428245.14	1428245.15
Heavy metals, screen As,Cd,Cr,Cu,Ni,Pb,Zn,Hg						
Total Recoverable Zinc	mg/kg dry wt	88	89	82	89	94
Organochlorine Pesticides Screening in Soil						
Aldrin	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
alpha-BHC	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
beta-BHC	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
delta-BHC	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
gamma-BHC (Lindane)	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
cis-Chlordane	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
trans-Chlordane	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Total Chlordane [(cis+trans)* 100/42]	mg/kg dry wt	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04
2,4'-DDD	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
4,4'-DDD	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	0.022
2,4'-DDE	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
4,4'-DDE	mg/kg dry wt	0.017	0.032	0.024	0.041	0.074
2,4'-DDT	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
4,4'-DDT	mg/kg dry wt	< 0.010	0.015	0.029	0.057	0.057
Dieldrin	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Endosulfan I	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Endosulfan II	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Endosulfan sulphate	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Endrin	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Endrin aldehyde	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Endrin ketone	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Heptachlor	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Heptachlor epoxide	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Hexachlorobenzene	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Methoxychlor	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010

	Sample Name:	ORCH08-R-Env2015 13-May-2015	ORCH09-I-Env2015 13-May-2015	ORCH09-R-Env2015 13-May-2015	ORCH10-I-Env2015 13-May-2015	ORCH10-R-Env2015 13-May-2015
	Lab Number:	1428245.16	1428245.17	1428245.18	1428245.19	1428245.20
Individual Tests						
Total Recoverable Uranium	mg/kg dry wt	1.20	1.15	1.19	1.00	0.93
Fluoride*	mg/kg dry wt	490	420	460	310	420
Heavy metals, screen As,Cd,Cr,Cu,Ni,Pb,Zn,Hg						
Total Recoverable Arsenic	mg/kg dry wt	9	21	21	9	8
Total Recoverable Cadmium	mg/kg dry wt	0.15	0.18	0.16	0.29	0.14
Total Recoverable Chromium	mg/kg dry wt	18	17	18	16	16
Total Recoverable Copper	mg/kg dry wt	45	189	126	30	38
Total Recoverable Lead	mg/kg dry wt	25	22	22	19.9	20
Total Recoverable Mercury	mg/kg dry wt	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Total Recoverable Nickel	mg/kg dry wt	16	15	15	16	14
Total Recoverable Zinc	mg/kg dry wt	92	96	93	80	85
Organochlorine Pesticides Screening in Soil						
Aldrin	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
alpha-BHC	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
beta-BHC	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
delta-BHC	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
gamma-BHC (Lindane)	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
cis-Chlordane	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
trans-Chlordane	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Total Chlordane [(cis+trans)* 100/42]	mg/kg dry wt	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04
2,4'-DDD	mg/kg dry wt	0.011	< 0.010	< 0.010	< 0.010	< 0.010
4,4'-DDD	mg/kg dry wt	0.027	< 0.010	< 0.010	< 0.010	< 0.010

Sample Type: Soil						
	Sample Name:	ORCH08-R-Env2015 13-May-2015	ORCH09-I-Env2015 13-May-2015	ORCH09-R-Env2015 13-May-2015	ORCH10-I-Env2015 13-May-2015	ORCH10-R-Env2015 13-May-2015
	Lab Number:	1428245.16	1428245.17	1428245.18	1428245.19	1428245.20
Organochlorine Pesticides Screening in Soil						
2,4'-DDE	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
4,4'-DDE	mg/kg dry wt	0.088	0.013	0.016	< 0.010	< 0.010
2,4'-DDT	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
4,4'-DDT	mg/kg dry wt	0.059	< 0.010	0.019	< 0.010	< 0.010
Dieldrin	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Endosulfan I	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Endosulfan II	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Endosulfan sulphate	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Endrin	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Endrin aldehyde	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Endrin ketone	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Heptachlor	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Heptachlor epoxide	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Hexachlorobenzene	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Methoxychlor	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010

	Sample Name:	ORCH11-I-Env2015 14-May-2015	ORCH11-R-Env2015 14-May-2015	VIN04-I-Env2015 14-May-2015	VIN04-R-Env2015 14-May-2015	VIN02-I-Env2015 14-May-2015
	Lab Number:	1428245.21	1428245.22	1428245.23	1428245.24	1428245.25
Individual Tests						
Total Recoverable Uranium	mg/kg dry wt	1.20	0.98	0.91	1.00	0.82
Fluoride*	mg/kg dry wt	520	480	330	250	370
Heavy metals, screen As,Cd,Cr,Cu,Ni,Pb,Zn,Hg						
Total Recoverable Arsenic	mg/kg dry wt	8	7	3	4	3
Total Recoverable Cadmium	mg/kg dry wt	0.52	0.21	0.26	0.35	0.39
Total Recoverable Chromium	mg/kg dry wt	18	17	9	10	7
Total Recoverable Copper	mg/kg dry wt	560	370	13	15	34
Total Recoverable Lead	mg/kg dry wt	25	24	10.9	11.3	11.7
Total Recoverable Mercury	mg/kg dry wt	< 0.10	0.26	< 0.10	< 0.10	< 0.10
Total Recoverable Nickel	mg/kg dry wt	15	15	8	7	4
Total Recoverable Zinc	mg/kg dry wt	310	173	56	68	57
Organochlorine Pesticides Screening in Soil						
Aldrin	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
alpha-BHC	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
beta-BHC	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
delta-BHC	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
gamma-BHC (Lindane)	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
cis-Chlordane	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
trans-Chlordane	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Total Chlordane [(cis+trans)* 100/42]	mg/kg dry wt	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04
2,4'-DDD	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
4,4'-DDD	mg/kg dry wt	0.018	0.011	< 0.010	< 0.010	< 0.010
2,4'-DDE	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
4,4'-DDE	mg/kg dry wt	0.103	0.078	0.118	0.149	0.58
2,4'-DDT	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	0.026
4,4'-DDT	mg/kg dry wt	0.100	0.105	0.012	0.012	0.033
Dieldrin	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Endosulfan I	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Endosulfan II	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Endosulfan sulphate	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Endrin	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Endrin aldehyde	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Endrin ketone	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Heptachlor	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Heptachlor epoxide	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010

Sample Type: Soil						
	Sample Name:	ORCH11-I-Env2015 14-May-2015	ORCH11-R-Env2015 14-May-2015	VIN04-I-Env2015 14-May-2015	VIN04-R-Env2015 14-May-2015	VIN02-I-Env2015 14-May-2015
	Lab Number:	1428245.21	1428245.22	1428245.23	1428245.24	1428245.25
Organochlorine Pesticides Screening in Soil						
Hexachlorobenzene	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Methoxychlor	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010

	Sample Name:	VIN02-R-Env2015 14-May-2015	VIN05-I-Env2015 18-May-2015	VIN05-R-Env2015 18-May-2015	VIN06-I-Env2015 18-May-2015	VIN06-R-Env2015 18-May-2015
	Lab Number:	1428245.26	1428245.27	1428245.28	1428245.29	1428245.30
Individual Tests						
Total Recoverable Uranium	mg/kg dry wt	0.74	0.69	0.88	0.44	0.36
Fluoride*	mg/kg dry wt	340	270	290	280	240
Heavy metals, screen As,Cd,Cr,Cu,Ni,Pb,Zn,Hg						
Total Recoverable Arsenic	mg/kg dry wt	4	2	4	5	5
Total Recoverable Cadmium	mg/kg dry wt	0.20	0.21	0.29	< 0.10	< 0.10
Total Recoverable Chromium	mg/kg dry wt	7	9	11	12	13
Total Recoverable Copper	mg/kg dry wt	43	11	16	17	14
Total Recoverable Lead	mg/kg dry wt	11.5	10.0	11.1	15.3	14.8
Total Recoverable Mercury	mg/kg dry wt	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Total Recoverable Nickel	mg/kg dry wt	5	6	7	9	8
Total Recoverable Zinc	mg/kg dry wt	82	52	72	72	67
Organochlorine Pesticides Screening in Soil						
Aldrin	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
alpha-BHC	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
beta-BHC	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
delta-BHC	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
gamma-BHC (Lindane)	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
cis-Chlordane	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
trans-Chlordane	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Total Chlordane [(cis+trans)* 100/42]	mg/kg dry wt	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04
2,4'-DDD	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
4,4'-DDD	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
2,4'-DDE	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
4,4'-DDE	mg/kg dry wt	0.165	< 0.010	< 0.010	< 0.010	< 0.010
2,4'-DDT	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
4,4'-DDT	mg/kg dry wt	0.010	< 0.010	< 0.010	< 0.010	< 0.010
Dieldrin	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Endosulfan I	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Endosulfan II	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Endosulfan sulphate	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Endrin	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Endrin aldehyde	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Endrin ketone	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Heptachlor	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Heptachlor epoxide	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Hexachlorobenzene	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Methoxychlor	mg/kg dry wt	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010

	Sample Name:	VIN01-I-Env2015 18-May-2015	VIN01-R-Env2015 18-May-2015			
	Lab Number:	1428245.31	1428245.32			
Individual Tests						
Total Recoverable Uranium	mg/kg dry wt	0.70	0.69	-	-	-
Fluoride*	mg/kg dry wt	290	330	-	-	-
Heavy metals, screen As,Cd,Cr,Cu,Ni,Pb,Zn,Hg						
Total Recoverable Arsenic	mg/kg dry wt	4	4	-	-	-
Total Recoverable Cadmium	mg/kg dry wt	0.13	0.12	-	-	-
Total Recoverable Chromium	mg/kg dry wt	16	15	-	-	-
Total Recoverable Copper	mg/kg dry wt	51	56	-	-	-

Sample Type: Soil						
	Sample Name:	VIN01-I-Env2015 18-May-2015	VIN01-R-Env2015 18-May-2015			
	Lab Number:	1428245.31	1428245.32			
Heavy metals, screen As,Cd,Cr,Cu,Ni,Pb,Zn,Hg						
Total Recoverable Lead	mg/kg dry wt	13.1	13.5	-	-	-
Total Recoverable Mercury	mg/kg dry wt	< 0.10	< 0.10	-	-	-
Total Recoverable Nickel	mg/kg dry wt	12	11	-	-	-
Total Recoverable Zinc	mg/kg dry wt	60	68	-	-	-
Organochlorine Pesticides Screening in Soil						
Aldrin	mg/kg dry wt	< 0.010	< 0.010	-	-	-
alpha-BHC	mg/kg dry wt	< 0.010	< 0.010	-	-	-
beta-BHC	mg/kg dry wt	< 0.010	< 0.010	-	-	-
delta-BHC	mg/kg dry wt	< 0.010	< 0.010	-	-	-
gamma-BHC (Lindane)	mg/kg dry wt	< 0.010	< 0.010	-	-	-
cis-Chlordane	mg/kg dry wt	< 0.010	< 0.010	-	-	-
trans-Chlordane	mg/kg dry wt	< 0.010	< 0.010	-	-	-
Total Chlordane [(cis+trans)* 100/42]	mg/kg dry wt	< 0.04	< 0.04	-	-	-
2,4'-DDD	mg/kg dry wt	< 0.010	< 0.010	-	-	-
4,4'-DDD	mg/kg dry wt	< 0.010	0.013	-	-	-
2,4'-DDE	mg/kg dry wt	< 0.010	< 0.010	-	-	-
4,4'-DDE	mg/kg dry wt	0.029	0.060	-	-	-
2,4'-DDT	mg/kg dry wt	< 0.010	< 0.010	-	-	-
4,4'-DDT	mg/kg dry wt	0.023	0.060	-	-	-
Dieldrin	mg/kg dry wt	< 0.010	0.018	-	-	-
Endosulfan I	mg/kg dry wt	< 0.010	< 0.010	-	-	-
Endosulfan II	mg/kg dry wt	< 0.010	< 0.010	-	-	-
Endosulfan sulphate	mg/kg dry wt	< 0.010	< 0.010	-	-	-
Endrin	mg/kg dry wt	< 0.010	< 0.010	-	-	-
Endrin aldehyde	mg/kg dry wt	< 0.010	< 0.010	-	-	-
Endrin ketone	mg/kg dry wt	< 0.010	< 0.010	-	-	-
Heptachlor	mg/kg dry wt	< 0.010	< 0.010	-	-	-
Heptachlor epoxide	mg/kg dry wt	< 0.010	< 0.010	-	-	-
Hexachlorobenzene	mg/kg dry wt	< 0.010	< 0.010	-	-	-
Methoxychlor	mg/kg dry wt	< 0.010	< 0.010	-	-	-

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.

Sample Type: Soil			
Test	**Method Description**	**Default Detection Limit**	**Sample No**
Environmental Solids Sample Preparation	Air dried at 35°C and sieved, <2mm fraction. Used for sample preparation. May contain a residual moisture content of 2-5%.	-	1-32
Heavy metals, screen As,Cd,Cr,Cu,Ni,Pb,Zn,Hg	Dried sample, <2mm fraction. Nitric/Hydrochloric acid digestion, ICP-MS, screen level.	0.10 - 4 mg/kg dry wt	1-32
Organochlorine Pesticides Screening in Soil	Sonication extraction, SPE cleanup, dual column GC-ECD analysis (modified US EPA 8082).. Tested on dried sample	0.010 - 0.04 mg/kg dry wt	1-32
Total Recoverable digestion	Nitric / hydrochloric acid digestion. US EPA 200.2.	-	1-32
Total Fluoride in solids alkaline fusion*	Alkaline fusion of sample. Methods of Soil Analysis 2nd Edition, Pt2, 26-4.3.3.	-	1-32
Total Recoverable Uranium	Dried sample, sieved as specified (if required). Nitric/Hydrochloric acid digestion, ICP-MS, screen level. US EPA 200.2.	0.10 mg/kg dry wt	1-32
Total Fluoride in solids*	Ion selective electrode. Methods of Soil Analysis 2nd Edition, Pt2, 26-4.3.3.	10 mg/kg dry wt	1-32

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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Analytical Report

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Job Number: PJ14034

Customer: Hawke's Bay Regional Council
Barry Lynch

Date Received: 12/05/2015

Date Reported: 04/08/2015

Core No.	Site name	Sample ID	Particle density	Dry bulk density	Porosity	Macro-porosity	Air capacity	Field capacity	AWC
			(g/cm^3)	(g/cm^3)	(%)	(%)	(%)	(%)	(%)
817	ORCH01-Ia	PP14-1366	2.63	1.27	52	9	11	41	14
798	ORCH01-Ib	PP14-1367	2.63	1.17	55	10	12	44	19
896	ORCH01-Ic	PP14-1368	2.63	1.14	57	10	12	45	17
848	ORCH01-Ra	PP14-1369	2.62	1.21	54	10	11	42	17
943	ORCH01-Rb	PP14-1370	2.63	1.22	54	10	12	42	17
955	ORCH01-Rc	PP14-1371	2.60	1.10	58	12	14	44	20
863	ORCH02-Ia	PP14-1372	2.61	1.32	49	12	14	36	15
836	ORCH02-Ib	PP14-1373	2.62	1.30	50	14	16	35	15
932	ORCH02-Ic	PP14-1374	2.63	1.38	48	10	12	36	18
940	ORCH02-Ra	PP14-1375	2.64	1.32	50	15	17	34	17
950	ORCH02-Rb	PP14-1376	2.63	1.31	50	14	15	35	15
985	ORCH02-Rc	PP14-1377	2.62	1.30	50	14	15	35	15
857	ORCH03-Ia	PP14-1378	2.64	1.40	47	13	16	31	17
806	ORCH03-Ib	PP14-1379	2.64	1.41	46	8	11	35	19

741	ORCH03-Ic	PP14-1380	2.64	1.44	45	13	16	30	17
921	ORCH03-Ra	PP14-1381	2.64	1.30	51	17	20	31	18
824	ORCH03-Rb	PP14-1382	2.63	1.28	51	14	17	35	19
977	ORCH03-Rc	PP14-1383	2.64	1.33	49	16	20	30	17
778	ORCH04-Ia	PP14-1384	2.57	1.05	59	12	13	46	16
890	ORCH04-Ib	PP14-1385	2.58	1.17	55	9	10	45	15
775	ORCH04-Ic	PP14-1386	2.60	1.16	55	11	13	43	14
731	ORCH04-Ra	PP14-1387	2.60	1.15	56	7	8	48	17
909	ORCH04-Rb	PP14-1388	2.60	1.20	54	9	10	44	15
966	ORCH04-Rc	PP14-1389	2.61	1.16	56	12	13	43	16
947	ORCH05-Ia	PP14-1390	2.62	1.25	52	10	12	40	16
762	ORCH05-Ib	PP14-1391	2.63	1.25	52	10	12	40	17
776	ORCH05-Ic	PP14-1392	2.63	1.26	52	12	14	38	16
883	ORCH05-Ra	PP14-1393	2.64	1.28	52	12	14	38	14
874	ORCH05-Rb	PP14-1394	2.62	1.25	52	9	10	42	23
895	ORCH05-Rc	PP14-1395	2.63	1.20	54	14	16	39	21
794	ORCH06-Ia	PP14-1396	2.64	1.29	51	13	15	36	21
735	ORCH06-Ib	PP14-1397	2.64	1.25	53	16	18	35	21
742	ORCH06-Ic	PP14-1398	2.64	1.27	52	11	13	39	22
898	ORCH06-Ra	PP14-1399	2.63	1.24	53	14	17	36	22
924	ORCH06-Rb	PP14-1400	2.63	1.41	46	4	6	41	25
892	ORCH06-Rc	PP14-1401	2.65	1.33	50	10	13	37	22
979	ORCH07-Ia	PP14-1402	2.58	1.13	56	6	7	49	26
928	ORCH07-Ib	PP14-1403	2.60	1.14	56	8	9	48	20
937	ORCH07-Ic	PP14-1404	2.58	0.98	62	7	8	54	21
974	ORCH07-Ra	PP14-1405	2.59	1.09	58	9	10	48	21
967	ORCH07-Rb	PP14-1406	2.60	1.11	57	6	7	50	23
981	ORCH07-Rc	PP14-1407	2.59	1.13	57	6	7	50	20
751	ORCH08-Ia	PP14-1408	2.56	1.19	54	8	9	45	16
834	ORCH08-Ib	PP14-1409	2.60	1.25	52	7	8	44	16
802	ORCH08-Ic	PP14-1410	2.58	1.18	54	6	8	47	25
763	ORCH08-Ra	PP14-1411	2.58	0.97	63	22	25	38	22
747	ORCH08-Rb	PP14-1412	2.60	0.99	62	22	24	38	21
938	ORCH08-Rc	PP14-1413	2.61	1.08	59	16	17	41	23

1541	ORCH09-Ia	PP14-1414	2.61	1.03	61	9	10	51	26
993	ORCH09-Ib	PP14-1415	2.61	1.13	57	6	7	50	24
968	ORCH09-Ic	PP14-1416	2.57	1.09	58	8	8	49	25
839	ORCH09-Ra	PP14-1417	2.62	1.03	61	7	8	52	29
702	ORCH09-Rb	PP14-1418	2.60	0.95	63	15	15	48	26
926	ORCH09-Rc	PP14-1419	2.62	1.12	57	10	10	47	22
886	ORCH10-Ia	PP14-1420	2.63	1.16	56	8	9	47	19
710	ORCH10-Ib	PP14-1421	2.56	1.11	57	9	10	46	24
807	ORCH10-Ic	PP14-1422	2.58	1.19	54	5	6	48	26
918	ORCH10-Ra	PP14-1423	2.58	0.95	63	20	20	43	17
879	ORCH10-Rb	PP14-1424	2.61	1.10	58	9	10	48	23
755	ORCH10-Rc	PP14-1425	2.57	0.94	63	19	20	43	20
825	ORCH11-Ia	PP14-1426	2.65	1.36	49	9	10	39	12
771	ORCH11-Ib	PP14-1427	2.64	1.45	45	4	5	40	12
811	ORCH11-Ic	PP14-1428	2.64	1.41	47	7	8	39	12
882	ORCH11-Ra	PP14-1429	2.60	0.89	66	28	30	36	17
885	ORCH11-Rb	PP14-1430	2.60	1.21	53	15	16	38	10
923	ORCH11-Rc	PP14-1431	2.65	1.32	50	11	12	38	12
958	VIN04-Ia	PP14-1432	2.54	1.27	50	15	17	33	13
862	VIN04-Ib	PP14-1433	2.51	1.08	57	19	23	34	17
782	VIN04-Ic	PP14-1434	2.49	1.05	58	17	21	37	17
972	VIN04-Ra	PP14-1435	2.57	1.22	53	19	22	30	11
880	VIN04-Rb	PP14-1436	2.51	1.01	60	21	26	34	20
995	VIN04-Rc	PP14-1437	2.51	0.98	61	20	27	34	20
856	VIN02-Ia	PP14-1438	2.35	0.83	65	19	25	40	26
859	VIN02-Ib	PP14-1439	2.44	0.94	62	17	22	40	26
788	VIN02-Ic	PP14-1440	2.40	0.87	64	27	30	34	20
870	VIN02-Ra	PP14-1441	2.46	0.78	68	27	33	35	24
912	VIN02-Rb	PP14-1442	2.44	0.88	64	22	26	38	24
942	VIN02-Rc	PP14-1443	2.42	0.78	68	26	31	37	24
908	VIN05-Ia	PP14-1444	2.53	1.05	58	23	26	32	19
818	VIN05-Ib	PP14-1445	2.55	1.15	55	21	24	31	19
721	VIN05-Ic	PP14-1446	2.54	1.08	57	24	28	29	17
931	VIN05-Ra	PP14-1447	2.56	1.16	54	20	22	32	16

800	VIN05-Rb	PP14-1448	2.55	1.26	51	16	19	32	18
994	VIN05-Rc	PP14-1449	2.57	1.23	52	18	21	31	18
989	VIN01-Ia	PP14-1450	2.63	1.20	54	16	17	37	20
919	VIN01-Ib	PP14-1451	2.63	1.20	54	17	19	36	20
884	VIN01-Ic	PP14-1452	2.65	1.36	49	11	13	36	15
899	VIN01-Ra	PP14-1453	2.64	1.38	48	13	15	33	16
987	VIN01-Rb	PP14-1454	2.64	1.39	47	11	12	35	13
988	VIN01-Rc	PP14-1455	2.64	1.36	48	15	16	32	14

Core No.	Site name	Sample ID	Gravimetric water content (%w/w)				Volumetric water content (%v/v)			
			Field moisture	-5 kPa	-10 kPa	-1500 kPa	Field moisture	-5 kPa	-10 kPa	-1500 kPa
817	ORCH01-Ia	PP14-1366	31	34	33	21	39	43	41	27
798	ORCH01-Ib	PP14-1367	33	39	37	21	39	45	44	25
896	ORCH01-Ic	PP14-1368	35	41	39	25	40	46	45	28
848	ORCH01-Ra	PP14-1369	31	36	35	20	37	44	42	25
943	ORCH01-Rb	PP14-1370	25	36	34	20	30	43	42	25
955	ORCH01-Rc	PP14-1371	30	41	40	21	34	45	44	23
863	ORCH02-Ia	PP14-1372	22	28	27	16	30	37	36	21
836	ORCH02-Ib	PP14-1373	20	28	27	15	26	37	35	20
932	ORCH02-Ic	PP14-1374	18	28	26	13	25	38	36	18
940	ORCH02-Ra	PP14-1375	18	27	25	13	23	35	34	17
950	ORCH02-Rb	PP14-1376	19	28	27	15	24	36	35	20
985	ORCH02-Rc	PP14-1377	14	28	27	16	18	36	35	20
857	ORCH03-Ia	PP14-1378	18	25	22	10	24	35	31	14
806	ORCH03-Ib	PP14-1379	20	27	25	12	29	38	35	16
741	ORCH03-Ic	PP14-1380	17	23	21	9	25	33	30	13
921	ORCH03-Ra	PP14-1381	17	26	23	9	22	34	31	12
824	ORCH03-Rb	PP14-1382	19	30	27	13	24	38	35	16
977	ORCH03-Rc	PP14-1383	18	25	22	9	23	33	30	12
778	ORCH04-Ia	PP14-1384	36	45	43	29	38	47	46	30
890	ORCH04-Ib	PP14-1385	31	39	38	25	36	46	45	29
775	ORCH04-Ic	PP14-1386	31	38	37	25	36	44	43	29
731	ORCH04-Ra	PP14-1387	37	42	41	27	43	49	48	31
909	ORCH04-Rb	PP14-1388	32	38	37	24	38	45	44	29
966	ORCH04-Rc	PP14-1389	31	38	37	24	36	44	43	27
947	ORCH05-Ia	PP14-1390	25	34	32	20	31	42	40	25
762	ORCH05-Ib	PP14-1391	24	33	32	19	30	42	40	23
776	ORCH05-Ic	PP14-1392	24	32	30	18	30	40	38	23
883	ORCH05-Ra	PP14-1393	26	31	30	19	34	39	38	24
874	ORCH05-Rb	PP14-1394	27	35	34	15	33	44	42	19
895	ORCH05-Rc	PP14-1395	25	34	32	15	30	41	39	18
794	ORCH06-Ia	PP14-1396	25	30	28	12	32	38	36	15
735	ORCH06-Ib	PP14-1397	26	30	28	11	33	37	35	14
742	ORCH06-Ic	PP14-1398	26	32	31	13	33	41	39	17
898	ORCH06-Ra	PP14-1399	23	31	29	12	29	38	36	14

924	ORCH06-Rb	PP14-1400	26	30	29	12	37	42	41	16
892	ORCH06-Rc	PP14-1401	21	30	28	12	28	40	37	15
979	ORCH07-Ia	PP14-1402	41	44	43	20	46	50	49	23
928	ORCH07-Ib	PP14-1403	40	43	42	24	45	49	48	28
937	ORCH07-Ic	PP14-1404	52	55	55	33	51	55	54	32
974	ORCH07-Ra	PP14-1405	42	45	44	25	46	49	48	27
967	ORCH07-Rb	PP14-1406	46	46	45	24	51	51	50	27
981	ORCH07-Rc	PP14-1407	41	45	44	27	46	51	50	30
751	ORCH08-Ia	PP14-1408	32	39	38	24	38	46	45	29
834	ORCH08-Ib	PP14-1409	33	36	35	23	41	45	44	28
802	ORCH08-Ic	PP14-1410	33	41	39	18	39	48	47	22
763	ORCH08-Ra	PP14-1411	33	42	39	17	32	41	38	16
747	ORCH08-Rb	PP14-1412	32	40	39	17	32	40	38	17
938	ORCH08-Rc	PP14-1413	33	39	38	17	36	42	41	18
1541	ORCH09-Ia	PP14-1414	44	50	49	24	46	51	51	25
993	ORCH09-Ib	PP14-1415	42	45	44	22	47	50	50	25
968	ORCH09-Ic	PP14-1416	42	46	45	22	46	50	49	24
839	ORCH09-Ra	PP14-1417	48	52	51	23	49	53	52	24
702	ORCH09-Rb	PP14-1418	44	51	50	23	42	49	48	22
926	ORCH09-Rc	PP14-1419	39	43	42	22	43	48	47	24
886	ORCH10-Ia	PP14-1420	38	41	41	24	44	48	47	28
710	ORCH10-Ib	PP14-1421	39	43	42	20	44	48	46	23
807	ORCH10-Ic	PP14-1422	37	41	40	19	45	48	48	22
918	ORCH10-Ra	PP14-1423	41	46	45	27	38	43	43	26
879	ORCH10-Rb	PP14-1424	41	44	44	23	45	49	48	26
755	ORCH10-Rc	PP14-1425	42	47	46	24	39	44	43	23
825	ORCH11-Ia	PP14-1426	25	29	28	19	34	40	39	27
771	ORCH11-Ib	PP14-1427	26	28	27	19	37	40	40	28
811	ORCH11-Ic	PP14-1428	25	28	27	19	35	39	39	26
882	ORCH11-Ra	PP14-1429	34	42	40	21	31	37	36	19
885	ORCH11-Rb	PP14-1430	28	32	31	23	34	39	38	28
923	ORCH11-Rc	PP14-1431	25	29	29	20	33	39	38	26
958	VIN04-Ia	PP14-1432	19	27	26	16	24	35	33	20
862	VIN04-Ib	PP14-1433	21	35	32	16	22	38	34	18
782	VIN04-Ic	PP14-1434	23	39	35	19	24	41	37	20
972	VIN04-Ra	PP14-1435	16	28	25	16	19	34	30	19
880	VIN04-Rb	PP14-1436	20	39	33	14	20	39	34	14
995	VIN04-Rc	PP14-1437	20	42	34	14	19	41	34	14
856	VIN02-Ia	PP14-1438	30	55	48	17	25	46	40	14
859	VIN02-Ib	PP14-1439	31	47	43	15	29	44	40	14

788	VIN02-Ic	PP14-1440	28	42	39	16	24	36	34	14
870	VIN02-Ra	PP14-1441	25	53	45	14	20	41	35	11
912	VIN02-Rb	PP14-1442	31	47	43	16	28	42	38	14
942	VIN02-Rc	PP14-1443	32	55	47	16	25	42	37	12
908	VIN05-Ia	PP14-1444	27	33	30	12	29	35	32	13
818	VIN05-Ib	PP14-1445	22	29	27	10	25	34	31	11
721	VIN05-Ic	PP14-1446	24	31	27	11	25	33	29	12
931	VIN05-Ra	PP14-1447	25	30	28	14	29	34	32	16
800	VIN05-Rb	PP14-1448	20	28	26	11	25	35	32	14
994	VIN05-Rc	PP14-1449	18	28	25	11	22	34	31	13
989	VIN01-Ia	PP14-1450	30	33	31	14	36	39	37	17
919	VIN01-Ib	PP14-1451	27	31	30	13	32	37	36	16
884	VIN01-Ic	PP14-1452	25	28	27	16	34	37	36	22
899	VIN01-Ra	PP14-1453	23	25	24	12	32	35	33	17
987	VIN01-Rb	PP14-1454	24	26	25	15	34	36	35	21
988	VIN01-Rc	PP14-1455	22	25	24	14	30	34	32	19

Water-stability of 2-4 mm aggregates									
Sample name		ORCH01-R	ORCH01-I	ORCH02-R	ORCH02-I	ORCH03-R	ORCH03-I	ORCH04-R	ORCH04-I
Sample ID		PP14-1552	PP14-1553	PP14-1554	PP14-1555	PP14-1556	PP14-1557	PP14-1558	PP14-1559
Net % aggregates	2 mm	31.7	51.0	23.4	62.4	26.6	39.2	34.0	76.8
	1 mm	51.9	64.6	44.4	73.8	45.4	58.9	55.0	85.1
	0.5 mm	69.0	75.3	60.0	80.0	57.4	66.5	70.8	90.5
Mean weight diameter		1.46	1.88	1.23	2.14	1.28	1.61	1.53	2.49

Water-stability of 2-4 mm aggregates									
Sample name		ORCH05-R	ORCH05-I	ORCH06-R	ORCH06-I	ORCH07-R	ORCH07-I	ORCH08-R	ORCH08-I
Sample ID		PP14-1560	PP14-1561	PP14-1562	PP14-1563	PP14-1564	PP14-1565	PP14-1566	PP14-1567
Net % aggregates	2 mm	26.2	63.2	21.2	37.2	14.5	47.9	13.5	62.4
	1 mm	51.0	77.7	45.7	58.1	31.5	62.3	31.3	75.6
	0.5 mm	67.7	85.2	64.1	72.4	52.7	74.7	50.1	84.3
Mean weight diameter		1.36	2.21	1.23	1.61	0.97	1.81	0.94	2.18

Water-stability of 2-4 mm aggregates									
Sample name		ORCH09-R	ORCH09-I	ORCH10-R	ORCH10-I	ORCH11-R	ORCH11-I		
Sample ID		PP14-1568	PP14-1569	PP14-1570	PP14-1571	PP14-1572	PP14-1573		
Net % aggregates	2 mm	20.9	63.4	42.1	50.0	23.0	45.7		
	1 mm	43.6	79.5	61.2	67.3	51.0	66.3		
	0.5 mm	62.7	88.9	77.5	79.8	71.2	79.3		
Mean weight diameter		1.20	2.24	1.73	1.90	1.33	1.83		

Water-stability of 2-4 mm aggregates									
Sample name		VIN01-I	VIN01-R	VIN02-I	VIN02-R	VIN04-I	VIN04-R	VIN05-I	VIN05-R
Sample ID		PP14-1574	PP14-1575	PP14-1576	PP14-1577	PP14-1578	PP14-1579	PP14-1580	PP14-1581
Net % aggregates	2 mm	18.1	7.9	88.5	82.9	40.7	40.9	33.0	32.7
	1 mm	37.8	19.6	93.8	87.5	59.9	59.7	58.0	56.0
	0.5 mm	54.5	26.1	95.4	90.9	67.7	71.7	69.4	67.8
Mean weight diameter		1.08	0.65	2.76	2.60	1.65	1.67	1.53	1.50

Notes:

All samples collected by HBRC.

Macro-porosity cited here is determined between total porosity and tension of -5 kPa, for consistency with the National Soils Database of New Zealand (NSD).
Air Capacity cited here is determined between total porosity and tension of -10 kPa. This may be referred to as Macro-porosity for specifications requiring this characteristic to be measured at -10 kPa. It is important to be aware what tension has been used, particularly with historical or NSD

References:

Gradwell, M.W. 1972: Methods for physical analysis of soils. *Scientific Report 10C*. Lower Hutt, N.Z. Soil Bureau.

Gradwell, M.W. 1972. Water stability of soil aggregates - C5.A. Wet-sieving test. Methods for physical analysis of soils. N.Z. Soil Bureau. Scientific Report 10.

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